Appendix H

Summary Presentations submitted by working focus groups on engineering, hydrology, water quality, biology, wildlife disease and contaminants

Hydrologic Modeling: Pacific Institute Impoundment Proposal

Paul A. Weghorst, PE
Bureau of Reclamation
January 8, 2002

Purpose

- Characterize hydrologic conditions
  - Main Sea
  - South Impoundment
  - North Impoundment

(Both impoundments evaluated with dikes constructed at –245 feet)

General Modeling Assumptions

- Reductions in inflow will occur
  - Start at baseline = 1.24 maf/yr
  - Future inflow = 1.00 maf/yr
    - Approximates possible reductions from water transfers
    - Consistent with evaluation of other restoration alternatives
- Simulation Period: 2000 to 2074
- Dike Construction
  - Constructed In Water
  - Dikes Closed in 2007

Sediment Load Assumptions

- Sediment Load Rate = 0.53 tons/af
  - From Draft Report:
    - Sedimentation / Siltation Total Maximum Daily Load for the Alamo River
  - Assumed same for New, Alamo, and Whitewater Rivers
- Sediment Density = 1.2 tons/yd^3
- Impoundment trap rate = 100 percent

Nutrient Load Assumptions

- Nutrient Loading for 1999 [1/] Prorated According to Annual Inflows
  - Total N
  - Total P

1999 Alamo River Total P Loading	0.574	mg/l
1999 Alamo River Total N Loading	7.08	mg/l
1999 New River Total P Loading	0.66	mg/l
1999 New River Total N Loading	4.96	mg/l
1999 Whitewater River Total P Loading	0.053	mg/l
1999 Whitewater River Total N Loading	1.03	mg/l

1/ Source: Setmire, Jim et al., 2001. Eutrophic Conditions at the Salton Sea. A Topical Paper From the Eutrophication Workshop Convened at the University of California at Riverside, Sept. 7-8, 2000.

Wetlands Assumptions

- Water Losses = 0.8 * Pan Evaporation [1/]
- Surface Area Requirements
  - Based on Imperial Wetlands
    Requirement = 0.012 acres/af
- Sediment Removal = 90 Percent [2/]
- Nutrient Removal [3/]
  - Total N Removed = 34 %
  - Total P Removed = 11 %

1/ Source: Kadlec, R.H., and R.L. Knight. 1996 Treatment Wetlands. Lewis Publishers, Boca Raton, FL.

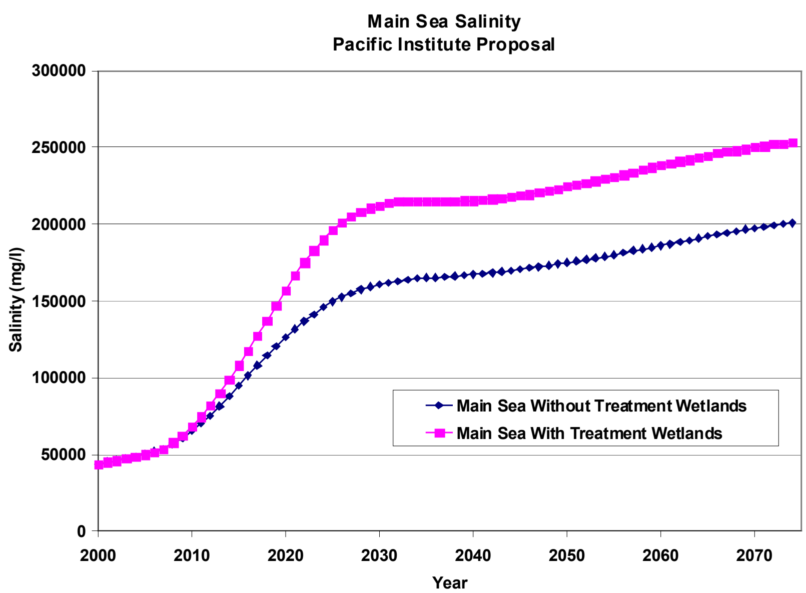
2/ General observation of data collected at Imperial and Alamo Wetlands

3/ Personal communication from Jim Sartoris, USGS, Mid-continent Ecological Science Center – unpublished data

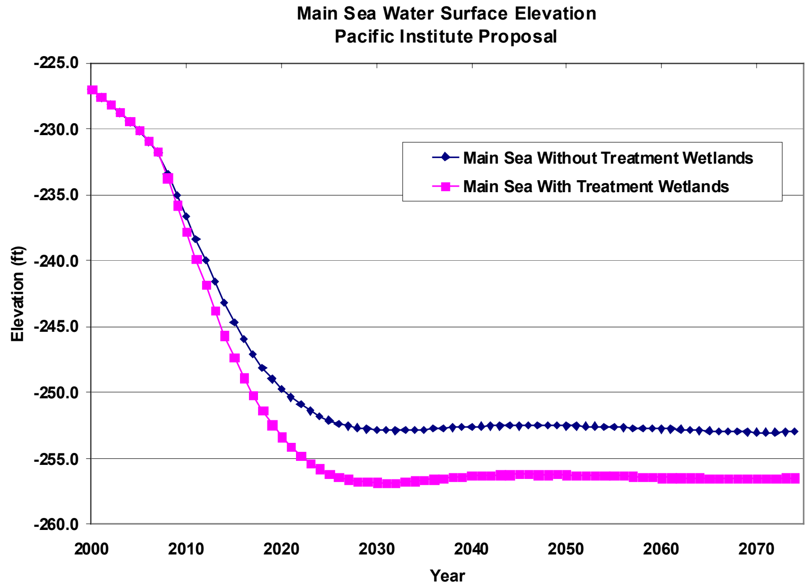
Main Sea Simulation Simulation Results

(Based on Application of the Bureau of Reclamation's Salton Sea Accounting Model)

