COLLEGE OF AGRICULTURE & LIFE SCIENCES
COOPERATIVE EXTENSION

WATER RESOURCES RESEARCH CENTER

CAP
CENTRAL ARIZONA PROJECT

Water and People – Implementing Technologies Across Borders

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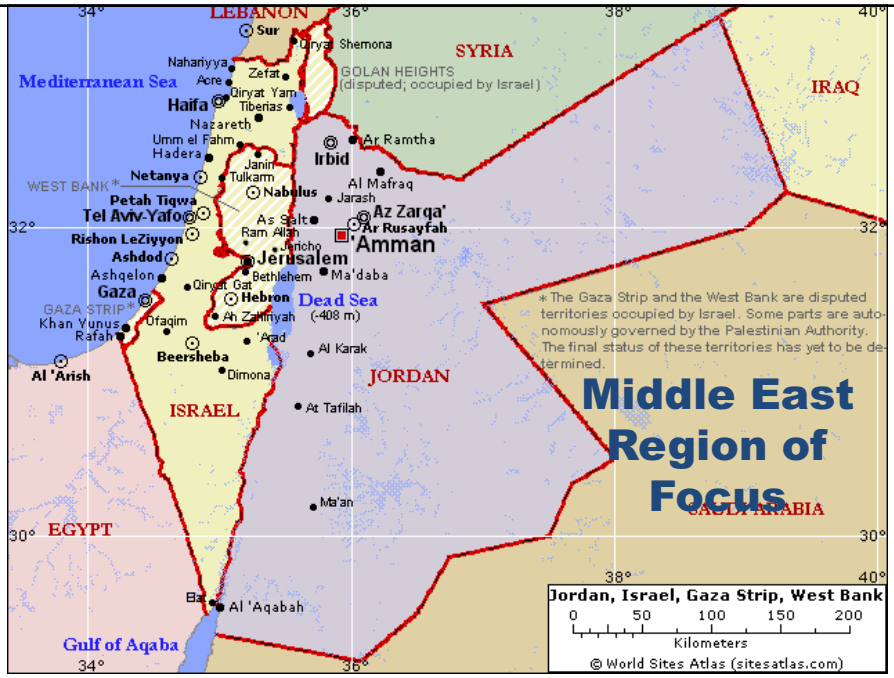
19 November 2019

wrrc.arizona.edu
CentralArizonaProject.com

1



SOURCE: http://travelquaz.com/jordan-map-free.html/political-map-of-israel-jordan-and-the-israeli-occupied

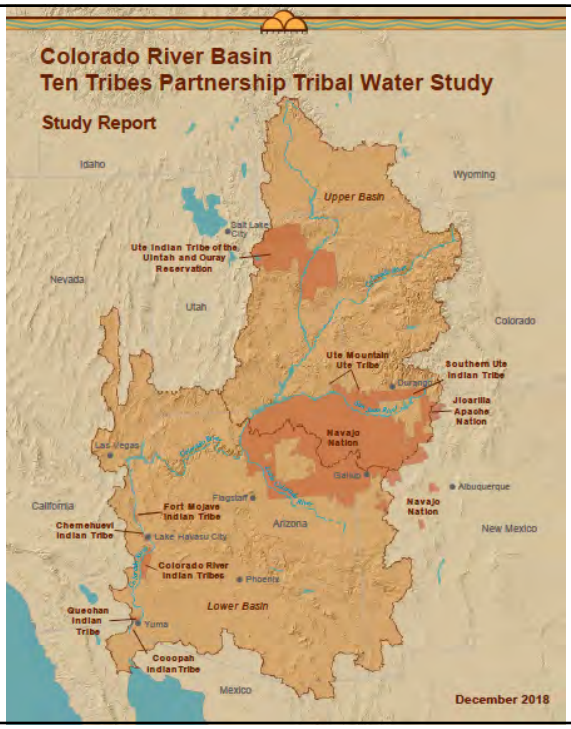
2

Source: U.S. Bureau of Reclamation

Colorado River Basin Region of Focus

Source: University of Arizona Water Resources Research Center

3



Colorado River Basin

Many Sovereign Tribal Nations

4

Question: What are the most important variables or factors that contribute to implementing technologies across borders?

5

Order of the speakers

Oded Fixler – Senior Deputy Director General – RSDS Project, Ministry of Regional Cooperation

Doron Markel – Chief Scientist, KKL-JNF

Greg Walch – General Counsel, Southern Nevada Water Authority

Chuck Cullom – Manager of Colorado River Programs, Central Arizona Project

Sergio Avila – Director, State of Sonora (Mexico) Water Commission

Andrea Alonso – Environmental Program Manager, Libra Ingieneros Civiles

Lela Perkins – Client Services Manager, Black & Veatch

6

Oded Fixler

7

Israel Water Sector Regional Cooperation – Challenges and Solutions RSDS Project

ODED FIXLER – Deputy Director General, Ministry of Regional Cooperation

Water and the Israeli-Jordanian Peace Treaty October 1994

Basic Stipulations

- There is not enough water
- Development of additional water resources is essential
- Practical solutions are needed
- Maintaining of existing uses (Annex II)
- Mutual assistance in alleviating water shortages

Precedents

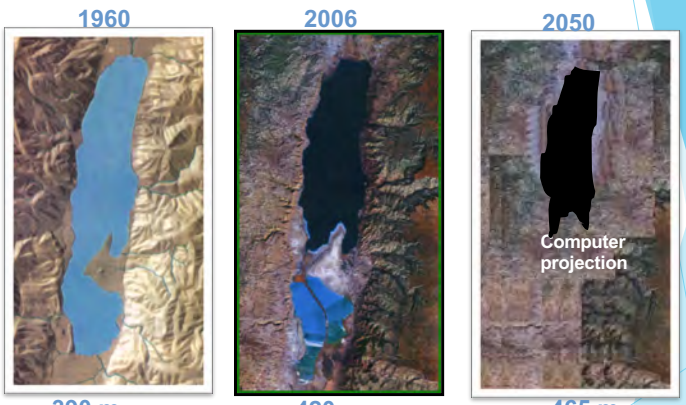
- Each party operates facilities on the sovereign territory of the other
- Explicit reference to “future” water

Water and the Israeli-Jordanian Peace Treaty October 1994

Water related matters (Annex II)

- Allocations – 35 MCM
- Storage - Up to 20 MCM
- Sold Water – 2010 minutes of meeting
- Water Quality and Protection
- Ground Water in Ha`arava / Wadi Araba
- Notification and Agreement
- Co-operation
- Joint Water Committee

The shrinking of the Dead Sea



Red Sea-Dead Sea Conveyance feasibility Study

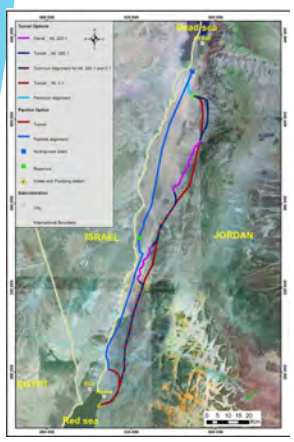
Israel, Jordan, the Palestinian Authority and the World Bank agreed that the WB would conduct a feasibility study for the project.

