

FOREWORD

This report develops a water balance forecast model for Mono Lake, a terminal lake noteworthy for its biologic and geologic peculiarities. The lake has attracted considerable attention in recent years as diversions of its tributary streams have resulted in lower lake levels and higher salinities. Fundamental to an understanding of the lake's biotic and abiotic systems is a knowledge of the lake's water balance and its response to human-induced and climatic changes in the hydrologic regime. Previous Mono Lake water balances have been methodologically flawed and have not had the accuracy required for the resolution of complex management questions that have arisen as a result of the artificial lowering of the lake.

Although a terminal lake water balance is conceptually simple, its development as a predictive management tool can be quite complicated. Each component of the balance is the result of a complex array of incompletely understood physical processes, the accurate quantification of which is deserving of its own research project. Because of the inherent errors in quantifying components and the difficulty of identifying some of the components, there is a tendency in many water balance models to substitute subjective judgement for rigorous analysis in developing a calibrated model; unknown components and errors are commonly lumped together and quantified as the residual to make a model fit observed data or the boundaries of the model are not specifically

delineated. Such models, by their subjectivity, tend to become "black box" models that are hard for independent researchers to reproduce, and are of limited use in predicting lake response outside the range of the calibration data.

The model described in this report follows a rigorous methodology outlined in Chapter I and discussed in detail in Chapter II. The key elements of the methodology are:

1. Establishment of a water balance model boundary
2. Identification of all significant inflow, outflow and storage change components.
3. Independent quantification of each component over a carefully selected base period,
4. Quantification of component and overall water balance error
5. Regression of the overall error against statistically significant components,
6. Verification of model with a different time period than that used in calibration.

The water balance model is used to forecast lake levels and salinities. This is done in Chapter III, for different hydroclimatic and water export assumptions. Although the environmental implications of a given lake level are beyond the scope of this study, the model provides an essential tool for water policy and management decisions in the Mono Basin.

A project as big as this required a lot of assistance. I

want to thank all the people who helped me, endured my perfectionism, and kept their sense of humor. A number of these of people deserve special mention. My thesis committee -- Tom Pagenhardt, Scott Stine, John Vann, and Marlyn Shelton - provided editorial and technical feedback. This thesis is an outgrowth of a project I started for the consulting firm of Philip Williams and Associates and that was initially funded by the National Audubon Society. Philip Williams directed the project initially and furnished essential technical guidance. David Fryberg of the Environmental Engineering Department at Stanford University also gave me valuable technical advice. Jody Goldenring, Jody Bailey, Mark Smaalders, and Diana Hickson provided graphics support. Hank Roberts proofread parts of the manuscript. Ed Elhauge, Alex Bittenbinder, Dave Sloves, Carl Farrington, and Peter Chamberlin answered my cries for computer help. David Loveall helped determine the acreage of the phreatophytes on the exposed lake bottom. Lynne Preslo aided in the initial data compilation. Linda Garcia, Terre Beynart, and Caitlin Manning typed the many versions of the manuscript. I also want to thank all the unmentioned people who answered my questions.

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And finally I thank my parents for bringing me to the Eastern Sierra as a child and teaching me that a little bit of endurance goes a long way. I of course take full responsibility for the content of this report.

ABBREVIATIONS

AGENCIES

| | |
|----------|---|
| CADPW: | California Department of Public Works |
| CADWR: | California Department of Water Resources |
| CASWRCB: | California State Water Resources Control Board |
| JLPUD: | June Lake Public Utilities District |
| LADWP: | Los Angeles Department of Water and Power |
| WPUD: | Lee Vining Public Utilities District |
| NOAA: | National Oceanic and Atmospheric Administration |
| SCE: | Southern California Edison |
| UC: | University of California |
| USBLM: | United States Bureau of Land Management |
| USFS: | United States Forest Service |
| USGS: | United States Geological Survey |
| WMO: | World Meteorological Organization |

COMPONENTS

Inflows

| | |
|-------|------------------------------------|
| DS: | Diffuse Seepage |
| GLP: | Grant Lake Reservoir Precipitation |
| GWR: | Groundwater Recharge |
| HR: | Hidden Recharge |
| ISP: | Land Surface Precipitation |
| NLSP: | Net Land Surface Precipitation |
| MLP: | Mono Lake Precipitation |
| NMI: | Net Municipal Inflow |

NSP: Non-Sierra Precipitation
NSR: Non-Sierra Runoff
S: Springflow
SNGR: Sierra Nevada Gaged Runoff
SNP: Sierra Nevada Precipitation
USR: Ungaged Sierra Runoff
VCI: Virginia Creek Inflow

Outflows

BGE: Bare Ground Evaporation
GE: Grant Lake Reservoir Evaporation
GWEX: GroundWater Export
ILET: Irrigated Land Evapotranspiration
LSET: Land Surface Evapostranspiration
MLE: Mono Lake Evaporation
NGLE : Net Grant Lake Evaporation
NSET: Non-Sierra Evapotranspiration
PETA: Phreatophyte Evapotranspiration Above 6428 ft
PETB: Phreatophyte Evapotranspiration Below 6428 ft
RET: Riparian Evapostranspiration
SNET: Sierra Nevada Evapotranspiration
SWEX : Surface Water Export

Storage Changes

GTSC: Grant Lake Reservoir Storage Change
GWSC: Groundwater Storage Change
MLSC: Mono Lake Storage Change
SMSC: Soil Moisture Storage Change

UNITS

| | |
|--------|-----------------------|
| ac: | acre(s) |
| ac-ft: | acre-feet |
| cfs: | cubic feet per second |
| F: | Farenheit |
| ft: | feet |
| gal: | gallons |
| g/l: | grams/liter |
| in: | inches |
| mi: | miles |
| PPm: | parts per million |
| yr: | year |

MISCELLANEOUS

| | |
|---------|------------------------------|
| avg: | average |
| cr: | creek |
| est: | estimate |
| evap: | evaporation |
| ET: | evapotranspiration |
| FM: | flow measurement |
| MGWB: | Mono Groundwater Basin |
| msmt: | measurement |
| P .: | page |
| PET: | potential evapotranspiration |
| precip: | precipitation |
| Resv: | reservoir |
| SD: | standard deviation |

SNARL: Sierra Nevada Aquatic Research Laboratory
SPSS: Statistical Package for the Social Sciences
TDS: total dissolved solids