UNHCR Square Water Reservoir 10m³

Tools and Guidance for Refugee Settings

UNHCR The UN Refugee Agency
UNHCR Standardized Designs for Refugee Settings
Square Reinforced Concrete Water Reservoir 10m$^3$

FOREWORD
These square 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.
10cm 1:2:4 concrete slab (dosage 320kg/m³)

8mm dia high tensile steel weld mesh 17cm x 17cm each way

1" breather pipe (water hammer protection)

10cm thick 1:1.5:3 concrete wall (dosage 380kg/m³)

12mm high tensile steel weld mesh 14cm x 14cm each way

Concrete footing
20cm deep 1:3:6
min cement dosage 240kg/m³

Depth 180 cm

Internal plastering consisting of three layers using sikalite 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

3" DELIVERY PIPE ASSY

20 cm

300 cm

2" INLET PIPE ASSEMBLY

2" float valve

Freeboard 20 cm

10 cm

Roof slab thickness 10 cm

10cm 1:1.5:3 slab (dosage 380kg/m³)

8mm rebar 20cm x 20cm (2 layers)

5mm blinding sand and plastic sheeting

15cm thick compacted hardcore base

Sectional View

D-312

10m Square Water Reservoir

Sectional View

PROJECT

Project Name, Country

DRAWN BY

M. Burt - 15/11/16

APPROVED BY

B. Harvey - 11/10/16

SCALE

1:30

UNITS

metres

SHEET

1 of 3

DATE PUBLISHED

15/11/16
3" DRAIN AND OVERFLOW PIPE ARRANGEMENT

1% drainage slope

Access hole 60 cm x 60 cm

Wall thickness 10 cm

2" INLET PIPE ARRANGEMENT

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.
4. Valve boxes should be sized according to inlet and outlet arrangements.
Pipe Assembly Detail

3" DELIVERY PIPE ASSEMBLY

- 220cm x 1" Ø GI Pipe
- 30cm x 3" Ø GI Pipe
- 3" GI Elbow
- 85cm x 3" Ø GI Pipe
- 3" Gate Valve
- 3" GI Nipple
- 3" GI Tee
- 3" x 1" Ø GI Reducer (M-F)
- 1" GI Nipple
- 1" GI Elbow
- 110cm x 1" Ø GI Pipe
- 25cm 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.

3" Gate Valve
90mm Ø PE Pipe Adaptor (Male)
90mm Ø PE Pipe
63mm Ø PE Pipe

2" INLET PIPE ASSEMBLY

- 16cm 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

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.
Please follow the step-by-step procedure for the 30m³ water reservoir D313/2016a. Note that the process is similar but the dimensions will be different.
**BILL OF QUANTITIES**

<table>
<thead>
<tr>
<th>Description</th>
<th>QTY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wooden Stakes (65cm x 5cm x 5cm)</td>
<td>46 pcs</td>
</tr>
<tr>
<td>Wooden Planks (4m x 20cm x 2.5cm)</td>
<td>71 pcs</td>
</tr>
<tr>
<td>Wooden Posts (4m x 5cm x 5cm)</td>
<td>36 pcs</td>
</tr>
<tr>
<td>Wooden Beams (4m x 5cm x 2.5cm)</td>
<td>5 pcs</td>
</tr>
<tr>
<td>Nails (6cm Galvanized)</td>
<td>3 kg</td>
</tr>
<tr>
<td>Nails (8cm Galvanized)</td>
<td>1 kg</td>
</tr>
<tr>
<td>High Tensile Steel Weld-Mesh Ø6mm 20cm x 20cm</td>
<td>17 m²</td>
</tr>
<tr>
<td>High Tensile Steel Weld-Mesh Ø12mm 17cm x 17cm</td>
<td>29 m²</td>
</tr>
<tr>
<td>High Tensile Steel Weld-Mesh Ø8mm 17cm x 17cm</td>
<td>8.5 m²</td>
</tr>
<tr>
<td>Tying Wire Ø 1mm</td>
<td>0.5 kg</td>
</tr>
<tr>
<td>Plastic Sheeting</td>
<td>10 m²</td>
</tr>
<tr>
<td>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)</td>
<td>1 pc</td>
</tr>
<tr>
<td>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)</td>
<td>1 pc</td>
</tr>
<tr>
<td>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)</td>
<td>1 pc</td>
</tr>
<tr>
<td>Metallic Valve Box Covers (70cm x 70cm x 2mm)</td>
<td>4 pcs</td>
</tr>
<tr>
<td>Coarse Sand</td>
<td>4.5 m³</td>
</tr>
<tr>
<td>Coarse Gravel (12mm – 25mm)</td>
<td>4.6 m³</td>
</tr>
<tr>
<td>Cement (50kg sacks)</td>
<td>40 sacks</td>
</tr>
<tr>
<td>Compacted Hardcore Sub-Base</td>
<td>1.9 m³</td>
</tr>
</tbody>
</table>
Bill of Quantities

