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EWRI/ASCE 34-01

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American Society of Civil Engineers

Standard Guidelines for Artificial Recharge of Ground Water

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EWRI/ASCE 34-01

Environmental and Water Resources Institute
American Society of Civil Engineers

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ASCE

Published by the American Society of Civil Engineers
1801 Alexander Bell Drive
Reston, Virginia 20191-4400

0759600 0034901 09T

ABSTRACT

Standard Guidelines for Artificial Recharge of Ground Water are intended to complement ASCE's *Ground Water Management Manual* and ASCE's *Operation and Maintenance of Ground Water Facilities Manual.* All three of these publications are refined from work originally done by the Technical Committee on Ground Water, which was within the Irrigation and Drainage Division. This Standard has been developed by the Artificial Recharge of Ground Water Committee within the Standards Development Council of the Environmental & Water Resources Institute of the American Society of Civil Engineers.

Library of Congress Cataloging-in-Publication Data

Standard guidelines for artificial recharge of ground water / Environmental and Water Resources Institute, American Society of Civil Engineers.
p. cm.
"EWRI/ASCE 34-01."
Includes bibliographical references and index.
ISBN 0-7844-0548-4
1. Artificial recharge of groundwater. I. Environmental and Water Resources Institute (U.S.)
TD404 .S73 2001
627'.56—dc21 00-054310

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Library of Congress Catalog Card No: 00-054310
ISBN 0-7844-0548-4
Manufactured in the United States of America.

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In April 1980, the Board of Direction approved ASCE Rules for Standards Committees to govern the writing and maintenance of standards developed by the Society. All such standards are developed by a consensus standards process managed by the Management Group F (MGF), Codes and Standards. The consensus process includes balloting by the balanced standards committee made up of Society members and nonmembers, balloting by the membership of ASCE as a whole, and balloting by the public. All standards are updated or reaffirmed by the same process at intervals not exceeding 5 years.

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ANSI/ASCE 1-82 N-725 Guideline for Design and Analysis of Nuclear Safety Related Earth Structures

ANSI/ASCE 2-91 Measurement of Oxygen Transfer in Clean Water

ANSI/ASCE 3-91 Standard for the Structural Design of Composite Slabs and ANSI/ASCE 9-91 Standard Practice for the Construction and Inspection of Composite Slabs

ASCE 4-98 Seismic Analysis of Safety-Related Nuclear Structures

Building Code Requirements for Masonry Structures (ACI 530-99/ASCE 5-99/TMS 402-99) and Specifications for Masonry Structures (ACI 530.1-99/ASCE 6-99/TMS 602-99)

ASCE 7-98 Minimum Design Loads for Buildings and Other Structures

ANSI/ASCE 8-90 Standard Specification for the Design of Cold-Formed Stainless Steel Structural Members

ANSI/ASCE 9-91 listed with ASCE 3-91

ASCE 10-97 Design of Latticed Steel Transmission Structures

SEI/ASCE 11-99 Guideline for Structural Condition Assessment of Existing Buildings

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ASCE 14-93 Standard Guidelines for Operation and Maintenance of Urban Subsurface Drainage

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ASCE 17-96 Air-Supported Structures

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ASCE 25-97 Earthquake-Actuated Automatic Gas Shut-Off Devices

ASCE 26-97 Standard Practice for Design of Buried Precast Concrete Box Sections

ASCE 27-00 Standard Practice for Direct Design of Precast Concrete Pipe for Jacking in Trenchless Construction

ASCE 28-00 Standard Practice for Direct Design of Precast Concrete Box Sections for Jacking in Trenchless Construction

EWRI/ASCE 33-01 Comprehensive Transboundary International Water Quality Management Agreement

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FOREWORD

These Standard Guidelines for Artificial Recharge of Ground Water are intended to complement the ASCE Ground Water Management Manual and ASCE Operation and Maintenance of Ground Water Facilities Manual. All three of these publications are refined from work originally done by the Technical Committee on Ground Water, which was within the Irrigation and Drainage Division. This standard has been developed by the Artificial Recharge of Ground Water Committee within the Standards Development Council of the Environmental & Water Resources Institute of the American Society of Civil Engineers.