The study was completed and its results are that the proposed project has feasibility.

The projects main goals are:

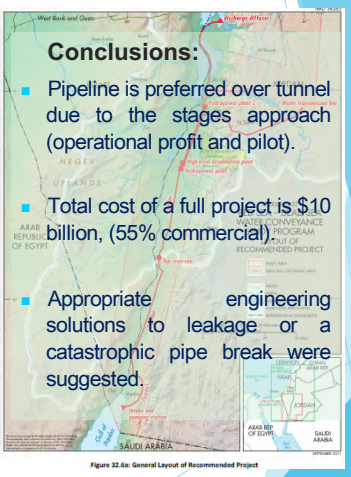
- Decreasing/Stopping the drop in the Dead Sea water level
- Desalination and supply of water
- Production of Electricity based on Hydroelectric Power Plants

Selection of the Route and analysis of the Environmental Effects on the Arava



- The open canal alternative was disqualified for environmental reasons and groundwater sensitivity
- Possible routes for tunnels and pipelines were defined. The pipelines are preferred because they offer more financial flexibility
- An earthquake risk assessment was performed. Technical solutions have been prepared for the possibility of leakage of seawater or brine into the aquifer.
  The impact on the ecosystem was assessed.
- In light of the dimensions and costs of the full project and in order to reduce risks, it was decided to carry out a pilot - Phase I is limited in its dimensions and costs.

Feasibility Study Results



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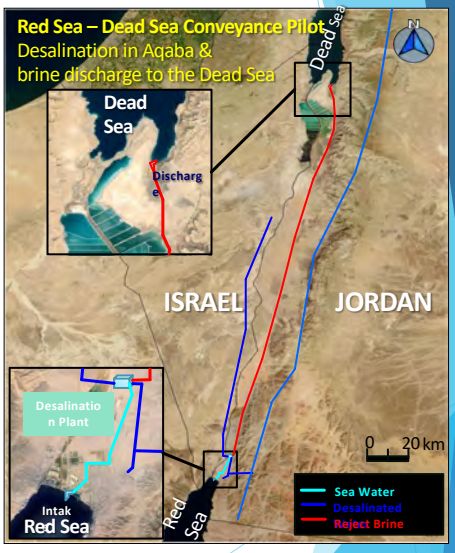
Phase I

- Red Sea Intake capacity 300MCM
- Desalination plant with capacity of 65MCM – 35 for Israel and 30 for Jordan
- Discharge to the Dead Sea 235MCM
- 31 MW of HEPP
- BOT project managed jointly by Israel and Jordan

Pilot/Phase I Project:

- Will produce drinking water faster
- Will enable the exploration of the impact on the Dead Sea at field scale
- Will initiate the project through a careful step, in order to minimize the environmental risks



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The SWAP Deal:

- 35 MCM for Southern Israel
- 50 MCM for Jordan in the north
- 20-30MCM to the Palestinian Authority

Status

- A preliminary screening process (PQ) was conducted to select consortiums that could participate in the tender process. 5 groups were selected.
- The draft tender documents (RFP) have been prepared detailing the objectives, the project description, the conceptual design, the parameters and the risks
- A Governmental Decision must be approved in Israel before the tender is distributed.
- Complementary Agreements to the G2G should be agreed, at least in principles, with the Jordanian government
- An examination of the possibility of other sources of electricity should be completed