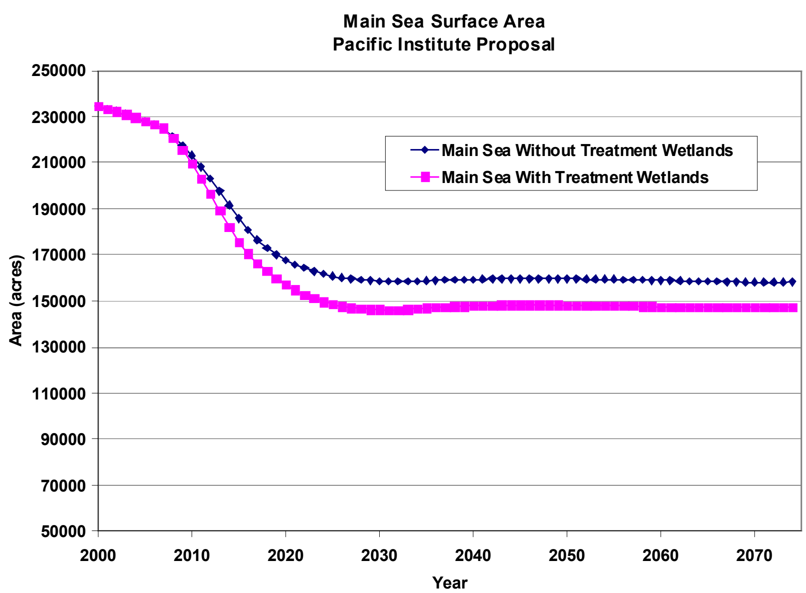
Main Sea Salinity



Main Sea Water Surface Elevation

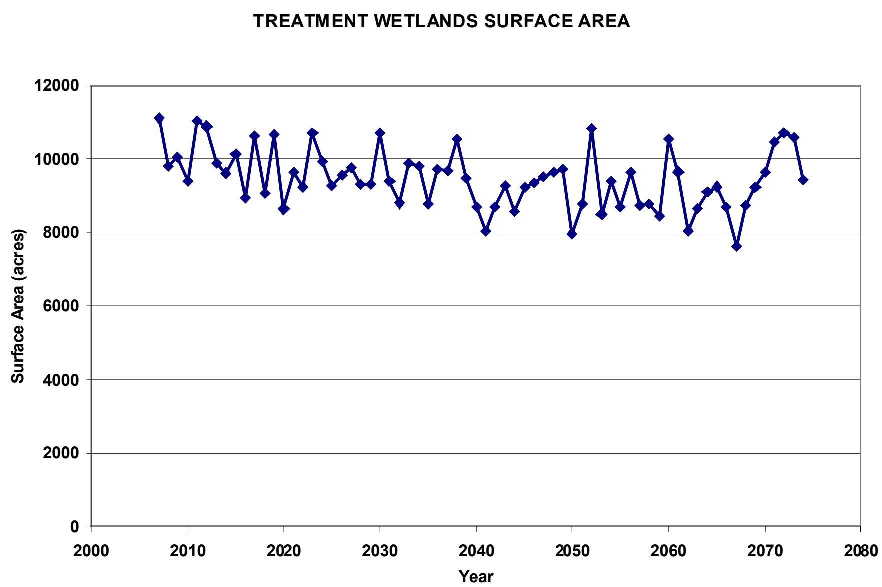


Main Sea Surface Area

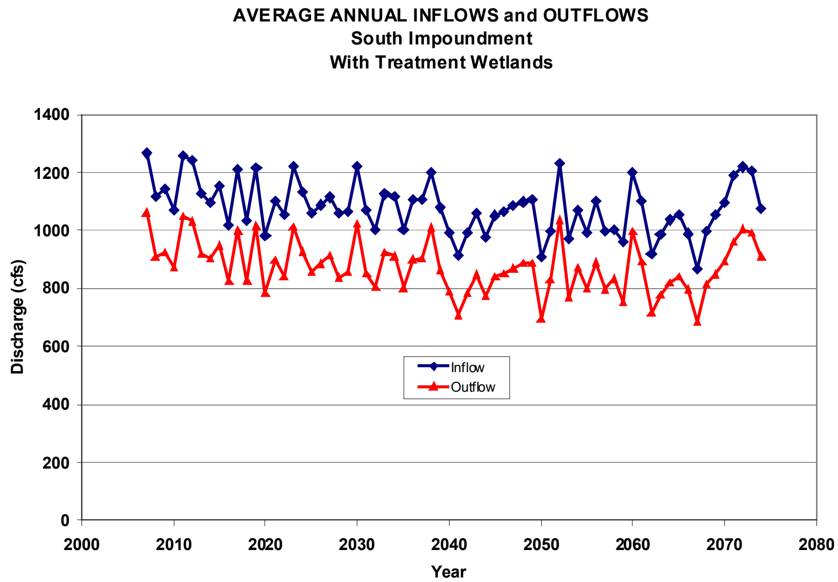


South Impoundment Simulation Results

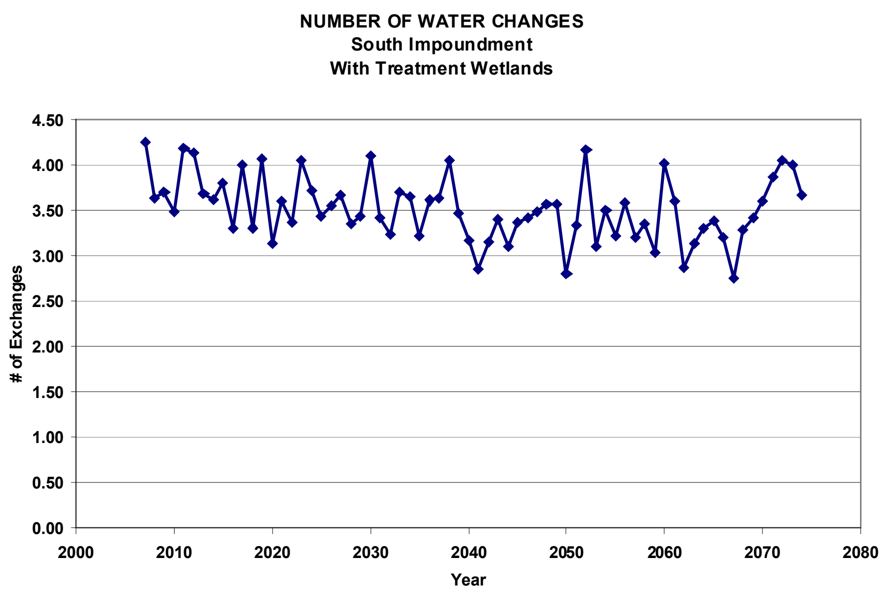
Wetlands Surface Area Requirements



