Rainwater Harvesting Provisions for Building Code of Pakistan - 2023

Pakistan Engineering Council - 2023

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PART II

Statutory Notifications (S.R.O.)

GOVERNMENT OF PAKISTAN

MINISTRY OF SCIENCE AND TECHNOLOGY

NOTIFICATION

Islamabad, the 11th August, 2025

S.R.O. 1531 (I)/2025.— In exercise of the powers conferred by section 25 of the Pakistan Engineering Council Act, 1975 (V of 1976), the Governing Body of the Pakistan Engineering Council, with the previous sanction of the Federal Government, is pleased to direct that the following further amendments shall be made in the Pakistan Engineering Council (Conduct and Practice of Consulting Engineers) Bye-Laws, 1986, namely:—

2345 (1—6)

Price: Rs. 10.00

[1634(2025)/Ex.Gaz.]

In the aforesaid Bye-Laws, after bye-law 13, the following new bye-laws shall be added, namely:–

"**14. Application of Green Building Code of Pakistan - 2023**.–(1) The Green Building Code of Pakistan-2023 (herein after referred to as "this Code") provides rules and minimum requirements for the siting, design, construction and plans for operation of *high-performance green buildings* to:

(a) comply with the site sustainability;

(b) reduce emissions from building and building systems;

(c) enhance building occupant health and comfort;

(d) conserve water and energy resources;

(e) protect local biodiversity, and ecosystem services;

(f) promote sustainable and regenerative materials cycles;

(g) enhance building indoor environment and air quality; and

(h) enhance resilience to natural, technological, and human-caused hazards.

(2) The provisions of this Code shall,-

(a) apply to the design, construction, addition, alteration, equipment, change of occupancy, relocation, replacement, demolition and removal of every building or structure or any appurtenances connected or attached to such buildings or structures and to the building site on which the building is located. Occupancy classifications shall be determined in accordance with the Building Code of Pakistan-2021; and

(b) not apply to the following:

(a) single-family dwellings;

(b) multiple-family dwellings of three stories or fewer above grade;

(c) manufactured houses (mobile homes);

(d) manufactured houses (modular); and

(e) building projects that use none of the following:

(i) electricity;

(ii) fossil fuels; and

(iii) water.

(3) This Code shall be adopted by the federal and provincial governments, organizations, authorities, both public and private, as and when notified.

(4) Construction and modification of high performance buildings in violation of this Code shall be considered as violation of professional engineering work as specified under clause (xxv) of section 2 of the Pakistan Engineering Council Act, 1975 (V of 1976).

(5) The implementation and enforcement of this bye-law shall vest with the authority having jurisdiction (AHJ) within their respective jurisdiction and circles as follows:

(a) building control, housing and development authorities;

(b) district administration;

(c) tehsil or town administration;

(d) municipal administration;

(e) station headquarters (army, air force and navy) ;

(f) cantonment administration;

(g) housing authorities;

(h) union council administration;

(i) autonomous bodies;

(j) industrial estates;

(k) directorates of civil defense;

(l) export processing zones; and

(m) other federal or provincial authorities as and when notified.

(6) All the concerned AHJs shall implement this bye-law immediately in respective jurisdiction within the prescribed manner under their respective legal regime.

(7) All relevant AHJs shall ensure compliance and implementations of this bye-law and accordingly adopt or amend their relevant regulations, bye-laws or rules, if needed, as the case may be.

(8) This bye-law shall apply to both new, and existing buildings subject to the required retrofitting as approved by the AHJs:

(a) high performance buildings permitted for construction after the adoption of these green provisions shall comply with the provisions stated herein for new buildings forthwith;

(b) existing buildings may adopt these green provisions subject to prior approval by the concerned AHJ such as, efficient use of water and energy, green design

modifications, retrofitting of building envelope, green roof, rainwater harvesting provisions etc.;

(c) site sustainability requirements for building projects that pertain to site selection, site development, mitigation of heat island effect, light pollution reduction, mitigation of transportation impacts and shall be uniformly applicable on all buildings;

(d) the building site shall be physically accessible, environmentally suitable and compliant to master plan as approved by AHJ;

(e) the indoor space of the green buildings shall be naturally ventilated. Natural ventilation may be achieved by cross ventilation or passive ventilation; and

(f) any person who fails to comply with this bye-law or fails to carry out an order made pursuant to these provisions, or violates any condition attached to a permit, approval, or certificate shall be subject to the penalties in accordance with the regulations of AHJ.

(9) The provisions of this bye-law shall first be reviewed and updated after five years of notification, and thereafter every five years or earlier, on the basis of data and feedback received by the committee, as constituted by the Council.

15. Application of rainwater harvesting provisions - Building Code of Pakistan - 2023.– (1) The rainwater harvesting provisions - Building Code of Pakistan – 2023 provides rules and minimum standard requirements for rainwater harvesting systems that provide water for both new and existing buildings and building-like structures:

(a) single-family residential building applications;
(b) multi-story residential building applications;
(c) non-residential buildings applications for all commercial buildings or farmhouses; and
(d) industrial or manufacturing units.

(2) The provisions of this bye-law shall cover the use of rainwater and stormwater as the source of harvested rainwater.

(3) Rainwater includes all forms of water from natural precipitation including but not limited to rain, snowmelt etc. The term "rainwater harvesting" is used generically and shall refer to the harvesting of either rooftop, runoff, surface runoff, or stormwater.

(4) These provisions shall apply to the design, materials, installation, and operation of rainwater harvesting systems for potable and non-potable applications.

(5) Rainwater harvesting provisions for Building Code of Pakistan-2023 shall be adopted by the federal and provincial governments, organizations, and authorities, both public and private, as and when notified.

(6) The implementation and enforcement of this bye-law shall vest with the authority having jurisdiction (AHJ) within their respective jurisdictions and circles as follows:

(a) all building control, housing and development authorities;
(b) district Administration;
(c) tehsil or town administration;
(d) municipal administration;
(e) water and sanitation agencies (WASA);
(f) water and sanitation services companies (WSSC);
(g) metropolitan corporations (MC);
(h) solid waste management companies (SWMC);
(i) water boards;
(j) station headquarters (army, air force and navy);
(k) cantonment administration;
(l) union council administration;
(m) autonomous bodies;
(n) industrial estates;
(o) directorates of civil defence;
(p) export processing zones; and
(q) other federal/provincial authorities as and when notified.

(7) All the concerned AHJs shall implement this bye-law immediately in respective jurisdiction within the prescribed manner under their respective regime.

(8) All relevant AHJs shall amend their relevant regulations, bye-laws or rules, if needed, as the case may be.

(9) This bye-law shall apply to both new, and existing buildings subject to required retrofitting as approved by the AHJs:

(a) the buildings permitted for construction after the adoption of these rainwater harvesting provisions shall comply with the provisions stated herein for new buildings forthwith;

(b) existing buildings constructed prior to adoption of these rainwater harvesting provisions shall adapt these provisions subject to prior approval by the concerned AHJ, and

(c) any person who fails to comply with this bye-law or fails to carry out an order made pursuant to these provisions, or violates any condition attached

to a permit, approval, or certificate shall be subject to the penalties in accordance with the regulations of AHJ.

(10) The provisions of this bye-law shall be reviewed and updated after every five years of notification, or earlier, on the basis of data and feedback received by the committee, as constituted by the Council.".

[No. PEC/P&S/RWHP-SRO/2024.]

ENGR. WASEEM NAZIR ,
Chairman.
Pakistan Engineering Council

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PART II

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GOVERNMENT OF PAKISTAN

MINISTRY OF SCIENCE AND TECHNOLOGY

NOTIFICATION

Islamabad, the 11th August, 2025

S.R.O. 1532 (I)/2025.— In exercise of the powers conferred by section 25 of the Pakistan Engineering Council Act, 1975 (V of 1976), the Governing Body of the Pakistan Engineering Council, with the previous sanction of the Federal Government, is pleased to direct that the following further amendments shall be made in the Pakistan Engineering Council (Construction and Operation of Engineering Works) Bye-Laws, 1987, namely:—

2347 (1—6)

Price: Rs. 10.00

[1635(2025)/Ex.Gaz.]

In the aforesaid Bye-Laws, after bye-law 11, the following new bye-laws shall be added, namely:–

"**12. Application of Green Building Code of Pakistan - 2023**.–(1) The Green Building Code of Pakistan-2023 (herein after referred to as "this Code") provides rules and minimum requirements for the siting, design, construction and plans for operation of *high-performance green buildings* to:

(a) comply with the site sustainability;

(b)reduce emissions from building and building systems;

(c) enhance building occupant health and comfort;

(d) conserve water and energy resources;

(e) protect local biodiversity, and ecosystem services;

(f) promote sustainable and regenerative materials cycles;

(g) enhance building indoor environment and air quality; and

(h) enhance resilience to natural, technological, and human-caused hazards.

(2) The provisions of this Code shall,-

(a) apply to the design, construction, addition, alteration, equipment, change of occupancy, relocation, replacement, demolition and removal of every building or structure or any appurtenances connected or attached to such buildings or structures and to the building site on which the building is located. Occupancy classifications shall be determined in accordance with the Building Code of Pakistan-2021; and

(b) not apply to the following:

(a) single-family dwellings;

(b) multiple-family dwellings of three stories or fewer above grade;

(c) manufactured houses (mobile homes);

(d) manufactured houses (modular); and

(e) building projects that use none of the following:

(i) electricity;

(ii) fossil fuels; and

(iii) water.

(3) This Code shall be adopted by the federal and provincial governments, organizations, authorities, both public and private, as and when notified.

(4) Construction and modification of high performance buildings in violation of this Code shall be considered as violation of professional engineering work as specified under clause (xxv) of section 2 of the Pakistan Engineering Council Act, 1975 (V of 1976).

(5) The implementation and enforcement of this bye-law shall vest with the authority having jurisdiction (AHJ) within their respective jurisdiction and circles as follows:

(a) building control, housing and development authorities;

(b) district administration;

(c) tehsil or town administration;

(d) municipal administration;

(e) station headquarters (army, air force and navy) ;

(f) cantonment administration;

(g) housing authorities;

(h) union council administration;

(i) autonomous bodies;

(j) industrial estates;

(k) directorates of civil defense;

(l) export processing zones; and

(m) other federal or provincial authorities as and when notified.

(6) All the concerned AHJs shall implement this bye-law immediately in respective jurisdiction within the prescribed manner under their respective legal regime.

(7) All relevant AHJs shall ensure compliance and implementations of this bye-law and accordingly adopt or amend their relevant regulations, bye-laws or rules, if needed, as the case may be.

(8) This bye-law shall apply to both new, and existing buildings subject to the required retrofitting as approved by the AHJs:

(a) high performance buildings permitted for construction after the adoption of these green provisions shall comply with the provisions stated herein for new buildings forthwith;

(b) existing buildings may adopt these green provisions subject to prior approval by the concerned AHJ such as, efficient use of water and energy, green design

modifications, retrofitting of building envelope, green roof, rainwater harvesting provisions etc.;

(c) site sustainability requirements for building projects that pertain to site selection, site development, mitigation of heat island effect, light pollution reduction, mitigation of transportation impacts and shall be uniformly applicable on all buildings;

(d) the building site shall be physically accessible, environmentally suitable and compliant to master plan as approved by AHJ;

(e) the indoor space of the green buildings shall be naturally ventilated. Natural ventilation may be achieved by cross ventilation or passive ventilation; and

(f) any person who fails to comply with this bye-law or fails to carry out an order made pursuant to these provisions, or violates any condition attached to a permit, approval, or certificate shall be subject to the penalties in accordance with the regulations of AHJ.

(9) The provisions of this bye-law shall first be reviewed and updated after five years of notification, and thereafter every five years or earlier, on the basis of data and feedback received by the committee, as constituted by the Council.

13. Application of rainwater harvesting provisions - Building Code of Pakistan - 2023.– (1) The rainwater harvesting provisions - Building Code of Pakistan – 2023 provides rules and minimum standard requirements for rainwater harvesting systems that provide water for both new and existing buildings and building-like structures:

(a) single-family residential building applications;
(b) multi-story residential building applications;
(c) non-residential buildings applications for all commercial buildings or farmhouses; and
(d) industrial or manufacturing units.

(2) The provisions of this bye-law shall cover the use of rainwater and stormwater as the source of harvested rainwater.

(3) Rainwater includes all forms of water from natural precipitation including but not limited to rain, snowmelt etc. The term "rainwater harvesting" is used generically and shall refer to the harvesting of either rooftop, runoff, surface runoff, or stormwater.

(4) These provisions shall apply to the design, materials, installation, and operation of rainwater harvesting systems for potable and non-potable applications.

(5) Rainwater harvesting provisions for Building Code of Pakistan-2023 shall be adopted by the federal and provincial governments, organizations, and authorities, both public and private, as and when notified.

(6) The implementation and enforcement of this bye-law shall vest with the authority having jurisdiction (AHJ) within their respective jurisdictions and circles as follows:

(a) all building control, housing and development authorities;
(b) district Administration;
(c) tehsil or town administration;
(d) municipal administration;
(e) water and sanitation agencies (WASA);
(f) water and sanitation services companies (WSSC);
(g) metropolitan corporations (MC);
(h) solid waste management companies (SWMC);
(i) water boards;
(j) station headquarters (army, air force and navy);
(k) cantonment administration;
(l) union council administration;
(m) autonomous bodies;
(n) industrial estates;
(o) directorates of civil defence;
(p) export processing zones; and
(q) other federal/provincial authorities as and when notified.

(7) All the concerned AHJs shall implement this bye-law immediately in respective jurisdiction within the prescribed manner under their respective regime.

(8) All relevant AHJs shall amend their relevant regulations, bye-laws or rules, if needed, as the case may be.

(9) This bye-law shall apply to both new, and existing buildings subject to required retrofitting as approved by the AHJs:

(a) the buildings permitted for construction after the adoption of these rainwater harvesting provisions shall comply with the provisions stated herein for new buildings forthwith;

(b) existing buildings constructed prior to adoption of these rainwater harvesting provisions shall adapt these provisions subject to prior approval by the concerned AHJ, and

(c) any person who fails to comply with this bye-law or fails to carry out an order made pursuant to these provisions, or violates any condition attached

to a permit, approval, or certificate shall be subject to the penalties in accordance with the regulations of AHJ.

(10) The provisions of this bye-law shall be reviewed and updated after every five years of notification, or earlier, on the basis of data and feedback received by the committee, as constituted by the Council.".

[No. PEC/P&S/RWHP-SRO/2024.]

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Preface

Pakistan Engineering Council (PEC) is a statutory regulatory body constituted under PEC Act 1976 by the Parliament. PEC under the auspicious of the Ministry of Science and Technology acts as a bridge between various federal and provincial entities in formulating national policies and strategic plans for national development connected to engineering, science and technology. For this purpose, PEC constituted various high-profile technical committees on Water, Energy, Construction & Infrastructure, Building Codes etc. PEC technical committees are comprised of eminent professional engineers, scientists and allied experts from academia, industry, research, and development organizations across Pakistan. These technical committees are mandated to identify gaps, major challenges and issues of national importance and suggest appropriate way forward in line with the internationally recognized standards and best practices. In this regard, PEC with the assistance of reputed international organizations successfully developed and published the following national codes and standards:

1. Green Building Code of Pakistan – 2023.
2. Building Code of Pakistan – 2021.
3. Standardization of Building Codes, Standards and Specifications for Low-Cost Units – 2021.
4. Building Code of Pakistan - Fire Safety Provisions – 2016.
5. Pakistan Electric and Telecommunication Safety Code – 2014.
6. Building Code of Pakistan - Energy Provisions – 2011.

The PEC Water Resources Development Committee diligently evaluated the huge potential of rainwater harvesting in Pakistan keeping in view the global practices. Presently, many countries in the world have developed Rainwater Harvesting (RWH) homogenized systems include (Rooftop, Surface and Recharge) techniques and supplementing their potable and non-potable water availability and storage capacities. Our neighboring countries like India, China, Bangladesh, Sri Lanka and Iran have largely adopted RWH systems particularly for their rain-fed areas. Additionally, large number of countries developed RWH regulations, standards specifications and codes worldwide.

Pakistan's population was about 34 million, which has soared to 222 million in 2022 and would further increase to 262 million by 2030. According to Falkenmark Indicator water availability of 1000 m3 per capita is the threshold value of water scarcity. In Pakistan, per capita water availability has already fallen below 1000 m3. Currently, groundwater is the principal source accounting for 90% of municipal (residential) and 100% of industrial water, which is causing rapid depletion of the aquifers. Apparently, the daily water consumption of 61 liters per capita is assumed in urban centers across Pakistan. Considering the average family size of 5 persons (Population Census 2017), the annual water consumption of average family is estimated as 111,235 liters. In Pakistan, the average annual rainfall pattern is ranging between 50 - 1200 mm as per rainfall data recorded by Pakistan Metrological Department (PMD) across the country. It is estimated that the RWH potential through building's rooftop can meet 50% of water requirements in rain-fed regions and up to 20% in areas with abundant rainfall intensity in summers.

As per strong recommendations laid down in the National Action Plan-2015, Pakistan Water Charter-2018, and National Water Policy-2018 that "RWHS shall be adopted as key resource of IWRM to overcome the shortage of water". Accordingly, the Senate Standing Committee on Science and Technology in its meeting dated 19th January 2019, directed for adoption of innovative

technologies in the country. In this regard, the Ministry of Science and Technology directed PEC for development of Rainwater Harvesting for commercial and residential buildings in the country on war-footing basis. PEC Water Resources Development Committee under convenorship of Engr. Raghib Abbas Shah in its 10th meeting dated 15th October, 2022 recommended the development of Rainwater Harvesting Provisions for Building Code of Pakistan (RWHP-BCP-2023), which shall be included as an integral part of building design with a proper techno-legal framework for its effective implementation by Authorities Having Jurisdictions (AHJs). Accordingly, PEC notified a technical committee of experts for fast-track development of Rainwater Harvesting Provisions for Building Code of Pakistan-2023 in line with well recognized standards and best practices of worldwide.

