



Desalination for Drinking Water

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Module 1. Introduction

Learning Objectives

By the end of this section, you will be able to:

- **Identify** the global drivers necessitating the adoption of desalination technologies.
Evaluate the fundamental differences between saline and freshwater treatment requirements regarding public health.
- **Select** appropriate risk management frameworks to address the "aggressive" nature of desalinated water.

Executive Summary: Desalination is a critical solution to global water scarcity, transitioning from traditional thermal methods to cost-effective membrane technologies. While providing a robust barrier against contaminants, it introduces unique public health challenges—specifically regarding water stabilization and remineralization—that require site-specific Water Safety Plans (WSPs) to ensure consumer safety.

The Global Context of Water Scarcity

Water scarcity currently impacts approximately one in three people across all continents. Nearly 20% of the global population resides in regions facing physical water shortages. This demand is projected to intensify due to several compounding factors:

- **Population growth** and rapid **urbanization**.
- **Climate change** impacts on existing freshwater sources.
- Escalating **household and industrial** water consumption.

Desalination Applications and Technologies

Desalination is utilized across a spectrum of salinity levels, treating **brackish groundwater**, **estuarine water**, and **seawater**. In certain geographic regions, these systems serve as the primary source of potable water.

Technological Evolution


- **Thermal Distillation:** Historically the dominant method, primarily through **flash distillation**. While many thermal plants remain operational, they are less common in new installations.
- **Membrane Systems:** Technological advancements have made membranes a more **cost-effective** alternative, leading to their increased selection for modern infrastructure.

Design Fundamentals and Public Health

Unlike freshwater, saline sources **always require substantive treatment**. Although desalination processes act as a significant barrier to pathogens and chemical contaminants, this protection is **not absolute**.

Key Technical Challenges

- **Aggressive Water:** Desalinated water often lacks minerals, making it corrosive to distribution infrastructure.
- **Stabilization:** Engineers must implement **remineralization** steps to prevent the water from damaging piped systems.
- **Risk Management:** These issues must be integrated into a site-specific health risk management plan.

 **Design Tip:** When transitioning a system from traditional freshwater sources to desalinated water, engineers should prioritize the compatibility of existing distribution materials with the potentially "aggressive" nature of the new supply.

Checkpoint Quiz

1. Which factor is primarily responsible for the shift from thermal distillation to membrane-based desalination for new systems?

- a) Total elimination of all pathogens.
- b) Higher tolerance for varying salinity levels.
- c) Increased cost-effectiveness due to technological advances.
- d) Reduced need for pretreatment steps.

Answer: (c). While desalination was historically dominated by thermal processes like flash distillation, technological advancements have made membrane-based systems a more cost-effective alternative and the preferred choice for new infrastructure.

2. Why do saline sources require a "substantive treatment step" compared to typical freshwater sources?

- a) They contain higher levels of volatile organic compounds.
- b) The inherent salinity levels always necessitate a fundamental phase change or membrane barrier.
- c) They are more susceptible to industrial runoff.
- d) They have a higher natural mineral content that prevents corrosion.



Answer: (b). Unlike freshwater, saline sources require a substantive treatment step using either a phase change or a membrane barrier to effectively remove the high concentrations of naturally occurring inorganic ions.

3. According to the text, what is a unique challenge of desalinated water compared to traditional piped water systems?

- a) Management of urbanization impacts.
- b) Ensuring the water is not "aggressive" through remineralization.
- c) Preventing population growth from affecting supply.
- d) Identifying the source of the water (brackish vs. seawater).

Answer: (b). Desalinated water is low in minerals and poorly buffered, necessitating remineralization or stabilization to prevent it from being "aggressive" and corroding distribution and plumbing materials.

Module 2: Desalination and Water Safety Plans

Learning Objectives

By the end of this section, you will be able to:

- **Evaluate** the role of a Water Safety Plan (WSP) in identifying system-specific hazards and treatment barriers.
- **Implement** operational monitoring and management procedures to mitigate microbial and chemical risks.
- **Develop** comprehensive emergency and supporting programs for desalination facilities.

Executive Summary: The development of a Water Safety Plan (WSP) is the foundational step for providing safe drinking water, requiring a comprehensive mapping of the supply chain from catchment to tap. For desalination engineers, the WSP must specifically integrate preventive risk management, operational monitoring of treatment barriers, and the stabilization or remineralization of treated water to address unique saline source hazards.

Framework for Preventive Risk Management

Implementing a WSP is essential for both new and existing desalination plants:

- **New Systems: Initiate** the WSP during the planning phase and maintain it through construction and commissioning.
- **Existing Plants: Utilize** WSPs to identify available barriers and introduce preventive management for quantity and quality risks.



Figure 1: Framework for safe drinking-water (WHO, 2011)

System Mapping and Hazard Identification

A robust WSP facilitates a thorough understanding of the system through detailed mapping.

- **Hazards:** These include physical, microbial, and chemical contaminants impacting health or water acceptability (e.g., taste and odor), as well as circumstances threatening plant operations.
- **Risks:** The potential for a hazard to reach consumers in concentrations that cause illness or exceed national standards.
- **Management Components:** Beyond technical specs, engineers must document **training, record-keeping, and periodic reviews** of operating procedures.

Core Elements of a Desalination WSP

The following table outlines the necessary components and corresponding actions for a desalination-specific WSP.

Table 1: Elements of a water safety plan for desalination

Component	Action
Description of the system, including the water source and sources of hazards.	Thoroughly understand and document the system from the source to the tap.
Assess the risks of hazards reaching consumers in numbers or concentrations of concern, and ensure that steps are in place to mitigate the risks.	Determine the pathogens or chemicals that could be introduced at each stage, and ensure that barriers or operational procedures are in place to reduce the risks to meet health-based targets.
Ensure that the barriers are working efficiently at all times, and develop procedures for responding when efficiency starts to fall.	Develop operational monitoring to demonstrate that processes are working efficiently and an alert system to warn upon a decrease in effectiveness. Develop management procedures to ensure that <u>all</u> of the procedures are followed.
Verification that the WSP is working adequately and that a safe and acceptable supply of drinking-water is delivered.	Analyse key indicators of water quality and safety, and assess against appropriate standards and guidelines.
Develop supporting programmes.	Activities in such programmes are tailored to the specific needs and priorities of the water supply system and may vary from consumer education and community engagement to workforce training programmes.
Periodically review the WSP, and update the WSP in the wake of problems or emergencies.	Ensure that operation and management procedures are kept up to date and revised to incorporate lessons learnt.

Mitigation and Operational Controls

Once hazards are identified, risks must be mitigated through specific treatment barriers and sound operational management.



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