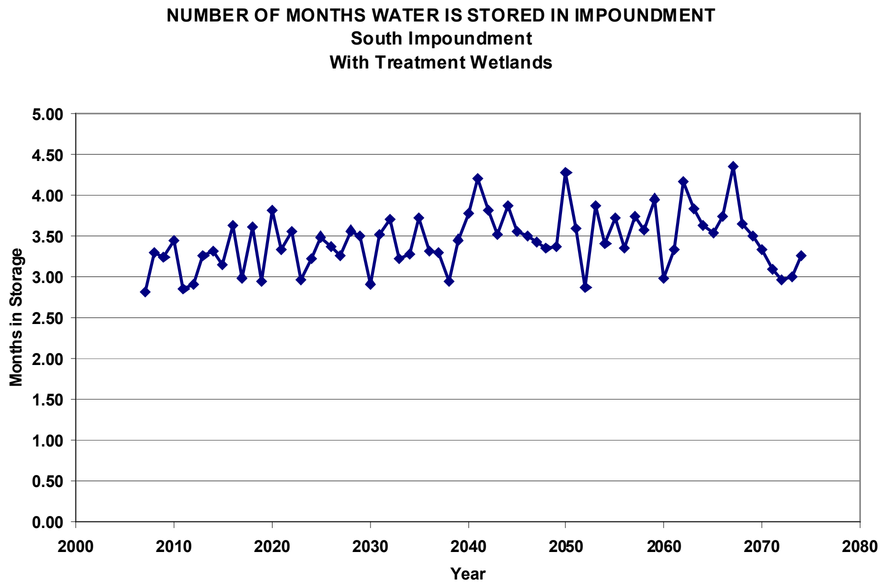
Inflows/Outflows: South Impoundment



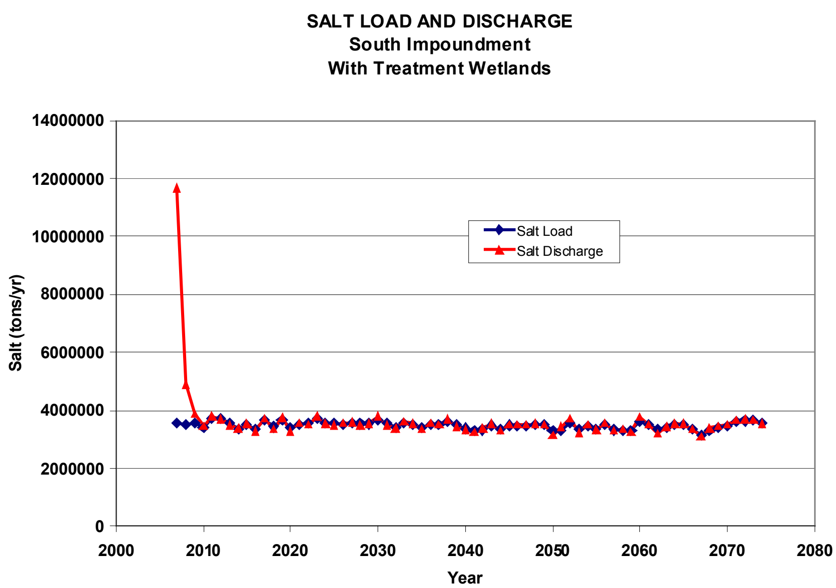
Water Exchanges: South Impoundment



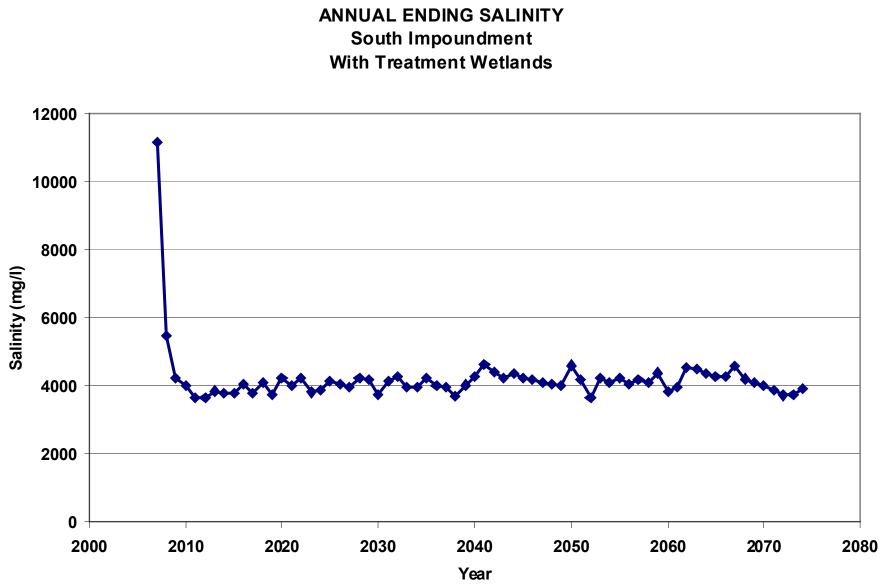
Months in Storage:South Impoundment



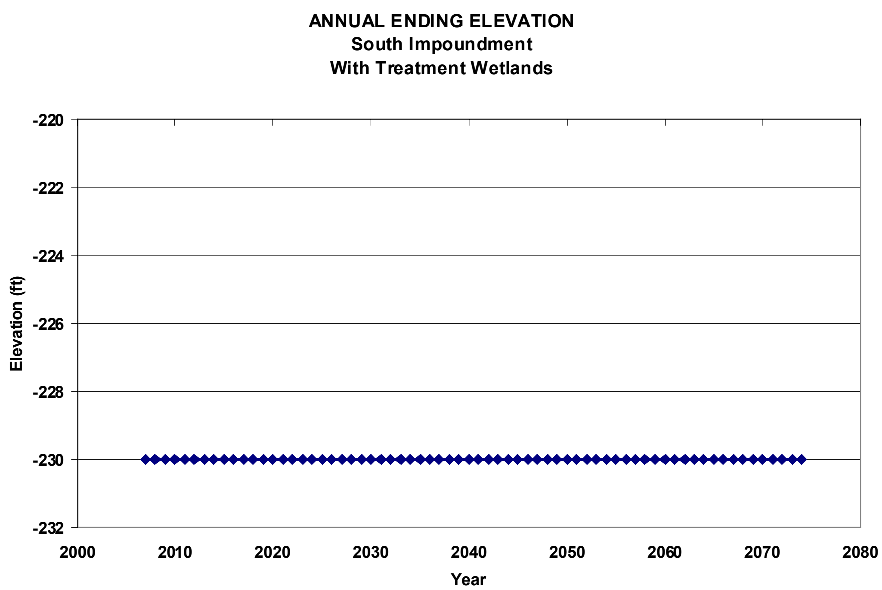
Salt Load and Discharge: S. Impound.