The Committee selected the Rainwater Harvesting Systems CSA B805-18/ICC 805-2018 as base document for the development of Rainwater Harvesting Provisions for Building Code of Pakistan 2023. The provisions of this standard shall apply to the design, materials, installation, and operation of rainwater harvesting systems for potable and non-potable applications, which provides minimum benchmark to ensure effective implementation of rainwater harvesting design qualification and application for the residential, commercial, and industrial buildings across Pakistan. The implementation of said provisions vests with the (AHJs) within their jurisdictions and circles across Pakistan.

PEC highly admires significant role of all the Chief Secretaries of Government of Sindh, Punjab, Baluchistan, Khyber-Pakhtunkhwa, Azad Jammu & Kashmir, and Gilgit Baltistan in soliciting the valued comments and feedback from all provincial and state governments while development and notification process of GBCP-2023.

The Government of Pakistan has notified the RWHP-BCP-2023 after the prolong consultation process which conducted through the Ministry of Science and Technology by taking on board all the Chief Secretaries of Government of Sindh, Punjab, Baluchistan, Khyber-Pakhtunkhwa, Azad Jammu & Kashmir, and Gilgit Baltistan. The Federal Cabinet approved the RWHP-BCP-2023 vide Cabinet decision No. 486/Rule-19/2025/672 dated 28th July 2025 in the PEC Bye-Laws. Accordingly, Ministry of Science and Technology, Government of Pakistan notified RWHP-BCP-2023 vide the Gazette Statutory Notifications: S.R.O. 1531 (I)/2025 (Conduct and Practice of Consulting Engineers) Bye-Laws, 1986 and S.R.O. 1532 (I)/2025 (Construction and Operation of Engineering Works) Bye-Laws, 1987 dated 11th August 2025.

Acknowledgements

Pakistan Engineering Council (PEC) acknowledges that the development of 1st Edition of Rainwater Harvesting Provisions for Building Code of Pakistan (RWHP-BCP-2023) is based on Rainwater harvesting systems CSA B805-18/ICC 805-2018 (Copyright © 2018 Canadian Standards Association and International Code Council, Inc. All rights reserved). PEC admires significant contribution of Mr. Mark A. Johnson, Executive Vice President & Director of Business Development, ICC, USA and Mr. Faiz ul Sibtain, Member and Secretary to Committee for the successful accomplishment of deed of "International Development License Agreement" inked between International Code Council (ICC), USA, Canadian Standards Association (CSA) and PEC dated 1st October 2023 through the PEC Think Tank on Water Resources Development Committee with exclusive copyright permission to PEC for developing the RWHP-BCP-2023.

PEC admires key role of Engr. Raghib Abbas Shah, Ex-Chairman, WAPDA, Member Governing Body and Convener to PEC Water Resources Development Committee (WRDC), this committee in its 10th meeting had recommended the development of RWHP-BCP-2023 in compliance of directions of the Senate Standing Committee on Science and Technology. Accordingly, PEC notified a technical committee under convenorship of Dr. Muhammad Ashraf, Chairman, PCRWR for development of RWHP-BCP-2023. The technical committee worked with due diligence and performed derivative work by considering local climate conditions, technical parameters, data sets and allied expertise within stipulated time. Engr. Raghib Abbas Shah also acknowledged the efforts of Dr. Nasir Mahmood Khan, Registrar/ Secretary, PEC for his ownership of this national initiative, and the extended efforts of Mr. Faiz ul Sibtain for maturing ICC and CSA licensing agreement. He also admired the dedicated efforts of Dr. Noor Muhammad and his colleagues Dr. Ghulam Hussain and Engr. Faraz ul Haq on their in-depth review of the document and provided valuable feedback to the committee. PEC appreciates the dedicated contribution of Dr. Muhammad Ashraf, Convener and members of PEC Technical Committee, professional researchers of PCRWR including Dr. Hifza Rasheed, Ms. Saiqa Imran, Engr. Bareerah Fatima, Engr. Muhammad Kashif Manzoor, Engr. Muhammad Umar Munir, Engr. Arslan Mumtaz and Mr. Faiz ul Sibtain in carrying out the technical review and valued inputs in the development of RWHP-BCP-2023.

PEC Water Resources Development Committee

1.	Engr. Dr. Syed Raghib Abbas Shah, Ex-Chairman, WAPDA/ Member PEC Governing Body, Sindh	Convener
2.	Engr. Nasir Majeed, Vice Chairman, PEC Baluchistan	Deputy Convener
3.	Engr. Dr. Aneel Kumar, Professor, Department of Civil Engineering Mehran University of Engineering and Technology, Jamshoro	Member
4.	Engr. Muhammad Waseem Asghar, CEO Kasib Associates Kasib Associates Engineers, Consultants & Architects, Islamabad	Member
5.	Engr. Muhammad Naeem, CEO, Pakhtunkhwa Energy Development Organization (PEDO), Peshawar	Member
6.	Dr. Muhammad Ashraf, Chairman, Pakistan Council of Research in Water Resources, Islamabad	Member
7.	Engr. Dr. Prof. Noor Muhammad Khan, Director, CEWRE, UET, Lahore	Member

8.	Engr. Shahid Mushtaq Meer, Advisor (LADP), Dasu Hydropower Project, WAPDA, Kohistan	Member
9.	Engr. Syed Mehar Ali Shah, Joint Secretary (Water), Ministry of Water Resources, Islamabad	Member
10.	Engr. Abdus Salam Khan, Ex-Secretary Irrigation, Government of Baluchistan, Quetta	Member
11.	Engr. Dr. Muhammad Bashir Lakhani, Director, Water & Energy Division Techno-Consult International, Karachi	Member
12.	Engr. Dr. Nasir Mahmood Khan, Secretary/ Registrar, Pakistan Engineering Council, Islamabad	Member
13.	Mr. Faiz ul Sibtain, Environmentalist, Assistant Director, Policy and Strategy Division, Pakistan Engineering Council, Islamabad	Member & Secretary to Committee

PEC Technical Committee for Development of Rainwater Harvesting Provisions for BCP-2023

1.	Dr. Muhammad Ashraf, Chairman, Pakistan Council of Research in Water Resources, Islamabad	Convener
2.	Engr. Dr. Noor Muhammad Khan, Director, CEWRE, UET, Lahore	Member
3.	Mr. Jawed Ali Khan, Country Program Manager, UN-HABITAT, Islamabad	Member
4.	Engr. Ghazala Channar, Member, Dy. Chief Water Resource, Ministry of Planning Development & Special Initiatives, Islamabad	Member
5.	Engr. Ashfaq Ahmed Memon, Joint Technological Adviser, Ministry of Science and Technology, Islamabad	Member
6.	Arch. Abdul Qayum, Ex-Chief, Urban Planning, Ministry of Planning Development & Special Initiatives, Islamabad, Islamabad	Member
7.	Engr. Zeeshan Ullah, Member, Director, Buildings, NEECA, Islamabad	Member
8.	Mr. Faiz ul Sibtain, Environmentalist, Assistant Director, Policy and Strategy Division, Pakistan Engineering Council, Islamabad	Member & Secretary to Committee

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1.1 Applicability

The provisions of this standard apply to the design, materials, installation, and operation of rainwater harvesting systems for potable and non-potable applications.

1.1.1 Source waters

This Standard covers the use of rainwater and storm water as the source water.

Note: Rainwater includes all forms of water from natural precipitation including but not limited to rain, snowmelt etc. The term "rainwater harvesting" is used generically in this Standard and can refer to the harvesting of either rooftop runoff, surface runoff or storm water.

1.1.2 Applications

This standard covers rainwater harvesting systems that provide water for both new and existing buildings and building like structures:

a) Single-family residential building applications.
b) Multi- story residential building applications.
c) Non-residential buildings applications for all commercial buildings/ farmhouses.
d) Industrial or manufacturing units.

1.2 Exclusions

This Standard does not cover rainwater harvesting systems that provide water distribution systems for commercial agricultural processes.

1.3 Terminology

In this Standard, "shall" is used to express a requirement, i.e., a provision that the user is obliged to satisfy in order to comply with the Standard; "should" is used to express a recommendation or that which is advised but not required; and "may" is used to express an option or that which is permissible within the limits of the Standard.

Notes to tables and figures are considered part of the table or figure and may be written as requirements.

Annexes are designated normative (mandatory) or informative (non-mandatory) to define their application.

1.4 Units of measurement

The values given in SI units are the units of record for the purposes of this Standard. U.S. customary units given in parentheses are for information and comparison only.

1.5 Awareness Programs

AHJ shall develop and implement a public awareness program as deemed necessary with respect to the potential advantages of Rainwater Harvesting within the jurisdiction.

Chapter 2 Reference Publications

This Standard refers to the following publications and where such reference is made, it shall be to the edition listed below, including all amendments published thereto.

National Policies:

1. National Water Policy (2018).
2. National Hazardous Waste Management Policy (2022).
3. National Climate Change Policy (2012 & 2021).
4. National Forest Policy (2016).
5. National Disaster Risk Reduction Policy (2013).
6. National Sanitation Policy (2012).
7. National Rangeland Policy (2010).
8. National Drinking Water Policy (2009).
9. National Environmental Policy (2005).
10. National Resettlement Policy (2002).

Codes:

1. Green Building Code of Pakistan (2023).
2. Building Code of Pakistan (2021).
3. Standardization of Building Codes, Standards and Specifications for Low-Cost (Affordable) Units-2021.
4. Building Code of Pakistan - Fire Safety Provisions (2016).
5. Pakistan Electric and Telecommunication Safety Code (2014).
6. Building Code of Pakistan - Energy Provisions (2011).

Standards:

1. Pakistan Standards and Quality Control Standards.
2. National Environmental Quality Standards.
3. International Mechanical Code (IMC-2015).
4. International Plumbing Code (IPC-2015).
5. National Environmental Quality Standards for Ambient Air, Drinking Water and Noise vide (S. R.O. 1062(I)/2010 & S.R.O. 1063(I)/2010 & S.R.O. 1064(I)/2010).
6. National Environmental Quality Standards for Motor Vehicle Exhaust and Noise Vide No. (S.R.O 72(KE)/2009).
7. National Environmental Quality Standards (Self-Monitoring and Reporting by Industries) Rules, 2001.
8. Revised National Environmental Quality Standards for Municipal and Liquid Effluents (mg/l, Unless Otherwise Defined) & NEQS for Gaseous Emissions (mg/Nm^3 Unless Otherwise Defined) Vide S.R.O. 549 (I)/2000.

9. National Environmental Quality Standards Relating to Municipal and Liquid Industrial Effluents vide S.R.O. 742 (I)/93 & S.R.O. 1023 (I)/95.

Rules and Regulations:

1. Hospital Waste Management Rules, 2022.
2. Handling, Manufacture, Storage, Import of Hazardous Waste and Hazardous Substances Rules, 2022.
3. Initial Environmental Examination and Environmental Impact Assessment) Regulations, 2022.
4. Environmental Samples Rules, 2001.
5. Environmental Tribunal (Procedure and Functions) Rules, 1999.
6. Hospital Waste Management Rules, 2005.
7. Pakistan Environmental Protection Act, 1997.
8. Self-Monitoring and Reporting by Industries Rules 2001 Amended.
9. National Environmental Quality Standards (Certification of Environmental Laboratories) Regulations, 2000.
10. Pakistan Environmental Protection Agency (Review of IEE and EIA) Regulations, 2000.
11. Pakistan Environmental Protection Agency Ban on (Manufacturing, Import, Sale, Purchase.
12. PSQCA approved Drinking Water Quality Standards.
13. PSQCA approved International Electrical Codes/ Standards.
14. Storage and Usage) Polythene Bags Regulations, 2019.
15. Rainwater Harvesting Systems Guidelines developed by PCRWR-2023.

International Standards:

1. AASHTO (American Association of State Highway and Transportation Officials).
2. M43-2005 (Reaffirmed 2009).
3. Standard Specification for Sizes of Aggregate for Road and Bridge Construction.
4. APHA (American Public Health Association).
5. Standard Methods for the Examination of Water and Wastewater edition, 2017
6. ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers)
7. ANSI/ASHRAE 188-2015.
8. Legionellosis: Risk Management for Building Water Systems
9. ASME (The American Society of Mechanical Engineers).
10. B16.5-2013 Pipe Flanges and Flanged Fittings.
11. ASTM International.
12. A36-14 Standard Specification for Carbon Structural Steel.

13. A592-10 (2015) Standard Specification for High-Strength Quenched and Tempered Low-Alloy Steel Forged Parts forPressure Vessels.
14. A675-14 Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality, Mechanical Properties.
15. C1227-13 Standard Specification for Precast Concrete Septic Tanks.
16. D413-98(2013) Standard Test Method for Rubber Property - Adhesion to Flexible Substrate
17. D471-2016a Standard Test Method for Rubber Property - Effect of Liquids.
18. D751-06(2011) Standard Test Methods for Coated Fabrics.
19. D1204-14 Standard Test Method for Linear Dimensional Changes of no rigid Thermoplastic Sheeting or Film at Elevated Temperature.
20. D1998-15 Standard Specification for Polyethylene Upright Storage Tanks.
21. D2136-02 (2012) Standard Test Method for Coated Fabrics - Low-Temperature Bend Test.
22. D3389-15 Standard Test Method for Coated Fabrics Abrasion Resistance (Rotary Platform Abrader).
23. D4833-07 (2013) e1 Standard Test Method for Index Puncture Resistance of Geo membranes and Related Products.
24. E2727-10e1 Standard Practice for Assessment of Rainwater Quality.
25. AWWA (American Water Works Association).
26. D100-11 Welded Carbon Steel Tanks for Water Storage.
27. D103-09 Factory-Coated Bolted Carbon Steel Tanks for Water Storage.
28. D107-10 Composite Elevated Tanks for Water Storage.
29. D115-06 Tendon Pre-Stressed Concrete Water Tanks.
30. D120-09 Thermosetting Fiberglass-Reinforced Plastic Tanks.
31. D121-12 Bolted Aboveground Thermosetting Fiberglass-Reinforced Plastic Panel-Type Tanks for Water Storage.
32. DVGW (Deutscher Verein des Gas- und Wasserfaches - German Technical and Scientific Associationfor Gas and Water).
33. W294 UV-Geräte zur Desinfektion in der Wasserversorgung.
34. FTM (Federal Test Method).
35. International Bottled Water Association (IBWA) Standards.
36. STD. No. 101C (method 2065) Test Method for Puncture Resistance and Elongation Test (1/8 in. radius probe).
37. IAPMO (International Association of Plumbing and Mechanical Officials).
38. IAPMO/ANSI Z1002-2014 Rainwater Harvesting Tanks.
39. NFPA (National Fire Protection Association).

40. 13-2016 Standard for the Installation of Sprinkler Systems.
41. 13D-2016 Standard for the Installation of Sprinkler Systems in One and Two-Family Dwellings and ManufacturedHomes.
42. 13R-2016 Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies.
43. 14-2016 Standard for the Installation of Standpipe and Hose Systems.
44. 22-2013 National Electrical Code (NEC).
45. 1142-2017 NRC (National Research Council Canada).
46. NSF/ANSI 53-2015 Drinking Water Treatment Units — Health Effects.
47. NSF/ANSI 55-2015 Ultraviolet Treatment.
48. NSF/ANSI 60-2015 Drinking Water Treatment Chemicals — Health Effects.
49. NSF/ANSI 61-2014a Drinking Water System Components — Health Effects.
50. NSF/ANSI 372-2016 Drinking Water System Components — Lead Content.
51. P151-2014 Health Effects from Rainwater Catchment Systems Components.
52. Technical Bulletin S-82 UL (Underwriters Laboratory).
53. 58 Standard for Steel Underground Tanks for Flammable and Combustible Liquids.
54. 142 Steel Aboveground Tanks for Flammable and Combustible Liquids.
55. 508 Standard for Industrial Control Equipment.
56. 508A Standard for Industrial Control Panels.
57. 1316 Glass-Fiber-Reinforced Plastic Underground Storage Tanks for Petroleum Products, Alcohol and Alcohol-Gasoline Mixtures.
58. ULC (Underwriters Laboratory Canada) CAN/ULC-S601-14.
59. Shop Fabricated Steel Aboveground Tanks for Flammable and Combustible Liquids.
60. CAN/ULC-S603-14 Standard for Steel Underground Tanks for Flammable and Combustible Liquids.
61. Ultraviolet Disinfection Guidance Manual (UVDGM).
62. US-EPA Guidelines.
63. World Health Organization (WHO) Guidelines.

Chapter 3 Definitions and Abbreviations

3.1 Definitions

The following definitions shall apply in this Code.

Accessible — fabricated to be exposed for cleaning and inspection using simple tools (screwdriver, pliers, open-end wrench).

Air gap — the unobstructed vertical distance through the free atmosphere between the outlet of the pipe and the flood level rim of the receptacle into which the pipe is discharging.

Alarm — a signal indicating a critical component or system failure requiring immediate action.

Alarm set point — the threshold conditions under which a sensor activates an alarm.

Alert — a signal or notification indicating a non-critical component or system condition.

Authority Having Jurisdiction (AHJ)

An organization, office, or individual responsible for enforcing the requirements of these Provisions, or for approving equipment, materials, an installation, or a procedure. AHJ shall be the following, whichever has jurisdiction and circle:

1. All Building Control, Housing and Development Authorities.
2. District Administration.
3. Tehsil or Town Administration.
4. Municipal Administration.
5. Water and Sanitation Agencies (WASA).
6. Water and Sanitation Services Companies (WSSC).
7. Metropolitan Corporations (MC).
8. Solid Waste Management Companies (SWMC).
9. Water Boards.
10. Station Headquarters (Army, Air Force and Navy).
11. Cantonment Administration.
12. Union Council Administration.
13. Autonomous Bodies.
14. Industrial Estates.
15. Directorates of Civil Defence.
16. Export Processing Zones.
17. Other Federal/Provincial Authorities as and when notified.