Doron Markel

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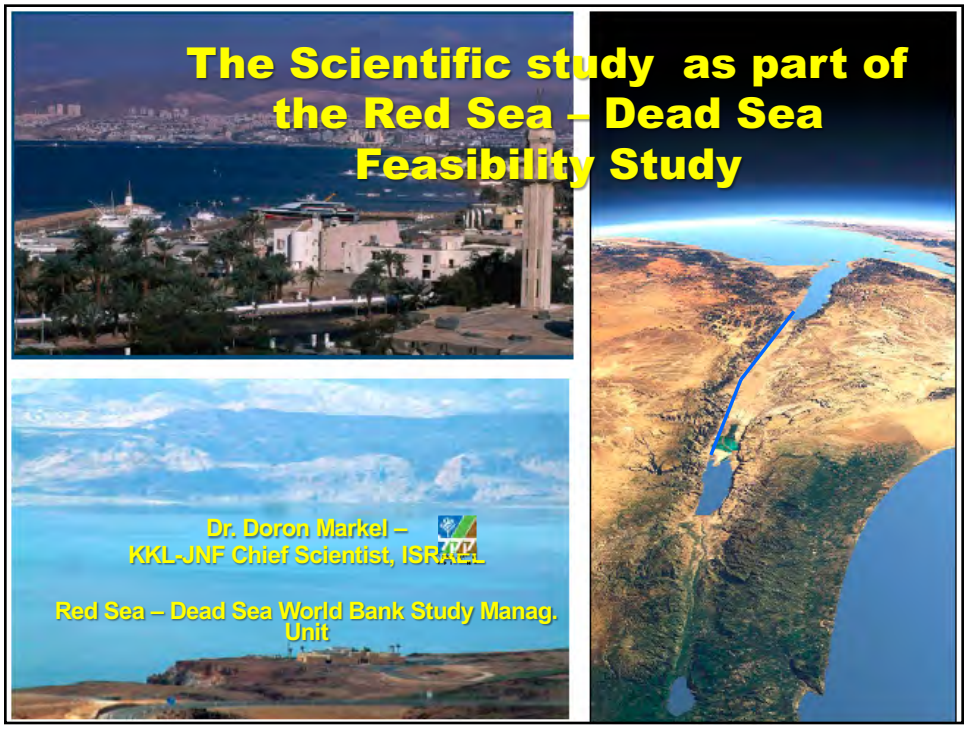
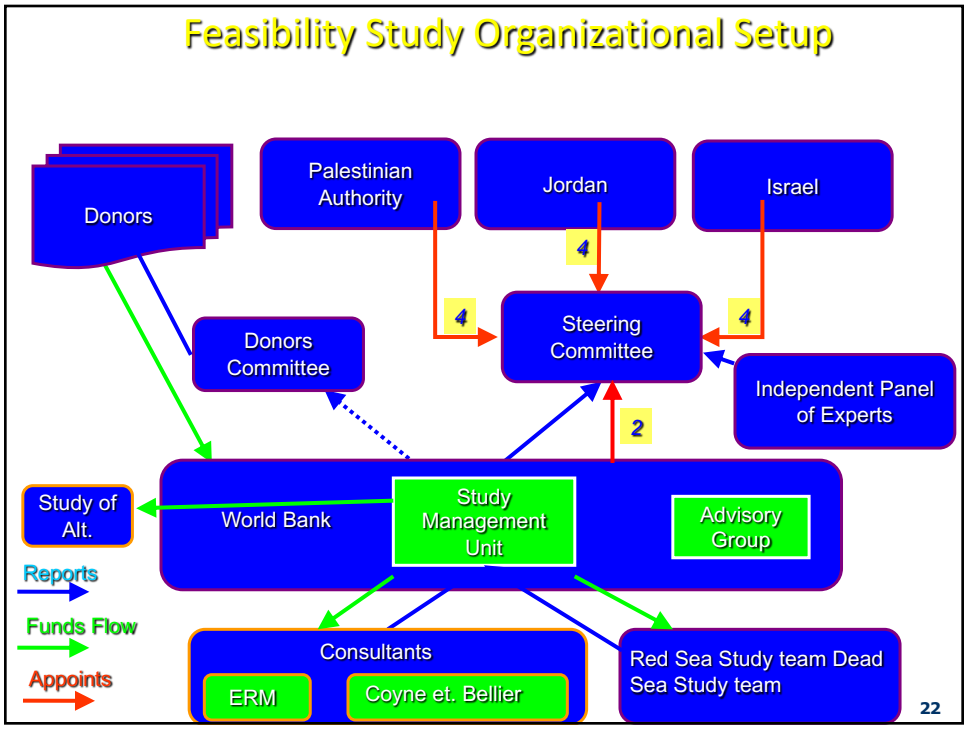
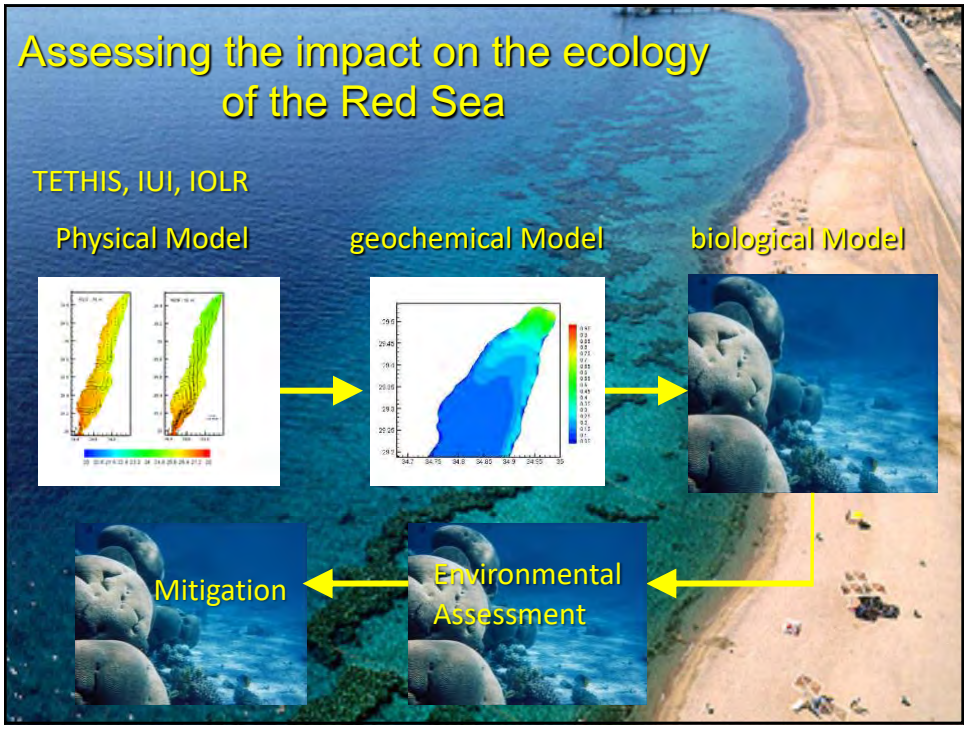
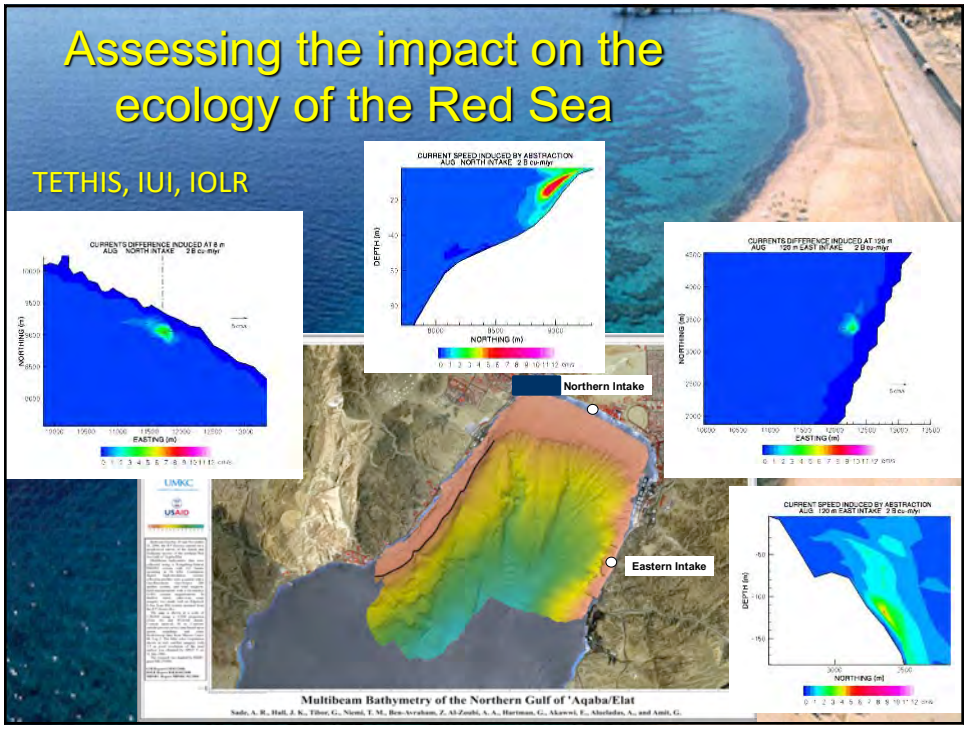
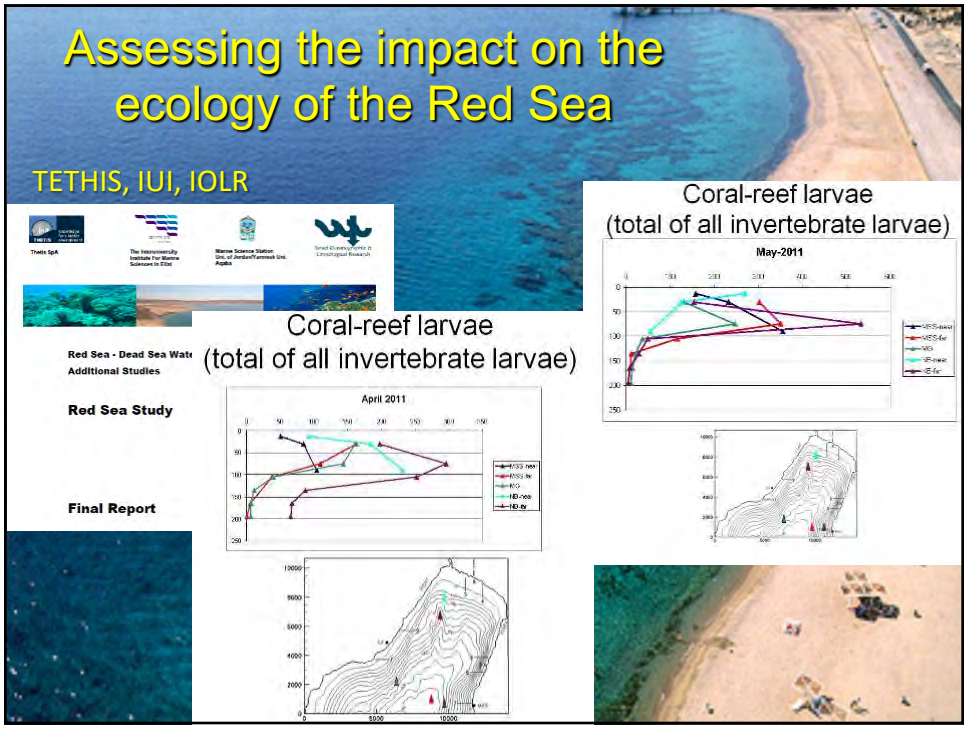
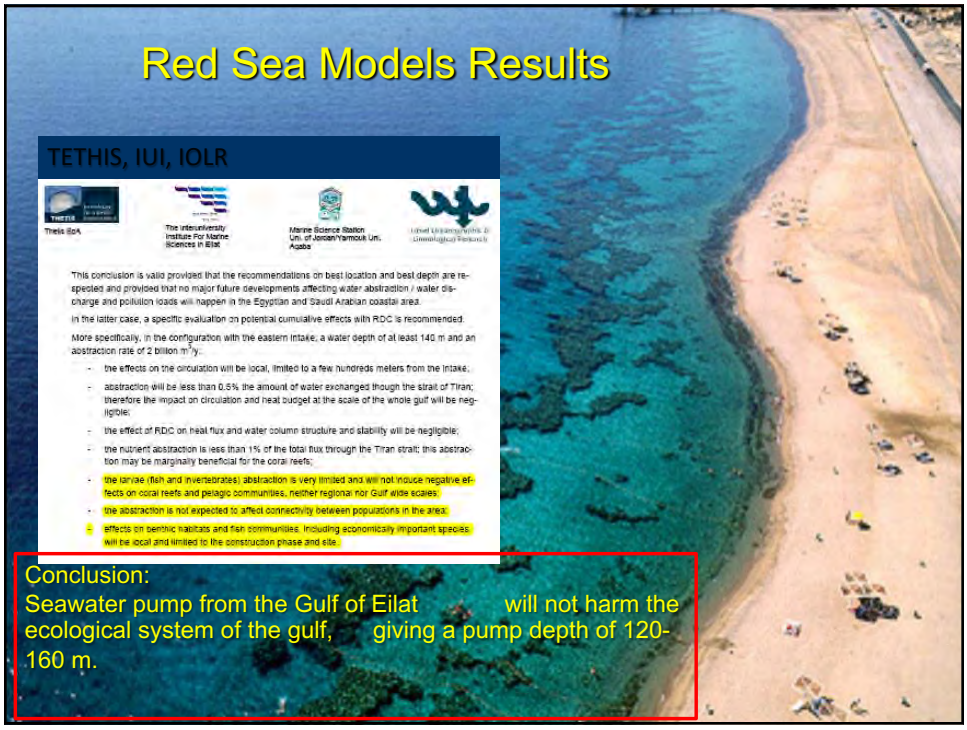