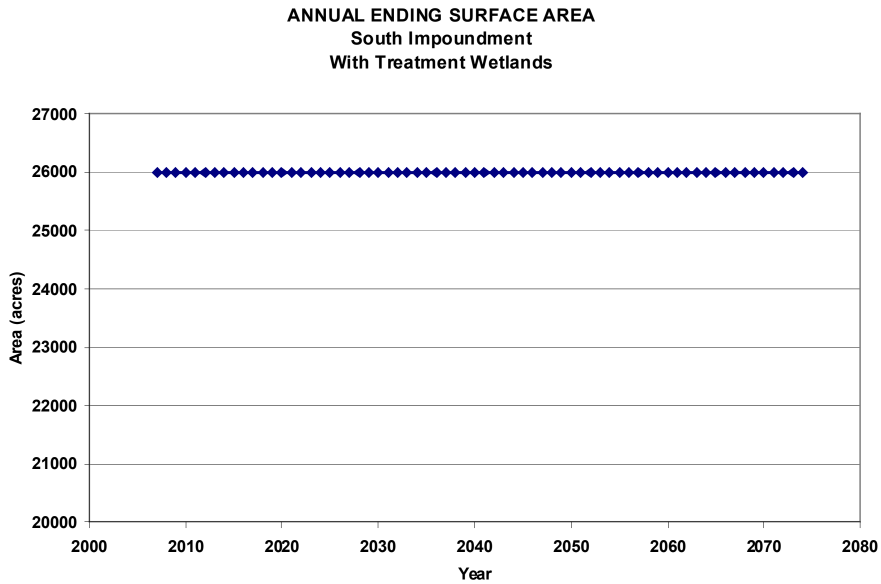
Salinity: South Impoundment



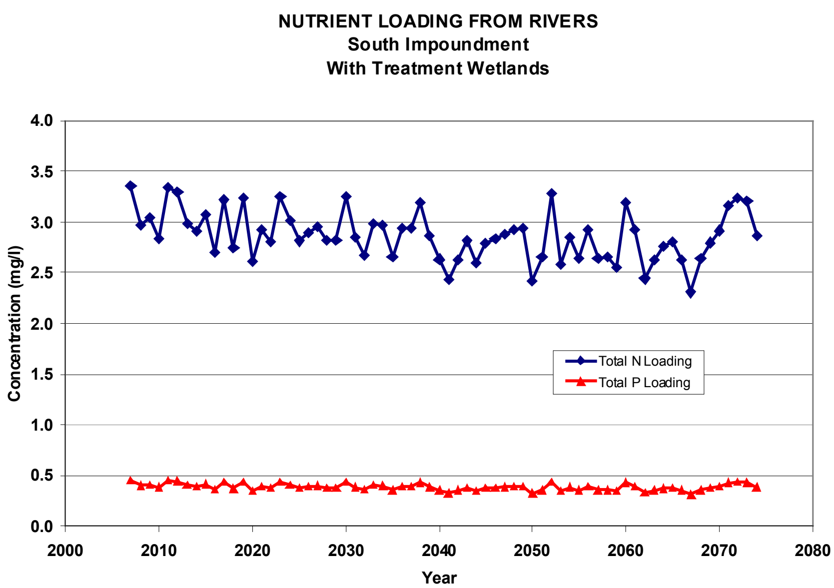
Elevation: South Impoundment



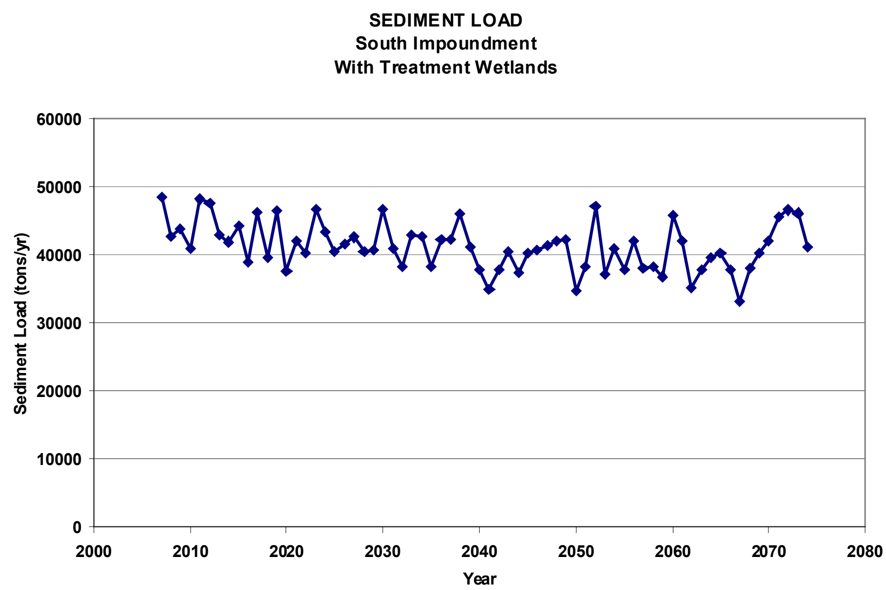
Surface Area: South Impoundment



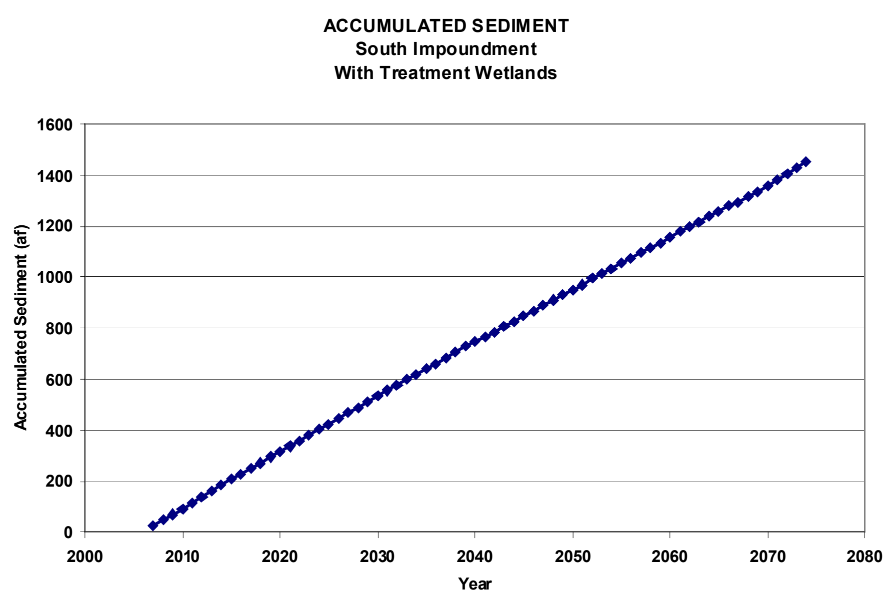
Nutrient Load: South Impoundment



Sediment Load: South Impoundment

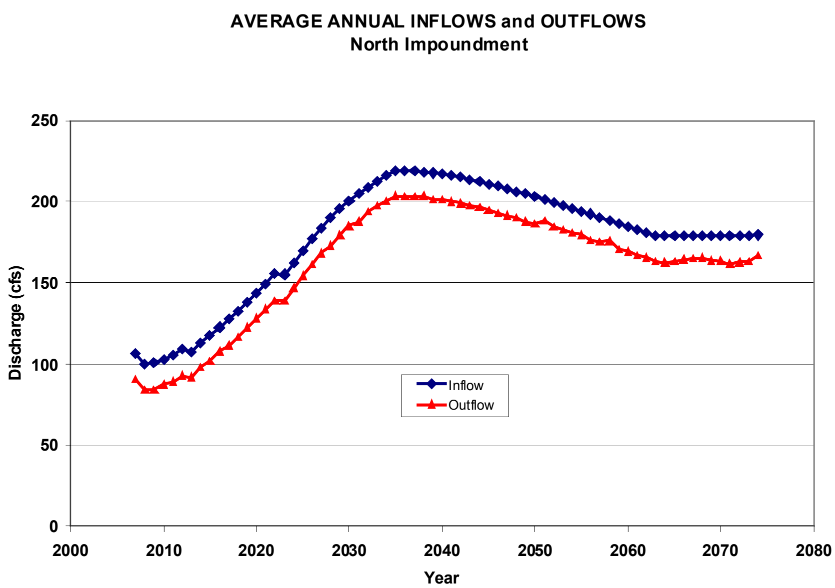


Sediment Trapped: S. Impoundment

