Contextual Analysis –
Drinking Water Safety in Sudan
5 December 2017
The process leading to the development of the Sudan Drinking Water Safety Strategic Framework was funded by the Qatar Fund for Development and the World Health Organization (WHO), with financial contributions also from UNICEF. The Core Team who managed and facilitated the process included: Federal Ministry of Health (FMoH); Drinking Water and Sanitation Unit (DWSU), Ministry of Water Resources, Irrigation and Electricity (MoWRIE); WHO; the United Nations Children’s Fund (UNICEF); and RedR Sudan.

Note on photographs:
All photographs in this report have been taken by S. House / RedR Sudan unless otherwise specified.
Contents

1. EXECUTIVE SUMMARY ............................................................................................................................11

2. INTRODUCTION AND SCOPE ............................................................................................................19
   2.1 INTRODUCTION .................................................................................................................................19
   2.2 TERMS OF REFERENCE ......................................................................................................................19
   2.3 STAGES AND SCHEDULE ..................................................................................................................19
   2.4 METHODOLOGIES ..............................................................................................................................19
   2.5 STRUCTURE OF THIS REPORT ...........................................................................................................20
   2.6 LIMITATIONS ..................................................................................................................................20

3. CONTEXT - HAZARDS, HAZARDOUS EVENTS, RISKS, STRENGTHS, BOTTLENECKS AND THEORY OF CHANGE ....21
   3.1 HAZARDS – DWS RELATED CONTAMINANTS & ACCESS TO SDW ..................................................21
      3.1.1 Access to improved drinking water supply ..................................................................................21
      3.1.2 Water quality – physical, chemical, microbiological ................................................................22
   3.2 HAZARDOUS EVENTS .........................................................................................................................25
   3.3 RISKS – DISEASES ..............................................................................................................................27
      3.3.1 Water-based diseases in Sudan ......................................................................................................27
      3.3.2 Water-related and water-washed diseases in Sudan ....................................................................27
      3.3.3 Other risks ....................................................................................................................................27
   3.4 SUMMARY OF DWS RELATED STRENGTHS, BOTTLENECKS AND THEORY OF CHANGE ......................27
      3.4.1 Summary of DWS related strengths ............................................................................................27
      3.4.2 Bottleneck analysis ......................................................................................................................28
      3.4.3 Theory of Change ..........................................................................................................................28

4. CONTEXT – WATER SUPPLY CHAIN ..................................................................................................31
   4.1 WATER SOURCES PROTECTION AND ABSTRACTION .....................................................................31
   4.2 BULK WATER TREATMENT ..............................................................................................................33
      4.2.1 Urban WTPs ...................................................................................................................................34
      4.2.2 Rural WTPs ...................................................................................................................................35
   4.3 BULK STORAGE AND DISTRIBUTION NETWORKS TO COLLECTION POINTS ......................................36
   4.4 COLLECTION OF WATER AND TRANSFER TO HOUSEHOLD ..........................................................40
   4.5 HOUSEHOLD WATER SUPPLY, TREATMENT AND SAFE STORAGE (HWTS) / POINT OF USE (PoU) .................42
   4.6 BELIEFS, COMMUNITY ENGAGEMENT, HYGIENE PROMOTION, CITIZEN FEEDBACK AND ENFORCEMENT/ ACTIVATION OF LAWS .................................................................44
      4.6.1 Beliefs and practices related to DWS ...........................................................................................44
      4.6.2 DWS and AWD campaigns in humanitarian context ...................................................................44
      4.6.3 Community engagement and hygiene promotion on DWS in longer term context .......................45
      4.6.4 WASH and Health Committees and community volunteers .......................................................46
      4.6.5 Citizen feedback and complaints ..................................................................................................47
      4.6.6 Enforcement/ activation of laws ....................................................................................................48
   4.7 SPECIFIC CONTEXTS ..........................................................................................................................49
      4.7.1 Regulation of packaged/bottled water ..........................................................................................49
      4.7.2 Schools, health facilities and other institutions ............................................................................53
      4.7.3 Nomadic communities ..................................................................................................................53
      4.7.4 Humanitarian contexts ................................................................................................................54

5. CONTEXT - CROSS-CUTTING ISSUES ...............................................................................................55
   5.1 GENDER, EQUITY AND VULNERABILITY .........................................................................................55
   5.2 SUSTAINABILITY, ENVIRONMENT, CLIMATE CHANGE AND DISASTER RISK REDUCTION ..................56

6. CONTEXT – BUILDING BLOCKS FOR WATER SAFETY .......................................................................58
   6.1 LEGAL AND POLICY FRAMEWORK ....................................................................................................58
      6.1.1 Codes, Laws, Acts and regulations ...............................................................................................58
<table>
<thead>
<tr>
<th>Annex</th>
<th>Title</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>VII</td>
<td>Annex VI</td>
<td>Capacity – Job Descriptions of FMOH Water Safety Team</td>
</tr>
<tr>
<td>V</td>
<td>Annex V</td>
<td>Water Sources and Water Quality Monitoring Forms and Databases</td>
</tr>
<tr>
<td>IV</td>
<td>Annex IV</td>
<td>Capacity – Water Quality Analysis</td>
</tr>
<tr>
<td>III</td>
<td>Annex III</td>
<td>Documents</td>
</tr>
<tr>
<td>II</td>
<td>Annex II</td>
<td>Schedules</td>
</tr>
<tr>
<td>I</td>
<td>Annex I</td>
<td>Desk Based Research</td>
</tr>
</tbody>
</table>

**ANNEX VII**

7.

III.9

III.7

III.3

III.1

A

A

A

6.4

6.3

6.2

6.1

DESIGN BASED RESEARCH

6.5.4

6.5.1

6.5.2

6.5.3

6.5.5

6.5.6

Water quality standards and guidelines

6.4.7

6.4.6

6.4.5

6.4.4

6.4.3

6.4.2

6.4.1

6.3.5

6.3.4

6.3.3

6.3.2

6.3.1

6.3

6.2.7

6.2.6

6.2.5

6.2.4

6.2.3

6.2.2

6.2.1

6.2

6.1.5

6.1.4

6.1.3

6.1.2

6.1.1

6.1

5.5

5.4

5.3

5.2

5.1

4.7

4.6

4.5

4.4

4.3

4.2

4.1

4

3

2

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5.6

5.5

5.4

5.3

5.2

5.1

4.7

4.6

4.5

4.4

4.3

4.2

4.1

4

3

2

1

171 162 153 102 98 94 90 77 75 73 72 69 67 65 64 62 61

ANNEX IV

ANNEX III

ANNEX II

ANNEX VII

ANNEX VI

ANNEX V
ANNEX VIII - JMP POST 2015 – WATER SAFETY RELATED ..............................................................................................................173

ANNEX IX - REFERENCES ..........................................................................................................................................................177

IX.1 SUDAN – RECENT STRATEGIC, CAPACITY BUILDING, MONITORING AND OTHER DOCUMENTATION .................................................177
IX.2 SUDAN – TRAINING MATERIALS, MONITORING AND DATABASE FORMS ........................................................................................................180
IX.3 SUDAN – DRINKING WATER QUALITY ........................................................................................................................................182
IX.4 GLOBAL – DRINKING WATER SAFETY, WATER SAFETY PLANNING AND SURVEILLANCE GUIDANCE .................................................182
IX.5 GLOBAL – DRINKING WATER QUALITY, DISEASES, PARAMETERS, ASSESSMENT AND TREATMENT ........................................................184
IX.6 GLOBAL - TECHNICAL / CONSTRUCTION ....................................................................................................................................186
IX.7 GLOBAL – REGULATION, BOTTLED WATER & HEALTH AND SAFETY ................................................................................................187
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- Sudanese Standards and Metrology Organisation (SSMO)

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- State Water Corporations (SWC) – Khartoum, Kassala, White Nile, North Darfur, East Darfur, Central Darfur, South Darfur

Communities, Refugee and IDP camp communities:
- Alagaya refugee camp residents and water treatment plant staff, White Nile
- Rural community water yard caretaker in Kassala Rural Locality
- Zamzam internally displaced persons camp residents, Health and Water Committees and water yard caretakers, North Darfur

Laboratories (including those within Ministries and State Water Corporations)
- Drinking Water and Sanitation Training (DWST) Centre laboratory, MoWRIE – Khartoum
- Groundwater and Wadis laboratory, MoWRIE – Khartoum
- Khartoum University, Environmental Health Laboratory
- State MoH Central laboratories – Khartoum; Kassala; East Darfur; South Darfur
- National Public Health Laboratory, FMoH - Khartoum
- SWC laboratories – Central Lab Khartoum at Mogran WTP; Burri Water Treatment Plant and laboratories, Khartoum; Central Lab, Kassala; Central Lab at Kosti Treatment works, White Nile; WES Lab East Darfur; WES Lab South Darfur; WES lab West Darfur; WES Lab Central Darfur

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- Bahari University
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- DWST Centres – Khartoum and White Nile
- Khartoum University
- University of Gezira

Private Sector:
- Airba
- Airwan Co.
- Bannaga Consult
- Co. Pact Company
- HACCP Co.
• National Company for Manufacturing Water Equipment
• NewTech
• Rasd Tech Company
• SIPCO Co.
• Thames Water Utilities Ltd. UK
• Wagtech Projects

Civil Society Organisations:
• Khartoum:
  o Action on Disability and Development (ADD)
  o RedR Sudan
• South Darfur:
  o Ahmassar
• North Darfur:
  o American Refugee Committee (ARC)
  o Assist
  o Catholic Relief Services (CRS)
  o Care International Switzerland (CIS)
  o Cooperazione Intenationale (COOPI)
  o Dar es Salaam Development Programme
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  o RedR Sudan

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• United Nations High Commissioner for Refugees (UNHCR)
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Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>AAU</td>
<td>Alzaem Alaaahari University</td>
</tr>
<tr>
<td>AC</td>
<td>Asbestos cement</td>
</tr>
<tr>
<td>AfDB</td>
<td>African Development Bank</td>
</tr>
<tr>
<td>AWD</td>
<td>Acute Watery Diarrhoea</td>
</tr>
<tr>
<td>CBI</td>
<td>Community Based [Development] Initiative</td>
</tr>
<tr>
<td>CBO</td>
<td>Community based organisations</td>
</tr>
<tr>
<td>CEHA</td>
<td>WHO Regional Centre for Environmental Health Actions</td>
</tr>
<tr>
<td>COR</td>
<td>Commission for Refugees</td>
</tr>
<tr>
<td>CPDD</td>
<td>Continuous Professional Development Directorate, FMoH</td>
</tr>
<tr>
<td>CSO</td>
<td>Civil Society Organisations (NGOs, CBOs, FBOs)</td>
</tr>
<tr>
<td>DFID</td>
<td>Department for International Development, UK Government</td>
</tr>
<tr>
<td>DG</td>
<td>Director General</td>
</tr>
<tr>
<td>DRR</td>
<td>Disaster risk reduction</td>
</tr>
<tr>
<td>DWI</td>
<td>Drinking Water Inspectorate</td>
</tr>
<tr>
<td>DWQ</td>
<td>Drinking water quality</td>
</tr>
<tr>
<td>DWS</td>
<td>Drinking water safety</td>
</tr>
<tr>
<td>DWST</td>
<td>Drinking Water and Sanitation Unit Training Centre</td>
</tr>
<tr>
<td>DWSU</td>
<td>Drinking Water and Sanitation Unit, MoWRIE (previously known as PWC)</td>
</tr>
<tr>
<td>EH</td>
<td>Environmental health</td>
</tr>
<tr>
<td>FAO</td>
<td>Food and Agriculture Organisation</td>
</tr>
<tr>
<td>FBO</td>
<td>Faith Based organisation</td>
</tr>
<tr>
<td>FGD</td>
<td>Focus group discussion</td>
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<tr>
<td>FRC</td>
<td>Free residual chlorine</td>
</tr>
<tr>
<td>FMoH</td>
<td>Federal Ministry of Health</td>
</tr>
<tr>
<td>GDP</td>
<td>Gross Domestic Product</td>
</tr>
<tr>
<td>GWDD</td>
<td>Groundwater and Wadis Directorate, MoWRIE</td>
</tr>
<tr>
<td>HAC</td>
<td>Humanitarian Aid Commission</td>
</tr>
<tr>
<td>HACCP</td>
<td>Hazard analysis critical control point</td>
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<tr>
<td>HDPE</td>
<td>High density poly ethylene</td>
</tr>
<tr>
<td>HP</td>
<td>Hygiene promotion / Health promotion</td>
</tr>
<tr>
<td>HP</td>
<td>Hand Pump</td>
</tr>
<tr>
<td>HPLC</td>
<td>High Performance Liquid Chromatograph</td>
</tr>
<tr>
<td>H_{2}S</td>
<td>Hydrogen Sulphide</td>
</tr>
<tr>
<td>HTH</td>
<td>High test hypochlorite</td>
</tr>
<tr>
<td>HWTS</td>
<td>Household water treatment and safe storage</td>
</tr>
<tr>
<td>HYWY</td>
<td>High yield water yard</td>
</tr>
<tr>
<td>IDP</td>
<td>Internally displaced person</td>
</tr>
<tr>
<td>INGO</td>
<td>International non-governmental organisation</td>
</tr>
<tr>
<td>IOM</td>
<td>International Office for Migration</td>
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<tr>
<td>ISO</td>
<td>International Standards Organisation</td>
</tr>
<tr>
<td>IWWM</td>
<td>Integrated Water Resources Management</td>
</tr>
<tr>
<td>JICA</td>
<td>Japan International Cooperation Agency</td>
</tr>
<tr>
<td>JMP</td>
<td>Joint Monitoring Programme, WHO/UNICEF</td>
</tr>
<tr>
<td>KAP</td>
<td>Knowledge, attitude and practice</td>
</tr>
<tr>
<td>KPI</td>
<td>Key performance indicator</td>
</tr>
<tr>
<td>KPI</td>
<td>Knowledge, attitude and practice</td>
</tr>
<tr>
<td>LWWY</td>
<td>Low yield water yard</td>
</tr>
<tr>
<td>M&amp;E</td>
<td>Monitoring and Evaluation</td>
</tr>
<tr>
<td>MDG</td>
<td>Millennium Development Goals</td>
</tr>
<tr>
<td>MF</td>
<td>Membrane Filtration</td>
</tr>
<tr>
<td>MIC</td>
<td>Ministry of International Cooperation</td>
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<tr>
<td>MICS</td>
<td>Multi-Indicator Cluster Survey</td>
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<tr>
<td>Key Acronyms</td>
<td>Definition</td>
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<td>-------------</td>
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<tr>
<td>MIS</td>
<td>Management information system</td>
</tr>
<tr>
<td>MLSB</td>
<td>Membrane Lauryl Sulphate Broth</td>
</tr>
<tr>
<td>MoE</td>
<td>Ministry of Education</td>
</tr>
<tr>
<td>MoENRPD</td>
<td>Ministry of the Environment, Natural Resources and Physical Development</td>
</tr>
<tr>
<td>MoFNE</td>
<td>Ministry of Finance and National Economy</td>
</tr>
<tr>
<td>MoWRIE</td>
<td>Ministry of Water Resources, Irrigation and Electricity</td>
</tr>
<tr>
<td>MoWSS</td>
<td>Ministry of Welfare and Social Security</td>
</tr>
<tr>
<td>MP</td>
<td>Motor pump</td>
</tr>
<tr>
<td>MPN</td>
<td>Most Probable Number</td>
</tr>
<tr>
<td>NaDCC</td>
<td>Sodium dichloroisocyanurate</td>
</tr>
<tr>
<td>NERC</td>
<td>National Environmental Research Council</td>
</tr>
<tr>
<td>NGO</td>
<td>Nongovernmental organisation</td>
</tr>
<tr>
<td>NPHL</td>
<td>National Public Health Laboratory, FMoH (formerly known as STAK)</td>
</tr>
<tr>
<td>NSHC</td>
<td>National Sanitation High Committee</td>
</tr>
<tr>
<td>O&amp;M</td>
<td>O&amp;M</td>
</tr>
<tr>
<td>PAC</td>
<td>Polyaluminium Chloride</td>
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<tr>
<td>PoU</td>
<td>Point of use</td>
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<tr>
<td>PPE</td>
<td>Personal protective equipment</td>
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<tr>
<td>PTA</td>
<td>Parents and Teachers Association</td>
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<tr>
<td>RCF</td>
<td>Refugee Consultation Forum</td>
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<tr>
<td>RedR</td>
<td>Register of Engineers for Disaster Relief</td>
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<tr>
<td>RSF</td>
<td>Rapid sand filter</td>
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<tr>
<td>S&amp;H</td>
<td>Sanitation and hygiene</td>
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<tr>
<td>SDG</td>
<td>Sustainable Development Goals</td>
</tr>
<tr>
<td>SDW</td>
<td>Safe drinking water</td>
</tr>
<tr>
<td>SDWSSSF</td>
<td>Sudan Drinking Water Safety Strategic Framework</td>
</tr>
<tr>
<td>SHCC</td>
<td>School Health Coordination Council</td>
</tr>
<tr>
<td>SMoUDPI</td>
<td>Ministry of Urban Planning and Infrastructure – at State level (in some States the title ‘Infrastructure’ may be replaced by ‘Public Utilities’ or ‘Construction’)</td>
</tr>
<tr>
<td>SNSHSF</td>
<td>Sudan National Sanitation and Hygiene Strategic Framework</td>
</tr>
<tr>
<td>SSF</td>
<td>Slow Sand Filter</td>
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<tr>
<td>SSMO</td>
<td>Sudan Standards and Metrology Organisation</td>
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<tr>
<td>SWC</td>
<td>State Water Corporation</td>
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<tr>
<td>SWM</td>
<td>Solid waste management</td>
</tr>
<tr>
<td>TAG</td>
<td>Technical Advisory Group</td>
</tr>
<tr>
<td>UNHCR</td>
<td>United Nations High Commissioner for Refugees</td>
</tr>
<tr>
<td>UNICEF</td>
<td>United Nations Children’s Fund</td>
</tr>
<tr>
<td>uPVC</td>
<td>Un-plasticised Poly Vinyl Chloride</td>
</tr>
<tr>
<td>UWA</td>
<td>Urban Water Authority</td>
</tr>
<tr>
<td>UW4D</td>
<td>Urban Water for Darfur</td>
</tr>
<tr>
<td>WASH</td>
<td>Water, sanitation and hygiene</td>
</tr>
<tr>
<td>WES</td>
<td>Water and Environmental Sanitation [Project]</td>
</tr>
<tr>
<td>WHO</td>
<td>World Health Organization</td>
</tr>
<tr>
<td>WTP</td>
<td>Water treatment plant</td>
</tr>
</tbody>
</table>

**Key acronyms that have been used throughout the report:**

- SDW – Safe drinking water
- DWS – Drinking water safety
- DWQ – Drinking water quality

**Sudan data:**

Sudan has 18 States, 182 Localities and 3 or more Administrative Units per Locality
## Terminology and definitions

The following terminology has been adopted by the WHO/UNICEF Joint Monitoring Program (JMP)\(^1\) or used by the Sudan National Sanitation and Hygiene Strategic Framework (SNSHSF).

### Table 1 - Terminology and definitions

<table>
<thead>
<tr>
<th>Terminology and definitions as adopted by the WHO/UNICEF JMP</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Drinking water quality</strong></td>
<td>A measurement of the presence of physical, chemical, biological or radiological constituents in drinking water, with reference to benchmark values, in a sample of water collected from a particular location.</td>
</tr>
<tr>
<td><strong>Drinking water safety</strong></td>
<td>The risk posed by use of a particular drinking-water source over extended periods. Measurement of water safety requires assessment of risk management in addition to water quality monitoring.</td>
</tr>
<tr>
<td><strong>Water safety plan (WSP)</strong></td>
<td>A WSP is a systematic risk assessment and risk prevention approach encompassing all steps in the water supply system from the catchment to the consumer.</td>
</tr>
<tr>
<td><strong>Basic drinking water</strong></td>
<td>An improved drinking water facility is defined as a source or delivery point that by nature of its construction, or through active intervention, is protected from outside contamination, in particular from contamination with faecal matter. The following are considered as improved drinking water facilities: Piped drinking water; Supply on premises; Public taps/standposts; Tubewell/borehole; Protected dug well; Protected spring; Rainwater. Packaged water is considered improved if households use an improved water facility for other domestic purposes. Households are considered to have a basic water facility when they use an improved facility with a total collection time of 30 minutes or less for a roundtrip, including queuing.</td>
</tr>
<tr>
<td><strong>Universal</strong></td>
<td>Implies all exposures and settings including households, schools, health facilities, workplaces etc.</td>
</tr>
<tr>
<td><strong>Equitable</strong></td>
<td>Implies progressive reduction and elimination of inequalities between population sub-groups.</td>
</tr>
<tr>
<td><strong>Access</strong></td>
<td>Implies sufficient water to meet domestic needs is reliably available close to home.</td>
</tr>
<tr>
<td><strong>Safe</strong></td>
<td>Safe drinking water is free from pathogens and elevated levels of toxic chemicals at all times.</td>
</tr>
<tr>
<td><strong>Affordable</strong></td>
<td>Payment for services does not present a barrier to access or prevent people meeting other basic human needs.</td>
</tr>
<tr>
<td><strong>Drinking water</strong></td>
<td>Water used for drinking, cooking, food preparation and personal hygiene.</td>
</tr>
<tr>
<td><strong>For all</strong></td>
<td>Suitable for use by men, women, girls and boys of all ages including people living with disabilities.</td>
</tr>
</tbody>
</table>

### Terminology as adopted for the SNSHSF

<table>
<thead>
<tr>
<th><strong>Hygiene</strong></th>
<th>The conditions and practices that help to prevent the spread of diseases and maintain health and dignity.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hygiene promotion</strong></td>
<td>A planned, systematic approach which encourages and enables people to take action and adopt safe hygiene practices and behaviours to prevent diseases and protect health.</td>
</tr>
</tbody>
</table>

### English words for Arabic terms

- **Zeer** - A traditional clay pot used for storing drinking water (alternatively spelt as Zir or Zyr).
- **Wudu** - Ablution, washing before prayer.

---

1. Executive summary

Introduction to the Drinking Water Safety Strategic Framework

The aim of the Sudan Drinking Water Safety Strategic Framework (SDWSSF) is to provide strategic direction to the scaling up of access to safe drinking water (SDW) across Sudan. This will be through providing drinking water systems that are appropriately designed which effectively protect the drinking water at all times to minimise faecal contamination and elevated levels of toxic chemicals; and through ensuring that treatment processes are effective and sustainable.

The SDWSSF has been developed through a participatory and consultative process jointly led by the Ministry of Water Resources, Irrigation and Electricity (MoWRIE) and the Federal Ministry of Health (FMoH), it has involved representatives from Federal, State, Locality and community levels, across ministries and sectors (Health, Water and Environment) and has included representatives from government, civil society organisations, the private sector, higher education institutions, the UN and other development partners. The process has been financed by the Qatar Fund for Development and the World Health Organization (WHO), with some financial contributions also from UNICEF. The process has been supported by a core team consisting of the FMoH, MoWRIE, WHO, UNICEF and RedR Sudan.

An overview of the components of the SDWSSF can be seen in Fig 1.

Importance of drinking water safety

The need to increase attention on the safety of drinking water, rather than just the quantity has been acknowledged globally through the commitment to the Sustainable Development Goals (SDGs). SDG 6.1 focuses on achieving universal and equitable access to safe and affordable drinking water for all, and SDG 6.2 focuses on improving water quality by reducing pollution. The need for increased attention on drinking water safety (DWS) in Sudan has also been clearly illustrated by the AWD outbreak of 2016/17, which highlighted gaps and challenges being faced in ensuring DWS. See the box below for definitions of drinking water quality and drinking water safety.

**Drinking water quality (DWQ)** = A measurement of the presence of physical, chemical, biological or radiological constituents in drinking water, with reference to benchmark values, in a sample of water collected from a particular location.

**Drinking water safety (DWS)** = The risk posed by use of a particular drinking-water source over extended periods. Measurement of water safety requires assessment of risk management in addition to water quality monitoring.

Access to SDW is critical for human health, dignity and economic development. It also contributes to the attainment of a number of human rights including, but not limited to: survival, attaining an adequate standard of living, health, education and gender equality. The safety of drinking water has a direct impact on a range of diseases and illnesses and increasing access to SDW contributes to improving child, maternal and neonatal nutrition and reducing morbidity and mortality. It increases the time that is spent in school and work, due to less time off due to sickness and looking after the sick and it reduces the workload burden, particularly on women and girls. Accessible water supply facilities can also contribute to ensuring health, dignity and quality of life for people with disabilities and mobility limitations and well sited and functioning facilities can also contribute to reducing vulnerabilities to violence for women and girls and in some cases men and boys, particularly in conflict zones. There is clear evidence that the child stunting rate increases with both a reduction of access to improved water sources and with higher levels of open defecation in the States across Sudan.

It is estimated that the Benefit-Cost-Ratio is 4.0 (i.e. for every 1 USD spent on water supply that 4.0 USD is gained).

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Fig 1 - Sudan DWS Strategic Framework

Sudan Drinking Water Safety Strategic Framework (SDWSSF)

Water resource protection
- Regulation - enforcement - community engagement - monitoring, surveillance, citizen feedback and actions

- Water source and abstraction
- Bulk water treatment
- Bulk storage & distribution to collection point
- Collection of water & transfer to household
- Household water supply, treatment & storage

Water supply chain

Cross-cutting issues
- Gender, equity & vulnerability
- Sustainability, environment & climate change

Building blocks
- Planning, monitoring, research and learning
  - Water safety planning
  - Sanitary inspection/surveys
  - Water quality analysis

- Legal & policy framework
- Stakeholder responsibilities
- Capacity building
- Finance

Identification of: Hazards - Hazardous events - Risks

Control measure
- Selection, siting, design of system and construction
- Management, operation and maintenance
- Community engagement, hygiene promotion & enforcement / activation of laws

Quality assurance
- Operational monitoring, verification of effectiveness, surveillance, documentation & citizen feedback
- Post-monitoring actions
**Hazards and risks**

The Multi-Indicator Cluster Survey (MICS, 2014) indicated that an average of 68.0% of people have access to an improved water sources in Sudan, with an average of 63.8% and 78.3% in rural and urban areas respectively. Access varies greatly across the States from 27.7% in Gedaref and 32.7% in White Nile, to 88.9% in Gezira and 93.8% in the Northern States. Only 4.1% of households who use an unimproved water source use an appropriate water treatment method.

Hazards from drinking water may come from naturally occurring chemicals in the water or from external pollutants. These may occur due to: natural fluctuations in weather conditions; inadequate protection, siting, design and construction; inadequate management or O&M (O&M); or inadequate community engagement, communication and/or enforcement. In different areas of Sudan, problems are related to health risks, challenges for treatment or acceptance to consumers - with physical parameters such as turbidity, pH and temperature; or chemical parameters such as Fluorides, Nitrates, Chlorides, Total Dissolved Solids, Sulphates, metals, pesticides, insecticides, fertilisers, or petroleum products. Microbiological or biological hazards include a range of bacteria, viruses and protozoa, as well as algae. Examples of health based risks include AWD, Giardia, Shigella, Typhoid, Hepatitis A and E and Fluorosis.

**Key challenges – in the sustainable supply of safe drinking water**

Protection, selection, siting, design of system and construction – Sudan has over 38,000 water sources including groundwater, surface water and rainwater, with some cases including water that needs to be desalinated. Open defecation and poor management of wastes from human settlements including from septic tanks, wastes from industry and agriculture all pose challenges for DWS, as does the over-use of water resources, conflicts over water and climate change. See Fig 2.

**Fig 2 - Pollution risks and water resources protection**

Particular challenges are faced seasonally for the treatment of surface water due to the exceptionally high turbidity during the rainy season (up to 35,000 NTU), as most water treatment plant (WTP) systems were not designed effectively to deal with such high levels. WTPs in urban areas are aging and not all are fully functioning and the State Water Corporations (SWCs) find it difficult to afford the required chemicals for water treatment. Some refugee and internally displaced persons (IDP) camps and communities are using “compact units” which consist of all treatment processes combined into one compact system. However, due to population increases, sometimes these may be operating for many more people than they were designed for. Sudan regulations and guidelines recommend painting the insides of drinking water storage tanks, including those used in bottled water factories. Sudan does not however currently have processes for certifying the safety of non-toxic paints for use for rust prevention or waterproofing.
Management and O&M – Many of the piped networks are old and there are high levels of leakage. Repairs to the network tend to be reactive to complaints and to be only temporary fixes using rubber straps, rather than lasting solutions. Water supply tends to be intermittent, which risks the inflow of contaminants, and the lack of water meters in the networks and at households means that accurate leakage rates are not fully known. Some of the old asbestos piped networks are being replaced, but many still remain. Water yards and distribution points are sometimes poorly designed leading to ponding of water on the ground at collection points, which also poses contamination risks. Maintenance does not tend to be prioritised and not all SWCs know the actual cost required to maintaining a system effectively. Communities may also find it challenging to operate slow sand filters, which also struggle with high turbidity of water and many communities are still using open sources such as dams or hafirs with no water treatment. A number of examples were seen where no residual chlorine has been found at household level. This may be due to the water not being chlorinated correctly, inadequate chlorine levels for the heat and contamination levels, or the chlorine having lost its strength due to poor storage.

Community beliefs, engagement, hygiene promotion and enforcement / activation of laws – A number of community beliefs exist related to DWS, such that any water that is flowing is clean and also that chlorine is poison and can lead to disease or a person becoming infertile. These beliefs can become barriers to the acceptance of SDW. Most communities have not been involved in water safety planning and have had limited engaged in the issue of DWS, although their engagement has been increased during the AWD outbreak. In some communities, including in camps, there are Health and WASH Committees which are engaging in this issue. Some hygiene promotion efforts have included issues related to DWS and information is included in the FMoH health messages for schools, although it is reported to not be well integrated into the school curriculum. The use of the traditional clay pot or Zeer, poses challenges to DWS because traditionally the users share a cup and dip it into the pot to take water, both of which pose contamination risks. Some degree of enforcement of laws is occurring and it is reported to have been initiated by a range of stakeholders including State MoH, Localities and the Drinking Water and Sanitation Training (DWST) laboratory in the MoWRIE. It is reported that a number of water points have been shut down and private owners forced to chlorinate their water during the AWD outbreak.

Operational monitoring, verification of effectiveness, surveillance, documentation and citizen feedback - A range of monitoring forms exist across stakeholders, some of which are clearly well used and others not so regularly or do not exist. There does not seem to be a consistency in formats across key institutions and there is also a risk that some results may be completed based on what is expected rather than the reality. Some WTPs are undertaking regular tests to optimise the dosage of chemicals, but not in all. The MoH and Locality water safety teams are trying their best to undertake their role of surveillance of DWS but they are incapacitated by very few staff (commonly only one or two per State and one per Locality); very limited access to vehicles, with some only getting out when they can travel in partner organisation vehicles; and limited access to funds. Some systems exist for citizens to complain to the SWC when there are problems, but a lack of trust that the SWC will act, often leads to people employing a private technician instead to remedy the problem. A recent study (2016/17) by the FMoH of 55 bottled water factories across six states identified that there are multiple gaps and water quality risks. Only 34.5% of the factories had registration certificates, 23.6% of the factories do not sterilise their bottles before filling them and 40% of the factories fill and cap them manually; but at the same time 78.2% of the factories have no process for the sterilisation of the workers’ clothes and 45.5% of workers do not sterilise their hands before entering the halls. As a result E.coli or other microbiological contaminants were found in 16.4% of the samples tested.

Key challenges – Cross-cutting issues

Gender, equity and vulnerability – People who are chronically ill, older people, children and newborns are particularly vulnerable to the risks from unsafe drinking water, which can lead to disease or death. The MICS

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(2014) identified that in rural areas where households are less likely to have water on their premises, women are most likely to collect drinking water, then men, then girls and then boys. In urban areas men are more likely to collect water and then women and then boys and then girls. Challenges can be faced for people with disabilities or mobility limitations in reaching and carrying SDW from a distance and women and girls in particular can be vulnerable to violence when away from home collecting water, although this can also pose a challenge for men and boys particularly in conflict areas. Limited access to water supply can lead to conflicts, including in areas where there are both nomadic and sedentary populations. Many nomadic communities still use open water sources from dams or hafirs, which are also shared with their animals; and communities with large numbers of cattle, may be resistant to the protecting of shallow wells through the installation of a hand-pump, as they are more time consuming to use.

**Sustainability, seasonality, environment, climate change and disaster risk reduction** – There is a lack of sustainability of water supplies due to lack of attention and priority to on-going maintenance, the turnover of staff and poor quality spare parts. DWS is affected by the changing seasons and climate change, with increases in turbidity or algae which require additional treatment, and dropping water tables. Flooding can lead to damage to water sources and supply systems with ingress of pollutants. The viability of the main vibrio that causes the AWD in Sudan is also affected by the combination of temperature, salinity and pH and is transmitted mainly through the drinking of water and eating of contaminated food. There is a need to strengthen disaster risk reduction (DRR) to respond to the range of humanitarian contexts that Sudan faces, including disease outbreaks and the movement of people, whether refugees, IDPs or returnees, and their changing needs, as well as those of the host populations.

**Key challenges – Building blocks**

**Legal and policy framework** – It is estimated that 52 laws in Sudan make reference to drinking water and sanitation. A number of key laws, acts, regulations and standards have relevance to DWS with the most important ones being the: Environmental Health Law, 2009; Water Resources Code, 1995; Environmental Conservation (Protection) Act, 2001; Local Government Laws, 2003 and 2016; Regulations on DWS Control, 2014; Regulations of License of the Exploitation of Groundwater, 2014; and the Sudanese Drinking Water Quality Standards, 2016. The strategies and policies with most direct relevance to DWS include the Environmental Health Strategic Plan, 2015-16 and the Water, Sanitation and Hygiene (WASH) Sector Strategic Plan, 2012-16. The Sudan National Sanitation and Hygiene Strategic Framework (SNSHSF) (2017) and is still in the process of being finalised. A review is underway of the policies and laws for Sudan with relevance to WASH. The documents noted above have a range of useful requirements related to DWS, but also some overlaps and gaps, including in relation to the institutions that are and are not responsible for the approval of the use of water sources for drinking. There are currently no Sudan specifications for drinking water related equipment and chemicals, so sometimes international or British Standards are referred to, particularly for construction.

A number of guidelines exist which are of relevance to DWS including: 14 technical manuals (only in English) by the MoWRIE/Drinking Water and Sanitation Unit (DWSU); a number by the FMoH including a Manual on DWQ and Control (2016); a new set of Emergency WASH Guidelines to complement the existing ones (to be published 2017); and the School Health Guidelines, 2016. Although these guidelines include a range of useful information, a number of gaps and inconsistencies have also been identified, which need to be aligned in future updates. The existing chlorination guidelines are being updated.

**Stakeholder responsibilities** – Challenges related to stakeholder responsibilities have included a lack of clarity on some responsibilities, including over who should undertake surveillance, can approve the use of water sources for drinking and also who can enforce, including in relation to bottled water factories. Currently separate monitoring activities are being undertaken in relation to bottled water companies by the Sudanese Standards and Metrology Organisation (SSMO), the FMoH and the DWST laboratory, with the MoWRIE, with no coordination between them. The MoH at all levels has clear responsibilities for the approval of water for drinking purposes and enforcement in relation to bottled water producers, but for the MoWRIE and the SWCs the legal authority for the same is not clear. Responsibilities for the key stakeholders have been
grouped in an overview diagram (see Fig 3) around the areas of: a) Environmental protection of water resources; b) Control of water resources and supply of safe drinking water; and c) Surveillance of safe drinking water and enforcement and sanitation and hygiene promotion. The private sector undertakes a range of roles in Sudan from the provision and supply of equipment, water quality testing consumables and chemicals, and small scale ice and bottled water sellers, to technical construction services and advisory services. Major challenges that are faced by the private sector include: a lack of knowledge on the laws, regulations and standards of Sudan; challenges with accessing foreign currency; late payment of contracts and no contingency for inflation; high import taxes and problems with getting items cleared through customs in a timely manner.

**Financing and advocacy** – The World Bank estimates that 1.96% of GDP would need to be spent annually between now and 2030 for Sudan to reach the SDG on achieving universal access to safe drinking water (on-plot, continuous and safe water supply) and 0.22% annually to reach the target of reaching universal access to basic drinking water supply (Joint Monitoring Programme (JMP) ‘improved water’ but within 30 minutes of the home roundtrip). There is a lack of prioritisation and budget allocated to DWS in Sudan from government, development partners and other actors, which results in a range of the challenges noted above, including a lack of chemicals and ineffective treatment, and inadequate logistics and limited staff for DWS surveillance. Some SWCs have confirmed they do not know the real costs of effective maintenance to sustain their services and the water tariffs being collected are highly inadequate to cover the real costs of the services (including the costs for salaries and allowances; O&M; and depreciation). It is estimated that the cost recovery ratio for the SWC services in 4 main towns in the Darfur States were between 45% to 66% for three of the four towns and 95% for the other (data from Jan-March 2017). It has also been established in the same four Darfur towns and in Port Sudan that the low tariff effectively disadvantages the poorest members of the community the most, as they pay significantly more through purchasing water from water vendors than if they had been able to have a household supply by pipe. The poorest members of the community may pay up to 20 times the amount that households pay that have a piped supply for the same volume.

**Planning, monitoring, research and learning** – Water safety plans (WSPs) which identify and respond to risk factors for DWS are not yet widely implemented in Sudan, although recently a number of staff at Federal, State and Locality levels have been introduced to WSPs and a few WSPs have been trialled. 270 participants were also trained by the FMoH on the use of the FMoH DWQ and Safety Manual 2016, which includes the use of sanitary inspections/surveys. Examples were seen where monitoring was being undertaken and results reported from SMoH and Localities to a SWC for action during the AWD outbreak. Some monitoring of hygiene and water quality at household level is occurring, although this does not seem to be widespread practice. There are multiple and overlapping databases that record both water sources and water quality, across institutions and levels, although some are not currently active and some are being updated. The strongest database from the perspective of DWS is the spreadsheet based mapping system implemented by the FMoH/SMoH with the support of WHO. This includes information on the source, sanitary inspection / risk scores and water quality data.

**Capacities and capacity building** –

The teams working specifically on DWS in the FMoH, SMoH and Localities are small, tending to only be one or two staff with no access to their own vehicles and limited financial resources. Salaries for Environmental Health Professionals at all levels, staff within the SWCs and for university lecturers also tend to be low, which leads to a high turnover of staff, including those who leave for the Gulf States. A number of laboratories have five or more staff, but this varies across institution and location.

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6 Urban Water Administration Offices (2017) Key Performance Indicators (KPIs), Quarterly Report [Jan – Mar 2017], UWAs, 4 State Capitals in Greater Darfur – El Fasher, Zalingei, Geneina and Nyala
Fig 3 - Categories of stakeholder responsibilities for DWS

Environmental protection of water resources
- Supreme National Council for Environment and Natural Resources
- Ministry of the Environment, Natural Resources and Physical Development (lead)
- Ministry of Water Resources, Irrigation and Electricity
- Ministry of Health
- Ministry of Agriculture
- Ministry of Petroleum
- Ministry of Mines
- Ministry of Industry
- Ministry of Animal Resources & Fisheries
- High Environmental Councils - or State Environmental Ministries (if exist)
- Localities & Administrative Units
- Communities & community level institutions - women, men and children

Control of water resources and supply of safe drinking water
- National Council for Water Resources
- Ministry of Water Resources, Irrigation and Electricity (lead) – Drinking Water and Sanitation Unit; Groundwater and Wadis Directorate including laboratory; Drinking Water and Sanitation Training centre
- Ministry of Urban Planning and Infrastructure / State Water Corporations – including laboratories
- Private sector organisations
- Communities & community level institutions – women, men and children; schools, health facilities, markets etc
- Ministry of Education (Schools)
- State Ministry of Health (Health facilities)

Surveillance of safe drinking water and enforcement & sanitation and hygiene promotion
- National Council for Environmental Health
- Federal Ministry of Health (lead) – Environmental Health; Health Promotion; Emergency Health Action; National Public Health Laboratory
- Sudanese Standards and Metrology Organisation (SSMO)
- State Ministry of Health – Environmental Health; Health Promotion; Emergency Health Action; Laboratories
- Setting standards, laws and policies
- Localities
- Administrative Units
- Communities & community level institutions – women, men and children

Supporting
- Ministry of Finance and National Economy
- Ministry of Welfare and Social Security
- Higher education Institutions
- Sudanese civil society orgs. (NGOs, CBOs, FBOs)
- Development partners, humanitarian donors, UN and associated agencies and INGOs

(Note: This is a simplified image – In reality some institutions also have lesser roles in other categories)
There are many DWQ laboratories in Sudan, including the central laboratories for the FMoH, the MoWRIE / Groundwater and Wadi’s Directorate (GWD), the SSMO and the National Environmental Council at Federal level, with some laboratories of other Ministries being used for specific contaminants (such as related to mining, petroleum or radiological contaminants). Most SWCs and SMoH have some form or laboratory or access to field testing equipment, but not all is currently used. Some Localities have access to field equipment. The capacity of laboratories in terms of laboratory space, equipment and staff varies significantly across institution, location and level. Major challenges are being faced for the purchase of and maintenance of equipment, the purchase of consumables (for some labs) and access to logistics to be able to take samples. Only two laboratories in the country have the ability to test for pesticides and insecticides. 

A range of departments across universities and higher education institutions provide training on DWS (for example: Public Health; Environmental Health; Water Resources Engineering; and Environmental Engineering), but they may face challenges to provide adequate opportunities for students to gain practical and laboratory experience due to large numbers of students and limited laboratory access and equipment. A number of students have completed projects related to DWS which could potentially be better used by the sector. The DWST in the MoWRIE runs training on DWQ as well as a range of other courses, including one on the maintenance of drinking water systems which appears to be the only such course in the country. The FMoH Continuous Professional Development Directorate (CPDD) also runs training courses, including one on DWQ and surveillance, usually given to SMoH or Locality level Public Health Officers. A number of INGOs and UN agencies also support training, including some that have recently started to train on WSPs.

**Sudan Drinking Water Safety Strategic Framework**

Refer to the Sudan Drinking Water Safety Strategic Framework (SDWSSF) for the strategies established to respond to the challenges noted above.
2. Introduction and scope

2.1 Introduction
The Government of Sudan is planning to develop a Water Quality Policy. As a step towards its development, this report identifies the current context of drinking water safety in Sudan, from which the most appropriate strategies and policies will be determined. It also contributes to meeting the strategic objectives related to DWS in the Sudan National Sanitation and Hygiene Strategic Framework (SNSHSF).

2.2 Terms of reference
The Terms of Reference for the consultancy to support this process stated the following aims:

1. Assess the policies, existing water quality monitoring networks and the information management system
2. Develop a strategic framework for DWS management and surveillance for the national and state levels
3. Update the existing water quality monitoring and surveillance guidelines

2.3 Stages and schedule
The assignment has been undertaken in 6 stages:

1. Stage 1 – Agree ToR and sign contract
2. Stage 2 (June) – Desk study
3. Stage 3 – (July-Sept) Sudan visit 1 (July) - for information gathering + write up of assessment report, first draft of the strategic framework (Aug-Sept)
4. Stage 4 – Sudan visit 2 (Sept-Nov) – additional meetings, three workshops to review the first draft of the strategic framework and the proposal for the revised guidelines + two rounds of revision based on feedback
5. Stage 5 – Sudan visit 3 (Dec) – validation workshop - for the final draft of strategic framework and conclusion on the revised guidelines + revision based on feedback and approval of outputs by FMoH / MoWRE / WHO / UNICEF

Annex I - Includes the completed schedule for trip 1 and trip 2.

2.4 Methodologies
The methodologies used for the assignment include:

- Desk review - search for good practice (global and Sudan) and Sudan policies, strategies and guidelines
- Key informant interviews (KIIs) – with government (Federal, State, Locality), universities and training institutions, UN and development partners who have supported water quality related capacity building
- KIIs and/or Focus Group Discussions (FDGs) – at community and camp level
- Observations of various places in the water chain – at community and camp level
- Visits to water quality laboratories - in government institutions, universities and training institutions and observation of equipment and consumables
- Workshop based discussion and review of draft outputs
2.5 Structure of this report

This report has been structured around the water chain and the components of the Sudan Drinking Water Safety Strategic Framework (SDWSSF). Please see Fig 1 for an overview of the SDWSSF. It is split into the following sections:

- Hazards, hazardous events, risks, strengths and bottlenecks
- Water supply chain and communication, dialogue and enforcement/ activation of laws
- Cross-cutting issues related to water safety
- Building blocks for water safety

2.6 Limitations

The limitations for this assignment are highlighted in the table which follows.

**Table 2 - Limitations**

<table>
<thead>
<tr>
<th>Limitation</th>
<th>Approach to respond to limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Many actors involved in water safety but limited time to visit all</td>
<td>Efforts were made to meet a range of stakeholders responsible for water safety in different roles and at different levels (from federal-state-locality-community levels) and to see water quality testing equipment and water safety related documentation. Workshops were also used to double check drafts of outputs so offered opportunities to identify any missing issues or good practices.</td>
</tr>
<tr>
<td>2 Current water quality related guidelines are in Arabic but consultant does not speak Arabic</td>
<td>Current guidelines were translated into English. The new guideline was written in English and will be translated into Arabic when finalised.</td>
</tr>
</tbody>
</table>
| 3 Limited time to visit all contexts across Sudan to assess water safety related issues in each | Teams and communities in 7 States to offer lessons on the situation from different contexts:  
  - Trip 1 – Kassala (development and more remote)  
  - Trip 1 – White Nile (refugees and AWD affected)  
  - Trip 1 – Khartoum (urban)  
  - Trip 2 – North Darfur (IDPs and conflict)  
  - WHO/RedR – visited North, South, Central and East Darfur (conflict and IDPs) |
3. Context - Hazards, hazardous events, risks, strengths, bottlenecks and Theory of Change

This section is split into the following sub-components:

- 3.1 Hazards – DWS related contaminants and access to SDW
- 3.2 Hazardous events
- 3.3 Risks – diseases
- 3.4 Summary of DWS related strengths, bottlenecks and theory of change

3.1 Hazards – DWS related contaminants & access to SDW

3.1.1 Access to improved drinking water supply

Fig 4 - provides an overview of the access to improved water sources as per data from the Multi-Indicator Cluster Survey (MICS, 2014) with variations by rural/urban and by State. There are also significant differences by wealth quintile. See Fig 5.

Fig 4 - Access to improved water sources (MICS, 2014)
MICS (2014) also indicates that:

- 68% of households have access to improved water sources
- 4.1% of households who use unimproved water sources use an appropriate water treatment method
- 43.4% of the population have water (improved or unimproved) on their premises; 19% have to walk for less than 30 minutes to collect water; 31.4% have to walk for longer than 30 minutes; 6.2% don’t know
- 40.9% of households have a dedicated place for hand-washing and 25.8% having a dedicated place as well as availability of water and soap
- 55.4% of households have soap or another cleaning agent present

For JMP trends of access to safely managed and basic water over time and also estimates of water supplies against the new SDG JMP drinking water ladder see the SDWSS - Section 3.6.1.

### 3.1.2 Water quality – physical, chemical, microbial

The main water quality contaminants in Sudan occur due to:

- High usage of surface water including from the White Nile, Blue Nile and River Nile and irrigation canals which are polluted from:
  - Open defecation and effluents from septic tanks (and discharges of sludge from water treatment works)
  - Human activities involving the use of pesticides and fertilisers
  - Industrial effluents and wastes

- Groundwater sources contaminated, through:
  - Natural sources
  - Depleting groundwater levels which concentrate natural contaminants - levels are dropping due to overuse, climate change and desertification
  - The use of septic tanks or in some cases boreholes or ponds used for disposal of sewage (such as in the South of Khartoum State)

#### Physical

The main physical water quality issues in Sudan include:

**Turbidity** – Turbidity poses major risks for DWS in Sudan because of the high usage of surface water and the problems it causes for water treatment and in particular chlorination. Water from the Nile can get up to 20-35,000 NTU a day during the flood period. Data provided by the Khartoum SWC indicates that the ranges of turbidity for the three Nile rivers are: Blue Nile – 6 to 35,000 NTU; White Nile – 16 to 225 NTU; and River Nile
– 65 to 22,000NTU. The Sudan SSMO standards for chlorination require a turbidity of 5 NTU. Most water treatment plants, many of which are now ageing, struggle to reduce the turbidity to acceptable levels for chlorination and hence sometimes release the water into distribution networks with high turbidity and no chlorination. In the White Nile, it is noted that the converse exists where turbidity is a bigger problem when the water in the river is low. The turbidity from hafirs are also likely to be over 500 NTU without additional treatment7.

**Temperature** – Temperature in Sudan can get very high. This has an impact on the ability of chlorine to remain in water as a residual. Recent research in South Sudan and a number of other countries8 has found that the standard WHO recommendations for free residual chlorine (FRC) at the distribution point are not adequate for countries with very high temperatures and high levels of contamination as the residual may disappear before the water reaches the end user. MoWRIE/DWSU (2009, draft) technical guidelines on WTPs states that the temperature of the water to be supplied should be between 10 to 20°C as temperature above 25°C is objectionable. Most groundwater in Sudan is reported to be of a temperature of between 30-38°C9.

