

# **UNHCR Circular Water Reservoir 10m<sup>3</sup>**

**D315-2016a**

**Tools and Guidance for  
Refugee Settings**



**UNHCR**  
The UN Refugee Agency

**UNHCR Standardized Designs for Refugee Settings  
Circular Reinforced Concrete Water Reservoir 10m<sup>3</sup>**

**FOREWORD**

These circular reinforced concrete water reservoir designs form part of UNHCR’s series of Standardized WASH Design Guidelines for Refugee Settings which are the result of an extensive review process with WASH actors active in refugee settings. It is recognized that the Standardized WASH Designs will require continuous review and amendment in response to changes in engineering best-practice and feedback from the field. Therefore further review will be managed by a Technical Review Committee which will meet regularly to discuss issues related to the use of the design and an annual review will be reported back to the WASH community. More urgent amendments will be reported as, and when, required. Note that this reservoir is based on a design used by Water for People Guatemala.

**FOREWORD..... 1**

**ENGINEERING DRAWINGS ..... 2**

**STEP-BY-STEP ASSEMBLY DRAWINGS ..... 5**

**BILL OF QUANTITIES ..... 6**

**VISUAL BILL OF QUANTITIES..... 7**

**SPECIFICATIONS FOR CONSTRUCTION OF WATER SUPPLY RELATED  
INFRASTRUCTURE IN REFUGEE SETTINGS ..... 8**

**300SCOPE ..... 8**

**301SITE SELECTION ..... 8**

**302PREVENTION OF SURFACE OR GROUNDWATER CONTAMINATION ..... 8**

**303SPECIFICATIONS OF COMMON CONSTRUCTION MATERIALS..... 8**

**304SOAKAGE PIT SIZING BASED ON SOIL INFILTRATION RATES ..... 10**

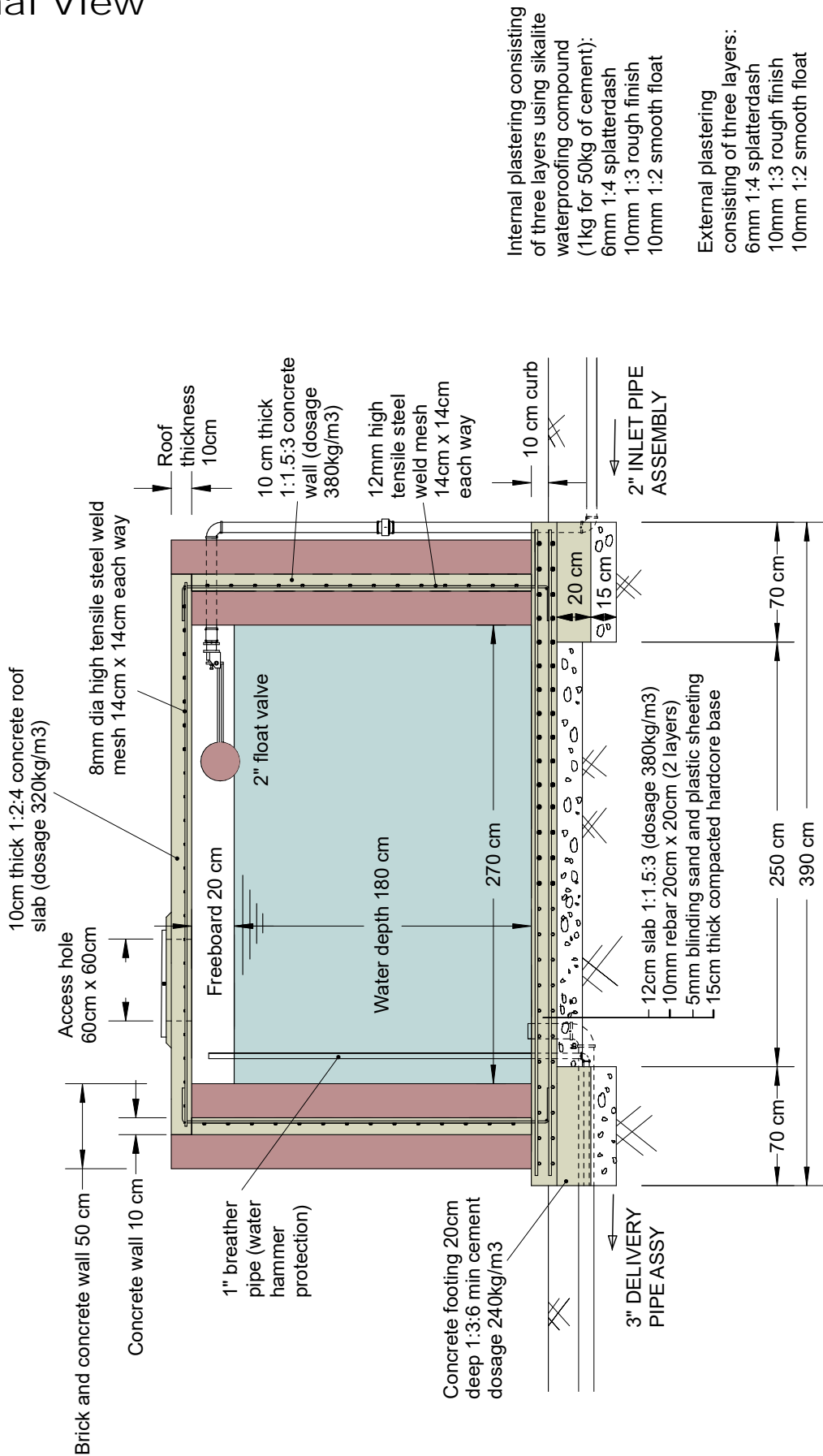
**305SLOPES FOR WATER COLLECTION POINTS AND DRAINAGE CHANNELS ..... 11**

**306SURFACE FINISHES AT PUBLIC WATER COLLECTION POINTS ..... 11**

**UNHCR STANDARD DESIGNS FOR WATER SUPPLY ..... 12**

**USEFUL REFERENCES..... 13**

Sectional View



Internal plastering consisting of three layers using sikkalite waterproofing compound (1kg for 50kg of cement):  
6mm 1:4 splatterdash  
10mm 1:3 rough finish  
10mm 1:2 smooth float

External plastering consisting of three layers:  
6mm 1:4 splatterdash  
10mm 1:3 rough finish  
10mm 1:2 smooth float