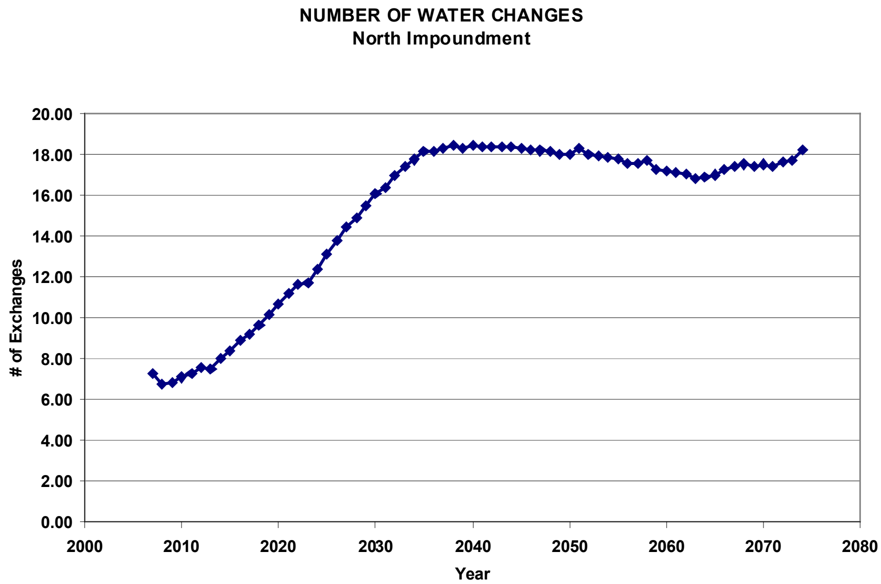


North Impoundment Simulation Results

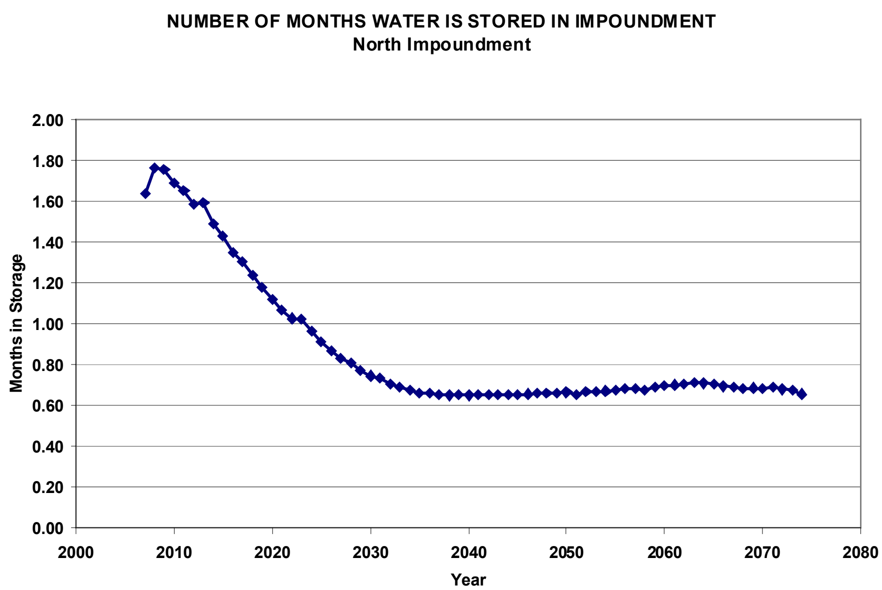
Inflows/Outflows: North Impoundment



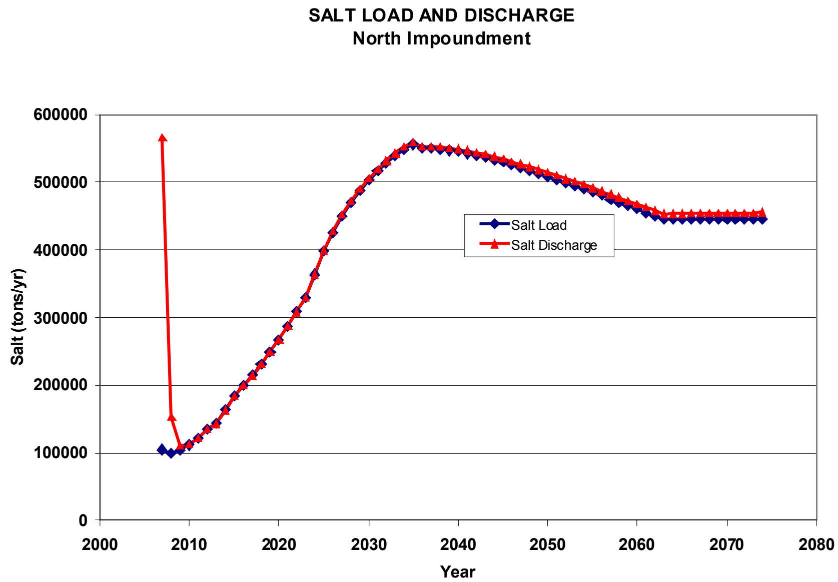
Water Exchanges: North Impoundment



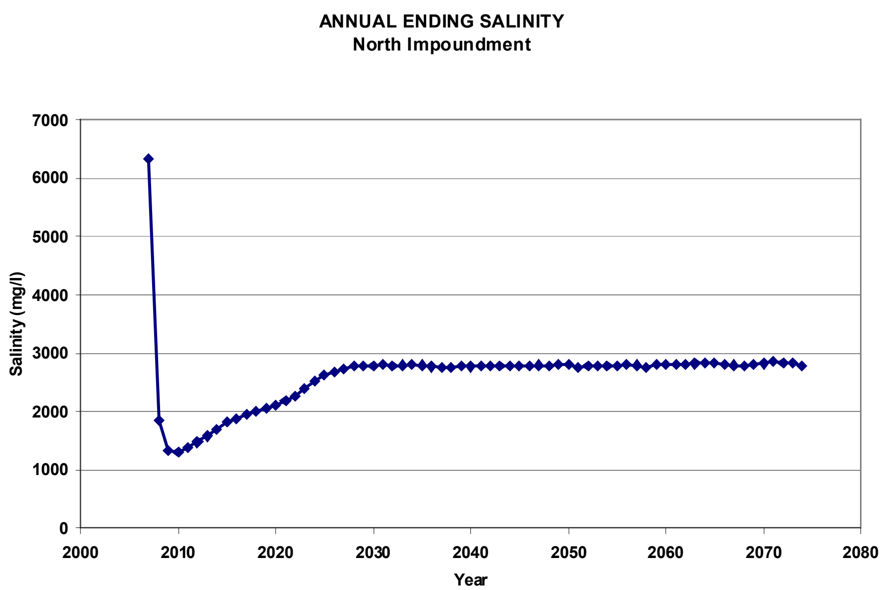
Months in Storage:North Impoundment



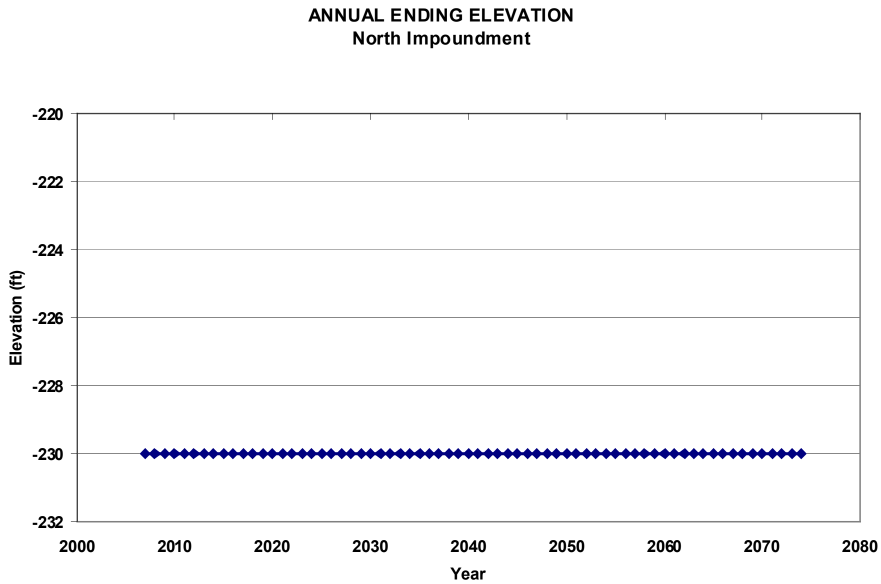
Salt Load and Discharge: N. Impound.