**pH** – The pH of water affects corrosion and treatment processes. Most groundwater in Sudan is reported to have a pH of between 7 - 8.510. But some areas have <6.5, which poses a problem for corrosion.

**Chemical**

**Fluorides** – Fluorides can be found in some groundwaters in Sudan, with the northern States having the highest probability. In some places they are above Sudan SSMO and WHO health guideline limits (>1.5mg/l), but are still used for drinking water due to limited alternatives, leading to fluorosis in some communities. In Kassala the maximum fluoride levels are at 4mg/l. Gezira State, Khartoum State in East Nile and in Gebel Maya in Sennar State also have problems with Fluoride. In Central Darfur in some places in Gebal Mara and Rongatas11, Fluorides are found from 1.5mg/l – 2mg/l and in Wadi Salih to 8mg/l.

**Nitrates** – Nitrates can be problems in Kassala, Darfur and Khartoum State. In general water sources are rejected with high nitrates / nitrites. But in some cases where the alternative sources have higher nitrates, groundwater sources with levels above the Sudan DWQ standards have been approved for use. In South and North Kordofan levels have been found to be above 300 mg/l as NO3 in the Bara Basin. This is from pit latrines, legumes and fertilisers. In Zamzam IDP camp some groundwater sources have increased in both nitrates and salinity over time, with nitrates rising to around 100 mg/l as NO3. These sources have been discarded for use as drinking water.

**Ammonia** – Ammonia has been found in Khartoum South and North, but is removed by aeration.

**Sulphates** – Sulphates are found in some areas of Sudan (for example they have been found in Khartoum State, White Nile and a few times in Kassala). There is no SSMO or WHO health guideline for Sulphate, but they can cause diarrhoea in new users and affect taste.

**Hardness** - Most groundwater in Sudan is reported to have a hardness of between 200-300 mg/l as CaCO312. But some areas have ranges from 60 to 300 mg/l as CaCO3 with Darfur having soft water in wells and wadis and also soft water in some areas of South Kordofan.

**Total dissolved solids** - Most groundwater in Sudan is reported to have a TDS of between 100 to 1,000 mg/l but with some places at >1,500mg/l13. In Gezira and White Nile State levels have been found at >15,000 mg/l.

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7 MoWRI/DWSU (2009, draft) on WTPs
9 MoWRI/DWSU (2009, draft) on HDWs with MPs and the MoWRIE GWD laboratory
10 MoWRI/DWSU (2009, draft) on HDWs with MPs
11 Spellings may vary from those noted here
12 MoWRI/DWSU (2009, draft) on HDWs with MPs
13 Spellings may vary from those noted here
**Chlorides** – Salinity is a problem particularly in the Eastern States and some areas of White Nile. Some Reverse Osmosis systems are utilised but the systems suffer from the fouling of the membranes. In the Red Sea State water from desalination is the second most common water source used in the State all year and in the hot and dry season it is the main source of water.

**Iron** – Some of the northern States and Gezira have problems with high iron levels.

**Metals** – In the past there have been problems with Cadmium and Chromium in the Nile River because of tannery waste from a factory in Central Khartoum. But they have now constructed their own water treatment plant to deal with this. A fish kill in the Nuba Lake in Northern State was investigated by the Ministry of Petroleum laboratory and they found Mercury and Lead. This had come from the by-products of gold mining. Today the Ministry of Mines has banned the use of Mercury so mechanical methods are now used to extract the gold. Mining occurs in Northern State, River Nile and South Kordofan. Other risks come from the inappropriate disposal of hazardous wastes, including electronic wastes, which may leach into the groundwater.

**Bromium** – Bromium is found in groundwater in Gedaref. It can be converted to the by-product of Bromate during the process of treatment with ozone, which is sometimes used in the process to produce bottled water in Sudan. There is no WHO health guideline for Bromium as the levels found in drinking water are too low to be of health significance. But there is a WHO health guideline for Bromate of 10\(\mu\)g/l\(^{14}\) and Sudan DWQ standard of 6.67\(\mu\)g/l.

**Arsenic** – Most laboratories visited noted that Arsenic has not been found to be a problem, although one noted that it has been found but at very low levels. Note should however be made that the availability of Arsenic in countries in Africa is mostly unknown, partly due to the lack of testing\(^{15}\). Various predictive mapping based on climate, elevation and geology has predicted that arsenic may be present in various locations in Africa.

**Pesticides and fertilisers** – Pesticides and fertilisers are contaminants of water sources in Sudan, including in Gezira State, although limited monitoring of contamination and action currently occurs due to lack of capacity for testing and treatment. A case study of this problem is in Kassala State. Fertilisers are used with additives which are sprayed from a plane. These chemicals have also got into the canal used as a water source during the rains. There is reported to be a high level of kidney problems and cancers in the area. But the laboratories in Kassala do not have the capacity to test for pesticides and fertilisers and although support on this issue has been requested by the SWC, no support has been offered or remedial action taken. The monitoring capacity for pesticides and fertilisers in Sudan is weak with only the MoH National Public Health Laboratory (NPHL) and the SSMO national laboratory having capacity to test for these parameters.

**Petrochemical wastes** – These can be a problem in South Kordofan, West Kordofan and East Darfur.

**Biological/microbiological:**

**Faecal contamination** – Faecal contamination of water sources in Sudan is high. MICS (2014) indicates that only 32.9% of the population has access to an improved latrine and 29.2% practice open defecation with a large variation across urban/rural, wealth quintiles and state. Faeces includes a wide range of pathogens (bacteria, viruses, protozoa and oocysts) causing a range of diseases. See below for information on diseases prevalent in Sudan.

**AWD** – The bacteria that is causing the current AWD outbreak is endemic in Sudan and as with other countries has a cyclic pattern of return every few years. Globally it is understood that the bacteria remains in environmental sources until the conditions (pH, temp, salinity) are suitable for it to re-emerge and is ingested by humans. It is a bacteria transmitted mainly through water and food, but also human to human.

\(^{14}\) But this guideline level is also indicated as A, T, which means that it is a provisional level as it is lower than the level that is quantifiable and also as it is below the level that is achievable through treatment processes

contact. In outbreaks in other countries health facilities and funerals can also be particular risk areas for transmission. The last big outbreak was in 2006/7 before the separation with South Sudan. In 2016/17 the AWD affected almost all States in Sudan.

Slaughter houses – There is also a risk from the wastes from slaughter houses polluting water sources. This has been seen to be a risk in IDP camp situations.

Algae – Algae is a problem in some water treatment works in Sudan. For example the problem has been reported by Khartoum SWC for water taken from the Blue Nile for the past 5 years. Algae blooms tend to appear in the water coming into the Gebel Awlia WTP once the dam starts to operate. Algae could also be visibly seen in the Mogran WTP. The problems with algae are that some algae cause bad taste and smells and some, such as blue-green algae, can produce poisonous cyanobacteria toxins that can cause damage to the liver (microcystins) and others can cause cancer. The following graphs show the variation in types of algae during the different seasons at two of the Khartoum SWC WTPs. July to November is the period which has the highest turbidity and December to February is considered the period where there is the highest proliferation of algae of various types due to Eutrophication.

Fig 6 - Variation in counts for algae of different types in two Khartoum SWC WTPs

See Sections 4.2.1 and 6.5.3 below for more discussion on the identification and treatment of algae.

Guinea worm – Guinea worm has been a problem in Sudan. There have been no indigenous cases in Sudan since 2002, but there were imported cases from South Sudan until 2008. Sudan was in the pre-certification stage before June 2013, but there have been some more cases. Sudan is now awaiting verification that it has been eradicated.

Radiological:

Radiological risks exist in some areas of South and North Kordofan and Darfur.

3.2 Hazardous events

Examples of hazardous events that can lead to problems with DWS in Sudan can be seen in Table 2. The likelihood of these different events will vary depending on whether the drinking water supply is from an urban WTP or network, or the source is in a rural area. The user water collection and handling habits can pose some of the largest risks to DWS.

---

19 No author (no date, draft) Burden of NTD in Sudan
### Table 3 - Possible hazardous events related to water safety in Sudan

<table>
<thead>
<tr>
<th>Water source and abstraction</th>
<th>Bulk water treatment</th>
<th>Bulk storage and distribution system to collection point</th>
<th>Collection of water and transfer to household</th>
<th>Household water supply, treatment and storage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Related to natural fluctuations:</strong></td>
<td><strong>Related to natural fluctuations:</strong></td>
<td><strong>Related to inadequate community engagement and enforcement/activation of laws:</strong></td>
<td><strong>Related to inadequate community engagement and enforcement/activation of laws:</strong></td>
<td><strong>Poorest selection, design, siting or construction:</strong></td>
</tr>
<tr>
<td>1. Flooding leading to contamination of source</td>
<td>1. Flooding leading to flooding of underground tanks or damage to the network</td>
<td>• Flooding leading to flooding of or reducing access to collection points</td>
<td>1. No first flush discharge device for rainwater harvesting</td>
<td>1. Poor design of underground water tanks leading to cracks and contamination</td>
</tr>
<tr>
<td>2. Seasonal turbidity variations (surface sources and shallow wells)</td>
<td>2. Poorly designed water storage units with inadequate protection from pollution or with increased difficulty for cleaning</td>
<td>• Conflict leading to reducing access to water collection points</td>
<td>2. Poor design of underground water tanks leading to cracks and contamination</td>
<td><strong>Inadequate management, O&amp;M:</strong></td>
</tr>
<tr>
<td><strong>Related to inadequate management, O&amp;M:</strong></td>
<td>3. Intermittent or low pressure supply leading to inflow of contaminants in pipes</td>
<td><strong>Related to poor selection, design, siting or construction:</strong></td>
<td>3. Poor hand hygiene when handling drinking water</td>
<td>3. Poor hand hygiene when handling drinking water</td>
</tr>
<tr>
<td>5. Over abstraction / over capacity of borehole</td>
<td>4. Air blocks in pipeline resulting in reduced velocity, due to bad initial design and/or pipe laying, or no consideration of design when tapstands/extensions added later – leading to reduced flow and people going to alternative potentially less safe sources</td>
<td>• Taps giving water do not match the opening of the containers used for collection and transfer (e.g. handpump spout larger than jerry can, thereby wasting water and ponding of water)</td>
<td>4. Lack of cleaning of containers</td>
<td><strong>Lack of use of household water treatment options</strong></td>
</tr>
<tr>
<td>6. Surface water inlets blocked with weeds</td>
<td>5. Water hammer and excessive flow at taps resulting in tap damage and water wastage, due to bad initial design or lack of means to reduce pressure at tapstans</td>
<td>• Buckets used to abstract water from shallow wells</td>
<td>5. Poor maintenance of household water treatment equipment (such as not replacing filters)</td>
<td>5. Poor maintenance of household water treatment equipment (such as not replacing filters)</td>
</tr>
<tr>
<td>8. Illegal connections</td>
<td>7. Collection points are located in areas where some people (such as women, girls or minority groups) do not feel safe to collect water – leading to them taking water from unsafe sources</td>
<td>Related to inadequate management, O&amp;M:</td>
<td>Related to inadequate community engagement and enforcement/activation of laws:</td>
<td>Related to inadequate community engagement and enforcement/activation of laws:</td>
</tr>
<tr>
<td><strong>Pipes:</strong></td>
<td>8. Lack of O&amp;M of storage, pipelines and collection points</td>
<td>• Containers for collection and transfer are contaminated by stagnant water at collection or abstraction points</td>
<td>8. Containers for collection and transfer are uncovered (including missing lids or caps)</td>
<td>8. Storage in wide-mouthed or uncovered containers (even dedicated dipping cups can lead to contamination)</td>
</tr>
<tr>
<td>10. Leakage of pipes</td>
<td>9. Poor maintenance of treatment units</td>
<td>• Pipe at source for filling donkey carts is contaminated (e.g. falls on ground)</td>
<td>• Containers are not cleaned</td>
<td><strong>Related to inadequate community engagement and enforcement/activation of laws:</strong></td>
</tr>
<tr>
<td>11. Ineffective pipe repairs due to lack of knowledge, inadequate numbers of isolating valves to allow pipe drying (for PVC pipes) or suitable pipe bonding equipment (for PE pipes)</td>
<td>10. Treatment units out of action due to damage or need for repair and no alternative</td>
<td>Related to inadequate community engagement and enforcement/activation of laws:</td>
<td>• Donkey carts and tankers transferring water and are not cleaned or maintained</td>
<td><strong>Related to inadequate community engagement and enforcement/activation of laws:</strong></td>
</tr>
<tr>
<td>12. Disposal of sediments in a way that risks contamination of the source</td>
<td>11. Build up of bio-films or algae</td>
<td><strong>Related to poor selection, design, siting or construction:</strong></td>
<td><strong>Related to inadequate community engagement and enforcement/activation of laws:</strong></td>
<td><strong>Related to inadequate community engagement and enforcement/activation of laws:</strong></td>
</tr>
<tr>
<td><strong>Tanks:</strong></td>
<td>12. Disposal of sediments in a way that risks contamination of the source</td>
<td>• Taps giving water do not match the opening of the containers used for collection and transfer (e.g. handpump spout larger than jerry can, thereby wasting water and ponding of water)</td>
<td><strong>Related to inadequate community engagement and enforcement/activation of laws:</strong></td>
<td><strong>Related to inadequate community engagement and enforcement/activation of laws:</strong></td>
</tr>
<tr>
<td>14. Rusting and leakage of tanks</td>
<td><strong>Distribution point:</strong></td>
<td>• Buckets used to abstract water from shallow wells</td>
<td><strong>Related to inadequate community engagement and enforcement/activation of laws:</strong></td>
<td>8. Storage in wide-mouthed or uncovered containers (even dedicated dipping cups can lead to contamination)</td>
</tr>
<tr>
<td>15. Cracks and build up of sludge or other contaminants in tanks</td>
<td>17. Ponding of water around tapstands and pipes</td>
<td>Related to inadequate management, O&amp;M:</td>
<td>Related to inadequate community engagement and enforcement/activation of laws:</td>
<td><strong>Related to inadequate community engagement and enforcement/activation of laws:</strong></td>
</tr>
<tr>
<td>16. Ingress of runoff through inspection covers</td>
<td><strong>Reasons:</strong></td>
<td>• Containers for collection and transfer are uncovered (including missing lids or caps)</td>
<td>8. Storage in wide-mouthed or uncovered containers (even dedicated dipping cups can lead to contamination)</td>
<td><strong>Related to inadequate community engagement and enforcement/activation of laws:</strong></td>
</tr>
<tr>
<td><strong>Reasons:</strong></td>
<td><strong>Reasons:</strong></td>
<td>• Containers are not cleaned</td>
<td><strong>Related to inadequate community engagement and enforcement/activation of laws:</strong></td>
<td><strong>Related to inadequate community engagement and enforcement/activation of laws:</strong></td>
</tr>
<tr>
<td>• Poor hand hygiene when handling drinking water</td>
<td><strong>Reasons:</strong></td>
<td>• Donkey carts and tankers transferring water and are not cleaned or maintained</td>
<td><strong>Related to inadequate community engagement and enforcement/activation of laws:</strong></td>
<td>8. Storage in wide-mouthed or uncovered containers (even dedicated dipping cups can lead to contamination)</td>
</tr>
</tbody>
</table>
3.3 Risks – diseases

3.3.1 Water-based diseases in Sudan

The MoWRIE/DWSU (2009, draft) Technical Guideline and Manual of Drinking Water Treatment Facilities for Field Staff and Practitioner’s – indicates that common water-borne diseases in Sudan include: typhoid fever, para typhoid fever, dysenteries (both amoebic and bacillary), gastro-enteritis, infectious hepatitis, schistosomiasis and Asiatic cholera and that in some parts of Sudan Guinea Worm is a serious problem (which related to the whole of Sudan before it partitioned).

Data from the FMoH for the first 9 months of 2017 indicates that the number of reported cases was: a) Typhoid - 108,246 (no deaths); b) Dysentery – 153,420 (no deaths); and Hepatitis E – 2,359 (21 deaths).

3.3.2 Water-related and water-washed diseases in Sudan

A range of other water –related and water-washed diseases also occur or have occurred in Sudan, such as:

- **Water-related**: Schistosomiasis; Yellow fever; Lymphatic filariasis; Onchocerciasis; Dengue; Chikungunya; Malaria.
- **Water-washed**: Trachoma

However as this report is related to DWS these have not been included in the analysis.

3.3.3 Other risks

The following other risks exist in Sudan in relation to unsafe drinking water: Loss of time that could be spent on income generating or other productive activities; loss of time from schooling; malnutrition, stunting and wasting; and increased opportunities for violence against women and girls (if they cannot easily access safe water sources and instead seek out more remote but less safe sources).

3.4 Summary of DWS related strengths, bottlenecks and Theory of Change

3.4.1 Summary of DWS related strengths

The following summarises some of the strengths in Sudan related to ensuring DWS:

1. Some very committed staff working with difficult limitations such as limited equipment and logistics
2. Training available for staff in different roles and levels
3. Some availability of by-laws and guidelines
4. Range of WTPs are operating some for many years (even near 100)
5. Range of labs and water quality equipment seen, some in use
6. Khartoum State – It is clear that the MoH and some localities are doing some monitoring and feeding back to the SWC on performance of WTPs – and good coordination between MoH and SWC
7. Some enforcement/ activation of laws is occurring related to bottled water companies
8. There is evidence that there is increased levels of chlorination being undertaken related to the current AWD situation
9. Some documentation of water quality testing exists and being reported to varying levels – for example through the MoH system
10. Databases – Several databases exist and there have been various attempts to mapping (for example the WHO supported water source WQ database of 7 States three years ago had sanitary survey included)
11. There are reported to have been a few WSP trials

12. There has been training on WSPs in Kassala and Kordofan (supported by UNICEF) and in Darfur (supported by WHO and REDR)

13. Increased efforts have been made on strengthening the O&M in some SWCs with the support of JICA and UNOPS/UNICEF/DFID (in the Urban Water for Darfur project)

3.4.2 Bottleneck analysis
See Fig 7 - for a bottleneck analysis Related to ensuring DWS in Sudan.

3.4.3 Theory of Change
See Fig 8 - for the Theory of Change related to safe drinking water in Sudan.
<table>
<thead>
<tr>
<th>Enabling environment</th>
<th>Sector institutional capacity and coordination</th>
<th>Legislation, policies, strategies, guidelines</th>
<th>Prioritisation</th>
<th>Sector funding</th>
<th>Planning, monitoring, evaluation and review</th>
<th>Capacities and capacity development</th>
<th>Water supply services in urban, rural and humanitarian and development contexts</th>
<th>Supply</th>
<th>Private sector</th>
<th>Demand</th>
<th>Social norms</th>
<th>Water quality</th>
<th>Monitoring, review and action</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Unclear division of responsibilities between Ministries and State and Locality level actors</td>
<td>• Gaps and overlaps in legislation, policies, strategies and guidelines</td>
<td>• Water safety not prioritised by government, development partners or communities – priority is for water availability</td>
<td>• Limited funding for water safety – staff, logistics, equipment, chemicals, maintenance</td>
<td>• Water safety plans do not exist at Federal, State, Locality or community levels</td>
<td>• Urban - old distribution systems and WTPs; significant gaps in maintenance, of source protection, water treatment plants and distribution networks; limited funds for chemicals</td>
<td>• Private sector not aware of regulations, standards and guidelines</td>
<td>• Limited attention to water safety; limited household water treatment and safe storage</td>
<td>• Limited logistical and staff capacity for regular monitoring of pollution risks and water quality; variation and availability and maintenance of equipment for testing water quality</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Limited staff in MoH structure with very low access to logistics allocated to water safety surveillance at each level</td>
<td>• Limited enforcement, processes too long, penalties too small</td>
<td>• SWCs, SMoH and Localities relying on UN and other development partners for chlorine supplies</td>
<td>• Turnover of trained staff and limited re-training particularly at Locality level</td>
<td>• Limited knowledge and experience on the use of water safety plans</td>
<td>• Gaps in capacities of laboratories for water quality testing</td>
<td>• Problems with very high turbidity from surface water sources</td>
<td>• Widespread use of the Zeer with shared dipping cup and some problematic beliefs over the use of chlorine</td>
<td>• Problems with high turbidity from the Nile; high levels of faecal contamination; specific chemical issues including Fluoride, nitrates and nitrites</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• No institution for water regulation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Limited commitment to maintenance of all levels of water supply system</td>
<td></td>
<td>• Challenges for women and girls to collect water in insecure areas</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Fig 7 - Bottleneck analysis – related to insuring water safety in Sudan**
### Contextual analysis (problems)
- Inadequate access to appropriate drinking water supply, excreta disposal & hygiene-washing facilities at household, community & institutional levels
- Poorly sited, designed & constructed drinking water supply systems
- Broken down, unhealthy & poorly functioning drinking water systems & toilets
- Pollution of water sources & the environment from agriculture, industry & human settlements
- Low levels of water tariffs, inadequate funds for the operation, maintenance & replacement of drinking water supply systems
- Natural disasters, insecurity, damage facilities & lead to population displacements increasing demand on sources
- Lack of prioritisation on DWS
- Weak private sector engagement
- Lack of logistics, fuel & staff resources at all levels for DWS surveillance
- Lack of knowledge on HWTS
- Inadequate gender-sensitive SDW related programming
- Disparities in access to SDW by income, geographical location & other factors

### Activities/ inputs

#### Enabling environment
- Strengthening laws, policies, strategies & guidelines
- Clarification of stakeholder responsibilities & strengthening coordination & partnerships
- Increase in tariffs & finances
- Increased action on operation & proactive as well as reactive maintenance
- Strengthening of planning, monitoring, review & learning – including WSPs
- Building capacities
- Strengthening programming from a gender & equity perspective

#### Demand
- Engagement of communities, particularly empowering females & vulnerable groups
- Understanding & building on social norms & commitment to ensuring SDW
- Reducing dependency, increasing demand & ownership

#### Supply
- Scaling up services & supply chain
- Engagement of the private sector

#### Quality
- Monitoring, validation, surveillance & learning; strengthened strategies, standards & guidelines

### Outputs
- Laws, policies, strategies & guidelines exist that are supportive of the scaling up of access to DWS across Sudan
- Clear stakeholder responsibilities & effective coordination & partnerships
- Increased finances
- Strengthened planning, monitoring, review & learning – including water safety plans
- Supply systems which breakdown less often & are repaired more quickly & effectively
- Increased cognitive function & concentration in school

### Outcomes
- Improved child health & reduced morbidity
- Improved maternal & neonatal health & reduced morbidity
- More balance in DWS workloads of females & males
- Increased sustainability of SDW facilities & materials
- Increased cognitive function & concentration in school

### Impacts

**Contribution to the attainment of the following rights**
- Survival
- Health
- Gender equality
- Education
- Dignity
- Adequate standard of living
- Gain a living by work
- Life free from violence & discrimination
- Participation in & benefit from development

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*Acronyms: DWS = drinking water safety; HWTS = household water treatment & safe storage; SDW = safe drinking water; WSPs = water safety plans*
4. Context – water supply chain

This section is split into the following sub-components:

- 4.1 Water sources and abstraction
- 4.2 Bulk water treatment
- 4.3 Bulk storage and distribution to collection points
- 4.4 Collection of water and transfer to household
- 4.5 Household supply, treatment and storage
- 4.6 Beliefs, community engagement, citizen feedback and enforcement/activation of laws
- 4.7 Specific contexts

4.1 Water sources protection and abstraction

The two main water sources in Sudan are groundwater and surface water including from the Blue, White and River Niles as well as irrigation channels. In rural areas rainwater is also collected in earth dams or hafirs and some households also use rainwater harvesting.

Groundwater including springs

Some areas of Sudan rely on groundwater abstracted from hand dug wells and boreholes, with handpumps, motorised pumps or by hand by bucket and rope. Some urban areas rely entirely on groundwater, such as Kassala Town in Kassala State. Spring water is also utilised in some areas of Sudan.

Particular challenges for water safety related to groundwater include:

- High levels of fluoride, nitrates / nitrites and sometimes sulphates.
- Contamination of hand dug wells that are not protected.
- Resistance of some communities, particularly in pastoral areas to cover and protect hand dug wells, because queuing for water from a handpump is more time consuming for abstracting water for livestock than using separate buckets.
- Maintenance of abstraction systems such as handpumps and motorised pumps.
- Dropping water tables due to climate change or due to over-abstraction against the capacity of the borehole.
- Pollution of groundwater sources from septic tanks and pit latrines.
- Some boreholes not having tanks and hence water is pumped into a pond lined with a plastic sheet.

In Sudan disposing of sludge on the ground surface in ponds is also not prohibited, and it is one of the main hazards not only to groundwater but also to human health, especially in areas such as Alazhari in the southern part of the Khartoum city. This is located in a residential area and the area has no impermeable underground geological boundaries to prevent leakage from the upper aquifer into the lower one. The Khartoum state government is managing the business of sludge disposal because of revenues that are collected from private tankers disposing the sludge in these pools. Limited capacity of the government to construct sewage systems along with associated treatment plants has therefore contributed to contamination of groundwater in Khartoum State.

For discussion on groundwater databases see Section 6.4.5 and legislation and enforcement/activation of laws see Section 4.6.6 and 6.1.1.

Surface water

As noted in Section 3.1.2 turbidity poses a significant challenge for the supply of SDW. Specific challenges it poses include:

- Challenges for turbidity removal and getting down to <5 NTU for effective chlorination.
- Speed of blocking of slow sand filters (SSFs).
High sludge volumes to dispose of from WTPs.

Solid wastes around water sources (including recharge ponds for groundwater)

Other challenges relate to the changing water levels of water sources, to blockage by weeds and challenges of access for repairing damaged inlet pipelines. For example, problems with a damaged inlet pipeline have led to the Alagaya WTP supplying two refugee camps in the East of White Nile, being out of order for periods of up to a week. This leaves the refugees without access to SDW, who then take water directly from the Nile. The operators of this WTP also note that they also face challenges with reaching the inlet to remove algae as they do not have transport to travel the 3 km to the inlet so have to undertake the journey on foot.

Particular challenges are being faced in Khartoum State in relation to algae blooms from the River Nile and its tributaries at certain periods of the year. The risk with some algae is that they can produce poisonous toxins which can cause damage to the liver or the nervous system. They also have posed problems for the treatment processes as the units have not been designed to receive high numbers of algae.

### Problems from algae in WTPs in Khartoum State

*These organisms can cause serious problems in treatment plant basins by the accumulation of growths on the walls, frequently clogging of filters, affecting the treatment processes and increase the dose of coagulant and chlorination. Clogging of the filters that means more backwash, high electricity consumption and reduced water supply level to consumers. It also affects the quality of purified water by increasing alkalinity and pH and slightly increase[ing] water turbidity. In addition the consumers complain from bad smell and odor starting from grassy, spicy, musty, and fishy to septic water”.*

It was reported that a few years ago there was a significant problem with algae covering the Blue Nile and this caused concern for the general public. However no negative health consequences were reported. See Section 4.2.1 below for discussion on water treatment for algae blooms and Section 6.5.3 on the challenges of identification of algae.

### Rainwater

Earth dams and *hafirs* are commonly used to collect rainwater across Sudan. Some earth dams and *hafirs* are unprotected. Good practice recommends that they are protected with fencing and have an abstraction mechanism feeding into a subsequent treatment process, such as a SSF. Some households use roof water harvesting.

Particular water safety challenges related to rainwater include:

- High levels of turbidity and pollution in water collected in earth dams and *hafirs*.
- Lack of protection of earth dams and *hafirs* with both animals and humans entering the water and drinking from the same water source.
- Poor water storage for roof water harvesting and lack of mechanism to dispose of the ‘first flush’ of roof water to remove the pollution from deposits from the roofing and guttering structures.

### Numbers of water sources and associated technologies across Sudan

The following two tables provide an overview of the numbers of different types of water sources in Sudan. The second table of water sources in Kassala provides some information on the number of water sources that are broken (although it also has some differences to the data in the country-wide table). Note that water desalination as a source of drinking water is not included here, but is the most common source in the Red Sea State during the hot and dry season and the second source during the other seasons.

---

Table 4 - Record of water source type by state21

<table>
<thead>
<tr>
<th>State</th>
<th>Artesian wells</th>
<th>Dams</th>
<th>River / canal</th>
<th>Hafir</th>
<th>HPs</th>
<th>Wells (shallow+ boreholes)</th>
<th>Sand filter</th>
<th>Public networks + WTPs</th>
<th>Broken sources</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>River Nile</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>91</td>
<td>0</td>
<td>667</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>763</td>
</tr>
<tr>
<td>Blue Nile</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>1,792</td>
<td>91</td>
<td>6</td>
<td>12</td>
<td>0</td>
<td>2,001</td>
</tr>
<tr>
<td>South Kordofan</td>
<td>240</td>
<td>14</td>
<td>0</td>
<td>178</td>
<td>2,614</td>
<td>0</td>
<td>0</td>
<td>24</td>
<td>0</td>
<td>3,070</td>
</tr>
<tr>
<td>South Darfur</td>
<td>134</td>
<td>0</td>
<td>0</td>
<td>17</td>
<td>1,238</td>
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<td>-</td>
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<td>158</td>
<td>7</td>
<td>24</td>
<td>215</td>
<td>104</td>
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<td>580</td>
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<td>6,091</td>
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<td>391</td>
<td>495</td>
<td>0</td>
<td>897</td>
<td></td>
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<tr>
<td>White Nile</td>
<td>53</td>
<td>10</td>
<td>191</td>
<td>231</td>
<td>109</td>
<td>1,859</td>
<td>21</td>
<td>28</td>
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<td>77</td>
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<td>East Darfur</td>
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<td>103</td>
<td>0</td>
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<td>West Darfur</td>
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<td>8</td>
<td>1,344</td>
<td>688</td>
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<td>20</td>
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<tr>
<td>North Darfur</td>
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<td>2,334</td>
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<td>8</td>
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<tr>
<td>Total</td>
<td>1297</td>
<td>78</td>
<td>857</td>
<td>1,651</td>
<td>12,218</td>
<td>20,703</td>
<td>1,800</td>
<td>1,800</td>
<td>93</td>
<td>38,833</td>
</tr>
</tbody>
</table>

Note: The above data was provided by the FMoH, but the records of water sources varies by the institution reporting:

- The SWC in Khartoum said that they have 12 treatment plants, 5 high stations and 2,000 boreholes and produce 1.5 million m³/day.
- The MoWRIE/GWD laboratory provided data that in Khartoum State there are 2500 deep wells (depth 350 ft-1000 ft). The total number of wells used for drinking water supply is about 1,841 with 994 wells connected to the pipeline network and 724 are out connection, while the rest are 123 private wells (source: GWD information centre + Khartoum Water Corporation - planning section)

Table 5 - Register of water sources in Kassala State22

<table>
<thead>
<tr>
<th>Total sources</th>
<th>Broken sources</th>
<th>Villages using a river / canal</th>
<th>Out of network</th>
<th>Hafir</th>
<th>Handpump</th>
<th>Shallow well</th>
<th>Borehole</th>
<th>Sand filter</th>
<th>Main network</th>
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</thead>
<tbody>
<tr>
<td>875</td>
<td>60</td>
<td>158</td>
<td>353</td>
<td>7</td>
<td>24</td>
<td>68</td>
<td>147</td>
<td>104</td>
<td>14</td>
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</tbody>
</table>

4.2 Bulk water treatment

There are multiple water treatment plants (WTPs) in Sudan operating in urban and rural areas.

22 It is not clear if the sand filter feeds from the hafirs or rivers also counted in this table?
4.2.1 Urban WTPs

The common water treatment processes being used in urban areas in Sudan are:

- Aeration
- Coagulant dosing using PAC and flocculation
- Rapid sand filters
- Chlorination using either solutions of powdered chlorine or chlorine gas.

It was noted that when the turbidity is high coming from a WTP, that sometimes the SWCs do not chlorinate the water because it would not be effective. But at present it does not seem clear that any awareness raising is undertaken with the general public to let them know when the water has not been chlorinated and hence likely to not be safe without additional treatment.

Desalination is also common in some States with both public and private desalination plants. Desalination is the only water source and treatment method used during the hot and dry seasons in Red Sea State.

Some WTPs have been functioning for a number of years, even as long as a 100 years and new plants are under construction. Some are being funded on a grant basis by external donors, such as JICA, and others through a system of loans, such as from Saudi Arabia. Some newer plants are working less well than the older ones. In Halfa in Kassala State the newer WTP built by the SWC is not working, whereas the older one (built in 1956) works well but needs injectors. In Kassala State it has been observed that some of the newer WTPs work less effectively than older plants. For a new plant that was constructed in 2014, it is reported that the main water storage tanks have not been cleaned even once since it was constructed. One WTP has malfunctioning scrapers in the coagulation tanks, leading to the growth of large plants/algae, short circuiting of the water and high turbidity in the effluent on a regular basis to levels such as 130 NTU.

A new high tech WTP has recently been constructed in Khartoum, Manara, on a Build Operate and Transfer basis and is currently being managed by a British Company in conjunction with Sudanese counterparts. This has automated sampling and reading of results which are fed to a computer system. The plant is reported to get water to < 1 NTU. There is also another new plant being constructed in Khartoum, Soba, which will have a pre-sedimentation process before the main treatment processes.

There is a desalination plant in Port Sudan – it is less than 10 years old but it looks like 40 years old as the maintenance is very poor. Even basic gauges are broken. There is currently limited capacity in maintenance of desalination plants.

In White Nile State, it is noted that the regular maintenance of the WTPs is undertaken in the cold season when there is less need for water. This is when they maintain the filters and piped network. JICA supported one training on O&M. Before the SWC used to take the pumps to the market but now they can maintain their machines themselves. JICA also provided them with a crane so they can more effectively maintain wells.

Particular water safety challenges related to urban WTPs include:

- Poorly designed treatment processes.
- The use of less effective dosing methods, such as use of solutions of dissolved powdered chlorine, which it is reported does not distribute evenly throughout the water.
- Chlorine powder not stored correctly, leading to a reduction in its strength.
- SWCs not always dosing with chlorine because of the high cost.
- Manual controls for dosing of coagulants and chlorine pose challenges for establishing accurate dosages.
- Lack of preventative maintenance of the treatment units and connecting pipework.
- Lack of regular desludging of the tanks.
• Limited finances for the purchase of PAC and chlorine. Reliance on UN and other Development Partners for chlorine.
• Limitations in laboratory equipment for water quality testing for monitoring of the influent and effluent turbidity, pH and chlorine residuals.
• Limited access or use of Jar Testing equipment to establish the optimum dosage of coagulant.
• Build up of biofilms of algae. See Fig 9 below.
• Disposal of sludge back into the main water source downstream of the abstraction point (for example back into the Nile Rivers).
• Fouling of Reverse Osmosis membranes in the Eastern States where water is saline.

Cost of chemicals
In Kassala, the SWC noted that they do not get any help from Federal or State level for water treatment chemicals but that they are very costly for surface water sources with turbidity over 7,000 NTU. A calculation undertaken to prepare for a three months period of flooding indicated that the total cost is > SDG 1.25 million. One 45 Kg barrel costs SDG 5,000.

It was reported that the Government said it would provide DWSU SDG 147 million for chlorine and PAC from the Ministry of Finance and National Economy but no funding had so far been received at the date of the visit (July 2017).

Algae:
Algae, including blue-green algae is a problem for some months of the year in certain WTPs, fed from the three Nile rivers, including the Blue Nile downstream of the dam. Sugar factories dump waste into the Nile which depletes the oxygen and increases the algae. Algae can lead to a bad taste in the water and also concerns that some forms, such as particular Blue-Green algae if present may produce toxins. At present the algae is being removed by hand from the tanks in the Mogran WTP (see photos below). Khartoum SWC has been investigating the options for improving the efficiency of the removal processes. It has received a quote for SDG 30,400,000 to install a sonic system and activated carbon in the Jabal-Awlia WTP (June 2017). It is not clear how big the problem is across Sudan or how serious the risks are in the Sudan context. This needs further investigation.

Fig 9 - Algae in the Mogran WTP, Khartoum State

See Section 3.1.2 for more details on the algae types and seasonality and Section 6.5.3 for further discussion on WQ testing capacities for algae.

4.2.2 Rural WTPs
Slow Sand Filters (SSFs) are common treatment processes in rural areas. They may treat water from a stream, perennial river, irrigation canal, hafir or dam. They may need pre-treatment from the river bed through infiltration, horizontal roughing filtration, vertical roughing filtration and plain sedimentation. They
need trained operators to operate and maintain the system. ‘Compact’ water treatment systems are also one of the options used in water supply systems, particularly in humanitarian contexts, such as in the White Nile State. A private company, the National Company for Water Equipment Manufacture, is also in the process of manufacturing a local model of the compact treatment works with some simplification of the processes to encourage increased sustainability for use by rural communities with *hafirs*. See Fig 10.

**Fig 10 - Locally manufactured Compact units**

| Locally manufactured compact unit for use with *hafirs* under testing | Small compact unit for use with *hafirs* under fabrication |

Challenges that can occur related to DWS for rural WTPs:

- High turbidity of the source water to be treated by SSFs, leading to the need for effective pre-treatment.
- Limited maintenance of SSFs and lack of clarity of who is responsible for their maintenance.
- No technicians available in rural areas to calculate chlorination.
- Power costs and chemical costs are high.
- Because of maintenance and durability problems with SSFs and there is no rehabilitation of broken systems - some communities by-pass the SSFs (reported from White Nile State)
- A particular challenge expressed in Kassala was how to dose for long pipelines from over 48 or 60 km to ensure adequate chlorine residuals at all stages of the pipeline.
- Limited use of household water treatment processes for the effluent from a SSF.
- Reliance on UN and other partners for chlorine
- The chlorine supplies are significantly less than the needs.

### 4.3 Bulk storage and distribution networks to collection points

This section includes bulk storage and distribution to the collection points via networks, tankers or other means.

**Design of distribution networks and points:**

The WTP system and the water points in the Alagaya refugee camp (5,100 people and 10 tapstands) and its neighbouring camp were designed for a much smaller population than currently resides in the camp. In the neighbouring camp the pressure on the tapstands (15,000 people and 10 tapstands) means that residents sometimes walk the 30 minutes to their neighbouring camp to collect water, which is a shorter time than the waiting time in their own camp. However even in this situation, the WTP is sometimes out of operation and residents of both camps walk several kilometres to take polluted water directly from the River Nile.
Storage tanks:

Storage tanks are often welded from steel plate, but brick, plastic and fibreglass are also used. Tanks are widely painted inside, including those that are fibreglass and also water tankers. Underground tanks made of brick and cement are also painted. These tanks are used in areas such as urban areas in the Kordofan States where water is scarce and where it is stored for several weeks. Fibreglass tanks were widely used in the 1970s but after 10 years fibres were seen to have got into the water and people were having reactions/rashes from using the water. Both fibreglass and plastic tanks need to be in the shade and in the very hot weather, it has been observed that water can gain a smell from the plastic.

The MoWRIE/DWSU (2009, draft) technical guidelines and manuals make a recommendation for the standardisation of raised water tanks for water yards and that these are to be painted internally with bitumous non-toxic paint. The Drinking Water Quality and Control Regulations 2014, also recommend the painting of the inside of storage tanks, but do not state they should be non-toxic. Epoxy paints are manufactured in Sudan and recently a company has also started to trial bitumous paints. There is currently no process for certifying the non-toxic nature of paints or for waterproofing materials for the inside of drinking water tanks. One national company noted that the company which supplies the epoxy paints said it was tested by the SSMO (but the SSMO indicated that there are no producers of the paints/waterproofing products produced in Sudan, so this would need more clarification). The national company has also tried to get one of the paints tested themselves by a University laboratory, but this is their own initiative and the process for testing is not specified in national standards. The cost of the epoxy paints is high against standard paints – for example the cost for a 25m³ tank would be 10-15 times the cost (for example SDG 10,000 for the epoxy paints versus 600 to 1,000 for normal paints). This would be an influencing factor for most people to use standard paints which may be toxic, in addition to the fact that there is a lack of clear certification, guidance and enforcement on the need to use non-toxic paints. There are also currently no laboratories in Sudan that can test for Volatile Organic Compounds (VOCs).

Fig 11 - Epoxy paints manufactured in Sudan

Chlorination of water tanks:

During the AWD outbreak, some chlorination is being undertaken of water in donkey carts or when a storage tank is filled. The well keeper is sometimes paid an incentive by the MoH or works for the Locality for their work.

Maintenance of distribution networks:

In some States the SWC is replacing some of the older asbestos cement (AC) and iron pipes with High Density Poly-Ethylene (HDPE) as an agreement with JICA. In Kassala Town they are replacing 400 km of pipes which
have been laid but not yet connected. It is estimated that they should be able to reduce leakage from 30% to <5%. It has been funded by a donation from the Farmer’s Bank (SDG 100 million). In Girba the pipes are still old and a mixture of AC and uPVC. In the White Nile some old networks are being replaced by the SWC as a pre-condition to get a new WTP. 

In most places the repairs being undertaken on piped networks are only temporary repairs. There are also challenges about who should be doing the repairs, including in IDP contexts. In Zamzam camp a community has been repairing a leak to the main supply line to their water yard on many occasions themselves over a number of years, as the Water and Environmental Sanitation (WES) team have not responded to requests to repair it. But the WES team note that the community should repair it because they take a fee for the water for the management of the yard. This raises a question over where the line for responsibility lies? Good practice would usually be that the main supply line is maintained by the supplier (in the case of the IDPs camps this would be the WES team). This same situation is reported to also occur in urban network areas, where community members are left to repair pipes, even main supply lines with limited expectation that the SWC will repair it themselves. 

In the Urban Water Project for Darfur (UW4D), Key Performance Indicators (KPIs) have been introduced which include those on leakage, time for repairs to be undertaken and cost recovery. In the project areas meters and valve chambers have been installed and a gang is on stand-by to respond to the maintenance of large pipes, with the community being left to be responsible for smaller pipes. The UW4D project is implemented by the SWCs in 4 State Capitals of Greater Darfur - El-Fasher, Zalingei, Geneina and Nyala. It is funded by the UK Department for International Development and supported by UNOPS and UNICEF. 

**Challenges that can occur related to water safety in relation to bulk storage and distribution to collection points:**

- Pipeline design and contaminants:
  - The pipelines may have poor designs with inadequate numbers of isolating valves to allow for pipe drying (for Poly Vinyl Chloride, PVC pipes) or lack of equipment for pipe bonding (for PE pipes), poorly designed or non-existent valve chambers (see Fig 12), air blocks (which can reduce flow leading to people using other sources), water hammer or excessive pressure at tapstands (leading to wastage)

**Fig 12 - Contamination risks to water systems**

- **Lack of valve chamber and flooding around pipeline valves, White Nile**
  (photo credit: Photographer unknown/ WASH Sector)

- **Intake flooded with solid wastes, White Nile**
  (photo credit: Photographer unknown/ WASH Sector)
Some supplies are intermittent (such as in Alagaya refugee camp and areas in the towns in North Darfur which are supplied in a shift system), which increases the risk of inflow of pollutants when the water pressure drops.

- There may be illegal connections
- Risks of cross-contamination from sewage pipes, septic tanks and other sources
- The volume of water may not be adequate for the number of users, leading to the users using more polluted sources

**Distribution system maintenance:**

- Many of the distribution systems have old pipes, including Asbestos cement (AC), Iron and PVC, and there may be corrosion and high levels of leakage
- Regular monitoring and preventative maintenance does not appear to be happening
- It appears that most maintenance is done in response to customer complaints and then the repairs tend to be temporary fixes using rubber strips, which are not replaced (see Fig 13)
- Not all consumer complaints are responded to by the SWC and citizens may feel that they need to pay someone from the private sector to respond to problems (although a report from the UW4D Project indicated that all complaints were responded to within an average of 4 hours)\(^2\)

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**Fig 13 - Temporary repair of pipes and leaking tanks**

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- The SWC’s may not have the required equipment for identification of leaks and repairs
- Spare parts are purchased from the local market but are often of poor quality

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\(^2\) Urban Water Administration Offices (2017) Key Performance Indicators (KPIs), Quarterly Report [Jan – Mar 2017], UWAs, 4 State Capitals in Greater Darfur – El Fasher, Zalingei, Geneina and Nyala
- The distribution network maintenance teams may not have access to vehicles which is then difficult for moving materials and equipment
- The distribution teams may not have the correct equipment – for example in Kassala town the teams do not have a washing system for the pipes and also the pipes do not have washing values
- Some tree roots get into pipes and lead to a bad smell in the water and customer complaints

- In water yards and distribution points there can be problems from:
  - Basic design gaps – such as lack of cement drainage curtains and drainage channels to move the wastewater away from the source
  - Inadequate maintenance of the water distribution points with no-one taking responsibility to prevent ponding etc.
  - Poor design of water points including tap and platform and inadequate drainage leading to ponding and muddy surrounds risking contamination of containers.

- For water tanks:
  - They may be old and corroded
  - There may be ingress of pollutants from inappropriately designed or damaged inspection covers
  - Tanks may be underground and not well sealed

### 4.4 Collection of water and transfer to household

**Transfer to household by hand**

Water containers for transfer to the household tend to be plastic containers with or without lids. Some containers were seen with lids fixed to the container with string. Some were clean and others dirty with a build up of algae inside. Some were brittle and cracked. See below for a photo of a plastic container that has been repaired using melted plastic. It is reported that gravel is used to clean the inside of the containers.

**Fig 14 - Drinking water storage containers**

| Repaired drinking water container with melted plastic (no lid), Zamzam camp | House owner and household storage of water, drinking water, Zamzam IDP camp |
### Fig 15 - Distribution points

<table>
<thead>
<tr>
<th><img src="image1" alt="Muddy collection point in a water yard in Kassala Rural Locality with stagnant water and solid waste" /></th>
<th><img src="image2" alt="Designed water point at Alagaya refugee camp (to left and above):" /></th>
</tr>
</thead>
</table>
| - Taps some distance from containers  
- High pressure as right next to raised supply tank  
- Overflow of water leading to muddy entrance  
- Steps to reach taps and fencing and a small area for collection leading to many people crowding into the small space | These pose possible health and safety risks to the users due to slippage. |

| ![Concrete drainage system under taps in a water yard](image3) | ![Fencing around a water yard and water collection point in Zamzam IDP camp](image4) |
Transfer by donkey carts/ tankers:

Some concern was expressed about the recommendations for dosage of chlorine for donkey carts at 2 x 1.67 gram NaDCC tablets per a 400 litre tanker. In Khartoum one tablet is being used for a 400 litre tanker but in Kassala, the recommendation has been to use 0.5 tablets. On reflection both of the dosages may be correct:

- The guidance for an emergency situation from the manufacturers is to dose at 2 tablets per 400 litre tanker. This leads to a starting dose of 5 mg/l. It is assumed that the manufacturer has assumed for this dose that the water will have a degree of turbidity and there is no testing/control/calibration.
- However where the water is from a groundwater source and should have limited contamination a lower dosage would be applicable. In Kassala the starting dosage that is being used is equivalent to 1.25 mg/l and in Khartoum 2.5 mg/l.

Therefore the variation seen in the two locations could both be appropriate depending on the quality of the water and the contamination risks and if these levels have been determined based on testing of residuals. It is important to ensure that the dosage is established against the actual conditions. Testing should be established when setting up the dosage regime and on-going monitoring should be undertaken to ensure that the end residual remains adequate. See the new Chlorination Protocol being developed 2017.

Kassala Rural Locality mentioned that they have been informed that they will no longer be provided with tablets but instead will be given powder. This is of concern to them as they will need training on how to use the powder, which is more complicated to handle and dose than the tablets.

Khartoum State MoH confirmed that all donkey cart owners need to be registered and that they undertake regular training and monitoring of the donkey cart owners and their carts. The Regulations on DWS Control, 2014, also states that all donkeys need veterinary certificates and the operators need up to date health certificates.

Challenges for DWS in relation to collection of water and transfer to the household:

- Water containers may have wide tops or no caps
- Where water is collected by donkey cart or tanker, the water may be contaminated during the process of collection
- The pipe at the source for the filling of the donkey cart or tanker may become contaminated by falling on the ground

4.5 Household water supply, treatment and safe storage (HWTS) / Point of Use (PoU)

HWTS/ PoU:

Discussions with various stakeholders indicated that not much HWTS/ PoU is undertaken in Sudan. What HWTS is undertaken in Sudan is reported to be mainly undertaken by women. The MICS, 2014 – states that the average percentage of households using unimproved drinking water sources across Sudan who also use an appropriate household treatment method is 4.1%:

- No treatment is undertaken by – 70.9%
- Let it stand and settle – 22.4%
- Strain through a cloth – 4.0%
- Boil – 2.2%
- Add bleach / chlorine – 1.3%
- Use water filter – 0.8%
- Solar disinfection – 0.2%
- Other – 1.4%
Variations included:

- Urban/ rural - Urban 3.7% and rural – 4.2%
- Variations across States – from 11.5% in Gezira and 8.5% in Red Sea State to almost zero in South Kordofan
- Wealth quintiles – 2.9% of poorest households to 7.0% of richest

Stakeholders met shared that the following are, or have been, used in Sudan (although note that not all of these are approved by the FMoH for use in water treatment):

- Boiling (in some areas it is reported that most people even in rural areas use gas for cooking)
- Storage / sedimentation including in Zeers
- Putting the water in the sun for 3-4 hours
- Use of local materials such as:
  - Alluvial (clay) in the north
  - Groundnut
  - Moringa [and possibly Neem] – but it does not have a good taste
  - Trees (Mohved, Kadara)
  - Nana plant/ Mint
  - Lemon
  - Oil put on top of water after boiling

A few rapid HWTS activities have been supported as part of the AWD response:

- Use of chlorine tablets
- PUR sachets
- Lifestraw (a few hundred)

HWTS has been included briefly in the water treatment related MoWRIE/DWSU (2009, draft) technical guideline and manual, but is not generally being taught on the Environmental Health courses in universities in Sudan. A PhD student at Gezira University studied traditional water treatments (two seeds and one type of root).