1. Wooden Stakes (pc)  
   5cm x 5cm x 65cm  
   x38

2. Wooden Planks (pc)  
   2.5cm x 20 cm x 4m  
   x71

3. Wooden Posts (pc)  
   5cm x 5cm x 4m  
   x36

4. Wooden Beams (pc)  
   10cm x 5 cm x 4m  
   x5

5. Nails 6cm (kg)  
   x3

6. Nails 8cm (kg)  
   x1

7. Steel Weld-Mesh  
   Ø6mm x 20cm x 20cm  
   17m²

8. Steel Weld-Mesh  
   Ø12mm x 17cm x 17cm  
   7.2m² x 4

9. Steel Weld-Mesh  
   Ø8mm x 17cm x 17cm  
   8.5m²

10. Valve and Pipe  
    Assemblies (pc)  
    x3

11. Metallic Covers 70cm  
    x 70cm x 2mm  
    x4

12. Cement 50kg (sacks)  
    x40

13. Sand (m3)  
    4.5m³

14. Gravel (m3)  
    4.6m³

15. Cement 50kg (sacks)  
    1.9m³
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 soak-away 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 1,500μS/cm². 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 be 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/mm²). 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.

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/m³. 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/m³. 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/m³. 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.

<table>
<thead>
<tr>
<th>Concrete Mix</th>
<th>Machine Mixing</th>
<th>Hand Mixing</th>
<th>Coarse Dry Sand (m³)</th>
<th>Aggregate 12mm – 25mm (m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gravel</td>
<td>Gravel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:1.5:3</td>
<td>370</td>
<td>380</td>
<td>0.42</td>
<td>0.84</td>
</tr>
<tr>
<td>1:2:4</td>
<td>290</td>
<td>300</td>
<td>0.45</td>
<td>0.90</td>
</tr>
<tr>
<td>1:3:6</td>
<td>190</td>
<td>200</td>
<td>0.46</td>
<td>0.92</td>
</tr>
</tbody>
</table>

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

303.7 **Cement plasters** Interior and exterior plasters for water reservoirs 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. All interior plasters of water retaining structures should mixed with sikalite
waterproofing compound at a dosage of 1kg per sack (50kg) of cement. The quantities of cement and sand for a 100m$^2$ area of cement plaster can be found in the table below.

<table>
<thead>
<tr>
<th></th>
<th>100m$^2$ 6mm thick</th>
<th>100m$^2$ 12mm thick</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cement (kg)</td>
<td>Sand (m3)</td>
</tr>
<tr>
<td>1:4 splatterdash</td>
<td>274</td>
<td>0.766</td>
</tr>
<tr>
<td>1:3 rough finish</td>
<td>- - -</td>
<td>- - -</td>
</tr>
<tr>
<td>1:2 smooth float</td>
<td>- - -</td>
<td>734</td>
</tr>
<tr>
<td></td>
<td>979</td>
<td>1.541</td>
</tr>
</tbody>
</table>

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.

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

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.