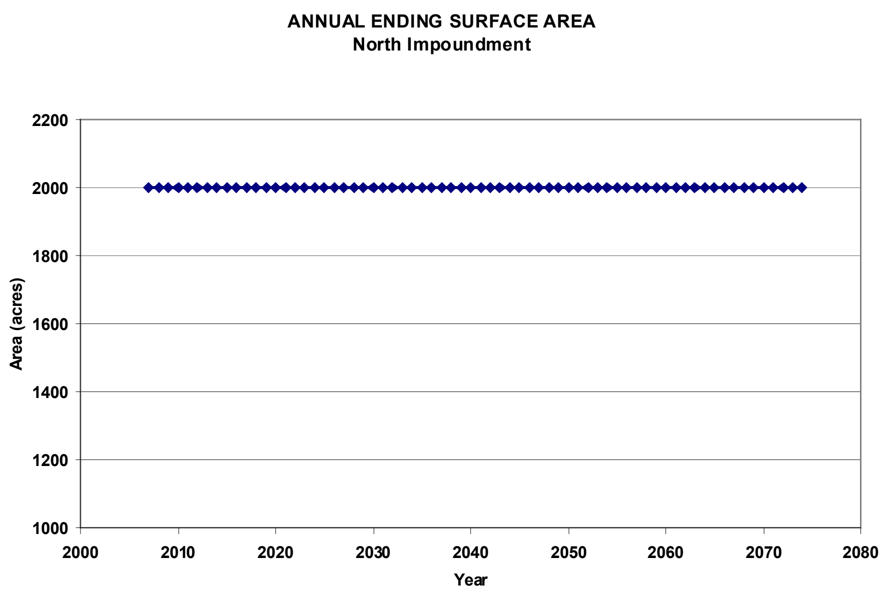
Salinity: North Impoundment



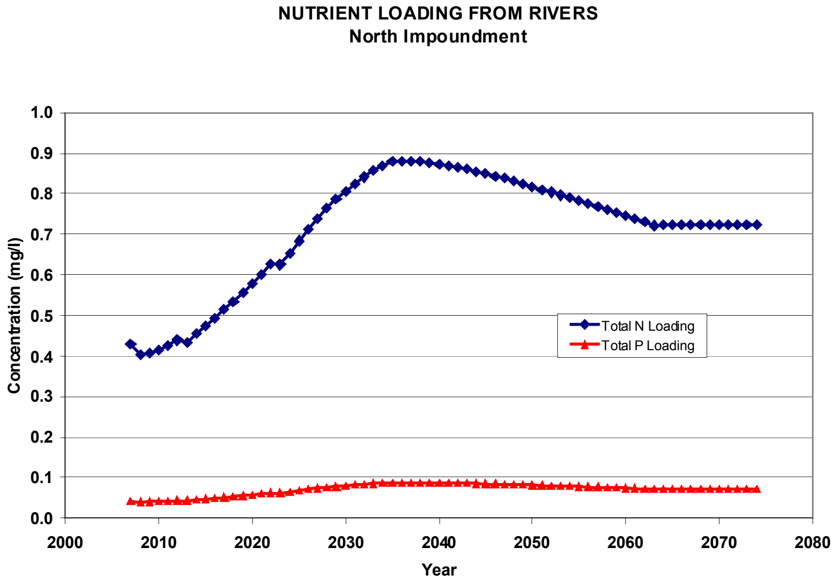
Elevation: North Impoundment



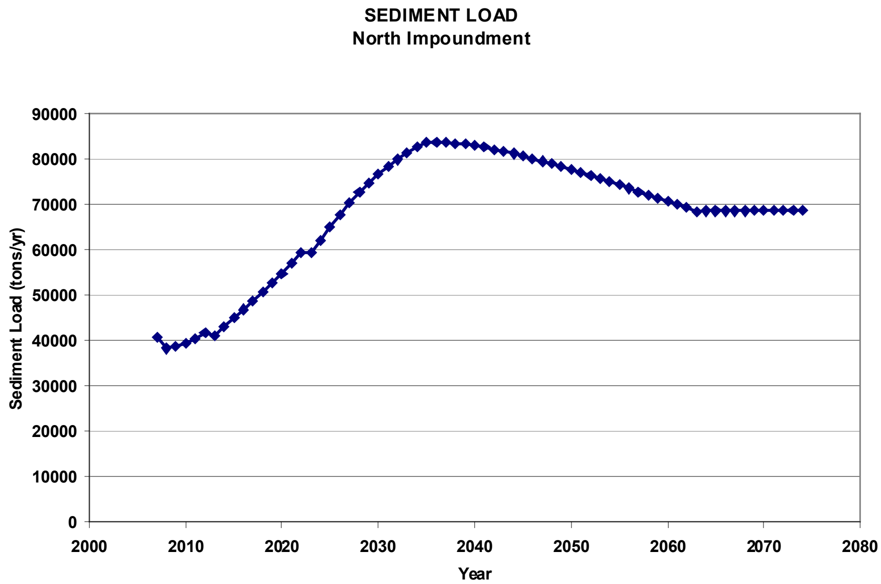
Surface Area: North Impoundment



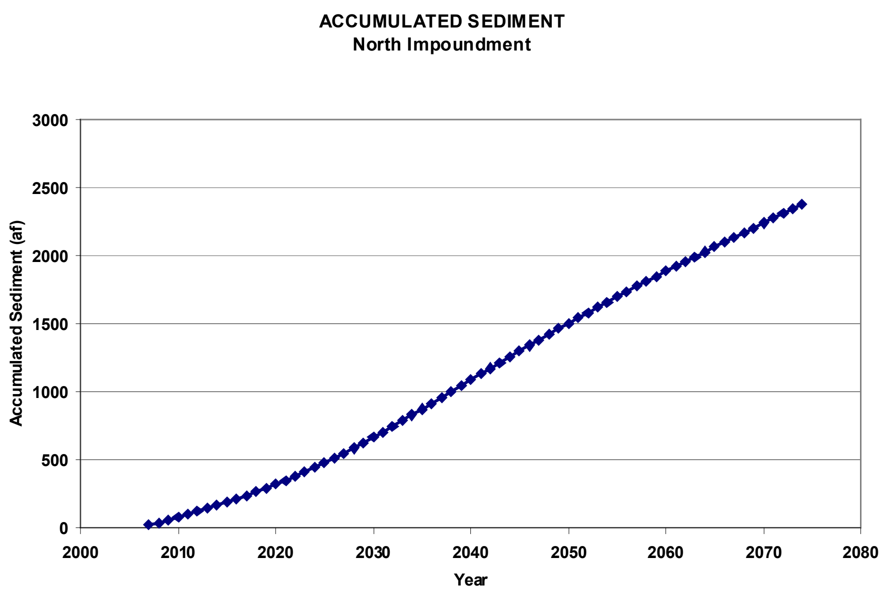
Nutrient Load: North Impoundment



Sediment Load: North Impoundment



Sediment Trapped: N. Impoundment



Pacific Institute Impoundment Proposal

Engineering Assessment
8 January 2002

Agenda

- Contributors
- Design Considerations
- Engineering Issues
- Cost

Contributors

William Brownlie, PE, PhD	Senior Vice President, Registered Civil Engineer Tetra Tech, Inc.
Elston Grubaugh, PE	Supervising Engineer - Water Resources Imperial Irrigation District
Leo Handfelt, PE	Vice President, Registered Civil and Geotechnical Eng. URS Corporation
William Thompson, PE	Senior Design Engineer, Registered Civil Engineer U.S. Bureau of Reclamation
Paul Weghorst, PE	Principal Hydraulic Engineer, Registered Civil Engineer US Bureau of Reclamation
Dick Wiltshire, PE	Principal Embankment Engineer, Registered Civil Eng. U.S. Bureau of Reclamation

Design Considerations

- Greater than 50 acre-feet and more than 6 feet in height → dam
  - Likely be considered as dams by the California Division of Safety of Dams
- Levee exclusion if primary purpose to control floodwaters probably does not apply

Design Considerations

- Dams
  - – Dam safety a major concern
  - – Need to pass project flood
  - – Need spillway or weirs and channels to convey water to the new Sea
  - – Dam break risk analysis required
  - – Design for seismic stability

Seismicity

- One of most highly seismic areas in CA
- Imperial and Coachella Valley Segment of San Andreas Faults
- Possible embankment failure
  - – Catastrophic slump/slope failure
  - – Liquefaction and slumping of crest
  - – Several minutes to an hour or more
  - – Zipper effect when water spills through breach

Embankment Design

- Underwater uncompacted construction
- Poor hydraulic barriers
- Possible failure from internal erosion by seepage after Sea elevation falls
  - Similar to Teton Dam failure
- Added cost for improved hydraulic and seismic design

Flooding Issues

- South impoundment need to handle project flood
  - Spillway or multiple weirs
  - Costs would need to be considered
- North impoundment need to pass ~80,000 cfs Whitewater R. project flood
  - Spillway or other means to pass flood

Wetlands

- About 9,000 acres estimated to be needed
  – Available area in the river bottoms estimated at 2,000 acres
  – Areas on bluffs difficult to use
  – Limited area at river mouths
- Difficult to treat drains that discharge into the Sea

Siltation

- IID has existing dredging program
  – In channel near mouth
  – No dredging in delta
- Need to continue dredging to keep delta areas from clogging
- Dikes would interfere with circulation
  – Exacerbate dredging problem

Agricultural Drains

- Complex plumbing for drains at the south end
- May need to reconfigure/extend some across exposed area to impoundment

Cost

Dikes/Berms (north & max. south)	**Cost**
Uncompacted underwater berm design	$370,000,000 to $450,000,000
Sheet pile design for seismic and hydraulic protection	$1,040,000,000
Wetlands	
Wetlands (9,000 acres X $50,000/acre)	Up to $450,000,000
Total	$820,000,000 to $1,490,000,000

Water quality Impacts of the Pacific Institute's Proposal to Preserve and Enhance Habitat at the Salton Sea

Evaluation Meeting on December 17, 2001 at the University of Redlands

Panelists:

Milt Friend, Ph.D. – Chief Scientist, Salton Sea Science Office

Chris Amrhein, Ph.D.– University of California at Riverside, Professor of Soil and Water Science

Jim Sartoris – USGS on detail to USBR, Civil Engineer, MS, Certified Professional Wetland Scientist

Jim Setmire – USGS on detail to USBR, Hydrologist

Water-quality evaluation

Goal: **determine the QW in the impoundments and the potential implications of that water quality on biota/beneficial uses.**

Underlying premise:

QW in impoundments is directly correlated to inflowing river quality – no target salinity

Tacitly settled on southern impoundment at –245 contour to begin evaluation

Southern impoundment at –245 ft contour

QW controlled by inflowing New and Alamo Rivers plus drains discharging directly to Sea along southern shore

Distinct water quality differences across the impounded water - Mouths of rivers 12 miles apart – minimal mixing of water from Alamo River with water from New River

Constituent	New River at Outlet	Alamo River at Outlet
TDS	3,000 mg/L	2020 mg/L
N total	8 mg/L	10 mg/L
P total	0.4 mg/L	0.2 mg/L
Se dissolved	4 ug/L	8 ug/L
Suspended sediment	510 mg/L	590 mg/L
Pesticides	na*	na*
Flow	500K acre-ft/yr	600K acre-ft/yr

Selenium

Selenium conc. in Salton Sea currently is 1 ug/L

Southeastern part of impoundment will be 8 ug/L Se

Southwestern part of impoundment will be 4 ug/L Se

EPA criterion for protection of aquatic life is 5 ug/L, but lower limits such as 2 ug/L are being considered for areas having significant bioaccumulation and magnification

Entire loading annual loading of 7 tons of Se to the Salton Sea will be concentrated in 11 % of the Sea's volume – the impoundment

Currently, this Se is entombed in the deeper sediments of the Sea where it is not available to the biota

Selenum – cont'd

Role of Se in current disease issues and reproductive success is unknown, but is at levels of concern

The southern end of Sea where impoundment is to be located contains major shorebird feeding areas as well as feeding areas for many other waterfowl and waterbirds – Se currently is 1 ug/L in water and <1mg/Kg in bottom sediments of these areas.

There is significant concern that increasing the Se conc. from 1 ug/L to 8 ug/L in selected areas of the impoundment along with decay and deposition of the algae will alter the existing biological system causing major reproductive impairment.