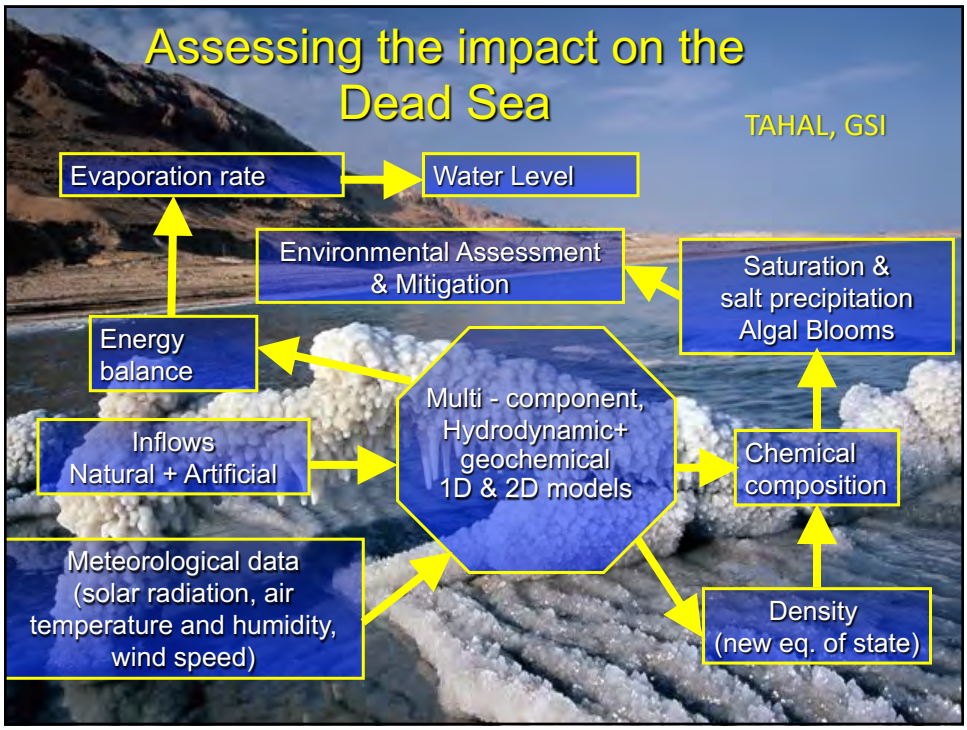

Feasibility Study Organizational Setup
Donors
Palestinian Authority
Jordan
Israel
4
4
4
Steering Committee
Donors Committee
Independent Panel of Experts
2
Study of Alt.
World Bank
Study Management Unit
Advisory Group
Reports
Funds Flow
Appoints
Consultants
ERM
Coyne et. Bellier
Red Sea Study team Dead Sea Study team
22


Assessing the impact on the ecology of the Red Sea
TETHIS, IUI, IOLR
Physical Model
geochemical Model
biological Model
Mitigation
Environmental Assessment


Assessing the impact on the ecology of the Red Sea
TETHIS, IUI, IOLR
Northern Intake
Eastern Intake
Multibeam Bathymetry of the Northern Gulf of 'Aqaba/Elat


Assessing the impact on the ecology of the Red Sea
TETHIS, IUI, IOLR
Red Sea - Dead Sea Wate
Additional Studies
Red Sea Study
Final Report
Coral-reef larvae
(total of all invertebrate larvae)
April 2011
Coral-reef larvae
(total of all invertebrate larvae)
May-2011