In Kassala Town and Khartoum, clay pots - Zeers [which are also sometimes spelt Zyr or Zir] are observed at the side of the road with cups. This is for public use of water. There are quite large potential contamination risks with these open pots including related to AWD, the pots not being clean and the provision of contaminated water. There are also public dispensers generally outside homes of wealthier people.

**Fig 16 - Traditional Zeers for DW storage**
Storage in the household:
Water in the household either tends to be stored in plastic containers, in ceramic Zeers or in tanks, including underground tanks constructed of bricks and cement. For Zeers often a shared cup is utilised that is dipped into the container.

Drinking water quality in the household:
Testing of the water quality at the household does not appear to be common, but in a number of cases where results were available, the FRC was found to be zero in household storage containers. Three examples of this include draft data from a study under the UW4D project, where 32 of 47 households tested had water that was considered contaminated. One of the data sheets from the State MoH in North Darfur also indicated no residual free chlorine in households in an IDP camp, and it is also reported that in a study in the Kordofan States out of 35 households tested, 20 had E.coli present. The lack of FRC in household containers may be due to inadequate chlorination dosage for the heat and the level of contamination throughout the supply chain or chlorine that has lost its strength due to poor storage. There is also a lack of inspection of underground tanks in households.

Refer to Section 4.3 for discussion on painting / waterproofing storage tanks.

4.6 Beliefs, community engagement, hygiene promotion, citizen feedback and enforcement/ activation of laws
Good practice related to water safety, particularly at community and household level requires effective community engagement and communication to inform and motivate people to undertake positive DWS practices.

4.6.1 Beliefs and practices related to DWS
Beliefs of relevance to DWS vary across communities and areas of the country. Examples include:

- There are some beliefs that the chlorine will have negative effects such as making people sterile, or that it will affect Wudu and prayer, it will bring disease, or is poisonous. This can make people reticent to use drinking water with chlorine in.

- If water is running it can’t be contaminated.

It was reported that one Locality in White Nile State has piped water, but many people prefer to take water from donkey carts that get water from the river because it is cheaper. Likewise in East Darfur State and the southern part of South Darfur State, the main water source is groundwater. However during the rainy season the boreholes are closed as hafirs are preferred for animal and domestic use, which are also free of charge. People also prefer surface water to other sources such as groundwater if it has too high salinity.

4.6.2 DWS and AWD campaigns in humanitarian context
Hygiene promotion in relation to DWS has been integrated into the AWD campaigns. This has included persuading people to accept chlorine in their drinking water even though some people are reticent.

See the box below for the content of a water safety related poster from Kassala.

Kassala Rural Locality explained how they did awareness raising on how to use the chlorine tablets in jerry cans when they were distributed to 500 households in host communities and 5,000 people in refugee camps.
DWS poster for AWD awareness raising - MoH and WHO Kassala

1. Drinking water must be clean and safe for use (no flavour, no colour and without smell)
2. Ensure that the water is disinfected and treated with chlorine or boiling or other type of treatment recommended by the MoH that can remove the germs
3. Cleaning of water storage (water tanks) or wells (twice in a year) will reduce the contamination
4. Water test must be adapted and used for water sources because of the pathogenic organisms that cannot be seen by the eye
5. It’s good to use chlorine for water treatment because it is easy to use and effective for water treatment
6. Please ask the specialised people who are working in water quality when it is needed or if you have any concern about water
7. Animals must be away from water sources when it is used for water transportation, it might cause contamination of the source
8. Protect your water sources from contamination by fencing and do not defecate near it as this will contaminate the source

Khartoum MoH also explained how they:
- Do training with the donkey cart owners on personal hygiene, how to use the chlorine tablets and how to clean the water tank and jerry cans.
- Engage students, the youth and Women’s Union during hygiene promotion.
- Had done between 42-45 sessions with the media in the previous 15 days, (presumably focussed on AWD more generally rather than only DWS).
- Use drama, culture and undertake activities in market places.

The North Darfur MoH working in Zamzam camp undertake the following activities:
- Share hygiene messages including in schools
- Distribution of chlorine to households and check residuals
- CHAST training and distribution of posters in schools
- PHAST activities at community level
- Focus group discussions on cleaning jerry cans and storing drinking water

It has been noted that there has been a lack of standards and standard materials for HP related to the AWD outbreak.

4.6.3 Community engagement and hygiene promotion on DWS in longer term context

The FMoH and SMoH utilises a number of approaches including the ‘Healthy City Approach’\(^{24}\) and has the ‘Community Based Development Initiatives Programme’\(^{25}\). The CBI programme (CBI) looks at communities more as partners, with more of a facilitation role by the outside agencies and supports a bottom-up approach. A manual exists on ‘Community Empowerment Guidelines in Water and Environmental Sanitation’ by FMoH, MoWRIE and UNICEF (no date). These guidelines have sections on: water sources and protection methods; on water storage in the household including good practice in using Zeers and keeping the water hygienic; and household water treatment and storage.

The following box provides the good practice guidance provides for household transportation and storage in the community empowerment guidelines.

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\(^{25}\) FMoH (2005) National Strategy for Community-based Development Initiatives Program (CBI), Sudan, Directorate General of Primary Health Care, FMoH
Transportation and storage protection methods

The utensil used to transport water must be appropriate and subject to the following elements:

- Be dedicated for the only purpose of carrying water.
- Made of materials that do not affect the physical or chemical properties of the water (color, taste and smell) and rustproof.
- Be clean with a cover that does not allow the entry of any dirt or dust or insects.
- Filling and emptying methods for the bowl must be designed in a way to prevent any possibility of contamination in case of taking water from open basins. Do not insert the pot into the basin, but to be poured by the vessels designated to the extraction of water.
- The person who frequents the water source should be clean in body and healthy, not complaining of any disease transmitted to humans by using contaminated water or a germs carrier.
- Animals that carry out water, in case of use, should be free of diseases that can be transmitted to humans using the water.

During use

In case of using Zeers\(^2\) (water jars), tanks and barrels:

- Ensure the cleanliness in and out and to make sure of removing deposits before pouring water.
- After collecting water, cover immediately and preferably with a cover designated for this purpose.
- Do not insert hands to prevent water pollution and preferably install a tap of a suitable height in the Zeer, especially in schools. (Constant taps should be put to fill Zeer, reservoirs and another one for drinking)
- Put reservoir on an iron or other stretcher, with a height of at least a meter from the ground so that dirt, animals and children do not reach them, also places of pollution in the house like latrine and the barrel for keeping pots of dirty water.
- Empty Zeer of water every three days, wash and dry from the inside before pouring the new water to prevent mosquito breeding.

It is understood that it is not common for the community to be informed if the drinking water supplied by the SWCs does not meet the required quality standards, for example if the turbidity is too high to make the chlorination effective. Therefore they will not know if they need to undertake a household treatment such as boiling. As there is also very little household water treatment and safe storage in Sudan, it is also assumed that very little communication has been undertaken on this issue in the past (HWTS).

It is not clear how much attention has been given to ensuring that people who may be vulnerable or disadvantaged are being reached through the communication methods used and how much they are being encouraged to engage in the processes related to DWS.

The following photos indicate some of the posters used for hygiene promotion in a health centre run by Relief International. These have been incorporated into the health promotion activities for mothers in the supplementary feeding centre. Using SDW for children that are malnourished is essential to reduce the risk of diarrhoea as this can be fatal for such children.

4.6.4 WASH and Health Committees and community volunteers

As described in Zamzam IDP camp in North Darfur, the roles of the WASH and Health Committees related to DWS may include:

- Raising awareness of the community;
- Follow-up on the safety of water in sources and households (using a pooltester and observation);
- Chlorination of water sources in camp;
- To ensure the jerry cans and tanks are clean and covered;

\(^2\) The spelling in this report is: "Azyar"
If big problems they ask the WES team for help;
If small problems – the committee is prepared to maintain and buy the spares from a local market;
A tariff is collected for motorised schemes and if there is a problem for handpump then do a collection for repair.

Fig 17 - Posters used for health promotion in the health facility run by Relief International in Zamzam camp including for mothers of malnourished children

Hygiene promotion is often undertaken by community committees and volunteers with no incentives, which is usually a strategy used to support sustainability. But this may be challenging for the time inputs required, particularly during outbreak situations. They also may not have an official location to meet and appreciate having capacity building to be able to undertake their tasks.

Note that whilst there is useful information on the second poster, it has missed the guidance to not dip the cup into the container, which is included in the empowerment guidelines noted above.

4.6.5 Citizen feedback and complaints

There is reported to be a Consumer Protection Society that is involved in the MoWRIE committee on bottled water producers. Citizens can also phone a number for SWCs to report problems or visit the SWC or WES compounds. But it is common that citizens often do not expect the SWC to respond and undertake repairs to networks, so they may use the private sector to resolve them themselves.

One stakeholder commented that “It is essential to change the engagement of communities – wake them up to the responsibilities of the SWCs and demand the SWCs to act, not to just go to the private sector to get problems resolved”

Establishing some form of publicly accessible records of the complaints / requests made and the follow up actions by the SWC with dates, could be a useful tool both to encourage increased attention on problems by the SWCs and also to encourage an increased level of demand from citizens.

JICA have supported the establishment of websites for the DWSU, Khartoum SWC and the DWST and there are plans to expand the establishment of websites for other SWCs. It is proposed that these can be tools for
the sharing of good practice and also to enable users to be able to access information on what is happening in relation to their water services.

One key step to be able to assist the community to demand their rights is to clarify the system of accountability at all levels and the specific responsibilities of all stakeholders. The community must also be engaged at each step as well, as the Locality and community leaders. Community leaders who it is suggested would be positive to ensure they are involved include the: Women's Unions, religious leaders and the Youth Union. A Public Committee already exists which is a government structure at community level. This involves the Women’s Union and youth, and they already discuss development related issues such as water and health. But they are not always trusted to act in the best interest of the citizens.

4.6.6 Enforcement/activation of laws

Legal authority to enforce:

Enforcement/activation of laws related to water supply is mentioned in several Acts (related to Environmental Health; the Environment; Water Resources; Sudan Penal Code; and the Act to set up the SSMO), which adds to the lack of clarity over who is responsible and for what. In relation to legal authority for enforcement:

- The Ministry of Health at all levels (Federal, State and Locality) has clear legal responsibilities for enforcement in relation to drinking water under the Environmental Health Act, 2009 and associated regulation, including for the approval of water sources for use as drinking water and for the monitoring and enforcement in relation to bottled water and ice producers.

- The MoWRIE and SWCs have clear responsibilities for the approval for abstraction of water resources under the Water Resources Act, 1995 and associated regulation, but it is not clear/not specified that they have authority for the approval of the use of water resources for the purpose of drinking water, or that they have a role in the monitoring and enforcement in relation to bottled drinking water producers. The EH Act, 2009, Clause 8 says “Must for anyone working in the field or drinking water in the various levels of government to abide by the conditions and regulations of the following: (A) To confirm the validity of drinking water and pollution-free networks in accordance with the approved specifications”. But it is not clear if this refers to the supply of drinking water from their own systems, or they can approve the use of water for drinking? The Regulations for DWQ and Control, 2014, specify that the establishment of any project of drinking water should receive a licence from the ‘competent health authority’.

- A range of stakeholders are considered as ‘Competent Authorities’ under the Environmental Conservation (Protection) Act, 2001, for the purposes of protecting the environment and also are able to enforce, including citizens who can bring Civil Actions.

- Under the Local Government Law, 2003 (temporary) and the Local Government Act, 2016, the Localities have the power to prepare ‘Local Orders’ and to enforce against these and from the side of health have the powers to undertake surveillance of drinking water and validate/guarantee the water is not polluted. They also have the power to monitor and ensure that food and drink places have licences.

The situation where the SWCs are not clearly legally authorised to certify water sources fit for drinking poses challenges in the situation where the MoH and Locality laboratories below Federal do not have the capacity to test for the full range of physical, chemical and microbiological parameters needed to establish if drinking water is fit for drinking. Therefore potentially some formal transfer of power for this approval process may be required, at least until the point at which the State MoH laboratories have the capacity to approve water for drinking.

Evidence of enforcement/activation of laws happening:

Some evidence has been shared of enforcement/activation of laws occurring in relation to drinking water. These included:
1. Kassala Rural Locality – Enforced the chlorination of private borehole water sources during the AWD outbreak using by-laws and involving the police.

2. MoWRI/ The Groundwater and Wadis Directorate reported that some boreholes have been declined for use. For example:
   - 8 to 10 have been closed because they had high fluoride levels, some over 40 mg/l.
   - One example was provided where there were boreholes in North Kordofan that had nitrates above the Sudan WQ standards (noted at around 150 mg/l). But they had very limited options in the particular villages and so a team went to check the options. It was found that the shallow wells had higher nitrates at around 100 to 200 mg/l. Medical doctors also visited the area and did not find any associated health problems. Therefore it was agreed that the boreholes could be used.

3. SWC Kassala – The lab technician reports when there are problems with quality to the SWC who are expected to follow up.

4. The DWST at federal level - It had been involved in one bottled water company being closed down due to not meeting the required water quality standards.

5. Other examples were provided of food premises being shut off after environmental inspections, as going through courts is long process. In Kassala Rural Locality they have a committee that sits to monitor the enforcement/activation of the laws, which involves the security services and police. This is not an example specific to DWS, but provides some evidence that activities related to enforcement/activation of laws are being undertaken by Environmental Health officials.

6. The MoH in Khartoum State noted that if there is a DWS related problem that they have identified that is not being remedied, the State Minister for Health would call the Governor of the Locality to get action.

7. MoH South Darfur note that they have closed water sources (shallow well equipped with motor pump) when they are contaminated and also enforced the chlorination of private borehole water sources during the AWD outbreak. They also reported these to the police and there were some cases have been transferred to the court.

8. The MoH in Kassala has also stopped the use of a water source in Tandalti because of pollution.

Challenges with enforcement/activation of the laws:
The following are challenges with enforcement/activation of laws:

1. Long processes to enforce that lead to punishments
2. Low punishments at the end of the process
3. It is not fully clear who is responsible for enforcement/activation of laws
4. Enforcement/activation of laws is particularly weak between Ministries (for example between the MoH and the water or other related ministries and State Water Corporations)
5. Not everyone is confident to enforce action by the private sector
6. The Locality do not always fulfil their responsibilities for the enforcement / activation of laws (as they may lack staff, vehicles and finances).

4.7 Specific contexts

4.7.1 Regulation of packaged/bottled water
The current situation in Sudan in relation to bottled drinking water includes:

Regulations for bottled drinking water:
The Regulations for DWS Control, 2014 has sections on bottled water and ice factories. It covers issues such as:
• Guidance on the building location, construction, lighting, ventilation, doors and windows
• Toilet facilities, availability of detergents and toilet tissue, hand-washing facilities, signs for washing hands with soap
• Cleaning of the facility and waste disposal
• Permission needed to change the factory from the competent health authority
• Specifies that the production line should be mechanical and bottles labelled
• Workers should have health cards testifying fitness and that they are free from communicable diseases, wear uniforms, maintain high personal hygiene, that anyone who is sick should be excluded from the work
• Specifies that the product should be registered at the MoH and kept for 48 hours (incubation period) and chemical and bacteriological analysis carried out
• Documentation and reference samples should be kept for 4 weeks
• That the water should be a safe source of water supply and the competent health authority should agree on drilling of the water or sewage well [a borehole for the disposal of sewage].
• Nets and tanks of water shall be manufactured from non-reactive materials with water or other materials used in the water production

But:
• It does not mention anything about the treatment processes required including disinfection.
• It mentions painting the inside of the water tanks to facilitate the cleaning but does not specify using non-toxic paints.

For the ice factory the guidance is similar but in addition it adds:
• The ice shall be colourless and free from bubbles
• The melted water should be according to the Sudanese standards for drinking water
• It should have residual chlorine according to the Sudanese standards for drinking water
• Warehouse with suitable temperature for ice preservation
• Water tanks, pumping pipes and packing equipment should be cleaned with a disinfectant with chlorine daily

For both it also has a general provision that the inspector can enter and carry out an inspection to any place of work in preparation, selling, manufacturing, packaging or storing drinking water and take lab samples for testing.

Regulation of bottled/packaged drinking water companies in Sudan:
The engagement with the bottled water industries in Sudan seems to currently be fragmented:
• MoWRI – Heads a committee involving the MoWRI and the Consumer Protection Society, which it is reported meets monthly.
• FMoH with support of WHO – Undertook a survey of bottled water across six States in 2016/7. See below for more details.
• MoWRIE, DWST in Khartoum – Undertakes some testing of the water in bottled water factories, particularly to check for Bromide.
• SSMO – Undertakes monitoring of bottled / packaged water factories and enforces action where they are not up to standard.

An example of regulation was shared by the DWST who noted that if they find a high level of Bromide in the water above the upper permitted level, they then contact the factory and give two options: a) to change the source; or b) to reduce the amount of ozone used. They also reported that one factory has been shut down. The Factory Inspectorate in Khartoum is under the SSMO and undertakes the inspections and sends samples of the water back to the laboratory in the SSMO for checking.
This is positive that some form of regulation is happening. However, the Regulations for DWS Control, 2014 seems to specify that the ‘competent health authority’ has the key role in the regulation of bottled water companies, but it is not clear how they have been involved in all cases. Hence there may be some gaps in clarity over roles and responsibilities. The Ministry of Health at the federal and state levels are also monitoring factories and taking samples and test them, but it is reported that there is no systematic follow up.

Survey to assess the quality and safety of bottled water in Sudan, 2017\(^\text{27}\)

The study of the bottled water factories across six states (by FMoH supported by WHO), found a range of problems with the factories. The study visited 55 factories and took 61 water samples. The factories were in: Khartoum (25), Gezira (4), Gedaref (3), Red sea (10), North Kordofan (8) and South Darfur (5). From the factories visited:

- 34.5% took their water from the urban water network, 58.2% from an internal well, 3.6% direct from the River Nile or the sea, and 3.6% from outside the factory.
- 98.2% have some form of water treatment. 10.9% have carbon filters, 9.1% have sand and 69.1% both carbon and sand. 83.6% have chlorine added. 60% have exposure to UV and 60% have Ozone gas added.

Examples of the problems found include:

- Only 34.5% of factories had product registration certificates
- Only 54.5% test the drinking water daily
- Only 54.5% had laboratory records available
- 14.1% of factories do not have specialized personnel in the laboratory
- 16.4% had positive results for microbiological tests, i.e. were contaminated (had either \(E\).\(coli\), Thermotolerant coliform or \(Staphylococcus\) \(Aureus\) present).
- 14.5% of the factories the raw water storage is underground reservoir which can expose them to contamination
- 18.2% of factories the raw water storage locations are not suitable
- 27.3% of the factories the cleanliness level around the water storage is bad
- The general cleanliness of the factory was considered bad in 32.7% and medium in 32.7%
- 23.6% of factories do not sterilize the bottles before filling
- 40.0% of factories both fill the water and cap the bottles manually
- 10% of the factories do not have an internal sewerage system
- 10.9% of water bottling factories do not have toilets, 25.5% of factories do not have adequate number of toilets and the condition and cleanliness of 34.5% of the toilets were considered bad
- 34.5% of factories have workers without a medical fitness certificate
- 63.6% of factories have workers without uniforms, 78.2% have no process for sterilisation of their clothes
- 65.5% have no process for sterilisation of workers before entering the water processing halls and 45.5% of workers do not disinfect their hands before entering the halls

See Fig 18.

Fig 18 - Bottled water factories

- Bottle filling
- Manual filling of bottles
- Production unit
- Waste bins
- Tanker filling a raw water tank
Database for the bottled water industry in Sudan:
It is reported that the Factories Inspectorate has a database of bottled / packaged water factories in Khartoum, but not outside.

Guidance and capacity building for bottled drinking water producers in Sudan:
There is currently no advisory information or capacity building for bottled drinking water producers in Sudan.

4.7.2 Schools, health facilities and other institutions
The FMoH Regulations for DWS Control, 2014 do not mention schools, health facilities or other institutions. The National School Health Strategy, 2016-20 (draft) and the National Guidelines for Implementation of an Effective School Health Programme, 2003-16 (draft) include a number of elements related to DWS. These relate to issues such as: establishing water points relevant to the number of staff and students; providing SDW; that teachers can be trained on water chlorination with tablets; and then a number relating to hand-washing, promoting good practices, availability of toilets and solid waste disposal. No mention is made of ensuring adequate drainage, how to reduce the risks of water pollution or how to prevent contamination related to sharing cups. There is a need to check on the constant availability of soap and on the need for children to bring their own cups for use for drinking water.

### Availability of soap in public institutions
One health facility visited in an area affected by AWD did not have hand-washing soap by the water points. The reason for this was explained that it is because soap gets stolen, so the staff keep it in their offices and it can be requested. However, this is not an ideal solution, particularly in an outbreak situation as people may not be aware of it. There is a need to find a solution, such as cutting the soap into small pieces, using powdered soap dissolved in water in a squeezable bottle or other options.

In White Nile it is reported that most schools and other institutions have their own water storage and supply. If they have a tank they are being chlorinated during the AWD outbreak.

It is also reported that the school curriculum does not include DWS\(^{28}\). But the FMoH has produced a health messages document for schools that includes a series of health messages used in the morning queue. It includes drinking water and contamination of drinking water. Examples of posters by Relief International have included DWS into general health promotion for mothers of children who are malnourished which are used at their health facility and supplementary feeding centre. Using unsafe water can be particularly dangerous for children which are malnourished. See Fig 17.

DWS in schools should be included in the general surveillance system, in the monitoring of water resources, be part of health facilities and school inspections and be included in specific trainings for staff (teachers, religious teachers, health facility managers and staff). Quraan schools are currently overlooked in support for improving DWS and monitoring / surveillance.

A number of projects have been undertaken by students at the University of Khartoum related to the drinking water situation in schools in Sudan, but the results not viewed.

4.7.3 Nomadic communities
Most nomadic communities are drinking raw surface water, often directly shared with their animals, for example in ponds, dams or hafirs. In areas where there are conflicts between farmers and nomadic communities, access to safe water supplies may also be limited by the conflict and risks of violence related to use of the source.

\(^{28}\) Although the curriculum was not viewed
4.7.4 Humanitarian contexts

Particular challenges for humanitarian contexts include:

- Changing numbers of displaced populations, including refugees, leading to water systems that are being used to supply much larger numbers of people than they were designed for, leading to people to look for alternative sources.
- Poorly maintained water supply systems from the development context, leading to risks for contamination and spread of communicable diseases such as AWD.
- High density of populations living in camp contexts may lead to pit latrines being placed near to water points or storage tanks.
- Inadequate access to chemicals for sustaining water treatment – at all times, but particularly during outbreaks.
- If people feel the water points are not safe to visit in conflict situations this may lead them to seek and use less safe water supplies.
- Access to water supplies for on-going monitoring and water treatment in conflict areas.
5. Context - Cross-cutting issues

This section is split into the following sections related to cross-cutting issues:

- 5.1 Gender, equity and vulnerability
- 5.2 Sustainability, seasonality, environment, climate change and disaster risk reduction

5.1 Gender, equity and vulnerability

Examples of issues which might affect adequate access to safe water supplies:

- People who are chronically ill, older people, children and newborns are particularly vulnerable to the risks from drinking unsafe water supplies, which can lead to disease or death.
- If anyone, but women and girls in particular, do not feel safe collecting water at specific water points it may lead them to look for alternative sources including those that may be less safe.
- If safe water supplies break down or are not provided on a constant basis, this means that women and girls may have to walk to more remote locations to collect water from open sources, putting them at increased risks of violence.
- Women and girls who are most likely to be the people who collect water, may have the least say over how a water supply is designed, water points sited, and the systems managed or how household money is spent including on water storage or household water treatment equipment or chemicals.
- People who have a disability or mobility limitation, such as older people, may find it difficult to reach and queue for water supplies, particularly if there are long queues, or face difficulty using a handpump. In Zamzam camp the Health and WASH Committees said that family members help people who may be vulnerable and can’t afford to pay for drinking water as the community is close-knit and they take care of their relatives, but the problem is with transportation when the near-by water source is out of action. The poorest people may not be able to buy soap and household water treatment equipment or consumables.
- It is not clear how much consideration has been made in the methodologies for communication and engagement with people who are particularly vulnerable, marginalised or disadvantaged to ensure they are involved in and benefit from DWS activities.

Fig 19 - provides an overview of which member of the household usually collects drinking water in Sudan by gender, age, wealth quintile and by urban and rural location. The graph indicates that in rural areas women are more likely to collect drinking water than men, but in urban areas men are more likely to collect it than women and also that adults are more likely to collect water in both contexts than children. It also shows that the lower the wealth quintile, the more likely that women will collect drinking water rather than men and the more likely that girls will collect drinking water rather than boys. In the highest wealth quintile men are more likely to collect water than women and boys more likely than girls.

Refer also to Section 4.7.4 for information on the humanitarian context.
Sustainability, environment, climate change and disaster risk reduction

**Sustainability** - The sustainability of water sources, treatment process, water supplies and monitoring and remedial action systems will all significantly affect on-going access to safe water. Examples of current problems include:

- The poor maintenance of water sources, treatment works, distribution systems and supply points.
- Lack of access to adequate water treatment chemicals on an on-going basis.
- Income generated by water supply services, not covering the cost of their O&M and replacement.
- Major gaps in the on-going monitoring and remedial action related to water supply systems.
- Turnover of staff, including staffs that are responsible for water quality monitoring.
- Broken laboratory and field equipment and gaps in access to consumable such as buffers for calibration on an on-going basis.

**Environment and climate change** – The changing climate and environmental conditions may affect water safety in the following ways:

- Dropping water tables leading to reduced yields and changing concentrations of naturally occurring chemicals in water sources, leading to increased conflicts and population displacements.
- Infiltration of pollutants into water sources or poorly maintained water pipelines can occur from blocked drains, piles of solid waste, poorly disposed of faecal wastes or chemical effluents from industries.
- Flooding also poses significant risks for the contamination of water sources.
- The changing weather and chemical effluents from industries may change the nutrient consistency of water bodies such as the Nile and lead to increases in algae blooms risking the release of toxins and increasing the pressure on water treatment process plants.
- Increasing temperatures also lead to people drinking more water and hence being at higher risk of being affected by contaminants.
- The changes in temperature, salinity and zooplankton blooms in surface water sources (which can be linked to the *El Niño* phenomenon) can lead to the re-emergence of the vibrio that causes the AWD outbreak. This can then be transmitted to humans when the surface water is drunk without treatment and can lead to an outbreak.
Sudan is part of a number of regional initiatives such as the Nile Basin Initiative and the Global Environmental Monitoring Service. The Ministry of Environment, Natural Resources and Physical Development (MoENRPD) and the Higher Council for Environment and Natural Resources have also published a National Adaptation Plan for Sudan\textsuperscript{29}. This specifies recommendations by state related to water resources to respond to the issue of climate change. These relate to undertaking geophysical studies, increasing the range of water resources, repairing water points and monitoring water resources. For more details on possible increases in hazards due to climate change and control measures refer to the WHO document on WSPs and climate change\textsuperscript{30}.

Disaster risk reduction (DRR) – Because of the range of humanitarian contexts that Sudan faces as well as on-going challenges from environmental degradation and climate change, there is a need to strengthen DRR (including early warning systems, emergency preparedness and also to consider climate change whilst undertaking WSPs\textsuperscript{31}). This contextual analysis has been undertaken while an on-going AWD outbreak (2016/17) has reached almost every State in Sudan. This outbreak has highlighted a number of gaps that influence DWS, including the lack of clarity on institutional responsibilities, lack of access to logistics for DWS monitoring, repair of supplies and networks and inadequate access to water treatment chemicals. Strengthening DRR and emergency preparedness would lead to more effective responses when new outbreaks, flooding or displacement contexts occur again in the future.


\textsuperscript{31} WHO (2017) Climate-resistant Water Safety Plans: Managing health risks associated with climate variability and change
6. Context – building blocks for water safety

This section is split into the following sections:

- 6.1 Legal and policy framework
- 6.2 Stakeholder responsibilities
- 6.3 Financing
- 6.4 Planning, monitoring, research and learning
- 6.5 Capacity building

6.1 Legal and policy framework

It is reported that there are 52 laws that have reference to water and sanitation in Sudan including criminal law, although to prosecute against criminal law takes time to go through the courts. Some laws and regulations in Sudan mention some aspects related to DWS but with some gaps/limitations. The MoWRIE is currently leading a project on Water Sector Reform funded under the African Development Bank and hence a number of the water sector laws, regulations and associated strategies and policies are likely to be updated in the coming few years.

6.1.1 Codes, Laws, Acts\(^{32}\) and regulations

**Environmental Health Law, 2009** – Includes clauses related to:

- The prevention of pollution of water sources
- That anyone working in the field of drinking water in various levels of government must confirm the validity of drinking water and pollution-free networks in accordance with the approved specifications
- That employees working on drinking water must disclose that they have maintained their health and they are free from infectious diseases

But other than this there are no other clauses in the Act related specifically to the safety of drinking water. It includes punishments for violation of the law by imprisonment for a period of not less than 1 year or fines or both.

**Water Resources Code, 1995**

**Water Resources Code, 1995** – This document establishes the “National Council of Water Resources” and has powers to define the general policy related to water resources including the “prevention of the effects of natural disasters caused by droughts and floods, protection of those resources against pollution and deterioration of them, of an integrated and balanced manner, with other natural resources, thereby ensuring maximum benefit and achieve the desired coordination and cooperation with the other competent agencies”. In particular it specifies that: “The overall supervision of the withdrawal of water from the Nile, other rivers, streams and groundwater for irrigation, drinking, industry, hydraulic power generation, sanitation and other as well as the distribution and use of water, including the identification of cultivated land area, the installations set up for various uses, the protection of streams and water against pollution by sewage, industrial and agricultural chemicals and treatment of streams water in coordination with the Supreme Council for Environment and Natural Resources and the competent authorities”. The MoWRIE has the power to issue permits for the withdrawal of water. Penalties under this Act should not exceed 6 months imprisonment or a fine or both.

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\(^{32}\) Code = a specific type of action made by the legislature that covers a complete system of laws; Act = an enactment / a statute / a bill / a regulation which has passed through several legislative steps and which has become law. Acts if passed become laws; Law = rules and guidelines set up by social institutions to govern behaviour. They are made by government officials.
Other key legislation of relevance to DWS\textsuperscript{33} includes:

- **The Constitution, 2005** - States that The People of Sudan shall have the right to a clean and diverse environment and that the State and the citizens have the duty to preserve and promote the country’s biodiversity. It makes the responsibility of shared water (such as used by different communities such as water from the River Nile) under the responsibility of the central government.

- **The Environmental Conservation (Protection) Law, 2001** - This establishes the Supreme Council for the Environment and Natural Resources, identifies ‘the competent agencies’ to protect the environment and includes punishments for polluters of water involving suspending projects or revoking the licence. The competent agencies include a wide range of actors including citizens who can bring civil actions.

- **Local Government Law, 2003 (temporary) and Local Government Act, 2016** – The Local Government Act, 2016 notes that the Local Council may issue local orders which have the force of law and any local order approved by the Local Council shall include a penalty for the gradual violation of the administrative warning to the fine to imprisonment and may include heavier penalties in the case of continuous violations. The Local Government Law 2003 (temporary) instructs that the authorities for small towns must cooperate with the Localities and that the Local Government has jurisdiction of:
  
  o **Engineering Matters**: The establishment and protection of drinking water facilities and sewerage [or drainage?] in rural areas.
  
  o **Health and hygiene**: Monitoring / surveillance of drinking water, ensuring its validity, securing its sources and preventing pollution; plan and implement projects related to environmental health; health related awareness raising; cleaning, constructing public toilets and monitoring the healthy environment in housing, agriculture and industry; and watching and observing [monitoring] places where people prepare, drink, sell and show food and monitor the employees and ensure they have a license.

- **Food Control Law, 1973** – Has particular relevance to bottled or packaged drinking water.

- **Khartoum Water Corporation Law, 2009** - The law prohibits any person to use drinking water for commercial or industrial purposes or to set up any water exploitation facility such as surface and underground wells without a permit, including the non-eligibility of any citizen to dig a well or siphon or to carry out any work leading to pollution of surface and groundwater drinking water. Whoever violates the law is liable to imprisonment for a period not less than three months and not more than a year or a fine set by the court, along with the right to revoke the license and fill the well, confiscating the equipment and others for the benefit of the Corporation.

- **The Sudan Penal Code, 1991 / Criminal Law** – Includes punishment of up to 3 years for putting people at risk by placing poisonous or harmful substances in a well.

- **Anti-terrorism Act, 2001** - A person who commits an act that seriously harms the aquatic environment and exposes people’s lives to risk is considered a terrorist offence and is punishable by imprisonment for up to 20 years and a fine.

- **School Health Act, 1974** - Stipulated the State Council for School Health must ensure that the health of the environment in which students or pupils live is adequate and that there are adequate conditions for health safety against the dangers of wells.

- **Public Health Law, 2008**

- **Pesticides and Pest Control Products Act, 1994**

- **Establishment of the SSMO, 2007 and the Law of Standards and Metrology, 2008.**

Regulations of DWS Control, 2014 (FMoH) - Includes clauses related to:

Selling of potable water:

- The need for a valid certificate on potability for human consumption from a competent health authority
- That only substances for the treatment, disinfection, transportation or storage of drinking water or bottled water approved by the competent health authority can be used
- The need for a health licence for workers in the drinking water profession
- Drinking water should not be sold on the streets and in markets by water vendors
- The location of a well must be approved by the competent health authority, drainage should be included and it should be no less than 50m from latrines
- The well owner must comply with a competent health authority in case of any indicator or water pollution

Health specifications for the worker and means of transportation (karo):

- Workers must have a valid medical card and not have wounds on the hand
- Some specifications for the containers for transport – such that it should be of stainless steel or painted internal and external [see note below]
- Requirements for the animal to have a valid card from the vet, renewed each 6 months
- Requirement for tanker truck operators to have a valid certificate from the competent health authority

Specifications for buildings of bottled water and ice factories:

- Specifies requirements for the siting, design, construction, lighting, doors and windows and ventilation of the buildings to reduce risks for pollution
- Specifies the number of toilets, showers and hand-washing facilities and some aspects of their design and the need to have signs to direct employees to wash their hands
- Specifies some cleaning requirements and that there should be a changing room
- Specifies that the production must be by machine and not manually, the bottles must be labelled with the mineral ingredients and that the product should be registered at the MoH and kept for 48 hours and chemical and bacteriological analysis should be carried out
- Specifies need for workers to have valid health card
- For the ice factory it also specifies that the ice should have residual chlorine and also that the equipment and utensils should be disinfected daily
- That the inspector may enter and carry out inspections and take samples for testing in a lab.

A few issues that should be resolved in future updates:

1. To revise the recommendation for painting metallic containers internally – to ensure that if so, that this is with non-toxic paints
2. To consider requirements for the effective disinfection of bottled drinking water
3. To include specific requirements for the handling of ice by small ice sellers
4. To ensure that recommendations about keeping sewage sources away from water sources, tanks and pipes are consistent - currently it notes:
   a. The water source should be 50m from a latrine
   b. Sewage disposal should be through a sewage system or a soil absorption field at least 10m away from ground tanks of drinking water and in level less than 0.5m
   c. Construction or digging of any latrine or well to keep the sewage in distance less than 3m from any line of drinking water
See the report on ‘Recommendations for strengthening DWS components of WASH sector guidelines (2017)’ for more information.

**Regulations of License of Exploitation of Groundwater, 2014 (which came into effect 2016)**

These require “Any person who wishes to obtain a license to exploit the groundwater, develop the groundwater well, clean it up, increase its capacity, increase its diameter or test its productivity by means of a digger or any means of installing a pump must submit an application to the competent authority according to the following: a) A study of technical, environmental and economic feasibility according to the indicators determined by the competent authority; b) Certificate of registration of the company or partnership or work name according to the laws governing it; c) Indicating that he owns the land or a valid lease for the required license period; and d) Accreditation of the competent authority upon the conclusion of any contract requiring the drilling of underground wells”. It also notes that the license shall be valid for two years and then renewed each year. Penalties under this regulation revolve around issuing warnings and withdrawal of the license.

For extracts from the laws and regulations refer to Annex III.

### 6.1.2 Water quality standards and guidelines

**Sudanese Drinking Water Standards by the Sudan Standards and Metrology Organization (SSMO), 2016** – The Sudanese Drinking Water Standards appear to have been established based on the structure and parameters of the WHO 2004 and 2011 Guidelines. The WHO Guidelines have since been updated (latest version is 2017) and some of the parameters have been removed from the hazardous lists and new ones have been added. In addition the groupings of the parameters have been changed. Comparison between the SSMO standards, 2016, and the WHO guidelines, 2017 (see Annex III.5), also indicates that quite a few of the Sudanese maximum permissible levels are lower than the WHO guidelines, which indicates that the Sudanese standards are stricter than the WHO ones. This is permitted in the WHO guidelines, where the WHO guideline level is not realistic for specific countries. The rationales provided as to why some of the Sudanese standards are stricter than the WHO guidelines include that: a) The SSMO studies a range of international and other government drinking water standards before making a decision, rather than only the WHO guidelines; and b) Sudan is very hot and hence people drink more water, so the levels have been proposed to compensate for this.

The WHO guidelines are established based on an assumption that an adult will drink 2 litres of water a day with 50% of this being assumed to be boiled or in food. In very hot climates people may drink double this amount. So making some guideline levels stricter may be appropriate for some parameters. But WHO also notes that it is only for some parameters (such as Fluoride or Arsenic) that it may be appropriate for modifying the levels based on the climate and volume of water drunk. This is because the proportion of such chemicals coming from drinking water is relatively high. But for many parameters where a person’s intake from drinking water is very small compared to other sources, no adjustment is necessary. It also notes that for some parameters it isn’t physically possible to measure them below a certain level. Hence these issues should also be considered when next updating the Sudanese DWQ standards.

The Sudanese DWQ standards were updated in 2016, but by October 2017, a number of key institutions with responsibilities for DWS did not know that the updated versions existed and did not have copies (including the DWS teams in the FMoH and MoWRIE and key teams in the national drinking water quality labs associated with both Ministries). The SSMO has technical committees that meet weekly including one on drinking water, which is the committee that establishes the updated standards. However, some key teams are not represented on the committee (such as the MoWRIE GWD laboratory; FMoH DWS team members; and the DWSU representative responsible for DWS).

**Standards for equipment and chemicals** – Sector stakeholders noted that in the 1980s the Rural Water arm of government used to have standards for water troughs and towers, but today these are not used. Those who do use standards for design, construction or equipment would tend to use British Standards (and previously American standards but this is now less common). The SSMO has noted that they have some
standards, but these have not been seen and no sector stakeholder has mentioned knowing about them. The MoWRIE/DWSU has a series of 14 technical guidelines (2009, draft and in the process of being updated) that are sometimes referred to as standards. But they don’t at present include many detailed specifications for equipment or designs such as for water tower structures.

Two specifications for water treatment chemicals were shared by Khartoum SWC, but it is not clear whether these are only used in Khartoum State or if they are Sudanese specifications applicable to the whole of Sudan. One of the challenges noted by stakeholders is the poor quality of spares available in the local market, which has an impact on sustainability.

6.1.3 Policies and strategies

The **25-year strategy for Sudan, 2007** – has clauses related to reducing the pollution of water supplies.

**Sudan’s National Health Policy, 2017-2030 (draft as of September 2017)**

Under the section on Health Sections Functions, Environmental Health Services are mentioned and that environmental factors are responsible for almost 60% of all disease in Sudan. It notes that according to the local governance act that environmental services are the responsibility of localities, which has resulted in the negligence of environmental health at federal level. [However this is not specifically mentioned in the 2016 version of the Act]. It has policy statements related to environmental determinants of health and working on developing resilient systems and communities, but it doesn’t specifically mention drinking water or drinking water safety.

**WASH Sector Strategic Plan, 2012-2016**

Includes some reference to pollution of groundwater and the Nile and confirms the *polluter pays* principle (both in alignment with the policy). It highlights particular issues for pollution with the younger sediment basins and also the increase in population pressure along the Nile and the lack of sewerage / agriculture drainage water treatment that the water related health risks are increasing.

It highlights that ‘safe water handling and reuse’ is part of community based hygiene and sanitation promotion and this one of the six components of the rural sanitation and hygiene approach. The urban sanitation approach focuses on the role of the water corporations and highlights the old infrastructure and poorly functioning water treatment systems.

In relation to drinking water standards it notes: ‘**Current drinking water standards for Sudan shall be actively enforced to ensure the standards are applied. Water from new water sources shall be tested to certify that the water is fit for human consumption and water from existing water sources shall be regularly monitored to ensure proper quality standards are maintained**’.

It also has a component on planning and monitoring and sector learning. This includes a recommendation for establishment of a MIS integrated with a GIS system. It also notes: ‘**Ensure that M&E Unit at PWC and SWC is well established and functioning and also starts monitoring the Sanitation and Hygiene components of the Water, Sanitation and Hygiene Sector Monitoring of different water resources, include basic overview of trends in water use, especially human use and livestock, rural and urbanisation and possible environmental (waste water) problems and measure coverage and access to, and functionality and use of water supply and sanitation services in urban and rural areas to new target policy until 2016**’.

So some elements relevant to DWS are touched upon in various sections, but when updating the strategic plan it would be positive to ensure that DWS is strengthened including integrating the need for water safety plans at each level.

**National Environmental Health Strategic Plan, 2015-16**

This includes three priority actions related to drinking water management:

- Strengthen and establishment of water quality monitoring and surveillance system at 15 states.
- Strengthen advocacy and promotion activities in water safety, sanitation and hygiene.
• Strengthen monitoring, surveillance and evaluation system.

It includes a number of actions:

• Generate a biannual report on assessment and analysis of the water and sanitation sector
• Development of guidelines and manuals (water quality, safety and sanitation and hygiene)
• Mapping of drinking water sources
• Establishment of two regional laboratories for WQ
• Capacity building of 18 SMoH laboratories (personnel, laboratories, equipment etc) to conduct regular water quality test
• Conduct supervising visits
• Conduct advocacy to involve decision-makers to improve sanitation and hygiene promotion
• Raising awareness of communities
• Conduct different campaigns (usage of safe water, latrine, hand washing, food safety and vector control)

Sudan National Sanitation and Hygiene Strategic Framework (SNSHSF) (final draft)

The SNSHSF includes a strategic objective on water safety:

1. To improve water safety across Sudan through the protection of sources, water surveillance and treatment and capacity building.

The related strategies include:

Enabling environment:

1. Develop water safety plans at State, Locality, community, water point and household levels (handling, storage, transportation and treatment).

Supply:

2. More attention to be put into the protection of water resources - such as through borehole design, water storage and distribution systems through fencing, improving drainage and separation of water points for animals and humans.
3. Strengthen water surveillance systems, including using sanitary inspections, water quality testing, monitoring and record keeping; and including survey and monitoring at household levels.
4. Support the use of water treatment including chlorination with appropriate pre-treatment and point of use water treatment systems.
5. Undertake capacity building of water surveillance staff at Locality and community levels (water committees, operators).

National School Health Strategy, 2016-20, Draft

This mentions safe water briefly in three strategies (p30):

• Establish/improve water supply in all schools (at least installation of handpumps)
• Safe reservation of water & promote a community based chlorination system
• Improve source of water in health facilities in catchment areas

The mentions are very brief. More emphasis should be placed on ensuring water safety in future strategies. For example, focussing on water source and supply protection, sanitary inspections, training of teachers and pupils on how to safely handle drinking water and what mechanism is going to be used for access to cups for taking the drinking water.
Multi-year Humanitarian Strategy, 2017-19

This strategy has outcomes related to affected populations (affected by natural or man-made disasters, displaced populations, refugees, returnees and host communities) receiving assistance and basic services; and that vulnerable populations have improved nutrition status and increased resilience. It emphasises linking to development programming and establishing durable solutions and contributing to peace building and social cohesion. It also emphasises the importance of the cross-cutting issues protection, accountability, gender and age-sensitive programming, the consideration of climate change and the protection of the environment.

For extracts of the above policies and strategies - refer to Annex III. For information on enforcement/activation of laws – see Section 4.6.6.

6.1.4 Guidelines

Analysis of the existing guidelines in Sudan which have been identified as part of four categories can be found in a separate report identifying recommendations for updating the WASH sector guidelines (Dec 2017). The four categories are:

- A – DWSU set of 14 ‘Technical Guidelines and Manuals’ (supported by UNICEF)
- B – WASH sector emergency guidelines (new guidelines supported by UNICEF/REDR)
- C – FMoH supported chlorination and water safety guidelines (supported by FMoH, WHO, GAVI etc)
- D – MoE and FMoH – National Guidelines for Implementation of an Effective School Health Programme, 2013-16 (Draft)

6.2 Stakeholder responsibilities

6.2.1 Challenges related to stakeholder responsibilities

Challenges raised and observed in relation to stakeholder roles and responsibilities:

1. The institutions with responsibilities in relation to DWS cut across Ministries and sectoral areas – for example, Water, Health, Environment, Agriculture, Industry, Education and there has been some confusion over the division of responsibilities both vertical and horizontal.

2. In some areas the division of roles seems to be working better than others. For example, the Khartoum State MoH and Khartoum Locality both provided documentation of monitoring of water quality and the SWC also reported that the MoH reports to them when problems have been found to have occurred to ask for remedial action.

3. There seems to be a lack of consistency in understanding of roles and responsibilities for some elements. The AWD has highlighted gaps, with institutions saying they are not responsible for specific issues and they are other’s responsibilities. For example:
   a. Who is responsible for the maintenance and report of Slow Sand Filters?
   b. Some institutions have been stepping in to provide support in areas that are not their usual areas of responsibilities, such as the FMoH providing or fixing on-line chlorination equipment to SWCs (in Gezira, White Nile and Red Sea)?
   c. It is not clear who should be responsible for household chlorination during the AWD outbreak?
   d. The WES teams only became involved in the AWD response at a later stage.

4. It does not appear to be clear who is responsible for enforcement/activation of laws:
   a. Different people provided different responses as to who is responsible for enforcement/activation of laws and whether this enforcement/activation of laws is legally supported.
Examples of institutions mentioned included: the Locality, the State MoH, the MoWRIE GW&WD, the SWC and the SSMO.

5. If the Locality is the main institution that is responsible to enforce, then the limitations in their ability to test a number of water quality parameters, leads to a weakness in the system of being able to enforce.

6. Communities are not involved much in the dialogue on water safety.

7. In White Nile State it was noted that since 1995 the responsibilities have been handed down from States to Localities to community committees. The SWC is taking control of some damaged systems, but for good systems there has been some fighting / conflicts over them.

8. There is limited coordination and collaboration between Development Partners, including in critical areas such as support for improving O&M where significant changes are needed.

6.2.2 Coordination for DWS

Coordination:

The following table identifies the coordination bodies that have a role in DWS.

**Table 6 - Coordination bodies with a role in DWS**

<table>
<thead>
<tr>
<th></th>
<th>Name</th>
<th>Purpose</th>
<th>Chair / Coordinator</th>
<th>Members</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>National committee on drinking water safety</td>
<td>Main focus is currently on AWD</td>
<td>Chaired by Under Secretary of FMoH</td>
<td>Vice President of Sudan and FMoH, SWC DGs, Health DGs, Social Affairs DGs, Education DGs, FMoH and MoWRIE</td>
</tr>
<tr>
<td>2</td>
<td>National Sanitation and Hygiene Committee</td>
<td>Coordination / oversight on sanitation and hygiene across Sudan</td>
<td>Chaired by FMoH / Deputy MoWRIE, DWSU</td>
<td>Members across sectors, government ministries, universities and the private sector</td>
</tr>
<tr>
<td>3</td>
<td>WASH Sector coordination mechanism (humanitarian)</td>
<td>To coordinate humanitarian response.</td>
<td>Coordinators DWSU and UNICEF</td>
<td>All humanitarian actors</td>
</tr>
<tr>
<td></td>
<td></td>
<td>There used to be a Hygiene and Sanitation TWG, but this is no longer functional</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>SSMO Task Committee on Drinking Water</td>
<td>Setting and updating standards and discussing other related drinking water issues.</td>
<td>Secretariat is the SSMO</td>
<td>SSMO, FMoH, WHO, University of Khartoum Faculty of Public and Environmental Health and The Higher Council of Environment and Natural Resources. Currently from the FMoH, the Head of the Sanitation Unit and an EHA team member are members. The DWS team in the FMoH, the lead for DWS in the MoWRIE/DWSU, the laboratory team in the MoWRIE/GWD are not currently members.</td>
</tr>
<tr>
<td>5</td>
<td>National AWD Committee Task Force</td>
<td>To coordinate the AWD response</td>
<td>Chaired by the Minister for Federal System</td>
<td>Ministries, State, Governors of Localities, All stakeholders (except CSOs and communities) – Women’s Union, National Youth Union and Red Crescent are members.</td>
</tr>
<tr>
<td>---</td>
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</tr>
<tr>
<td>6</td>
<td>Refugee Consultation Forum (RCF), WASH Technical Advisory Group (TAG) and Refugee Working Groups at field level</td>
<td>RCF - To coordinate refugee responses including WASH services TAGs – To conduct strategic sectoral planning for all phases of the response with implementing and operational partners</td>
<td>UNHCR and the Commission for Refugees (COR) Co-chair the RCF. Some line Ministries co-chair the TAGs</td>
<td>UNHCR, COR, line ministries and development partners.</td>
</tr>
</tbody>
</table>

**Gaps related to coordination:**

Gaps were also identified in relation to coordination. These are highlighted by the following examples:

1. The number of overlapping databases and MIS systems in existence and being developed (see Section 6.4.5)

2. It is not clear who is responsible for monitoring, certification and enforcement/activation of laws in relation to the bottled water industry. For example the MoWRIE heads its own committee consisting of only the MoWRIE and a citizens group and involves the DWST in testing water; the FMoH and WHO have done a study on bottled water companies (2017); the Control of Drinking Water Regulations mentions a key role for ‘the competent health authority’; and the SSMO notes that it is mandated by the President and can close down any bottled water factory that is not meeting its standards and engages its Factories Inspectorate to undertake the visits to monitor the factories (see Section 4.7.1). There is currently no coordination between these institutions in relation to this oversight role.