513-D

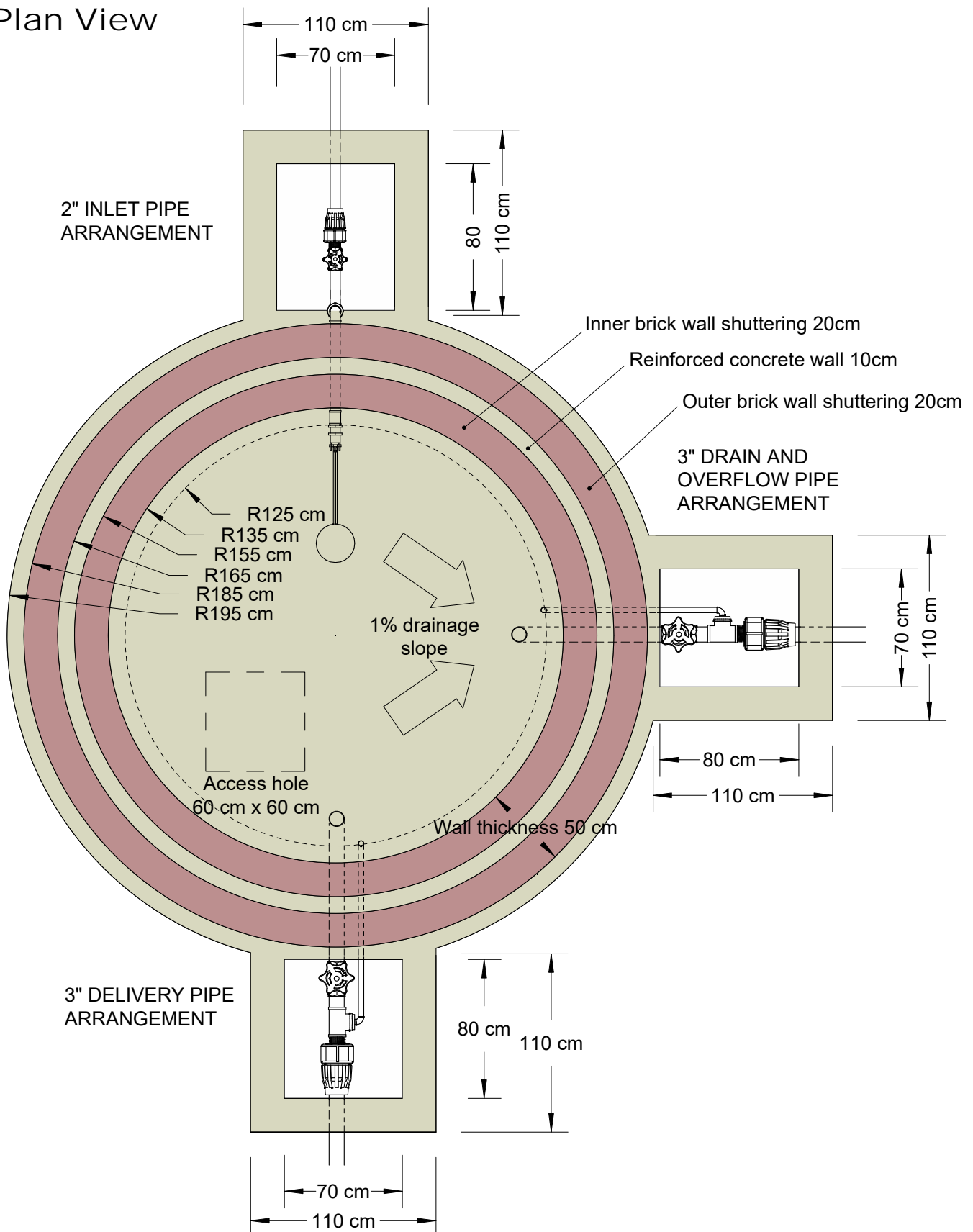
TITLE  
10m<sup>3</sup> Round Water Reservoir  
Sectional View  
PROJECT  
Project Name, Country

DRAWN BY  
B. Harvey - 11/10/16  
APPROVED BY  
M. Burt - 15/11/16  
SCALE  
1:30

UNITS  
metres  
SHEET  
1 of 3  
DATE PUBLISHED  
15/11/16



## Plan View



### NOTES

1. Ensure concrete is not over-watered = risk of cracking (no more than 1/4 height reduction during slump test).
2. Slabs to be cast in one continuous operation. All concrete works to be well rodded (preferably vibrated).
3. Ensure all concrete works are kept damp and out of direct sunlight for at least 7 days while curing.

D-315

TITLE  
10m<sup>3</sup> Round Water Reservoir  
Plan View and General Layout  
PROJECT  
Project Name, Country

DRAWN BY  
B. Harvey - 11/10/16  
APPROVED BY  
M. Burt - 15/11/16  
SCALE  
1:40

UNITS  
metres  
SHEET  
2 of 3  
DATE PUBLISHED  
15/11/16



# Pipe Assembly Detail

## 3" DELIVERY PIPE ASSEMBLY

220cm x 1" Ø GI Pipe

30cm x 3" Ø GI Pipe

3" GI Elbow

125cm x 3" Ø GI Pipe

3" Gate Valve

3" GI Nipple

3" GI Tee

90mm Ø PE Pipe Adaptor (Male)

90mm Ø PE Pipe

3" x 1" Ø GI Reducer (M-F)

1" GI Nipple

1" GI Elbow

25cm x 1" Ø GI Pipe

1" GI Elbow

150cm x 1" Ø GI Pipe

## 3" DRAINAGE PIPE ASSEMBLY

DRAINAGE PIPE ASSEMBLY  
EXACTLY THE SAME AS  
DELIVERY PIPE EXCEPT  
VERTICAL 3" DRAIN PIPE IS  
5CM SHORTER.

## 2" INLET PIPE ASSEMBLY

56cm x 2" Ø GI Pipe

2" GI Elbow

2" GI Socket

2" Float Valve  
Assembly

105cm x 2" Ø GI Pipe

2" Ø GI Union (F-F)

105cm x 2" Ø GI Pipe

2" GI Elbow

35cm x 2" Ø GI Pipe

3" Gate Valve

90mm Ø PE Pipe Adaptor (Male)

63mm Ø PE Pipe

### Notes

1. Alternative valve and pipe arrangements may be used if the inlet or outlet pipe diameters are different.
2. Valves to be positioned centrally. Valve box dimensions may be increased or reduced to match valve assembly arrangements.
3. The bottom of the valve box should be kept open (i.e. filled with compacted hardcore) to allow any excess water to drain.

