

RESERVOIRS  
FOR  
IRRIGATION  
WATER-POWER  
AND  
DOMESTIC  
WATER-SUPPLY

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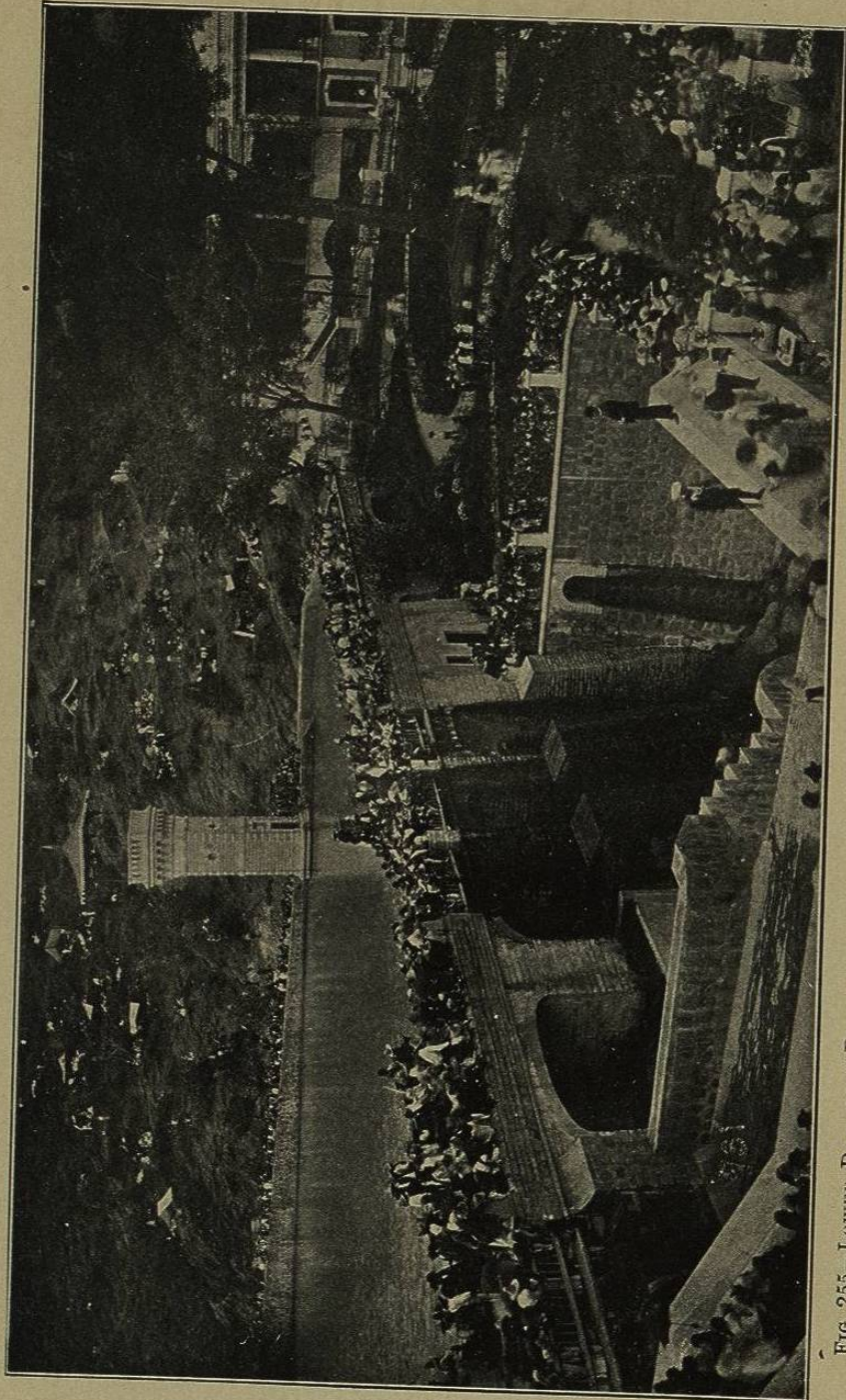


FIG. 255.—LOWER DAM, OR "PRESA DE LA OLLA," GUANAJUATO, MEXICO. VIEW TAKEN DURING THE FEAST DAY WHEN THE GATES ARE RAISED AND THE RESERVOIR EMPTIED.

[Frontispiece.]