**6.2.3 Stakeholder responsibilities**

It is not clear how active the following Councils are but they all have legal responsibilities related to DWS:

- **National Council for Water Resources** – For drawing up the policy for water resources, protecting streams and water from pollution in collaboration with others and laying the foundations for the establishment of drinking water and regulating deep and shallow wells.

- **Supreme Council for the Environment and Natural Resources** - The most important of its functions is the preservation of different water resources, its right to set up an inventory of natural resources, the protection of natural resources from pollution and and that it can require environmental impact studies.

- **National Council for Environmental Health** - The most important function is to follow the implementation of any law related to human health and propose the laws projects which are needed to issued according to scientific improvement.

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• **National Council for Civil Defense** - In the event of any disaster, the Minister of the Interior may temporarily seize the water resources and assign those who manage them to the manner in which they are determined.

See **Fig 13** which provides a simplified overview of the split of responsibilities into three key categories:

- **Environmental protection of water resources:**
  - Lead Ministry - MoENRPD

- **Control of water resources and supply of safe drinking water:**
  - Lead Ministry – MoWRIE

- **Surveillance of safe drinking water and enforcement and sanitation and hygiene promotion:**
  - Lead Ministry – FMoH

The overall coordination for the WASH sector is by the MoWRIE/DWSU.

### 6.2.4 The private sector and DWS in Sudan

**Roles of the private sector in Sudan**

The private sector already undertakes a range of roles that impact on DWS in Sudan. These include:

- Provision of water supply equipment – such as pumps, pipes, taps, water storage tanks, water treatment plants, paints/sealants and associated equipment and materials
- Construction personnel – providing services to construct and maintain water supply systems at city, town, village and household levels
- Provision of bottled drinking water and ice
- Small-scale private water sellers including donkey carts
- Small-scale ice sellers
- Provision of water supplies through tankering in humanitarian contexts
- Sales of household water treatment products, water containers, jerry cans, soap
- Supply of water treatment chemicals
- Supply of water quality testing equipment and consumables
- Water quality testing services
- Repair of water quality testing equipment
- Consultancy for water safety related studies
- Private training institutions providing training related to DWS
- The media and public-private partnerships for the promotion of household-water treatment products and processes and household water hygiene

**Challenges faced in relation to the private sector relevant to water safety**

These include:

**Registration and competence of the private sector:**

- Some private operators start up businesses without knowledge of how to run a business or without technical experience of the area they are operating in
- Without adequate regulation and penalties, the quality of services provided may not be adequate to ensure water safety
- A registration process for the private sector is reported to exist in the MoWRIE but it isn’t fully utilised and the private sector may not be aware of the process (The Ministry of Commerce has a system of registration of all private sector institutions)
- Water sold on the road – users can’t be sure they have not been refilled
- People drilling without supervision or permission
Some private companies are only with a bag on their shoulder

**Policies, laws, standards, guidelines, enforcement, coordination etc:**

- There is an absence of standards / specifications for materials and equipment including for water treatment chemicals – so anyone can buy them from the local market including government, but these could result in poisonous materials being put into the drinking water.
- Poor quality equipment – it breaks down within few years / cheap products from China etc
- Each person they meet tells a different story about policy and strategy and there are different laws and regulations at Federal and State levels
- There is poor coordination between the Government and the private sector
- There are no unified standards – consultancies use international standards. Most private sector organizations which attended the national workshop (except for one) did not note any specific law or regulation that they follow, which could indicate lack of knowledge / awareness within private sector
- Weak enforcement against those who disobey
- There are few public-private partnerships

**Money and customs related:**

- They do not have access to hard currency so they have to use the black market to be able to purchase items from outside of Sudan
- There is limited flexibility in contracts for fluctuations in exchange rate when the costs of the work increases
- Sanctions have proven challenging particularly related to the high costs for American products (although as the sanctions have now been lifted this will hopefully improve)
- They face multiple problems with importation:
  - Customs delays which can also lead to chemicals expiring
  - Lack of trust (sometimes the customs do not understand what the water quality testing kits are for and are concerned they are explosive devices)
  - The importation taxes are too high
  - Different laboratories used as part of the importation process have different parameters
  - Staff involved in importation are not qualified / knowledgeable on all areas
- Delays in payments from government for government contracts

**Capacity building:**

Some private sector organizations have had some capacity building – such as on water quality testing. Participants from the private sector suggested that trainings could also extend to private sector (even if pay some fees) or they asked if the government could share training protocols with the private sector? Training is provided in some project tenders.

**Suggested areas for capacity building for the private sector include:**

- O&M of desalination plants
- Standards and specifications for equipment and chemicals
- DWQ testing
- Water treatment
- Water management
- Establish water manual
- Sustainability
- Customer service staff about chemicals and equipment

Issues related to the current processes for the regulation of bottled water have been discussed in Section 4.7.1.
6.3 Financing SDW

6.3.1 Global estimates for SDW to meet the SDGs

Global estimates of costs for DWS for Sudan

The following graphs published by the World Bank (Hutton and Varughese, 2016) provide an estimate of the annual costs of meeting the SDGs for water supply – both:

- Basic drinking water (JMP ‘improved water’ but within 30 minutes of the home round trip)
- Safely managed water supply (on-plot, continuous and safe water supply)

The first graph provides a breakdown by urban and rural and also the annual capital cost (CapEx), capital maintenance costs (CapManEx) and operations costs (OpEx). The second graph provides estimates of the percentage of Gross Domestic Product (GDP) that will be required annually to meet the SDG targets for basic and safe drinking water as well as sanitation and hygiene.

Fig 20 - Estimates of the annual cost breakdown for meeting the SDGs for drinking water

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35 Hutton, G and Varughese, M (2016) The Costs of Meeting the 2030 Sustainable Development Goal Targets on Drinking Water, Sanitation and Hygiene - Data catalogue entries for Sudan, World Bank
6.3.2 Challenges for financing of SDW

There is a lack of budget allocated (by Government, development partners, the private sector and other stakeholders) specifically to DWS more generally and also for the implementation of WSPs and money is more likely to be allocated for infrastructure but not for surveillance. The lack of finances, staff and limited logistics impacts on: inadequate volumes of chemicals; WTPs supplying much larger populations than they were designed for; old pipes are not being replaced or repaired effectively – only temporary repairs are undertaken; staff are not able to reach many water sources and supplies to check for contamination as it is difficult to get to Localities, private sector suppliers and communities to provide supportive supervision.

There is also a particular risk that SWCs omit the chlorination stage of the water treatment process because the chemicals are so expensive. All of these impact on the safety of drinking water and the health and ultimately the development of the nation.

6.3.3 Real costs of supplying drinking water including costs for maintenance

In the Urban Water for Darfur (UW4D) study in the 4 State capitals\textsuperscript{37}, the expenditure from 2016 was split: a) salaries and allowances (42% of the total); b) O&M (45%); and c) finance and depreciation (13%). At the moment only 9% of the O&M budget goes on maintenance and repairs of infrastructure. But the Urban Water Authorities (UWAs) acknowledge that they do not have a clear understanding of the real costs of O&M of their water services. Hence preventative maintenance is not carried out, only maintenance on a reactive basis subject to available funds or ad hoc requests to Government for funds.

The Key Performance Indicators (KPIs) report for the UW4D Project for the period Jan–March 2017\textsuperscript{38}, indicates that in the 4 towns under the project that the cost recovery ratio varies from 45% to 66% for three of the towns (Nyala, El-Fasher and Zalengei) to 95% for Geneina.

The Strategic Investment Programme for Port Sudan\textsuperscript{39} notes: “The Red Sea State Water Corporation operates at a loss. It is an unsustainable financial burden on the State budget, relying on a State grant for annual emergency works. Annual losses in 2012 & 2013 were about 7-8 million SDG (equivalent to US$1.2m). Losses

\textsuperscript{36} Hutton, G and Varughese, M (2016) The Costs of Meeting the 2030 Sustainable Development Goal Targets on Drinking Water, Sanitation and Hygiene - Data catalogue entries for Sudan, World Bank
\textsuperscript{37} No author (2017) Tariff Study – Volume IV, Key Findings, North Darfur State
\textsuperscript{38} Urban Water Administration Offices (2017) Key Performance Indicators (KPIs), Quarterly Report [Jan – Mar 2017], UWAs, 4 State Capitals in Greater Darfur – El Fasher, Zalengei, Geneina and Nyala
would be higher if the required operating and maintenance costs were included. Revenue from water sales is unable to cover even the costs of salaries. Tariffs do not reflect the real cost of provision of services. The flat rate tariff per month does not relate to actual consumption of water which encourages wasteful practices. Tariffs and revenue would need to be 90% higher for RSSWC to break even, and probably 150% higher to cover adequate maintenance. As the size and hence asset value of the network increases with any future infrastructure provision, the maintenance cost must also increase”.

It is also reported that in some States the drinking water tariff does not go directly to the SWC, but is paid directly to the Ministry of Finance and National Economy. In some cases this is when the payments for water and electricity have been combined into one payment (for example in River Nile, Gezira, Sennar and Kassala). It is reported that in some States that only a small proportion of the fee is paid back to the SWC which means it has even less money to cover its staff, O&M, replacement and overhead costs. River Nile State is understood to be an exception where over 85% of the tariff is paid back to the SWC.

**Tariffs and their impact on the poorest**

The charges that are made for drinking water are very low. In Khartoum this ranges from 30, 50 or 80 SDG per month, which is a very low charge whether you use a small or large volume of water.

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**Provisional tariffs low disproportionately disadvantages lower income communities**

Provisional findings from a study of the tariffs and costs to households in four State capitals in Darfur has been established that it is the households which are not connected to the network or have less regularity in service who pay significantly more for their water by using water vendors to supplement supply. For example from the Water Market Survey in El Fasher, peri-urban households spend SDG 245 per month for water, urban households SDG 229 and IDP 119 per month, but the charges for connection to a pipe varies from SDG 30 to 40 per month.

The Strategic Investment Programme for Port Sudan, also comes to the same conclusion. It notes that “the majority of households... and especially the poorest households in the marginal areas of the city, have to buy water from privately owned water tankers and donkey cart vendors. The cost of buying water from vendors is 10 to 25 times more expensive than from the public water supply network. The average price to households buying vendor water in jerry cans is SDG 50 per m³ (US$ 8.40) rising to as high as SDG 125 per m³ (US$ 20) in the dry season (June-September). The poorest residents in Port Sudan therefore pay significantly more than the wealthiest. On average, poorer residents spend up to 20% of their income on water, reducing their ability to pay for food, education, and health. The annual average cost is equivalent to US$ 12.5 per m³, compared with the piped network of US$ 0.67 per m³.

Part of the challenge for water tariffs are that the politicians will not permit an increase in tariff. But the findings of the two examples above indicate that setting the tariffs too low, means that the cost of maintenance is not effectively covered, piped networks are not expanded and that this tends to most disadvantage the lower income communities.

As houses and other premises are not metered there is no charge against the amount of water used. In addition several households may also connect through one bill paying household, hence reducing the income for the SWC.

**Prioritisation of finances for DWS**

DWS has generally been given a low priority by most actors and when it is integrated into broader budgets it tends to get lost and teams working specifically on DWS in the MoH tend to be small. It has had some increased attention because of AWD with some Ministry of Finance funds allocated, but still not as high as it needs to be and this is not expected to continue after the AWD outbreak is over. The main priority seems to

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40 No author (2017) *Tariff Study – Volume IV, Key Findings, North Darfur State*
be on the quantity of water (which is also important), but the quality of the water does not seem to have been of such a concern to those supporting water supply. One stakeholder noted that most of the Health Sector and WASH Sector’s funds are used for humanitarian purposes (however figures for the split between humanitarian and longer term were not seen to confirm this); and the Health sector as a whole only gets 2% of GDP when it should be 6-12%. WHO and UNICEF provide some funds for this area but most is targeted for specific projects / activities.

As examples of the limitation in funding allocated for water safety in the joint plan of WHO and the MoH:

- WASH has only a very small budget from WHO
- USD 1.5 million is allocated for health for development purposes, but only USD 50,000 for a two year period is allocated for DWS
- Less than USD 15 million is allocated for emergency projects, of which water quality and vector control is allocated 7%
- There is a USD 1 million budget for AWD – 7% or USD 70,000 is allocated for water quality

### 6.4 Planning, monitoring, research and learning

#### 6.4.1 Humanitarian and refugee response plans

**Humanitarian Response Plan, 2017**

Includes several references to DWS:

- For continued access to sufficient quantity and quality of water, special emphasis will be placed on water resource management, water safety and sanitary risk control. For all interventions in 2017, the sector will deliver a comprehensive package which encompasses improved access to SDW, sanitation and hygiene services.

- WASH partners will continue to address long-term WASH priorities including quality assurance and functionality of WASH facilities, generation of evidence, development of water supply business plans and cash-based market interventions, integrated water resources management as well as sanitary and disaster risk mitigation.

- National authorities and communities will continue to be key actors in the O&M of WASH facilities and sanitary risk management (safe water handling, end of open defecation, handwashing and water source protection).

- In 2017, the sector will continue to develop the capacity of WASH partners and affected people to ensure they ultimately manage WASH infrastructures and integrated services. Concrete examples include capacity building of national authorities and communities for O&M of WASH facilities to carry out sanitary risk mitigation activities and environmental awareness.

- The WASH Sector will develop its programme and implement its activities at national, state and local levels. In year one, WASH will develop a 3-year strategy and annual plans and it will address the issue of water quality, enhance community-based O&M and improve the situation in substandard camps.

- To address and prevent malnutrition and communicable diseases such as acute watery diarrhoea, the WASH Sector will work with the Health Sector to ensure that vulnerable people have sufficient clean drinking water and encourage latrine use and hand-washing.

- To reduce its environmental footprint and better manage scarce water resources, the WASH Sector will move away from using fossil fuel and encourage solar water pumping, it will also protect water source protection, monitor water levels, minimize wastewater and adopt preventive methods for vector control to reduce the use of chemicals.
This mentions aspects related to water safety briefly:

- The response will continue to improve safe water supply access, with emphasis on water quality monitoring and maintenance, and the provision of WASH-related core items to all refugee households.
- The provision of basic sanitation services at all refugee sites will be ensured, including improvements in the provision of wastewater disposal, solid waste and sludge collection and refuse disposal. Intensified hygiene promotion at refugee sites will also be pursued, including hand washing and latrine usage, safe water handling and storage and water conservation, with special attention paid to the hygiene needs of children at risk of malnutrition.

### 6.4.2 Water safety plans (WSP) and monitoring of plans

WSPs are currently not being done. A few examples have been identified where they have been tried:

1. It is reported that UNICEF has supported WSPs to be done in Kassala in 4 villages and in the Kordofan States.
2. JICA supported the mapping water sources with their current status in one Locality in White Nile State during a training course. The WN SWC notes that it intends to continue the mapping process in the other Localities to develop a Water Atlas.
3. Water Point mapping with risk analysis has been undertaken in White Nile State as part of the AWD response and the cases of AWD mapped against the water points. In addition the communities that have been most affected by AWD have been mapped against the type of water source. The Draft map in Fig 20 indicates that communities that are along the White Nile with less access to boreholes or hafirs have been those most affected by the AWD.

### FMoH and MoWRIE – Water Safety Plan for AWD

The MoH and MoWRIE have prepared a document called a ‘Water Safety Plan 2017’. This plan focuses on how to ensure that all water sources are chlorinated across Sudan. It is not in reality a WSP identifying the hazards, hazardous events, risks and control mechanisms as per generally accepted practice. But it includes some recommendations for control mechanisms which will impact on improving DWS.

The specific objectives of the plan are:

1. Strengthening drinking water purification systems (chlorination)
2. Strengthening the system of supervision, follow-up and control over all stages of production, distribution and transportation of drinking water.
3. Capacity-building and training of cadres and volunteers in the field of DWS.
4. Raising awareness and sense of health among citizens to ensure the safe transfer, storage, and use of drinking water.

The activities include those focussing on: evaluating the water treatment systems at existing stations, training staff and volunteers on field inspection and chlorination, providing chlorine and water quality testing equipment, training the Women’s Union and Red Crescent in health promotion and use of radio and television in the states.
Recent training has also been undertaken on WSPs (see Section 6.5.4 for more details):

1. By UNICEF – in the four Kordofan States
2. By REDR / WHO – in five Darfur States
3. By REDR / WHO – at Federal level with participants from across States

One of the new guidelines for WASH in emergencies also focuses specifically on WSPs.

It has not yet been established if there are any components of WSPs being undertaken by the SWCs, for example any mapping of the distribution networks with plans for maintenance to reduce pollution risks. It is understood that in some SWCs monitoring only tends to happen if a problem is reported.
In the UW4D project a process has been undertaken to map the network which is one step in the process towards undertaking WSPs and there are plans to also undertake WSPs with a particular focus on the collection process and transfer to and use in the home.

6.4.3 Sanitary inspection

Sanitary inspection formats have been integrated into the FMoH Manual on DWQ and Safety, 2016, and they are also included in the new WASH in emergencies guidelines on water source selection. It is not clear as of yet how widely they are being used, or if the findings are being responded to.

An example of a Water Quality and Safety report by the State MoH Environmental Health Section in South Darfur highlights the percentage of sources contaminated and sanitary inspection scores (low, medium and high risk). The same reports also indicate how many of the wells have been chlorinated and whether training on chlorination has been given.

6.4.4 DWS – documentation and reporting

Water quality analysis is being undertaken to some degree at different levels and by different institutions. A range of record keeping has also been observed. Key observations included:

- There are a range of different forms that are being used for the recording of DWS related issues – which is positive, although it was not clear that they have been standardised across States and Localities
- Certificates to confirm that water is acceptable for drinking (including in relation to bottled water) were seen issued by a SWC Central Lab and the National Public Health laboratory.
- The FMoH is collecting data which is being fed up from Locality to State to Federal levels – this includes water quality data and availability of equipment
- Frequency of reporting through the MoH system:
  - Usually reporting is monthly
  - During the AWD response:
    - Reporting has been daily
    - Meetings have been held on a weekly basis
    - Feedback is given for immediate corrections – video conferencing is used to communicate with State levels
- The MoWRIE collects data from State level WES teams mainly on water related activities such as construction or rehabilitation and water treatment chemical supplies
- Reports from the Khartoum State MoH to the Khartoum State SWC were also seen and both parties confirmed that the DWQ monitoring results are provided identifying issues when they arise:
  - During the normal times it was noted that the MoH would take 1 result per week and the Localities would take 2 per week before the distribution stage.
  - They also would investigate and do sampling if complaints occur such as diarrhoea.
- An example of good practice is the quarterly KPIs that have been established as part of the UW4D project. See the box below. It would be positive to add one more KPI to this list on DWS.
Quarterly Key Performance Indicators (KPI) reports

KPI reports are being produced quarterly under the Urban Water for Darfur Project (UW4D). These encourage tracking of progress against a set of key indicators, which include:

- KPI-1: Water Production
- KPI-2: Energy utilisation
- KPI-3: Water availability
- KPI-4: Leakage management
- KPI-5: Customer database
- KPI-6: Customer complaints management
- KPI-7: Nonrevenue water
- KPI-8: Revenue collection
- KPI-9: Unit operational cost
- KPI-10: Cost recovery

Some examples were seen where records were not kept on site – for example in Zamzam IDP camp. The MoH representatives had personal notebooks and filled in sheets were viewed at State level. The WES team reported some data to the State level. Having log books on site would be positive to keep a track on the checks over time and also how particular problems have been responded to.

WES record sheets from South Darfur include monitoring results on water sources, supplies and recommendations for action.

Log books were seen in laboratories attached to WTPs and the White Nile laboratory also had WQ data in a computer.

A few errors were seen on sheets (use of Total coliform; mg/l next to pH) although most seemed OK.

The Alagaya refugee camp WTP used record sheets for both water quality results, fuel used and also maintenance checks. The maintenance check one was not fully clear as to what the ticks meant but the principle of having such a sheet is very positive.

In two locations records were seen of tests being undertaken along the water supply chain to the household, but this does not seem to be a common occurrence in all locations. One positive example of this happening was in relation to the supplies in the White Nile refugee camps – with data shared by WHO; the other was MoH record keeping sheets in North Darfur related to the IDP camps. These sheets provided evidence of checking free residual chlorine (that was zero) as well as the hygiene of the toilets and the condition of the jerry cans.

An attempt was also seen of mapping water quality with AWD cases, by WHO and partners in the White Nile. No pattern was apparent but this is still a worthwhile exercise if the data is available as it can be used to help target priority actions. Also see the map produced by UNICEF in Fig 20.

Some data was also collected for AWD activities including some comments on the distribution of chlorine tablets.

With record keeping and recording water quality data there is always a risk that the person reporting may just write what they know is an acceptable level – care will be needed in training and supervision to raise awareness that this is not acceptable and that accuracy to the real situation is what is required.

For more details of the documentation currently being used in relation to water safety – see Annex IV.

For more details of the water quality analysis capacities and gaps in Sudan see Section V.
6.4.5 Databases

There are a range of organizations holding and supporting databases and M&E systems that cover some elements of DWQ. See Table 23 in Annex IV. There is a significant risk of duplication and overlap between the different databases. For example the same water sources may be included in the databases established by the MoWRIE/DWSU, the MoWRIE/GWD and the FMoH with support from: UNEP, UNICEF and WHO and those held by the SWCs. The databases used by the DWST lab and the GWD laboratory at national level (which is ACCESS based) are not linked to the main MoWRIE GWD water sources database. The reason given for this is that there is a need for GPS data for any water quality data to be entered into the main GWD database (which the lab data does not consistently have). There is a need for all of these organizations to sit together to look at the content of the databases each are supporting, their purposes and users, and to discuss and agree if there is a need to consolidate any of the databases (such as to have a consolidated water source database at State levels), or they should remain separate. Consolidation would pose significant challenges as it would require close collaboration between the Ministries as well as the Development Partners and an agreement on who would be responsible for the funding, design and management of the database. Collaboration takes time, the various funding channels and mechanisms may be challenging to align and each Ministry and State level institution will have its own reasons for wanting to manage the database as they may use the data for different purposes and have different data collection systems. Therefore a decision may be made to keep them separate and overlapping.

In terms of the existing databases, the MoWRIE/GWD database has the most comprehensive range of water quality parameters indicated. The FMoH spreadsheet based database that was established with support of WHO when a water source and water quality mapping was undertaken in 7 States in 2014, seems the most useful for DWS as it is in a simple spreadsheet format and includes a column for a sanitary survey score and priorities for action as well as key details of the water points and water quality. This mapping has also been supported by WHO in East Darfur in 6 of 9 localities in 2016/17. The Water Atlas as described in White Nile has not yet been viewed, but is understood to include maintenance status. The MoWRIE/DWSU/WES database that is currently not functional, but where there are plans for updating, has some information on water quality and on the water point but it was mainly used on a project basis. Some questions have been raised about the accuracy of the data included on some of the databases relating to specific water sources.

6.4.6 National and targeted surveys

Some data related to the type of water source and the type of HWTS used by households who use unimproved sources is already included in the last MICS, but there is an intention to strengthen this in the next MICS. Also UNICEF is planning to support a mapping of school WASH in 2017, which will also include DWS.

6.4.7 Research and learning

There has been some research by the University of Gezira on water quality along the water source chain from the Blue Nile to the household, undertaken in collaboration with the Gezira State and universities in Kenya and South Africa; and the University of Gezira has also undertaken research into WSPs in Darfur.

JICA has been supporting the establishment of websites for the DWSU, DWST and SWCs which will serve as an opportunity to share information on good practices as well as enable the citizens to access information on their water services.

University students are undertaking research projects into DWS related issues. The following image shows a pilot plant that has been used at the Mogran WTP in Khartoum by a PhD student who was studying turbidity issues in the Nile water.
Examples of titles of water safety related projects that have been done by students on the Environmental Health course at the University of Khartoum include:

1. Evaluating efficiency of treatment units of Tuti treatment plant–Khartoum
2. Assessment of DWQ in Khartoum teaching hospital and Gaafer Ibn Awf specialized Children’s Hospital
3. Water from wells that connected to public water distribution system, Umbada locality
4. Evaluation of treatment efficacy of Buri plant, Khartoum locality
5. Assessment of water returned to the river from filtration and sedimentation tanks of Al-Mugran treatment plant
6. Groundwater quality of principal hospitals in Khartoum
7. Bacteriological quality of drinking water (several research projects)
8. Assessment of drinking water quality of different municipalities (several research projects)
9. The quality of water of swimming pools
10. Evaluating efficiency of Soba waste water treatment plant
11. Assessment of mixed water distribution systems (groundwater with surface water)
12. Sufficiency and storage of water in several schools (several research projects)
13. Quality of vendor-provided water (several research projects)

There are similar types of research undertaken by students in other universities, but otherwise there is generally limited availability of research, surveys and learning related to DWS.
6.5 Capacities and capacity building

6.5.1 Human resources for DWS

There are many staff working in the sector who have a Bachelor and Masters degrees, including in environmental health and water resources or engineering related disciplines.

Challenges faced in relation to human resources for water safety:

a. The teams working specifically on water safety in the MoH and at Localities tend to be small and need more training/capacity building, for example:
   a. FMoH - there are three staff
   b. Khartoum State - there is one staff member
   c. Khartoum Locality - there are two staff
   d. Kassala Rural Locality - there is one staff
   e. In the Darfur States – there tends to be one staff member at State level and one per Locality

b. The small number of staff also limits the time available to undertake DWS related activities which are also severely limited by lack of allocation of budget and vehicles.

c. Salaries also tend to be low contributing to low motivation.

d. The low status of the Environmental Health profession generally and limited opportunities for advancement also reduces the number of people who choose to work in or stay in the profession.

e. There is also a high turnover of staff trained in DWQ analysis at State and Locality levels, leading to gaps in capacities for people who take over their posts without the associated training.

f. In the universities there is a high turnover of professors in EH who are attracted to work in the Gulf States where there are much better working conditions. Likewise skilled and trained personnel working at SWC level also go to Saudi Arabia and other Gulf State countries to work.

g. In the River Nile State, it is reported that the SWC has been able to increase salaries from the water tariff, which may help to retain trained staff.

h. In Central Darfur the SWC has three sections for maintenance of the water supply systems covering – mechanical/electrical and piped systems.

The following box provides an overview of the qualifications of staff.

<table>
<thead>
<tr>
<th>Numbers and qualifications of staff in White Nile State</th>
</tr>
</thead>
<tbody>
<tr>
<td>There are 43 EH staff in White Nile State. There are three at State level and 40 at Locality level.</td>
</tr>
<tr>
<td>At State level the staff have BSc qualifications in Public Health and one has an MSc in Vector Control.</td>
</tr>
<tr>
<td>At Locality level, 10 staff have an MSc in Public/Environmental Health.</td>
</tr>
<tr>
<td>Not all have been trained. The DWS staff member at State level has had to train herself to use the field kits and the water surveillance system.</td>
</tr>
<tr>
<td>2 trainers have trained 19 people from the localities in 2014-16 – they covered: equipment, sanitary surveys, frequency of sampling, surveillance and water related diseases.</td>
</tr>
</tbody>
</table>

As examples of current activities for water quality testing see the following box.
Khartoum Locality Water Safety Team

All of the Khartoum Locality is within the water network. All houses are connected but sometimes there is not enough water so the households use donkey carts. They have over 900,000 people living in the Locality. The whole EH team consists of: technical staff working on food safety, sanitation and water. They have 41 Public Health Officers and 112 Sanitary Overseers, 20 labour workers (most old) and some temporary staff for spraying. There are two Water Safety team members and two photometers but only one turbidity meter. The whole EH team has 1 vehicle covering 15 administrative units, but the vehicle is not in good condition so they plan to rent.

The activities of the water team include:

- The team monitors each WTP twice per week in normal times – chlorine and turbidity – but daily during the emergency period
- In the network they monitor a particular target area per week – and take 10 samples for bacteria test, free residual, chlorine and turbidity
- If there are citizen’s complaints – then they take 5 samples of the same test
- During an emergency – they do disinfection of water storage and donkey carts and work in high risk areas such as markets – they also check the chlorine in the donkey carts – they have 800 donkey carts
- For AWD they also checked free residual chlorine – they went household by house and provided chlorine depending on the storage
- From 28 May to 5 July (1 week) they distributed 13,704 chlorine tablets, visited 1,142 households and did 20 samples of chlorine and turbidity

MoH Kassala - Water Safety Team

They have 11 Localities – with one person responsible for the Locality and one person in charge of water and chlorination

In the normal situation they try to visit four Localities per month covering 15-20% of the whole water resources

In one day they can do a maximum of 10 sources, but if they are far apart they can do a maximum of four sources

The Water Safety team does not have a dedicated vehicle. If they manage to get one from the MoH, they only get one for a few days and then can only have one day per vehicle.

6.5.2 Logistics

A lack of access to logistics is one of biggest issues for maintenance, monitoring and surveillance. Laboratory teams reported to not be able to respond to complaints and routine monitoring is not undertaken. Laboratory staff from the Kassala SWC Central laboratory reported to sometimes taking public transport to try and reach locations to respond to complaints. MoH staff responsible for water safety at State and Locality level reported not being able to get to many water points due to limited access to vehicles. The White Nile SWC team managing a WTP for a refugee camp reported having difficulty getting to the inlet in the White Nile (3 km away) to be able to clear away materials blocking the inlet or for repairs and also to get between camps. In White Nile some Localities have 500 or more water sources, so the Localities may focus on monitoring at the WTPs.
Examples of the number of vehicles available to the DWS teams include:

- **FMoH** – The DWS team does not have a dedicated vehicle.
- **Khartoum State MoH** – The Environmental Health team does not have any vehicles for the whole team, so has to rely on hired vehicles.
- **Kassala State MoH** – The DWS team does not have a vehicle. If they get one from the MoH they only get it for a few days and only get 1 day per locality to take samples.
- **White Nile State MoH** – The MoH has in total about 20 vehicles, approximately one per team across all departments. The EH team has one vehicle but it does not function well. There is no vehicle specifically for the DWS team so they have to plan in alignment with when a vehicle is moving for other purposes. They manage to visit one Locality weekly. The Locality staff have the same problem.
- **Khartoum State Locality** – The DWS team has one vehicle (covering 15 administrative units), but it is not fully functional so they plan to rent.
- **Kassala Rural Locality** – The team does not have any vehicles – they sometimes use the TB team’s vehicle or the Executive Manager’s vehicle. If enough money has been collected for the Locality they can sometimes rent a vehicle. During the emergency they have been able to check 3-4 water sources per day, but it should be 20 (there are 56 water yards, 10 handpumps and four hafirs in the locality), but they are restricted by not having a vehicle.
- **South Darfur** State MoH water safety section do not have vehicle. They using WHO vehicle and sometimes requesting vehicles from partners and is similar to Central Darfur.
- **East Darfur, State MoH laboratory** – Most of the time they rent a car supported by their partner, WHO, or another department from the SMoH.
- **North Darfur** – The WES laboratory have access to a vehicle, but the SMoH Water, Hygiene and Safety Coordinator does not have access to a vehicle.
- **Central Darfur SWC laboratory** – The team only uses NGO partner vehicles.

The issue of whether motorbikes could be a possible solution was discussed. If they were to be introduced then it was proposed that they could only be used by men but not women. They are also not thought to be practical as there is a need to travel with equipment and sometimes chemicals. One stakeholder suggested that bicycles may also be helpful – the example was given of the Carter Centre having supplied them to community workers for the Guinea Worm eradication programme.

### 6.5.3 Analytical capacities – laboratories / field equipment

**Laboratories and teams with DWQ equipment:**

There are a wide range of laboratories and institutions operating in Sudan which undertake DWQ testing and a wide variation of capacities and access to laboratory facilities and equipment. For example:

- **Government laboratories at Federal level:**
  - National Public Health Laboratory of the FMoH (previously known as STAC) – which is the main reference laboratory for the whole of Sudan
  - MoWRIE, Groundwater and Wadi’s Directorate laboratory
  - MoWRIE laboratory at Federal level for the electricity distribution companies
  - National Environmental Research Council (NERC)
  - Sudan Standards and Metrology Organization (SSMO) – National
  - Sudanese Armed Forces
  - Ministry of Oil and Petroleum
  - Ministry of Minerals
• **Universities and training institutions:**
  - DWST – National and in some States (equipped by JICA)
  - Allied Health Sciences – National and in all States (may not all have own labs)
  - University of Khartoum, Bahari and AAU EH Departments (as examples)
  - College of Water Resources, Sudan, Department of Water Resources

• **State level:**
  - EH Department, State MoH
  - SWC – including Central Lab and labs at WTPs (there are GWD central labs in Kassala, South Kordofan, North Kordofan and Sennar)
  - State SSMO

• **Locality level:**
  - Water Safety team, Health Affairs Dept., Locality

• **Private sector:**
  - It is also reported that a number of private sector organizations also have laboratories with DWQ capacities

**Capacities of laboratories:**

The capacities of the laboratories vary significantly. Examples of the variations include:

- The SSMO laboratory is accredited by the International Standards Organization (ISO) through undertaking international proficiency tests. Their main laboratory is in Khartoum but that also have a large branch in the Red Sea State. Their laboratory covers food and water, but there is also a laboratory for paints (but which it is understood does not currently test for waterproof materials / paints for drinking water tanks and there are no standards in Sudan for the same). The SSMO sets the standards for DWQ (see Section 6.1.2) and it is understood it also approves licences for other laboratories in Sudan.

- The laboratories with the widest range of equipment and ability to undertaking a wider range of tests include: the FMoH National Public Health Laboratory (NPHL) and the DWST national training laboratory. But even the NPHL has gaps in the functionality of its equipment and the laboratory facilities are quite old.

- The NPHL and the SSMO laboratory have the capacity to test for pesticides and insecticides; but the NPHL would communicate with the following laboratories if other specific contaminants are found:
  - The Ministry of Oil and Gas for suspected oil related contaminants
  - The Sudan Armed Forces for suspected radiological contaminants
  - The Ministry of Minerals for other contaminants for example related to mining processes

- The MoWRIE/GWD is also starting to do isotopic analysis with support of the International Atomic Agency, but the equipment is broken down (due to power fluctuations) and needs spare parts and some work on the software. This needs support from outside of Sudan to resolve. There is a plan to combine the central MoWRIE GWD, DWST and Electricity laboratories into one laboratory.

- No laboratories in Sudan have the capacity to test Volatile Organic Compounds (VOCs), which are relevant to assessing the toxicity of paints. Also it is not clear that any water related laboratory has the capacity to test for protozoa in water, which is required as one of the Sudan DWQ standards. Medical laboratories can test protozoa but these are likely to be from stool samples.

- The SWC central laboratories visited were based in one of the State capital’s WTPs:
  - The Khartoum SWC Central laboratory based at Mogran WTP if functioning well but missing some equipment. The team are identifying algae by manual methods using a microscope and
a black and white photocopy of an algae identification book. The team would like to obtain: *An inverted microscope - fully motorised and automated (complete system) and Schedwic slide for algae counting*\(^42\) which is an automated counting devise.

- The SWC Central laboratory in Kassala has been set up in a meeting room at a relatively new WTP (2014 supported by JICA) which does not have its own water supply or sinks. But the laboratory is staffed by highly committed and competent staff who are clearly looking after the equipment that they have access to and utilising the equipment and space they have to provide an effective DWQ service.

- The central laboratory in White Nile, at the Kosti WTP, has a formal laboratory and quite a large number of laboratory staff, but less access to functional equipment. A number of items of equipment broke down several years ago and have not been repaired. The laboratory is only able to test for chlorine residual and pH using a pooltester as it has no functional photometers.

- Some WTPs have laboratories but most only have basic equipment (such as for measuring turbidity and chorine residuals) or no equipment. Where the jar test is done (such as in Burri WTP in Khartoum State) the jar test has established variations in optimal PAC dosage from 1 to 50 mg/l (the latter in the Autumn), which is quite a range.

- The capacity of the MoH laboratories visited at State level have more significant problems:
  - The MoH DWQ laboratory in Khartoum only undertakes microbiological testing of different forms. All of the equipment that it had to measure physical and chemical parameters was broken at the time of the visit and seemed to have been for some years, although some was reported to be under maintenance and later noted to now be functional. The lab also has one piece of expensive equipment, a High Performance Liquid Chromatograph (HPLC), but this has not been used since it was obtained in 2011 and is still wrapped in plastic. The lab does not have consumables and it is reported that as the consumables are so expensive they are considering to instead use it for blood testing.
  - The MoH DWQ laboratory in Kassala has a formal laboratory and some field based equipment but currently has no laboratory staff. It also has a large box of consumables for a range of parameters that can be measured with a Palintest Photometer, but does not seem to have a Palintest Photometer.
  - The WQ team of MoH in White Nile have a range of DWQ field equipment, but no laboratory, so the equipment is being kept in a metal cabinet in the team’s office.

- **Darfur States:**
  - The WES Units in the Darfur States currently have access to different resources – For example: in East Darfur they have three key items of equipment (a Spectrophotometer; a Flame Photometer; and digital burettes) but they do not yet have a laboratory space so they are not used; in North Darfur the WES team have a laboratory and five trained laboratory staff and basic physical / chemical kits as well as a microbiological kit (but this is not used).
  - In response to the humanitarian situation in Darfur, WHO supported water quality monitoring in the camps and host communities. Since 2011, it extended support to all States for the surveillance system including field kits and operational costs. In addition WHO is supporting the construction of five reference laboratories, one in each State, funded by the Qatar Fund for Development.

\(^42\) Khartoum State Water Corporation, Sudan (2017) *Requirements for Water Testing Analytical Laboratory Equipment*
• At locality level:
  o In Khartoum State, there are two staff in the Water Safety team and they have two Photometers which they use for chlorine residual, but only one turbidity meter. For microbiological testing they collect bottles of media from the MoH Central lab and send samples to this lab for testing.
  o In Kassala Rural Locality the Health Affairs Department has one staff member working on Water Safety. He took over from someone who had previously been trained on DWQ analysis including microbiological testing, but who had left the post. The team have an older design Wagtech Potatest and associated items but they are not used and not kept in a good condition. Testing is undertaken using a Pooltester only, mainly for chlorine residual.

• The Alagaya refugee camp WTP in White Nile, now being managed by the SWC, has a Wagtech Potatest and a Palintest Photometer. They do not appear to be using the Potatest for microbiological testing. The MoH are undertaking monitoring of the water supply.

• For the training institutions:
  o Out of the three Universities met as part of the process to establish the context, Khartoum University, Bahari University and AAU – only Khartoum University has its own departmental laboratory, although AAH can access a laboratory shared across multiple departments and Bahari has some items of field equipment but no laboratory. The University of Khartoum laboratory and equipment is good quality and is clearly very well looked after but they only have limited numbers of items, for example, only 2 turbidity meters; so they can only usually provide demonstrations for the students (in groups of 40).
  o For Bahari, AAU and the Academy of Health Sciences – they mostly rely on sending their students to other laboratories run by the MoH, SWC at WTPs, the SSMO and NERC. But as some of these laboratories also have limitations in equipment and consumables, this will also limit the student’s learning experience.
  o There are a range of other universities that cover DWS across Sudan, which may or may not have laboratory capacities. For example in Gezira, the Blue Nile Institute for Communicable Diseases; and in Northern State the University of Dongola.
  o It is also reported that some of the SWC DWSTs not visited also have laboratories.

• The only location where we were able to see some H₂S bottles, was the White Nile MoH, who just had a few bottles.

• A variety of tests are undertaken for microbiological analysis, including:
  o The multiple tube fermentation (of most probable number, MPN) technique + confirmatory tests (using MacConkeys, Brilliant Green and Lactose broths)
  o The membrane filtration method (using Membrane Laurel Sulphate Broth, MLSB) – but this was found to be less common and even where the Wagtech Potatest kits existed only one seen across institutions appeared to currently be in use. The cost of the consumables appeared to be an issue in some of the more established laboratories.

In terms of numbers of equipment:
See the Table 7 for an overview of the equipment available, needed, functional and non-functional in Kassala State.
### Table 7 - Example of WQ test equipment available at locality level – Kassala State – 12 localities

<table>
<thead>
<tr>
<th></th>
<th>TDS test</th>
<th>Turbidity test</th>
<th>Chlorine test</th>
<th>Chemical test</th>
<th>Bacteriological test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Needed</td>
<td>Existing</td>
<td>Needed</td>
<td>Existing</td>
<td>Needed</td>
</tr>
<tr>
<td>Functional</td>
<td>9</td>
<td>4</td>
<td>11</td>
<td>4</td>
<td>40</td>
</tr>
<tr>
<td>Broken</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
</tbody>
</table>

Other examples:

- There are 188 Localities in Sudan. The FMoH supported by WHO provided 190 Pooltesters, 83 Palintest Potatest kits and 75 pH/conductivity meters were distributed to State and Locality levels (although not all are functioning). Last rainy season also 75 PrimeLab photometers and 75 turbidity meters were also distributed.
- The Kordofan States were given 600 Pooltesters as part of the AWD response by UNICEF.
- The Khartoum MoH noted that each of the Localities have five or six Pooltesters and one or two Photometers

For more detailed notes on key equipment (both functional and non-functional) and observations of and challenges faced by the laboratories see Annex V.

**Functionality and repair of equipment:**

Some laboratories are managing to keep their equipment in good order (such as the University of Khartoum, the national DWST and the Kassala SWC Central laboratory), but others have many items that are not functioning (such as the Khartoum MoH Central and Kassala SWC central labs).

Even the NPHL noted that they currently had a non-functional Atomic Absorption Spectrometer with a broken lamp (but is now repaired). The NPHL laboratory also noted that they would like to train up a number of biomedical engineers / technicians to be able to repair laboratory equipment and establish a repair workshop, so that all laboratories would be able to access it. The MoWRIE noted however that there is already a department in the University of Khartoum that already has the capacity to repair equipment and this is where they take their broken equipment for repair, so the option would need some investigating.

A recommendation was also made that it would be helpful if engineers/technicians could be sent to the appropriate country to learn how to repair the Wagtech and Palintest equipment so that they can then repair it in country rather than it needing to be sent outside. There is a supplier for the Wagtech / Palintest equipment in Khartoum, who can arrange for repair. The consultant also had the opportunity to meet with the Palintest team in the UK (who have taken over the old Wagtech equipment models) and they noted that such a discussion had already started and they would be open to sending trainers to Sudan to perform such training in country.

In relation to repair, other challenges include:

- There are a wide range of items of DWQ testing equipment. It is more difficult to have engineers / technicians to repair such a wide range. This particularly relates to the equipment in the SWC laboratories, but also some MoH laboratories. The model adopted for supply of one make to the MoH at State level and Locality level, is a sensible strategy, considering both training and maintenance and repair.
- Some of the equipment, for example, made by HACH, is particularly expensive and difficult to repair as it is a USA company and hence affected by the sanctions (as the sanctions have now been lifted this will hopefully improve this situation).

**Access to consumables:**

- Some consumables, such as DPD1 tablets, can be purchased in the local market and from private companies - but not all are functional (i.e. tablets that do not work correctly in the Pooltesters)
• The MoH laboratories can get their consumables from the Medical Central Supplies
• Some consumables come from outside, such as for some of the HACH kits, which have to be purchased through an interim country as they come from the USA

**Summary of challenges as expressed by the laboratories and staff with field kits:**

1. Old laboratories and equipment – need for updating
2. Some state MoH have no laboratory and some WTPs have very limited if any equipment
3. The MoWRIE GWD laboratory has no administrative link to the labs at State level and can only provide administrative support
4. There is no coordination between laboratories and no central database
5. Broken equipment that is not repaired – sometimes repair has been asked for repeatedly for years
6. There is a deficiency in maintenance skills for both field and laboratory equipment
7. Staff need training on new techniques – training tends to only be available when it is linked to a specific project
8. Some consumables have expired or do not function as expected (even new ones coming in the Pooltester kits) – this can lead to inaccurate results, such as in relation to chlorine residuals
9. Procurement time and cost for consumables and calibration fluids (which only last for a few years) – particularly those that come from outside of Sudan (for example HACH and MF consumables)
10. No vehicles to be able to go out for sampling and to respond to complaints
11. Gap for the identification of algae
12. Not enough equipment for students to practice in educational institutions
13. Turnover of staff leaving replacement staff without appropriate training

See Tables 24 and 25 in Annex V for more details of challenges.

**Issues for consideration:**

1. It is a pity that some expensive equipment, such as the HPLC in the MoH Khartoum State laboratory has remained unused for the past 6 years, when the universities and colleges do not have adequate equipment. Plus also that there are so many broken items of equipment that could be made use of if they were repaired. It would be worth discussing a strategy to reclaim some of the broken items, even if it means transferring them to an institution such as the universities to repair at their own cost, but so at least they can put them to use in training upcoming professionals.

2. Health and safety was not discussed much during the visits, but it was observed that the visiting team were rarely if ever asked to wash their hands when leaving laboratories, including microbiological laboratories, and other staff were also observed leaving the laboratories without washing their hands. This may be a small indicator of a possible gap, but an issue to be considered in the strategic framework.

3. There are some methodological issues that need review and related capacity building:
   a. An example was seen of ethanol being used instead of methanol for sterilisation of membrane filtration equipment. Ethanol is easier to procure but does not form formaldehyde on burning and hence should not be used as an alternative.
   b. It was not clear that everyone knew that Total coliform is not a faecal indicator, as it also indicates non-feecal coliform.
   c. There is concern globally about the use of the H2S tests, despite the claim by the producers of the bottles being used in Sudan. This is because they can lead to false positives which can lead to water sources being rejected, when they are in fact not contaminated with faecal contamination, but naturally occurring coliform. Hence they should be used with caution and if a positive is obtained, then this should be followed up using the MPN or FC methods to identify faecal coliform.
The photos below provide an overview of the issues noted above.

**Fig 24 - Photos of DWQ equipment used for field testing (no laboratory)**

<table>
<thead>
<tr>
<th>Description</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functional photometer and turbidity meter and chlorine tablets</td>
<td>Khartoum Locality</td>
</tr>
<tr>
<td>Broth for microbiological testing provided by MoH</td>
<td>Khartoum central lab</td>
</tr>
<tr>
<td>Pooltester – only item of equipment being used for DWQ testing</td>
<td>Kassala Rural Locality, but</td>
</tr>
<tr>
<td></td>
<td>probably the same for most</td>
</tr>
<tr>
<td></td>
<td>localities in Sudan</td>
</tr>
<tr>
<td>Palintest photometer (used) and Wagtech Potatest</td>
<td>Alagaya refugee camp</td>
</tr>
<tr>
<td>Stocks of equipment and consumables</td>
<td>White Nile MoH</td>
</tr>
<tr>
<td>Cabinet storing DWQ testing equipment – no lab</td>
<td>White Nile MoH</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Image</td>
<td>Description</td>
</tr>
<tr>
<td>-------</td>
<td>-------------</td>
</tr>
<tr>
<td><img src="image" alt="Broken AA Spectrometer" /></td>
<td>Broken AA Spectrometer (Khartoum SWC Central lab)</td>
</tr>
<tr>
<td><img src="image" alt="Example of broken equipment" /></td>
<td>Example of broken equipment (Khartoum MoH Central laboratory)</td>
</tr>
<tr>
<td><img src="image" alt="HPLC" /></td>
<td>HPLC never used since it was obtained in 2011 (Khartoum MoH Central laboratory)</td>
</tr>
<tr>
<td><img src="image" alt="Older model Wagtech Potatest" /></td>
<td>Older model Wagtech Potatest not currently used (Kassala Rural Locality)</td>
</tr>
<tr>
<td><img src="image" alt="Spectrophotometers" /></td>
<td>Spectrophotometers in a well managed laboratory – one broken and one borrowed as replacement – requests have been made for years to get the broken one repaired (White Nile SWC Central lab)</td>
</tr>
<tr>
<td><img src="image" alt="DWQ laboratory" /></td>
<td>DWQ laboratory not used as they currently do not have any lab technicians (Kassala MoH laboratory)</td>
</tr>
</tbody>
</table>

**Photo to the left:**

Spectrophotometer, Atomic Absorption Flame Photometer and Digital Burettes not being used because of current lack of laboratory space (East Darfur WES team)  
(credit: Khalid Babiker Mohammed Ahmed/WHO)
<table>
<thead>
<tr>
<th>Photos of functioning equipment / labs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Algae identification book in black and white print (Khartoum SWC Central lab)</td>
</tr>
<tr>
<td>2. Titration being undertaken by hand (Khartoum SWC Central lab at Mogran WTP)</td>
</tr>
<tr>
<td>3. Good quality DWQ laboratory (Khartoum University)</td>
</tr>
<tr>
<td>4. Two spectrophotometers – well maintained (Khartoum University)</td>
</tr>
<tr>
<td>5. Sterilising equipment and MF equipment (Kassala SWC Central laboratory)</td>
</tr>
<tr>
<td>6. Microbiological MPN test underway in incubator (Khartoum State MoH laboratory)</td>
</tr>
</tbody>
</table>
The MoWRIE is planning to consolidate its GWD laboratory, Electricity laboratory and the Khartoum SWC Central laboratory to establish one Central laboratory under the MoWRIE. UNICEF has discussed the possibility of supporting the establishment of regional laboratories. The discussion / plan has not been finalised.