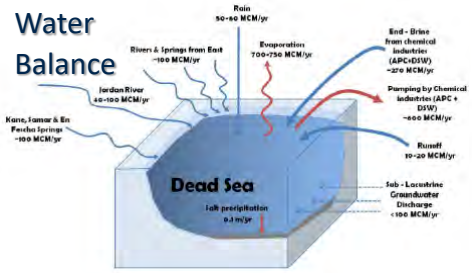

Red Sea Models Results
TETHIS, IUI, IOLR
The Interuniversity Institute For Marine Sciences in Eilat
Marine Science Station Uni. of Jordan/Yarmouk Uni. Aqaba
This conclusion is valid provided that the recommendations on best location and best depth are respected and provided that no major future developments affecting water abstraction / water discharge and pollution loads will happen in the Egyptian and Saudi Arabian coastal area.
In the latter case, a specific evaluation on potential cumulative effects with RDC is recommended.
More specifically, in the configuration with the eastern intake, a water depth of at least 140 m and an abstraction rate of 2 billion m3/y:
- the effects on the circulation will be local, limited to a few hundreds meters from the intake;
- abstraction will be less than 0.5% the amount of water exchanged though the strait of Tiran; therefore the impact on circulation and heat budget at the scale of the whole gulf will be negligible;
- the effect of RDC on heat flux and water column structure and stability will be negligible;
- the nutrient abstraction is less than 1% of the total flux through the Tiran strait; this abstraction may be marginally beneficial for the coral reefs;
- the larvae (fish and invertebrates) abstraction is very limited and will not induce negative effects on coral reefs and pelagic communities, neither regional nor Gulf wide scales;
- the abstraction is not expected to affect connectivity between populations in the area;
- effects on benthic habitats and fish communities, including economically important species will be local and limited to the construction phase and site.
Conclusion:
Seawater pump from the Gulf of Eilat will not harm the ecological system of the gulf, giving a pump depth of 120-160 m.


Assessing the impact on the Dead Sea
TAHAL, GSI
Evaporation rate
Water Level
Environmental Assessment & Mitigation
Saturation & salt precipitation Algal Blooms
Energy balance
Multi - component, Hydrodynamic+ geochemical 1D & 2D models
Inflows Natural + Artificial
Chemical composition
Meteorological data (solar radiation, air temperature and humidity, wind speed)
Density (new eq. of state)

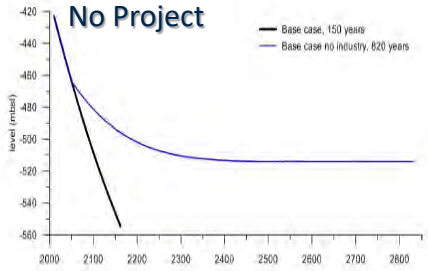
Assessing the impact on the Dead Sea

TAHAL, GSI

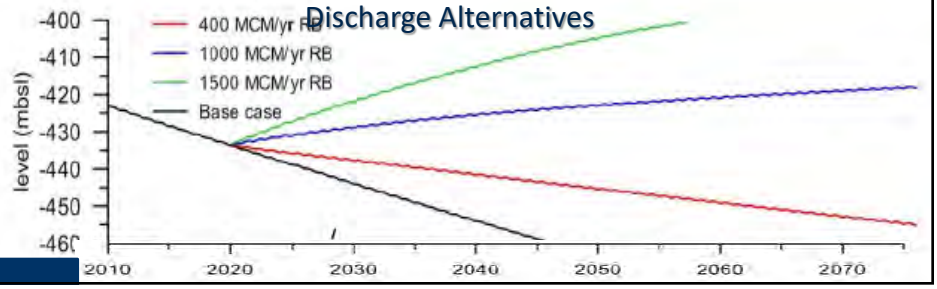
Water Balance



No Project



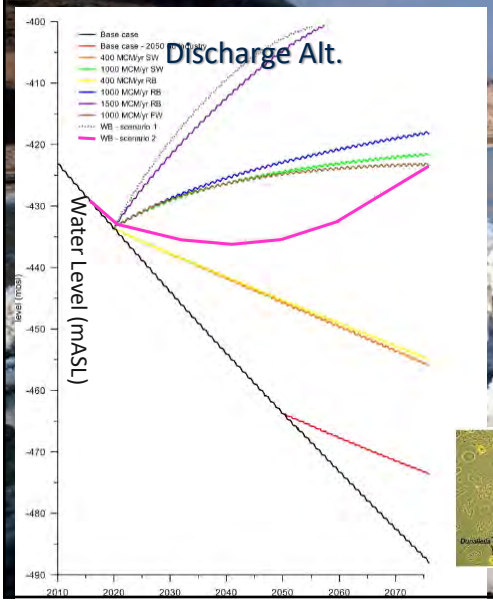
Discharge Alternatives



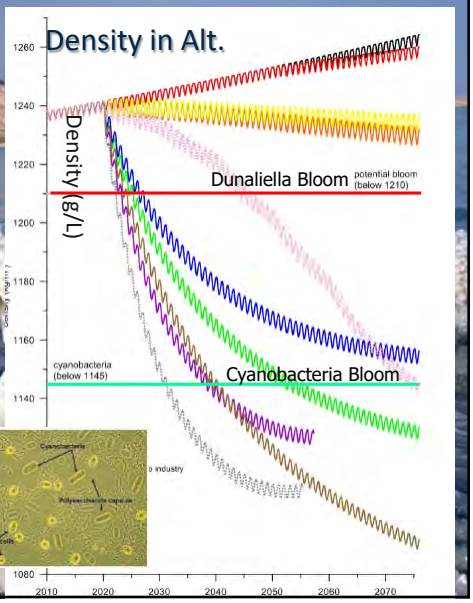
Assessing the impact on the Dead Sea

TAHAL, GSI

Discharge Alt.

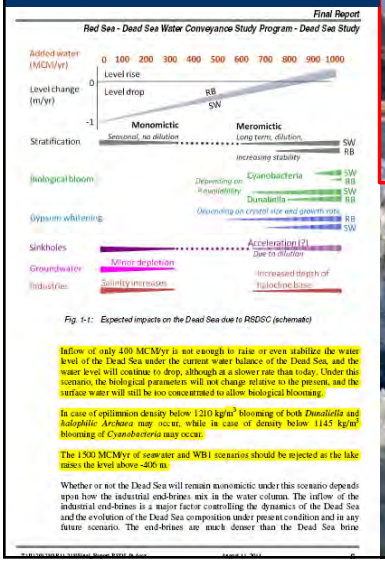


Density in Alt.