Se has been found at 3 ppm in filamentous algae in the Imperial Wetland

Se cont'd

Worst case scenario –

- **All of Se load deposited in impoundment**
- **Sufficient time for algae to grow, die and deposit in bottom sediment of impoundment**
- **In future – if tailwater and operational loss are conserved to provide source water for water transfer – Se in Alamo and New Rivers could increase by 30 % - lead to 10 to 12 ug/L Se in Alamo River and eastern portion of impoundment;**
- **6 ug/L Se in New River and western portion of impoundment**

If water for transfer obtained by fallowing poorer quality land (saline soils) might reduce Se conc by 10%

Nutrients

Salton Sea is strongly P limited – entire load of N and P will be deposited in an area that represents only 11 percent of the current Salton Sea

Algal blooms in the impoundment will be incredible

High nutrient loading will translate to supersaturated DO during daylight, causing increased pH and could lead to increased conc. of unionized ammonia

Sulfate ppt and calcite formation which removes P in the Sea will not occur in the impoundment

Will be significant internal loading of P from decaying algae and release of P to water column fueling the algal cycle in the impoundment producing dark green water

Nutrients cont'd

Primary productivity in the impoundment will be higher than currently in the main body of the Salton Sea.

Michael Anderson from UC Riverside used BATHTUB to make some tentative water quality simulations for the –240 and –245 ft impoundments.

Model predicts that total N, total P, and chlorophyll *a* levels will be very high in the impoundment leading to hypereutrophic conditions.

Chlorophyll a	**= 75-94 mg/L**
Secchi Depths	**= 0.4m**
TP	**= 0.3-0.4 mg/L**

Nutrients cont'd

- **Two possible ecological states:**
  - **Turbid algal dominated system**
  - **Clear macrophyte dominated system**
  - **Presence of carp will push toward algal system**
- **Topic interfaces with biological evaluation**

Impact of Constructed Wetlands

- **90-95% reduction in sediment loads going to impoundment**
  - **DDE associated with fine sediments will deposit in wetlands**
  - **Other sediment adsorbed compounds will be removed**
- **Underlying assumption that wetlands will remove nutrients from inflowing water**
  - **Wetlands generally are a sink for nitrogen, so nitrogen loading to the impoundment will be reduced**
  - **Wetlands are not effective at phosphorus removal –**
  - **Some depositional loss of refractory sediment associated P**
  - **Hemet wetlands averaged between 5-11% P removal**

Impact of Constructed Wetlands

Selenium – total load will likely decrease, but concentration will stay the same

Selenium uptake by plants, algae, and sediments plus possibility of Se volatilization as dimethylselenide

- **3 ppm Se found in filamentous algae in Imperial Wetland**

Water loss in wetland due to evapotranspiration – about 8%

Northern Impoundment

30 years to come to equilibrium – built at –240 ft

- **Short residence time – quick turnover**
- **Overdraft of aquifer feeding northern end of Sea will cause changing QW in drainwater feeding impoundment**

Impoundment will have lower dissolved solids and suspended sediment concentrations than southern impoundment

Same high productivity as the southern impoundment

Changes in QW of Main Body of Salton Sea

External loading of nutrients will be eliminated

Algal blooms should cease

Clarity will increase

Sulfate reduction will continue with some H_2S production

Intense calcite precipitation in sediments and co-precipitation of P

P will remain in sediments, but rate of sequestration will be reduced

Questions & Summary

How much P will be in bird excrement of the southern impoundment?

What is impact of this P on impoundment?

South impoundment at –240 ft would provide the worst QW impacts

South impoundment at –245 ft is better

North impoundment is different, high exchange rate, long time to equilibrium

Hydrology Working Group

- Michael Anderson—Ph. D. from Virginia Tech, 1990. At UC Riverside 11 years; now Associate Professor, Department of Environmental Sciences. Nutrient studies at sediment-water interface in Salton Sea.
- Paul Weghorst—Registered professional engineer with Bureau of Reclamation, Denver. Salinity and elevation modeling for the Salton Sea.
- Roy Schroeder—Ph. D. from Scripps Institution of Oceanography, 1974. Salton Basin selenium and New River contaminants studies since 1988.

Overview of Our Process

- **Review of proposal and instructions**
- **Descriptive maps—U. Redlands**
- **Hydrologic modeling—Reclamation**
- **Key points developed for:**
  - Impoundments
  - Main Salton Sea
  - Transition (construction phase)
- **Met with water-quality group**

Key Hydrologic Features

- Residence time (turn-over rate)
- Mixing time (circulation rate)
- "Reaction rates"

- South impoundment
  - Residence time is 3 to 4 months
  - Salinity about 4,000 mg/L

- North impoundment
  - Residence time drops from 7 to 3 weeks
  - Salinity increases from 1,200 to 2,800 mg/L

- Mixing
  - Wind more important than advection

Other Key Points

- Multiple outflows to prevent stagnation
- Transition rapid as closure nears
- Must dredge rivers and cut drain channels
- Suspended mineral matter retained
- Turbidity greater than in main water body
- Temperature range greater
- Wet and salty land between dike and Sea
- Need cumulative depth vs. area graph
- No longer a temporal imperative

Biological Evaluation of the Pacific Institute's Proposal for the Salton Sea

Panelists

Dan Anderson, Ph.D., Professor of Wildlife Biology, UC Davis
Eugenia McNaughton, Ph.D., Environmental Scientist, US EPA
Stuart Hurlbert, Ph.D., Professor, Professor of Biology, Director, Center for Inland Waters, San Diego State University
Albert Johnson, Ph.D., Professor Emeritus of Biology, San Diego State University
Kathy Molina, Avian Ecologist, Natural History Museum of Los Angeles County
Make Saiki, Ph.D., Research Fishery Biologist, USGS
Rey Stendell, Ph.D., Senior Scientist, USGS
Joan Dainer, graduate student, San Diego State University
Lucy Caskie, Fish and Wildlife Biologist, USFWS
Doug Barnum, Ph,D., Science Coordinator, Salton Sea Science Office

HABITAT TYPES CONSIDERED

- **High salinity (the open sea)**
- **Impoundments (at the river deltas)**
- **Wetlands (rivers and sea)**
- **Mud and salt flats**
- **Rivers**
- **Uplands**

HABITAT	EXPECTED CHANGES
Open Sea	Increasing salinity > less biodiversity > fish > brine flies > brine shrimp
Mud – Salt flats	Different habitats within the area > some stagnant conditions > more biodiversity
Impouded areas	Lower wind and circulation impact > decreasing salinity > freshwater vegetation
Rivers	Lower flow > exposed river channel > no change in diversity
Wetlands	Increased acreage > sediment traps > freshwater vegetation
Uplands	No change

ASSUMPTIONS

- Impoundments at -245 ft with wetlands
- Wet habitat will be reduced by 10%
- No infrastructure
- No management
- Impoundments to provide open water habitat

PHYSICAL CHANGES THAT WILL AFFECT THE BIOLOGY

- Lower salinity (3-5ppt)
- Lower sediment load
- Lower turbidity
- Less wind/current effect
- Creation of stagnant conditions
- Anoxic conditions

THE OPEN SEA

- Introduced marine and salinity-tolerant fish populations will not be able to reproduce
- Pelicans and grebes (fish eaters) will lose wintering habitat
- Invertebrate species will dominate
  - Brine flies and water boatmen at first
  - Brine shrimp in very high salinity conditions

IMPOUNDED AREAS

- **Submergent and emergent vegetation**
- **Likely exotic species invasion**
- **Tilapia**
- **Desert pupfish habitat and escape routes compromised**
- **Periphyton and epiphyton replace phytoplankton**
- **Snag habitat lost**
- **Snowy plover breeding area may be lost**
- **Amphibian habitat created**