6.5.4 Capacity building for DWS

A number of training opportunities exist in Sudan that have relevance to DWS. Overview observations include:

1. The DWSTs seem to be the only training institution at present with a specific course on O&M, an area that is a major gap in relation to ensuring DWS in Sudan.

2. There has already been an increase in focus on sanitary investigations and water safety plans in trainings, with examples of trainings conducted recently covering both.

3. Much of the materials are still in English, which may reduce their value, as many people working at State and Locality level may not have strong enough English to make the most of the materials.

4. The use of videos (UNICEF supported training in Kordofan) to highlight particular hazards and the field work integrated into the WSP trainings with discussion and feedback (supported by UNICEF and REDR/WHO) are both positive developments.

5. An observation from some of the WSP trainings in Darfur is that the participants have found it quite difficult to make decisions in response to the findings.

6. There are a range of departments at universities and the network of Academy of Health Sciences institutions that include DWS related topics in their courses. But large student numbers and lack of access to water quality equipment and laboratory access, limits the opportunities for student learning. Also projects tend to be more descriptive rather than interventional, which the universities feel would be more beneficial for building the skills of the students.

7. FMoH supported DWQ and surveillance trainings are provided through the Continuous Professional Development Directorate (CPDD) of the FMoH and the FMoH has also trained 370 Public Health Officers in the use of the FMoH Manual on DWQ and Safety.

8. The REDR/WHO supported training that was held in Khartoum on ‘Water quality and infrastructure’ was very practical and focussed on the likely issues that are likely to be seen at sub-national and community levels. The DWSTs tend to provide quite detailed DWQ training, suitable particularly for staff that are likely to have a laboratory role. In general, it is positive for all institutions to consider the most relevant topics, parameters and equipment that are likely to be used by the specific groups of trainees, to ensure the most benefit from the trainings, rather than risking being too theoretical on subjects that the trainees are unlikely to use.

State level trainings

At State level a range of training has also been undertaken – for example:

- In Kassala – UNICEF has supported the training of: 462 chlorinators; have run general WASH trainings including DWS; have trained the Sudanese Red Crescent Society on water quality and the use of chlorine; and training for the health promoters on guidelines including DWS.

- In White Nile – WHO and UNICEF have supported trainings on water quality and monitoring systems for PH Officers, MoH; WHO National staff have trained Locality staff in the State, but could do with advanced and ToT trainings; and some community level people have been trained in the use of a Pooltester for chlorine and pH.

The following are examples of the institutions and the training they provide.
Drinking Water Supply Training (DWST) institutions:

- **Central DWST** - is based in the MoWRIE in Khartoum.
- **State level DWSTs** - have been established in the following States: Northern; River Nile; Red Sea; Gezira; White Nile; Sennar; North Darfur.

Most trainees come from the SWCs, but the White Nile DWST has also run training courses on a private basis, for example:

- A course on community management of water points - paid for by Plan International-Sudan
- A course for refugees – focussing on O&M and mobile maintenance, for example of motorbikes and water pumps – the training is conducted in the refugee camps

The DWSTs were set up with the support of JICA, who provided knowledge and techniques for the establishment of the courses and some of the equipment (for example for detecting leakage for O&M). Some participants have also been supported to attend trainings in Morocco, Japan and India. Morocco is seen as a model country and is also Islamic and African. The SWC funds the equipment and salaries for the operation of the centre.

Some DWSTs have workshops for the maintenance training and some have laboratories. The White Nile Training Centre has a workshop but not its own laboratory. They use the SWC Central laboratory which is next to the facility at the Kosti WTW, but there are multiple equipment limitations in this laboratory (see Section 6.5.3). The DWSTs also share some of the training with the MoH – for example on health education.

The courses being run of most relevance to water safety include:

- Pipe network management and design (2 weeks)
- Mechanical management / water supply facilities (2 weeks)
- O&M of water treatment plants (2 weeks)
- Water quality analysis – 4 courses (7 weeks in total)
- Water well management – 2 courses (2 weeks each)
- Data management (GIS) (2 weeks)
- Monitoring and evaluation (2 weeks)
- Baseline survey (2 weeks)

See Table 26 in Annex VI which provides an overview of the content of the courses noted above.

The DWST was the only training institution identified that is running training courses related to O&M of treatment plants and pipe networks. The water quality analysis courses are quite technical and focus on the use of a range of laboratory equipment, some very high tech such as a HPLC. These courses seem most appropriate for people undertaking laboratory analysis roles, rather than people who have more general responsibilities or work at Locality or field level, who are likely to only have access to field equipment.

**Universities:**

University courses in Sudan which have relevance to DWS include those related to:

- Public health / Environmental health
- Environmental engineering / Civil engineering / Chemical engineering
- Water resources

To provide an idea of the numbers of students graduating each year from Universities with training in environmental health, which includes elements focussing on DWS. Table 8 - provides an overview of the numbers of students who are graduating each year from three of the Khartoum based Universities which run courses on Public Health / Environmental Health. There are currently eight universities that run EH courses to degree levels or above. These include: University of Khartoum; Alzaeem Alazhari University (AAU)

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43 China and Egypt were also mentioned by other stakeholders
(Khartoum); Bahari University (Khartoum); Shandi Uni – River Nile State; Alqazeria University - Gezira; Alemam Almahadi University - White Nile; Kordofan University - North Kordofan; and in West Kordofan. They cover all areas of S&H and EH. In addition there are several more universities which are considering to start new courses.

Table 8 - Numbers of students graduating in Public Health (including Environmental Health course) in three Khartoum universities

<table>
<thead>
<tr>
<th>University</th>
<th>Undergraduate</th>
<th>Postgraduate</th>
<th>PhD (related to water safety)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Khartoum</td>
<td>120 - 1 year / 650 total</td>
<td>80 per year – 2 years</td>
<td>2-3 water subjects now 2 graduated on water subjects</td>
</tr>
<tr>
<td>Bahari</td>
<td>87 – 1 year / 450 total</td>
<td>27 total</td>
<td>2 PhD water subjects</td>
</tr>
<tr>
<td>AAU</td>
<td>70 – 1 year / 300</td>
<td>25 total</td>
<td>PhD – 2 water related</td>
</tr>
</tbody>
</table>

The following summarises the course content of relevance to DWS at the three universities (Khartoum, Bahari and AAU) and an overview of the universities’ access to laboratories for use by the students:

- All universities cover DWS related subjects as part of their EH course.
- The subjects across courses include: water and health, water quality, water treatment, distribution, environmental education (re water sources), inspection of water treatment plants, water hygiene.
- None of the universities currently cover HWTS and currently only the Bahari University includes some elements of WSPs.
- All three universities have students who do projects on DWS related issues including a few PhD students – see Section 6.4.7 for examples of projects.
- Only the University of Khartoum has access to its own laboratories for practical training; although Bahari has some field kits and AAU has access to a laboratory that supported multiple departments. For Bahari and AAU, they rely on placements at laboratories run by the MoH, SWC, and Khartoum High Council for the Environment for the students to again some experience of using laboratory equipment. See below for challenges in relation to the laboratories for the universities and Section 6.5.3 for challenges related to other laboratories.

Alzaiem Alazhari University (AAU), Faculty of Public Health, Environmental Health Department

Course title: Water Safety and Hygiene

By the end of the course, the student should be able to: know the importance of water and it’s relation to public health, sources and characteristics of water and how to protect them from pollution; be able to conduct surveillance and sanitary inspections for drinking water supplies; how to take samples for laboratory examination and to interpret laboratory reports; ensure quality standard as well as the national and international standards and guidelines for water quality and water treatment; and to request appropriate examination for water quality.

See Tables 27 and 28 in Annex VI which provides an overview of the content of the noted courses and the access to laboratories and equipment for practical training.

Challenges being faced by the universities in training on DWS:

- High numbers of students against the resources provided
- Inadequate access to laboratories and equipment to enable students to practice – for example the University of Khartoum only has two turbidity meters so can only do demonstrations with groups of 40 students, limiting their opportunity to gain practical experience
Inadequate funds for reagents for laboratories – in AAU the students have to pay for the reagents they use in their experiments

Turnover of staff – moving to Saudi Arabia and other Arab states

Limited funding for interventional research – tends to be descriptive

Students are not attracted to work in EH as lack of resources to this profession, blocked against promotion, not seen as a good environment to work in

Academy of Health Sciences (AHS), Kassala:
The Academy of Health Sciences train to Technical Diploma level (equivalent to a Baccalaureate level) and are established in Khartoum and have branches across the whole of Sudan. The trainees would usually support PH Officers. It was also reported that it will be this level of professional that will be employed as lab technicians in the MoH lab Kassala.

The MoH funds trainees in the areas of Community Health Workers, Medical Assistants and Midwives but not other courses, so the students have to self-fund on this course. It costs SDG 2,500 per year per course.

The following provides an overview of the AHS courses of relevance to DWS:

- The Kassala AHS had 75 students graduating last year.
- The course is 60% practical, 30% theory and 10% assignments, but they do not have their own laboratory so they send students to the MoH (for DWS) and SSMO laboratory (for food hygiene).
- The Public and EH course of relevance to DWS covers: biochemistry, biology, DWS and sewerage systems, basic management and quality and practical field and research methods.
- For the DWS section, it covers water related diseases and control, water sources, water cycle, water contamination, treatment, storage and distribution, drinking water standards and guidelines, water testing, sampling.

See Table 29 in Annex VI which provides an overview of the content of the noted courses.

FMoH Continuous Professional Development Directorate (CPDD)
The CPDD provides a five day training on DWS for MoH and Locality employees. The trainees are mainly Public Health Officers who already have a four year BSc or MSc. The courses therefore act as refreshers and to update staff on latest techniques. These courses focus on monitoring, surveillance, water quality testing, community engagement, water treatment. Their training is mostly theoretical, maybe some demonstration + field visits. They also have courses related to hygiene promotion, environmental health impact, food safety (which may have some relevance for bottled water and ice) and pesticides and insecticides (which may have some content relevant to pollution of drinking water).

The CPDD is mandated by Ministerial Decree as the institution that should provide training to the MoH staff. It has a pool of trainers which it calls upon to run the trainings. They run 52 different courses across all disciplines which are <3 month in-service courses. They can also train government officials or community leaders and would be open to also collaborating with NGOs. They mainly do Training of Trainers courses so that the trainees can go back to their States and train others (for example Sanitary Oversees and Assistant Sanitary Overseers). They have 6 lecture halls.

UNESCO Chairs a committee on EH activities under the CPDD.

REDR/WHO/Qatar Fund for Development:
REDR/WHO has supported training in 2017 in: Water Quality and Infrastructure in Khartoum; Water Safety Plans in Darfur; Water quality in the Darfur states. An overview of the courses of relevance to water safety includes:

- **Water Quality and Infrastructure** (7 day, Khartoum, supported by WHO) – Comprehensive and practical training covering all elements of needs assessments, WASH assessments, water quality,
water treatment, water safety plans, and technical details of different types of water sources. Includes a range of practical work and site visits. Materials in English.

- **Water Safety Plans** (2 day, Darfur States, supported by WHO) – Covers introduction and overview of WSPs, WSP planning theory including each step, water supply visit (0.5 day), water safety risk assessment based on the visit and water safety improvement and monitoring. Materials in English.

- **Water quality for Locality staff** (3 or 5 day courses, Darfur States, supported by WHO) – Covers water sources, drinking water standards, water contamination, water surveillance, by-laws, sanitary inspection and field tests; and for the 5 day also more details on the parameters, water treatment, water guidelines, sampling, field visits and group work. Course materials are in a mixture of English and Arabic.

See Table 30 in Annex VI which provides an overview of the content of the noted courses.

**UNICEF/Korea funding:**

UNICEF has supported training in WSPs in the Kordofan States in 2017. An overview of the courses of relevance to DWQ includes:

- **WSPs** (five day course, Kordofan States, supported by UNICEF) – Covers introduction to WSPs, global framework for WSPs, developing a community-based WSP (step-by-step through the stages), Water quality within the WSP (including standards, sampling, water quality results and using the data, water quality monitoring and surveillance), special session on chlorination for AWD and human behaviour and water quality. It also includes field work (1 day) and feedback by the groups and discussion (0.5 days). Nice use of videos, as a learning tool. Materials in English, but participants fed back in Arabic.

See Table 31 in Annex VI which provides an overview of the content of the noted courses.

**NGOs:** CARE, OXFAM and other NGOs have provided training on water quality.

### 6.5.5 Health and safety and PPE

Six workers at a White Nile refugee camp WTP have no safety clothes and equipment / PPE for the chlorination process. Two experiences were also shared where staff involved in the management of chlorine were injured by the chlorine because they were not wearing appropriate PPE. One person got chlorine gas in their eyes and he was blinded. However it was reported that even after this incident the staff did not start to wear protective clothing including masks suitable for chlorine gas or glasses. This perhaps indicates a lack of culture of understanding the importance of using appropriate PPE.

**Fig 27 - Chlorination respirator face masks**

![Respirator Face Mask](Credit: Health and Safety Executive of the British Government)

The image to the left shows a face mask which has filters suitable for use with chlorine. The operator should also wear some form of glasses or visa to protect the eyes.

This type of face mask is not commonly used in Sudan at present, but would protect the user from damage to the lungs from the vapours released by chlorine gas or powders.

### 6.5.6 Need for capacity building

See the Sudan Drinking Water Safety Strategic Framework (SDWSSF) - Section 7.5 and Annex II for details.

---

44 Health and Safety Executive (UK) (2013) Respiratory Protective Equipment at Work, A practical guide
7. Desk based research

A range of desk based research has been undertaken to respond to some of the areas of inconsistencies across the guidelines and a few areas where challenges are being faced. This has been included in the report on ‘Recommendations for strengthening DWS components of WASH sector guidelines’ (2017). This covers the following areas:

A. Minimum distances to prevent pollution
B. Minimum chlorine residuals
C. Chlorine levels for long pipelines
D. Microbiological testing
E. Intervals for monitoring drinking water quality/safety
F. SSMO standards or WHO guidelines
G. Height of headwalls and depth of grouting for borehole casings
H. Paints acceptable for drinking water tanks
I. Good practice in the regulation of the packaged/bottled water industry
J. Specifications for health and safety equipment for handling chlorine and storage
K. Identification and removal of algae
Annexes

Annex I - Schedules

This annex includes the schedules for the consultancy visits 1 & 2.

Table 9 - Schedule for Trip 1 to Sudan – Completed

<table>
<thead>
<tr>
<th>Day</th>
<th>Activity</th>
<th>Provisional meeting / visit schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fri 7</td>
<td>Leave UK</td>
<td>Travel to Sudan</td>
</tr>
<tr>
<td>Sat 8</td>
<td>Arrive Sudan</td>
<td>Arrive Sudan</td>
</tr>
</tbody>
</table>
| Sun 9 | Khartoum                  | AM: REDR & WHO & FMoH  
PM: UNICEF & WASH Sector Co-lead                                                                                                                                                                                                                                                   |
| Mon 10| Khartoum                  | AM: MoWRE & National DWST  
PM: FMoH & WHO                                                                                                                                                                                                                                                                       |
| Tues 11| Khartoum                 | AM: UNICEF & FMoH & FMoH - National Public Health Laboratory  
PM: MoWRIE – Groundwater and Wadi Development Directorate                                                                                                                                                                                                                             |
| Weds 12 | Khartoum State          | AM: Khartoum State Water Corporation & Central Laboratory & visits to Burri and Mogran Water Treatment Plants  
PM: Khartoum State MoH & AfDB                                                                                                                                                                                                                                                          |
| Thurs 13 | Khartoum State Locality & Khartoum | AM: Khartoum State MoH laboratory and Locality visit, Khartoum State  
PM: Representatives of Khartoum, Bahari and Alzaem Alazhari Universities & visit to Khartoum University laboratories                                                                                                                                                                       |
| Fri 14| Write up                  | Write up                                                                                                                                                                                                                                                                             |
| Sat 15| AM – flight to Kassala    |                                                                                                                                                                                                                                                                                    |
| Sun 16| Kassala                   | AM: HAC & DG & EH team, MoH Kassala & WHO & UNICEF Kassala & view lab equipment  
PM: DG Kassala State Water Corporation DG & Central lab & distribution maintenance team member                                                                                                                                                                                      |
| Mon 17| Kassala                   | AM: Academy of Health Sciences, Kassala & Kassala Rural Locality  
PM: Visit to water yard in rural village & donkey cart owners and managers of water yard                                                                                                                                                                                                 |
| Tues 18| Travel & Khartoum         | AM: Flight from Kassala to Khartoum  
PM: MoWRE & travel from Khartoum to White Nile                                                                                                                                                                                                                                           |
PM: DG and State Water Corporation team including WES team & visit DWST & Kosti WTP and central laboratory                                                                                                                                                                           |
| Thurs 20| White Nile + to Khartoum  | AM: HAC & travel to refugee camp & visit to eastern refugee camp  
PM: Travel to Khartoum                                                                                                                                                                                                                                                               |
| Fri 21| Write up Return to UK    | Trip 1 debriefing meeting – FMoH / MoWRE / WHO / UNICEF / REDR  
Leave Khartoum for UK                                                                                                                                                                                                                                                                |
| Sat 22| Return to UK             | Arrive UK                                                                                                                                                                                                                                                                         |
### Table 10 - Schedule for Trip 2 to Sudan - Completed

<table>
<thead>
<tr>
<th>Activity</th>
<th>Date/Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>22 Sept Fri - Travel to Sudan</td>
<td></td>
</tr>
<tr>
<td>23 Sat - Sudan arrive + preparations/printing</td>
<td></td>
</tr>
<tr>
<td>24 Sun - Prep for workshops + meetings + Core team meeting MoWRE/FMoH/WHO/UNICEF/REDR</td>
<td></td>
</tr>
<tr>
<td>25 Preparation for meetings</td>
<td></td>
</tr>
<tr>
<td>26 1 day - Private sector meeting</td>
<td></td>
</tr>
<tr>
<td>27 Day 1 - Khartoum review workshop</td>
<td></td>
</tr>
<tr>
<td>28 Day 2 - Khartoum review workshop</td>
<td></td>
</tr>
<tr>
<td>Fri 29 ½ day off + write up</td>
<td></td>
</tr>
<tr>
<td>Sat 30 Travel to Darfur + write up</td>
<td></td>
</tr>
<tr>
<td>Sun 1 Oct Visit to HAC and State MoH and SWC</td>
<td></td>
</tr>
<tr>
<td>Mon 2 1 day – Senior staff orientation workshop - Darfur</td>
<td></td>
</tr>
<tr>
<td>Tues 3 Darfur – visit to locality and camp or community</td>
<td></td>
</tr>
<tr>
<td>Weds 4 Travel to Khartoum</td>
<td></td>
</tr>
<tr>
<td>Thurs 5 Meetings / visits – Khartoum: JICA and CPDD/FMoH</td>
<td></td>
</tr>
<tr>
<td>Fri 6 Write up – compile comments for core group meeting</td>
<td></td>
</tr>
<tr>
<td>Sat 7 Write up – compile comments for core group meeting</td>
<td></td>
</tr>
<tr>
<td>Sun 8 Meetings – Khartoum: MoWRIE/GWD laboratory; National Public Health Laboratory, FMoH; and FMoH – HP / Community engagement / School health team</td>
<td></td>
</tr>
<tr>
<td>Mon 9 Meetings / visits – Khartoum and write up: NEWTECH – Legal Reform team</td>
<td></td>
</tr>
<tr>
<td>Tues 10 Meetings / visits – Khartoum: DFID; SSMO; National Company for Manufacturing Water Equipment</td>
<td></td>
</tr>
<tr>
<td>Weds 11 Debriefing – core group + travel to UK</td>
<td></td>
</tr>
<tr>
<td>Thurs 12 Arrive UK</td>
<td></td>
</tr>
</tbody>
</table>
Annex II - DWS - Information gathering frameworks

Annex II.1 Trip 2 - Information gathering checklist

Table 11 - SDWSSF – Trip 2 - Information gathering checklist

<table>
<thead>
<tr>
<th>Areas to check</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Background data</strong></td>
<td></td>
</tr>
<tr>
<td>• 1 USD spent on water supply X% is gained and XX% of its GDP annually is lost due to poor access to water supply</td>
<td></td>
</tr>
<tr>
<td>• Updated refugee / IDP etc data - 2017</td>
<td></td>
</tr>
<tr>
<td><strong>Water chain &amp; control measures</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Water chain</strong></td>
<td></td>
</tr>
<tr>
<td>• Check hazardous events table</td>
<td></td>
</tr>
<tr>
<td>• Main problems with springs</td>
<td></td>
</tr>
<tr>
<td>• Check water treatment processes in rural areas – if all are used in Sudan (4.2.2) – pre-treatment (infiltration, horizontal roughing filtration, plain sedimentation, vertical roughing filtration)</td>
<td></td>
</tr>
<tr>
<td><strong>HWTS</strong></td>
<td></td>
</tr>
<tr>
<td>• Check the different types – see list in SDWSSF (Nana/Mint, Moringa, Neem, Zira, Groundwater, Lemon)</td>
<td></td>
</tr>
<tr>
<td>• Check the posts used on the roadside + take pictures</td>
<td></td>
</tr>
<tr>
<td><strong>HP</strong></td>
<td></td>
</tr>
<tr>
<td>• Check what beliefs exist related to water safety</td>
<td></td>
</tr>
<tr>
<td>• More info on what HP / communication related activities happen in relation to water safety:</td>
<td></td>
</tr>
<tr>
<td>o Normal times</td>
<td></td>
</tr>
<tr>
<td>o Humanitarian</td>
<td></td>
</tr>
<tr>
<td>• Photo of Kassala WHO poster</td>
<td></td>
</tr>
<tr>
<td><strong>Citizen feedback &amp; engagement</strong></td>
<td></td>
</tr>
<tr>
<td>• What are the mechanisms for citizen feedback on problems?</td>
<td></td>
</tr>
<tr>
<td>o How does this work?</td>
<td></td>
</tr>
<tr>
<td>o How many complaints are responded to?</td>
<td></td>
</tr>
<tr>
<td>o Any tracking of the responses?</td>
<td></td>
</tr>
<tr>
<td>• How are communities engaged in water safety at present?</td>
<td></td>
</tr>
<tr>
<td>o Examples?</td>
<td></td>
</tr>
<tr>
<td><strong>Packaged / bottled water</strong></td>
<td></td>
</tr>
<tr>
<td>• Does packaged water exist (such as bags) as well as bottled?</td>
<td></td>
</tr>
<tr>
<td>• Lists of bottled water companies / database?</td>
<td></td>
</tr>
<tr>
<td>• FMoH / WHO study on bottled water – 2016</td>
<td></td>
</tr>
<tr>
<td>• Capacity building / guidance?</td>
<td></td>
</tr>
<tr>
<td>o What exists?</td>
<td></td>
</tr>
<tr>
<td>o Who does it?</td>
<td></td>
</tr>
<tr>
<td>o Get copies of guidance provided</td>
<td></td>
</tr>
<tr>
<td>• Certification mark?</td>
<td></td>
</tr>
<tr>
<td>o Does it exist?</td>
<td></td>
</tr>
<tr>
<td>o Process for issue?</td>
<td></td>
</tr>
<tr>
<td>• Coordination and institutional responsibilities:</td>
<td></td>
</tr>
<tr>
<td>o Who leads?</td>
<td></td>
</tr>
<tr>
<td>o Who enforces?</td>
<td></td>
</tr>
<tr>
<td>o MoWRIE committee:</td>
<td></td>
</tr>
<tr>
<td>▪ Members and minutes?</td>
<td></td>
</tr>
<tr>
<td>o FMoH:</td>
<td></td>
</tr>
<tr>
<td>▪ Coordination?</td>
<td></td>
</tr>
<tr>
<td>▪ Role?</td>
<td></td>
</tr>
<tr>
<td>o Other’s roles:</td>
<td></td>
</tr>
</tbody>
</table>
| Private sector | • What are their contributions to water safety?  
• Challenges they face?  
• Regulation that applies to them?  
  o Which regulations?  
  o How are they regulated?  
  o By whom?  
  o Any examples?  
• Capacity building of the private sector?  
  o Information they receive from the government?  
  o Trainings they have received?  
  o Capacity building for the smaller private sector?  
• What do they think needs to be done to:  
  o Improve water safety in Sudan?  
  o Facilitate more engagement of the private sector?  
• Small ice sellers – what support could be provided to them to ensure DWS? |
| --- | --- |
| Schools, health facilities and other institutions | • Data on DWS in schools or health facilities?  
• HP on DWS in schools  
• University of Khartoum projects – on institutions – copy and translate  
• Guidance on DWS in institutions (workplaces, schools, health facilities) |
| Building blocks & cross-cutting | |
| quality & labs | o Check if any arsenic  
o GW heat – 30-40oC? – seems high  
o Check general list of parameter problems in different states  
o Metals?  
- Other labs to visit:  
o SSMO  
o College of Water Resources of Sudan (Env. Eng. Dept / WR Dept.)  
o UNESCO Water Treatment Centre  
o NERC? |
| SSMO and Standards | o Standards:  
o Updating planned for when? Alignment with WHO?  
o Micro standards – not clear in table  
- Labs:  
o What do they do?  
o Capacities?  
o Approval for other labs?  
- Bottled water:  
o SSMO role?  
o Coordination? |
| Databases | o Check JICA WASH Atlas  
- Check – DWST data – is it linked to GWD or WES database or separate? |
| Cross-cutting | |
| Gender, equity, disadvantage | o Check in workshop |
| Specific questions for institutions | |
| FMoH | o Data:  
o Check data on water sources + with MoWRIE  
o Kassala data – are they the same villages? (4.1)  
- Monthly reports:  
o What are ‘health standards for hafirs’?  
o What do average figures mean  
- Reports on minutes of meeting with Vice President in Sudan + FMOH – workshop with SDGs across sectors to resolve water quality problem  
- JDs:  
o Check couple of words not clear (see Annex VIII)  
- Check diseases data:  
o Translation of data given already  
o Other data  
- AWD data for 2006/7 outbreak and this one? (national and by states)  
o Guinea worm?  
o Eye-worm / Loa Loa in Blue Nile province  
- Access to vehicles:  
o None? How do they get them?  
- Kits distributed:  
o Was it also Wagtech Potatests as well as Photometer 7500 and Palintest 800?  
- Bottled water study  
- Visit to MoH CPD:  
o Practical training on water safety? |
| **MoWRIE** | • Asia – permission to use photos  
• National water source data – compare with FMoH  
• Scope of legal reform work – Inception Report does not mention actually updating regulations or guidelines (only Policy and Strategy?)  
• Check if monthly reports:  
  o Are just from WES teams or from whole of SWCs?  
  o Are stock records just from State central level or also from locality / WTP levels? |
| **WHO** | • Bottled water study  
• CEHA training on water safety in Sinnar state:  
  o Details  
  o When  
  o How many people  
• Databases – incident reporting  
• Permission to use photos for video + whose photos |
| **UNICEF** | • Kassala WSP examples at community level  
• Distributed 600 pooltesters to Kordofan States |
| **DWST** | • Central:  
  o Is the Flame High Performance Liquid Chromatography (HPLC) still working?  
  o Length of the four WQ courses?  
  o Content of the fourth course – is it just on the HPLC?  
  o Bottled water committee minutes  
  o Database – linked to GWD or WES or separate  
  o Trainings in Egypt, Morocco, Japan, India, China  
• White Nile DWST:  
  o Check title of course – Mechanical management / water supply facilities |
| **UNESCO** | • Chair of committee on EH under MoH CPD training centre  
• Trainings?  
• Labs? |
| **Universities** | • Khartoum:  
  o Can we get copies of the students projects related to schools and health facilities?  
• Bahari & AAU:  
  o Do they cover HWTS? (I think not but to double check)  
  o Bahari – when established? |
| **States follow up** | • Khartoum State MoH:  
  o 1 staff or 5 for DWS?  
  o Permission to use photos  
• Khartoum State Locality:  
  o 1 vehicle per WS team or EH team?  
• Khartoum State WC:  
  o Some form of water safety planning report / maintenance / treatment / risks etc  
• White Nile SWC:  
  o Water Atlas example |
| **REDR** | • Report on water quality mapping – North and South Kordofan  
• Final water quality training materials for Darfur |
| **JICA** | • Water Atlas example  
• Experience of supporting efforts to improved maintenance  
• Recommendations for the framework |
Annex II.2 Darfur States information gathering format

The following questionnaire was used by the RedR team for gathering information on the water safety situation in 4 of the Darfur States (East, Central, North and South).

DWS Strategic Framework
& Water Quality Monitoring and Surveillance Guidelines

Questions for Darfur States

Background

The Government of Sudan is planning to develop a Water Quality Policy. This consultancy supports initial steps towards this goal. It has been designed to help identify the current situation and set the basic path towards the later development of a policy.

The consultancy is being funded by WHO to support the MoWRIE and FMoH to assess the current situation, develop a strategic framework for water safety and update the existing water quality and monitoring guidelines. The FMoH and MoWRIE will be supported in this process by WHO, UNICEF and RedR.

Aims of the overall process

The overall aims of the overall process are as follows:

1. Assess the policies, existing water quality monitoring networks and the information management system
2. Develop a strategic framework for DWS management and surveillance for the national and state levels
3. Update the existing water quality monitoring and surveillance guidelines

Introduction to the questionnaire

The following questions are to be asked by the REDR team travelling to the Darfur States in August 2017.

The aims of the questions are to gain some understanding of the water safety situation in the Darfur States, particularly: a) What things are going well?; and b) What are the main challenges?

It is proposed that:

1. The questions can be asked to the following institutions (depending on the time available):
   a. State MoH – people responsible for water safety; M&E/data management; laboratory/field testing equipment
   b. State Water Corporation – people responsible for water safety; water treatment; water supply network maintenance; M&E/data management; laboratory/field testing equipment

2. The interviewers do not need to ask all questions and can adapt them as they see fit at the time

3. The interviewers should ask the questions and seek to triangulate the answers through different means such as:
   a. Ask to see the documentation for M&E – see what it contains and how well it has been completed
   b. Ask to see the laboratory/field equipment – see if it has been used; see if the consumables are available; see if they are in-date
Outline questions for the semi-structured interviews

Table 12 - Questionnaire for Darfur semi-structured interviews

A - State Water Corporation

<table>
<thead>
<tr>
<th>1</th>
<th>Who has responsibilities for DWS in your State?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>What are your responsibilities?:</td>
</tr>
<tr>
<td></td>
<td>• Rural? Urban?</td>
</tr>
<tr>
<td></td>
<td>• IDP camps?</td>
</tr>
<tr>
<td></td>
<td>• What are the specific responsibilities of the SWC?</td>
</tr>
<tr>
<td><strong>Note:</strong></td>
<td>Here we are hoping to understand how they see their responsibilities in relation to the MoH and the localities</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2</th>
<th>What are the main challenges you face in ensuring the DWS in your state?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• This can be related to any element of the process in providing drinking water</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3</th>
<th>What strategies, by-laws, guidelines etc do you follow to ensure DWS?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Ask to see copies if any are mentioned</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>4</th>
<th>Have you ever done any activities to map the risks for pollution of the drinking water supply system or undertaken any water safety planning?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• If so please could you describe?</td>
</tr>
<tr>
<td></td>
<td>• Please can we see (and take) a copy?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5</th>
<th>Have you ever had to use any enforcement/ activation of laws in relation to water safety?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• If so please explain / describe what happened?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>6</th>
<th>What are the usual procedures for maintaining your drinking water supply systems?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Water treatment system?</td>
</tr>
<tr>
<td></td>
<td>• Piped networks?</td>
</tr>
<tr>
<td></td>
<td>• Water supply points?</td>
</tr>
<tr>
<td></td>
<td>• Point sources?</td>
</tr>
<tr>
<td><strong>Note</strong>  - here you are trying to understand if:</td>
<td>They do any preventative maintenance or just reactive maintenance when there is a problem?</td>
</tr>
<tr>
<td></td>
<td>How well they do the maintenance – just a temporary fix or a permanent one?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>7</th>
<th>What water treatment processes do you use for:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Urban supplies?</td>
</tr>
<tr>
<td></td>
<td>• Rural point sources?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>8</th>
<th>What maintenance do you do to the water treatment plant and related to the processes?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Is any maintenance preventative?</td>
</tr>
<tr>
<td></td>
<td>• How often does it occur?</td>
</tr>
<tr>
<td><strong>Note:</strong></td>
<td>If you have a chance to visit a water treatment plant then do</td>
</tr>
<tr>
<td></td>
<td>• If so look at the state of repair of the system – Is it in good repair or not? Do the clarifiers look clean? Is there algae in the treatment units? What chlorination methods do they use?</td>
</tr>
<tr>
<td></td>
<td>• See if you can see the water quality records for the outlet turbidity and chlorine residual? What are the usual ranges?</td>
</tr>
</tbody>
</table>
9 What private sector organizations have a role in the provision of SDW in your state?
   - What do they do?
   - Are there any roles that the private sector should do that they don’t at present?

10 What capacities do you have for the testing of water quality?
   - What labs exist?
   - What equipment do they have – note the type of equipment for each of the following?
     - Can they test for chlorine residual?
     - Can they test for turbidity?
     - Can they test for pH?
     - Can they test for other parameters such as nitrite, nitrate, fluoride?
     - Can they do membrane filtration tests for thermotolerant bacteria / E.coli?
     - Do they have any higher tech equipment such as an Atomic Absorption Spectrometers?
   - If possible – ask to see the equipment to see its condition and how well it is maintained
   - How often do they test?
   - Do they have enough consumables?
     - If not which ones do they not have?
   - Do they have trained staff?
     - What qualifications?
   - Do they have transport to be able to do water testing in the field?

11 What record keeping do you have for data on water safety – what does it consist of?
   - What record keeping exists?
   - For what purpose?
   - Is there a database that is used / or databases?
   - Are the used currently? If not why not?
   - Strengths / gaps?

12 What recommendations would you have for what should be included in the strategic framework for DWS?

13 Any other relevant information

B - State Ministry of Health

1 Who has responsibilities for DWS in your State?
   What are your responsibilities?:
   - Rural?
   - Urban?
   - In the IDP camps?
   - What are the specific responsibilities of the MoH?
   Note:
   - Here we are hoping to understand how they see their responsibilities in relation to the SWC and the localities

2 What are the main challenges you face in ensuring the DWS in your state?
   - This can be related to any element of the process in providing or monitoring or controlling drinking water
<table>
<thead>
<tr>
<th></th>
<th>What strategies, by-laws, guidelines etc do you follow to ensure DWS?</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Ask to see copies if any are mentioned</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Have you ever done any activities to map the risks for pollution of the drinking water supply system or undertaken any water safety planning?</td>
</tr>
<tr>
<td>4</td>
<td>If so please could you describe?</td>
</tr>
<tr>
<td></td>
<td>Please can we see (and take) a copy?</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Have you ever had to use any enforcement/ activation of laws in relation to water safety?</td>
</tr>
<tr>
<td>5</td>
<td>If so please explain / describe what happened?</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>How many staff are involved in water safety in your state?</td>
</tr>
<tr>
<td>6</td>
<td>At state level for the MoH?</td>
</tr>
<tr>
<td></td>
<td>In each locality?</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>What transport do the staff responsible for water safety have access to?</td>
</tr>
<tr>
<td>7</td>
<td>How often can they use the transport?</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>What private sector organizations have a role in the provision of SDW in your state?</td>
</tr>
<tr>
<td>8</td>
<td>What do they do?</td>
</tr>
<tr>
<td></td>
<td>Are there any roles that the private sector should do that they don’t at present?</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>What capacities do you have for the testing of water quality?</td>
</tr>
<tr>
<td>9</td>
<td>What labs exist?</td>
</tr>
<tr>
<td></td>
<td>What equipment do they have – note the type of equipment for each of the following?</td>
</tr>
<tr>
<td></td>
<td>Can they test for chlorine residual?</td>
</tr>
<tr>
<td></td>
<td>Can they test for turbidity?</td>
</tr>
<tr>
<td></td>
<td>Can they test for pH?</td>
</tr>
<tr>
<td></td>
<td>Can they test for other parameters such as nitrite, nitrate, fluoride?</td>
</tr>
<tr>
<td></td>
<td>Can they do membrane filtration tests for thermotolerant bacteria / E.coli?</td>
</tr>
<tr>
<td></td>
<td>Do they have any higher tech equipment such as a Atomic Absorption Spectrometers?</td>
</tr>
<tr>
<td></td>
<td>If possible – ask to see the equipment to see its condition and how well it is maintained</td>
</tr>
<tr>
<td></td>
<td>How often do they test?</td>
</tr>
<tr>
<td></td>
<td>Do they have enough consumables?</td>
</tr>
<tr>
<td></td>
<td>If not which ones do they not have?</td>
</tr>
<tr>
<td></td>
<td>Do they have trained staff?</td>
</tr>
<tr>
<td></td>
<td>What qualifications?</td>
</tr>
<tr>
<td></td>
<td>Do they have transport to be able to do water testing in the field?</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>What record keeping do you have for data on water safety – what does it consist of?</td>
</tr>
<tr>
<td>10</td>
<td>What record keeping exists?</td>
</tr>
<tr>
<td></td>
<td>For what purpose?</td>
</tr>
<tr>
<td></td>
<td>Is there a database that is used / or databases?</td>
</tr>
<tr>
<td></td>
<td>Are the used currently? If not why not?</td>
</tr>
<tr>
<td></td>
<td>Strengths / gaps?</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>What recommendations would you have for inclusion in the strategic framework for DWS?</td>
</tr>
<tr>
<td>11</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Any other relevant information</td>
</tr>
</tbody>
</table>
Annex II.3  Trip 1 - Information gathering framework

The following table provided a framework for the information gathering during the first trip to Sudan in July 2017.

**Table 13 - Information gathering framework using first consultancy visit to Sudan - by subject area**

<table>
<thead>
<tr>
<th>Subject area</th>
<th>Questions</th>
</tr>
</thead>
</table>
| 1 Water safety related policies, strategies, guidelines, standards | • What policies, regulations, strategies, guidelines and associated documents already exist that have content relevant to water safety?  
• What are the water quality standards for Sudan?  
• Regulations for monitoring / controlling private water suppliers?  
• Stage of finalisation of guidelines for emergencies developed with the support of Toby?  
• Gaps in documents?  
• Strengths/gaps in content? |
| 2 Water quality issues in Sudan | See Annex  
• What are the main water quality issues in Sudan?  
• Main reasons for the presence of contaminants?  
• Suggested solutions for reducing contamination?  
**Chemical contaminants:**  
• Are the following issues and if so at what level?:  
  o Arsenic  
  o Nitrates / Nitrites  
  o Fluoride (from Africa map – Sudan is indicated as medium levels)  
  o Iron; calcium/magnesium; sulphate; sodium chloride (salts)  
• Other chemical contaminants of particular concern?  
  o Industrial pollution?  
  o Agricultural pollution / fertilisers and pesticides?  
  o Pharmaceutical pollution?  
  o Radiological pollution?  
  o Microcystsins – from Blue-Green Algae (such as Cyanobacteria)  
**Microbiological contaminants:**  
• AWD related (*Vibrio cholerae*)  
• Shigella, amoebic dysentery, giardia, typhoid, polio, Hep A&E  
• Guinea worm (I think probably not but to double check)  
• Any other biological contaminants of particular concern?  
**Water related insect vector and water washed diseases (versus water based):**  
• What are the water related insect vectors and water washed diseases prominent in Sudan?  
• Penetrating skin - Schistosomiasis  
• Biting near to water – Sleeping sickness  
• Breeding in water – Lymphatic filariasis, malaria, mosquito borne arbovirus’ - Yellow/Rift Valley/ Dengue fevers, Arbovirus Chikungunya |
| 3 | Existing water quality monitoring systems / networks & remedial actions | • What existing water quality monitoring systems / networks exist?  
• What is their scope / what do they consist of?  
• Roles and responsibilities?  
• Periods between monitoring?  
• Control / remedial actions – what is done / how quickly / how effective?  
• Strengths / gaps?  
Consider:  
• Urban water utilities  
• Rural systems  
• MoUPI / WES and equivalent systems  
• MoH systems  
• Monitoring of private water suppliers  
• Community based |
|---|---|---|
| 4 | Water safety plans | • Which actors are currently engaged in preparing water safety plans or training on the same in Sudan?  
• What guidance is already being used?  
• Who has already prepared water safety plans at different levels:  
  o Federal  
  o Water Utility  
  o State  
  o Locality  
  o Administrative Unit  
  o Community  
• See copies of the water safety plans  
• Any follow up / monitoring of the effectiveness of WSPs?  
• Any linkages with CATS/CLTS mapping and WSPs? |
| 5 | Water treatment | **Bulk:**  
• What bulk water quality treatment processes are utilised at present in:  
  o Urban areas  
  o Rural areas  
  o Piped schemes  
  o Point schemes  
• How many water treatment plants exist:  
  o Where?  
  o Capacity?  
  o Processes used?  
  o Functionality?  
• For piped and point bulk treatment systems:  
  o Availability of consumables?  
  o Monitoring of efficiency of treatment processes?  
  o Monitoring of water quality at points along piped networks?  
  o Modifications for emergency contexts (such as increasing chlorine dosages for piped schemes during AWD outbreaks)?  
  o Who manages each stage of the process?  
  o Strengths / weaknesses? |
<table>
<thead>
<tr>
<th>Household:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Storage:</strong></td>
</tr>
<tr>
<td>o Typical storage containers – variations by State and area?</td>
</tr>
<tr>
<td>▪ Small neck / large opening?</td>
</tr>
<tr>
<td>▪ Plastic?</td>
</tr>
<tr>
<td>▪ Ceramic?</td>
</tr>
<tr>
<td>o Cleaning processes?</td>
</tr>
<tr>
<td>o Scoops?</td>
</tr>
<tr>
<td><strong>HWTS processes are currently used in Sudan?</strong></td>
</tr>
<tr>
<td>o Boiling?</td>
</tr>
<tr>
<td>o Household chlorination?</td>
</tr>
<tr>
<td>o Use of Moringa or other coagulants?</td>
</tr>
<tr>
<td>o Ceramic filters?</td>
</tr>
<tr>
<td>o Commercial filters?</td>
</tr>
<tr>
<td>o Other?</td>
</tr>
<tr>
<td><strong>Any data / studies on HWTS in Sudan including:</strong></td>
</tr>
<tr>
<td>o HWTS options usage?</td>
</tr>
<tr>
<td>o Effectiveness of treatment processes?</td>
</tr>
<tr>
<td>o Cost, market viability and availability?</td>
</tr>
<tr>
<td>o Sustainability?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Water quality laboratories, equipment and consumables</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>See:</strong></td>
</tr>
<tr>
<td>o <a href="#">Annex VI in the Information Gathering report</a> – other information on water quality parameters</td>
</tr>
</tbody>
</table>

**Laboratory equipment**

The level and purpose of the laboratory will determine the type of equipment and tests that should be performed. The following checklist is for general use to assess access to testing and ability to run tests on a continuous basis.

<table>
<thead>
<tr>
<th>What laboratories exist:</th>
</tr>
</thead>
<tbody>
<tr>
<td>o Where?</td>
</tr>
<tr>
<td>o Who manages them?</td>
</tr>
<tr>
<td>o Who funds them?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>For each laboratory:</th>
</tr>
</thead>
<tbody>
<tr>
<td>o Scope of testing?</td>
</tr>
<tr>
<td>o Equipment?</td>
</tr>
<tr>
<td>o Consumables?</td>
</tr>
<tr>
<td>o Logistics?</td>
</tr>
<tr>
<td>o Staff – how many / qualifications / training?</td>
</tr>
<tr>
<td>o Charges for services?</td>
</tr>
<tr>
<td>o Funds for consumables and fuel / transport?</td>
</tr>
<tr>
<td>o Back-up generator and fuel?</td>
</tr>
<tr>
<td>o Strengths / challenges / gaps?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Where laboratories do not exist, but teams have field equipment:</th>
</tr>
</thead>
<tbody>
<tr>
<td>o What equipment do they have?</td>
</tr>
<tr>
<td>o Consumables?</td>
</tr>
<tr>
<td>o Logistics?</td>
</tr>
<tr>
<td>o Staff – who have been trained?</td>
</tr>
<tr>
<td>o Charges for services?</td>
</tr>
<tr>
<td>o Funds for consumables and fuel / transport?</td>
</tr>
</tbody>
</table>
Strengths / challenges / gaps?

**Methods / equipment available:**

- **Physical:**
  - Turbidity meters / tubes
  - pH meters
  - Conductivity / TDS meters
  - Thermometers

- **Chemical:**
  - Colorimetric:
    - Pooltesters/Checkits, tube and colour discs with comparators
    - Photometer
    - Dip sticks
  - Titrimetric:
    - Tablet and drop count methods
    - Various types of chromatographs / spectrophotometers
    - Higher tech – optical probes (such as the Macro 900)

- **Microbiological and biological?**
  - Membrane filtration:
    - Membrane Lauryl Sulphate Broth (yellow colonies – Thermotolerant)
    - Pre-packaged broth (blue colonies)
  - Most Probable Number method
  - Colilert Plate / Tubes + UV light
  - Nissui Compact Dry Plate test
  - Dipslides
  - Presence / Absence - Hydrogen Sulphide (H2S) Tubes (not faecal indicator)
  - Sterilising equipment
  - Incubators – 25-35°C (Nissui Plates & ColiPlate), 37°C (Total) and 44°C (Thermotolerant)
  - Broths for plates
  - Microscopes

- **Calibration of equipment:**
  - Do you have buffers for calibrating probes?
  - Can I see these?
  - How often do you calibrate?

- **Consumables:**
  - Which consumables do they tend to run out of?
    - Broths / pads / papers for MF?
    - Broths for other bacteriological plates?
    - Reagents for chemical tests?
    - Buffers for calibration?
  - How often are they without them?
  - Where are they procured from?
  - Any challenges with procurement?

---

- Check laboratories at:
  - Federal level:
<table>
<thead>
<tr>
<th>7</th>
<th><strong>Management information systems (MIS)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>What MIS are currently used for water safety related issues?</strong></td>
<td></td>
</tr>
<tr>
<td><strong>At what levels are they used?</strong></td>
<td></td>
</tr>
<tr>
<td><strong>How regularly updated?</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Success of use at different levels?</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Successes / gaps?</strong></td>
<td></td>
</tr>
<tr>
<td><strong>What would be needed to strengthen the MIS to be an effective tool(s) for water safety</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Systems:**
- **MoWRE:**
  - Water resources monitoring system (supported by WHO)
  - WES M&E system (supported by UNICEF)
- **FMoH:**
  - HMIS section for WASH – does it include water quality related data?
- **State and Locality:**
  - To confirm if they feed into Federal systems + if water quality is included
- **WHO:**
  - Water quality matrix
  - Incident Tracking System (ITS) – focus on disasters
  - Health Resources Availability Mapping System (HeRAMS) – does this include water quality for health centres?
- **UNICEF:**
  - Collects data from other’s systems for reporting on the UNICEF supported programmes – does it report on water safety?
- **WASH sector (humanitarian):**
  - 4 Ws mapping – any water quality related information?