#### TITLE

**10m<sup>3</sup> Round Water Reservoir**  
Pipe Assembly Detail

#### PROJECT

Project Name, Country

#### DRAWN BY

B. Harvey - 11/10/16

#### APPROVED BY

M. Burt - 15/11/16

#### SCALE

1:25

#### UNITS

metres

#### SHEET

3 of 3

#### PUBLISHED

15/11/16



**UNHCR**  
The UN Refugee Agency



## STEP-BY-STEP ASSEMBLY DRAWINGS

Please follow the step-by-step procedure for the 30m<sup>3</sup> water reservoir D313/2016a.

Note that the process is similar but the dimensions will be different.



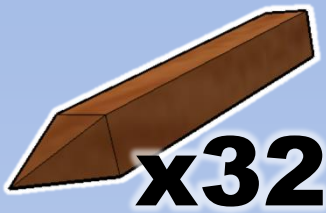
## BILL OF QUANTITIES

Description	QTY
Wooden Stakes (65cm x 5cm x 5cm)	32 pcs
Wooden Planks (4m x 20cm x 2.5cm)	17 pcs
Wooden Posts (4m x 5cm x 5cm)	4 pcs
Wooden Beams (4m x 5cm x 2.5cm)	4 pcs
Nails (6cm Galvanized)	2 kg
High Tensile Steel Weld-Mesh Ø8mm 14cm x 14cm	11 m <sup>2</sup>
High Tensile Steel Weld-Mesh Ø10mm 20cm x 20cm	30 m <sup>2</sup>
High Tensile Steel Weld-Mesh Ø12mm 14cm x 14cm	28 m <sup>2</sup>
Tying Wire Ø 1mm	0.5 kg
Plastic Sheeting	16 m <sup>2</sup>
Inlet Pipe Assembly (2" Gate Valve, 2" GI Pipe x 35cm, 2" GI Elbow, 2" GI Pipe x 105cm, 2" GI Union, 2" GI Pipe x 105cm, 2" GI Elbow, 2" GI Pipe x 16cm, 2" GI Socket, 2" Float Valve)	1 pc
Outlet Pipe Assembly (3" GI Tee, 3" GI Nipple, 3" Gate Valve, 3" GI Pipe x 85cm, 3" GI Elbow, 3" GI Pipe x 105cm, 3" GI Pipe x 30cm, 3" – 1" GI Reducer (M-F), 1" GI Nipple, 2" GI Elbow, 1" GI Pipe x 110cm, 1" GI Pipe x 220cm)	1 pc
Drain Pipe Assembly (3" GI Tee, 3" GI Nipple, 3" Gate Valve, 3" GI Pipe x 85cm, 3" GI Elbow, 3" GI Pipe x 105cm, 3" GI Pipe x 25cm, 3" – 1" GI Reducer (M-F), 1" GI Nipple, 2" GI Elbow, 1" GI Pipe x 110cm, 1" GI Pipe x 220cm)	1 pc
Metallic Valve Box Covers (70cm x 70cm x 2mm)	4 pcs
Coarse Sand	7.2 m <sup>3</sup>
Bricks 20cm x 9cm x 6cm	5,500 pcs
Coarse Gravel (12mm – 25mm)	5.8 m <sup>3</sup>
Cement (50kg sacks)	60 sacks
Compacted Hardcore Sub-Base	2.1 m <sup>3</sup>



# Bill of Quantities

1. Wooden Stakes (pc)  
5cm x 5cm x 65cm



**x32**

2. Wooden Planks (pc)  
2.5cm x 20 cm x 4m



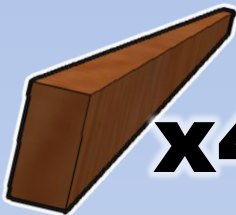
**x17**

3. Wooden Posts (pc)  
5cm x 5cm x 4m



**x4**

4. Wooden Beams (pc)  
10cm x 5 cm x 4m



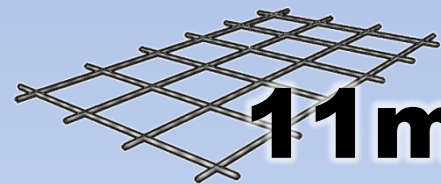
**x4**

5. Nails 6cm (kg)



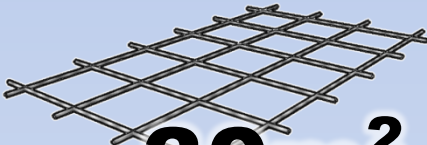
**x2**

6. Steel Weld-Mesh 8mm  
Ø x 14cm x 14cm



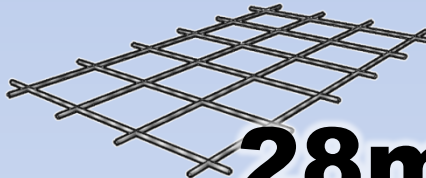
**11m<sup>2</sup>**

7. Steel Weld-Mesh  
10mm Ø x 20cm x  
20cm



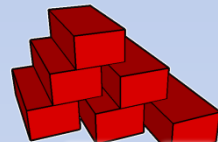
**30m<sup>2</sup>**

8. Steel Weld-Mesh  
12mm Ø x 14cm x  
14cm



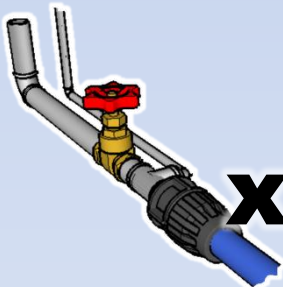
**28m<sup>2</sup>**

9. Bricks 20cm x  
9cm x 6cm



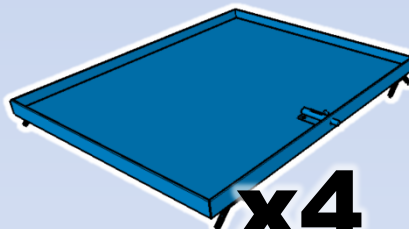
**5,500**

10. Valve and Pipe  
Assemblies (pc)



**x3**

11. Metallic Covers 70cm  
x 70cm x 2mm



**x4**

12. Cement 50kg (sacks)



**x60**

13. Sand (m3)



**7.2m<sup>3</sup>**

14. Gravel (m3)



**5.8m<sup>3</sup>**

15. Compacted Crushed  
Hardcore Base (m3)



**2.1m<sup>3</sup>**



## **SPECIFICATIONS FOR CONSTRUCTION OF WATER SUPPLY RELATED INFRASTRUCTURE IN REFUGEE SETTINGS**

### **300 SCOPE**

300.1 These design guidelines specifically define the quality of materials and workmanship to be used when constructing water supply related infrastructure in refugee settings. A description of principles of water supply programmes in refugee settings, in addition to technical options and their advantages and disadvantages, can be found in the UNHCR WASH Manual.