SALTON SEA PUPFISH HABITAT

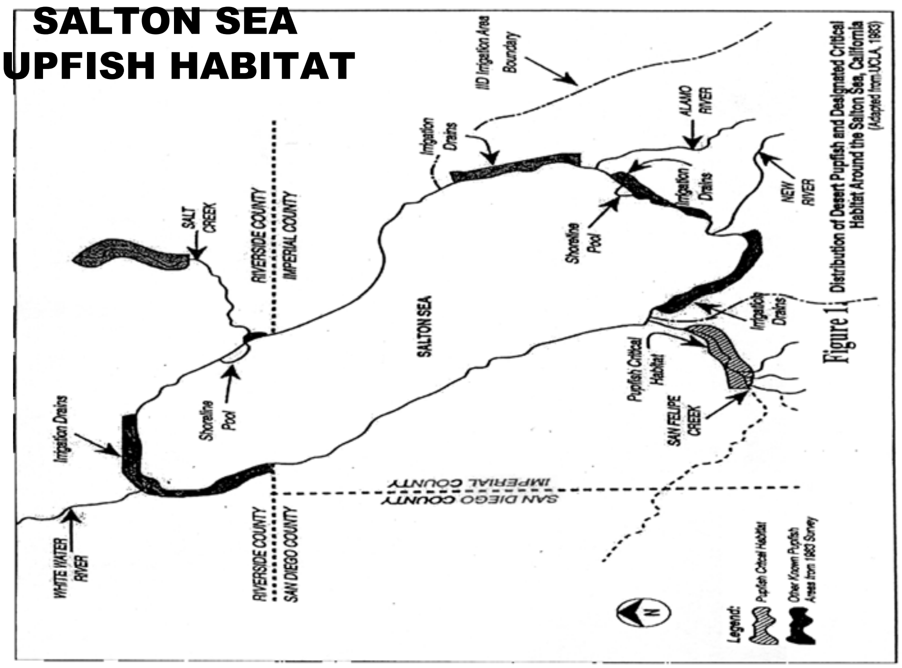


Figure 1: Distribution of Desert Pupfish and Designated Critical Habitat Around the Salton Sea, California (Adapted from UCLA, 1983)

MUD and SALT FLATS

- Not completely dry
- Patches of salty areas
- Shorebird habitat relatively unchanged
- Less flow to refresh remaining shallow areas
- Potential for tamarisk invasion
- Vegetation will bring habitat changes

RIVERS

- Lower flow
- Lower turbidity
- Exposed river channel
- Little aquatic species change
- Vegetation (tamarisk) to water's edge

THE ALAMO RIVER

WETLANDS

- Similar to impoundments
- Ducks, geese, rails, cormorants
- Emergent vegetation
- Small fish and tilapia
- Mosquito habitat in stagnant areas

NEW RIVER WETLANDS
IMPERIAL SITE

NEW RIVER WETLANDS
BRAWLEY SITE

UPLANDS

- Egrets, ibis, curlew in fields
- Raptors
- Impoundment levies
  - nesting habitat for some bird species
  - predator pathway

GENERAL PREDICTIONS

- Biota will be qualitatively different
- Biomass will be less abundant
- Plant productivity will increase per unit area
- Plants will invade the impoundments within 5 years
- Plants will change the aquatic community
- More habitat for amphibians

RECOMMENDATIONS

- **Management program is needed**
  - **Impoundment infrastructure for water movement and depth manipulation**
  - **Vegetation control**
  - **Fish and wildlife habitat**

CONTAMINANTS AND DISEASE

CONTAMINANTS

- Selenium is major concern because of 1) its ability to bioaccumulate in the food chain, 2) the narrow window between the amount that is nutritionally beneficial and the amount that is toxic (i.e., a steep dose-response curve), 3) its effect on reproduction in aquatic birds and fish including congenital anomalies (teratogenesis), 4) and its potential effects on human health.
  - Past use of large-scale biological treatment technologies (e.g wetlands, evaporation ponds) for selenium removal elsewhere has generated serious ecological problems and hazardous selenium waste.
  - With diking proposal, entire selenium load from New and Alamo Rivers will be concentrated within impounded area (including wetlands).
  - Impoundments could become a problem of increasing proportions over time for selenium not removed by wetlands; conversely, wetlands could become a problem if they are efficient in removing selenium.

   - Food web exposure is the main route of transfer, and predators, rather than prey, are most sensitive to selenium contamination. Efficiency of bioaccumulation and trophic transfer will depend on food chain that results in wetlands and impoundments, but accumulation in tissues and eggs is likely to increase. Depressed immune system , mass wasting, and winter stress syndrome also are effects attributable to excessive selenium.
   - Selenium volatilization may occur as a mechanism for selenium loss from the system but is unlikely to be a significant factor.

CONTAMINANTS

- Organochlorine pesticides: most entering the New and Alamo Rivers will be removed by wetlands due to sedimentation. A temporal decline in organochlorine pesticides in wetlands will occur as the finite amounts deposited within the agriculture fields continues to be removed; same situation will also probably occur within impoundments.

- Heavy metals: Concentrations in impoundments will increase over present concentrations in the sea due to less dilution.

- Microbial contaminants (e.g. fecal coliforms, viral pathogens): Loading within the impounded area will increase over that present in the Sea due to the concentration of waters in a more limited area.
   - Wetlands will remove 90-99% of microbial contaminants depending on their efficiency, however there will be a significant level of microbial contaminants in the impoundments because of the large numbers entering the system.

- Without wetlands, the full load of microbial contaminants would likely be concentrated within the impoundments; the use of the impoundments for recreational activities would be unlikely.

- The Imperial and Coachella Valleys are areas of known activity of St. Louis encephalitis and western equine encephalomyelitis virus activity in birds, although currently, human disease is rarely reported.
    - Both the impoundments and wetlands pose a potential to facilitate SLE and WEE transmission to humans by increasing mosquito habitat, primarily in the south. Water less than 1 foot in depth with emergent vegetation provides the best habitat for the primary mosquito vector, Culex tarsalis; freshwater to brackish water is best. The expected fluctuation in water level in the southern impoundment will flood into shoreline areas providing ideal breeding areas for Cx. tarsalis.
    - Increased recreational opportunities will provide opportunities for increased interactions between mosquitoes, birds and humans, so the probability of human exposure to arboviruses will increase.

- The potential expansion of West Nile Virus into California is an added concern of increasing mosquito habitat with the proposed impoundments and wetlands.

FISH DISEASE

- Infections of both Vibrio sp. and the parasite *Amylodydidium occelatum* in fish will greatly decrease due to the decreased salinity in impoundments.

- Heavy nutrient loads and high temperatures in impoundments will increase algal growth and the potential for toxic algae which could result in large fish kills.

- Impoundment fish would likely be heavily infected with such metazoan parasites as flukes, tapeworms, and roundworms due to more established populations of their intermediate hosts (snails, crustaceans, and insects).

- A harmful fish parasite, the Asian tapeworm *Bothriocephalus acheilognathi*, that already has been found in fish in creeks draining into the Sea will likely become a major parasite of Cyprinids of the impoundments.

- Trematode parasites will likely become well established within impoundments because the freshwater and vegetation will facilitate snail intermediate hosts.
    - Swimmers itch is likely to develop as a human disease (schistosomiasis) resulting from the snail-fish-bird life cycle of the causative fluke.
    - Trematode infections in fish, such as “black spot disease”, will be evident in the flesh of sport fish, making them less desirable for human consumption.

AVIAN DISEASE

- An evaluation of current diseases resulted in the following projections for those diseases within the compound.

Classical type C avian botulism	⇧	due to increased numbers of waterfowl, environmental conditions and maggot cycle.
Type C avian botulism in fish eating birds	??	dependent upon fate of pelican and tilapia populations.
Avian cholera	⇧	due to increased numbers of waterfowl, the primary source of disease carriers in wild birds.
Salmonellosis	⇧	due to freshwater environment and likely increased concentrations of colonial nesting species within impoundments.
Algal toxins	⇧	due to high nutrient loads and shift to blue-green and green algae.
Newcastle disease	??	dependent on cormorant use of dikes as ground nesting areas.
Grebe mortality	??	cause is unknown, therefore, projections cannot be made.

- Under certain environmental conditions, salt encrustation and other problems may eventually occur if birds use the highly saline shallow areas of the main Sea for roosting or in escaping disturbances within the impoundments.

CONTAMINANTS AND DISEASE WORKING GROUP

Dr. Milton Friend	Former Director, USGS National Wildlife Health Center and Adjunct Professor, Department of Animal Health and Biomedical Sciences, University of Wisconsin, Madison
Dr. Tonie Rocke	Epizootiologist, USGS National Wildlife Health Center
Hugh Lothrop	Associate Specialist, Center for Vector-borne Disease, University of California, Davis
Dr. Victoria Matey	Adjunct Professor, Center for Inland Waters, San Diego State University
Dr. Boris Kuperman	Center for Inland Waters, San Diego State University
Dr. Rex Sohn	Wildlife Disease Specialist, USGS National Wildlife Health Center
Dr. Theresa Presser	Research Chemist, U.S. Geological Survey, Water Resources Division, Menlo Park, California
Dr. Rick Gersberg	Professor of Environmental Health, Graduate School of Public Health, San Diego State University