Dead Sea Models Results

TAHAL, GSI


Final Report
Red Sea - Dead Sea Water Conveyance Study Program - Dead Sea Study

Added water (MCM/yr) 0 100 200 300 400 500 600 700 800 900 1000
Level change (m/yr) 0 -1 Level rise Level drop RB SW
Stratification Monomictic Seasonal, no dilution Meromictic Long term, dilution, increasing stability SW RB
Biological bloom Cyanobacteria Dunaliella Depending on Rewetability SW RB
Gypsum whitening Depending on crystal size and growth rate RB SW
Sinkholes Acceleration (?) Due to dilution
Groundwater Minor depletion
Industries Salinity increases Increased depth of halocline base

Fig. 1-1: Expected impacts on the Dead Sea due to RSDSC (schematic)

Inflow of only 400 MCM/yr is not enough to raise or even stabilize the water level of the Dead Sea under the current water balance of the Dead Sea, and the water level will continue to drop, although at a slower rate than today. Under this scenario, the biological parameters will not change relative to the present, and the surface water will still be too concentrated to allow biological blooming.

In case of epilimnion density below 1210 kg/m³ blooming of both *Dunaliella* and *halophilic Archaea* may occur, while in case of density below 1145 kg/m³ blooming of *Cyanobacteria* may occur.

The 1500 MCM/yr of seawater and WB1 scenarios should be rejected as the lake raises the level above -400 m.

Whether or not the Dead Sea will remain monomictic under this scenario depends upon how the industrial end-brines mix in the water column. The inflow of the industrial end-brines is a major factor controlling the dynamics of the Dead Sea and the evolution of the Dead Sea composition under present condition and in any future scenario. The end-brines are much denser than the Dead Sea brine

Conclusion:
seawater or desalination reject brine should be discharged to the Dead Sea in **phases** of 200-300 MCM/y every ~10 y,
"Stages Approach"

Greg Walch

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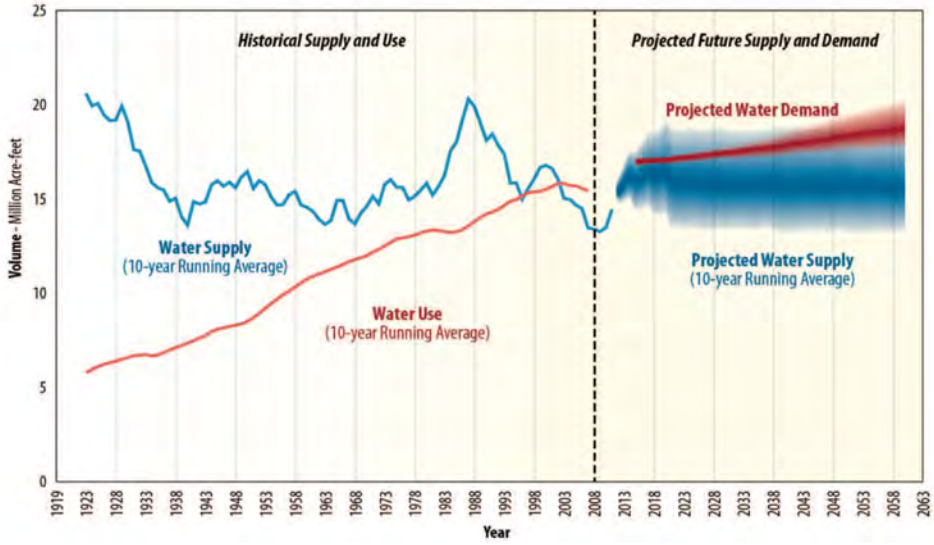

Historical Supply and Use
Projected Future Supply and Demand
Projected Water Demand
Water Supply
(10-year Running Average)
Water Use
(10-year Running Average)
Projected Water Supply
(10-year Running Average)
Volume - Million Acre-feet
Year
0
5
10
15
20
25
1919
1923
1928
1933
1938
1943
1948
1953
1958
1963
1968
1973
1978
1983
1988
1993
1998
2003
2008
2013
2018
2023
2028
2033
2038
2043
2048
2053
2058
2063


CANADA
WASHINGTON
OREGON
CALIFORNIA
IDAHO
NEVADA
MONTANA
WYOMING
UTAH
ARIZONA
COLORADO
NUEVO MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LOUISIANA
WISCONSIN
ILLINOIS
MICHIGAN
INDIANA
OHIO
KENTUCKY
TENNESSEE
MISSISSIPPI
ALABAMA
GEORGIA
FLORIDA
SOUTH CAROLINA
NORTH CAROLINA
VIRGINIA
WEST VIRGINIA
PENNSYLVANIA
NEW YORK
MAINE
VERMONT
NEW HAMPSHIRE
MASSACHUSETTS
RHODE ISLAND
CONNECTICUT
NEW JERSEY
DELAWARE
MARYLAND
PACIFIC OCEAN
ATLANTIC OCEAN
GULF OF MEXICO
BAHAMAS
CUBA
HAITI
JAMAICA
BELIZE
GUATEMALA
HONDURAS
NICARAGUA
BAJA CALIFORNIA
BAJA CALIFORNIA SUR
SONORA
CHIHUAHUA
COAHUILA
NUEVO LEON
DURANGO
SINALOA
NAYARIT
JALISCO
COLIMA
MICHOACAN
GUERRERO
MORELOS
OAXACA
CHIAPAS
TABASCO
CAMPECHE
YUCATAN
QUINTANA ROO
QUERETARO
HIDALGO
TLAXCALA
VERACRUZ
PUEBLA
MEXICO D.F.
SAN LUIS POTOSI
ZACATECAS
AGUASCALIENTES
GUANAJUATO
TAMAULIPAS
Albers equal area projection

Framework for Mexico Deliveries

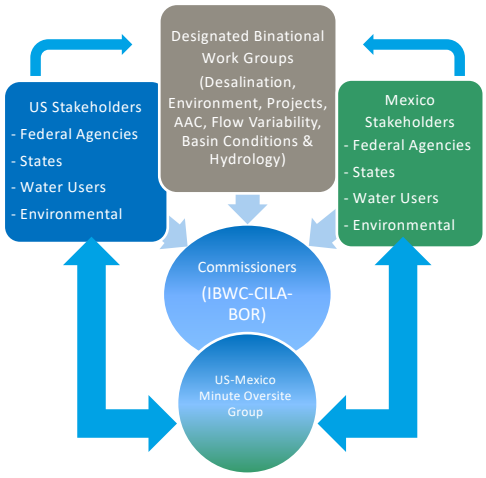
- 1922 Compact
- 1944 Treaty
  - Established IBWC as international body with jurisdiction over boundary areas of Rio Grande and Colorado Rivers
  - Carry out the rights and obligations of the two countries under the Treaty
  - Established means to record and make enforceable "decisions" through "Minutes"

Morelos Dam, Colorado River Pulse Flow.