Approved — acceptable to the code official or other AHJ.

Backflow — a flowing back or reversal of the normal direction of flow.

Backflow preventer — a device that prevents backflow.

Backwater valve — a device installed in the drainage system that prevents liquid wastes from backing up into a lower level or fixtures.

Catch basin — a ground-level rainwater harvesting system inlet designed to capture surface waters or discharge from a scupper.

Cistern — see Storage tank.

Cleanout — an access opening in the drainage system utilized for the removal of obstructions.

Note: Types of cleanouts include a removable plug or cap and a removable fixture or fixture trap.

Conveyance subsystem — the portion of a rainwater harvesting system that directs collected rainwater from the collection to the point of untreated rainwater storage.

Note: Conveyance subsystem components include gutters, downspouts, leaders, roof drains and conductors.

Conveyance piping — unpressurized pipe used within the conveyance subsystem that drains rainwater or storm water to a storage tank by gravity.

Conductor — a pipe inside a building that conveys rainwater or storm water from the roof to a storm or combined building drain.

Note: See “Leader.”

Contaminant — an undesirable organic or inorganic, soluble or insoluble substance in the water.

Note: Contaminants include microbiological organisms.

Controls — manual or automatic devices or algorithms designed to regulate the operation of a system.

Corrosion-resistant — capable of maintaining original surface characteristics under prolonged contact with the intended end use environment and exposure to cleaning or sanitizing procedures in accordance with the manufacturer’s recommendation.

Day tank — a temporary holding tank for a limited volume of treated water to be provided for end use.

Note: Day tanks are also known as “buffer tanks” or “batch tanks”.

Disinfection — the act of eliminating disease-causing micro-organisms from contaminated water either by physical removal or by killing or inactivating them.

Distribution system — piping and other components that convey rainwater from the end point of treatment to the point of end use.

Evaporative cooling system — an assembly of equipment and appliances that cools air through the evaporation of water.

First-flush diverter — a device or method for removal of sediment and debris from collection surface by diverting initial rainfall from entry into the storage tank.

Inlet pre-filter — a device installed on the rainwater conveyance pipe prior to the primary storage vessel on a rainwater system.

Note: An inlet pre-filter is intended to mitigate the introduction of, e.g., vermin, leaves, sticks, needles, tree fruit, bark, moss, or any other unwanted debris or roof contaminant that could enter the system.

Leader — an exterior drainage pipe for conveying storm water from roof or gutter drains to a means of disposal or treatment.

Note: See Conductor.

Multi-barrier approach — a system management approach that includes source water protection, treatment, integrity of the distribution system and operation and monitoring.

Non-potable water — water not safe for drinking or for personal or culinary utilization.

Non-potable water system — an assembly or equipment that collects and distributes non-potablewater.

Note: Equipment used in non-potable water systems includes pipes, fittings, valves, various appurtenances, storage tanks, pressurization equipment, treatment systems etc.

Potable water — water that meets human consumption quality standards as established by the AHJ.

Note: Potable water is more commonly referred as “drinking water”.

Rainfall abstraction — a measure of the amount of rainfall that is lost from absorption into roof surfaces or the amount of water that is lost due to the operation of first-flush diverters

Note: First-flush diverters usually collect the first 2 mm (0.08 in) of rainfall and prevent it from reaching the tank. Rainfall abstraction is usually expressed in mm or inches.

Rainwater — collected water from natural precipitation.

Rainwater harvesting system — a system intended to collect, convey, store, treat, distribute, soak, recharge or inject rainwater for multiple uses.

Note: Rainwater harvesting systems are also known as “rainwater collection systems” or “rainwater catchment systems.”

Rainwater inlet — the point of discharge from the conveyance piping into the storage tank.

Rainwater outlet — the point of entrance at the storage tank into the distribution system.

Roof runoff — rainwater that is intercepted by an elevated impervious roof surface that is not subject to pedestrian access.

Secondary water supply — an alternative source of water that serves a rainwater harvesting system.

Scupper — a drainage structure from a flat or low-sloped roof that allows rainwater to free-fall to a catch basin below.

Note: Scuppers are also known as “canals”.

Storage tank — a liquid retention tank connected to a plumbing system or irrigation system.

Note: Storage tanks are also known as “cisterns”.

Storm water runoff — rainwater that is not roof runoff.

Note: This includes precipitation runoff from rain or snowmelt that flows over land and/or impervious surfaces (e.g. streets, parking lots, vegetative roofs and roofs with public access).

Surface water — all water naturally open to the atmosphere (e.g., rivers, lakes, reservoirs, ponds, streams, impoundments, seasoned estuaries).

Third-party certification agency — an approved agency operating a product or material certification system that incorporates initial product testing, assessment and surveillance of a manufacturer's quality control system.

Third-party certified — certification obtained by the manufacturer indicating that the function and performance characteristics of a product or material have been determined by testing and ongoing surveillance by an approved third-party certification agency. Assertion of certification is in the form of identification in accordance with the requirements of the third-party certification agency.

Treatment — the use of biological, physical, or chemical means to make water fit for the intended use.

Ultraviolet transmittance (UVT) — the measure of the fraction of incident germicidal ultraviolet light remaining after passing through 1 cm (0.39 in) of sample water expressed as a percentage of the transmission through pure water.

Note: This value is a measurement of the water. For example, water from a metal roof after a 350-micron filter might have a UVT of 90%. As water quality changes, the UVT% of said water also changes.

Vegetative roof — an assembly of interacting components designed to waterproof and normally insulate a building's top surface that includes by design, vegetation and related landscaping elements.

Note: Also known as a "green roof" or "bio roof".

Water distribution system — an assembly of pipes, fittings, valves and other equipment that conveys water from its source to its intended point of use or destination.

Water safety plan (WSP) — a plan to ensure the safety of water used for specified purposes through the application of a comprehensive risk and management approach that encompasses all steps from the source water to end use.

3.2 Abbreviations

The following abbreviations shall apply in this Standard:

AHJ	Authority Having Jurisdiction
ANSI	American National Standards Institute
BOD_5	5-Day Biochemical Oxygen Demand
CFU	Colony Forming Units
CMF	Commercial/Multi-Family
COD	Chemical Oxygen Demand
CT	Disinfectant Concentration Times / the Contact Time
CMD	Cubic Meter Per Day
CMS	

	Cubic Meter Per Second
GPD	Gallons Per Day
GPM	Gallons Per Minute
HPC	Heterotrophic Plate Count
NOAA	National Oceanic and Atmospheric Administration
NR	Not Recommended
NTU	Nephelometric Turbidity Unit
ORP	Oxidation-Reduction Potential
PVC	Polyvinyl Chloride
RU	Residential Use
SCC	Standards Council of Canada
SF	Storage Loss Factor
SFR	Single-Family Residential
TDS	Total Dissolved Solids
TPO	Thermoplastic Polyolefin
TSS	Total Suspended Solids
U.S. EPA	United States Environmental Protection Agency
UV	Ultraviolet
UVDGM	Ultraviolet Disinfection Guidance Manual
UVT	Ultraviolet Transmittance
WSP	Water Safety Plan

Chapter 4 Administration and Enforcement

4.1 (a) Compliance with other codes and allied requirements

Rainwater Harvesting Systems shall comply with the requirements of the AHJ. Where local requirements do not exist, the relevant requirements of the Green Building Code of Pakistan-2023, Building Code of Pakistan 2021, Building Code of Pakistan - Fire Safety Provisions-2016, Pakistan Electrical and Telecommunication Safety Code-2014, Building Code of Pakistan – Energy Provisions-2011), Plumbing Specifications/ Systems or any other standard approved by AHJ shall apply, as applicable across Pakistan:

1. All installations, operation and maintenance of rainwater harvesting systems shall be in accordance with this Code.
2. These provisions shall be applicable to all existing buildings, new buildings, extensions and retrofitting related to rainwater supply facilities or environment.
3. In case of existing installations, whether maintenance or replacement, such installations are required to be in compliance with this Code.
4. All the management of the AHJs shall comply with this Code.

(b) Administrative Requirements

1. The implementation and enforcement of this Code shall be through a statutory notification by the Government of Pakistan through Ministry of Science and Technology.
2. All relevant regulators shall ensure compliance and implementation of this Code through necessary regulations, orders and directives.
3. All AHJs shall comply with this Code by adopting or amending their relevant byelaws or rules for implementation.

4.2 Conflicts with referenced standards

Where conflicts occur between provisions of this code and the referenced standards, the provisions of this code shall apply.

4.3 Superiority of laws

The Provisions of this Code shall not be deemed to nullify any provisions of local, district, provincial or federal law jurisdictions. In the case of a conflict between the provisions of this code and those of the applicable regulations, the provisions of this code shall prevail.

4.4 Supplementary Information

1. This Code shall be reviewed and updated, after every five (5) years of implementation; and, thereafter every six (6) years or earlier on the basis of data and feedback received from the concerned regulators and by the Standing Committee of RWHP for BCP-2023 at Pakistan Engineering Council (PEC).
2. The concerned authority may require supplementary information necessary to verify compliance with this Code, such as calculations, worksheets, compliance forms, manufacturer's literature or other data.

4.5 Alternatives.

The specific requirements of these Provisions shall be permitted to be altered by AHJ to allow alternative methods that will ensure water quality, but in no case below the already notified local, provincial and federal approved national water quality standards

Chapter 5 General System Requirements

5.1 General objectives and requirements

5.1.1 Output water quality

Rainwater harvesting systems shall be designed to treat, maintain and deliver water at a quality that is fit for the intended use, as specified in Clause 5.2.

Notes:

1) *Where water is used for public drinking water supplies, the AHJ should be consulted for specific regulatory requirements for water quality management.*
2) *Rainwater harvesting systems should employ multi-barrier or a treatment train design approach to reduce accumulation, introduction and re-introduction of contaminants into the system.*

5.1.2 Water Safety Plan (WSP)

5.1.2.1 General

A WSP shall be developed by AHJ for all rainwater harvesting systems.

Note:

Guidance on developing a WSP is included in Annex D.

5.1.2.2 Rationale for a WSP

The WSP should reflect national, provincial, regional, local and site-specific water quality concerns. A WSP should be intended to recognize, address, improve water quality and water quality concerns for rainwater harvesting systems for potable and non-potable uses. It is important to document the full scope of the rainwater harvesting system in order to identify system components, scope of system supply, parties responsible for system maintenance and operational guidelines for the rainwater harvesting system.

5.1.2.3 Elements of a WSP

Based on intended uses, the elements of a WSP for rainwater harvesting shall include the following:

a) Site assessment for source water suitability;
b) Fit for intended uses;
c) Hazard identification and risk prioritization;
d) System design and identification of control points;
e) Operational monitoring, system verification and response; and
f) Supporting programs, measurement procedures and documentation.

5.1.3 Continuity of supply

Where rainwater harvesting systems serve as an additional supply for a distribution system, a secondary water supply shall be provided when required by the AHJ. The secondary supply shall comply with Clause 7.3.7. When a secondary water supply is approved by the AHJ, the secondary system shall be sized to meet the maximum demand of the end use.

5.1.4 System sizing

The required storage capacity of the system for the intended system design needs shall be based on: -

a) Precipitation data generated by Pakistan Metrological Department or authentic localized data available;

b) Available collection area;

c) Anticipated demand; and

d) Applicable code requirements as approved by AHJ.

Note:

Refer to Annex C for guidance on tank sizing.

5.1.5 Limited effect on other building systems and structures

Installation of a rainwater harvesting system shall not compromise the site, the structural integrity of the building and related structures, or the safety of the building occupants and general public.

5.1.6 Protection of potable water system

5.1.6.1 General

Rainwater harvesting systems shall be designed, installed and maintained to prevent contamination of potable water supplies and the potable water distribution piping.

5.1.6.2 Backflow prevention

Potable water systems connected to rainwater harvesting systems shall be protected against backflow by: -

a) An air gap; or

b) A backflow preventer suitable for the application in accordance with the plumbing specifications/ standards.

5.1.7 Protection of harvested water from contamination

Harvested rainwater shall be protected from external contamination from point and non-point sources of pollution.

5.1.8 Insect and vermin intrusion control

Rainwater harvesting systems shall be protected to prevent the entrance of insects and vermin intostorage tanks, vents and piping systems.

5.1.9 Local site conditions

The system design, installation and materials shall be suitable for local site conditions, including, but not limited to

a) Freezing;

b) Excessive Heat;

c) High Wind;

d) Seismic;

e) Extreme Rainfall;

f) Contaminants;

g) Elevation Of Water Table;

h) Flooding; And

i) Sunlight Exposure.

5.1.10 Access

Access to rainwater harvesting system components shall be restricted in order to minimize contamination, vandalism and unauthorized access in accordance with this standard and applicable codes as approved by AHJ.

5.1.11 System documentation

A manual shall be supplied with all systems and include standard operating procedures under normal operating conditions, such as system start-up and shutdown procedures, as well as contingencies and emergency procedures for system failure, loss of treatment or other emergency conditions. The manual shall include a system description, detailed system piping and wiring schematics and locations of all system components as installed. The manual shall provide a maintenance schedule and procedures for all system components requiring periodic maintenance. Consumable parts, including filters, shall be noted along with part numbers.

5.1.12 Permits/ Approval

5.1.12.1 General

Any owner, or owner's authorized agent who desires to construct, alter or abandon a rainwater harvesting system shall first submit application for required permits, in accordance with the requirements of the AHJ. Where the end use of an existing rainwater harvesting system is changed or modified, the system design parameters shall be re-evaluated and all requirements of this code shall apply.

5.1.12.2 Construction documents

The following documents shall be provided to the AHJ along with an application for permit/ approval:

a) System description and design narrative;
b) List of intended end uses;
c) Site layout plan;
d) System specification and bill of materials;
e) Piping diagram;
f) Wiring schematics;
g) Water safety plan (refer to annex d); and
h) Operations and maintenance manual.

5.1.13 Removal from service

5.1.13.1 Intentionally left blank

5.1.13.2 Decommissioning

Rainwater harvesting systems removed from service shall comply with the requirements of the applicable building codes as approved by AHJ. In addition, when a rainwater harvesting system is seasonally or temporarily removed from service,

a) All system piping connected to a utility-provided water system shall be locked out or disabled;

b) The storage tank shall be secured from unauthorized access;

c) Inlet piping shall be redirected to approved drain systems; and

d) Electrical power shall be shut down.

5.2 End use tiers

5.2.1 General

5.2.1.1 End use tier categorization

The end use tier categorization shall be as specified in Table 5.1. Each end use tier is categorized based on the following three elements:

a) Potable or non-potable water quality;

b) End uses; and

c) Potential for human contact, including ingestion, inhalation and skin contact.

Each end use tier comprises common end use applications and is not intended to be an exhaustive list. Where end uses are not listed, the application shall be categorized based on the criteria specified in Clause 5.2.1.2.

5.2.1.2 End uses and potential for human contact

The potential for human contact through ingestion, inhalation or skin contact is characterized as low, medium or high under normal operation for the intended use. A low exposure potential applies to end uses where humans rarely come in contact with the treated rainwater due to the nature of the installation that limits direct or indirect contact under normal operation. A medium exposure potential applies to end uses where human contact with the treated rainwater is indirect or limited under normal operation. A high exposure potential applies to end uses where human contact with the treated rainwater is direct under normal operation.

5.2.2 End use tiers

Rainwater collected shall be categorized based on Table 5-1.

Table 5-1

End use tiers and the likelihood of exposure without mitigation measures

(See Clause 5.2.2.)

End use tier	Category	End uses	Likelihood of exposure*			
			Ingestion	Inhalation	Skin contact	Overall
1	Non-potable	• Trap primers • Spray irrigation (restricted access or exposure) † • Surface and subsurface irrigation (drip, bubbler) • Fire protection • Ice rinks	Rare	Unlikely	Unlikely	Unlikely

2	Non-potable	• Toilet and urinal flushing • Clothes washing • HVAC evaporative cooling (e.g., cooling tower, evaporative condenser, spray cooler, direct and indirect evaporative cooling) • Rooftop thermal cooling	Rare	Possible	Possible	Possible
3	Non-potable	• Hose bibs • Pressure washing • Decorative fountains • Vehicle washing • Spray irrigation (non-restricted access or exposure)†	Possible	Likely	Likely	Likely
4	Potable	• Human consumption • Oral care • Food preparation • Dishwashing • Bathing, showering and hand washing • Pools, hot tubs, spas and splash pads • Misting stations • Swamp coolers	Certain	Certain	Certain	Certain

* Typical representative outcomes are gastrointestinal illness from ingestion, Legionellosis from inhalation and bacterial wound infection from skin contact.

† The WSP shall establish whether a given application has restricted or unrestricted access or exposure. The WSP may also categorize the end use in a different tier than what is reflected in this Table.

Chapter 6 System Design and Installation General

6.1 Material compatibility

Rainwater harvesting systems shall be manufactured of materials adequate for the intended applications and compatible with the water treatment processes.

6.2 Materials for potable water systems

With the exception of collection surfaces and conveyance subsystems, materials contacting rainwater collected for potable water applications shall comply with NEQS/PSQCA/NSF/ANSI 61 and shall have a weighted average lead content of 0.25% or less when evaluated in accordance with NEQS/PSQCA/NSF/ANSI 372. Solders and fluxes used in rainwater harvesting systems supplying potable water shall not have a lead content greater than 0.2% by mass.

6.3 Operational conditions

Components used in rainwater harvesting systems shall be suitable for use at the components' anticipated maximum and minimum operating water temperatures, pressures and flow rates.

6.4 Seismic considerations

Rainwater harvesting systems and components shall be designed and installed to withstand the anticipated seismic forces in accordance with the Building Code of Pakistan - 2021.