### **301 SITE SELECTION**

301.1 A basic requirement is that the site selected for water supply related infrastructure is free from the risk of high winds, flooding, subsidence, or erosion.

### **302 PREVENTION OF SURFACE OR GROUNDWATER CONTAMINATION**

302.1 UNHCR and WASH actors must ensure that all water supply related infrastructure including treatment systems and soakaway systems do not contaminate surface water or shallow groundwater sources. Risks are generally low and related to contamination from water treatment chemicals, water treatment by-products and sludges and contamination from wastewater.

302.2 All tapstands, or other water collection and usage points, should be equipped with adequately designed soakage systems located at least 30 metres away from groundwater sources. The bottom of any pit or soakaway must be at least 1.5m above the highest average groundwater table level. These distances should be increased for fissured rocks and limestone.

302.3 In some situations temporary groundwater contamination from on-site soakage systems may not be of immediate concern if the groundwater is non-potable. An example of this can be found in areas where groundwater is heavily saline beyond drinking water health limits of  $1,500\mu\text{S}/\text{cm}^2$ . In all cases, local legislation should be respected.

### **303 SPECIFICATIONS OF COMMON CONSTRUCTION MATERIALS**

303.1 Gravel used for constructing concrete footings and slabs must be clean and free from mud, dust and plant material. Rounded aggregates are preferred. If crushed stone aggregates are used then additional cement should be added (see table below). UNHCR and WASH actors must ensure that only aggregates between 12mm and 25mm are used to prevent inter granular crack propagation across load bearing concrete structures (e.g. tapstand floor slabs, water reservoir roof slabs, and columns used in reinforced concrete water towers) and to ensure an adequate covering of steel reinforcement bars.

- 303.2 Sand used for water supply related concrete works should be coarse (no fines), clean and free from mud, dust and plant material.
- 303.3 Water should be non-saline and free from organic matter.
- 303.4 Cement must be fresh (manufactured in the last three months) dry, and should be stored in a safe, dry, place at least 15cm off the ground.
- 303.5 Reinforcement bars should be free from rust and of the correct type and size for concrete construction work (typically a characteristic yield stress of at least 210 N/mm<sup>2</sup>). Steel reinforcement should be placed as per the designs (typically 7/8 of the slab or wall thickness) to ensure the bars function correctly in tension. All bars should have at least 12mm concrete covering under every bar. All laps should be a minimum of 25cm.
- 303.6 Concrete mix strengths Mass concrete footings should be cast with a 1:3:6 concrete mixture with a minimum cement dosage of 240 kg/m<sup>3</sup>. Concrete slabs and drainage channels should be cast as single continuous structures using a 1:2:4 concrete mixture with a minimum cement dosage of 320kg/m<sup>3</sup>. Water retaining structures (reservoir walls and bases) should be cast using a waterproof 1:1.5:3 concrete mixture (note that 1:2:4 is not waterproof) with a minimum cement dosage of 380kg/m<sup>3</sup>. Additional cement should be added if hand mixing (see table below). Care should be taken to ensure that concrete mixtures are not over watered (bucket slump test should show no greater than ¼ reduction in the slump height). Cast concrete works should be immediately covered with plastic sheeting, straw, cement bags, sacking or leaves to keep the concrete moist and cool during the full curing period. All concrete should be well rodded (ideally vibrated) to remove air voids. The concrete should be cured with frequent watering at least twice daily for at least 10 days before use. The quantities of cement, sand and aggregate for 1m<sup>3</sup> of concrete can be found in the table below.

	Quantity of Cement in Kg					
Concrete Mix	Machine Mixing		Hand Mixing		Coarse Dry Sand (m <sup>3</sup> )	Aggregate 12mm – 25mm (m <sup>3</sup> )
	Gravel	Broken Stone	Gravel	Broken Stone		
1:1.5:3	370	390	380	400	0.42	0.84
1:2:4	290	310	300	320	0.45	0.90
1:3:6	190	210	200	220	0.46	0.92

Source: Indian Civil Engineer's Handbook (Khanna, 2001)

- 303.7 Cement plasters Interior and exterior plasters should be applied as three layers as follows:

6mm 1:4 splatterdash  
 10mm 1:3 rough finish  
 10mm 1:2 smooth float

Each layer should preferably be applied when the previously layer is still 'green' (not fully cured). Each layer should be thoroughly wetted and the previously layer keyed (scratched) to ensure proper bonding. Interior

plasters of water retaining structures should be mixed with sikalite waterproofing compound (1kg per 50kg cement). The quantities of cement and sand for a 100m<sup>2</sup> of plaster can be found in the table below.

	100m <sup>2</sup> 6mm thick		100m <sup>2</sup> 12mm thick	
	Cement (kg)	Sand (m3)	Cement (kg)	Sand (m3)
1:4 splatterdash	274	0.766	- - -	- - -
1:3 rough finish	- - -	- - -	734	1.541
1:2 smooth float	- - -	- - -	979	1.371

Source: Indian Civil Engineer's Handbook (Khanna, 2001)

- 303.8 **Brick mortar strengths** Above ground general purpose load bearing brick walls used in normal building construction, exposed to weather and heat, should be laid with a 1:6 mortar mixture with a minimum cement dosage of 250 kg/m<sup>3</sup>. Below ground brick walls subject to soil pressure or seismic conditions should be laid with a 1:4 mortar mixture with a minimum cement dosage of 380 kg/m<sup>3</sup>. Joint thickness should be 8mm - 12mm. The quantity of mortar required can be calculated as 0.23 to 0.25 of the brick wall volume. The quantities of cement and sand for 1m<sup>3</sup> of wet mortar can be found in the table below.

