

from
Tectonicus
Constructs

SOLAR RIVER

Computer Rendering

CalTestBed



GEORGE CAIRO ENGINEERING, INC.



CAPLA / CAP class 2017



from
Tectonicus
Constructs

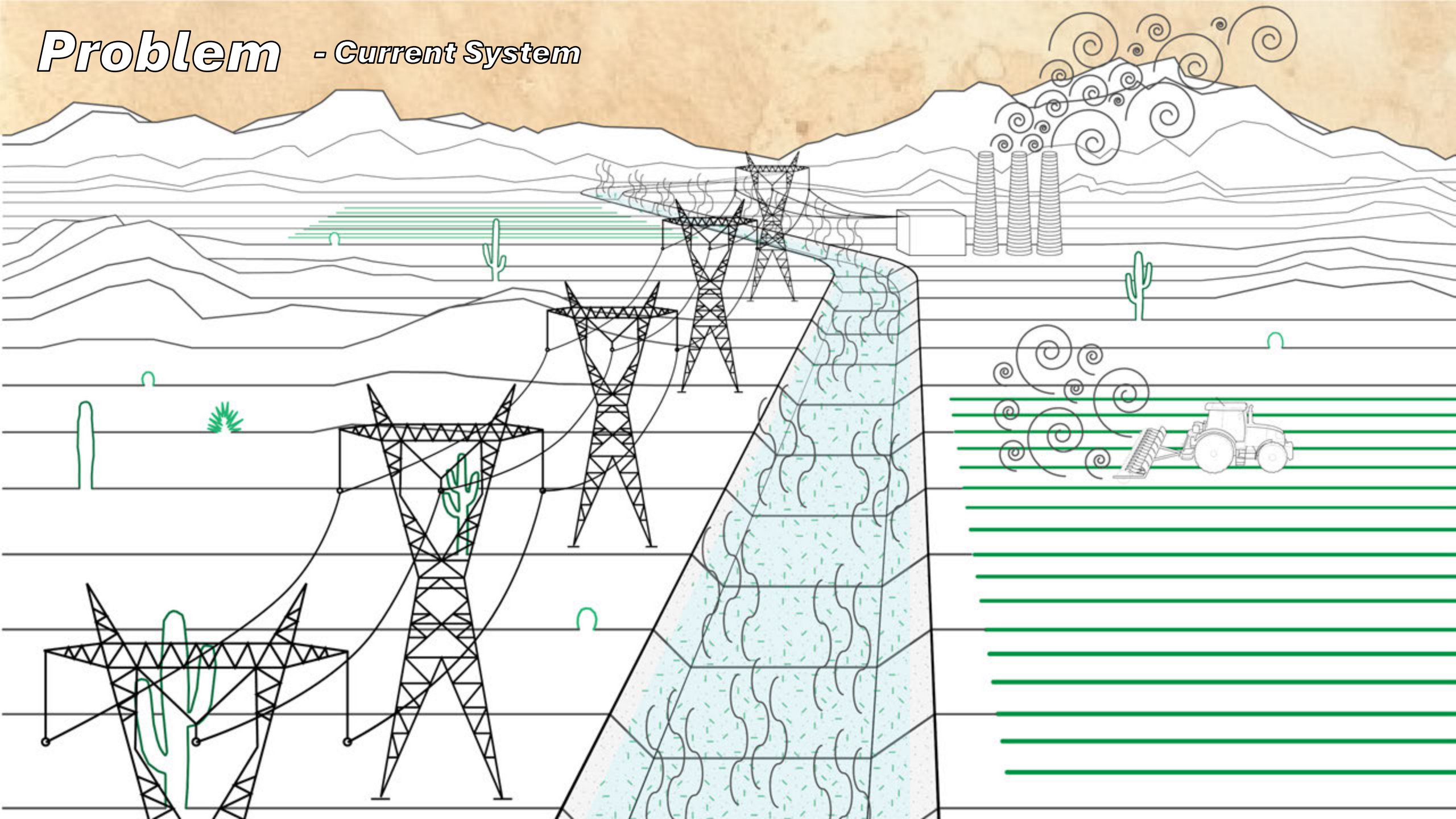
SOLAR RIVER

Computer Rendering

CalTestBed



Problem - Current System



Canal-Spanning Solar Projects (CS) versus Land-Based Solar Projects (LS)