# RESERVOIRS

FOR IRRIGATION, WATER-POWER

AND

DOMESTIC WATER-SUPPLY

WITH AN ACCOUNT OF VARIOUS TYPES OF DAMS AND THE METHODS, PLANS AND COST OF THEIR CONSTRUCTION

ALSO CONTAINING MISCELLANEOUS DATA UPON

THE AVAILABLE WATER-SUPPLY FOR IRRIGATION IN VARIOUS SECTIONS OF ARID AMERICA; DISTRIBUTION, APPLICATION, AND USE OF WATER; RAINFALL AND RUN-OFF FROM VARIOUS WATERSHEDS; EVAPORATION FROM RESERVOIRS; EFFECT OF SILT UPON THE USEFUL LIFE OF RESERVOIRS; AVERAGE COST OF RESERVOIRS PER UNIT OF CAPACITY, ETC.

BY

JAMES DIX SCHUYLER

Member American Society of Civil Engineers; Member Institution of Civil Engineers, London;  
Member Technical Society of the Pacific Coast; Member Engineers and Architects'  
Association of Southern California; Member Franklin Institute;  
Corresponding Member National Geographic Society

SECOND EDITION, REVISED AND ENLARGED

FIRST THOUSAND

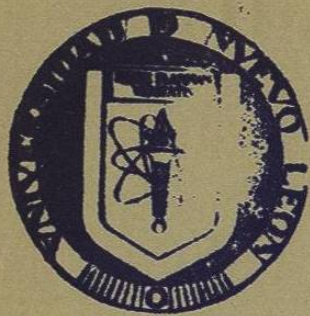
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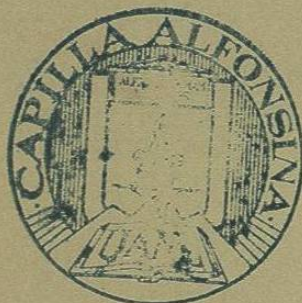
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The Scientific Press  
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New York



TO THE MEMORY OF MY BROTHER,

HOWARD SCHUYLER,

LATE M. AM. SOC. C. E.,

AN ENGINEER OF BRILLIANT ATTAINMENTS AND CHARMING CHARACTER,  
WHO SACRIFICED HIS LIFE IN UNTIRING DEVOTION TO THE CON-  
STRUCTION OF THE MEXICAN CENTRAL RAILWAY AS ITS  
FIRST CHIEF ENGINEER, THE INSEPARABLE  
COMRADE OF MY CHILDHOOD, AND IN  
YOUTH MY "GUIDE, PHILOSOPHER,  
AND FRIEND," INSPIRING MY  
AMBITION TO THE ACHIEVE-  
MENT OF EVER HIGHER  
IDEALS,

THIS BOOK IS AFFECTIONATELY DEDICATED

BY

THE AUTHOR.

## PREFACE TO THE SECOND EDITION.

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THE kindly reception given to the first edition of this book, which appeared in 1901, and which has been in sufficient demand to necessitate a return of the forms to the press several times to supply the unanticipated call for it, has been so flattering to the author that he has been encouraged to accept the urgent advice of his publishers and many friends among the engineering profession, and attempt such a revision of the work as will bring it more nearly up to date. In the past ten or twelve years, since the first compilation of data on the construction of dams in western America was undertaken, the world in general appears to have entered upon a new era of dam and reservoir creation, and there has been such a remarkable degree of activity displayed in the conservation and utilization of water, that it may be quite reasonable to state that more dams have been built in the decade that has just passed than during any fifty years of previous history. This is true not only of the United States but also of Europe and other countries. The present appears to be an age of dam construction, and there has developed an eager demand for information regarding the actual works accomplished, their dimensions, character, plan, materials, methods of construction and cost. The author has been gratified to find his book in the hands of engineers in every part of the globe he has visited, which may be accepted as an attestation of the fact that there is a wide field for such a work. He has therefore felt it to be a duty to make it more complete, and more worthy of the interest taken in it.

Much new matter has been added and some of the old has been taken out as obsolete and of little present value. The chapter on Hydraulic-fill Dams has been greatly extended by descriptions of later constructions, and two new chapters have been added, descriptive of reinforced concrete dams, the latest claimant to public attention, and of structural steel dams, which have increased in numbers and size.