	1:4	1:5	1:6	1:7
Cement (kg)	380	312	250	220
Sand (m3)	1.1	1.1	1.1	1.1

Source: Indian Civil Engineer's Handbook (Khanna, 2001)

### 304 SOAKAGE PIT SIZING BASED ON SOIL INFILTRATION RATES

- 304.1 The sizing of soakage pits, trenches and drain fields is dependent upon local site soil infiltration rates, the number of users and the quantity of waste water that is expected to be generated per person. Soakage pit dimensions should be determined by on-site soil infiltration tests (see Appendix 20 of Engineering in Emergencies. Alternatively refer to the table of typical soil infiltration rates on page 213 of the UNHCR WASH Manual). Soakage pits for wastewater from showers or septic tanks are likely to be much bigger than those for wastage from tapstands (see table below). In some cases communal shower blocks and septic tank installations may require drain fields rather than soakage pits.

	Clean Water (litres/m2/day)	Wastewater (Sewage and Sullage) (litres/m2/day)
Sand	720 – 2,400	33 - 50
Sandy Loam	480 – 720	24
Silt Loam	240 - 480	18
Clay Loam	120 - 240	8
Clay	24 - 120	Unsuitable

Source: Engineering in Emergencies (RedR, 2010)

## **305 SLOPES FOR WATER COLLECTION POINTS AND DRAINAGE CHANNELS**

- 305.1 All water collection surfaces and drainage channels should be inclined to ensure that there is no standing water at water points. In general a slope of 1% should be sufficient to ensure that the water is gradually evacuated towards soakage pits.

## **306 SURFACE FINISHES AT PUBLIC WATER COLLECTION POINTS**

- 306.1 All concrete surfaces at water collection points should be given a non-slip finish (the surfaces should be lightly brushed with a yard brush before the surface has cured) to ensure safe access by all users including the elderly, pregnant women, disabled users and small children. The surface should be sufficient to facilitate cleaning while also preventing slipping.



## UNHCR STANDARD DESIGNS FOR WATER SUPPLY

The following technical designs for water supply are available from UNHCR.

D-300/2015a	Emergency Tapstand (Wooden Pallets) with Drainage
D-301/2015a	Post Emergency Tapstand Design (Rectangular Concrete)
D-302/2015a	Post Emergency Handpump Apron Design (Rectangular Concrete)
D-303/2015a	Post Emergency Hand Dug Well Apron Design (Circular Concrete)
D-304/2015a	Borehole Design (Fractured Rock)
D-305/2015a	Borehole Design (Alluvial Aquifer)
D-306/2015a	Emergency Raised Water Platform (Sandbags)
D-307/2015a	Emergency Raised Water Platform (Concrete Rings)
D-308/2015a	Emergency Raised Water Platform (Corrugated Steel Rings)
D-309/2015a	Elevated 6m Water Tower with 20m <sup>3</sup> , 25m <sup>3</sup> , 50m <sup>3</sup> 60m <sup>3</sup> and 75m <sup>3</sup> Water Reservoir (Reinforced Concrete)
D-310/2015a	Elevated Water Tower 15m high with 109m <sup>3</sup> Reservoir (Steel)
D-311/2015a	Post Emergency Elevated Water Tower 4m (Steel)
D-312/2015a	Square Water Reservoir 10m <sup>3</sup> (Reinforced Concrete)
D-313/2015a	Square Water Reservoir 30m <sup>3</sup> (Reinforced Concrete)
D-314/2015a	Square Water Reservoir 50m <sup>3</sup> (Reinforced Concrete)
D-315/2015a	Circular Water Reservoir 10m <sup>3</sup> (Reinforced Concrete)
D-316/2015a	Circular Water Reservoir 25m <sup>3</sup> (Reinforced Concrete)
D-317/2015a	Circular Water Reservoir 50m <sup>3</sup> (Reinforced Concrete)
D-318/2015a	Circular Water Reservoir 75m <sup>3</sup> (Reinforced Concrete)
D-319/2015a	Circular Water Reservoir 100m <sup>3</sup> (Reinforced Concrete)
D-320/2015a	Circular Water Reservoir 45m <sup>3</sup> (Ferrocement)
D-321/2015a	Circular Water Reservoir 75m <sup>3</sup> (Ferrocement)
D-322/2015a	Circular Water Reservoir 90m <sup>3</sup> (Ferrocement)

These designs may be found at <http://wash.unhcr.org/wash-technical-designs/>.

## USEFUL REFERENCES

### Emergency water supply

- ◆ ACF (2005), 'Water, sanitation and hygiene for populations at risk – second edition'. ACF, Paris, France.  
[http://www.actioncontrelafaim.org/publications/fichiers/wsh\\_acf\\_0.pdf](http://www.actioncontrelafaim.org/publications/fichiers/wsh_acf_0.pdf)
- ◆ Chalinder, A. (1994), 'Water & sanitation in emergencies: a good practice review', Overseas Development Institute (ODI), London,  
<http://www.odihpn.org/download/gpr1pdf>
- ◆ House S., and Reed, B. (2004) 'Emergency water sources 3rd Ed.', WEDC, Loughborough University, UK.  
[http://wedc.lboro.ac.uk/resources/books/Emergency\\_Water\\_Sources\\_-\\_Complete.pdf](http://wedc.lboro.ac.uk/resources/books/Emergency_Water_Sources_-_Complete.pdf)
- ◆ Lambert, R., and Davis, J. (2002), 'Engineering in emergencies 2nd Ed.', Register of Engineers for Disaster Relief (RedR), London.
- ◆ SPHERE (2011) 'Humanitarian charter and minimum standards in disaster response'. <http://www.sphereproject.org/resources/download-publications>
- ◆ UNHCR (2007), 'Handbook for emergencies – third edition'. UNHCR, Geneva. <http://www.unhcr.org/472af2972.html>
- ◆ UNHCR (1992), 'Water manual for refugee situations', UNHCR, Geneva.  
<http://www.unhcr.org/3ae6bd100.pdf>