6.5 Buried collection and distribution piping

Except for irrigation piping located outside of a building and downstream of a backflow preventer, buried collection and distribution piping shall: -

a) Maintain the separation distances from potable water piping specified by the AHJ;

b) Be protected from damage and potential sources of contamination;

c) Identified as non-potable in accordance with the guidelines, where applicable.

6.6 Electrical wiring

6.6.1 General

Electrical wiring shall be sized and installed in accordance with the PSQCA-3632 approved allied electrical standards and the manufacturer's instructions.

6.6.2 Wiring identification

Control circuit wiring and terminals shall be identified in accordance with the PSQCA-3632 electrical standard.

6.6.3 Protection of electrical components

Overload and overcurrent protection of electrically operated components shall be consistent with the maximum current rating of the device and the electrical code.

6.7 Controls

6.7.1 General

Controls for rainwater harvesting systems shall ensure

a) Effective and safe operation of the system;

b) Continuous supply of water, as applicable;

c) That operation is within intended design parameters of the system; and

d) That volume and discharge rates are in compliance with storm water management requirements as specified by the AHJ.

6.7.2 Environmental protection

Controls and associated components shall be suitable for the environment in which they are installed. Wires, connections, sensors, pneumatic lines and hydraulic lines used to transmit control signals shall be protected from corrosion or signal degradation that would compromise system operations.

6.7.3 Bypass and override

Alarm conditions shall not be capable of being bypassed or over ridden except for diagnostic or manual operation of system.

6.7.4 Access and labeling of controls

Control systems and components shall be labeled and accessible for operation and maintenance in accordance with this standard and applicable codes.

6.7.5 Alerts and alarms

6.7.5.1 Alerts

Alerts shall be provided for critical control points identified by the WSP to indicate when the rainwater harvesting system is operating outside design parameters but not causing a hazard to health or safety, or damage to the system.

6.7.5.2 Alarms

Alarms shall be provided for critical control points identified by the WSP to indicate when the rainwater harvesting system is operating outside the design parameters and potentially causing a hazard to health and safety or damage to the system.

6.7.5.3 Alarm and alert output

Onsite alarms and alerts shall have audible or visible outputs. Visual alarms shall continue to operate for the duration of the alarm or alert condition. A remote alarm or alert system using electronic communication may be used to advise the responsible person that the system has failed or that failure is imminent, in addition to the onsite alarm or alert.

6.7.6 Controls for dedicated firefighting reserves

Controls of rainwater harvesting systems supplying water for fire sprinkler systems or standpipes shallcomply with the requirements of the Building Code of Pakistan - Fire Safety Provisions-2016 and Pakistan Telecommunication and Electric Safety Code (PETSAC-2014).

6.7.7 Control panels

Control panels for rainwater harvesting systems utilized in commercial occupancies shall comply with UL 508 or UL 508A/ or any standard as applicable and approved by AHJ.

6.8 Point of use signage and identification for non-potable water

6.8.1 General

Signage shall be provided at the point of use where non-potable water is used and dispensed in accordance with the requirements of this Standard.

6.8.2 Non-potable water outlets

Non-potable water outlets, such as hose bibs, open-ended pipes and faucets shall be identified at the point of use for each outlet. Where no such requirements exist, non-potable water outlets shall be identified with the following words:

“Non-potable water utilized for [application name].

CAUTION: NON-POTABLE WATER – DO NOT DRINK”. -یہ پانی پینے والا نہیں۔ پانی نہیں پینا

The words shall be legibly and indelibly printed on a tag or sign made of corrosion-resistant, fade- resistant, waterproof material or shall be indelibly printed on the fixture. The letters shall be at least 13 mm (0.5 in) in height and shall be of a color that contrasts with the background on which they are printed. In addition to the required words, the pictograph shown in Figure 6.1 shall appear on the required signage.

6.8.2.1 Figure 6 -1 Point of use signage:

6.8.2.2 (See Clause 6.8.2.)

NON-POTABLE WATER – DO NOT DRINK”. یہ پانی پینے والا نہیں۔ پانی نہیں پینا

Figure 6-1 Point of use signage

Chapter 7 Subsystem Design and Installation

7.1 Collection surfaces

7.1.1 Minimization of ponding and retention

Rainwater collection surfaces shall collect and convey rainwater to the inlets of the conveyance subsystem and minimize ponding and retention after the precipitation event.

7.1.2 Roof runoff versus storm water runoff

Rainwater that is intercepted by roof material and

a) not subject to pedestrian access, except for maintenance purposes, shall be considered roof runoff; and

b) subject to pedestrian access or intercepted by ground level surfaces (e.g., vegetative roofs, pedestrian surfaces, porous pavement, landscape runoff, paved parking and street, freeway and shoulder areas on roadways) shall be considered storm water runoff.

7.1.3 Collection surface types for end use tiers

7.1.3.1

Subject to the assessment of the WSP, based on the prescriptive approach, collection surfaces shall only supply water for the end use tiers specified in Table 7.1 where a system supplies multiple end uses, the collection surface shall comply with Table 7.1 for each end use.

7.1.3.2

Colder climate regions subject to some degree of snowfall during the year and use of salt for de-icing shall not collect storm water runoff for use unless appropriate treatment is undertaken to address saltcontent.

Note: *Water end use tiers are specified in Clause 5.2.*

Table 7-1
Collection surfaces per water end use tier for the prescriptive approach

(See Clause 7.1.3.1.)

Collection surface		**End use tier**
Roofing material	Asbestos cement	‡
	Asphalt	1, 2, 3, 4
	Asphalt felt and bituminous and tarmembranes	1, 2, 3
	Ceramic	1, 2, 3, 4
	Clay	1, 2, 3, 4
	Concrete	1, 2, 3, 4
	Copper	1, 2, 3

	Fiberglass	1, 2, 3, 4
	Glass	1, 2, 3, 4
	Polyethylene membrane	1, 2, 3, 4
	Polymer and acrylic	1, 2, 3
	Rubber/Butyl /EPDM membrane	1, 2, 3
	Steel, coated	1, 2, 3, 4
	Steel, stainless	1, 2, 3, 4
	Tin	1, 2, 3, 4
	PVC	1, 2, 3, 4
	TPO	1, 2, 3, 4
Public pedestrian accessible roofs		1, 2, 3
Vegetated roofs		1, 2*, 3
Pedestrian and parking surfaces (e.g., sidewalks, courtyard, driveways,parking areas, pervious surfaces)		1, 2*, 3
Landscaped runoff		1, 2*, 3
Street, freeway, shoulder areas		‡
Collection surface		**End use tier**
Subsurface collection†		1, 2, 3
Surface waters and storm water detention ponds		‡

* HVAC evaporative cooling applications not included.

† Subsurface water shall not be collected from sites which contain contaminated soils.

‡ Not in the scope of this Standard.

7.1.4 Collection surfaces for potable water applications

Roofing materials used for collection of rainwater for potable applications shall be third-party certified to PSQCA approved, unless the water collected is treated to address the constituent contaminants. Paints, liners and coatings applied to surfaces used for collection of rainwater for potable applications shall be third-party certified to PSQCA or AHJ approved and applied in accordance with the manufacturer's installation instructions. Lead or chromium shall not be used on surfaces used for collection of rainwater for potable applications.

7.1.5 Equipment and appliances mounted on collection surfaces

Except where potential discharge of equipment and appliances is limited to potable water or clear water waste and the collection surface supplies rainwater harvesting systems utilized exclusively for Tier 1 or 2 applications (excluding evaporative cooling), equipment and appliances mounted on collection or runoff surfaces shall have a means of preventing the introduction of contaminants into the rainwater harvesting system. Equipment and

appliances containing toxic fluids or other potentially harmful substances shall not be installed on collection surfaces.

7.2 Conveyance subsystems

7.2.1 General

Conveyance subsystems and components shall be designed and installed to facilitate the transport of collected rainwater with minimal loss and contamination and without degradation of any associated structure.

7.2.2 Roof drains

Where rainwater harvesting conveyance systems serve as all or a portion of the primary roof drainage for a structure, the system shall be sized, designed and installed in accordance with the notified Building Code Pakistan and the plumbing specifications/systems as approved and applicable by AHJ. Secondary roof drains that connect to a combined primary and secondary roof drainage system shall not discharge to a rainwater harvesting conveyance system.

7.2.3 Storm water management

Conveyance subsystems that also function as elements of storm water management systems for the site shall be designed and installed in accordance with requirements of relevant provisions of Building Code of Pakistan-2021 as approved by the AHJ.

7.2.4 Materials

Conveyance subsystems shall be constructed of materials that are fit for the intended use. Collection devices shall be constructed of materials that are compatible with the collection surfaces, anticipated rainwater quality and the treated water quality required for the intended end use.

7.2.5 Joints

Joints between components in the conveyance system shall be watertight.

7.2.6 Cleanouts

Cleanouts shall be provided in the water conveyance system to allow for cleaning and clearing of blockages in pipes, leaders and downspouts.

7.2.7 Access

Inlets, debris excluders, filters, first-flush diverters, cleanouts and any conveyance system components requiring service shall be accessible.

7.2.8 Vermin control

Conveyance systems and inlets shall be protected to prevent the entrance of insects and vermin.

7.2.9 Conveyance system inlets

7.2.9.1 Conveyance inlet sizing

Inlets to conveyance subsystems that also serve as primary or secondary roof drains or storm water management systems shall comply with the minimum size requirements specified by the AHJ.

7.2.9.2 Pre-filtration

Inlets accepting water from collection surfaces shall be protected with a debris excluder, inlet pre-filter, or equivalent device to prevent the entry of large contaminants and debris into the conveyance system (e.g., vermin, leaves, sticks, needles, tree fruit, bark, moss, or any other unwanted debris or roof contaminant that could enter the system).

7.2.10 First-flush diverters

First-flush diverters shall operate automatically and not rely on manually operated valves or devices. Diverted rainwater shall be discharged in a manner consistent with the storm water runoff requirements of the AHJ and shall not drain on to rainwater collection surfaces.

7.2.11 Gutters

Roof gutters used to convey captured rainwater shall be installed and sized in accordance with the requirements of the AHJ. In the absence of such requirements, installation and sizing shall be in accordance with the applicable code.

7.2.12 Roof drain systems

The collection and conveyance of rainwater shall not adversely impact the function of roof drain systems. Roof drain systems shall be designed and installed in accordance with the requirements of the applicable notified provisions of relevant Building Codes of Pakistan and manufacturer's requirements as approved by AHJ.

7.2.13 Vertical conveyance

7.2.13.1 General

Leaders, vertical conductors and other devices conducting captured rainwater from elevated collection surfaces shall be designed, sized and installed in accordance with the requirements of the applicable notified building code as approved by AHJ.

7.2.13.2 Scuppers and catch basins

Scuppers used with elevated collection surfaces shall allow for the free fall of water to a catch basin without obstructions in the path of travel. Scuppers and catch basins shall be designed to prevent water from splashing the exterior of the structure. Catch basins used in conjunction with scuppers shall comply with Clause 7.2.

7.2.14 Conveyance piping

7.2.14.1 General

To convey captured rainwater, rainwater harvesting systems shall use drainage piping suitable for use within plumbing specifications for drainage or pressure systems as approved by AHJ.

7.2.14.2 Design and installation of conveyance piping

Collection piping conveying captured rainwater shall be designed, sized and installed in accordance with the requirements of the AHJ. The size of a drainage pipe shall not be reduced in the direction of flow.

7.3 Storage tanks

7.3.1 General

7.3.1.1 Compliance

Tanks shall comply with either

a) The applicable requirements given in Clauses 7.3.1.2 to 7.3.1.5; or

b) The applicable requirements of at least one the following standards:

   i) NDWQS, 2010

   ii) PSQCA approved standards

   iii) Any suitable standard as approved by AHJ or;

c) Other International standards

   i) ASTM C1227;

   ii) ASTM D1998;

iii) AWWA D100;

iv) AWWA D103;

v) AWWA D107;

vi) AWWA D115;

vii) AWWA D120;

viii) AWWA D121;

ix) CAN/CSA-B126 Series;

x) IAPMO/ANSI Z1002;

xi) NFPA 22;

xii) UL 58;

xiii) UL 142;

xiv) UL 1316;

xv) CAN/ULC-S601; or

xvi) CAN/ULC-S603.

xvii) WHO Guidelines

xviii) ISO Standards

Tanks used for fire protection shall comply with the Building Code of Pakistan – Fire Safety Provisions-2016.

7.3.1.2 Precast concrete tank requirements

7.3.1.2.1 Materials

7.3.1.2.1.1 Intentionally left blank.

7.3.1.2.1.2 Sulphate soils

Concrete for tanks exposed to moderate or high sulphate soils shall be rated for resistance to sulphate exposure, as appropriate.

7.3.1.2.1.3 Potable water applications

Tanks intended for potable water applications and all associated components (e.g., sealants, fittings and linings contacting collected water) shall comply with the applicable requirements of NDWQS, 2010/PSQCA/NSF/ANSI 61. Non-toxic form release agents shall be used in the production of all molded components installed on tanks for potable water applications as approved by AHJ.

7.3.1.2.2 Field testing

Field testing shall be in accordance with the tank manufacturer's instructions by respective AHJ.

7.3.1.3 Modular plastic tanks

7.3.1.3.1 Materials

Tanks for potable applications shall comply with NDWQS, 2010/PSQCA/NSF/ANSI 61.

7.3.1.3.2 Design life

The design life of a polymer tank shall be determined in accordance with the life expectancy of the specific project.

7.3.1.3.3 Below-ground tanks

Where water is introduced into the tank through infiltration, the soil mix and plant material shall be selected to provide required infiltration rates and shall not contain contaminants.

7.3.1.4 Flexible tanks

Note: *Flexible tanks are also known as "pillow tanks" and "bladder tanks".*

7.3.1.4.1 Materials

Materials for flexible tanks shall comply with the requirements specified in Table 7.2. Flexible tanks used for potable water applications shall comply with NDWQS, 2010/PSQCA/ NSF/ANSI 61 or any other approved standard by AHJ.

Table 7-2
Requirements for flexible tank materials

(See Clause 7.3.1.4.1.)

Property	Requirements	Test conditions	Test method
Tear strength	Minimum 133/133 N (30/30 lbf)	—	ASTM D751, Trap tear
Breaking yield strength	Minimum 1110/890 N (250/200 lbf)	—	ASTM D751, Grab tensile
Hydrostatic resistance	Minimum 2.07 MPa (300 psi)	—	ASTM D751, Procedure A
Low temperature resistance	Pass -32 °C (-25 °F)	1/8 in mandrel, 4 h	ASTM D2136
Dimensional stability	Maximum 5% in each direction	100 °C (212 °F), 1 h	ASTM D1204
Bursting strength	Minimum 1557 N (350 lbf)	—	ASTM D751, Ball tip
Blocking resistance	Maximum #2 Rating	82 °C (180 °F)	ASTM D751
Adhesion-ply	Minimum 2.1 kN/m (12 lbf/in)	—	ASTM D413, Type A
Abrasion resistance	Minimum 2000 cycles before fabric exposure and maximum weight loss of 50 mg/100 cycles	H-18 Wheel, 1 kg load	ASTM D3389
Water absorption	Maximum 0.05 kg/m^2 at 21 °C (70 °F) and 0.28 kg/m^2 at 100 °C (212 °F)	7 d	ASTM D471, Section 12
Wicking	Maximum 3.2 mm (0.125 in)	—	ASTM D751
Puncture resistance	Minimum 225 N (50 lbf)	—	ASTM D4833
	Minimum 912 N (205 lbf)	—	FTM STD. No. 101C (Method 2065)

7.3.1.4.2 Seams

Seams shall be made water-tight using radio frequency, heat bonding, or equivalent methods and shall comply with the applicable requirements specified in Table 7.3, depending on the fabric and seam type.

Table 7-3 Minimum requirements for flexible tank seams

Test	Minimum requirements	Test method
Adhesion heat welded seam	1.75 kN/m	ASTM D751, Dielectric seam
Dead load seam strength	17.5 kN/m at 21 °C (70 °F)and 8.75 kN/m at 70 °C (160 °F)	ASTM D751
Bonded seam strength	1112 N	ASTM D751, Grab test Method, Procedure A

7.3.1.4.3 Fittings

7.3.1.4.3.1 Reinforcement patches

Fitting ports shall be reinforced with patches made of the same material used in the manufacture of the flexible tank. Patches shall be thermally welded to the flexible tank.

7.3.1.4.3.2 Location

Fittings shall be located at least 200 mm (8 in) from seams or as approved by AHJ.

7.3.1.4.3.3 Bulkhead fittings

Bulkhead fittings shall be bolt-on.

7.3.1.4.3.4 Flexible piping or tubing

Side and top fittings shall be connected to a section of flexible pipe or tubing that is sufficiently long to compensate for tank flexing without imparting excessive stress on the piping or tank.

7.3.1.5 Installation

Flexible tanks shall be installed on level and smooth surfaces.

7.3.2 Sizing

The minimum capacity of the rainwater storage tank shall consider the output water demand, dedicated fire reserve volume, storm water management (detention or retention) volume and storage loss factors and shall be in accordance with the requirements of the AHJ. See also Annex C for guidance on tank sizing methodologies and calculations.

7.3.3 Materials

7.3.3.1 General

Tanks, liners, coatings, pipes, pipe fittings and appurtenances shall be constructed of durable, non-absorbent materials. Storage tank materials shall be compatible with disinfection agents or processes that come in contact with the tank, the water to be stored and the intended end use. Seams and joints shall be watertight.

7.3.3.2 Material compatibility for potable end use

Storage tanks, liners, coatings, pipes, pipe fittings and appurtenances contacting collected rainwater intended for potable end uses shall comply with NDWQS, 2010/PSQCA as approved standards by AHJ.