<table>
<thead>
<tr>
<th>8</th>
<th><strong>Training institutions, courses, learning</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Institutions and organizations training on water safety:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Which institutions train on water safety:</strong></td>
<td></td>
</tr>
<tr>
<td>- DWST</td>
<td></td>
</tr>
<tr>
<td>- Universities (see those with EH courses from the SNSHSF)</td>
<td></td>
</tr>
<tr>
<td>- Colleges</td>
<td></td>
</tr>
<tr>
<td>- INGOs</td>
<td></td>
</tr>
<tr>
<td><strong>Obtain copies of course curriculum where possible?</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Field experience?</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Laboratory capacities? (see questions above)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Trained staff – lecturing / lab work</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Strengths / gaps?</strong></td>
<td></td>
</tr>
<tr>
<td>Roles and responsibilities and coordination</td>
<td></td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>--</td>
</tr>
<tr>
<td><strong>WHO CEHA training on water safety:</strong></td>
<td></td>
</tr>
<tr>
<td>• When did they train?</td>
<td></td>
</tr>
<tr>
<td>• Who did they train?</td>
<td></td>
</tr>
<tr>
<td>• Where did they train?</td>
<td></td>
</tr>
<tr>
<td>• Copy of curriculum?</td>
<td></td>
</tr>
<tr>
<td><strong>Other learning opportunities on water safety:</strong></td>
<td></td>
</tr>
<tr>
<td>• Any learning events specifically on water safety in WASH or other sectors?</td>
<td></td>
</tr>
<tr>
<td>• Any cross-sectoral learning?</td>
<td></td>
</tr>
<tr>
<td>• Any CSOs or other organizations which champion learning on water safety?</td>
<td></td>
</tr>
<tr>
<td><strong>Roles and responsibilities for water safety at each level?</strong></td>
<td></td>
</tr>
<tr>
<td>• Development contexts?</td>
<td></td>
</tr>
<tr>
<td>• Humanitarian contexts?</td>
<td></td>
</tr>
<tr>
<td>• Complex contexts?</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Coordinate and communication across sectors for water source protection:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• MoWRE</td>
<td></td>
</tr>
<tr>
<td>• MoH</td>
<td></td>
</tr>
<tr>
<td>• MoENRPD/High Environment Councils (or State Environmental Ministries where they exist)</td>
<td></td>
</tr>
<tr>
<td>• MoE – for school related water safety</td>
<td></td>
</tr>
</tbody>
</table>

| Overlaps / challenges? |  |
| **Capacities at each level** |  |

<table>
<thead>
<tr>
<th>Federal:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• See questions above for bulk water treatment</td>
<td></td>
</tr>
<tr>
<td>• Knowledge on water safety?</td>
<td></td>
</tr>
<tr>
<td>• Staff trained in water safety plans / water surveillance / HACCPs/ water quality assessment / water treatment / remedial action?</td>
<td></td>
</tr>
<tr>
<td>• Logistics, consumables and equipment needs (see also lab section above)</td>
<td></td>
</tr>
<tr>
<td>• Gaps / capacity building needs?</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Khartoum and other State Water Utilities:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• See questions above for bulk water treatment</td>
<td></td>
</tr>
<tr>
<td>• Knowledge on water safety?</td>
<td></td>
</tr>
<tr>
<td>• Staff trained in water safety plans / water surveillance / HACCPs/ water quality assessment / water treatment / remedial action?</td>
<td></td>
</tr>
<tr>
<td>• Logistics, consumables and equipment needs (see also lab section above)</td>
<td></td>
</tr>
<tr>
<td>• Gaps / capacity building needs?</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>State level - MoH:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Knowledge on water safety?</td>
<td></td>
</tr>
<tr>
<td>• Staff trained in water safety plans / water surveillance / HACCPs/ water quality assessment / water treatment / remedial action?</td>
<td></td>
</tr>
<tr>
<td>• Logistics, consumables and equipment needs (see also lab section above)</td>
<td></td>
</tr>
<tr>
<td>• Gaps / capacity building needs?</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Locality level:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Knowledge on water safety?</td>
<td></td>
</tr>
<tr>
<td>• Staff trained in water safety plans / water surveillance / HACCPs/ water quality assessment / water treatment / remedial action?</td>
<td></td>
</tr>
<tr>
<td>• Logistics, consumables and equipment needs (see also lab section above)</td>
<td></td>
</tr>
<tr>
<td>• Gaps / capacity building needs?</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Administrative Unit level:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Knowledge on water safety?</td>
<td></td>
</tr>
</tbody>
</table>
- Staff trained in water safety plans / water surveillance / HACCPs / water quality assessment / water treatment / remedial action?
- Logistics, consumables and equipment needs (see also lab section above)
- Gaps / capacity building needs?

Community / camp level:
- Consider:
  - Staff managing camps
  - Community based health workers
  - Private water suppliers
  - Community WASH Committees or other community representatives
- Knowledge on water safety?
- Training in water safety plans / water surveillance / HACCPs / water quality assessment / water treatment / remedial action?
- Logistics, consumables and equipment needs
- Gaps / capacity building needs?

Table 14 - Information gathering framework - by stakeholder

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Khartoum level</strong></td>
<td><strong>(Refer to details of questions in table by subject areas above for more details)</strong></td>
</tr>
<tr>
<td>1 MoWRIE</td>
<td>Current status of water safety in Sudan:</td>
</tr>
<tr>
<td></td>
<td>- Current strengths of the systems?</td>
</tr>
<tr>
<td></td>
<td>- Current weaknesses / challenges?</td>
</tr>
<tr>
<td></td>
<td><strong>Sub-areas:</strong></td>
</tr>
<tr>
<td></td>
<td>- Policies, strategies, guidelines etc:</td>
</tr>
<tr>
<td></td>
<td>- What exists at present?</td>
</tr>
<tr>
<td></td>
<td>- What is the ‘5 year WASH framework plan’? (as noted in the Humanitarian Response Plan, 2017)</td>
</tr>
<tr>
<td></td>
<td>- Stage of finalisation of guidelines supported by Toby Gould?</td>
</tr>
<tr>
<td></td>
<td>- Can I have copies of the guidelines?</td>
</tr>
<tr>
<td></td>
<td>- Water safety planning:</td>
</tr>
<tr>
<td></td>
<td>- See questions above</td>
</tr>
<tr>
<td></td>
<td>- Water treatment and monitoring capacities:</td>
</tr>
<tr>
<td></td>
<td>- See questions above</td>
</tr>
<tr>
<td></td>
<td>- Laboratories:</td>
</tr>
<tr>
<td></td>
<td>- See questions above</td>
</tr>
<tr>
<td></td>
<td>- Responsibilities for water safety in Sudan:</td>
</tr>
<tr>
<td></td>
<td>- Across sectors</td>
</tr>
<tr>
<td></td>
<td>- At different levels</td>
</tr>
<tr>
<td></td>
<td>- Capacities:</td>
</tr>
<tr>
<td></td>
<td>- See questions above</td>
</tr>
<tr>
<td></td>
<td><strong>MIS systems:</strong></td>
</tr>
<tr>
<td></td>
<td>- Particularly focus on MoWRIE &amp; WES systems, but also discuss other systems:</td>
</tr>
<tr>
<td></td>
<td>- What exists</td>
</tr>
<tr>
<td></td>
<td>- How it functions</td>
</tr>
<tr>
<td></td>
<td>- Information included</td>
</tr>
<tr>
<td></td>
<td>- Who uses it + what levels</td>
</tr>
</tbody>
</table>
Overlaps with other systems?

Strengths / gaps

**DWST:**
- Role, scope, strengths / weaknesses
- Visit to find out info (see training institution section above)
- Visit to see laboratories (see laboratory section above)

**Other current planned activities to strengthen water safety:**
- AFDB support of M&E system?
  - Reports available?
- JICA – support of urban water quality monitoring system:
  - Reports available?
- JICA – support for DWSTs
- Other?

**Recommendations:**
- Recommendations for key issues that need to be highlighted in the water safety framework

<table>
<thead>
<tr>
<th>2</th>
<th>FMoH</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Current status of water safety in Sudan:</strong></td>
<td></td>
</tr>
<tr>
<td>• Current strengths of the systems?</td>
<td></td>
</tr>
<tr>
<td>• Current weaknesses / challenges?</td>
<td></td>
</tr>
<tr>
<td><strong>Sub-areas:</strong></td>
<td></td>
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<td>- Stage of finalisation of guidelines supported by Toby Gould?</td>
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<td>- How should these new ones link in with the ones developed with the support of Toby?</td>
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<td>- Can I have copies of the guidelines? (translation - RedR)</td>
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<td>• Water safety planning:</td>
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<td>- Strengths / gaps</td>
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**FMoH Centre for Professional Development:**
- Does it cover water safety? (it wasn’t noted when we did the SNSHSF)

**Other planned activities to strengthen water safety systems:**
- Any specific donors supporting through FMoH Water Safety Dept
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<td><strong>Recommendations:</strong></td>
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<td><strong>3</strong></td>
<td><strong>WHO</strong></td>
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</table>
| **Scope of assignment:** | **Components of outputs – strategic framework & update guidelines**  
**Manuals / protocols – were also mentioned but not specifically mentioned in the ToR – to discuss how this will fit with other outputs?**  
**Any thoughts on style of framework or other preferred?** |
| **WHO’s role:** | **Re-clarify WHO’s interest, role and actions in this area?** |
| **CEHA training:** | **Details on the CEHA training done so far on water safety?**  
**See questions above** |
| **Current status of water safety in Sudan:** | **Current strengths of the systems?**  
**Current weaknesses / challenges?** |
| **Sub-areas:** | **Policies, strategies, guidelines etc:**  
**Water safety planning:**  
**Water treatment and monitoring capacities:**  
**Laboratories:**  
**Responsibilities for water safety in Sudan:**  
**Capacities:**  
**MIS systems:**  
**Particularly focus on WHO supported systems, but also discuss other systems:**  
**Recommendations:**  
**Recommendations for key issues that need to be highlighted in the water safety framework** |
| **4** | **UNICEF** |
| **UNICEF’s role:** | **Clarify UNICEF’s interest, role and actions in this area?**  
**How does the work supporting CATS/CLTS overlap?** |
<p>| <strong>Current status of water safety in Sudan:</strong> | <strong>Current strengths of the systems?</strong> |</p>
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<th>REDR</th>
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<td>• REDR training that includes a water safety component?</td>
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<td>• Who is training for?</td>
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<td>• How many people have been trained?</td>
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<td>• Training plans?</td>
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<td>• Strengths / gaps seen in this area through experiences of training?</td>
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<th>Universities and training institutions (at both Khartoum and State level)</th>
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<td>Universities / Training institutions:</td>
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<td>• Scope of your courses related to water safety?</td>
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<td>o What do you teach?</td>
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<td>o To whom?</td>
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<td>o How many students per year?</td>
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<td>• Course curriculum – is it possible to have a copy?</td>
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<td>• Laboratories:</td>
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<td>o See questions above</td>
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<td>• Do students get the chance to do field experience related to water safety surveillance etc?</td>
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<td>• Trained staff – lecturing / lab work / field work?</td>
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<td>• Past, current and planned involvement in water safety in Sudan</td>
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<td>• Support for DWSTs?</td>
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<td>• Support for urban monitoring systems?</td>
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<td>• Any reports on assessments or plans?</td>
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<td>• Monitoring systems?:</td>
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<td>• UNHCR?</td>
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<td>• Linking in with govt systems?</td>
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<td>• How responsibilities align / overlap with those of the Localities and Administrative Units?</td>
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<td>• Work on strengthening the WASH sector?</td>
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<td>• Work on strengthening the M&amp;E systems?</td>
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<td>WASH Sector (humanitarian) lead</td>
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<td>WASH Cluster’s involvement in water safety:</td>
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<td>Influence / role in water safety?</td>
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<td>Committee on Refugees</td>
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<td>Membership?</td>
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<td>Khartoum State Water Utilities</td>
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<td>State MoUPI / WES team (Kassala &amp; White Nile)</td>
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<td>Any specific regulations controlling water utilities?</td>
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</table>
**Recommendations:**
- Recommendations for key issues that need to be highlighted in the water safety framework

### 4 Locality (in Khartoum State)

#### Local level

**Current status of water safety in the Locality:**
- Current strengths of the systems?
- Current weaknesses / challenges?

**Sub-areas:**
- Locality level regulations / guidelines etc:
  - What exists at present?
- Water safety planning:
  - See questions above
- Water treatment and monitoring capacities:
  - See questions above
- Laboratories:
  - See questions above
- Responsibilities for water safety in the Locality:
  - Across sectors
  - At different levels
- Capacities:
  - See questions above

**MIS systems:**
- Particularly focus on the Locality-supported system:
  - What exists
  - How it functions
  - Information included
  - Who uses it + what levels
  - Overlaps with other systems?
  - Strengths / gaps

**Recommendations:**
- Recommendations for key issues that need to be highlighted in the water safety framework

### 5 Community / refugee camp (Kassala & White Nile)

*Ideally speak with women, men, community WASH Committee and representatives of disadvantaged groups – including when visiting households* 

**Current status of water safety in the refugee camp / community:**
- Current strengths of the systems?
- Current weaknesses / challenges?

**Sub-areas:**
- Water safety planning:
  - Have you been involved?
  - What did it consist of?
  - Where you trained in this?
    - If so by whom
    - What did the training consist of?
- Water surveillance capacities:
  - Is water surveillance undertaken?
  - Who undertakes it?
  - What do you do?
  - Can you give any examples of what problems you have found?
  - Can you give examples of what was done about the problems and by whom?
- Water treatment and monitoring capacities:
o Is any water treatment undertaken in the community?
o At community or water point levels?
o At household levels?
o How is this done?
o Does anyone check the quality of the water?
o Problems / challenges?
o Is there anyone in the community who cannot treat their own water at household level?
o If so then why?
o What do you think could be the solutions?
• Capacities:
o Have any community members – community leaders / WASH Committees / households etc – been trained on any aspect of water safety?
o Are there any areas that you think people in all communities / camps should be trained on in the future?

MIS systems:
• Do you have any records of the water safety planning I can see?
• Do you have any records of the water surveillance activities that I can see?

Water chain and household visits:
• Visit to water sources / supply points
• See water carrier systems
• Visit households
• Look at water storage
• Look at water treatment
• Discuss water safety with water suppliers
• Discuss / ask questions on water safety with households (female / male / children)

Recommendations:
• Recommendations for key issues that need to be highlighted at State and Federal level as to how water safety can be improved in the future for all communities and camps?
Annex III - Extracts from sector related laws, policies, strategies, guidelines and associated documents

The following section includes extracts from various WASH sector related laws, policies, strategies and guidelines and associated documents.

III.1 Environmental Health Act, 2009

The following are extracts from the Environmental Health Act, 2009:

Definitions:

- "Water pollution" means the introduction of any material in any source of drinking water is a voluntary way or involuntarily, directly or indirectly result in harm, or threaten human health or hinder the water activities or detract from the enjoyment or alter the properties,
- "Water source" means any sea or a river or a lake or a channel or a fountain or a stream or a flood or rain However or a well or water system or any other source is used for drinking,
- Hazardous materials "means hazardous characteristics, which are harmful to human health or adversely affect the health of the environment and include toxic or infectious substances, or explosive or ionizing radiation
- "Drinking water" means potable water for human use in accordance with the approved specifications,

Chapter III – Preservation of drinking water and air

Prevent water pollution:

7 - No person may be thrown or works to throw or discharge any solid or liquid or gaseous at any source of drinking water sources to the detriment or potentially detrimental to human health or the human use of water in other purposes without prejudice to the generality of the foregoing shall not anyone can throw at any drinking water sources:

- (A) industrial solid waste, liquid or gaseous treated or untreated,
- (B) chemicals interfere in any type of industry types with or without treatment,
- (C) the sewage or sewage treatment resulting from water courses or kitchens or bathrooms or toilets,
- (D) solid waste treated or untreated due to human use in housing or factory or anywhere else,
- (E) the remains of dead animals or animals or beasts of Ruth near or inside a well or canal

Foundations and health controls to preserve the drinking water:

8 - Must for anyone working in the field of drinking water in the various levels of government to abide by the conditions and regulations of the following:

- (A) To confirm the validity of drinking water and pollution-free networks in accordance with the approved specifications,
- (B) Conduct regular disclosure to employees in sources of drinking water to maintain their health and make sure they are free from infectious diseases.


See Section 6.1.1 - for details of this Act and Regulation.

MoWRIE GWD is keen to apply the certification, but will apply it gradually.
III.3  Regulations of DWS Control, 2014

No further details added here as the content has already been summarised in Section 6.1.1.

III.4  Environmental Conservation (Protection) Act, 2001

This establishes the Supreme Council for the Environment and Natural Resources identifies the competent agencies to protect the environment and includes punishments for polluters of water involving suspending projects or revoking the licence. The following are English translations from the Arabic Act.

Environmental objectives:

4 - The competent agencies in the exercise of its power or develop policies seek to achieve the following:

a. The protection of the environment and purity and natural balance and maintain the competent of the basic elements and their social and cultural systems to achieve the safety and sustainable development for the benefit of future generations

b. Upgrade the environment and sustainable use of natural resources for the purpose of development and conservation

c. The link between environment and development issues

d. Emphasis on responsibility of the competent authorities for the protection of the environment and strive to achieve this protection

e. Activating the role of the competent authority and its subsidiary bodies and prevent lax and shortcoming in performance

Establishment of the Council:

5 (1) - A council called the Supreme Council for the Environment and Natural Resources and have a legal personality and sustainable recipe cascade and common seal, and the right to litigate with his name.

Functions and power of the Council:

7 - Its functions include:

a) Setting the public policy in coordination with the competent authorities in the following matters:

   o Firstly – for the natural resources including their inventory development and rationalization of methods of use and manage, and protect them from degradation in an integrated and balanced manner so as to ensure the sustainable and increasing continuous provision

   o Secondly - to protect the environment in general

b) Coordinating the work of the councils of states and effort to inventory the country’s natural resources and straightened them, and identify their uses now and the future and monitoring the changes therein and identify areas that vulnerable to the dangers of deterioration and crawl such as desertification and environmental pollution, and to develop priorities of surveys and general and integrated studies to these natural resources.

c) To develop a long-term federal program for optimal and balanced use and conserve natural resources and the preservation of the environment and monitoring its implementation in coordination with the competent authorities.

d) Periodic review of the relevant legislation to ascertain the extent to keep pace and relevance of international standards for the development of the environment and natural resources, use and maintenance and make recommendations to competent authorities.

e) To coordinate the efforts of the country with regard to global agreements on the environment and identifying those entrusted with the implementation of those agreement.
f) The formation of specialized technical committees to assist the council in carrying out its work.

g) To attract government, local and international funding sources, to implement development programs and conservation of natural resources and environmental protection in cooperation with the competent authorities.

h) To encourage scientific research in all fields of the environment and natural resources and support it in coordination with national research centre.

i) Develop a federal plan to promote environmental awareness and sustainable use of natural resources and their maintenance, and work to embed it in the curriculum in cooperation with the competent authorities.

j) To pass the organizational structure of secretariat.

k) Set a regulation to regulate the internal procedures of its meetings.

The administrational organisation of the Council:

8 (1) The Council shall meet twice a year at least and chairperson may call to convene whenever he deems it necessary, and the regulation determines the procedure how to manage meetings and quorum and voting system.

(2) The Council shall have a general secretariat headed by general secretary is appointed by the Council of ministers on recommendation of the president of the council and membership of heads of any technical or specialized councils appointed by the Council.

Council of States:

14 - There shall be established in each state under a state law a council to the environment and natural resources by a decision of the governor, headed by the state minister competent and membership of ministers relevant to the environment and agencies and relevant bodies and a number of members that meet the knowledge and experiences of environmental affairs and natural resources.

The competent authorities:

16 - Each of the agencies listed below are a competent authorities to protect the environment and seek to achieve the objectives set forth in article 4 and the agencies are:

- a) The council in accordance with functions and the power conferred upon it under the provisions of this law.
- b) The ministries and federal agencies and institutions concerned health and environment protection in all fields of health and agricultural, industrial and housing, economic, cultural, social and other in accordance with the powers granted to them under the law in force
- c) The Council, ministries and organs of state and bodies competent to protect and upgrade the environment
- d) Societies and national and foreign institutions interested in upgrading and environmental protection authorized to work in the country as the environmental protection work of the people requires enable the community to play its role in organizing gross-roots effort at the federal and state level.
- e) The civil administration

The duties of the competent authority in observance of environmental policies:

18 - The competent authority shall observe and follow the following policies and guidelines for the protection and promotion of the environment in country:

- a) The development and adoptions of quality standards which lead to the protection of the environment and prevent its degradation and follow-up the commitment.
b) Maintaining the different sources of water and protect it from pollution and rationalize the use of water.

c) Plus a range of others

Offences:
20 - The following are considered to be offences [wording may be slightly different]:

b) The contamination of water sources like rivers an seas, lakes, ponds streams and canals, streams and reservoirs or natural or artificial water reservoirs and other which kept the water for the human or animal use.

Penalties:
21 –

(1) Violations of the provisions of article 20 shall be punished with imprisonment for a term not exceeding three years or a fine not exceeding one million Sudanese dinars or both may also confiscated infringing materials in favour of relevant authority in violation.

(2) The court may in the event of a conviction stop the project of facility or place the source of offense in whole or in part or revoke the license in whole or in part .

(3) May be double punishment stipulated in item 1 in the case of repeat offense.

(4) May be sentenced compensation to redress the financial damage caused by the violation of the provisions of this law.

Severe punishment:
23 - If the punishment stipulated in article 21 interferes with any penalty provided for in any other law shall be punished for the same offense the court must apply more severe punishment.

General provisions:
Pollution control standards and methods
24 - The Ministry [the federal ministry responsible for environmental affairs] in coordination with the council and competent authority designate the standards and methods of pollution control and reduction it in various fields for the purpose of advertising and published in all media.

Procedure for the entry and inspection of institutions
25 - The competent authority may after obtaining permission from competent prosecutor, enter and inspect any facility or project, place or other so as adjust or stop or prevent violations of provisions of this law.

The authority to issue regulations
27 - The Council has right with the consent of the minister to make regulations necessary to implement the provisions of this law.

III.5 Drinking water quality standards and guidelines

The Sudan DWQ 2016 standards have been established against the structure of the WHO DWQ guidelines, 2004 and 2011. The WHO DWQ guidelines, 2017 are now organised differently and there are additional constituents that have been indicated as of health significance that are not indicated in the SSMO Sudanese DWQ Standards 2016. A range of the Sudanese DWQ Standards are stricter than those of WHO. This is noted to be because Sudan is very hot in climate and hence people drink more water.

This may be appropriate for some parameters but the box below also highlights some perspectives from WHO on this strategy that would also be useful for consideration when updating the standards in the future. This includes that for some parameters such as Fluoride or Arsenic it may be appropriate for modifying the
levels based on the climate and volume of water drunk, but for many parameters where a person’s intake from water is very small compared to other sources, no adjustment is necessary.

**WHO perspective on target setting for DWQ**

The WHO Geneva team notes that:

- The WHO guidelines are established based on the assumption that an adult will drink 2 litres of water a day with 50% of this being assumed to be boiled or in food and that in very hot climates people may drink double this amount.

- The WHO Guidelines for DWQ note that daily water intake can vary significantly in different parts of the world, seasonally and particularly where consumers are involved in manual labour in hot climates. Local adjustments to the daily water consumption value may be needed in setting local standards, as in the case of fluoride, for example. For most other substances, the drinking-water intake range is very small (perhaps a factor of 2–4) compared with the much larger range in the toxicological uncertainty factors; hence, no such adjustment is necessary.

- That practical aspects need to be considered in standard setting. Some of the guideline values have been set considering these practical aspects, i.e. on the basis of achievable quantification levels or practical treatment levels. In these cases, the GVs have been designation as provisional “A” and “T”, respectively. So for these, chemicals, another reason it wouldn’t make sense to propose a lower standard, is that it may not be achievable or detectable.

**WHO DWQ Guidelines 2017:**

Pg 36: “Although water can be a source of microbial, chemical or radiological hazards, it is by no means the only source. In setting targets, consideration needs to be given to other sources, including food, air, person-to-person contact and consumer products, as well as poor sanitation and personal hygiene. Where the overall burden of disease from multiple exposure routes is very high, there is limited value in setting strict targets for drinking-water. For example, there is limited value in establishing a strict target for a chemical hazard if drinking-water provides only a small proportion of the total exposure to that chemical. The cost of meeting such targets could unnecessarily divert funding from other, more pressing health interventions and is not consistent with the public health objective of reducing overall levels of risk from all sources of exposure to environmental hazards”.

Pg 42: “Guideline values are established on the basis of international risk assessments of the health effects associated with exposure to the chemical in water. In developing national drinking-water standards (or health-based targets) based on these guideline values, it will be necessary to take into consideration a variety of environmental, social, cultural, economic, dietary and other conditions affecting potential exposure, as well as the default assumptions that are used to derive the guideline values. Exposure from chemicals in drinking-water is typically minor in comparison with that from other sources (e.g. food, consumer products and air), with a few important exceptions (e.g. arsenic and fluoride). This may lead to national targets that differ appreciably from the guideline values. In some cases, it may be appropriate to take action to prevent exposure to a chemical from sources other than drinking-water (e.g. lead from soldered cans and from petrol)”.

“It is important that water quality targets are established only for those chemicals that, following rigorous assessment, have been determined to be of health concern or of concern for the acceptability of the drinking-water to consumers. There is little value in undertaking measurements for chemicals that are unlikely to be in the system, that will be present only at concentrations much lower than the guideline value or that have no human health effects or effects on drinking-water acceptability. One example is that of radionuclides in drinking-water, which may be present in such minute quantities that their contribution to the overall health risks from drinking-water will be negligible. Analysis of individual radionuclides requires
sophisticated and expensive procedures; hence, in such cases, measurements of gross alpha and gross beta activities may be adopted as the screening tests for the presence of radionuclides in drinking water..

A= Provisional guideline value because calculated guideline value is below the achievable quantification level
C= Concentration of the substance at or below the health-based guideline value may affect the appearance taste or odour of the water, leading to consumer complaints.
D= Provisional value because disinfection is likely to result in the guideline value being exceeded.
P= Provisional guideline value because of uncertainties in the health database
T= Provisional guideline value because calculated guideline value is below the level that can be achieved through practical treatment methods, source protection etc
TCU = True Colour Unit
NTU = Nephelometric Turbidity Unit

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### Table 15 - Microbiological and biological contaminants

<table>
<thead>
<tr>
<th>No</th>
<th>Organisms</th>
<th>Sudanese maximum value by SSMO, 2016</th>
<th>WHO guideline value, 2017</th>
<th>WHO – health based or other value</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bacteria in treated and untreated water (SSMO) and All water intended for drinking (WHO)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>E</em>-coli or thermotolerant coliform bacteria</td>
<td>Shall not be detectable in any 100 ml sample</td>
<td>Must not be detectable in any 100ml sample</td>
<td>Health - indicator</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pathogenic intestinal protozoa</td>
<td>Shall not be detectable in any 100 ml sample</td>
<td>Not noted</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sulfite reducing bacteria (<em>clostridium perfringens</em>)</td>
<td>Shall not be detectable in any 100 ml sample</td>
<td>Not noted</td>
<td></td>
<td>WHO in notes: Only indicated as useful for indication of disinfection and physical removal processes for viruses and protozoa</td>
</tr>
<tr>
<td>2</td>
<td>Treated water entering the distribution system / network</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>E</em>-coli or thermotolerant coliform bacteria</td>
<td>Shall not be detectable in any 100 ml sample</td>
<td>Must not be detectable in any 100ml sample</td>
<td>Health - indicator</td>
<td>WHO in notes: Total coliform bacteria are not acceptable as an indicator of the sanitary quality of water supplies, particularly in tropical areas, where many bacteria of no sanitary significance occur in almost all untreated supplies. They can be used as an</td>
</tr>
<tr>
<td></td>
<td>Total coliform bacteria</td>
<td>Shall not be detectable in any 100 ml sample</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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126
Pathogenic intestinal protozoa  Shall not be detectable in any 100 ml sample  Not noted

Treated water in the distribution system / network

E-coli or thermotolerant coliform bacteria  Must not be detectable in 100ml sample  Must not be detectable in any 100ml sample  Health - indicator

Total coliform bacteria  Must not be detectable in any 100ml sample. In the case of large supplies where sufficient samples are examined, must not be detectable in 95% of samples examined throughout any consecutive 12 months period.

Pathogenic intestinal protozoa  Must not be detectable in any 100ml sample  Not noted

### Table 16 - Inorganic chemicals harmful to health

<table>
<thead>
<tr>
<th>No</th>
<th>Dissolved substances in water</th>
<th>Sudanese maximum permissible (mg/l) by SSMO, 2016</th>
<th>WHO guideline value (mg/l), 2017</th>
<th>WHO – health based or other value</th>
<th>Notes (H/L = Sudan = Higher/Lower than WHO)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Antimony</td>
<td>0.013</td>
<td>0.02</td>
<td>Health</td>
<td>L</td>
</tr>
<tr>
<td>2</td>
<td>Arsenic</td>
<td>0.01</td>
<td>0.01 (A, T)</td>
<td>Health</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>Barium</td>
<td>0.5</td>
<td>1.37</td>
<td>Health</td>
<td>L</td>
</tr>
<tr>
<td>4</td>
<td>Boron</td>
<td>1.6</td>
<td>2.4</td>
<td>Health</td>
<td>L</td>
</tr>
<tr>
<td>5</td>
<td>Cadmium</td>
<td>0.003</td>
<td>0.003</td>
<td>Health</td>
<td>-</td>
</tr>
<tr>
<td>6</td>
<td>Chromium (total)</td>
<td>0.03</td>
<td>0.05 (P)</td>
<td>Health</td>
<td>L</td>
</tr>
<tr>
<td>7</td>
<td>Copper</td>
<td>1.33</td>
<td>2</td>
<td>Health</td>
<td>L</td>
</tr>
<tr>
<td>8</td>
<td>Cyanide</td>
<td>0.05</td>
<td>-</td>
<td>Health</td>
<td>No WHO value as occurs in drinking water below health concern except in spills</td>
</tr>
<tr>
<td>9</td>
<td>Fluoride</td>
<td>1.5</td>
<td>1.5</td>
<td>Health</td>
<td>-</td>
</tr>
<tr>
<td>10</td>
<td>Lead</td>
<td>0.01</td>
<td>0.01 (A, T)</td>
<td>Health</td>
<td>L</td>
</tr>
<tr>
<td>11</td>
<td>Mercury (for inorganic Mercury)</td>
<td>0.006</td>
<td>0.006</td>
<td>Health</td>
<td>L</td>
</tr>
<tr>
<td>12</td>
<td>Molybdenum</td>
<td>0.05</td>
<td>-</td>
<td>Health</td>
<td>No value as levels that occur are below level of health concern</td>
</tr>
<tr>
<td>13</td>
<td>Nickel</td>
<td>0.05</td>
<td>0.07</td>
<td>Health</td>
<td>L</td>
</tr>
<tr>
<td>14</td>
<td>Nitrate (as NO₃)</td>
<td>33</td>
<td>50 - Short term exposure</td>
<td>Health</td>
<td>-</td>
</tr>
<tr>
<td>15</td>
<td>Nitrate as nitrate-nitrogen</td>
<td>7.3</td>
<td>Not noted</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
16 Nitrite (as NO₂⁻) 2 3 - Short term exposure Health L
17 Nitrite as nitrite-nitrogen 0.6 Not noted -
18 Selenium 0.04 0.04 (P) Health -
19 Uranium 0.01 0.03 (P) Health L

Table 17 - Organic chemicals that have harmful impacts

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Permissible level in µg/l by SSMO, 2016</th>
<th>WHO guideline value in µg/l, 2017</th>
<th>WHO – health based or other value</th>
<th>Notes (H/L = Sudan = Higher/Lower than WHO)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benzene</td>
<td>6.7</td>
<td>10</td>
<td>Health</td>
<td>L</td>
</tr>
<tr>
<td>Carbon tetrachloride</td>
<td>2.7</td>
<td>4</td>
<td></td>
<td>L</td>
</tr>
<tr>
<td>1,2-Dichlorobenzene</td>
<td>666.66</td>
<td>1,000 (C)</td>
<td></td>
<td>L</td>
</tr>
<tr>
<td>1,4-Dichlorobenzene</td>
<td>200</td>
<td>300 (C)</td>
<td></td>
<td>L</td>
</tr>
<tr>
<td>1,2-Dichloroethane</td>
<td>20</td>
<td>30</td>
<td></td>
<td>L</td>
</tr>
<tr>
<td>1,2-Dichloroethene</td>
<td>33.3</td>
<td>50</td>
<td></td>
<td>L</td>
</tr>
<tr>
<td>Dichloromethane</td>
<td>13.3</td>
<td>20</td>
<td></td>
<td>L</td>
</tr>
<tr>
<td>Di(2-ethylhexyl)phthalate</td>
<td>5.33</td>
<td>8</td>
<td></td>
<td>L</td>
</tr>
<tr>
<td>1,4 Dioxane</td>
<td>33.3</td>
<td>50</td>
<td></td>
<td>L</td>
</tr>
<tr>
<td>Edetic Acid</td>
<td>400</td>
<td>600</td>
<td></td>
<td>L</td>
</tr>
<tr>
<td>Ethylbenzene</td>
<td>200</td>
<td>300 (C)</td>
<td></td>
<td>L</td>
</tr>
<tr>
<td>Hexachlorobutadiene</td>
<td>0.4</td>
<td>0.6</td>
<td></td>
<td>L</td>
</tr>
<tr>
<td>Nitrilotriacetic acid</td>
<td>133.3</td>
<td>200</td>
<td></td>
<td>L</td>
</tr>
<tr>
<td>Pentachlorophenol</td>
<td>6</td>
<td>9 (P)</td>
<td></td>
<td>L</td>
</tr>
<tr>
<td>Styrene</td>
<td>13.3</td>
<td>20 (C)</td>
<td></td>
<td>L</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>26.7</td>
<td>40</td>
<td></td>
<td>L</td>
</tr>
<tr>
<td>Toluene</td>
<td>466.7</td>
<td>700 (C)</td>
<td></td>
<td>L</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>13.3</td>
<td>20 (P)</td>
<td></td>
<td>L</td>
</tr>
<tr>
<td>Xylenes</td>
<td>333.3</td>
<td>500 (C)</td>
<td></td>
<td>L</td>
</tr>
<tr>
<td>Acrylamide</td>
<td>0.33</td>
<td>Not noted</td>
<td></td>
<td>No WHO guideline</td>
</tr>
<tr>
<td>Epichlorohydrin</td>
<td>0.27</td>
<td>Not noted</td>
<td></td>
<td>No WHO guideline</td>
</tr>
<tr>
<td>Parameter</td>
<td>SSMO, 2016, Maximum Permissible level in µg/l</td>
<td>WHO guideline value in µg/l, 2017</td>
<td>Notes</td>
<td></td>
</tr>
<tr>
<td>-----------</td>
<td>---------------------------------------------</td>
<td>-----------------------------------</td>
<td>-------</td>
<td></td>
</tr>
<tr>
<td><strong>Pesticides</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alachlor</td>
<td>13</td>
<td>20</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>Aldicarb</td>
<td>6.75</td>
<td>10 - Applies to Aldicarb Sulfonide and Aldicarb Sulfone</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>Aldrin/Dieldrin</td>
<td>0.02</td>
<td>0.03 – For combined Aldrin and Dieldrin</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>Atrazine &amp; it’s Cholor-s-triazine metabolites</td>
<td>100</td>
<td>100</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Carbofuran</td>
<td>4.7</td>
<td>7</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>Chlordane</td>
<td>0.13</td>
<td>0.2</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>Chlorotoluron</td>
<td>20</td>
<td>30</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>Chlorpyrifos</td>
<td>20</td>
<td>30</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>Cyanazine</td>
<td>0.4</td>
<td>0.6</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>2,4-Dichlorophenoxy acetic acid (2,4 D)</td>
<td>20</td>
<td>30</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>2,4-dichlorophenoxybutyric acid (2,4 DB)</td>
<td>60</td>
<td>90</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>1,2-Dibromo-3-Chloropropane</td>
<td>0.7</td>
<td>1</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>1,2-Dibromoethane</td>
<td>0.27</td>
<td>0.4 (P)</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>1,2-Dichloropropane</td>
<td>26.67</td>
<td>40 (P)</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>1,3-Dichloropropene</td>
<td>13.33</td>
<td>20</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>Dichlorprop</td>
<td>66.7</td>
<td>100</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>Dimethoate</td>
<td>4</td>
<td>6</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>Edrin</td>
<td>0.4</td>
<td>0.6</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>Fenoprop</td>
<td>6</td>
<td>9</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>Hydroxyatrazine</td>
<td>133.33</td>
<td>200</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Isoproturon</td>
<td>6</td>
<td>9</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>Lindane</td>
<td>1.33</td>
<td>2</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>4-(2-Methyl-4-chlorophenoxy) acetic acid</td>
<td>1.33</td>
<td>Not noted</td>
<td>No WHO guideline</td>
<td></td>
</tr>
<tr>
<td>Mocoprop</td>
<td>6.66</td>
<td>10</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>Methoxychlor</td>
<td>13.33</td>
<td>20</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>Metolachlor</td>
<td>6.66</td>
<td>10</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>Molinate</td>
<td>4</td>
<td>6</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>Pendimethalin</td>
<td>13.33</td>
<td>20</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>Simazine</td>
<td>1.3</td>
<td>2</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>2,4,5-Trichlorophenoxyacetic</td>
<td>6</td>
<td>9</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SSMO, 2016, Maximum Permissible level in mg/l</td>
<td>WHO guideline value in mg/l, 2017</td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------------</td>
<td>-----------------------------------------------</td>
<td>----------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chlorine</td>
<td>3</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monochloramine</td>
<td>2</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sodium (as sodium dichloroisocyanurate)</td>
<td>33</td>
<td>30 (Sodium dichloroisocyanurate as sodium dichloroisocyanurate)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dichloroisocyanurate (as Cyanuric Acid)</td>
<td>0.026</td>
<td>40 (Sodium dichloroisocyanurate as cyanuric acid)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Disinfectant by-products**

<table>
<thead>
<tr>
<th>Disinfectant by-products</th>
<th>SSMO, 2016, Maximum Permissible level in µg/l</th>
<th>WHO guideline value in µg /l, 2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bromate</td>
<td>6.67</td>
<td>10 (A,T)</td>
</tr>
<tr>
<td>Bromodichloromethane</td>
<td>40</td>
<td>60</td>
</tr>
<tr>
<td>Bromoform</td>
<td>66.67</td>
<td>100</td>
</tr>
<tr>
<td>Chlorate</td>
<td>466.67</td>
<td>700 (D)</td>
</tr>
<tr>
<td>Chlorite</td>
<td>466.67</td>
<td>700 (D)</td>
</tr>
<tr>
<td>Chloroform</td>
<td>200</td>
<td>300</td>
</tr>
<tr>
<td>Dibromoacetonitrile</td>
<td>46.67</td>
<td>70</td>
</tr>
<tr>
<td>Dibromochloromethane</td>
<td>66.67</td>
<td>100</td>
</tr>
<tr>
<td>Dichloroacetate</td>
<td>33.33</td>
<td>50 (D)</td>
</tr>
<tr>
<td>Dichloroacetonitrile</td>
<td>13.33</td>
<td>20 (P)</td>
</tr>
<tr>
<td>Monochloroacetate</td>
<td>13.33</td>
<td>20</td>
</tr>
<tr>
<td>N-Nitrosodimethylamine</td>
<td>0.07</td>
<td>0.1</td>
</tr>
<tr>
<td>Trichloroacetate</td>
<td>133.33</td>
<td>200</td>
</tr>
<tr>
<td>2,4,6-Trichlorophenol</td>
<td>133.33</td>
<td>200 (C)</td>
</tr>
<tr>
<td>Trihalomethanes</td>
<td>The sum of the ratio of the concentration of each to its respective guideline value should not exceed 1</td>
<td>The sum of the ratio of the concentration of each to its respective guideline value should not exceed 1</td>
</tr>
</tbody>
</table>

**Disinfectants and disinfectants’ byproducts**

The sum of the ratio of the concentration of each to its respective guideline value should not exceed 1.

**WHO:** Not recommended for direct addition to DW as WHO’s policy to exclude use of pyrethroids for larvacing of mosquito vectors of human disease.
### Table 19 - The maximum allowable radioactivity

<table>
<thead>
<tr>
<th>Activity</th>
<th>Max. Permissible level in Bq/l</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross alpha activity</td>
<td>0.33</td>
<td>WHO specifies guidelines by radionuclide type</td>
</tr>
<tr>
<td>Gross beta activity</td>
<td>0.7</td>
<td></td>
</tr>
</tbody>
</table>

### Table 20 - Physical parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Sudanese guideline value by SSMO, 2016</th>
<th>WHO guideline value, 2017 (reason for acceptability)</th>
<th>Notes (H/L = Sudan = Higher/Lower than WHO)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Levels likely to affect consumer acceptance of water</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Physical parameters</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Colour</td>
<td>15 TCU</td>
<td>15 TCU (colour)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taste and odour</td>
<td>Acceptable</td>
<td>Cold water – more palatable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature</td>
<td>Acceptable</td>
<td>Higher temp – promotes growth of micro-organisms; taste; odour; corrosion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turbidity</td>
<td>5 NTU</td>
<td>Ideally &lt; 1 NTU (for disinfection – ideally &lt; 0.5 NTU for large WTPs)</td>
<td>Noted as higher of WHO guideline levels</td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>6.5 – 8.5</td>
<td>&lt; 8 (ideally for chlorination) 6.5 – 8.5 (usually optimal in distribution system)</td>
<td></td>
<td>WHO – no health based guideline</td>
</tr>
<tr>
<td>2 Inorganic constituents</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aluminium</td>
<td>0.13 mg/l</td>
<td>0.1 – 0.2 mg/l (aesthetic)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ammonia</td>
<td>1.5 mg/l</td>
<td>1.5 mg/l (odour) 3.5 mg/l (taste)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chloride</td>
<td>250 mg/l</td>
<td>200-300 mg/l (taste)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydrogen Sulphide</td>
<td></td>
<td>0.05 – 0.1 mg/l (taste)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

WHO - Higher than expected in WTPs – no guideline level for health
WHO – Occurs in drinking water below levels of health concern
WHO - not of health concern at levels affecting acceptability
WHO - not of health concern at levels affecting acceptability
<table>
<thead>
<tr>
<th>Substance</th>
<th>Value 1</th>
<th>Value 2</th>
<th>WHO Standard</th>
<th>WHO Concern</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron (total)</td>
<td>0.3 mg/l</td>
<td>0.3 mg/l</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.3 mg/l (staining)</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Manganese</td>
<td>0.27 mg/l</td>
<td>0.1 mg/l (taste)</td>
<td>Varied</td>
<td>WHO - not of health concern at levels affecting acceptability</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.4 mg/l (Health)</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Sodium</td>
<td>250 mg/l</td>
<td>200 mg/l (taste)</td>
<td>H</td>
<td>WHO - not of health concern at levels affecting acceptability</td>
</tr>
<tr>
<td>Sulfate</td>
<td>250 mg/l</td>
<td>250 mg/l for Sodium Sulphate 1,000 mg/l for Calcium Sulphate (taste)</td>
<td>-</td>
<td>WHO - not of health concern at levels affecting acceptability</td>
</tr>
<tr>
<td>Total dissolved solids (TDS)</td>
<td>1000 mg/l</td>
<td>1000 mg/l (taste)</td>
<td>-</td>
<td>WHO - not of health concern at levels affecting acceptability</td>
</tr>
<tr>
<td>Zinc</td>
<td>3 mg/l</td>
<td>4 mg/l (taste)</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3-5 mg/l (greasy film)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organic constituents</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-Chlorophenol</td>
<td>5 μg/l</td>
<td>0.1 μg/l (taste)</td>
<td>Higher than taste threshold</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>10 μg/l (odour)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2,4-Dichlorophenol</td>
<td>2 μg/l</td>
<td>0.3 μg/l (taste)</td>
<td>Higher than taste threshold</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>40 μg/l (odour)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2,4,6-Trichlorophenol</td>
<td>0.13 mg/l</td>
<td>2 μg/l (taste)</td>
<td>Lower than taste threshold</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>300 μg/l (odour)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
III.6 National policies related to drinking water, sanitation and hygiene

The previous two versions of the draft policies related to WASH were never approved and hence have not been referred to in this strategic framework.

III.7 WASH Sector Strategic Plan (2012-2016)

The following are extracts from the WASH Sector Strategic Plan with direct relevance to water safety:

Groundwater in Sudan (p26)

Renewable groundwater is about 4.5 billion m$^3$, and contributes for about 63% of the drinking water produced in the Sudan, of which 60% for Khartoum.

Younger sediment basins - These include sediment basins of Gazira and Um Rawaba which are the most important basins following the Nubian sediment basins. Besides, there are other basins such as Al-Gash and Wadi Nyala on which Kassala and Nyala depend for drinking and irrigation water. In addition, there are the valleys basins of the Red Sea Mountains range and range of Jebel Marra in the Greater Darfur and Nuba mountains and Butana and the sediment basins of the Nile. Groundwater basins of younger sediments are characterized by having limited capacity and being more vulnerable to pollution. Besides, there is high pressure on them that requires protection measures.

Nile rivers (p27)

The status of water of the Nile rivers is such that to date no very serious contamination of water is taking place. However with the increase in population and economic activities along the Nile (among the highest population densities in the world) and the lack of drinking water and sewerage / agriculture drainage water treatment, the water related health risks are rapidly increasing.

Rural Sanitation and Hygiene Sector approach (p36)

The sanitation and hygiene strategies for rural communities shall concentrate on six components:

- Package approach, that is addressing sanitation for all based on the Open Defecation Free settlements (ODF) concept, and hygiene simultaneously in households, schools and health units.
- Community based hygiene and sanitation promotion.
- That includes safe water handling and use.
- Latrine access and use.
- Hand washing.
- Food hygiene and keeping a clean home environment.

Urban Water, Sanitation and Hygiene approach (p36)

In terms of Urban Water and Waste Water treatment, the situation is more complex and less defined than in rural areas. Khartoum State Water Corporation (KSWC) operates as a semi-autonomous parastatal entering into direct contracts with foreign companies for investment and management of Khartoum city water provision, biased to formal settlements and hence under-serving the large informal settlements that have grown and still growing rapidly around the city.

All other major cities, mainly state capitals, run their own often old water supply systems, most without properly functioning water treatment provisions. Little new investment is currently taking place, other than addressing bulk water supply needs in some parts of the country, notably for Port Sudan and Kassala. Most towns do not have a proper sewerage system and rely on individual septic tanks and traditional improved latrines.

Water service provision principles (p38)

Under normal circumstances the priority for water use shall be accorded to the personal use of water for drinking, cooking food, and personal hygiene, while in the case of drought and emergency situation supply of
water for drinking shall be given the highest priority among other water uses. The provision of safe, adequate and sustainable water supply in equitable basis helps to maintain and build social peace and shared prosperity among communities.

Government is the custodian of all water resources in the Sudan in terms of protection from pollution and overuse, ensuring sustainability and to achieve an equitable distribution among communities. All consumers who use the public water systems for drinking and other uses shall pay the water tariff, without exception. The principle of ‘the polluter pays’ indicates that surface and groundwater shall be kept free from contamination that result from uncontrolled sewage flows, solid and liquid waste disposal, industrial waste discharges, chemical fertilisers and pesticides and introduction of other pollutants into the surface water bodies and groundwater aquifers. And that polluters, whether individuals or organizations, shall be responsible for all the damage and required clean-up.

Drinking water standards (p45)

Current drinking water standards for Sudan shall be actively enforced to ensure the standards are applied. Water from new water sources shall be tested to certify that the water is fit for human consumption and water from existing water sources shall be regularly monitored to ensure proper quality standards are maintained.

Planning for monitoring and sector learning (p69)

Objective 1 - Ensure that M&E Unit at PWC and SWC is well established and functioning and also starts monitoring the Sanitation and Hygiene components of the Water, Sanitation and Hygiene Sector Monitoring of different water resources, include basic overview of trends in water use, especially human use and livestock, rural and urbanisation and possible environmental (waste water) problems and measure coverage and access to, and functionality and use of water supply and sanitation services in urban and rural areas to new target policy until 2016.

Objective 2 - Coordination of emergency preparedness operations at state level: There are three levels of coordination regarding the response to the emergency situation: at local, state and national level. Most of the states have emergency committee to manage the operations and facilitates linkages between the different levels. In most cases major support usually comes from the national level. UN agencies and NGOs usually play key role in emergency preparedness and response.

Objective 3 - Coordination of M&E with the States in training in M&E, and share guidelines and standards, joint resources allocation, modern different Water, Sanitation and Hygiene Sector acceptable and sustainable technology through foreign and local investment for federal, states rural and urban levels by 2012. Relationship between PWC and SWCs, roles and responsibilities are well defined.

Objective 4 - Establishment of a Management Information System (MIS) fully integrated with an affordable and user friendly Geographic Information System (GIS like the Water Point Mapper of WaterAid; mobile phone based monitoring systems are being tested) for proper performance through processing and analysing monitoring data in place by 2013.

Objective 5 - Monitor and report of national and internationally funded projects implemented at state level, which are channelled through PWSC.

A National Water, Sanitation and Hygiene Sector Resource Centre (p70)

Many countries have established so-called national (and at time sub-national) WASH sector resource centres to play a facilitating role in sector learning and sharing, through activities including providing meta level overview, access and “how to make best use” of existing information and knowledge sector wide (horizontal in terms of areas of knowledge) and across all levels (vertically from communities up to national and international levels).
The Sudan WASH sector will explore to what extent the emerging sector training facility of the WES Unit housed in PWC could start up such a Resource Centre Facility to engage in sector learning based networking. Such an initiative could also benefit the proposed communication strategy under component 2 and capacity development under component 3.

Monitoring framework (p70)

The Water, Sanitation and Hygiene sector will have to develop a comprehensive and integrated sector monitoring framework. This framework will form the basis of a revision and strengthening of the current sector Management Information System (MIS) and data obtained from the less frequent sector relevant household survey data. A comprehensive monitoring framework will cover all sub-sectors as identified in the National WASH Sector plan. In the future this WASH sector monitoring framework will also ensure its integration in a broader water resources management monitoring framework. To ensure the integration of the monitoring framework, key performance indicators at sub-state, state and national level will have to be formulated and made coherent.

The monitoring framework development and increased sophistication will have to be based on current affordability and monitoring capabilities at the various sector governance and management levels.

A top priority in this strategic sector plan has been given to the required monitoring capacity building at all relevant levels (see monitoring and sector learning estimates). Capacity building will not only aim at enhanced monitoring capacity but also at sector learning. Sector learning is the activity that is based on monitoring outcomes and ensures that sector management and governance are adjusted regularly based on the lessons learned from the monitoring activities.