The material presented in this publication has been prepared in accordance with recognized engineering principles. These Standard Guidelines should only be used under the direction of professionals competent in the planning and development of ground water resources including the fields of ground water hydrology and hydraulics. The publication of the material contained herein is not intended as a representation or warranty on the part of the American Society of Civil Engineers or any person named herein that this information is suitable for any general or particular use, or promises freedom from infringement of any patent or patents. Anyone making use of this information assumes all liability from such use.

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ACKNOWLEDGMENTS

The American Society of Civil Engineers (ASCE) acknowledges the work of the Artificial Recharge of Ground Water Committee, Standards Development Council, Environmental & Water Resources Institute. This group comprises individuals from many backgrounds including: consultants having a wide range of expertise and professionals in research, construction, education, law, and government.

The Committee acknowledges the assistance and technical input provided by the Bureau of Reclamation during the years of development of these Standard Guidelines.

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Standard Guidelines for Artificial Recharge of Ground Water

1.0 GENERAL

1.1 PURPOSE

The purpose of this document is to provide a standardized set of guidelines, rather than absolute standards. The intent of these Standard Guidelines is to describe the many steps required to develop, operate, and maintain a project for artificial recharge of ground water. These projects are inherently interdisciplinary so that persons with different expertise involved in the project need to understand how their work will fit with the work of others. Although the technical aspects of some tasks are not described in detail, the list of references in Appendix C provides additional technical information.

1.2 SCOPE

These Standard Guidelines describe the steps necessary to plan, design, construct, maintain, operate, and close a system to recharge ground water in a manner not occurring in nature, and to enhance ground water recharge where it is occurring naturally. They also describe the economic, environmental, and legal (water rights, laws, and regulations) considerations, as well as field investigation and testing procedures that may apply to all the proceeding steps. The recharge may be accomplished either by applying water to the ground surface for infiltration or by placing it directly into aquifers through wells. Although these Standard Guidelines have been developed to cover situations that may occur in many different types of projects, they can be applied to basic or small projects by selecting the portions of these Standard Guidelines that are appropriate to the proposed project.

1.3 GROUND WATER AND GROUND WATER MANAGEMENT CONCEPTS

Ground water is an important water resource and artificial recharge of ground water is an important management strategy. Ground water comprises 0.6% of the world's water, which is 67 times as much as the 0.009% in lakes and streams (Bouwer, 1978, and references therein). The rest of the world's water is in glaciers and ice caps (2%) or is salt water in oceans (97%). About one-half the people in the United States use ground water for domestic purposes. Three-fourths of the public water supply systems use ground water, and ground water is the only domestic water source for the 40 million rural and suburban people with wells. Ground water also is an important source of water for agriculture and industries.

Even though ground water use is widespread, typical consumers have only a vague concept of where their water originates, how it is produced, treated and delivered, and what steps are taken to assure its safety and sustainability for use as drinking water. Until relatively recently, the public's perception of an aquifer often was one of an underground stream or lake that produces a generally unlimited, safe, and dependable source of water supply. That perception has changed as reports of ground water contamination from leaking fuel storage tanks, municipal landfills, hazardous waste handling and disposal facilities, and pollution from countless other sources were publicized. Similarly, with increased reports of declining water tables and the resulting shortages in supply, the public now has a better comprehension that there are limits to the supply of ground water and the inability of natural recharge to sustain the demands being placed on aquifers throughout the country.

1.3.1 Ground Water Occurrence

Ground water is that portion of underground water that is at greater than atmospheric pressure so that it flows into a well or other hole. Geologic formations that contain ground water and are sufficiently permeable to yield usable quantities of water from wells are called aquifers. Aquifers are classified as either confined or unconfined. The top of unconfined aquifers is a free water table surface or water table that is free to move up and down as water is added or withdrawn from the aquifer. Confined aquifers are sandwiched between "impermeable" layers or aquicludes. If these layers are semi-permeable, they are called aquitards.

Unconfined aquifers are recharged by deep percolation from the land surface. Confined aquifers are recharged at their outcrops where they have become unconfined or through leaky confining layers (aquitards). Long-term natural recharge rates for unconfined aquifers are on the order of 50% of the av-