7.3.3.3 Environmental compatibility

Storage tanks and materials shall be constructed to withstand local environmental conditions. Storage tanks pipes and pipe fittings and appurtenances designed to be installed in a location subject to direct sunlight shall be constructed from a material designed to be stable under the UV light exposure anticipated during the life of the system.

7.3.4 Storage tank foundation and supports

7.3.4.1 General

Storage tanks shall be properly supported on a base capable of withstanding the weight of the storage tank when filled to capacity. Storage tanks shall be supported and restrained to prevent lateral movement. Support and restraint devices shall be placed in a manner that will not obstruct access for testing and maintenance. Support and restraint shall be in accordance with the building code, the manufacturer's installation instructions and any applicable standards related to the end use.

7.3.4.2 Tanks subject to buoyancy uplift conditions

Where there is high ground water or a risk of flooding, storage tanks shall be

a) Ballasted or otherwise secured to prevent them from floating or moving; and

b) Designed to withstand structural stresses caused by hydrostatic pressure and buoyancy.

7.3.4.3 Underground structural support

7.3.4.3.1 General

The design of buried or partially buried tanks shall consider the

a) External loads on the tank including the weight of the backfill together with hydrostatic,overburden and live loads;

b) Soil type at the site and the tank loading when the tank is either full and empty; and

c) Manufacturer's installation requirements.

7.3.4.3.2 Surface loads

Underground tanks subject to vehicular traffic shall be installed in accordance with the manufacturer's installation instructions and applicable codes and standards and shall be capable of withstanding anticipated loads as defined by PSQCA/NHA/ AASHTO M43 or any other standard approved by AHJ shall apply, as applicable.

7.3.5 Storage tank location

7.3.5.1 Restricted locations

Storage tanks and their access openings shall not be located directly under sanitary, waste, or storm drainage piping, or any potential source of contamination. Storage tanks shall not be installed above onsite sewage disposal systems.

7.3.5.2 Protection of water from direct sunlight

Water contained within storage tanks shall be protected from direct sunlight through the use of opaque, UV-resistant materials.

7.3.6 Access

7.3.6.1 General

At least one access opening shall be provided to allow inspection and cleaning of the interior of each tank. Access openings shall be located to facilitate the pumping and cleaning of tanks and the servicing and inspection of inlets and outlets. Access openings shall be secured to prevent unauthorized access. Openings shall be watertight and weatherproof and shall be constructed to prevent entry of vermin and insects and ingress of contaminants.

7.3.6.2 Access openings for human access

Where installed, openings intended for human access shall have a minimum dimension of 0.50 m (20 in) and an area of at least 0.20 m^2 (314 in^2). Access openings shall be designed to prevent water infiltration. Finished grade shall be sloped away from the access opening to divert surface water. Access openings and covers shall be secured to prevent unauthorized access and vandalism.

7.3.6.3 Covers

Covers shall be installed over service ports and access openings. Penetrations for wiring or piping shall not be installed on covers.

7.3.6.4 Tank abandonment

When permanently removed from service,

a) Below-ground storage tanks shall be removed or filled with inert material; and

b) Above-ground tanks shall be removed or secured to prevent unauthorized access.

7.3.7 Secondary water supply

7.3.7.1 General

Where an uninterrupted water supply is required for the intended application, a secondary source shall be provided. When installed, secondary water may be supplied by means of a makeup water system to refill the storage tank (s) or a bypass system that provides water directly to the distribution system.

7.3.7.2 Availability and minimum quality

Secondary sources of water supply shall have sufficient capacity to meet the anticipated demand supplied by the rainwater harvesting system. Secondary sources of water shall meet the minimum quality for the intended use as required in Clause 8. Where rainwater harvesting systems supply water for potable uses, secondary water supplies shall be potable.

7.3.7.3 Protection against backflow

The secondary water supply shall be protected against backflow in accordance with specific guidelines

7.3.7.4 Pipes, valves and fittings

Valves shall be accessible for inspection and maintenance. A full-open manual valve shall be installed on secondary water supply lines upstream of automatic level control or diverter valves for servicing and maintenance. Secondary water piping, joints, fittings and valves shall be designed and installed in accordance with the specification for the intended end use.

7.3.7.5 Makeup water supply systems

Where makeup water is utilized, it shall be provided to rainwater harvesting systems to maintain minimum water levels within the storage tank. Makeup water supply systems shall use automatic level control valves to maintain the minimum water level in the tank for

uninterrupted operation. The automatic level controls shall limit the makeup water level below the tank overflow.

7.3.7.6 Directly connected water supply

Directly connected water supplies shall be connected to the distribution system to maintain the water supply and sized to meet the maximum anticipated demand of the end use. Where an automatic directly connected water supply is utilized, an alert shall be provided in accordance with Clause 6.7.5 indicating when the directly connected water supply system is in operation.

7.3.8 Tank overflows

7.3.8.1 General

Storage tanks shall be equipped with an overflow not less than the capacity of the inlet(s). No single overflow pipe shall be less than 50 mm (2 in) in diameter.

7.3.8.2 Insect and vermin control

Tank overflow pipes shall be protected from insects and vermin.

7.3.8.3 Distance and direction

Tank overflow pipes shall discharge directed away from the tank and in accordance with the plumbing specifications/systems as approved by AHJ. Drainage from tank overflow pipes shall be directed to prevent a hazardous condition.

7.3.8.4 Shutoff valves

Shutoff valves shall not be installed in tank overflow piping.

7.3.8.5 Cleanouts

Cleanouts shall be provided on each tank overflow pipe in accordance with the plumbing specifications/systems as approved by AHJ.

7.3.8.6 Backwater valves

Where tank overflows are directly connected to sanitary or storm drainage systems, they shall have a means to prevent backflow.

7.3.9 Tank connections and penetrations

7.3.9.1 General

All inlets and outlets on storage tanks shall be installed and supported in accordance with the manufacturer's instructions. Flanged connections, when used, shall be at least Class 150 as specified in NDWQS, 2010/ PSQCA or ASME B16.5 as approved by AHJ.

7.3.9.2 Rainwater inlets

Rainwater inlets shall be constructed and arranged to minimize turbulence and disturbance of sediment within the storage tank.

7.3.9.3 Rainwater outlets

Rainwater outlets and pump suction shall be located at least 100 mm (4 in) above the bottom of the storage tank and shall not skim water from the surface. Floating outlets, when used,

shall be tethered to the top of the tank to prevent the intake from coming within 100 mm (4 in) of the bottom of the tank with changes to the water level.

7.3.9.4 Controlled flow outlets

Where rainwater harvesting systems are used for storm water management and detention, a controlled flow outlet shall be provided utilizing an orifice or flow restrictor sized to control the release rate from the rainwater harvesting system in accordance with the plumbing specifications as approved by AHJ. Controlled flow outlets shall not supersede the overflow requirements specified in Clause 7.3.8.

7.3.9.5 Pipe penetrations

Pipe penetrations through tank walls shall be watertight and shall comply with the plumbing specifications as approved by AHJ. Piping penetrations shall not impede access to the tank.

7.3.9.6 Interconnection of multiple tanks

Where multiple tanks are interconnected, piping connections shall be made with compliant fittings and installed in a manner that provides adequate flexibility to allow for tank settlement or movement.

7.3.9.7 Electrical penetrations

Electrical penetrations through tank walls shall

a) Be made above the highest water level in the tank (i.e., above the highest overflow);
b) Be watertight;
c) Comply with the electrical code; and
d) Not impede access to the tank.

7.3.10 Venting / Drainage

7.3.10.1 General

Tanks shall be vented

a) Through a vent or overflow piping; and
b) Directly to the atmosphere.

7.3.10.2 Vent pipes

Vent pipes shall

a) Be protected from contamination by means of a cap or U-bend installed with the opening directed downward:
b) Extend not less than 150 mm (6 in) above grade or as necessary to prevent surface water from entering the storage tank; or it may be decided after the preliminary survey for estimated potential of discharge.
c) Be protected against the entrance of vermin and insects in accordance with Clause 5.1.8; and
d) Not have air admittance valves installed.

7.3.11 Draining of tanks

All tanks shall be provided with a means to drain or empty the tank utilizing a gravity drain or pump. Where tanks are provided with a gravity drain, tank drain pipe(s) shall discharge as

required for the overflow pipe(s). The gravity drain or pump discharge shall not be less than 50 mm (2 in) in diameter.

7.3.12 Tank marking and signage

7.3.12.1 Markings

Tanks for rainwater harvesting systems shall have at least the following markings:

a) The rated capacity;

b) For storage tanks containing non-potable water, the words “CAUTION: NON-POTABLE WATER — DONOT DRINK”.

c) Where openings allow for the entry of personnel, the words “DANGER — CONFINED SPACE and a warning indicating the needfor procedures for safe entry into confined spaces.

7.3.12.2 Marking characteristics

Markings shall be indelibly printed on exterior tank walls or on a tag or sign constructed of a corrosion-resistant, waterproof material mounted on the tank in a visible location.

7.3.12.3 Letter size

The letters of the labels and markings shall be at least 13 mm (0.5 in) in height and shall be of a color that contrasts with the background on which they are printed.

7.3.13 Ladders, balconies and platforms

Interior and exterior ladders, platforms and balconies on tanks shall comply with NFPA 22.

7.4 Treatment and disinfection subsystems

7.4.1 General

Potable water systems shall be equipped with a fail-safe mechanism that will trigger an alarm in accordance with Clause 6.7.5 and turn the supply off should the treatment system malfunction.

7.4.2 Sampling ports

Sampling ports shall be installed to facilitate verification of the operation of each filtration and disinfection process.

7.4.3 Filtration systems

Collected rainwater shall be filtered as required for the intended end use as specified in Clause 8. Filters shall

a) Be installed in accordance with the plumbing specifications/systems as approved by AHJ;

b) Be accessible for inspection and maintenance;

c) Utilize a pressure gauge or other acceptable method to provide indication when it requires servicing or replacement; and

d) Have shutoff valves installed immediately upstream and downstream to allow for isolation during maintenance.

7.4.4 Disinfection systems

7.4.4.1 General

Where the intended end use requires disinfection, rainwater shall be disinfected to ensure that the required water quality is delivered at the point of use, as specified in Clause 8. Disinfection systems shall be designed and installed in accordance with the manufacturer's instructions and the plumbing specifications/systems as approved by AHJ.

7.4.4.2 UV disinfection systems

7.4.4.3 General

UV disinfection systems shall treat water for distribution downstream of the storage tank and upstream of the point of end use. For potable water applications, UV disinfection systems shall be third-party certified to Class A of NDWQS, 2010/PSQCA/ NSF/ANSI 55.

Where low UVT precludes the use of NDWQS, 2010 or NSF/ANSI 55/ compliant devices, alternative UV treatment systemsshall be used as approved by the AHJ.

Where rainwater harvesting systems employ day tanks, UV disinfection may be applied upstream of theday tank, provided measures are taken to maintain the required water quality.

7.4.4.4 UV disinfection system sizing

UV disinfection systems shall be sized based on the required dose taking into consideration the design flow and minimum UVT that is required for the disinfection specified for the end uses.

7.4.4.5 Filtration for UV systems

Filtration of 5 µm or less shall be installed upstream of the UV disinfection system.

7.4.4.6 Chemical disinfection systems

7.4.4.7 General

Rainwater harvesting systems that use chemical disinfection shall produce treatment levels in accordance with the requirements specified in Clause 8. Chemical feed and dosing systems shall be installed in accordance with the manufacturer's specifications.

7.4.4.8 Filtration for chemical disinfection systems

Filtration shall be installed as required for the chemical disinfection system and in accordance with the manufacturer's installation requirements.

7.4.4.9 Measurement and control for chemical disinfection systems

Chemical disinfection systems shall have means to measure and control the disinfection and oxidation levels within the treated water to comply with the treatment levels specified in Clause 8. Chemical feed pumps shall be controlled to prevent operation unless there is flow through the system.

7.4.4.10 Chemical disinfection systems

Chemicals used in disinfection systems for potable applications shall comply with NDWQS, 2010.

7.4.5 Microfiltration and ultrafiltration systems

When used, microfiltration or ultrafiltration systems shall be installed between the storage tank and the point of end use. Microfiltration and ultrafiltration systems shall be sized based on the design flow and installed in accordance with Clause 7.4.3 and the manufacturer's installation requirements.

7.5 Distribution systems

7.5.1 General

Distribution systems shall be designed and installed in accordance with the appropriate specification for the intended application. Distribution piping shall be identified and marked in accordance with the specification for use.

Note: Irrigation piping is excluded from the scope of this Standard.

7.5.2 Water pressure-reducing valves or regulators

Where the water pressure supplied by the pumping system exceeds 550 kPa (80 psi) static, a pressure-reducing valve shall be installed to reduce the pressure in the rainwater distribution system piping to 550 kPa (80 psi) static or less. Pressure-reducing valves shall be specified and installed in accordance with the plumbing specifications/systems as approved by AHJ.

7.5.3 Materials, joints and connections

Distribution piping, fittings, joints and connections shall comply with the specification.

7.5.4 Pumps

7.5.4.1 General

Pumps used in distribution systems shall be sized for the maximum anticipated end use demand and inaccordance with the requirements of the applicable code. Pumps used for potable water applications shall comply with NDWQS, 2010/PSQCA as approved by AHJ.

7.5.4.2 Pump controls

The pump controller shall be designed to ensure that pumps shall not operate when there is a low water level or low suction pressure condition. Pump failure alarms or alerts, when provided, shall be inaccordance with Clause 6.7.5.

Chapter 8 Water Quality

8.1 Treatment

8.1.1 Minimum performance criteria

Treatment shall comply with Table 8.1, 8.2, 8.3, or 8.4, as applicable based on the end use and source water. Treatment options shall include one of the options listed within each applicable table or another method acceptable to the AHJ. Equipment used shall be validated to meet the minimum performance criteria.

Notes:

The provisions of Tables 8.1, 8.2, 8.3 and 8.4 with respect to health requirements are subject to the approval of the AHJ. See Clause 4.1.

Tables 8.1, 8.2, 8.3 and 8.4 specify minimum performance criteria for each end use tier in consideration of the health risk and identifies possible treatment process options under the "minimum prescriptive requirement" column to meet the specified minimum performance criteria. While specific treatment technologies are addressed, the use of other treatment processes that meet the required performance criteria are not intended to be excluded by this Standard. Any treatment system needs to meet the applicable minimum performance criteria based on an estimated or assumed source water quality. The treatment processes established may differ from the minimum prescriptive requirements depending on the details of the WSP. Therefore, Tables 8.1 to 8.4 need to be used in conjunction with a WSP.

8.1.2 Multiple end uses

Where multiple end uses are supplied from a single system, the applicable performance criteria shall be satisfied for each end use.

8.1.3 Multiple sources

Where a rainwater harvesting system uses a combination of roof runoff and storm water runoff as the source water, either Table 8.2 or 8.4 shall be followed, as applicable.

8.1.4 Intentionally left blank

8.1.5 Multi-barrier approach

Rainwater harvesting systems shall employ a multi-barrier approach to reduce accumulation, introduction and re-introduction of contaminants into the system.

Table 8-1
Roof runoff water treatment requirements for single-family residential applications

(See Clauses 8.1.1 and 8.2.1.)

Application				Minimum performance criteria				Minimum prescriptive requirements				
				Log reduction (% reduction)				Options for post-storage treatment before end use				
								UV††		Chemical-based disinfectants‡‡		
End use tier	Category	Potential for human contact	Examples of uses	Viruses	Bacteria***	Protozoa	pH	Filtration	Disinfection	Filtration	Disinfection	Microfiltration or ultrafiltration
1	Non-potable	Low	• Trap primers • Spray irrigation (restricted access or exposure) §§ • Surface and subsurface irrigation (drip, bubbler) • Fire protection	0	0	0	—	None§				
2	Non-potable	Medium to high	• Toilet and urinal flushing • Clothes washing • HVAC evaporative cooling (e.g., cooling tower, evaporative condenser, spray cooler, direct and indirect evaporative cooling) • Rooftop thermal cooling • Hose bibs • Pressure washing • Decorative fountains • Vehicle washing • Spray irrigation (non-restricted access or exposure)§§	0*	2 (99%)	2 (99%)	—			5 µm	Residual chlorine 0.2 to 0.5 ppm	

(Continued)

Table 8.1 (Continued)

Application				Minimum performance criteria				Minimum prescriptive requirements				
				Log reduction (% reduction)			pH	Options for post-storage treatment before end use				
								UV†† **		Chemical-based disinfectants‡‡		Microfiltration or ultrafiltration**
End use tier	Category	Potential for human contact	Examples of uses	Viruses	Bacteria**	Protozoa		Filtration	Disinfection	Filtration	Disinfection	
3	Potable	High	• Human consumption • Oral care • Food preparation • Dishwashing • Bathing, showering and handwashing • Pools, hot tubs, spas, /splashpads • Misting stations • Swamp coolers	0*	6 (99.99%)	4 (99.99%)	7–8.5	5 µm	40 mJ/cm^2 and third- party certified toClass A of NSF/ ANSI 55	1 µm	CT for 6 Log reduction for bacteria†and at least 0.5 mg/L chlorine residual**	0.1 to 0.2 µm‡ third-party certified***

** It is unlikely that human infectious viruses are present in harvested rainwater sourced from elevated surfaces. If below-ground tanks are used where there is a potential for sewage contamination, a 4 log reduction shall be required in accordance with the WSP.*
† Due to complexity of operation and design, chemical-based disinfection should not be used for single-family dwellings.
‡ Pre-filters of 5 to 100 µm should be used to extend the life of the filter.
§ For operational purposes only, filters smaller than 500 µm, or, for drip irrigation only, filters smaller than 100 µm should be used.