Development of MIS (p71)

The sector information management system (MIS) has to be improved and regularly updated to accommodate the adopted monitoring system and various management information formats required in the sector.

There is no need to start with a composite and complicated system and high ambitions for the sector information management. Instead, a straightforward database system along with reliable data collection and data reporting tools can be introduced. Establishing an operational database alone is not sufficient to provide relevant information to management. There are other areas that need to be improved concurrently.

First, the data collection process must be efficient and effective in order to assure that all required management information at all relevant levels are made available in a timely fashion. Second, the data and analysis have to be quality controlled throughout the data handling process. Third, the required information management system needs to be complemented relevant analysis and clear management needs oriented reporting and visualization (Geographic Information System (GIS) for mapping). The GIS needs to demonstrate its value to justify its investment and operational costs, by delivering demand based outputs, that start with simple but useful products and as expertise increases incrementally expands its services and products to all relevant stakeholders in the sector.

These are the outlines of the planned and proposed information management system. Such system at its core is composed of a flexible, updatable database along with a GIS tools and should be able to rely on a quality chain of data collection, compilation, consolidation and sharing among all relevant sector management levels.

A continuous capacity development and maintenance programme needs to support this crucial sector management tool.
### III.8 National Environmental Health Strategic Plan, 2015-19

**Drinking water management, sanitation and hygiene**

**Priority actions:**
- Strengthen and establishment of water quality monitoring and surveillance system at 15 states.
- Strengthen advocacy and promotion activities in water safety, sanitation and hygiene.
- Strengthen monitoring, surveillance and evaluation system.

**Timeline, actions and indicators:**

*Table 21 - NEHS Plan, 2015-91 – Timeline, actions and indicators*

<table>
<thead>
<tr>
<th>Strategic Response</th>
<th>Action by MOH and other Government Agencies</th>
<th>Needed Support from WHO and other Partners</th>
<th>Indicator</th>
<th>Base Line</th>
<th>Target (2019)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Development and Establishment of water quality Monitoring &amp; surveillance system (15 states)</td>
<td>- Generate biannual rational report on assessment and analysis of the water and sanitation sector. - Development of guidelines and manuals (Water quality, safety sanitation and hygiene). - Mapping of drinking water sources. - Establishment two Regional laboratories WQ. - Capacity building of 18 SMOH (personnel, laboratories, equipment etc) to conduct regular water quality test - Conduct supervising visits.</td>
<td>Technical and financial support</td>
<td>- No of states establishing functional water surveillance system.</td>
<td>3 states</td>
<td>15 states</td>
</tr>
<tr>
<td>4. Strengthen hygiene promotion activities in water safety, sanitation and hygiene.</td>
<td>- Conduct advocacy to involve decision makers to improve sanitation and hygiene promotion - Raising sanitation awareness of communities - Conduct different Campaigns on five pillars. (Usage of safe water, latrine, hand washing, food safety and vector control.</td>
<td>Technical and financial support</td>
<td>- No of advocacy meeting done - No. of people disseminate key messages.</td>
<td>4 0 Every week</td>
<td></td>
</tr>
</tbody>
</table>
III.9 Sudan National Sanitation and Hygiene Strategic Framework: Water safety

The following extracts of key relevance to water quality have been taken from the SNSHSF.

### Vision

<table>
<thead>
<tr>
<th>All people in Sudan have access to and use improved sanitation (excreta disposal), dispose of solid and liquid wastes safely and practice healthy hygiene behaviours; contributing to a clean environment, a disease-free Sudan, the upholding of a range of human rights and the longer term prosperity and development of Sudan.</th>
</tr>
</thead>
</table>

### Purpose

<table>
<thead>
<tr>
<th>The SNSHSF will contribute to scaling up S&amp;H across Sudan in development, humanitarian and transitional contexts through:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Providing clear strategic direction, leading to increased harmonisation of approaches by all stakeholders across sectors, including government, non-governmental organizations and the private sector.</td>
</tr>
<tr>
<td>2. Increasing understanding of the cross-sectoral responsibilities and the contributions of S&amp;H to upholding a range of rights for the people of Sudan, including but not limited to: education, health, nutrition, dignity, gender equality and economic development.</td>
</tr>
<tr>
<td>3. Encouraging increased collaboration, partnerships and engagement across sectors, resulting in increased commitment, resources, learning and strengthened capacities of all stakeholders.</td>
</tr>
</tbody>
</table>

### Principles

<table>
<thead>
<tr>
<th>The scaling up of S&amp;H across Sudan will be undertaken with the following principles:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Principle 1 - Community engagement and equity</strong> - Community engagement and understanding the norms, skills, priorities and needs of communities, particularly women and girls and those of vulnerable or marginalised groups, will underpin efforts to develop solutions</td>
</tr>
<tr>
<td><strong>Principle 2 - Leadership, coordination and partnerships</strong> - Strong, clear and accountable leadership, coordination, partnerships and teamwork will underpin all efforts</td>
</tr>
<tr>
<td><strong>Principle 3 - Capacity development</strong> - Developing capacities at individual, institutional and enabling environment levels is recognised as a key step in the process of scaling up for sustained solutions</td>
</tr>
<tr>
<td><strong>Principle 4 - Sustainability</strong> - Sustainability of facilities and behaviours will be integral to the design of solutions</td>
</tr>
<tr>
<td><strong>Principle 5 - Monitoring, evaluation and learning</strong> - Innovation will be encouraged and the quality and effectiveness of interventions will be improved through continual monitoring, evaluation and the sharing of learning and fed back into designs for improved solutions</td>
</tr>
</tbody>
</table>

### Strategies - Water Safety

<table>
<thead>
<tr>
<th>Strategic objectives:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. To improve water safety across Sudan through the protection of sources, water surveillance and treatment and capacity building.</td>
</tr>
</tbody>
</table>
Strategies:

**Enabling environment:**
1. Develop water safety plans at State, Locality, community, water point and household levels (handling, storage, transportation and treatment).

**Supply:**
2. More attention to be put into the protection of water resources - such as through borehole design, water storage and distribution systems through fencing, improving drainage and separation of water points for animals and humans.
3. Strengthen water surveillance systems, including using sanitary inspections, water quality testing, monitoring and record keeping; and including survey and monitoring at household levels.
4. Support the use of water treatment including chlorination with appropriate pre-treatment and point of use water treatment systems.
5. Undertake capacity building of water surveillance staff at Locality and community levels (water committees, operators).

**Situation analysis**

The SNSHSF also provides situation analysis in the following relevant areas:

- Water safety
- MIS & M&E
- Capacity building
- Coordination, advisory bodies or decision-making bodies and legal and policy framework for water safety

However as this report has developed the contextual analysis further - the extracts from the SNSHSF have not been included here. Refer to the SNSHSF, final draft, 2016 for more information.
Organograms

Organograms for the MoH and MoWRE highlighting the departments that have a role in S&H, including water quality in Sudan.

Fig 28 - Organogram of the FMoH (1 of 2)
Fig 29 - Organogram of FMoH (2 of 2) - Directorate of Environmental Health & Food Control Administration

Fig 30 - Organogram for the MoWRE including DWSU and the WES Programme
III.10 Humanitarian strategies

Humanitarian response plan, 2017

Sector Strategy

Within Outcome 1, the WASH Sector will provide services as per the agreed standards for immediate, early and short term response, to address context specific WASH needs of Sudan. The response will be carried out through several channels such as contingency plans, pre-positioned supplies, joint assessment / implementation / monitoring, and will consider cross-cutting issues. At the onset of emergencies, WASH partners will ensure adequate service and management of facilities in collaboration with national, state and local authorities, and affected people.

By addressing the low coverage of WASH services, under Outcomes 2 and 3, the sector will provide resilience support to long-term affected people and will tackle the WASH-related causes of malnutrition by implementing durable approaches and promoting adequate hygiene behavior. Emphasis will be placed on water rationing, water tariff systems and cost reduction strategies. To avoid disease outbreaks, innovative approaches will target open defecation and will promote handwashing and vector control. For continued access to sufficient quantity and quality of water, special emphasis will be placed on water resource management, water safety and sanitary risk control. The overall response will target the most vulnerable people. Throughout the response cycle, national, state and local authorities as well as community members and their leaders will be fully integrated.

For all interventions in 2017, the sector will deliver a comprehensive package which encompasses improved access to SDW, sanitation and hygiene services. For Outcome 1, the response will target 40-50,000 displaced and 180,000 flood-affected persons. For Outcomes 2 and 3, the response will target 3.2 million affected people of whom 600,000 are malnourished children. The WASH response will target areas which have a vulnerability index of 4 and 5 and within those areas attention will be paid to at-risk groups such as children, women, female-headed households, older and disabled persons. A specific emphasis will be placed on addressing needs of IDP in camps where service is below the emergency standards.

Multi-Year Humanitarian Strategy and link with development planning

The WASH Sector’s 2017 strategy and activities align with several national development plans such as the Sustainable Development Goals (mainly SDG 6), UNDAF areas of focus 2, 3 and 4, the Government of Sudan 5-year WASH framework plan, and the WASH Sector Improvement Agenda elaborated by WASH partners. WASH partners will continue to address long-term WASH priorities including quality assurance and functionality of WASH facilities, generation of evidence, development of water supply business plans and cash-based market interventions, integrated water resources management as well as sanitary and disaster risk mitigation.

The WASH Sector will continue to implement durable technologies for improved service, as well as low cost / maintenance and eco-resilient infrastructures such as solar-powered and flood and drought resistant infrastructures. National authorities and communities will continue to be key actors in the O&M of WASH facilities and sanitary risk management (safe water handling, end of open defecation, handwashing, water source protection).

In 2017, the sector will continue to develop the capacity of WASH partners and affected people to ensure they ultimately manage WASH infrastructures and integrated services. Concrete examples include capacity building of national authorities and communities for O&M of WASH facilities to carry out sanitary risk mitigation activities and environmental awareness. Partners will also promote the development of private sector initiatives.

In line with the Multi-Year Humanitarian Strategy, the WASH Sector will develop its programme and implement its activities at national, state and local levels. In year 1, WASH will develop a 3-year strategy and annual plans and it will address the issue of water quality, enhance community-based O&M and improve the
situation in substandard camps. In year 2, the sector will harmonize its training curricula and community mobilization approaches. In year 3, the sector expects that sustainable mechanisms will allow the government to better manage WASH services.

**Inter-sectoral initiatives and collaboration**

In 2017, the WASH Sector will continue to ensure that the response among sectors is geographically coordinated. To address and prevent malnutrition and communicable diseases such as acute watery diarrhoea, the WASH Sector will work with the Health Sector to ensure that vulnerable people have sufficient clean drinking water and encourage latrine use and hand-washing. In collaboration with the Education Sector, the WASH Sector will provide children with favorable learning environments by ensuring that schools are served with nearby water points, clean latrines, that hygiene is part of the curriculum and work with Parent Teacher Associations on awareness-raising. In cooperation with the Health and Education Sectors, water and sanitation facilities will be extended to health clinics, feeding centres, schools, child-friendly and community spaces as well as reception / registration centres.

To ensure conditions for return are met in designated locations, WASH resources will be mapped and infrastructure will be rehabilitated in collaboration with the RRR Sector. Capacity building of affected people and local authorities in water point operation, maintenance and management will also be carried out in targeted communities.

In collaboration with RCF, the WASH Sector will support needs assessments and service provision to vulnerable refugees including ensuring access to sufficient clean water and distribution of hygiene, dignity and water kits.

**Cross-cutting issues**

WASH Sector programming will ensure that vulnerable people are included in decision-making and implementation bodies. WASH facilities will be properly located and adapted for convenient use and protection of vulnerable groups such as women, children and older persons. Water activities will include a management component that will prevent conflict over sources. To ensure that children and their families have access to basic WASH services, WASH partners will extend water connections and latrines to child-friendly spaces, registration centres and community spaces. To reduce its environmental footprint and better manage scarce water resources, the WASH Sector will move away from using fossil fuel and encourage solar water pumping, it will also protect water source protection, monitor water levels, minimize wastewater and adopt preventive methods for vector control to reduce the use of chemicals.

**South Sudan, Regional Refugee Response Plan, Jan – Dec 2017**

Addressing existing gaps in access to WASH facilities and services will be essential. The response will continue to improve safe water supply access, with emphasis on water quality monitoring and maintenance, and the provision of WASH-related core items to all refugee households. The provision of basic sanitation services at all refugee sites will be ensured, including improvements in the provision of wastewater disposal, solid waste and sludge collection and refuse disposal. Intensified hygiene promotion at refugee sites will also be pursued, including hand washing and latrine usage, safe water handling and storage and water conservation, with special attention paid to the hygiene needs of children at risk of malnutrition.
III.11 School WASH

The National School Health Strategy, 2016-20, Draft

Strategies (p30):

- Establish/improve water supply in all schools (at least installation of handpumps)
- Safe reservation of water & promote a community based chlorination system
- Improve source of water in health facilities in catchment areas

National Guidelines for Implementation of an Effective School Health Programme, 2003-16, Draft

Provision of healthful, integrated, safe and supportive school environment:

WASH

1. Establish water points relevant to the number of students and staff for the general use.
2. Provide SDW. In resource constrained setting, teachers can be trained on water chlorination with tablets.
3. Personal hygiene with focus on hand wash should be a daily programme in each school.
4. The private sector can be an effective partner on providing the washing facilities and provision of subsidized, attractive small pieces of soap manufactured for the purpose.
5. Promotion of soap utilization as gifts to students will promote the hand wash.
6. Students should be encouraged to have a small size soap (home left over)
7. Handwash emphasis can be made routinely as an instruction to all teachers, in the morning assembly and in the last five minutes before breakfast.
8. Teachers and student’s association should take the lead on promoting good practices.
9. Latrines should follow the national standards (1/50 student), gender friendly, clean and safe.
10. Establish a garbage disposal system that protects the health of students.
11. Distribution of safe dust bins along with clear attractive messages to encourage students to use them and keep clean environment.
Annex IV - Water sources and water quality monitoring forms and databases

The following table provides an overview of the different types of DWS related record keeping forms viewed at different levels and kept by different institutions during consultancy trip 1.

Table 22 - Examples of record keeping forms for DWQ analysis seen during trip 1

<table>
<thead>
<tr>
<th>Institution</th>
<th>Content and aim</th>
<th>How the form is used (if known)</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 FMoH</td>
<td>Monthly report by State to the Primary Health Directorate / EH and Food Safety – data provided by locality and includes:</td>
<td>Form sent from each State to FMoH for monitoring</td>
<td>Not clear what are the ‘average’ figures</td>
</tr>
<tr>
<td></td>
<td>• <strong>Tests for main WTPs and for public networks</strong> – bacteriological / pH / turbidity / chlorine</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• <strong>Tests for wells</strong> – bacteriological / conductivity / arsenic / nitrate / fluoride / other (average results and also targets / achieved)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• <strong>Tests for hafirs and for other sources</strong> – Fluoride / Nitrate / Arsenic / Alkalinity (and whether the water meets the ‘health standard for hafirs’)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• <strong>State supervision</strong> – How many sources meet the standard or otherwise and action needed</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• <strong>WQ test equipment</strong> – How many items exist of what specification – includes: Wagtech Potatext; Photometer 7500; Conductivity pH TDS; and Chemical reagents</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 MoWRIE / DWSU / WES Project</td>
<td>Achievements template used for WES teams to report to MoWRIE on a monthly basis. Includes:</td>
<td></td>
<td>Not clear why DPD4 would be needed?</td>
</tr>
<tr>
<td></td>
<td>• <strong>Activities</strong> – such as:</td>
<td></td>
<td>Presuming the stock records are for the stock at SWC central level [and not also including at Localities]</td>
</tr>
<tr>
<td></td>
<td>o New construction of water points</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>o Rehabilitations of water points</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>o O&amp;M activities</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>o DWQ tests – now FRC taken; bacteriological test; chemical tests</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>o Groundwater monitoring and geophysical surveys</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• <strong>Sanitation and hygiene promotion activities</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Institution</td>
<td>Content and aim</td>
<td>How the form is used (if known)</td>
<td>Comment</td>
</tr>
<tr>
<td>-------------</td>
<td>-----------------</td>
<td>---------------------------------</td>
<td>---------</td>
</tr>
<tr>
<td></td>
<td>School and health facilities water supply and sanitation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Capacity building – including operators trainings, Village Health Committee trainings and number of community members trained in water quality</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Needs assessments, KAPs and monitoring visits</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Monthly supply sheet update- includes:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>o The amount of chlorine – Chlorine powder 45kg drums; 1.67 g in 200 tab cans; 33mg in 10,000 tabs boxes</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>o Chlorine testers</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>o Chlorine DPD1, DPD3 and DPD4 tablets / 250 pc</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>o H₂S kits</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FMOH National Public Health Lab, Food and Microbiology Department and National Chemical Laboratories</td>
<td>Laboratory test results for DWQ test</td>
<td>To provide evidence of test results and certification of whether the samples meet the SSMO DWQ standards</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Examples seen of test results for bottled water – where Total coliform, E.coli and ‘Coagulade +ve Staph’ were tested + a range of physical and chemical tests. One set of test results were that the bottled water did not meet the SSMO water specification and the other did.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Khartoum State Water Corporation</td>
<td>Nile water analysis report – provides maximum / minimum levels for a range of physical and chemical parameters for the Blue, White and River Nile</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Burri WTP, Khartoum State</td>
<td>Daily report log book – includes:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>o Raw water, filtered water, treated water, clarified water by clarifier – tests for turbidity and pH with three time periods (2 completed for the day viewed)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>o Raw and final water – FRC, pH, pH alkalinity (not completed, and T.alkalinity</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>o Jar test – had been completed using three jars for the day viewed – includes dose, turbidity, pH, T.alkalinity and result</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

It was positive to see that a jar test had been undertaken on the day viewed. However not clear as to why the recommended dosage was 15ppm but the applied dosage was 20ppm? Maybe this related to the inability to control the dosage exactly as the controls did not seem to have clear dials.
<table>
<thead>
<tr>
<th>Institution</th>
<th>Content and aim</th>
<th>How the form is used (if known)</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mogran WTP, Khartoum State</td>
<td>Saw a laboratory book for tracking the types of algae – green; blue-green, diatoms, the number of organisms and algae / litre.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MoH, Khartoum State, Environmental Health Dept.</td>
<td>Residual chlorine and turbidity test results for water treatment plants – indicates the plant name (16 total), the Chlorine residual and turbidity and if any corrective action is needed.</td>
<td>This report is provided to the Khartoum SWC by WhatsApp at least two times a week. The receipt of the reports was also confirmed by the SWC.</td>
<td></td>
</tr>
<tr>
<td>Khartoum State Locality</td>
<td>Viewed a summary sheet indicating activities undertaken on a weekly basis in response to the AWD outbreak. This includes issues such as disinfection of houses.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| MoH White Nile | Water quality record sheet – includes:  
  - Total coliform  
  - pH (has a measurement of mg/l – which is not correct)  
  - NTU  
  - FRC | Few errors on the form – such as mg/l for pH and has total coliform instead of thermotolerant coliform / E.coli (Total coliform is not an appropriate indicator for faecal contamination) | |
| Refugee camp White Nile (WTP managed by SWC and MoH undertaking monitoring) | Two weekly record of consumable usage and water production records includes:  
  - Chemical volumes – PAC and chlorine  
  - Residual chlorine – at the water tank and the tap  
  - Turbidity – of the raw and clear water | The form is good, but the handwriting is very similar for every day for the two week period and also the chemical and WQ figures are very similar, so not 100% sure if these figures are all real figures (for example exactly the same amount of chlorine and PAC is reported for each day even though the flow and time of operation varies) | |
| | Water station checks form including daily, weekly and monthly checks for:  
  - Pump engine oil and fuel filter  
  - Chlorine check  
  - PAC check or aluminium sulphate  
  - Silage valve open | Another positive sheet in concept to prompt action, although not fully clear what the ticks mean so could be improved | Another positive sheet in concept to prompt action, although not fully clear what the ticks mean so could be improved  
  - The WTP does not have an electronic jar testing capacity. They report that they send samples to Kosti Town, several hours away |
<table>
<thead>
<tr>
<th>Institution</th>
<th>Content and aim</th>
<th>How the form is used (if known)</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| WHO White Nile | Water monitoring in South Sudanese arrivals camps by week – No samples, FRC, pH, turbidity, if the sample is safe – tests at the WTPs, water in the distribution units bladders, water in the households | • Only one biological sample was recorded as having been taken in this particular week.  
• Useful sheet indicating that monitoring is being undertaken on a systematic basis along the water supply chain. Could be useful for adaptation elsewhere.  
• But some concern that some of the results reported for compilation may not be real results – for example all the households (H/H) were reported to have an FRC or 0.1 or 0.2 and even with a turbidity of 40 in one camp at the H/H, all samples were still indicated as ‘safe’. However in the totals it was indicated that of 214 samples only 201 were considered safe. However it is not clear how ‘unsafe’ was established when the samples had chlorine residuals and in most cases microbiological tests were not done. | |
<p>| | | | |
|             |                 |                                 |         |
| Kassala State Water Corporation, Water Analysis Laboratory | Laboratory test results for WQ test of groundwater supplies. A range of physical and chemical tests are included but not microbiological tests. | For approval of a groundwater borehole for use for drinking water. | Microbiological tests not included. |</p>
<table>
<thead>
<tr>
<th>Institution</th>
<th>Content and aim</th>
<th>How the form is used (if known)</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>13 MoH Kassala – Water Supply Department / EH Directorate</td>
<td>Register of WQ testing equipment in Localities – current and needs</td>
<td>Record for requesting additional equipment for localities</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Register of water sources in the State by Locality</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Monthly WQ report indicating chlorine stock, chlorine distributed, water test analysis in the network and outside of the network – how many tests have been planned and taken</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14 Kassala Rural Locality, Health Affairs Dept</td>
<td>Weekly form for the distribution of chlorine to Water Yards – amount distributed and targeted and the result (example seen of Week 22)</td>
<td>This form appears to be counting the number of water networks where the test has been undertaken and indicating the residual (between 0.3-0.4mg/l).</td>
<td>Chlorine residuals indicated from 0.1 to 0.4 mg/l</td>
</tr>
<tr>
<td></td>
<td>Form called ‘Residual chlorine report - for water networks’ – indicating by water network both community and camp</td>
<td></td>
<td>No table for DWS activities, but notes included at the bottom of the table on how many tablets were distributed and the number of samples taken (3 on this particular day).</td>
</tr>
<tr>
<td></td>
<td>Daily report of activities related to Environmental Health. Includes tables for: EH campaigns, vector control, food safety, number of animals slaughtered.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15 North Darfur State WES</td>
<td>WASH programme Status Monitoring Sheet – which has information on the current status of water points including whether they are functioning or not functioning and repairs. They also have a space for chlorination and water quality results bacteriological – with spaces to indicate tests at water points and also in jerry cans and in the household. They also have spaces for latrine cleaning campaigns, solid waste campaigns and the distribution of hygiene kits and soaps.</td>
<td>The information is meant to be passed to the WES team at State level on a weekly basis</td>
<td>However, it is not clear if these forms are currently in use (the sample shared was from 2015). A summary weekly report in text format was also shared from 2016.</td>
</tr>
<tr>
<td></td>
<td>Analysis laboratory, North Darfur, Weekly Report – this form notes if the water point is a borehole or a handpump and if they are ‘fit’ or ‘unfit’. There is a column for reason but these are noted as codes which are not indicated on the sheet.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16 WES in Zamzam camp, North Darfur</td>
<td>No records were available at Zamzam camp level of any water quality or water safety related data. But information is fed through to the WES team at State level for the weekly reports.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Institution</td>
<td>Content and aim</td>
<td>How the form is used (if known)</td>
<td>Comment</td>
</tr>
<tr>
<td>-------------</td>
<td>----------------</td>
<td>--------------------------------</td>
<td>---------</td>
</tr>
</tbody>
</table>
| North Darfur State MoH | A range of completed monitoring sheets (SMoH and UNICEF) from the field staff filed in the State MoH office. Including ones that covered checks on household:  
- Free residual chlorine  
- Water storage – good / not good  
- Jerry cans with condition – broken / without cover  
- Hand-washing facilities with soap  
- Latrine with condition  
- Cleaning of kitchen  
- Solid waste disposal and environmental situation  
- Household members disaggregated  
Plus quarterly reports on activities | Field staff complete and pass to State MoH | Good range of DWS related checks at household level. |
<p>| MoH in Zamzam camp in north Darfur | MoH staff at camp level had a personal notebook with records in but did not have a log book/ structured record of the checks that are being done at household and community level in Zamzam camp. | | Gap of no structured records of monitoring kept in Zamzam. |</p>
<table>
<thead>
<tr>
<th>No</th>
<th>Name</th>
<th>Organization managing</th>
<th>Funded by</th>
<th>Notes on content</th>
<th>Sanitary survey or WSP related data</th>
<th>Water quality related components</th>
<th>Scope of use in 2017</th>
</tr>
</thead>
</table>
| 1  | WES database                | DWSU / WES            | UNICEF    | Includes technical details on the location, type of water source, construction, water quality, pump and well information and management information. Uses a designed database with data entry forms. It has a GIS application. It was mostly completed in a project basis. | No - only one entry on:  
  - Fencing status  
  - No details - of the drainage seal to the borehole or well, whether there is standing water, or if the covers and platforms are in good condition. | Includes data boxes for:  
  - Monitoring date  
  - Sampling date  
  - WQ analysis date  
  - Chemical quality (fit/not fit – not specifics)  
  - TDS  
  - Bacteriological quality  
  - Chemical comment  
  - Chlorination | Not in use |
| 2  | Water source and water quality mapping | MoH | WHO | Very positive model for water safety. Uses a simple spreadsheet database which has a number of very good elements – it includes a column for sanitary survey scores and priorities for action as well as water point GPS locations and standard details of the water point including key water quality. | Yes – includes:  
  - Who manages the water point  
  - Sanitary inspection score  
  - Risk analysis  
  - Whether action was taken & category | Includes columns for:  
  - E.coli/100ml  
  - Turbidity  
  - pH / TDS / E.C.  
  - F / NO₃ / Cl₂ / Fe  
  (but the Kassala database seen did not have the WQ components completed except for E.coli/100ml) | This was established with the support of WHO CEHA and mapping undertaken in 7 States 3 years ago. It was also supported by WHO in East Darfur in 2016/17. In most places it has not been updated for a few years, because of cost for mapping and updating large numbers of water points, but has locations and data for water sources from original mapping process. |
| 3  | Groundwater database        | MoWRIE/ GW Directorate | UNEP      | As well as details of the GW source, aquifer formations and details of the GW basins, it also has a broad range of water quality parameters (not all | No |  
  - Colour / Odour / Temp / Taste  
  - EC / pH / Dissolved Oxygen / TDS  
  - Turbidity | Established in 2014 to restart the mapping process. Currently has 12,000 boreholes entered. This replaces the very good |
<table>
<thead>
<tr>
<th></th>
<th><strong>GWD laboratory</strong></th>
<th><strong>MoWRIE</strong></th>
<th><strong>Access database with the DWQ</strong></th>
<th><strong>Laboratory tests a range of parameters in the following groups:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>MoWRIE GWD laboratory</strong></td>
<td><strong>MoWRIE</strong></td>
<td>results that it has tested</td>
<td>Physical – Colour / Turbidity / E.C. / Dissolved O2 / Odour / pH / taste / suspended solids</td>
</tr>
<tr>
<td></td>
<td><strong>Laboratory</strong></td>
<td><strong>MoWRIE</strong></td>
<td><strong>Access database with the DWQ</strong> results that it has tested</td>
<td>Aesthetic – TDS / Total hardness / various alkalinitities / Chloride / Sulphate / Ca / Mg / Na / K / Silica / Fe</td>
</tr>
<tr>
<td></td>
<td><strong>Laboratory</strong></td>
<td><strong>MoWRIE</strong></td>
<td><strong>Access database with the DWQ</strong> results that it has tested</td>
<td>Inorganic of health significance – Fl / NO₃⁻ / NO₂⁻ / NH₃ / Mn / As / Cu / Pb</td>
</tr>
<tr>
<td></td>
<td><strong>Laboratory</strong></td>
<td><strong>MoWRIE</strong></td>
<td><strong>Access database with the DWQ</strong> results that it has tested</td>
<td>Micro – <em>E.coli</em> / Faecal / Total coliform</td>
</tr>
</tbody>
</table>

The MoWRIE GWD laboratory database is not linked into the main MoWRIE GWD database. The argument that has been given for this is that to enter into the main database the water point data must have a GPS reading, whereas many of the samples in the laboratory do not, including private sector boreholes.

### Microorganisms

<table>
<thead>
<tr>
<th></th>
<th><strong>Water quality data</strong></th>
<th><strong>DWST</strong></th>
<th>The DWST has the ability to access water quality data in map format.</th>
<th>Not clear how large their database is. It is not linked to the MoWRIE GWD database or the WES database.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Water quality data</strong></td>
<td><strong>DWST</strong></td>
<td>The DWST has the ability to access water quality data in map format.</td>
<td>Not clear how large their database is. It is not linked to the MoWRIE GWD database or the WES database.</td>
</tr>
<tr>
<td></td>
<td><strong>Water quality data</strong></td>
<td><strong>DWST</strong></td>
<td>The DWST has the ability to access water quality data in map format.</td>
<td>Not clear how large their database is. It is not linked to the MoWRIE GWD database or the WES database.</td>
</tr>
<tr>
<td></td>
<td>M&amp;E system</td>
<td>MoWRIE</td>
<td>AfDB</td>
<td>A consultancy is in process to support the MoWRIE to develop a new M&amp;E system that is presumed is likely to include some form of database. It will also include some aspects of sanitation.</td>
</tr>
<tr>
<td>---</td>
<td>------------</td>
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<td>------</td>
<td>---------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>7</td>
<td>Sanitation and hygiene MIS system and update previous WES database</td>
<td>FMoH / MoWRIE</td>
<td>UNICEF</td>
<td>A consultant is currently being recruited to develop a sanitation and hygiene MIS system and to update the previous WES database.</td>
</tr>
<tr>
<td>8</td>
<td>Water Atlas</td>
<td>Understood to have been started in White Nile</td>
<td></td>
<td>As part of a training course, JICA supported the White Nile SWC to map the water sources in one Locality and to establish a WASH Atlas. It is believed that this includes the maintenance status of the water sources and supplies.</td>
</tr>
</tbody>
</table>
Annex V - Capacities – water quality analysis

The following table provides an overview of the access to water quality laboratories and equipment and their current state of repair, as visited July-Aug 2017.

### Table 24 - Overview of water quality analysis equipment in laboratories and field equipment in Sudan

<table>
<thead>
<tr>
<th>Lab / Field only</th>
<th>Microbiological test capacity</th>
<th>pH</th>
<th>Chlorine residual</th>
<th>Turbidity</th>
<th>Photometer / Spectrophotometer</th>
<th>Atomic Absorption Spectrometer</th>
<th>TDS / conductivity</th>
<th>High Performance Liquid Chromatography (HPLC) / Flame photometer (FP)</th>
<th>Other</th>
<th>Jar test</th>
<th>Pesticides / insecticides</th>
<th>Algae</th>
</tr>
</thead>
<tbody>
<tr>
<td>FMoH – equipment distributed to States / Localities</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Wagtech/ Palintest Potatest</td>
<td>Palintest 800</td>
<td>Primelab Photometer</td>
<td>Palintest 800</td>
</tr>
<tr>
<td>MoH National Public Health Laboratory</td>
<td>Have several labs</td>
<td>MF</td>
<td>Viruses Molecular PCR Agar gel</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>AAS – lamp broken</td>
<td>Yes</td>
<td></td>
<td>Titrator</td>
<td>Yes for both - other depts.</td>
<td></td>
</tr>
<tr>
<td>MoWRIE – Central DWST lab</td>
<td>Have lab</td>
<td>MF &amp; McConkeys</td>
<td>Portable electrode</td>
<td>Use AAS</td>
<td>AAS</td>
<td>Portable electrode</td>
<td>Flame HPLC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>MoWRIE – GWD lab</td>
<td>Have lab</td>
<td>Delagua Membrane filtration</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Jenway photometer</td>
<td></td>
<td>Shimadzu AA-6200 Flame Emission Spec Aqualytic AL800 Spect + HACH (order)</td>
<td></td>
<td>Isotopic – Tritium</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Khartoum SWC Central lab (at Mogran WTP)</td>
<td>Have lab + lab based equip</td>
<td>Agar gels</td>
<td>MF but no consumables</td>
<td>Jenway meter</td>
<td>Meter</td>
<td></td>
<td></td>
<td>Shimadzu</td>
<td>AA-6200 Flame Emission Spec Aqualytic AL800 Spect + HACH (order)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Khartoum SWC Burri WTP lab</td>
<td>Have lab but use field equip + jar test</td>
<td>MF kit but not consumables</td>
<td>Disc Electronic also</td>
<td>DR1200 Colorimeter</td>
<td>2100N</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Titrator</td>
</tr>
<tr>
<td>Khartoum MoH Central lab</td>
<td>Micro lab based</td>
<td></td>
<td>All other equipment is broken</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Function**
- Function
- Not function

**Not function**
- Function
- Not function

**Equipment**
- Photometer
- Spectrophotometer
- Atomic Absorption Spectrometer
- TDS / conductivity
- High Performance Liquid Chromatography (HPLC)
- Flame photometer (FP)
- Other
- Jar test
- Pesticides / insecticides
- Algae
<table>
<thead>
<tr>
<th>Lab / Field only</th>
<th>Microbiological test capacity</th>
<th>pH</th>
<th>Chlorine residual</th>
<th>Turbidity</th>
<th>Photometer / Spectrophotometer Atomic Absorption Spectrometer</th>
<th>TDS / conductivity</th>
<th>High Performance Liquid Chromatography (HPLC) / Flame photometer (FP)</th>
<th>Other</th>
<th>Jar test</th>
<th>Pesticides / insecticides</th>
<th>Algae</th>
</tr>
</thead>
<tbody>
<tr>
<td>Khartoum Locality Field equipment only</td>
<td>Field equipment only</td>
<td>Report have just a few H2S tubes Use bottled broth from Khartoum MoH lab</td>
<td>Use Photometer</td>
<td>1 x Turbidity meter – ELE Internat.</td>
<td>2 x Palintest Photometer 7500</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Khartoum University lab</td>
<td>Nice lab. Field equip + some lab equip</td>
<td>MPN and MF equipment (but MF only used occasionally due to cost)</td>
<td>Palintest pH sensor stick meter</td>
<td>Use photometers</td>
<td>2 meters – Hannah and Palintest 950</td>
<td>Palintest 7500 and 8000 Photometers + Jenway 6305 UV/V Spectrophotometer + Electronic dialCo.in – 2306 Visible Spectrophotometer (digital programme)</td>
<td>EuTech TDS stick sensor</td>
<td>Palintest conductivity stick sensor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kassala MoH lab</td>
<td>Have lab. Have field equip only</td>
<td>1 x Wagtech Potatest (1 x old + locality kit) No incubator except for Wagtech Potatest</td>
<td>Palintest Micro Multi 800</td>
<td>Photo meter 7100 (old) + 7500</td>
<td>Palintest Micro Multi 800</td>
<td>Palintest Micro Multi 800 – salinity + EC</td>
<td>Big box of Palintest consumables</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kassala SWC central lab</td>
<td>No lab – using a meeting</td>
<td>Wagtech Potatest (but not regularly)</td>
<td>Use Spectrophotometer</td>
<td>Yes</td>
<td>HACH DR3900 Spectrophotometer</td>
<td>HACH DR 4000 U spectrophotometer –</td>
<td></td>
<td>Digital titration for Chloride</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Lab / Field only**
- or not used
- Salmonella
- Shigella
- AWD

**Microbiological test capacity**
- Function
- Not function

**pH**
- Function
- Not function

**Chlorine residual**
- Function
- Not function

**Turbidity**
- Function
- Not function

**Photometer / Spectrophotometer Atomic Absorption Spectrometer**
- Function
- Not function

**TDS / conductivity**
- Function
- Not function

**High Performance Liquid Chromatography (HPLC) / Flame photometer (FP)**
- Function
- Not function

**Other**
- Function
- Not function

**Jar test**
- Function
- Not function

**Pesticides / insecticides**
- Function
- Not function

**Algae**
- Function
- Not function
<table>
<thead>
<tr>
<th>Lab / Field only</th>
<th>Microbiological test capacity</th>
<th>pH</th>
<th>Chlorine residual</th>
<th>Turbidity</th>
<th>Photometer / Spectrophotometer</th>
<th>Atomic Absorption Spectrometer</th>
<th>TDS / conductivity</th>
<th>High Performance Liquid Chromatography (HPLC) / Flame photometer (FP)</th>
<th>Other</th>
<th>Jar test</th>
<th>Pesticides / insecticides</th>
<th>Algae</th>
</tr>
</thead>
<tbody>
<tr>
<td>White Nile MoH</td>
<td>Field equip only</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wagtech Potatess – 3 at State level</td>
<td>Palintest 800</td>
<td>Use photometer</td>
<td>Palintest turbidity meter x 2</td>
<td>Palintest Photo-meter 7500 (not seen – but have consumables)</td>
<td>Palintest 800</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7 at Locality level – pool-testers only</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White Nile SWC</td>
<td>Central lab (at Kosti WTP)</td>
<td>MF unit</td>
<td>Pool-tester</td>
<td>Pool-tester</td>
<td>HACH MM374 Sensor (broken 2015)</td>
<td>HACH Pocket Colorimeter (used for 1 year – then no reagent)</td>
<td>HACH 2100</td>
<td>HACH 2100 N – broken lamp (since 2010)</td>
<td>Stick meter</td>
<td>Titratation by hand 1 x microscope</td>
<td>Yes – one per day</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Have lab + some field equip</td>
<td>Pool-tester</td>
<td>Pool-tester</td>
<td>Pool-tester</td>
<td>HACH Pocket Colorimeter (used for 1 year – then no reagent)</td>
<td>HACH 2100</td>
<td>HACH 2100 N – broken lamp (since 2010)</td>
<td>Stick meter</td>
<td>Titratation by hand 1 x microscope</td>
<td>Yes – one per day</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alagaya Refugee Camp WTP</td>
<td>Field equipment and table in grass hut</td>
<td>Palintest + Photometer</td>
<td>Pool-tester + Photometer</td>
<td>Pool-tester + Photometer</td>
<td>Turbidity tube (broken but just usable)</td>
<td>Palintest Photo-meter 7500</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Room. But have lab equip used) 1 x MF funnel + use MLSB (borrowed) which was used for 3 years then stopped working (15 years age)
<table>
<thead>
<tr>
<th>Lab / Field only</th>
<th>Microbiological test capacity</th>
<th>pH</th>
<th>Chlorine residual</th>
<th>Turbidity</th>
<th>Photometer / Spectrophotometer Atomic Absorption Spectrometer</th>
<th>TDS / conductivity</th>
<th>High Performance Liquid Chromatography (HPLC) / Flame photometer (FP)</th>
<th>Other</th>
<th>Jar test</th>
<th>Pesticides / Insecticides</th>
<th>Algae</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>East Darfur WES team laboratory</strong></td>
<td>Field</td>
<td>Function</td>
<td>Not function</td>
<td>Function</td>
<td>Not function</td>
<td>Function</td>
<td>Not function</td>
<td>Function</td>
<td>Not function</td>
<td>Function</td>
<td>Not function</td>
</tr>
<tr>
<td><strong>East Darfur SMoH laboratory</strong></td>
<td>Lab</td>
<td>Wagtech portable kit</td>
<td>Wagtech</td>
<td>Wagtech</td>
<td>Presumed to have a Photometer</td>
<td>Presumed to have a turbidity meter</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>South Darfur WES team laboratory</strong></td>
<td>Lab</td>
<td>Yes – but not used</td>
<td>Yes</td>
<td>Wagtech</td>
<td>Palintest photometer 7500</td>
<td>EC Meter</td>
<td>Have transport</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>South Darfur SMoH laboratory</strong></td>
<td>Lab and field kits</td>
<td>Wagtech field kit</td>
<td>Palintest 7100 x 4</td>
<td>Pooltesters x 20</td>
<td>Turbidity tube</td>
<td>Palintest photometer 7500</td>
<td>EC Meter</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Central Darfur SWC team laboratory</strong></td>
<td>Lab</td>
<td>Delagua kit</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>HACH Spectrophotometer 3900 and Photometer 5000</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>West Darfur WES team laboratory</strong></td>
<td>Lab</td>
<td>Delagua kit</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Spectrophotometer (?) 5000</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Notes:**

1. Radiological – if suspected then samples are taken to the Sudan Armed Forces lab for testing
2. Petrochemical spills / contaminants – Ministry of Oil and Gas or Ministry if Minerals laboratories
3. White Nile DWST – uses the SWC Kosti WTP laboratory for its trainings
4. Kassala AHS – does not have a laboratory so uses the Kassala MoH laboratory
5. H₂S kit:
   a. Only seen few samples of tubes + box in White Nile MoH
   b. Kassala Rural Locality – said they had received some before but they were already out of date
   c. Khartoum Locality – said just have a few H₂S tubes (but not clear they are used, as use bottles of broth from Khartoum MoH laboratory for micro test)
6. See Section 6.5.4 for further details of the university laboratories

---

**Table 25 - Summary of laboratory capacities, lab staff and major challenges**

<table>
<thead>
<tr>
<th>Lab</th>
<th>Summary of capacities</th>
<th>Lab staff</th>
<th>Major challenges</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>MoH National Public Health Laboratory</td>
<td>Most comprehensive capacity of all labs with ability to test for pesticides and some toxins and also have access to a poisoning lab that can test for insecticides. In 2007 was able to do environmental assays for <em>V.cholerae</em>. But still has some broken and old equipment.</td>
<td>Not discussed</td>
<td>• Laboratory needs updating</td>
<td>Would like to train the biomedical engineers in how to repair the specialised equipment and set up a workshop – that could then be accessed by other labs.</td>
</tr>
<tr>
<td>MoWRIE – Central DWST lab</td>
<td>Well equipped laboratory with some higher tech. equipment and capacity. Equipment well looked after, but not adequate in number for needs.</td>
<td>4 lab staff – 1 Chemist; 2 Chemical Engineers and 1 Microbiologist.</td>
<td>• Lack of funds for reagents (JICA provides some equipment and reagents sometimes)</td>
<td>Lab was provided by JICA. Reagents are available from HACCP a private company in Sudan, who get them from the USA. Takes 3 weeks if they don’t have them in stock.</td>
</tr>
<tr>
<td>Khartoum SWC Central lab (at Mogran WTP)</td>
<td>Have a range of equipment and a number of staff in both chemical and microbiological labs. Microbiologist doing analysis of algae by standard microscope for past 5 years. Have undertaken a 300 well survey. Also did a 20 well survey for AWD – 20 micro (total coliform) and 20</td>
<td>Multiple staff (did not record numbers but saw at least 8 on visit)</td>
<td>• Consumables are available in Sudan but very expensive</td>
<td>For repairs there is some capacity in Sudan – for example for Jenway equipment. For HACH equipment this is a US/Germany company – so need to buy from Emirates which is expensive.</td>
</tr>
<tr>
<td>Lab</td>
<td>Summary of capacities</td>
<td>Lab staff</td>
<td>Major challenges</td>
<td>Notes</td>
</tr>
<tr>
<td>------------------------------</td>
<td>----------------------------------------------------------------------------------------</td>
<td>--------------------</td>
<td>----------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Khartoum SWC Burri WTP lab</td>
<td>Doing basic testing for turbidity and chlorine residual as well as jar tests for PAC. Have some electronic meters but not using them.</td>
<td>2 chemical eng</td>
<td>• Staff feel they need training in chlorination using gas – system not integrated</td>
<td>Have some electronic equipment for pH and Chlorine residual but do not use it (batteries and find visual easier).</td>
</tr>
</tbody>
</table>
| Khartoum MoH Central lab     | Only has microbiological test capacity. All other equipment was broken at the time of the visit (several for 7 years) or no consumables. A later update included that the equipment was under maintenance is now functional. Has expensive HPLC equipment that has not been used. | 3 microbiologists out of 10 staff – also do blood analysis | • Broken equipment at the time of the visit  
• Not have access to consumables  
• HPLC – had since 2011 but not used – not trained, no supplies, consumables too expensive  
• Might use the HPLC for blood samples instead as consumables about SDG 240,000 per year instead of SDG 2 million for water related tests  
• Don’t go to the field to bring samples | It seems a waste to have a HPLC sitting for 7 years not being used, when other labs do not have this equipment, including the University of Khartoum who could make better use of it.  
The limited capacity of this lab is concerning as various other institutions mentioned using this lab for results (Khartoum State MoH; other universities sending students here etc). |
| Khartoum Locality            | Have two sets of Palintest 7500 photometer but only one turbidity meter. Sometimes visit schools. | 2 water quality staff | • Lack of vehicles – the EH team as a whole only has access to 1 for 15 localities  
• Two team members but only one turbidity meter  
• Sometimes they have run out of chlorine but rarely | Staff are clearly very active but suffer from lack of equipment and vehicles.  
They buy the DPD1 tablets from the market. |
| Khartoum University lab      | Good quality laboratory and clearly very well looked after equipment. But small numbers of equipment so it is only possible to demonstrate for large groups of students. | Several staff       | • Not enough equipment for students to have practical experience – only demonstrations for groups of 40 students. Only those who do research have the chance to use the equipment.  
• Cost of consumables. | If there is equipment not being used elsewhere it could be well used and maintained in University Departments such as this. |
| Kassala MoH lab              | Has some field equipment – Wagtech Potatetest (including one that is for a Locality) + a Multi meter. Also has a large box of Palintest | No lab staff – previously trained a chemist for this lab but they left - | • No lab staff  
• No vehicle to collect samples  
• No photometer to use some of the consumables available | Equipment and large box of consumables not being used.  
AHS students noted to use this lab. |
<table>
<thead>
<tr>
<th>Lab</th>
<th>Summary of capacities</th>
<th>Lab staff</th>
<th>Major challenges</th>
<th>Notes</th>
</tr>
</thead>
</table>
| Kassala SWC       | Does not have real lab so have converted a meeting room at a WTP. But no water or sink so carry by hand to/from room. Lab well looked after and equipment used well, but challenges for travelling to respond to complaints, and also repeated requests for equipment repairs not responded to. | Very committed Chemist + one or two other staff | • No real laboratory. So have adapted a meeting room and carry water by hand to the room (and no sink).  
• No vehicle to get to follow up on complaints + take samples – sometimes have to wait 7 days or go with MoH or WHO.  
• Requested repair of equipment over long period of time but no response from SWC.  
• Gap in equipment to test chemicals such as arsenic, pesticides etc. – need a AA Spectrophotometer; Flame Photometer; HPLC | Very impressive what is being done with limited facilities. Staff clearly highly committed and doing a good job with limited access to required items. |
| Kassala SWC – other labs at WTPs (not visited) | Reported in relation to other WTPs:  
• Girba – have pH meter / turbidimeter / chlorine pool tester  
• Watta Helo (surface water, no lab, new WTP) – Chlorine, pH and turbidity tube  
• Old stations do not have lab capacity/ equipment. | Information not requested | • Reported that other labs at WTPs across the State have very little equipment | It is difficult to see how the WTPs keep to Sudanese DWQ standards when some do not have any equipment. |
| White Nile MoH    | Have a range of field equipment but not all Wagtech Potatets have been used. No laboratory area so equipment is being stored in a filing cabinet in an office. | 3 staff in EH team at State level – 1 who is Water Safety team. | • Often don’t have transport. Only one vehicle available for EH team and not in good order. Can only visit one Locality weekly.  
• All workers not well trained.  
• No equipment for sampling and sterilisation  
• Only at State level they have a Photometer – so no measurement of turbidity and TDS at Locality level (although they have Potatets so | Staff met committed but trained themselves to use equipment.  
A couple of basic errors spotted such as doing Total coliform and using ethanol, so some capacity building support would be useful. |
<table>
<thead>
<tr>
<th>Lab</th>
<th>Summary of capacities</th>
<th>Lab staff</th>
<th>Major challenges</th>
<th>Notes</th>
</tr>
</thead>
</table>
| White Nile SWC Central lab (at Kosti WTP) | Has a laboratory but range of equipment broken or no consumables. Have a database on computer and could show examples of test results covering raw, filtered and tap water. | 12 lab / WQ staff in Kosti Locality and Central lab 28 lab staff in WN State | • Should be able to use the Turbidity Tube)  
• No formal laboratory in the whole of the State [although we visited a lab at the SWC at Kosti WTP] | Seemed quite a lot of staff for a laboratory with limited functioning equipment, although the lab is clearly active in monitoring at the WTP. |
| Alagaya refugee camp WTP | Has a Palintest Photometer but only with pH and chlorine consumables and are using pooltester. Have a Wagtech Potatest, but has not been used. Said they do jar tests in Kosti town, but this was not convincing as this is several hours away. | 6 staff run the WTP 1 MoH staff member does monitoring of residuals in both camps 1 WES staff covers both camps | • Turbidity tube was broken – just about usable but not easy to use.  
• No jar testing facilities on site (and staff don’t seem to be aware of field jar testing methods) | Good record keeping forms including for checking on fuel, coagulant, chlorine etc. But form could be clearer as to what ticks mean and some risk that figures may just be entered without checking (very similar figures + chlorine residuals checked on site where higher than noted on form). |
| East Darfur WES team laboratory | Currently only test for residual chlorine and pH | | • Have a spectrophotometer, a flame photometer and digital burettes but no laboratory so they are not used.  
• Lack of funds for operations including monitoring | |
| East Darfur SMoH laboratory | Laboratory of 3 rooms was supported by WHO since Sept 2017. | PHO, water quality technicians and public health overseer – 5 | • Currently only have Wagtech portable kits but WHO has committed to supporting all biological and chemical equipment (fixed). | All staff were trained on water quality monitoring and WSPs by WHO and FMoH |
| South Darfur WES team laboratory | Have a bacteriological field kit and photometer They also have transportation to go to the field | 5 trained staff with BSc in chemical science and water resources management | • They have not used the microbiological kit – this is to be shifted to be analysed at the SMoH  
• They don’t have a database | They have reports of water quality analysis (but no details noted) |
| South Darfur SMoH laboratory | Have a bacteriological field kit and photometer + stock for 4 months | 6 trained staff with qualifications at BSc level in chemical science and | • No means of transportation to be able to undertake water testing in the field  
• Don’t have a database | All the lab equipment was in good condition (the lab was established recently) Have forms including |
<table>
<thead>
<tr>
<th>Lab</th>
<th>Summary of capacities</th>
<th>Lab staff</th>
<th>Major challenges</th>
<th>Notes</th>
</tr>
</thead>
</table>
| Central Darfur SWC team laboratory      | Have a laboratory and kits to do chemical and microbiological tests and can also to titrations. They have a Spectrophotometer and a Photometer and can do titrations.                                                   | 3 staff in lab – Head of lab, a geologist and a chemist (temporary staff) | • They don’t have higher equipment  
• For chemical tests they are doing this when a new borehole is drilled  
• Sometimes they test their existing water networks every 3 months but this depends on the resources available (budget, vehicles, consumables etc)  
• They do not have their own transport and depend on their partners (NGOs)  
• They need training on how to remove parameters (such as Fluoride) so they don’t have to shut down sources | Sanitary inspection, surveillance, chlorination and chlorine distribution. Forms refer to ‘WHO standards’ and not SSMO. |
| West Darfur WES team laboratory         | Have a laboratory and kits to do chemical and microbiological tests and can also to titrations.                                                                                                                                 |                                                                            | • They do a chemical test for every new borehole drilled and also bacteriological every 3 months in the 3 IDP camps  
• They don’t have higher equipment |                                                                                                                                                                                                                   |
Annex VI - Capacity building – training courses

Drinking Water Supply Training (DWST) institutions:

The following table provides an overview of the courses and their elements of most relevance to water safety being run by the DWSTs.