<table>
<thead>
<tr>
<th>Design Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>D-300/2015a</td>
<td>Emergency Tapstand (Wooden Pallets) with Drainage</td>
</tr>
<tr>
<td>D-301/2015a</td>
<td>Post Emergency Tapstand Design (Rectangular Concrete)</td>
</tr>
<tr>
<td>D-302/2015a</td>
<td>Post Emergency Handpump Apron Design (Rectangular Concrete)</td>
</tr>
<tr>
<td>D-303/2015a</td>
<td>Post Emergency Hand Dug Well Apron Design (Circular Concrete)</td>
</tr>
<tr>
<td>D-304/2015a</td>
<td>Borehole Design (Fractured Rock)</td>
</tr>
<tr>
<td>D-305/2015a</td>
<td>Borehole Design (Alluvial Aquifer)</td>
</tr>
<tr>
<td>D-306/2015a</td>
<td>Emergency Raised Water Platform (Sandbags)</td>
</tr>
<tr>
<td>D-307/2015a</td>
<td>Emergency Raised Water Platform (Concrete Rings)</td>
</tr>
<tr>
<td>D-308/2015a</td>
<td>Emergency Raised Water Platform (Corrugated Steel Rings)</td>
</tr>
<tr>
<td>D-309/2015a</td>
<td>Elevated 6m Water Tower with 20m³, 25m³, 50m³, 60m³ and 75m³ Water Reservoir (Reinforced Concrete)</td>
</tr>
<tr>
<td>D-310/2015a</td>
<td>Elevated Water Tower 15m high with 109m³ Reservoir (Steel)</td>
</tr>
<tr>
<td>D-311/2015a</td>
<td>Post Emergency Elevated Water Tower 4m (Steel)</td>
</tr>
<tr>
<td>D-312/2015a</td>
<td>Square Water Reservoir 10m³ (Reinforced Concrete)</td>
</tr>
<tr>
<td>D-313/2015a</td>
<td>Square Water Reservoir 30m³ (Reinforced Concrete)</td>
</tr>
<tr>
<td>D-314/2015a</td>
<td>Square Water Reservoir 50m³ (Reinforced Concrete)</td>
</tr>
<tr>
<td>D-315/2015a</td>
<td>Circular Water Reservoir 10m³ (Reinforced Concrete)</td>
</tr>
<tr>
<td>D-316/2015a</td>
<td>Circular Water Reservoir 30m³ (Reinforced Concrete)</td>
</tr>
<tr>
<td>D-317/2015a</td>
<td>Circular Water Reservoir 50m³ (Reinforced Concrete)</td>
</tr>
<tr>
<td>D-318/2015a</td>
<td>Circular Water Reservoir 45m³ (Ferrocement)</td>
</tr>
<tr>
<td>D-319/2015a</td>
<td>Circular Water Reservoir 75m³ (Ferrocement)</td>
</tr>
<tr>
<td>D-320/2015a</td>
<td>Circular Water Reservoir 90m³ (Ferrocement)</td>
</tr>
</tbody>
</table>

These designs may be found at [http://wash.unhcr.org/wash-technical-designs/](http://wash.unhcr.org/wash-technical-designs/).
USEFUL REFERENCES

Emergency water supply
- Lambert, R., and Davis, J. (2002), 'Engineering in emergencies 2nd Ed.', Register of Engineers for Disaster Relief (RedR), London.

Surface water
- 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]
- USAID (1984), 'Constructing intakes for streams and rivers', USAID, Washington USA.
Spring captures


Hand dug wells

Hand drilled wells

Machine drilled wells


Rainwater harvesting


Water network design

Motorized water pumping


Handpumps

- [http://wedd.lboro.ac.uk/docs/research/WEJW2/Report_-_Uganda.pdf](http://wedd.lboro.ac.uk/docs/research/WEJW2/Report_-_Uganda.pdf)

Water storage

- USAID (1984), 'Methods of storing water', USAID, Washington USA. [https://www.lifewater.org/resources/rws5/rws5m.pdf](https://www.lifewater.org/resources/rws5/rws5m.pdf)