NOTABLE TREATY MINUTES

- Minute 242 ("Permanent")
- Minute 319 (Through 2017)
- Minute 323 (Through 2026)

Binational Work Group Process



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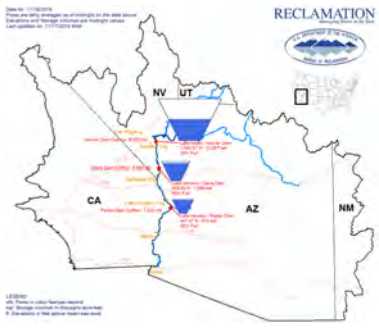
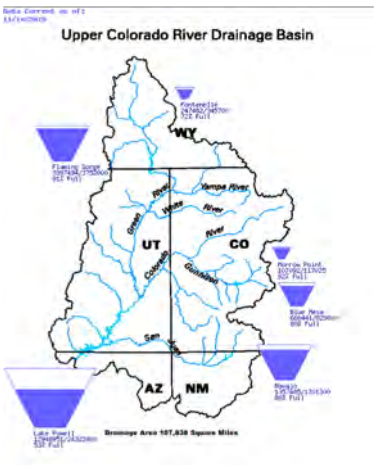
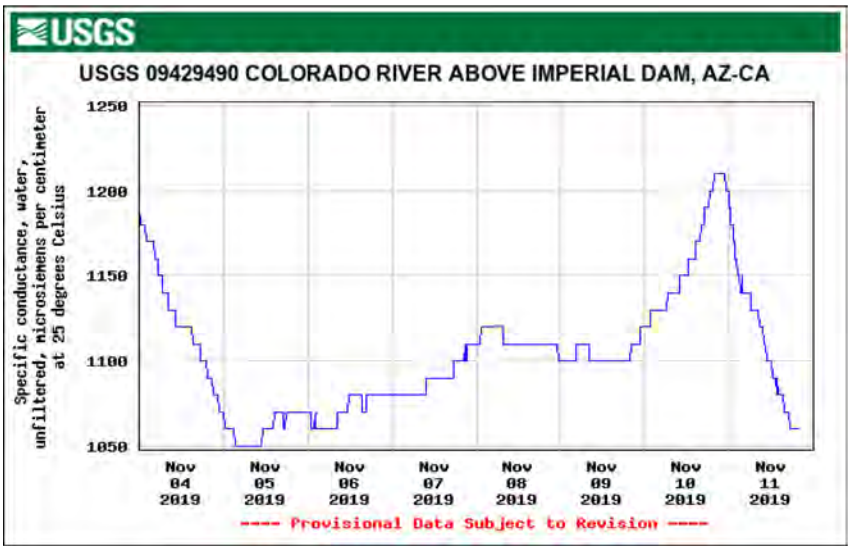




DAILY RIVER REPORT FOR 11-18-2019
PAGE 1
(Releases are averages over the hour.)
(Elevation and storage values are end-of-period readings.)

TIME (MST)	MEAD ELEV. (FT)	HOOVER RELEASE (CFS)	MOHAVE ELEV. (FT)	MOHAVE STORAGE (KAF)	DAVIS RELEASE (CFS)	HAVASU ELEV. (FT)	HAVASU STORAGE (KAF)	PARKER RELEASE (CFS)
0000-0100	1083.12	4852			4707			4477
0100-0200	1083.15	3473			4755			4489
0200-0300	1083.16	2347			4731			4477
0300-0400	1083.15	1960			4731			4465
0400-0500	1083.18	1900			4731			9172
0500-0600								
0600-0700								
0700-0800								
0800-0900								
0900-1000								



Chuck Cullom

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People and Water - Implementing technologies across borders: Yuma Desalting Plant (U.S. – Mexico)

Chuck Cullom
Colorado River Programs Manager
Central Arizona Project

November 19, 2019

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YOUR WATER. YOUR FUTURE.

Colorado River Water Quality Issues

- Water quality higher in the U.S. than in Mexico (700 ppm vs 840 ppm)
- Driver: Agricultural drainage (2600 ppm) returned to the Colorado River
- U.S. return flows increase water use efficiency
- Increased Colorado River salinity harms Mexico crop quality and soils

Yuma Desalting Plant (YDP): Technology to address Water Scarcity

- Conceived as a binational means to use technology to address water scarcity and water quality issues between U.S. and Mexico on the Colorado River:

1973 - Minute #242 – "Permanent and Definitive Solution to the International Problem of Salinity of the Colorado River"

- YDP = Brackish drainage water RO plant, 72 MGD
- Completed in 1992, operated briefly in 1992, 2007 and 2010-2011

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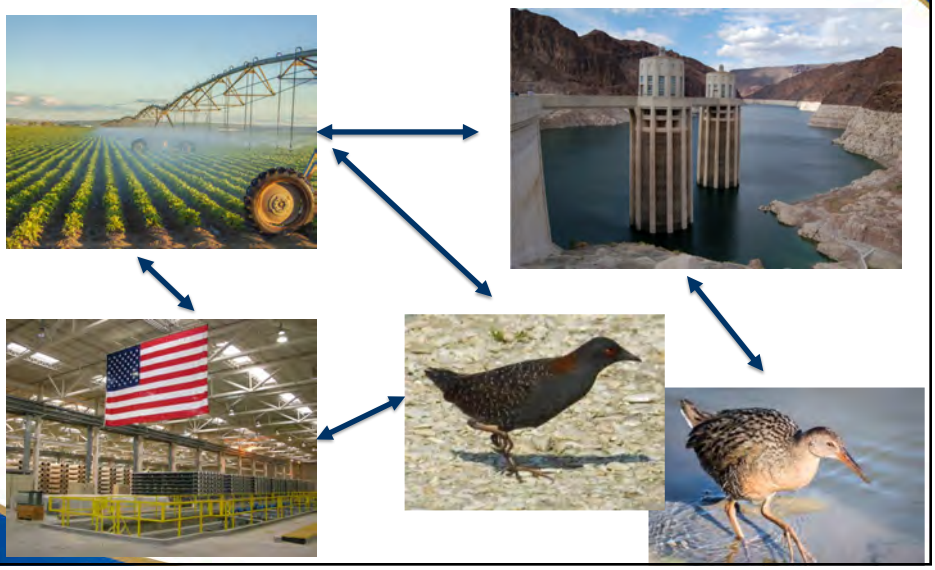
Yuma Desalting Plant, Regional Irrigation Systems, Drainage and CienegaCienega de Santa Clara

Water Scarcity Drives Tension Among water uses and values



Yuma Desalting Plant (YDP): Success & Failure

- Binational work group developed U.S. - Mexico agreement (Minute 316) in 2010-2011 to temporarily operate the YDP to study and test the impacts of operating the plant on U.S. and Mexico environmental values and water conservation goals.
- YDP was not included in Minute 319 nor Minute 323 resulting in the lost opportunity to balance water uses and values.