Continued

** Due to potential for growth of opportunistic pathogens in plumbing systems (e.g., Legionella, Pseudomonas aeruginosa and Mycobacterium avian complex), water stored at temperatures higher than 25 °C (77 °F) for extended periods shall not be used for tiers 2 and, 3, unless a chlorine residual of at least 0.5 mg/L is maintained. If chlorine is used, consideration should be given to the potential formation of disinfection by-products.

†† Filtration and disinfection shall both be required. Filtration of at least 5 µm shall be required upstream of the UV disinfection device.

‡‡ Filtration and disinfection shall both be required.

§§ The WSP shall establish whether a given application has restricted or unrestricted access or exposure.

*** Certification shall provide the prescribed log reductions for protozoa and bacteria. Applicable standards could include NSF/ANSI 53, NSF/ANSI 419, or other standards recognized by the AHJ.

Notes:

1). Figure A.1 shows the particle size spectrum for filtration.

2). There continue to be ongoing advances in the development of microfiltration and ultrafiltration technologies; however, at the time of publication, there are no available microfiltration and ultrafiltration devices that are certified to ANSI- or SCC-accredited standards that allow for use of these devices as a primary disinfectant for bacteria and virus. Designers proposing to use microfiltration and ultrafiltration devices as a primary disinfectant are encouraged to check manufacturer's specifications as to the adequacy of the proposed device in the context of the WSP.

Table 8-2

Storm water runoff treatment requirements for single-family residential applications

(See Clauses 8.1.1, 8.1.3 and 8.2.1.)

Application				Minimum performance criteria				Minimum prescriptive requirements				
				Log reduction (% reduction)			pH	Options for post-storage treatment before end use				
								UV††		Chemical-based disinfectants‡‡		
End use tier	Category	Potential for human contact	Examples of uses	Viruses	Bacteria**	Protozoa		Filtration	Disinfection	Filtration	Disinfection	Microfiltration or ultrafiltration
1	Non-potable	Low	• Trap primers • Spray irrigation (restricted access or exposure) *§§ • Surface and subsurface irrigation (drip, bubbler) • Fire protection • Ice rinks	0	0	0	—	None§				
2	Non-potable	Medium to high	• Toilet and urinal flushing • Clothes washing • HVAC evaporative cooling (e.g., cooling tower, evaporative condenser, spray cooler, direct and indirect evaporative cooling) • Rooftop thermal cooling • Hose bibbs • Pressure washing • Decorative fountains • Vehicle washing • Spray irrigation (non-restricted access	4	2(99%)	2(99%)	—			10 µm	Residual chlorine at least 0.5 ppm	

(Continued)

Table 8.2 (Continued)

Application				Minimum performance criteria				Minimum prescriptive requirements				
				Log reduction (% reduction)				Options for post-storage treatment before end use				
								UV††		Chemical-based disinfectants‡‡		
End use tier	Category	Potential for human contact	Examples of uses	Viruses	Bacteria**	Protozoa	pH	Filtration	Disinfection	Filtration	Disinfection	Microfiltration or ultrafiltration
3	Potable	High	• Human consumption • Oral care • Food preparation • Dishwashing • Bathing, showering and handwashing • Pools, hot tubs, spas and splash pads • Misting stations • Swamp coolers	Not in the scope of this Standard								

* The WSP shall establish whether a given application has restricted or unrestricted access or exposure.

† Due to complexity of operation and design, chlorine-based disinfection should not be used for single-family dwellings.

‡ Pre-filters of 5 to 100 µm should be used to extend the life of the filter.

§ For operational purposes only, filters smaller than 500 µm, or, for drip irrigation only, filters smaller than 100 µm should be used.

** Due to potential for growth of opportunistic pathogens in plumbing systems (e.g., Legionella, Pseudomonas aeruginosa and Mycobacterium avian complex), water stored at temperatures higher than 25 °C (77 °F) for extended periods shall not be used for tiers 2 and 3, unless a chlorine residual of at least 0.5 mg/L is maintained. If chlorine is used, consideration should be given to the potential formation of disinfection by-products.

†† Filtration and disinfection shall both be required. Filtration of at least 5 µm shall be required upstream of the UV disinfection device.

‡‡ Filtration and disinfection shall both be required.

Note: Figure A.1 shows the particle size spectrum for filtration.

Table 8-3

Roof runoff water treatment requirements for multi-residential and non-residential applications

(See Clauses 8.1.1, 8.1.3 and 8.2.1.)

Application				Minimum performance criteria				Minimum prescriptive requirements				
				Log reduction (% reduction)				Options for post-storage treatment before end use				
								UV‡‡		Chemical-based disinfectants§§		
End use tier	Category	Potential for human contact	Examples of uses	Viruses	Bacteria**	Protozoa	pH	Filtration	Disinfection	Filtration	Disinfection	Microfiltration or ultrafiltration
1	Non-potable	Low	• Trap primers • Spray irrigation (restricted access orexposure) *** • Surface and subsurface irrigation (drip, bubbler) • Fire protection • Ice rinks	0	0	0	—	None§				
2	Non-potable	Medium to high	• Toilet and urinal flushing • Clothes washing • Rooftop thermal cooling • Hose bibbs • Pressure washing • Decorative fountains • Vehicle washing • Spray irrigation (non-restricted access or exposure)***	0*	2(99%)	2(99%)	—			10 µm absolute **	CT for 2 Log reduction for bacteria and at least 0.2 to 0.5 mg/L chlorine residual**	
			• HVAC evaporative cooling (e.g., cooling • tower, evaporative condenser, spray cooler, direct and indirect evaporative cooling)	Treatment shall consider equipment manufacturer water quality requirements and be designed inaccordance to NDWQS, 2010								

(Continued)

Table 8.3 (Continued)

Application				Minimum performance criteria				Minimum prescriptive requirements				
				Log reduction (% reduction)				Options for post-storage treatment before end use				
								UV‡‡		Chemical-based disinfectants§§		
End use tier	Category	Potential for human contact	Examples of uses	Viruses	Bacteria**	Protozoa	pH	Filtration	Disinfection	Filtration	Disinfection	Microfiltration or ultrafiltration
3††	Potable	High	• Human consumption • Oral care • Food preparation • Dishwashing • Bathing, showering and hand washing • Pool/hot tubs/spas/ splash pads • Misting stations • Swamp coolers	0*	6 (99.9999%)	4 (99.99%)	6.5–8.5	5 µm	40 mJ/cm^2 and third-party certifiedto Class A of NSF/ANSI 55 or validated to U.S. EPA UVDGM or DVGW W294 with at least 0.5 mg/Lchlorine residual**	1 µm absolute	CT for 6 Log reduction for bacteria† and at least 0.5 mg/L chlorine residual**	0.1 to 0.2 µm‡ third- party certified††† with at least 0.5 mg/L chlorine residual**

* It is unlikely that human infectious viruses are present in harvested rainwater. For below-ground tanks where there is a potential for sewage contamination, a 4 log reduction shall be required in accordance with the WSP.

† Depending on source water quality, consideration should be given to the potential formation of disinfection by-products.

‡ Pre-filters of 5 to 100 µm should be used to extend the life of the filter.

§ For operational purposes only, filters smaller than 500 µm, or, for drip irrigation only, filters smaller than 100 µm should be used.

** Due to potential for growth of opportunistic pathogens in plumbing systems (e.g., Legionella, Pseudomonas aeruginosa and Mycobacterium avian complex), a chlorineresidual of at least 0.5 mg/L shall be maintained.

†† The AHJ might specify additional requirements for public drinking water supplies.

‡‡ Filtration and disinfection shall both be required. Filtration of at least 5 µm shall be required upstream of the UV disinfection device.

§§ Filtration and disinfection shall both required.

*** The WSP shall establish whether a given application has restricted or unrestricted access or exposure.

††† Certification shall provide the prescribed log reductions for protozoa and bacteria. Applicable standards could include NSF/ANSI 53, NSF/ANSI 419, or other standards recognized by the AHJ.

Notes:

CT = disinfectant concentration times the contact time.

Figure A.1 shows the particle size spectrum for filtration.

There continue to be ongoing advances in the development of microfiltration and ultrafiltration technologies; however, at the time of publication, there are no available microfiltration and ultrafiltration devices that are certified to ANSI- or SCC-accredited standards that allow for use of these devices as a primary disinfectant for bacteria and virus. Designers proposing to use microfiltration and ultrafiltration devices as a primary disinfectant are encouraged to check manufacturer's specifications as to the adequacy of the proposed device in the context of the WSP.

Table 8-4

Storm water runoff treatment requirements for multi-residential and non-residential applications

(See Clauses 8.1.1, 8.1.3 and 8.2.1.)

Application				Minimum performance criteria				Minimum prescriptive requirements				
End use tier	Category	Potential for human contact	Examples of uses	Log reduction (% reduction)			pH	Options for post-storage treatment before end use				
				Viruses	Bacteria†	Protozoa		UV**		Chemical-based disinfectants††		Microfiltration or ultrafiltration
								Filtration	Disinfection	Filtration	Disinfection	
1	Non-potable	Low	• Trap primers • Spray irrigation (restricted access or exposure) * • Surface and subsurface irrigation (drip, bubbler) • Fire protection • Ice rinks	0	0	0	—	None§				
2	Non-potable	Medium to high	• Toilet and urinal flushing • Clothes washing • Rooftop thermal cooling • Hose bibbs • Pressure washing • Decorative fountains • Vehicle washing • Spray irrigation (non-restricted access/ exposure)*	4 (99.99%)	4 (99.99%)	3(99.9%)	—			10 µm	CT for 4 Log reduction for bacteria and at least 0.5 mg/L chlorine residual†	

(Continued)

Table 8.4 (Continued)

Application				Minimum performance criteria				Minimum prescriptive requirements				
				Log reduction (% reduction)				Options for post-storage treatment before end use				
								UV**		Chemical-based disinfectants††		
Enduse tier	Category	Potential for human contact	Examples of uses	Viruses	Bacteria†	Protozoa	pH	Filtration	Disinfection	Filtration	Disinfection	Microfiltration or ultrafiltration
									0.5 mg/L chlorine residual			
			• HVAC evaporative cooling (e.g., cooling tower, evaporative condenser, spray cooler, direct and indirect evaporative cooling)	Treatment shall consider equipment manufacturer water quality requirements and designed inaccordance with NDWQS, 2010.								

(Continued)

Table 8.4 (Continued)

Application				Minimum performance criteria				Minimum prescriptive requirements				
				Log reduction(% reduction)			pH	Options for post-storage treatment before end use				
								UV**		Chemical-based disinfectants††		
Endusetier	Category	Potential for human contact	Examples of uses	Viruses	Bacteria†	Protozoa		Filtration	Disinfection	Filtration	Disinfection	Microfiltration or ultrafiltration
• 4	• Potable	• High	• Human consumption • Oral care • Food preparation • Dishwashing • Bathing, showering, and hand washing • Pools, hot tubs, spas, splash pads • Misting stations • Swamp coolers	• Not in the scope of this Standard								

*

The WSP shall establish whether a given application has restricted or unrestricted access or exposure.

† Due to potential for growth of opportunistic pathogens in plumbing systems (e.g., Legionella, Pseudomonas aeruginosa and Mycobacterium avian complex), a chlorine residual of at least 0.5 mg/L shall be maintained.

‡ A pre-filter of 5 to 100 µm should be used to extend the life of the filter.

§ For operational purposes only, filters smaller than 500 µm, or, for drip irrigation only, filters smaller than 100 µm should be used.

** Filtration and disinfection shall both be required. Filtration of at least 5 µm shall be required upstream of the UV disinfection device.

†† Filtration and disinfection shall both be required.

Notes:

- *CT = disinfectant concentration times the contact time.*
- *Figure A.1 shows the particle size spectrum for filtration*

8.2 Water quality verification and substantiation

8.2.1 General

To ensure the rainwater harvesting system equipment is operating effectively and as intended to meet the minimum performance criteria specified in Table 8.1, 8.2, 8.3, or 8.4, a water quality verification and substantiation program shall be implemented as required by the WSP (see Clause 5.1.2). The water quality verification and substantiation program shall include at least the following elements:

a) Inspection and monitoring of equipment, processes and controls to verify effective system operation;

b) Inspection, monitoring and cleaning of collection surfaces, conveyance piping, equipment and storage tanks; and

c) Water quality monitoring program for multi-residential and non-residential only,

8.2.2 Single-family residential applications

Any filter, UV lamp, or other consumable component shall be replaced in accordance with the manufacturer's recommendations and when required incase water quality tests turn out to be unsafe. If output water changes in clarity or odor, filters should be replaced and any sediment in the storage tank should be flushed or pumped out.

8.2.3 Multi-family residential applications

Any filter, UV lamp, or other consumable component shall be replaced in accordance with the manufacturer's recommendations and when required incase water quality tests turn out to be unsafe. Water quality monitoring shall include weekly measurement of turbidity and Ultraviolet Transmittance (UVT) of water leaving the treatment system, chlorine residual at the point of use and, for systems serving 500 or more people, grab samples for Heterotrophic Plate Count (HPC), Total Coliforms, Fecal Coliforms and E-coli to ensure treatment processes are operating within control limits. Where treatment processes are not operating within control limits, corrective action shall be taken.

8.2.4 Commercial applications

Any filter, UV lamp, or other consumable component shall be replaced in accordance with the manufacturer's recommendations and when required incase water quality tests turn out to be unsafe. Water quality monitoring shall include weekly measurement of turbidity and UVT of water leaving the treatment system, chlorine residual at the point of use and grab samples for Heterotrophic Plate Count (HPC), Total Coliforms, Fecal Coliforms and E-coli to ensure treatment processes are operating within controllimits. Where treatment processes are not operating within control limits, corrective action shall be taken.

8.2.5 Water quality substantiation

Water quality results that meet the limits outlined in Table 8.5 or 8.6, as required by the end use and source, shall substantiate that hazards are being effectively controlled. Corrective action shall be taken if output water quality requirements are not met.

The values in Table 8.5 or 8.6 are provided only as suitable indicator parameters to substantiate systemperformance and shall not be used as the only or primary criteria for the design of a treatment system.

Table 8-5
Output water quality requirement for applications using water sourced from roof collection surfaces

(See Clause 8.2.5.)

End use tier	Parameter	Turbidity (NTU)	HPC (CFU/100 mL)	Enterococci (CFU/100 mL)	pH‡	Chlorine§	
						CMF (mg/L)	SFR (mg/L)
1	Median	—	NT	—	—	—	—
	Maximum	—	—	—	—	—	—
2*	Median	≤2	<500§	≤5	–	0.5 – 2.0§	
	Maximum	5	—	<15	—		—
2†	Median	—	<500§	NT	7.0 – 8.2	—	—
	Maximum	—	—	—	—	—	—
3	Median	≤5	<500§	<5		0.5 – 2.0	
	Maximum	5	—	<15	—		—
4	—	Refer to applicable drinking water standards e.g. National Drinking Water Quality Standards (NDWQS, 2010), and any guidelines/standards from the local AHJ.					

* *Excluding evaporative cooling.*

† *Evaporative cooling only.*

‡ *A pH of less than 7 can be a concern for piping, fittings and other equipment but a required value is not set for most uses.*

§ *For systems supplying water to less than 25 people, UV disinfection may be used instead of chlorine.*

Notes:

1) *For systems serving a single-family dwelling, there is no requirement to undertake microbiological testing; however, the system shall be physically examined upon installation and periodically thereafter.*
2) Methods shall follow APHA Standard Methods for the Examination of Water and Wastewater or U.S. EPA-approved methods.

Table 8-6
Output water quality requirements for applications using water sourced from ground level collection surfaces

(See Clause 8.2.5.)

Tier	Parameter	Turbidity (NTU)	HPC (CFU/ 100 mL)	*E. coli* (CFU/ 100 mL)	Enterococci (CFU/ 100 mL)	*Bacteroides* HF183 and HumM2 Markers (GE/100 mL)	pH‡	Chlorine	
								CMF (mg/L)	SFR (mg/ L)
1	Median	—	—	—	—	—	—	—	—
	Maximum	—	—	—	—	—	—	—	—
2*	Median	≤5	<500	≤10	≤5	<60	—	0.5 – 2.0	0.5 – 2.0
	Maximum	5	—	<200	<70	<100	—	—	—
2†	Test average	—	<500	NT	NT	NT	7.0-8.2	—	—
	Maximum	—	—	—	—	—	—	—	—

* *Excluding evaporative cooling.*
† *Evaporative cooling only.*
‡ *A pH of less than 7 can be a concern for piping, fittings and other equipment but a required value is not specified for most uses.*

Table 8.6 (Continued)

Tier	Parameter	Turbidity (NTU)	HPC (CFU/ 100 mL)	*E. coli* (CFU/ 100 mL)	Enterococci (CFU/ 100 mL)	*Bacteroides* HF183 and HumM2 Markers (GE/100 mL)	pH‡	Chlorine	
								CMF (mg/L)	SFR (mg/L)
3	Test average	≤1	<500	<100	<35	<60	—	0.5 – 2.0	0.5 – 2.0
	Maximum	5	—	<200	<100	<100	—	—	—
4	—	Not permitted							

* *Excluding evaporative cooling.*
† *Evaporative cooling only.*
‡ *A pH of less than 7 can be a concern for piping, fittings and other equipment but a required value is not specified for most uses*

Chapter 9 Rainwater System Tests and Inspections

9.1 Testing for non-potable water distribution system cross-connection

9.1.1 General

Potable water distribution systems supplying water to rainwater harvesting systems shall be tested for cross-connections in accordance with Clauses 9.1.2 and 9.1.3, upon construction and after any modifications.

9.1.2 Cross-connection testing for water distribution systems

Water distribution systems shall be tested for cross-connection as follows:

a) Fill the water storage tank with sufficient potable water to conduct the test.

b) Ensure the water supply from the storage tank remains active.

c) Deactivate and drain the water in the potable water system.

d) Confirm that potable water is no longer supplied after the system has been drained.