The developments made in hydraulic-fill dams in the past few years, and the wide-spread interest manifested in this novel utilization of the forces of Nature to construct enduring barriers of unprecedented height, at moderate cost, would alone have justified the publication of a separate volume on that subject, embodying all the experiences of the author and other engineers in that most fascinating and interesting field of construction.

The chapter on Masonry Dams has been increased twofold by an attempt to make some mention of all the most notable dams of the world, and many that are very little known. Attention is particularly directed to Plates 1, 2, and 3, in which profiles are shown of all of the leading and better known masonry dams in existence, drawn to uniform scale for easy graphical comparison. No such complete collection of dam profiles has ever before appeared in print, assembled together on a common basis.

The endeavor has been made to give the book greater attractiveness by the addition of 234 new cuts and photographs,—some of which have been taken by the author's pocket camera—an inseparable companion.

Thus over sixty per cent of all the illustrations in the book are new, and probably as great or a greater proportion of the reading matter is also new or rewritten.

The labor involved in this revision has been enormous, but if his efforts shall prove of value to the engineering profession the author will feel amply repaid.

JAMES D. SCHUYLER.

LOS ANGELES, CALIFORNIA, October, 1908.

## PREFACE TO THE FIRST EDITION

IN 1896 the author was requested to prepare a brief descriptive account of such of the principal dams and reservoirs as had come under his observation in the course of his professional practice in the arid region of the United States, for publication among other Water-supply and Irrigation Papers issued by the U. S. Geological Survey for the general information of the public on topics of popular interest.

In compliance with this request a paper was written somewhat hastily in the rare leisure intervals of a busy season, which was printed and circulated as a portion of the 18th Annual Report of the Geological Survey, in a more pretentious form than had been anticipated when the manuscript was prepared. The rapidity with which the edition of the paper was exhausted testified to the existence of a widespread interest in the subject of water-storage in the West, and a general demand for the facts regarding the works which have been built and those which are projected. This has encouraged the author to republish the paper in another form, revising and adding to it as the material has become available. The work does not pretend to be an exhaustive treatise on the subject of dam-construction in western America, nor does it assume to cover the field by an account of all the important dams which have been built. It is chiefly a straightforward description of those works with which the author has become familiar, either as a consulting engineer, or as designer and constructor, or merely as an interested observer of the development of the ideas of other engineers. The field is too great to be completely covered by any one work, and new projects are developing with such rapidity as to render the task of enumerating them all quite beyond the power of any one individual.

For what it may be worth in the way of information or suggestion to the fellow members of his profession, or to others interested in the storage of water, the volume is modestly presented, craving indulgence for all errors of omission or commission.

JAMES D. SCHUYLER.

OCTOBER, 1900.



## INTRODUCTION.

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THE development of a water-supply for irrigation in the arid West sooner or later reaches a stage where the construction of storage-reservoirs becomes a necessity. If the stream is one of considerable volume, numerous irrigation-canals will be constructed from it at all convenient points, and its entire normal flow will be utilized before the impounding of flood-volumes is thought of as a possibility. But with the varying seasons there will occasionally come a year when the best of streams are so shrunken below the normal as to limit sharply the area which can be irrigated from it, and emphasize the regret that some means had not been provided for holding back the wealth of water which at times pours into the sea without benefit to any one, so as to render it available in the drier part of the year. Other streams there are, which drain very large districts and at certain times of the year are formidable and almost impassable rivers, that in the summer and fall are dry for months at a time. If these sources are to be rendered servicable storage-reservoirs must be built as the initial step in irrigation development.

All streams, except they be regulated by nature by means of lakes or subterranean reservoirs, are subject to great fluctuation. It is the function of artificial reservoirs to equalize in a measure these variations in flow, impounding the floods for use in the season when irrigation is necessary. Were it possible to conceive of a stream flowing throughout the year without change in volume, such a stream would not have its fullest measure of usefulness without storage of the water flowing during the period of the year when irrigation is not needed.

Inasmuch as the total available water-supply of the arid region is vastly short of the quantity needed for irrigating all the land requiring artificial watering, it is evident that, under every condition and with every class of stream, storage-reservoirs are needed to develop the fullest measure of usefulness of the existing supply.

Unfortunately it is beyond the possibility of hope that all the water flowing can be stored or utilized. There is such a wide range in the total run-off of every stream from one season to another that it would rarely be possible to find storage capacity for the extremes of flow. On large rivers