Sergio Avila

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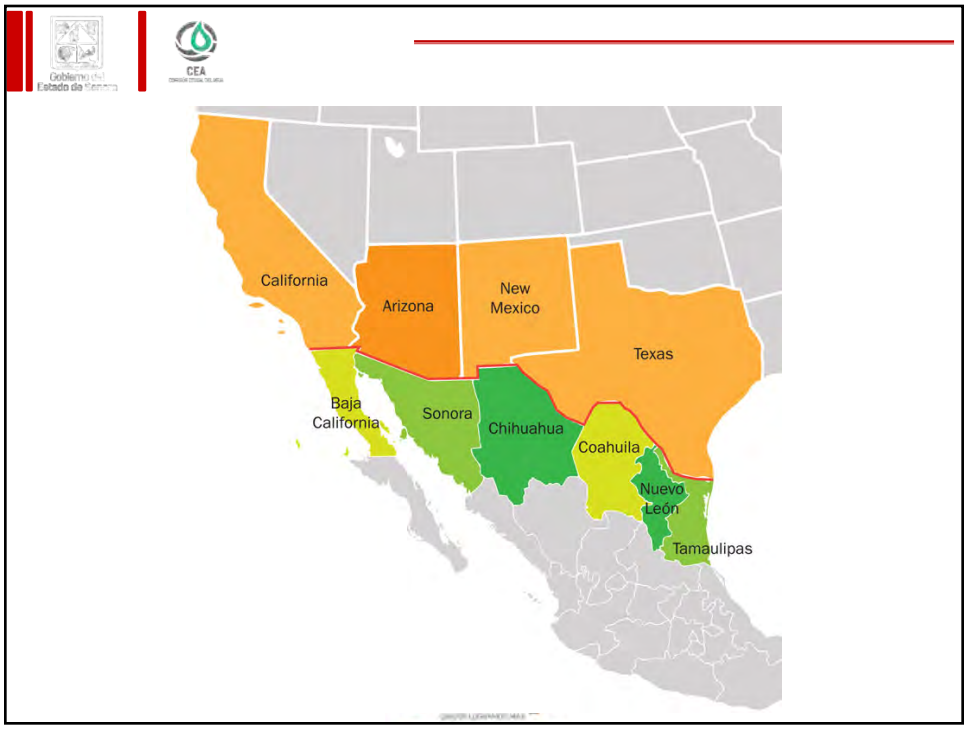
Gobierno del Estado de Sonora

CEA

ARIZONA-MEXICO COMMISSION

ARIZONA MEXICO COMMISSION

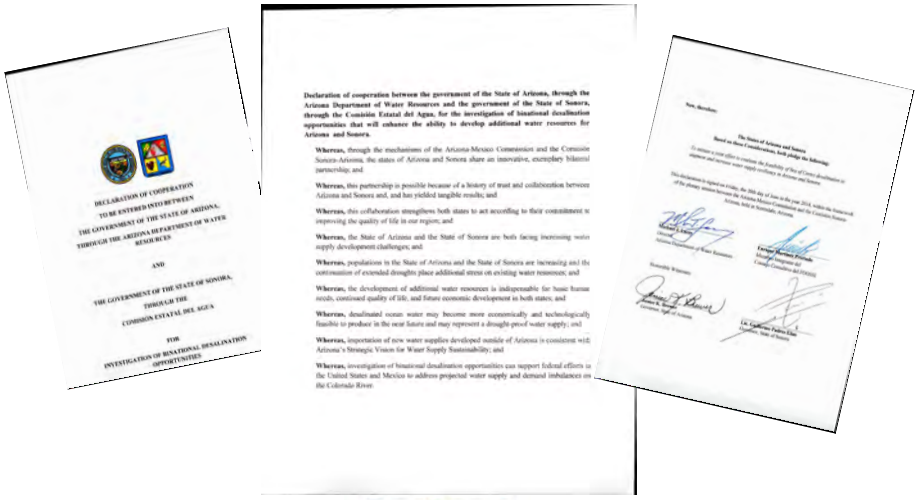
SONORA


California
Arizona
New Mexico
Texas
Baja California
Sonora
Chihuahua
Coahuila
Nuevo León
Tamaulipas


CELEBRATE
60
YEARS
1959•2019
ARIZONA-MEXICO
COMMISSION
SONORA

ANTECEDENTES

Memorándum de entendimiento entre el Arizona y Sonora de Junio del 2014



SONORA

Andrea Alonso

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Binational Study of Water Desalination Opportunities in the Sea of Cortez

- **Reconnaissance level study** to identify potential desalination opportunities along the Sonoran coast of the Sea of Cortez
- **Identification and development** of potential desalination opportunities that provide binational benefit to both Mexico and the United States
- Development of order of **magnitude costs**
- **Provide examples** to see if parties are interested in moving forward with such a concept

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Lela Perkins

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Major Study Tasks

- Summarize projected **unmet demands** in the Colorado River Basin using existing information to confirm the **need for new water sources**
- Identify **existing** and **emerging** desalination and brine management **technologies** and determine appropriateness
- Identify potential desalination **opportunities**
- Develop **information** about each opportunity
- Perform **brine dispersion modeling** for the potential opportunities
- Identify **differentiators** between opportunities, including risks, for future consideration
- Recommend **next steps**

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Technologies Considered in this Study

Desalination

- Reverse Osmosis
- Thermal Distillation
  - Multiple Effect Distillation
  - Multi-Stage Flash Distillation
  - Vapor Compression
- Electrodialysis
- Thermal-Membrane Hybrids

Brine Management

- Ocean Discharge and Dispersion
- Evaporation Ponds
- Deep Well Injection

Emerging

- Enhanced Recovery
- Zero Liquid Discharge
- Seawater Pumped Storage

How Potential Opportunities were Defined

- **Desalination facility location** – Within the defined study area, based on existing land uses/designations and bathymetry
- **Desalination technology** – Identified through the technology analysis
  - Reverse osmosis was recommended for all sites unless there is an existing power plant nearby, in which case a thermal process could be considered
- **Brine management** option – Identified through the technology analysis
  - Ocean discharge and dispersion was recommended for all coastal sites, while deep well injection was recommended for inland sites
- **Delivery/exchange locations** – Identified based on the supply/demand analysis

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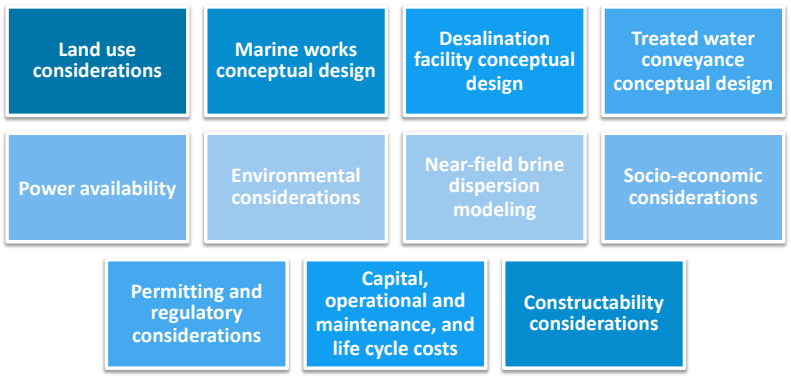
Information Developed for each Potential Opportunity



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Recommended Next Steps

- Tasks to further **refine** the potential opportunities
- **Additional investigation** of power availability and rights-of-way
- Development of an **exchange framework**
- **Comparison** to other identified projects