Note: *If a potable outlet keeps running, then it might not be connected to the correct water supply systemand the plumbing system should be reconfigured.*

e) Activate the non-potable water system outlets and confirm that water from the storage tank isprovided continuously.

Note: *If a non-potable outlet does not flow, it might not be connected to the proper water supply system and the plumbing system should be reconfigured.*

9.1.3 Post-test reconnection

After conducting the test specified in Clause 9.1.2,

a) All potable and non-potable outlets shall be closed;

b) The water system shall be restored to normal operation; and

c) Any air trapped in the water system shall be purged.

9.2 First-flush diversion test

First-flush diverters shall be inspected and tested by introducing water into the device. Proper diversionof the first quantity of water shall be verified.

9.3 Collection pipe and vent test

Drain, waste and vent piping used for rainwater collection and conveyance systems shall be tested inaccordance with the plumbing specifications/systems as approved by AHJ.

9.4 Tank test

Storage tanks shall be tested as follows:

a) Tanks shall be filled with water to the overflow outlet prior to and during inspection. All seams and joints shall be left exposed and the tank shall remain watertight without leakage for at least 24 h before completing subsequent tests.

b) Overflow systems shall be inspected for proper operation. Additional water shall be introduced for a period of 15 min at a rate similar to the anticipated influent flow to verify proper drainage through the overflow system without leaks.

c) Tank drains shall be inspected and tested for proper operation.

d) Makeup water systems, when provided, shall be inspected and tested for proper operation of theautomatic control valves, level controls and alarms.

9.5 Water supply system test

The testing of makeup water supply piping and distribution piping shall be conducted in accordance with the plumbing specifications/systems as approved by AHJ.

9.6 Inspection and testing of backflow prevention assemblies

The testing of backflow preventers shall be conducted in accordance with the plumbing specifications/systems and municipal water suppliers as approved by AHJ.

9.7 Inspection of vermin and insect protection

Inlets and vents to the system shall be inspected to verify each is protected to prevent the entrance of insects and vermin into the storage tank and piping systems in accordance with Clause 5.1.8.

9.8 Water quality

Water supplied to an end use shall be verified to meet the minimum water quality requirements for the intended application as specified in Clause 8. The quality of the water for the intended application shall be verified at the point of use in accordance with the requirements of this Standard and the applicable codes as approved by AHJ.

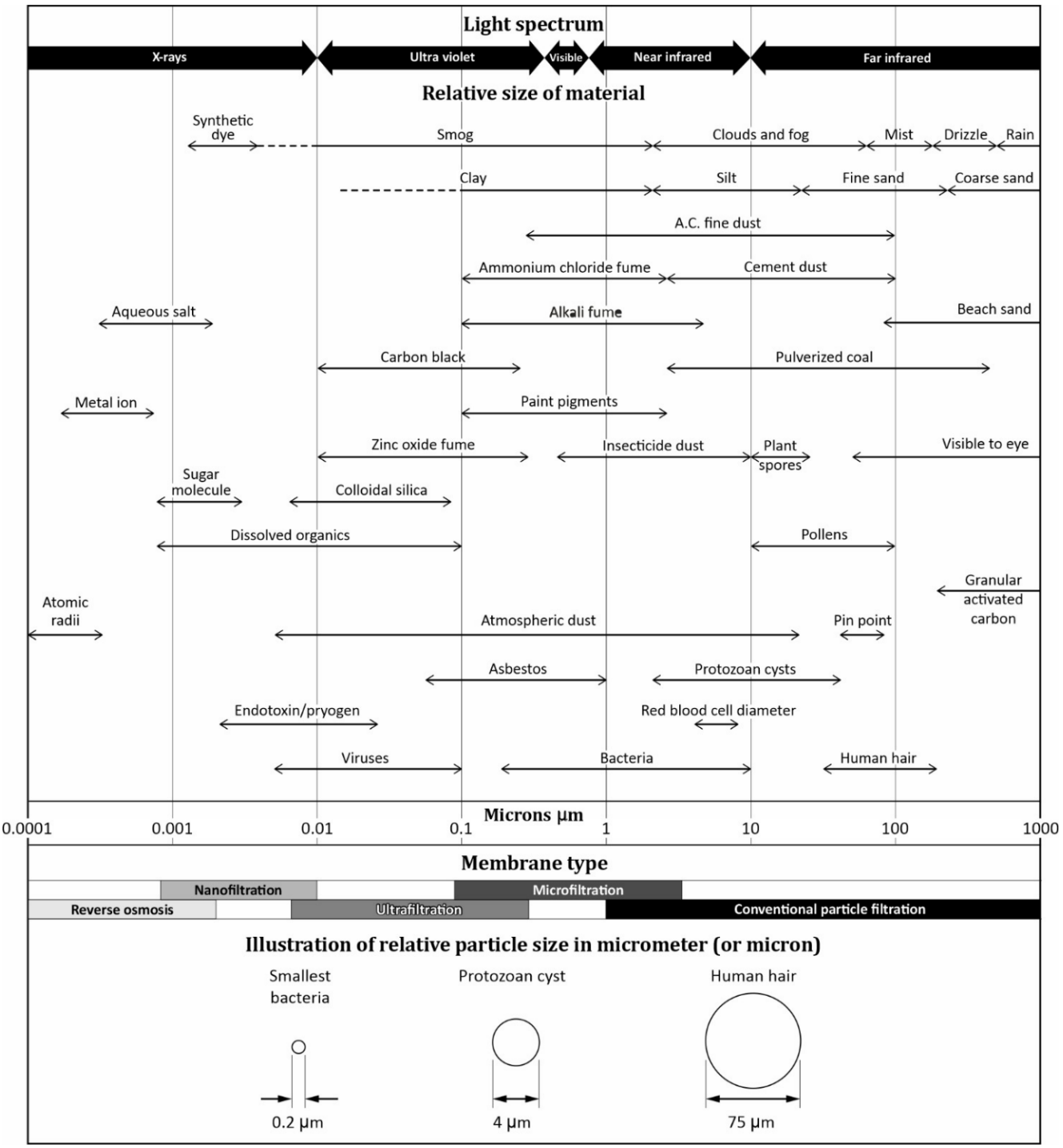
Annex A (informative)

Particle size spectrum

Note: *This Annex is an informative (non-mandatory) part of this Standard.*

A.1 Particle size spectrum for filtration

Figure A.1
Particle size spectrum.



Annex B (informative)

Suggested evaporative cooling water quality control levels.

Note: *This Annex is an informative (non-mandatory) part of this Standard.*

B.1 General

The suggested evaporative cooling water quality control levels are specified in Table B.1. Where an evaporative cooling equipment manufacturer specifies a different water quality control level, it shouldtake precedence over the suggested water quality control levels provided in Table B.1.

Table B.1

(See Clause B.1.)

Parameter	**Unit**	**Suggested limits**
BOD_5	mg/L	<50
TSS	mg/L	<25
Alkalinity, as $CaCO_3$	mg/L (ppm)	75–400
Total hardness, as $CaCO_3$	mg/L (ppm)	<1000
Chlorides	mg/L (ppm)	<250
Silica	mg/L (ppm)	<150
Copper	mg/L (ppm)	<10
Iron	mg/L (ppm)	<3
TDS	mg/L (ppm)	<3000
Conductivity	µS/cm	<3000
pH	—	7-8.8
Total coliform	per 100 mL	<10000

Annex C (informative)

Standard Specifications for Rooftop Rainwater System Design (Residential Buildings)

Designing steps for rooftop rainwater harvesting system.

A. Calculate roof surface area

i. 05 Marla Roof surface area = 25 m x 50 m
ii. 10 Marla Roof surface area = 37 m x 70 m
iii. 20 Marla Roof surface area = 50 m x 90 m.

B. Rainfall Runoff Estimation

$$Q = CiA$$

Where:

i. Q = Peak discharge in cubic meters per second (cm^3/s). Value of runoff is directly proportional to rainfall intensity.
ii. C = Surface runoff coefficient based on the characteristics of soil/land surface from where the runoff is generated. Its values range between 0.1 (for an un improved area) to 0.9 (an impervious area). Values of runoff coefficient are estimated standards (Annexure I).
iii. i = Rainfall intensity is defined as the maximum depth of rainfall over unit period of time (mm/hr). When the rainfall intensity is higher, duration of rainfall is generally low and peak flow is generated. Low intensity rainfall however generates less runoff and spans over longer duration.
A= Area of the catchment and determined in (square meters or hectares).

Maximum rainfall of Islamabad in a single event is 80 mm (PMD) was observed during the data analysis. However, average annual rainfall has been presented in Table C-1.

Table C-1

Average Annual Rainfall data of Islamabad.

Islamabad Rainfall data of 25 years																									Average (Annual)
Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	
Rainfall (mm)	1193	1576	1322	870	869	1320	917	1345	1029	898	1405	1395	1332	686	1040	1086	745	1657	1320	1622	867	971	1212	1212	1400	1172

Source: Pakistan Meteorological Department (PMD)

M Step 1 Calculate roof surface area

Step 2 Maximum rainfall of Islamabad in a single event: 80 (mm)

Step 3 Runoff coefficient = 0.8 (it varies with roof material and slope)

Step 4 Calculate runoff (mm) = rainfall x runoff coefficient

Step 5 Calculate volume of runoff (m^3) = roof area (m^2) x runoff (m)

Step 6 Liters (1 m^3 = 1,000 liters), (1 gallon = 4.5 liters)

C. Water demand

Number of people x water consumption per person x 365

Average minimum water requirement for 5 members' family (5x50x365=91250 liters)

Average maximum water requirement for 5 members' family (5x100x365=182500 liters)

According to the World Health Organization (WHO) Daily water consumption is estimated from 50 to 100 liters per person per day in Asia.

Table C-2
Rainwater harvesting potential for the 5 Marla house

Rainfall (mm) single event	Rooftop Area (m^2) 5 Marla House	Runoff Coefficient	Potential Runoff (Liters)
80	1250	0.8	80000
Total minimum water demand 5 persons			91250
Potential of harvested rainwater			87%

The potential of rooftop rainwater harvesting for the 5 Marla house is calculated in above table. RWH system can meet 87% of water demand of five member's family. However, other sizes of small or large houses can be calculated for design of RWH system.

Example 1: *Design of rooftop rainwater harvesting system*[1]

Design a rooftop rainwater harvesting system for a flat concrete roof if its size is 25 m × 15 m and maximum rainfall in a single event is 100 mm.

Given:

a. Roof surface area = 25 m x 15 m
b. Maximum rainfall in a single event = 100 mm
c. Calculate roof surface area = 25 m x 15 m = 375 m^2
d. Select runoff coefficient (from below Table C-3) = 0.8 (it varies with roof material and slope)
e. Calculate runoff (mm) = rainfall x runoff coefficient =100 x 0.8 = 80 mm
f. Calculate volume of runoff (m^3) = roof area (m^2) x runoff (m) = 375 x 80/1000 = 30 m^3
g. Determine runoff generated in a single event (liters) = 30x1000 = 30,000
h. Liters (1 m^3 = 1,000 liters) and (1 gallon = 4.5 liters) or 6,667 gallons.
i. Option 1: Arrange a tank of required capacity (say 7000 gallons).
j. Option 2: Construct a storage tank of the required capacity say 30 m^3 (3 m x 3 m x 3.3 m).
k. The size of the tank can be adjusted according to the situation/need. The tank should preferably be placed at least 1.5 m above the ground surface.

[1] *A manual: Promising land and water management practices, Ashraf (2015)*

This will eliminate the pumping required. If an underground tank is constructed, it should be deep enough to reduce surface area to minimize the evaporation losses.

Table C-3
Typical values of the runoff coefficient

Basin characteristics	Runoff coefficient
Sandy soil covered with heavy bushes	0.10
Sandy soil covered with high bushes	0.20
Gravel paving and bare soil	0.15-0.30
Loamy soils largely cultivated	0.40
Asphalt macadam paving	0.50
Concrete paving and flat roof surfaces	0.80
Clayey soils stiff and bare, pitched (inclined) roof surfaces	0.90

Example 2: ***Design of rainwater harvesting system storage tank*** [2]

Design a storage tank for an inclined rooftop with a surface area of 60 m^2 and rainfall event of 80 mm.

Given:

a. Surface area = 60 m^2
b. Maximum rainfall in a single event = 80 mm
c. Select runoff coefficient (from Table C-3) = 0.9
d. Calculate runoff (mm) = rainfall x runoff coefficient = 80 x 0.9 = 72 mm
e. Calculate volume of runoff (m^3) = roof area (m^2) x runoff (m) = 60 x 72/1000 = 4.32 m^3
f. Calculate runoff generated in a single event (liters) = 4.32x1000 = 4320
g. Liters (1 m^3 = 1000 liters) and (1 gallon = 4.5 liters) or 960 gallons.
h. Therefore, one tank of 3.8 m^3 (1000 gallons)' capacity will be enough.

Example: Rooftop Rainwater Harvesting System installed at Ministry of Water Resources, Islamabad by PCRWR (A case study for office/commercial building).

PCRWR technical team recently installed a rooftop rainwater harvesting system in the office building of Ministry of Water Resources, Islamabad. The rooftop rainwater harvesting potential was calculated. In fact, the estimation of potential runoff indicates the paramount importance for designing a rainwater harvesting system and calculating required storage for collection of rainwater in the particular building. The potential runoff estimation was carried out using rational method.

The overall area of Ministry's premises is 3300 m^2, however potential runoff from building rooftop area 930 m^2 has been estimated under different scenarios i.e. for rainfall ranging between 25 mm to 100 mm during a single event (Table C-5). The 100 mm rainfall has been

[2] *A manual: Promising land and water management practices, Ashraf (2015)*

considered the maximum daily rainfall and will produce a runoff of 84 m^3. For instance, the storage requirements have been proposed for a rainfall event of ≥ 25 mm i.e. 21 m^3. However, at later stages, the rainwater storage capacity may be enhanced based on the water needs and requirements of the building. The calculations of runoff potential from the paved/non paved area of the building under different scenarios of rainfall have been shown in tables below.

Table C-4
Area description of Ministry of Water Resources, Islamabad

Sr. No.	Description	Area (m^2)	(%) of total area
1	Rooftop area	930	28
2	Parking shed /Paved area	2040	62
3	Lawn area	330	10
Total		3300	100

Table C-5
Potential runoff from rooftop in Ministry of Water Resources, Islamabad

Rainfall (mm)	Rooftop Area (m^2)	Runoff Coefficient	Potential Runoff (m^3)
25	930	0.9	21
50		0.9	42
75		0.9	63
100		0.9	84

This quoted example may be used in designing the rainwater harvesting system for offices or commercial buildings.

Annex D (informative)

D.1 Guidance for developing a water safety plan (WSP)

Notes:

1) *This Annex is an informative (non-mandatory) part of this Standard.*
2) *This Annex provides guidance to help the user comply with the mandatory requirements specified inClause 5.1.2.*

D.1. General

D.1.1. Introduction

Water safety plans

a) Require the assessment of hazards, the pathway(s) of the hazards through the water system, the identification of control points and the likely concentration and impact of the hazards on exposedindividuals (i.e., the probability of the hazard occurring times the consequence of the hazard exposure);

b) Include parameters for monitoring and verifying the rainwater harvesting system to understand ifthe identified hazards can be mitigated or controlled and, if not, responses to bring the system back into line with the design parameters before unacceptable risk is reached; and

c) Have an element for review and revision based on experience and audit.

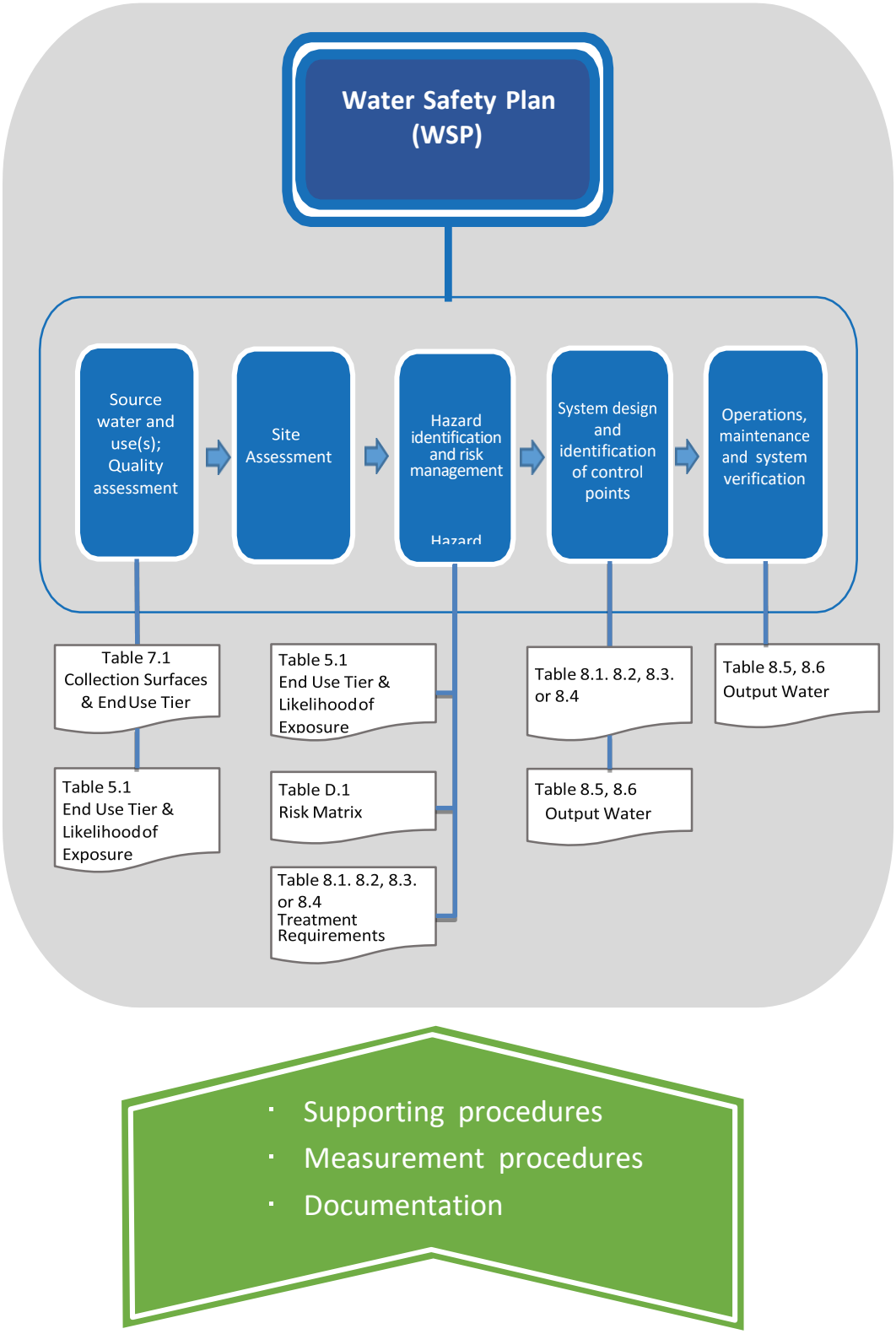
D.1.2 Elements of a WSP

An overview of a WSP is illustrated in Figure D.1. This Figure references the relevant tables from thisStandard and how they relate to each element of the WSP. These tables can be used to assist in the development of the WSP.