Table 26 - Courses run by DWSTs of particular relevance to water safety

<table>
<thead>
<tr>
<th>Course title</th>
<th>Duration</th>
<th>Participant level</th>
<th>Content of relevance to water safety (note: this does not include all elements of the course)</th>
</tr>
</thead>
</table>
| 1 Pipe network management & design               | 2 weeks  | Civil eng. Mech. eng. W/Res. eng. Technicians | • Problems with the pipe network management in Sudan
• Water leaks – prevention, detection and measures
• Yield and pipe network management
• Flow management and measurement
• Hydraulics, design criteria, pipe materials
• Operation of networks
• Design of pipe network using software |
| 2 Mechanical management / Water Supply Facilities | 2 weeks  | Mech eng. Electr. eng. | • Generators, pumps, electrical equipment
• Principles of electrical measuring instruments and handling
• Practical trouble shooting of pump and control panel
• Trouble shooting of generator
• Assembling of generator and pumps
• Visit to water treatment plant |
• Administration and management of the water treatment plant
• Water quality management
• Hydraulics, pumps, electricity |
| 4 Water quality analysis 1                       | 2 weeks  | Laboratory staff and engineers | Basic water quality analysis:
• Basics, sampling
• How to apply the standards
• Water quality concepts introduction |
| Water quality analysis 2                         | 2 week   | Laboratory staff and engineers | How to use instruments and calibrate:
• Spectrophotometer – how to use and calibrate
• May have DR/4000U HACH – (some 5000)
• Flame photometer – Na, K, Ca
• Atomic Absorption Spectrometer – trace elements – 6300 (P/N 206 – 51800) |
| Water quality analysis 3                         | 2 week   | Laboratory staff and engineers | How to check bacteriologically:
• Faecal – E.coli - M.Filtr. – media – LS Broth / McConkeys agar
• Salmonella - microscope
• How to apply the ISO 17025 – Laboratory standard |
| Water quality analysis 4                         | 1 week   | Laboratory staff and engineers | High performance liquid chromatography:
• HPLC |
| 5 Water well management 1                        | 2 weeks  | Hydrogeologist Drillers Mech. eng. W/Res eng. G/water eng. | • Elements of water well design
• Detection of well problems
• Groundwater hydraulics
• Borehole drilling methodologies |
| Water well management 2                         | 2 weeks  | Hydrogeologist Drillers Mech. eng. G/water eng. Geologist | • Well maintenance, operation and monitoring
• Guide for trouble shooting to detect problems |
6 Data management / GIS
2 weeks
Water eng technician
Engineers
Accountant
Administrators
- Introduction to GIS and remote sensing
- Using ArcGIS applications
- Map layouts from basic database files

7 Monitoring & evaluation
2 weeks
Engineers
Geologists
Computer eng.
M&E Unit team at Localities
- Monitoring indicators
- Roles in monitoring
- Collection of information
- Communicating results, accountability and using results for decision-making
- Promotes continuous learning and improvement

8 Baseline survey
1 week
Geologist
Engineers
- Flow meter installation and monitoring
- Monitoring and evaluation (General and Sudan standards)
- Social survey and data collection
- Data management and results

FMoH, CPDD:
- The CPDD provides a 5 day training on DWS for MoH and Locality employees.
- The trainees are mainly Public Health Officers who already have a 4 year BSc or MSc. The courses therefore act as refreshers and to update staff on latest techniques.
- These courses focus on monitoring, surveillance, water quality testing, community engagement, water treatment. Their training is mostly theoretical, maybe some demonstration + field visits.
- They also have courses related to hygiene promotion, environmental health impact, food safety (which may have some relevance for bottled water and ice) and pesticides and insecticides (which may have some content relevant to pollution of drinking water).
- The CPDD is mandated Ministerial Decree as the institution that should provide training to the MoH staff.
- It has a pool of trainers which it calls upon to run the trainings.
- They run 52 different courses across all disciplines which are <3 month in-service courses.
- They can also train government officials or community leaders and would be open to also collaborating with NGOs.
- They mainly do Training of Trainers courses so that the trainees can go back to their States and train others (for example Sanitary Oversees and Assistant Sanitary Overseers). They have 6 lecture halls.

Universities:
The following two tables provide an overview of the Environmental Health course content of relevance to water safety at the three universities and an overview of the universities’ access to laboratories for use by the students. These are just examples and there are likely to be variations across other Universities.

Table 27 - Overview of course content related to water safety

<table>
<thead>
<tr>
<th>University</th>
<th>Course content of relevance to water safety</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Khartoum</td>
<td>Undergrad:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Water quality – practical and theoretical</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Intro / basics</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Water and health + water related diseases – water borne</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Inspection water and treatment plants</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Not covering HWTS – only advanced filters</td>
</tr>
</tbody>
</table>
- Quick surveys (like sanitary surveys)
- Chlorination / disinfection – small scale dug wells etc
- Water treatment – large scale + small scale (filtration)
- Environmental education re water sources

**Post grad:**
- 2 courses EH – water quality and drinking water supply

**BSc / MSc / PhD projects:**
- Water source pollution / management and surveillance
- Water quality – both levels
- Lab – physical + chemical + micro
- 1 or 2 PhDs on water safety
- BSc – 5-10 on water safety related issues + water treatment

<table>
<thead>
<tr>
<th>Bahari</th>
<th>Undergraduate courses:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Similar to Khartoum (see above)</td>
</tr>
<tr>
<td></td>
<td>Focus on water hygiene and water safety</td>
</tr>
</tbody>
</table>

**Postgraduate:**
- WQ and surveillance
- Application of WSP process – source to consumption at HH including WQ analysis

**Postgraduate and undergrad projects:**
- Findings related to water quality; accessibility; quantity

<table>
<thead>
<tr>
<th>AAU</th>
<th>Undergraduate courses:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Focus on water hygiene and safety - 12 or 13 subjects:</td>
</tr>
<tr>
<td></td>
<td>- Water sources</td>
</tr>
<tr>
<td></td>
<td>- Water and public health</td>
</tr>
<tr>
<td></td>
<td>- Water distribution and treatment</td>
</tr>
<tr>
<td></td>
<td>- Water quality</td>
</tr>
<tr>
<td></td>
<td>- Water treatment efficiency</td>
</tr>
<tr>
<td></td>
<td>- Groundwater quality</td>
</tr>
<tr>
<td></td>
<td>- Lab work / sampling / sample techniques / chemical / biological and bacteriological</td>
</tr>
</tbody>
</table>

**Postgraduate courses:**
- 2 courses with an EH specialisation
- EH is a common introductory course for the Masters in Public Health including contents related to DWS
- DWS lectures and field visits

- Not covering HWTS

- Not covering HWTS
BSc/MSc/PhD projects

PhD
- Control of Turbidity and Suspended Solids in water at Khartoum state 2010
- Assessment of drinking Water Quality in Public Basic Schools in Bahri Locality

MSc
- Drinking water quality assessment, N.K. State
- Assessment of access to water and sanitation and hygiene in Jebel Awlia Refugee camp, Kh. State
- Water supply assessment at Shag Arab Refugee camp/ Eastern region
- Assessment of water quality in students residential complexes – national students welfare fund – Kh. State
- Study of microbiology quality of Almanar water treatment plant
- Assessment of water and environmental sanitation services of Khalawas (Religious studies) in the locality of Sharganeel

Table 28 - Overview of access to laboratories for practical training for students

<table>
<thead>
<tr>
<th>University</th>
<th>Access to laboratories for use by the students</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Khartoum</td>
<td>Equipment overview:</td>
<td>Three theory and one practical per week</td>
</tr>
<tr>
<td>(Established in 1902)</td>
<td>Portable turbidity meter (2)</td>
<td>Challenge – number of students vs resources for practicals – 40 students are in a single lab group</td>
</tr>
<tr>
<td></td>
<td>Conductivity / pH meter / electrode (2)</td>
<td>Good quality WQ laboratory but can only do demonstrations for students because of limited items of equipment</td>
</tr>
<tr>
<td></td>
<td>Portable equipment to test for: Residual chlorine, Mn, Pb, Fe, nitrate / nitrite, Chlorides, hardness, pH</td>
<td>Don’t have advanced instruments – only portable</td>
</tr>
<tr>
<td></td>
<td>Microbiological - <em>E. coli</em> / Total Coliform / Thermotolerant – uses the MPN method. Only uses Membrane Filtration method if need accurate result</td>
<td>Capacity lab is not adequate for both research and training</td>
</tr>
<tr>
<td></td>
<td>Key equipment:</td>
<td>Reduce sample size – for example from 50 needed, reduced to say 15</td>
</tr>
<tr>
<td></td>
<td>o Jenway 6305 UV/V Spectrophotometer (1)</td>
<td>Economical gap for reagents; couple of months to get reagents</td>
</tr>
<tr>
<td></td>
<td>o Palintest 7500 + 8000 Photometers (1 of each)</td>
<td>Sometimes collaborate with MoH labs + at WTPs</td>
</tr>
<tr>
<td></td>
<td>o 2306 Visible Spectrophotometer – ElectronicsIndiaCo.in (1)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>o Wastewater pollution – BOD, COD, efficiency plant – physical TSS + TDS</td>
<td></td>
</tr>
</tbody>
</table>
| **Bahari**  
*Established as the University of Juba / Upper Nile / BherElghaz before becoming the Bahari University*) | **AAU**  
*Established in 1990 as a private University and then in 1993 as government*) |
|---|---|
| **heavy metals, pH, EC**  
- Microscope (1) – algae, eggs, protozoa – but can also borrow microscopes from medical entomology / parasites laboratory | **Problem reagents + costs**  
- For microbiological analysis need to access a laboratory - have a strong connection with the following for student experience:  
  - Khartoum Uni  
  - Khartoum WTP and Central lab  
  - Students to WTPs – systems and labs  
  - Soba – wastewater plant trickling filter  
  - Khartoum High Council for Environment laboratory  
- Practical experience is done in groups – high number of students against the resources |
| **No laboratory**  
- Limited experience for individuals with portable kits:  
  - Turbidity  
  - Conductivity  
  - Chlorine residual | **One central lab for the courses in public health, medical, agriculture + instruments + technicians**  
- There is a plan for separate labs in the future  
- Can only do physical tests such as turbidity  
- If lab work need to pay technician and supplies and chemical – post and undergrad  
- Under grads - some collaboration with other institutions:  
  - Each state – water quality units  
  - PH lab Khartoum State [note limited capacity – see Annex V]  
  - FMoH - National Public Health Reference Laboratory |
| No laboratory | If lab work need to pay technician and supplies and chemical – post and undergrad  
- Under grads - some collaboration with other institutions:  
  - Each state – water quality units  
  - PH lab Khartoum State [note limited capacity – see Annex V]  
  - FMoH - National Public Health Reference Laboratory |
Academy of Health Sciences (AHS):

The following table provides an overview of the courses of relevance to water safety run by the AHS.

### Table 29 - Overview of the Academy of Health Sciences courses of relevance to water safety

<table>
<thead>
<tr>
<th>Course overview</th>
<th>Subjects covered</th>
</tr>
</thead>
<tbody>
<tr>
<td>● No students graduating from Kassala HSA:</td>
<td>● Curriculum for Public and Environmental Health – covers:</td>
</tr>
<tr>
<td>o 2016 - last year – 75 in 1 year</td>
<td>o Biochemistry</td>
</tr>
<tr>
<td>o 2008 first group - they graduated in 2011</td>
<td>o Biology</td>
</tr>
<tr>
<td>o 181 graduated 2008 – 2016</td>
<td>o Water safety and sewage systems</td>
</tr>
<tr>
<td>● The course is: 60% practical, 30% theory, 10% assignments</td>
<td>o Basic management and quality</td>
</tr>
<tr>
<td>● Use other PH laboratories – as no laboratory for the HSA - working 2 parts:</td>
<td>o Practical field and research methods</td>
</tr>
<tr>
<td>o Water surveillance – checking chlorine at the MoH lab</td>
<td>● Water safety and sewage systems – 4 weeks, 2 practical, 2 theory – water safety parts include:</td>
</tr>
<tr>
<td>o Food hygiene students send to SSMO laboratory</td>
<td>o Introduction / objectives / why</td>
</tr>
<tr>
<td>● Lecturers have:</td>
<td>o Importance of drinking water</td>
</tr>
<tr>
<td>o Masters in Health Education</td>
<td>o Water source and drinking water</td>
</tr>
<tr>
<td>o Master in Food Safety – hygiene (shortage of Masters in EH)</td>
<td>o Water source and precipitation</td>
</tr>
<tr>
<td></td>
<td>o Water cycle / treatment / storage / distribution</td>
</tr>
<tr>
<td></td>
<td>o Water standards</td>
</tr>
<tr>
<td></td>
<td>o Water testing</td>
</tr>
<tr>
<td></td>
<td>o Uses</td>
</tr>
<tr>
<td></td>
<td>o Samples for test</td>
</tr>
<tr>
<td></td>
<td>o Water related diseases and control</td>
</tr>
<tr>
<td></td>
<td>o Standards select water source</td>
</tr>
<tr>
<td></td>
<td>o Drinking water guidelines – WHO</td>
</tr>
<tr>
<td></td>
<td>definition of contamination</td>
</tr>
<tr>
<td></td>
<td>o Water contamination</td>
</tr>
</tbody>
</table>

REDR/WHO:

REDR/WHO has supported training in 2017 in: Water Quality and Infrastructure in Khartoum; Water Safety Plans in Darfur; Water quality in the Darfur states. Details of the courses of relevance to water safety can be seen in the table which follows.

### Table 30 - Overview of REDR/WHO trainings in 2017 of relevance to water safety

<table>
<thead>
<tr>
<th>Course name</th>
<th>Subjects covered</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water quality and Infrastructure 7 day course (held in Khartoum)</td>
<td>● Environmental health</td>
<td></td>
</tr>
<tr>
<td></td>
<td>● WASH needs and standards</td>
<td></td>
</tr>
<tr>
<td></td>
<td>● WASH assessments</td>
<td></td>
</tr>
<tr>
<td></td>
<td>● Water quality testing 1: Overview</td>
<td></td>
</tr>
<tr>
<td></td>
<td>● Water quality testing 2: Chemical and bacteriological testing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>● Water quality testing 3: Bacteriological test results</td>
<td></td>
</tr>
<tr>
<td></td>
<td>● Water treatment 1: Coagulation, flocculation &amp; sedimentation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>● Water treatment 2: Chlorination</td>
<td></td>
</tr>
<tr>
<td></td>
<td>● Water treatment 3: Household water treatment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>● Water treatment 4: Household water treatment marketplace</td>
<td></td>
</tr>
<tr>
<td></td>
<td>● Practical focus &amp; hands-on with range of practical tips</td>
<td></td>
</tr>
<tr>
<td></td>
<td>● Includes site visit</td>
<td></td>
</tr>
<tr>
<td></td>
<td>● Materials in English – but training held at</td>
<td></td>
</tr>
<tr>
<td>Water quality for State and Locality staff</td>
<td>3 day course (Localities):</td>
<td></td>
</tr>
<tr>
<td>------------------------------------------</td>
<td>--------------------------</td>
<td></td>
</tr>
<tr>
<td>Water sources</td>
<td>Following the first round of trainings in Darfur – it would be good</td>
<td></td>
</tr>
<tr>
<td>Drinking water standards</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drinking water contamination of sources</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>WSP 2 day course (held in 4 Darfur States)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 1:</td>
</tr>
<tr>
<td>* WASH essentials – includes introduction and overview of WSPs:</td>
</tr>
<tr>
<td>o Define the components of a WASH programme</td>
</tr>
<tr>
<td>o Describe the limitations of water testing for ensuring a water supply is safe for drinking</td>
</tr>
<tr>
<td>o Identify the rationale of WSPs</td>
</tr>
<tr>
<td>* WSP planning theory:</td>
</tr>
<tr>
<td>o Define the steps of a WSP</td>
</tr>
<tr>
<td>o Work with communities to describe a water supply system</td>
</tr>
<tr>
<td>o Work with communities to identify risks to that system and to identify measures to reduce those risks</td>
</tr>
<tr>
<td>o Describe key O&amp;M measures</td>
</tr>
<tr>
<td>Day 2:</td>
</tr>
<tr>
<td>* Water supply visit:</td>
</tr>
<tr>
<td>o Describe a water supply system</td>
</tr>
<tr>
<td>o Identify risks to that system and to identify measures to reduce those risks</td>
</tr>
<tr>
<td>o Identify key O&amp;M measures</td>
</tr>
<tr>
<td>* Water safety risk assessment:</td>
</tr>
<tr>
<td>o Considering stages of the water supply process</td>
</tr>
<tr>
<td>o Understanding how to identify and rank hazards and how to translate this into risks</td>
</tr>
<tr>
<td>* Water safety improvement and monitoring:</td>
</tr>
<tr>
<td>o Understanding how to translate this into improvement activities and an action plan</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>WSP 3 day course</th>
</tr>
</thead>
<tbody>
<tr>
<td>Includes site visit</td>
</tr>
<tr>
<td>Includes a case study of WSP implementation in Australia</td>
</tr>
<tr>
<td>Simpler version of WSP training than the training given by UNICEF in Kordofan</td>
</tr>
<tr>
<td>Materials in English – not clear if participants from State level can understand English adequately?</td>
</tr>
</tbody>
</table>

Khartoum level so assumed most participants would have a reasonable grasp of English?
UNICEF:
UNICEF has supported training in Water Safety Plans in the Kordofan States in 2017. Details of the course can be seen in the table which follows.

Table 31 - Overview of UNICEF WSP trainings in 2017

<table>
<thead>
<tr>
<th>Course name</th>
<th>Subjects covered</th>
<th>Notes</th>
</tr>
</thead>
</table>
| WSPs 5 days course (held in 4 Kordofan States) | **Day 1:**  
- Setting the stage:  
  - Introductory exercises to WSPs  
- Global framework for WSPs:  
  - SDGs and the WSP  
  - State level WSP roadmap  
- The WSP process:  
  - Overview of community-based WSPs  
**Day 2:**  
- Developing a community-based WSP (step-by-step approach):  
  - Step 1: Engaging the community and assembling to reflect on the materials and check that they are all appropriate to the Locality level of participant + revise where necessary  
  - Some materials in English and some in Arabic – not clear if participants from Locality level can understand English adequately  
  - Included use of several useful videos for discussion on hazards and risks  
  - Uses group work and discussion  
  - Spends 1.5 days on hands on field work and on presenting and discussing field work  
  - Also has additional session on chlorination for AWD  
  - More detailed version of WSP training than
<table>
<thead>
<tr>
<th>WSP team</th>
</tr>
</thead>
<tbody>
<tr>
<td>o Step 2: Describing the water supply system</td>
</tr>
<tr>
<td>o Step 3: Identify hazards, hazardous events, risks and existing control measures</td>
</tr>
<tr>
<td>o Step 4: Develop an action plan</td>
</tr>
<tr>
<td>o Step 5: Establish a regime of monitoring and preventative maintenance</td>
</tr>
</tbody>
</table>

**Day 3:**
- **Water Quality within WSP:**
  - Water quality definitions
  - Water quality standards and protocols
  - Water quality sampling and testing
  - Using water quality results and data
  - Water quality monitoring
  - Water quality surveillance (monitoring and verification)

**Special session on AWD:**
- **Chlorination as a means to address AWD:**
  - Types of chlorination
  - Free chlorine and residual chlorine
  - Practical chlorination of water
  - Testing for chlorination
- **Human behaviour and water quality**
- **Preparation for field work**

**Day 4:**

**Field work:**
- Teams to use the six steps as a first hand learning to collect the necessary information to develop a community WSP

**Day 5:**

**Team working session and presentation:**
- Teams develop the community WSP based on information collected from field
- Presentation on process, findings and observations

---

the training given by REDR in Darfur
- Logical training plan – but quite detailed materials (slides) in English – not clear if participants at State level can understand English well enough – (presentations the groups gave were all in Arabic)
Annex VII - Capacity – Job descriptions of FMoH Water Safety Team

Head of Water Quality and Safety Section

- Supervising the work of the units in the department
- Oversee the preparation of the performance plans in the department and follow up on their implementation
- Supervising research, studies and field surveys
- Supervising the preparation of training plans for employees in the department and follow up their implementation
- Participate in formation of laws, policies, guidelines and regulations for health and safety of water
- Participate in the training and capacity building of workers at federal and state levels
- Participation in meetings and chairmanship
- Participate in the preparation of management plans
- Participate in the preparation of the estimated budget
- Preparation of direct subordinates performance reports
- Preparation of periodic reports
- Solving business and employee problems
- Representing the Ministry
- Team leadership
- Any other functions assigned to him by the Director of the Department of Environmental Health and Food Control

Drinking Water Monitoring and Surveillance Unit

- Participate in the development of plans to establish monitoring and inspection systems for the quality of drinking water in the States
- Follow up the establishment of monitoring systems and check the quality of drinking water in the States
- Participate in the selection of qualitative specifications for microbiological and chemical analysis equipment
- Create a system to gather information from States
- Receive monthly reports from States and analyse them
- Obtain feedback on State interventions to address water safety problems
- Participate in the training of health officers in the centre and the States on the system of monitoring and testing the quality of drinking water
- Participate in the development of draft guidelines and protocols regarding the monitoring and inspection of the quality of drinking water
- Participate in the dates of the supervisory visits of the States to ensure the monitoring of the quality of drinking water as required
- Developing and updating the work forms of the monitoring system for the quality of drinking water
- Participation in water-related epidemiological events

Water Resources Protection Unit and Risk Assessment

- Participate in the development of the rainy/flooding season emergency plan and review with members of the Department of Health and Safety of Water
- Received complaints about the safety of drinking
• Receive weekly reports from the States and analyse them in emergency situations
• Create a system to gather information from States
• Receive feedback in the case of state interventions to address water safety problems in an emergency
• Participate in the meetings of the Technical Committee for the Emergency of rainy season
• Designing the various awareness messages for the safety of drinking water in the emergency period and follow up with the Department of Health Promotion in the Ministry
• Participate in the drafting of guidelines and protocols for the safety of drinking water during the emergency period
• Participate in the development and updating of work forms for the safety of drinking water during the emergency period
• Participate in the dates of the supervisory visits of the States during the emergency period
Annex VIII - JMP post 2015 – water safety related

The following includes extracts from JMP documents related to water safety for the post-2015 context (JMP, 2015 – Green Paper).

Target 6.1:

<table>
<thead>
<tr>
<th>LANGUAGE IN PROPOSED TARGETS</th>
<th>NORMATIVE INTERPRETATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>By 2010, achieve</td>
<td></td>
</tr>
<tr>
<td>universal</td>
<td></td>
</tr>
<tr>
<td>and equitable</td>
<td></td>
</tr>
<tr>
<td>access</td>
<td></td>
</tr>
<tr>
<td>to safe</td>
<td></td>
</tr>
<tr>
<td>and affordable</td>
<td></td>
</tr>
<tr>
<td>drinking water</td>
<td></td>
</tr>
<tr>
<td>for all</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sufficient quantity</td>
<td>Availability</td>
<td>Availability</td>
<td>Availability</td>
</tr>
<tr>
<td>Continuity of service</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safe for health</td>
<td>Quality</td>
<td>Quality/safety</td>
<td>Quality</td>
</tr>
<tr>
<td>Aesthetically acceptable</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time/distance required to collect</td>
<td>Accessibility (physical)</td>
<td>Accessibility</td>
<td>Accessibility (cross-cutting)</td>
</tr>
<tr>
<td>Suitable for use by all, including</td>
<td>Accessibility (economic)</td>
<td>Affordability</td>
<td>Affordability (cross-cutting)</td>
</tr>
<tr>
<td>disabled and older people</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Affordable</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-discrimination</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Basic water definitions and indicators.** The technical working group on drinking water proposed using the following definition and indicators for monitoring access to a ‘basic’ drinking water service. These definitions build on the existing improved/unimproved technology classification which focused on availability and quality (therefore providing continuity with the MDG era) and specify a maximum collection time (accessibility). The JMP proposes to continue using established sources of data to estimate the population using improved facilities and to apply adjustments based on nationally available information on collection times.

**Basic drinking water:** An improved drinking water facility is defined as a source or delivery point that by nature of its construction, or through active intervention, is protected from outside contamination, in particular from contamination with faecal matter. The following are considered as improved drinking water facilities: piped drinking water supply on premises; public taps/standposts; tube well/borehole; protected dug well; protected spring; rainwater. Packaged water is considered improved if households use an improved water facility for other domestic purposes. Households are considered to have a basic drinking water service when they use an improved facility with a total collection time of 30 minutes or less for a roundtrip including queuing.
Monitoring the quality of drinking water services

**Normative guidance, definitions and indicators.** Safe drinking water is free from pathogens and elevated levels of toxic chemicals at all times. WHO publishes normative guidelines on water quality which are reflected in most national standards. Sufficient water for drinking, cooking and personal hygiene is a minimum of 20 to 50 litres per person per day and must be accessible at times when it is needed. For the purposes of global monitoring, a proxy indicator “use of an improved source” has been used during the MDGs. This is a definition based on facility types and captures aspects of safety, sufficiency and accessibility. An improved source is one that protects drinking water from outside contamination, especially from faecal matter.

However, it is well-recognized that while improved drinking water sources include features designed to prevent faecal contamination, not all improved sources provide water which is actually safe. Faecal contamination has been documented in all types of improved supplies, including protected wells and springs, boreholes, and piped water systems. Chemical contamination with naturally occurring arsenic and fluoride affects hundreds of millions of people, and is most common in groundwater. Furthermore, improved sources may be inadequate in terms of providing sufficient water, accessible to all users when needed.

The JMP therefore proposes a new indicator of ‘safely managed drinking water services’ which captures at least partially the following aspects of water services: availability, accessibility and quality. The proposed indicator of “safely managed drinking water services” comprises four elements:

- an improved drinking water facility
- which is available when needed;
- located on premises;
- compliant with faecal and priority chemical standards

**Availability.** Improved sources may not always provide an uninterrupted supply of drinking water sufficient to meet a household’s needs. Interruptions can be due to low pressure in piped supplies, non-functional handpumps or seasonal availability (e.g. rainfall) and are common in many parts of the world. The JMP will develop and encourage the uptake of a harmonised question on whether a household has been unable to access sufficient drinking water for a day in the preceding two weeks. A possible formulation is the following question which will be included in the next round of DHS: “In the past two weeks, was the water from this source not available for at least one full day?”. In addition, information on reliability or continuity of water supplies should become available and standardised through increased engagement with regulatory authorities. For example, a key performance indicator often tracked by regulators of drinking water utilities is the number of hours of service per day, which could contribute towards an indicator for availability.

**Accessibility.** Many households do not have a water supply at home and need to spend substantial amounts of time collecting drinking water, a responsibility that often falls on women. Households that have to spend too long to collect water tend to use insufficient quantities for drinking and personal hygiene and there are many benefits to having easily accessible water at home. Time to collect drinking water is information that is routinely gathered in household surveys. On-site access can be measured through household surveys, though minor adjustments to household survey questions may be required. The JMP proposes that the ‘basic drinking water services’ level should include only sources within a 30 minute round trip collection time, and that the ‘safely managed drinking water services’ level should include only sources on premises (i.e. within the household, plot, or courtyard).

**Quality.** Globally, the single greatest risk to health from drinking water is faecal contamination. Presence of *E. coli* bacteria is the most reliable indicator of faecal contamination, and WHO guidelines and most national standards call for no detectable *E. coli* in a 100 mL sample (WHO, 2011). Faecal contamination of drinking water is widespread: it is estimated that at least 1.8 billion people use a drinking water source containing *E.*
coli. Thermotolerant coliforms are a less-preferred indicator of faecal contamination, but the JMP would make use of such data where *E. coli* data are lacking. Drinking water may also contain harmful chemicals: arsenic and fluoride are priority health parameters and the chemicals associated with the greatest disease burden in drinking water. It should be noted, however, that in most countries these priority chemical contaminants infrequently exceed health guidelines. The JMP will continue to adjust its estimates for countries, such as Bangladesh, where arsenic or fluoride are found at elevated levels and to support surveys where appropriate and capacity for additional testing exists. To this end, the JMP will maintain a list of arsenic and fluoride testing methods, provide technical support in their use including in household surveys and work with others to maintain a database of locations (countries/regions) where arsenic and fluoride are prevalent. Additional parameters may be included on the basis of new evidence and revisions to the WHO Guidelines or burden of disease estimates.

**Preventive risk management.** Robust independent surveillance and regulation is the long term goal for all countries. In addition WHO and UNICEF recommend the use of preventative risk management approaches including sanitary inspections (SI) and water safety planning (WSP). These qualitative approaches complement quantitative water quality testing and in combination provide a more reliable assessment of the overall safety of drinking water (Box 6). The JMP will collate information on SIs and WSPs (including verified plans). Their uptake and use will be encouraged and supported through initiatives including the International Network of Drinking Water Regulators (RegNet) which has clearly indicated its willingness to collaborate. Application of preventive risk management programmes is often closely tied to regulatory oversight. The JMP will look to build stronger links with regulators to assess operational definitions of regulation and preventive risk management, focusing primarily on settings where water infrastructure usually provides water that is free of microbial contamination. In rural settings, and in other settings where supplies are less likely to be subject to regulation, the JMP will continue to support Rapid Assessments of Drinking Water Quality in nationally representative surveys, which would include sanitary inspections of water supplies.

**Institution-based data sources for quality of service.** Institution-based data on water quality are ideally collected through the agencies responsible for oversight of water supply services (i.e. regulators) which include water safety, availability and accessibility, and affordability. In the absence of a formal drinking/water regulator, the JMP and may rely on other sources in countries where this function is delegated to another body or the responsibility of water utilities themselves. Through engagement with national authorities, the JMP will be well positioned to support capacity building and to ensure that global monitoring is cost effective. It is estimated that most of the 75 countries classified as “high-income” by the World Bank will have water service data available from regulatory or other administrative sources. In addition, approximately 30-40 low- and middle-income countries are known to have drinking water regulatory authorities, and this number is rising. Data from regulators, therefore, are already available from at least 100 countries around the world for SDG monitoring.

**Population-based data sources for quality of service.** Where substantial gaps remain in monitoring systems, the JMP will rely on new data collection primarily through household surveys since these have the advantage of lower marginal costs and simultaneous collection of socio-economic data that allow for tracking inequalities. In collaboration with household survey teams (MICS, LSMS), the JMP has piloted water quality testing in six countries. A standardised module based on these experiences is in development and will be finalised in 2015. Water quality is assessed at the source as well as in the home (“from a glass you would give a child to drink”) since quality can differ due to contamination during transport and storage and in order to provide information that is of greatest concern to both regulators and utilities and to politicians and public health agencies. Household surveys can also collect information on availability, accessibility, and affordability, as described previously.
Opportunities and challenges. Global monitoring and reporting of availability, accessibility and quality would have many benefits including: renewed focus on improving service quality; universally relevant targets including for high income countries; empowerment of regulators, promoting increased transparency; supporting national monitoring capacity; highlighting the importance of hygienic practices in households in preventing recontamination. Key outstanding challenges include:

- The development of flexible approaches to integrate information from different sources;
- Reconciling data on continuity or reliability of supply with sufficiency of water;
- Innovation in water quality monitoring;
- Addressing seasonal trends in faecal contamination;
- Establishing globally applicable definitions of water supply regulation.

Proposed service ladder (drinking water). Table 3 outlines a proposed ladder for global reporting of progress in access to drinking water at home, with the ‘safely managed drinking water services’ level serving as the global indicator for SDG target 6.1. The ladder is progressive: in order to reach the safely-managed level, one must first reach the basic services level. Therefore, progress towards achieving basic drinking water services should be seen as progress towards achieving safely managed drinking water services. It should be noted that the criteria and thresholds proposed for the ‘safely managed’ rung on the service ladder do not represent the highest possible level of service. A higher level (‘sustainable services’) is indicated in the ladder but is currently not considered as a feasible global indicator for the JMP to track. Nonetheless, many countries will have or strive to develop monitoring systems which go well beyond the elements considered in ‘safely managed drinking water services’.
Annex IX - References

IX.1 Sudan – recent strategic, capacity building, monitoring and other documentation

Legislation, policies:
- FMOH (2017, draft) Sudan National Health Policy, 2017 – 2030
- Republic of Sudan (2010 draft) Water Supply and Environmental Sanitation Policy, September 2010
- Republic of Sudan, Ministry of Water Resources and Sanitation Unit (DWSU) (2017, draft) Sudan Drinking Water, Sanitation and Hygiene (SDWASH) Policy of 2017
- Republic of Sudan, National Assembly (2009) Environmental Health Act, 2009, Order Articles [translation]

Strategies and plans:
- FMOH (2005) National Strategy for Community-based Development Initiatives Programme (CBI), Sudan, Directorate General of Primary Health Care, FMOH
- Republic of Sudan (2011) WASH Sector National Strategic Plan, 2012-16
- Republic of Sudan, FMOH (2016, final draft) Sudan National Sanitation and Hygiene Strategic Framework
- Republic of Sudan, FMOH, Directorate of Primary Health Care, Environmental Health & Food Control Department (2015) National Environmental Health Strategic Plan, 2015-2019
- Republic of Sudan, MoWRE, DWSU (no date) Drinking Water and Sanitation Unit Training Centre (DWSU), Short-Term and Long-Term Plan
UNHCR (2017) South Sudan Regional Refugee Response Plan, January to December 2017
UN-OCHA (2017) Humanitarian Response Plan, Sudan, January to December 2017

Guidelines - FMoH:

- FMoH (2013) Drinking Water Chlorination Protocol, General Directorate of Essential Health Care, Directorate of Environmental Health and Food Control, Department of Water Hygiene and Safety, published with support of GAVI, WHO and Federal Directorate of Health Promotion
- FMoH (2016) Health messages for schools
- FMoH (no date) Summarized Drinking Water Chlorination Protocol, Environmental Health and Food Control Department
- FMoH and UNICEF (no date) Community Empowerment Guidelines in Water and Environmental Sanitation, FMoH Water and Sanitation Department and UNICEF

Guidelines – MoWRIE/DWSU:

The following technical guidelines were published by: PWC, MIWR-GONU and MWRI-GOSS – all are drafts from April 2009. However as the institutions have now changed, they have been referred to throughout the report as: MoWRIE/DWSU documents. The series include:

- Technical Guidelines and Manual of Improved Small Dams for Field Staff and Practitioners (Draft)
- Technical Guideline and Manual of Improved Hafirs for Field Staff and Practitioners (Draft)
- Technical Guideline and Manual of Spring Development and Roof Water Harvesting (Draft)
- Technical Guideline and Manual for Hand Dug Wells with Handpumps for Field Staff and Practitioners (Draft)
- Technical Guideline and Manual for Hand Dug Wells with Motorized Pumps for Field Staff and Practitioners (Draft)
- Technical Guideline and Manual of Borehole with Handpump for Field Staff and Practitioners (Draft)
- Technical Guideline and Manual of Low Capacity (Mini) Water Yard – Borehole with Motorized Pump for Field Staff and Practitioners (Draft)
- Technical Guideline and Manual for High Capacity Water Yard – Borehole with Motorized Pump for Field Staff and Practitioners (Draft)
- Technical Guideline and Manual of Slow Sand Filtration System for Field Staff and Practitioners (Draft)
- Technical Guideline and Manual of Drinking Water Treatment Facilities for Field Staff and Practitioners (Draft)
- Technical Guideline and Manual for Drinking Water Distribution Networks for Field Staff and Practitioners (Draft)
- Technical Guideline and Manual of School Latrines for Field Staff and Practitioners (Draft)
- Technical Guideline and Manual of Latrines for Rural Health Institutions for Field Staff and Practitioners (Draft)
- Technical Guideline and Manual of Household Latrines for Field Staff and Practitioners (Draft)


- Introduction
- 6.1 – Emergency Water Supply
- 6.2 – Emergency Water Sources Selection
6.3 – Water Safety Plans
6.5 - Rehabilitating & O&M of Water Supplies
6.7 – Emergency Water Treatment
6.8 – Water Distribution

Sudan programmes, studies and reports:

- Elraheem, M.A. and Abdou, G.M (no date) Challenges Facing the Drinking Water Sector in Sudan
- FMOH (2005) National Strategy for Community-based Development Initiatives Programme (CBI), Sudan, Directorate General of Primary Health Care, FMOH
- Habila, O (2015) The WASH Sector Landscape and the Need for Development Partners Coordination, Presentation at the Inaugural Meeting of the WASH Sector DPs, at UNICEF Office, 08 Dec 2015
- JICA (2017) Outline of the Pilot Projects, Health Sector
- No author (2015) Bottleneck Analysis Workshop for Central States, Sennar State, 01-05 March 2015
- No author (2017) Tariff Study – Volume IV, Key Findings, North Darfur State
- No author (no date) Description of the Water Supply System in SSR Camps in White Nile
- No author (no date, draft) Burden of NTD in Sudan
- UNICEF (2014) Challenges and Opportunities in the Sudan WASH Sector, August 2014, PPT Presentation
- Urban Water Administration Offices (2017) Key Performance Indicators (KPIs), Quarterly Report [Jan – Mar 2017], UWAs, 4 State Capitals in Greater Darfur – El Fasher, Zalingei, Geneina and Nyala
- Urban Water Administration Offices (2017) Key Performance Indicators (KPIs), Quarterly Report [April – June 2017], UWAs, 4 State Capitals in Greater Darfur – El Fasher, Zalingei, Geneina and Nyala

Sudan data:
- FMOH (2017) Epidemiological data (in various formats)
IX.2 Sudan – training materials, monitoring and database forms

Training materials:

- FMoH / CPPD:
  - FMoH (2017) Curriculum, Continuing Professional Development Directorate

- RedR-UK / WHO:
  - RedR-UK and BushProof (2017) WASH in Emergencies - Water Safety Plans and all training PPTs
  - RedR-UK (2017) Water Quality - for locality staff – course materials including PPTs

- Universities:
  - AAU University, Faculty of Public Health – Water hygiene and safety course outline
  - Khartoum University – Research project titles

- UNICEF:

- DWST - White Nile:
  - Outlines of courses in:
    - Water supply facilities
    - O&M of water treatment plants
    - Water well management x 2
    - Baseline survey
    - Data management / GIS
  - PPTs for water quality courses

Monitoring & database forms:

Samples from:

- MoWRIE - DWSU:
  - WES Database
  - No author (2017) WASH Information System, Integration between GIS and Database Geographic Information Handling and Analysis
  - WES monthly reporting format
  - GWD – Groundwater and Wadi’s Database – Water Quality Report sample

- MoWRE - General Directorate of Groundwater and Wadis:
  - Routine Water Analysis

- FMoH:
  - EH and Food Safety Directorate:
    - Water Resources by States, 2017
    - Monthly report
    - Job descriptions for team members of Water Safety team
  - National Public Health Laboratory – Food and Water Microbiology Dept.:
    - Analysis certificate
• **SWCs:**
  - Khartoum:
    - Specifications for PAC and Chlorine
    - Nile water analysis report
    - Burri WTP Daily Report
    - Central lab at Mogran WTP – algae identification record book
  - Kassala:
    - Water analysis laboratory – chemical and physical analysis of water
  - White Nile – Central lab:
    - The needs of equipment for laboratories
  - White Nile - Alagaya refugee camp WTP:
    - Consumable usage and water production records
    - Water station checks

• **WES:**
  - North Darfur:
    - Weekly monitoring form – water points, sanitation and hygiene activities
  - South Darfur
    - Feedback and monitoring results form for water quality surveillance

• **State MoHs:**
  - Khartoum EH team:
    - Residual chlorine and turbidity result
  - Kassala:
    - Water safety equipment needs
    - Water sources in the State
    - Chlorine distribution and water test analysis
  - White Nile EH Team:
    - Water safety record sheets
  - North Darfur:
    - Water Safety Section – water quality and water safety activities in El-Fasher Town, Tawilla, Kapkapia, Shangel Topaya and Labet from 09

• Localities:
  - Kassala Rural, Department of Health Affairs:
    - Chlorine check weekly report sheet
    - Daily report

• **WHO:**
  - White Nile:
    - Water resources
    - Water monitoring in SS arrivals camps
- DWQ vs AWD cases data and graphs
  - Kassala:
    - Poster on water safety
    - Water sources monitoring sheet – Database sample

- Relief International:
  - Various posters covering issues related to personal hygiene, sanitation and drinking water safety

**IX.3 Sudan – Drinking water quality**

**Algae:**

**Arsenic:**

**Cholera:**
- ACAPS (2017) *Sudan Cholera Outbreak*, Briefing Note – 16 June 2017
- Ministry of Health, Republic of South Sudan (2017) *Situation Report #119 on Cholera in South Sudan*, As at 23:59 Hours, 5 May 2017

**Fluoride:**

**IX.4 Global – Drinking water safety, water safety planning and surveillance guidance**

**Water quality standards, JMP, thematic reports, data:**
- AMCOW (2010) *Water Supply and Sanitation in Northern Sudan, Turning Finance into Services for 2015 and Beyond, An AMCOW Country Status Overview*
- Fewtrell, L and Bartram, J (Eds) (2001) *Water Quality; Guidelines, Standards and Health: Assessment of risk and risk management for water-related infectious disease*
The Sphere Project (2011) *Humanitarian Charter and Minimum Standards in Humanitarian Response*


**Water sources:**

**Water quality surveillance and WSPs:**
- WHO (1997) *Surveillance and Control of Community Supplies, Vol 3*
- WHO and IWA (2016) *Water Safety Plans to Drive O&M; Excellence in Drinking Water Supply Systems*

**Global - DWQ related technical notes:**
Reed, R.A. (Series Editor.) *Technical Notes on Drinking-Water, Sanitation and Hygiene in Emergencies:*
- 1 - Cleaning hand dug wells
- 2 - Cleaning and rehabilitating boreholes
- 3 - Cleaning and disinfecting water storage tanks and tankers
- 4 - Rehabilitating small-scale piped water distribution systems
- 5 - Emergency treatment of drinking water at the point of use
- 6 - Rehabilitating treatment works after an emergency
- 11 – Measuring chlorine levels in water supplies
- 12 - Delivering safe water by tanker – useful summary
- 15 – Cleaning of wells after seawater flooding
HP and community engagement:


IX.5 Global – Drinking water quality, diseases, parameters, assessment and treatment

Diseases, water quality & assessment:

- Hutton, L.G. (1983) *Field Testing of Water in Developing Countries*, Water Research Centre
- No author (no date) *Examination of Water Quality Using Bacterial Indicators*
- Rottier, E and Ince, M (2003) *Controlling and Preventing Disease, The role of water and environmental sanitation interventions*, WEDC, Loughborough University, UK
- WHO (2017) *Chemical Mixtures in Source Water and Drinking-water*

Water quality testing equipment and chemicals:

**General:**

- Test kit information and instructions from:
  - Palintest – including Arsenic
  - Wagtech
  - Antenna Water – WataTest
  - Palintest – Colitag for Total coliforms and *E.coli* in P/A format

**Algae testing:**

- [https://en.wikipedia.org/wiki/Microcystin](https://en.wikipedia.org/wiki/Microcystin)
- Mohamed, A. A. (2017) *Personal communication*, Director of National Chemical Laboratories, National Public Health Laboratory, Sudan
- Raymond, R (2016) *Microcysts Analysis Methods*, Ohio Environmental Protection Agency
- WHO (no date) *New Section for Microcystin-LR: Treatment and control measures and technical achievability; and Analytical methods for Micocystins*

**H₂S method:**

- HIMEDIA (no date) *HiMedia’s Multi-Parameter Water Testing Systems, AquaLab Complete Solution to Water Testing, Test’N B-Sure Water Testing Kits*

Water quality – DRR / preparedness and response:
• UNICEF (2013) Cholera Toolkit

Water treatment:
Core texts:

Algae removal:
• Bojcevska and Jergil, E (2003) Removal of Cyanobacterial Toxins (LPS Endotoxin and Microcystin) in Drinking-water using the Biosand Household Water Filter, Uppsala University, Sweden

Chlorination:
• ARCH Chemicals (2009) HTH Calcium Hypochlorite, Material Safety Data Sheet
• Medentech (no date) Aquatabs, Medentech Ltd.
• WHO (1996) Chlorine Monitoring at Point Sources and in Piped Distribution Systems; Chlorination in epidemic and disaster situations, Fact Sheet 2.30

Coagulation:

Household water treatment and safe storage (HWTS):
A range of papers on individual HWTS are available. A few of the key references providing an overview:
• IFRC (2008) Household Water Treatment and Safe Storage in Emergencies, A field manual for Red Cross / Red Crescent personnel and volunteers
• PATH (2012) *Commercial Approaches to Delivering Household Water Treatment and Safe Storage Products and Solutions to Low-income Households, Perspectives*, Special Report
• WHO (2016) *Results of Round I of the WHO international scheme to evaluate household water treatment technologies*
• WHO (no date) *Considerations for Policy Development and Scaling-up Household Water Treatment and Safe Storage with Communicable Disease Prevention Efforts*
• WHO and UNICEF (2012) *A Toolkit for Monitoring and Evaluating Household Water Treatment and Safe Storage Programmes*

**IX.6 Global - Technical / construction**

**Water books:**

**Ground water pollution, boreholes and pipes in buildings:**
• Action Contre la Faim (2005) *Water, Sanitation and Hygiene for Populations at Risk*, Hermann
• Driscoll, F.G. (1986, 2nd edition) *Groundwater and Wells; A comprehensive study of groundwater and the technologies used to locate, extract, treat and protect this resource*, US Filter/Johnson Screens
• WHO (2016) *Health Aspects of Plumbing*, WHO

**Corrosion of pipes and tanks:**
• Outo Kumpu (2011) *Localised Corrosion of Stainless Steels Depending on Chlorine Dosage in Chlorinated Water*, A corrosion management and applications engineering magazine from Outokumpu, 3-2011
Paints for water tanks:

- BS 6920, ‘Suitability of Non-Metallic Products for Use in Contact with Water Intended for Human Consumption with Regard to their Effect on the Quality of Water’.
- JPCL (2011) Selecting and Sourcing Coating Systems for Water Tanks, Technology Publish. Company
- Welland, G (2017) Personal communication, Water Quality Policy and Regulations Manager, Thames Water Utilities Ltd. UK

IX.7 Global – Regulation, bottled water & health and safety

Regulation, bottled water and health and safety:

- Health and Safety Executive (UK) (2013) Respiratory Protective Equipment at Work, A practical guide

Codex Alimentarius (“Food Code”) Commission of the Joint FAO/WHO Food Standards Programme:

- Code of Hygienic Practice for Bottled/Packaged Drinking Waters (other than Natural Mineral Waters) (CAC/RCP 48-2001)
- Code of Practice: General Principles of Food Hygiene (CAC/RCP 1-1969)
- General Standard for Bottled/Packaged Drinking Waters (Other than Natural Mineral Waters) Codex Standard 227-2001
- http://www.codexalimentarius.net/