### Surface water

- ◆ House, S., Reed, B. and Shaw, R., (1989) 'Selecting sources of water: WEDC technical brief #55'. WEDC, Loughborough University, UK.  
<http://www.lboro.ac.uk/well/resources/technical-briefs/55-water-source-selection.pdf>
- ◆ Smout, I. and Shaw, R. (1989), 'Surface water intakes: WEDC technical brief #22'. WEDC, Loughborough University, UK.  
<http://www.bvsde.paho.org/eswww/tecapropiada/otratec/waterlin/tb22.pdf>
- ◆ Wijk-Sijbesma, C.A., and Smet, J.E.M. (2002), 'Small community water supplies: Surface water intakes and small dams', IRC International Water and Sanitation Centre, Delft  
[http://www.samsamwater.com/library/TP40\\_11\\_Surface\\_water.pdf](http://www.samsamwater.com/library/TP40_11_Surface_water.pdf)
- ◆ WEDC (2012), 'Intakes from rivers: WEDC trial course unit'. WEDC, Loughborough University, UK.  
[http://wedc.lboro.ac.uk/resources/units/EWS\\_Unit\\_5\\_Surface\\_Water\\_Intakes.pdf](http://wedc.lboro.ac.uk/resources/units/EWS_Unit_5_Surface_Water_Intakes.pdf)
- ◆ USAID (1984) 'Maintaining intakes', USAID, Washington USA.  
[http://www.watersanitationhygiene.org/Maintaining\\_Intakes\\_\(USAID\).pdf](http://www.watersanitationhygiene.org/Maintaining_Intakes_(USAID).pdf)
- ◆ USAID (1984), 'Constructing intakes for ponds, lakes and reservoirs', USAID, Washington USA. [http://www.watersanitationhygiene.org/Intakes\(USAID\).pdf](http://www.watersanitationhygiene.org/Intakes(USAID).pdf)
- ◆ USAID (1984), 'Constructing intakes for streams and rivers', USAID, Washington USA.

[http://www.watersanitationhygiene.org/Intakes for Streams and Rivers \(US AID\).pdf](http://www.watersanitationhygiene.org/Intakes for Streams and Rivers (US AID).pdf)

- ◆ USAID (1984), 'Designing intakes for ponds, lakes and reservoirs', USAID, Washington USA. <http://www.lifewater.org/resources/rws1/rws1d2.pdf>
- ◆ USAID (1984,) 'Designing intakes for streams and rivers', USAID, Washington USA. <https://www.lifewater.org/resources/rws1/rws1d3.pdf>
- ◆ USAID (1984), 'Designing intakes for ponds, lakes and reservoirs', USAID, Washington USA. <http://www.lifewater.org/resources/rws1/rws1d2.pdf>
- ◆ USAID (1984,) 'Designing intakes for streams and rivers', USAID, Washington USA. <https://www.lifewater.org/resources/rws1/rws1d3.pdf>

### Spring captures

- ◆ Skinner, B. and Shaw, R. (1989), 'Protecting springs an alternative to spring boxes: WEDC technical brief #34'. WEDC, Loughborough University, UK. <http://www.lboro.ac.uk/well/resources/technical-briefs/34-protecting-springs.pdf>
- ◆ Oxfam GB (2008), 'Spring protection: technical brief #5', Oxfam GB, Oxford, UK. <http://oxfamilibrary.openrepository.com/6/tbn5-spring-protection-030608-en.pdf>
- ◆ USAID (1984), 'Constructing structures for springs', USAID, Washington USA. <http://my.ewb-usa.org/theme/library/myewb-usa/project-resources/technical/rws1c1.pdf>
- ◆ USAID (1984), 'Designing structures for springs', USAID, Washington USA. <https://www.lifewater.org/resources/rws1/rws1d1.pdf>
- ◆ USAID (1984), 'Maintaining spring structures', USAID, Washington USA. <http://my.ewb-usa.org/theme/library/myewb-usa/project-resources/technical/rws1o1.pdf>

### Hand dug wells

- ◆ Abbott, S. (2001), 'Hand dug well manual'. <http://www.sswm.info/ABBOT%204000%20Hand%20Dug%20Well%20Manual.pdf>
- ◆ Colins, S. (2000), 'Hand dug shallow wells', Swiss Resource Centre for Development (SKAT), St. Gallen, Switzerland. <http://www.skat.ch/publications/2005-10-31.1053710342/file>
- ◆ Pickford, J. and Shaw, R. (1989), 'Upgrading traditional wells: WEDC technical brief #39'. WEDC, Loughborough University, UK. <http://www.lboro.ac.uk/well/39-upgrading-traditional-wells.pdf>
- ◆ Reed, A. and Luff, R. (2000), 'Instruction Manual for Hand Dug Well Equipment', Oxfam GB, Oxford, <http://oxfamilibrary.openrepository.com/oxfam/1/hand-dug-well-manual-250406-en.pdf>

- ◆ USAID (1984), 'Designing hand dug wells', USAID, Washington USA.  
<http://my.ewb-usa.org/theme/library/myewb-usa/project-resources/technical/rws2d1.pdf>
- ◆ USAID (1984), 'Selecting a well site', USAID, Washington USA.  
<http://my.ewb-usa.org/theme/library/myewb-usa/project-resources/technical/rws2p3.pdf>
- ◆ USAID (1984), 'Constructing hand dug wells', USAID, Washington USA.  
<http://my.ewb-usa.org/theme/library/myewb-usa/project-resources/technical/rws2c1.pdf>
- ◆ USAID (1984), 'Finishing wells', USAID, Washington USA. <http://my.ewb-usa.org/theme/technical/rws2c8.pdf>