Figure D-1

Water Safety Plan (WSP) overview including resource tables and their relationshipto elements of the WSP.

(See Clause D.1.2.)



D.1.3 Scope of the rainwater harvesting system

WSPs are intended to recognize, address, and improve water quality and water quality concerns for rainwater harvesting systems intended for potable and non-potable uses. This WSP applies to both systems collecting roof surface runoff from residential or commercial structures or storm water surface runoff from the identified catchment area. It is important to document the full scope of the rainwaterharvesting system in order to identify system components, including the system supply, parties responsible for system maintenance and operational guidelines for the system. The tiered approach within the WSP is designed to address the scale and level of risk that is to be managed.

The rainwater harvesting system information document should be completed in accordance with Clause D.5.

D.1.4 Source water and use(s) quality assessment

D.1.4.1 Baseline water quality

If possible, representative raw-water samples should be collected and analyzed to determine the baseline water quality and identify constituents that can adversely affect the intended use of the water.As it might not be possible to collect a source-water sample for greenfield projects, data from similar locations should be sought. If water samples can be collected, the samples should be collected during the initial portion of a storm event that follows a long dry-weather period that can result in accumulation of contaminants.

D.1.4.2 Samples

The collection of a grab or short-term composite-source water sample is unlikely to provide a comprehensive assessment of potential contaminants of concern, as the source and characteristics ofcontaminants can vary with seasons and age and condition of materials the rainwater comes into contact with, from collection to distribution. Subsequent source water samples should also be periodically collected and analyzed in conjunction with treated water samples for water quality compliance or system verification monitoring.

D.1.4.2 Assessment of potential contaminants

Whether or not a raw-water sample can be collected and analyzed, the assessment of potential contaminants for a rainwater collection system should not rely on the analyses. It is important that an assessment also be carried out of potential sources of contaminants within the air-shed as well as the solubility characteristics of the surfaces the rainwater will come into contact with during collection, storage and distribution and changes in the material characteristics and contaminants that might be released as the surfaces age. Storage temperature [higher than 20 °C (68 °F)] and accumulation of sediments are also important considerations for odor generation and potential growth of opportunistic pathogens, (e.g., *Legionella*).

All relevant water quality standards for the AHJ for the end water use should beadhered to.

D.1.4.3 Site assessment

D.2 Initial assessment

An initial site assessment should be conducted to identify potential contaminants that could enter or already exist in the catchment area and impact the water quality of the harvested rainwater. The goal isto assess the impact of the broader environment on the site and the collection surfaces as well as materials considered in the collection system so that the potential for human exposure can be characterized.

All rainwater harvesting systems and associated materials, except those installed on single-familyresidences using rainwater collected exclusively from a residential roof, should be assessed for suitability in accordance with the requirements of the AHJ.

C.D.2.2 Site assessment elements

The site assessment should provide, at least, a general description of the site, end uses for harvested rainwater and any potential chemical or microbial contamination that could be present. Therefore, theinformation provided in the site assessment should include at least the following:

a) Site location and a map showing all the properties within the proposed catchment area;

b) Sanitary maintenance hole covers on or in close proximity to the site;

c) Zoning classification of all properties contributing to the catchment area. If the site is zoned as industrial and the proposed catchment area contains surfaces other than the roof area, a more robust baseline investigation should be conducted to determine if chemical or microbial contamination is present;

d) Total size of the catchment area;

e) Description of site and surrounding area based on available information and data;

f) Short narrative of how the property was historically used;

g) Description of planned future uses of the site;

h) Summary of any environmental investigation(s);

i) Surface characteristics of the catchment area (e.g., is the catchment area subject to vehicular trafficor pedestrian traffic? Are there overflows or bleed-off pipes from roof mounted appliances, flues, or smoke stacks? What is the roofing material? Are there vegetated roof systems?); and

j) Summary of end uses for the harvested rainwater system.

Note: *ASTM E2727 provides useful guidance on site assessment related to rainwater quality.*

D.3 Hazards identification

D.3.1 General

Hazards identification involves determining sources of potential contaminants and assessing its impact to public health based on the likelihood and the consequence of exposure for the intended and unintended end use. Once the hazards are identified, solutions can be reasonably determined to help mitigate or reduce the threat to public health.

Note: *Characterizing the threat to public health is vital to the process as it helps to identify the key issues or hazards that need to be addressed.*

D.3.2 Potential sources of contamination

An evaluation of potential contaminants that could adversely affect runoff water quality should be performed. The following is a non-exhaustive list of potential sources of contaminants:

a) Fecal pathogens from animals;

b) Chemical contamination from roofing materials;

c) Vehicular traffic and de-icing activities;

d) Organic and nutrient contamination from plant debris, seasonal pollen and animal excreta;

e) Elevated salt concentration due to sea spray;

f) Air pollution in urban, industrialized, or farming areas;

g) Algae growth on collection and transport surfaces and in collection tanks;

h) Stagnation of water in collection tanks and in dead-ends of the distribution system;

i) Piping materials and coatings;

j) Airborne dust and degrading surface materials; and

k) Infiltration and inflow of surface and groundwater, primarily in situations where the water storagetanks are buried.

D.3.3 Summary and prioritization of risks (qualitative assessment)

D.3.3.1 Level of risk

The level of risk associated with the potential contaminants identified is dependent on the end use, the likelihood for exposure and the consequence of exposure. It is reasonable to assume that where no exposure exists, the level of risk is non-existent or low. Similarly, where a high likelihood for exposure exists, the level of risk can be high, depending on the contaminant(s) of concern and the consequence of exposure associated with the end use. Therefore, assessing the level of risk becomes critical in determining the appropriate and reasonable mitigation and control practice for the site and application.

For larger installations (e.g., those potentially impacting more than 25 people), there is value in prioritizing potential risks associated with each identified hazard and event combination in a risk matrix(i.e., the pathway that can lead the hazard to reach and impact people).

D.3.3.2 Risk matrix

A risk matrix is used during risk assessment to define the various levels of potential risk. It is a function of the likelihood (probability) of the hazard exposure and the consequence from it. While simplistic, the goal is to assist in managing rainwater harvesting risks associated with the rainwater harvesting system, through mitigation and controls (e.g., barriers and treatments). Analysis through a risk matrix should bemade for both intended and unintended uses and exposures. The types of individuals who will use the site should also be considered.

The likelihood of harm occurring might be categorized as “Certain”, “Likely”, “Possible”, “Unlikely”, or “Rare” based on reasonable assumption. For practicality, this qualitative evaluation should assess basedon whether it is plausible exposures will occur. However, very low probabilities might not be very reliable and overall this is a subjective assessment based on local understanding of the rainwater harvesting system. Hence, the assessment is generally best undertaken with more than one person, to reflect on the range of expertise and skills needed to understand and assess the complete system.

The consequence categories to consider are

a) Catastrophic – major outbreak of disease or poisoning with likely death in a few cases;

b) Critical – a few severe injuries or illnesses that can lead to death;

c) Marginal – one severe illness or multiple minor impacts; and

d) Negligible – minor impact.

The combined evaluation of the likelihood of exposure and consequence of exposure helps characterizethe level of risk and the threat to public health, which can be summarized in a risk matrix showing all possible outcomes. See Table D.1.

Table D.1 Risk matrix

(See Clause D.3.3.2.)

Likelihood of harm	**Risk Level for Different Consequence categories**			
	Negligible	**Marginal**	**Critical**	**Catastrophic**
Certain	High	High	Extreme	Extreme
Likely	Moderate	High	High	Extreme
Possible	Low	Moderate	High	Extreme
Unlikely	Low	Low	Moderate	Extreme
Rare	Low	Low	Moderate	High

The party responsible for the WSP should estimate the levels of risk for each hazard-event combinationand focus their mitigation and control practices accordingly.

D.4 Risk mitigation

D.4.1 General

An essential component of the incremental improvement plan is to ask questions related to eachidentified hazard, such as the following:

a) What is the source of the hazard and can the likelihood of contamination be eliminated or reduced? (e.g., removal of overhanging branches that could enable animals to access the roof, orthe placement of a fake owl to deter birds).

b) Where is the hazard located? (e.g., northern quarter of the catchment area).

c) How is the hazard assessed? (e.g., visual inspection or water quality testing).

d) What system components are impacted by the hazard? (e.g., collection surfaces, downspouts,storage reservoir, or distribution system).

e) Who is responsible for inspections and for monitoring the hazard(s)?

f) How often is the system likely to be inspected for each identified hazard and mitigation measuresadjusted?

g) What mitigation measures can be applied? (e.g., routine cleaning, first-flush diversion, removal ofoverhanging vegetation, bird deterrent systems, exclusion of roof areas from collection.)

D.4.2 Control measures

Control measures include routine verification that mitigation measures are in place and are effective for each identified hazard to minimize the likelihood of the hazard adversely impacting water quality and monitoring treatment operating conditions and water quality (see Clause D.3). Once appropriate and effective mitigation measures are identified and implemented, control measures provide the necessary operational inputs to ensure the mitigation measures continue to be effective and performing as expected. Typically for

small systems, the system owner is responsible for maintaining and monitoring the rainwater harvesting system control measures, but this may also be the responsibility of individuals contracted to operate and maintain the system.

D.5 Operational monitoring, system verification and responses

D.5.2 Rainwater harvesting system operations and maintenance documents

An operations and maintenance manual should be provided and a maintenance log kept to record information about the rainwater harvesting system, including flow readings, component condition observations and any repairs or component replacements. The operations and maintenance manualshould be more than just a collation of manufacturers' manuals and should include at least the following information:

a) Contact information (e.g., names, roles, telephone numbers and e-mail addresses) for
   i) Emergency personnel; and
   ii) Maintenance and operation personnel;
b) Operating procedures;
c) Maintenance procedures, including inspection and maintenance schedule;
d) System identifier (e.g., owner name, street address, building name);
e) General narrative of the overall collection, treatment, storage and distribution system, including
   i) Water uses (e.g., potable, irrigation, laundry);
   ii) Number of people served by the system;
   iii) Number and types of fixtures served by the system, including noting whether the fixtures arelabeled;
   iv) Raw and treated water storage volumes;
   v) Details of any make-up or auxiliary water supply and the method of connection; and
   vi) Material and equipment specifications;
f) Description of hazards, mitigation measures and controls (based on the risks identified in clause d.3);
g) Control measures to mitigate identified risks;
h) Dates of system construction, installation and commissioning;
i) Design drawings;
j) Permits (if applicable) and AHJ local authority contact information;
k) Warranty and supplier contact information;
l) Water testing data, if available; and
m) Log section to note
   i) Dates and times of routine inspections;
   ii) Equipment condition;
   iii) Maintenance and repairs carried out;
   iv) Verification of controls being in place and effective; and

v) New hazards identified.

D.5.2 System technical information

The general narrative of the overall collection, treatment, storage and distribution system shouldinclude the following technical information:

a) Catchment area size;
b) Roofing materials;
c) Vertical conveyance materials;
d) Conveyance pipe materials;
e) Storage tank information, including
    i) Tank volume;
    ii) Tank dimensions;
    iii) Tank construction materials; and
    iv) Location (i.e., above- or below-ground);
f) Pre-filtration system information, including
    i) Type of pre-filter(s);
    ii) Quantity of pre-filters;
    iii) Filtration particle size; and
    iv) Location (e.g., above- or below-ground);
g) Pump system information, including
    i) Type, brand, make and model of pump(s);
    ii) Capacities and heads; and
    iii) Horsepower;
h) Water treatment system information, including
    i) Narrative on treatment goal;
    ii) Intended level of disinfection (e.g., not applicable or log reduction of viruses, protozoa and bacteria);
    iii) Type of filtration or disinfection: (e.g., sediment, activated carbon, UV, or chlorine);
    iv) Make-up water or rainwater harvesting system bypass contingency;
    v) Water treatment components brands, makes and models; and
    vi) Date of equipment installation; and
i) Distribution piping information, including
    i) Distribution piping material(s); and
    ii) Length of distribution piping system.

D.5.3 Water quality verification

The operations and maintenance document should include the following water quality information:

a) Frequency of water quality sampling and control and mitigation inspections;

b) Microbial, chemical and physical parameters being monitored;

c) Water sampling locations;

d) Water quality records; and

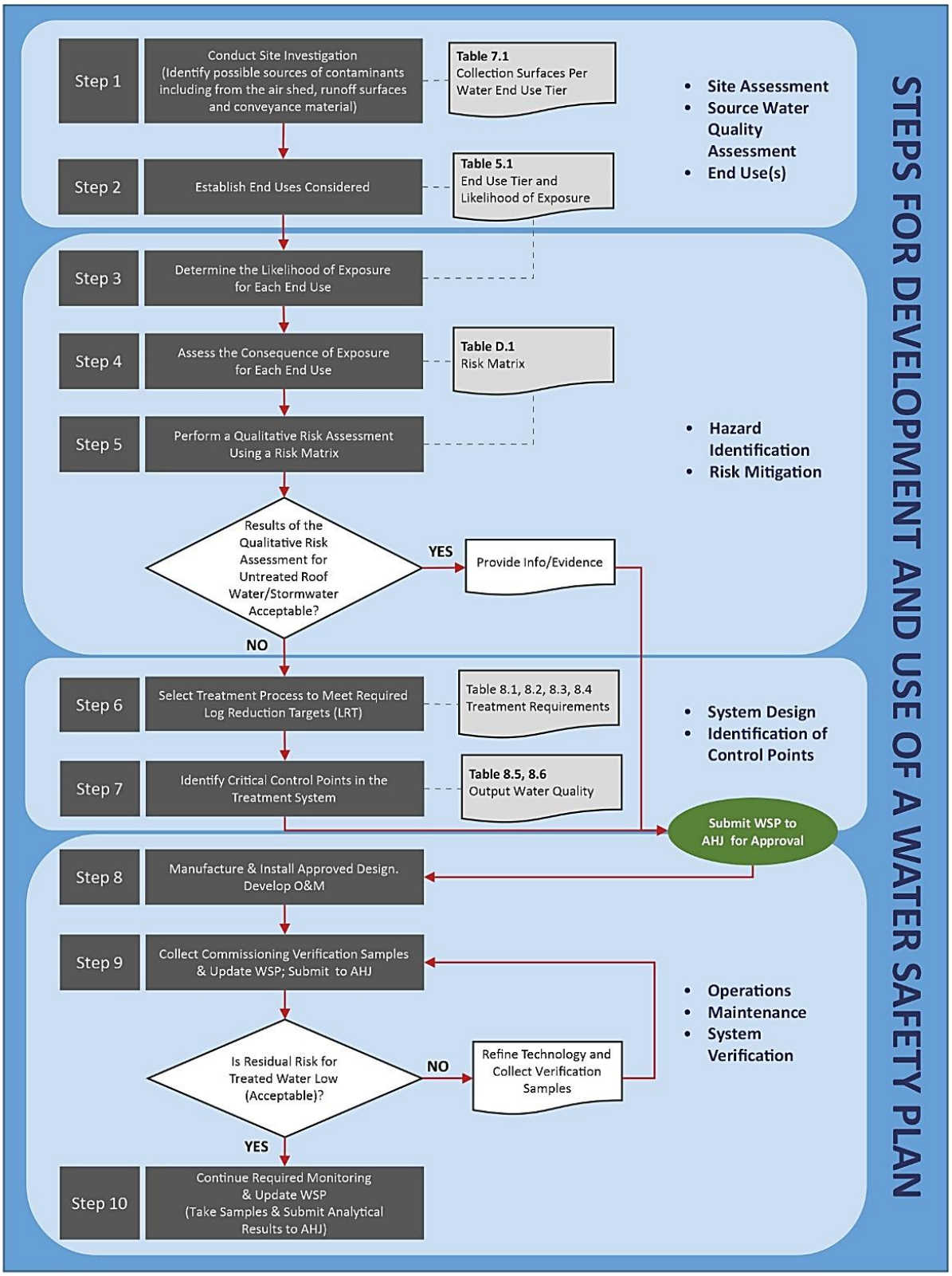
e) Sample log entry form (e.g. for recording dates and times of inspections, as well as sampling eventsand operating conditions at those times).

D.5.4 Audit and reporting

Once the WSP has been completed, the agency responsible should audit it and confirm the reporting needs. Auditing and maintenance checks may be undertaken by a third party, but when and what to report (e.g., a major risk event, annual reporting) should be confirmed by the AHJ.

Figure D-2

Steps for development and use of a Water Safety Plan (WSP)



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