## Hand drilled wells

- ◆ Elson, B. and Shaw, R. (1989), 'Simple drilling methods: WEDC technical brief #43'. WEDC, Loughborough University, UK.  
<http://www.lboro.ac.uk/well/resources/technical-briefs/43-simple-drilling-methods.pdf>
- ◆ Herwijnen, A. (2005), 'Rota Sludge and Stone Hammer Drilling Part One - Drilling Manual', ETC Foundation, Leusden. [http://www.itacanet.org/doc-archive-eng/water/Rota\\_sludge\\_drilling\\_Pt1.pdf](http://www.itacanet.org/doc-archive-eng/water/Rota_sludge_drilling_Pt1.pdf)
- ◆ Herwijnen, A. (2005), 'Rota Sludge and Stone Hammer Drilling Part One - Production Manual', ETC Foundation, Leusden. [http://www.itacanet.org/doc-archive-eng/water/Rota\\_sludge\\_drilling\\_Pt2.pdf](http://www.itacanet.org/doc-archive-eng/water/Rota_sludge_drilling_Pt2.pdf)
- ◆ Wurzel, P. (2001), 'Drilling boreholes for handpumps', Swiss Resource Centre for Development (SKAT), St. Gallen, Switzerland. <http://www.rural-water-supply.net/ressources/documents/default/148.pdf>
- ◆ USAID (1984), 'Designing bored and augured wells', USAID, Washington USA. <http://my.ewb-usa.org/theme/library/myewb-usa/project-resources/technical/rws2d4.pdf>
- ◆ USAID (1984), 'Designing driven wells', USAID, Washington USA. <http://my.ewb-usa.org/theme/library/myewb-usa/project-resources/technical/rws2d2.pdf>
- ◆ USAID (1984), 'Designing jetted wells', USAID, Washington USA. <http://my.ewb-usa.org/theme/library/myewb-usa/project-resources/technical/rws2d3.pdf>
- ◆ USAID (1984), 'Constructing bored and augured wells', USAID, Washington USA. <http://my.ewb-usa.org/theme/library/myewb-usa/project-resources/technical/rws2c4.pdf>
- ◆ USAID (1984), 'Constructing driven wells', USAID, Washington USA. <http://my.ewb-usa.org/theme/library/myewb-usa/project-resources/technical/rws2c2.pdf>
- ◆ USAID (1984), 'Constructing jetted wells', USAID, Washington USA. <http://my.ewb-usa.org/theme/library/myewb-usa/project-resources/technical/rws2c3.pdf>



## Machine drilled wells

- ◆ Ball, P. (2001), 'Drilling wells', Swiss Resource Centre for Development (SKAT), St. Gallen, Switzerland. [http://www.rural-water-supply.net/\\_ressources/documents/default/1-147-2-1355235564.pdf](http://www.rural-water-supply.net/_ressources/documents/default/1-147-2-1355235564.pdf)
- ◆ Carter, R., Chilton, J., Danert, K. and Olschewski, A., 'Siting of Drilled Water Wells - A Guide for Project Managers', Rural Water Supply Network (RWSN), St. Gallen, Switzerland. [http://www.rural-water-supply.net/\\_ressources/documents/default/187.pdf](http://www.rural-water-supply.net/_ressources/documents/default/187.pdf)
- ◆ Danert, K. et al (2010), 'Code of Practice for Cost Effective Boreholes', Rural Water Supply Network (RWSN), St. Gallen, Switzerland. [http://www.rural-water-supply.net/\\_ressources/documents/default/1-128-2-1344514867.pdf](http://www.rural-water-supply.net/_ressources/documents/default/1-128-2-1344514867.pdf)
- ◆ ICRC (2010), 'Borehole Drilling and Rehabilitation under Field Conditions: Technical Review', International Committee of the Red Cross (ICRC), Geneva. <https://www.icrc.org/eng/assets/files/other/icrc-002-0998.pdf>
- ◆ USAID (1984), 'Designing cable tool wells', USAID, Washington USA. <http://my.ewb-usa.org/theme/library/myewb-usa/project-resources/technical/rws2d5.pdf>
- ◆ USAID (1984), 'Constructing a cable tool wells', USAID, Washington USA. <http://my.ewb-usa.org/theme/library/myewb-usa/project-resources/technical/rws2c5.pdf>
- ◆ USAID (1984), 'Finishing wells', USAID, Washington USA. <http://my.ewb-usa.org/theme/library/myewb-usa/project-resources/technical/rws2c8.pdf>
- ◆ Wurzel, P. (2001), 'Drilling boreholes for handpumps', Swiss Resource Centre for Development (SKAT), St. Gallen, Switzerland. [http://www.rural-water-supply.net/\\_ressources/documents/default/148.pdf](http://www.rural-water-supply.net/_ressources/documents/default/148.pdf)

## Rainwater harvesting

- ◆ ITDG (2002), 'Rainwater harvesting technical brief', Intermediate Technology Development Group (ITDG), [http://www.watersanitationhygiene.org/Rainwater%20Harvesting%20\(ITDG\).pdf](http://www.watersanitationhygiene.org/Rainwater%20Harvesting%20(ITDG).pdf)
- ◆ USAID (1984), 'Evaluating rainfall catchments', USAID, Washington USA. <http://my.ewb-usa.org/theme/library/myewb-usa/project-resources/technical/rws1p5.pdf>
- ◆ USAID (1984), 'Designing roof catchments', USAID, Washington USA. <https://www.lifewater.org/resources/rws1/rws1d4.pdf>
- ◆ USAID (1984), 'Constructing, operating and maintaining roof catchments', USAID, Washington USA. <http://my.ewb-usa.org/theme/library/myewb-usa/project-resources/technical/rws1c4.pdf>

## Water network design

- ◆ Jordan, D. (1984), 'A Handbook of Gravity-Flow Water Systems', Practical Action, IT Publishing, UK.

- ◆ Knight, J. and Gonzalez Otalora, C. (2014), 'Design and installation of a water supply network, Batil refugee camp Maban County, South Sudan', Medair and Solidarites International.  
<https://data.unhcr.org/SouthSudan/download.php?id=1168>
- ◆ Oxfam GB (1999), 'Water supply scheme for emergencies', Oxfam GB, Oxford, UK. <http://www.bvsde.paho.org/texcom/desastres/oxfamwfm.pdf>
- ◆ Reed, B. and Shaw, R. (1989), 'Emergency water supply: WEDC technical brief #44', WEDC, Loughborough University, UK.  
<http://www.lboro.ac.uk/well/resources/technical-briefs/44-emergency-water-supply.pdf>
- ◆ USAID (1984), 'Designing gravity flow systems', USAID, Washington USA.  
<https://www.lifewater.org/resources/rws4/rws4d1.pdf>
- ◆ USAID (1984), 'Designing a transmission main', USAID, Washington USA.  
<https://www.lifewater.org/resources/rws4/rws4d3.pdf>
- ◆ USAID (1984), 'Designing community distribution systems', USAID, Washington USA. <https://www.lifewater.org/resources/rws4/rws4d4.pdf>
- ◆ USAID (1984), 'Constructing a distribution system with household connections', USAID, Washington USA.  
<https://www.lifewater.org/resources/rws4/rws4c5.pdf>
- ◆ USAID (1984), 'Constructing community distribution systems', USAID, Washington USA. <https://www.lifewater.org/resources/rws4/rws4c4.pdf>
- ◆ USAID (1984), 'Detecting and correcting leaking pipes', USAID, Washington USA. <https://www.lifewater.org/resources/rws4/rws4o1.pdf>
- ◆ USAID (1984), 'Installing pipes', USAID, Washington USA.  
<https://www.lifewater.org/resources/rws4/rws4c1.pdf>
- ◆ USAID (1984), 'Operating and maintaining household water connections', USAID, Washington USA.  
<https://www.lifewater.org/resources/rws4/rws4o5.pdf>
- ◆ USAID (1984), 'Selecting pipe materials', USAID, Washington USA.  
<https://www.lifewater.org/resources/rws4/rws4p3.pdf>

## Motorized water pumping

- ◆ Baumann, E. (2000), 'Water Lifting', Swiss Resource Centre for Development (SKAT), St. Gallen, Switzerland. <http://www.skat.ch/publications/2005-10-31.4419482767/file>
- ◆ Oxfam (2000), 'Instruction manual for surface water pumping' (Oxfam, 2000), Oxfam GB, Oxford,  
<http://www.oxfam.org.uk/equipment/Pumping%20Equipment%20Manual.pdf>
- ◆ Oxfam GB (1999), 'Water supply scheme for emergencies', Oxfam GB, Oxford, UK. <http://www.bvsde.paho.org/texcom/desastres/oxfamwfm.pdf>
- ◆ USAID (1984), 'Determining pump requirements', USAID, Washington USA.  
<https://www.lifewater.org/resources/rws4/rws4d2.pdf>
- ◆ USAID (1984), 'Selecting pumps', USAID, Washington USA.  
<https://www.lifewater.org/resources/rws4/rws4p5.pdf>

- ◆ USAID (1984), 'Selecting a power source for pumps', USAID, Washington USA. <https://www.lifewater.org/resources/rws4/rws4p4.pdf>
- ◆ USAID (1984), 'Installing mechanical pumps', USAID, Washington USA. <https://www.lifewater.org/resources/rws4/rws4c2.pdf>
- ◆ USAID (1984), 'Operating and maintaining mechanical pumps', USAID, Washington USA. <https://www.lifewater.org/resources/rws4/rws4o2.pdf>

## Handpumps

- ◆ Arlosoroff S. et al. (1987), 'Community water supply: the handpump option', The World Bank, Washington, DC. <http://www-wds.worldbank.org/external/PDF/multi0page.pdf>
- ◆ Baumann, E. (2000), 'Water Lifting', Swiss Resource Centre for Development (SKAT), St. Gallen, Switzerland. <http://www.skat.ch/publications/2005-10-31.4419482767/file>
- ◆ Erpf, K. (2007), 'Afridev handpump installation and maintenance manual (Revision 2-2007)', Swiss Resource Centre for Development (SKAT), St. Gallen, Switzerland. [http://rural-water-supply.net/\\_ressources/documents/default/286.pdf](http://rural-water-supply.net/_ressources/documents/default/286.pdf)
- ◆ [http://wedc.lboro.ac.uk/docs/research/WEJW2/Report - Uganda.pdf](http://wedc.lboro.ac.uk/docs/research/WEJW2/Report_-_Uganda.pdf)
- ◆ Skinner, B. and Shaw, R. (1989), 'VLOM Pumps: WEDC technical brief #41', WEDC, Loughborough University, UK. <http://www.lboro.ac.uk/well/resources/technical-briefs/41-vlom-pumps.pdf>
- ◆ USAID (1984), 'Installing Handpumps', USAID, Washington USA. <https://www.lifewater.org/resources/rws4/rws4c3.pdf>
- ◆ USAID (1984), 'Operating and Maintaining Handpumps', USAID, Washington USA. [http://water.engr.psu.edu/hill/teaching/rural\\_water/rws4o3.pdf](http://water.engr.psu.edu/hill/teaching/rural_water/rws4o3.pdf)

## Water storage

- ◆ Oxfam (2006), 'Water storage manual', Oxfam GB, Oxford, UK. <http://oxfamilibrary.openrepository.com/oxfam/bitstream/10546/126731/1/water-storage-manual-260406-en.pdf>
- ◆ Skinner, B., and Shaw, R. (1989), 'Buried and semi submerged water tanks : WEDC technical brief #56', WEDC, Loughborough University, UK. <http://www.lboro.ac.uk/well/resources/technical-briefs/56-buried-and-semi-submerged-tanks.pdf>
- ◆ Skinner, B., Reed, B., and Shaw, R. (1989), 'Ferrocement water tanks : WEDC technical brief #36', WEDC, Loughborough University, UK. <http://www.lboro.ac.uk/well/resources/technical-briefs/36-ferrocement-water-tanks.pdf>
- ◆ UNHCR (2006), 'Large ferro-cement water tank design parameters and construction details ', United Nations High Commissioner for Refugees UNHCR, Geneva. <http://www.unhcr.org/49d089a62.pdf>
- ◆ USAID (1984), 'Methods of storing water', USAID, Washington USA. <https://www.lifewater.org/resources/rws5/rws5m.pdf>

- ◆ USAID (1984), 'Designing a ground level water storage tank', USAID, Washington USA. <https://www.lifewater.org/resources/rws5/rws5d2.pdf>
- ◆ USAID (1984), 'Constructing a ground level water storage tank', USAID, Washington USA. <https://www.lifewater.org/resources/rws5/rws5c2.pdf>
- ◆ USAID (1984), 'Constructing a household cistern', USAID, Washington USA. <http://wiki.watermissions.org/GetFile.aspx?Page=Water%20Storage%20RWS5&File=rws5c1.pdf>
- ◆ USAID (1984), 'Designing an elevated water storage tank', USAID, Washington USA. <http://wiki.watermissions.org/GetFile.aspx?Page=Water%20Storage%20RWS5&File=rws5d3.pdf>
- ◆ USAID (1984), 'Constructing an elevated water storage tank', USAID, Washington USA. <http://wiki.watermissions.org/GetFile.aspx?Page=Water%20Storage%20RWS5&File=rws5c3.pdf>
- ◆ USAID (1984), 'Determining the need for water storage', USAID, Washington USA. <http://wiki.watermissions.org/GetFile.aspx?Page=Water%20Storage%20RWS5&File=rws5p1.pdf>
- ◆ USAID (1984), 'Maintaining water storage tanks', USAID, Washington USA. <http://wiki.watermissions.org/GetFile.aspx?Page=Water%20Storage%20RWS5&File=rws5o1.pdf>