Addressing Concerns from the Bureau of Reclamation

RECLAMATION
Managing Water in the West

Fundamental Considerations Associated with Placing Solar Generation Structures at Central Arizona Project Canal

Central Arizona Project, Arizona
Lower Colorado Region

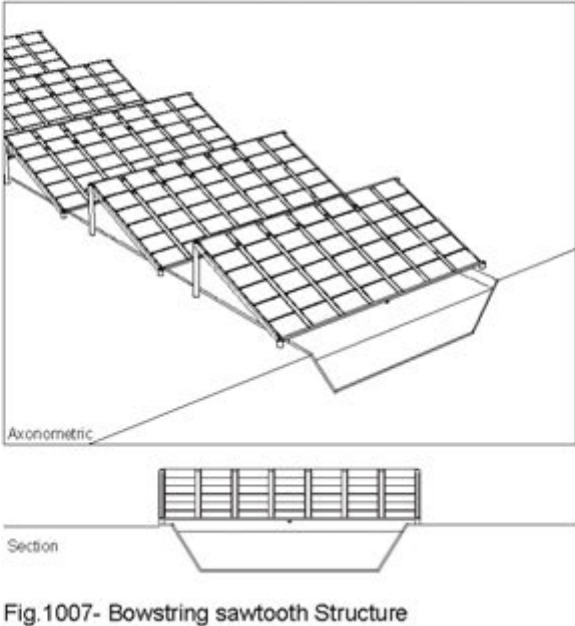
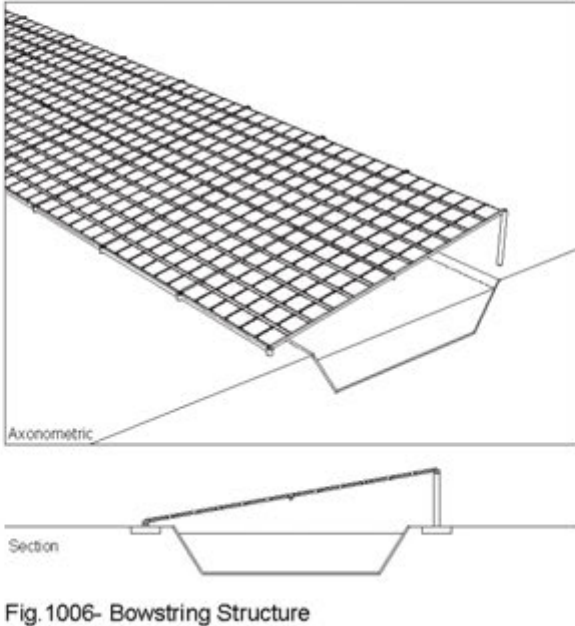
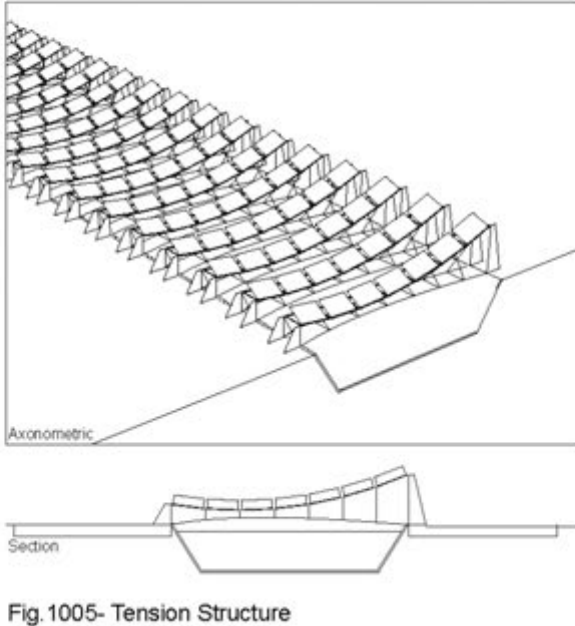
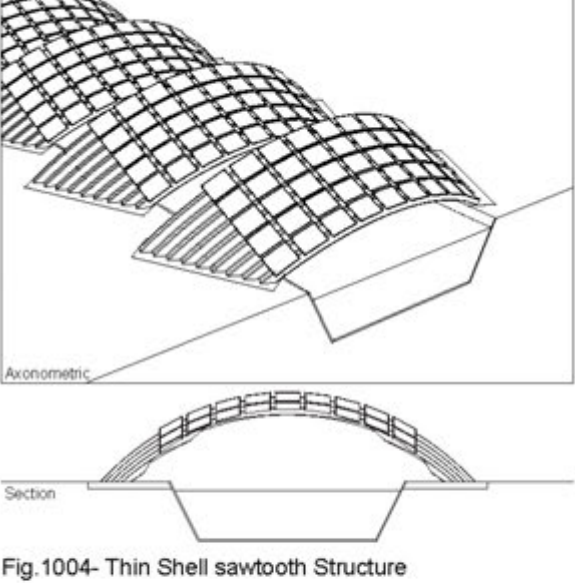
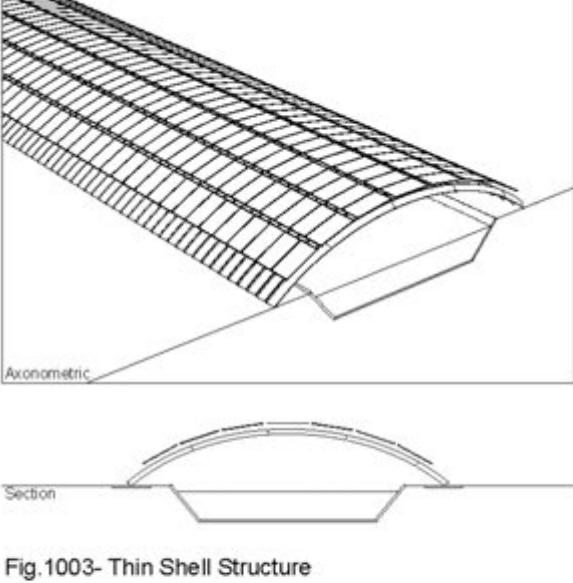
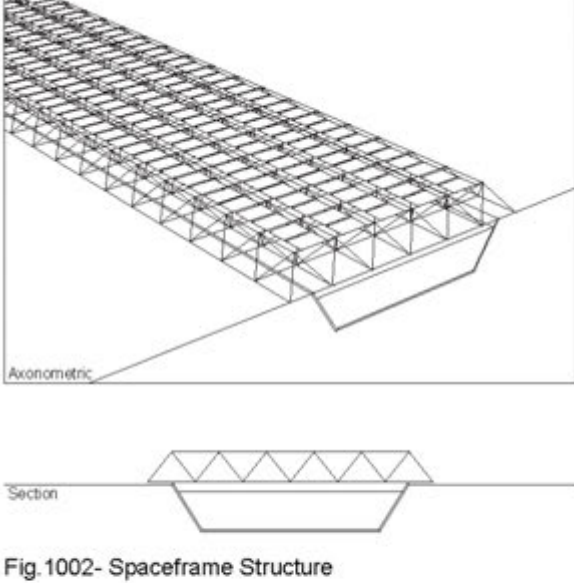
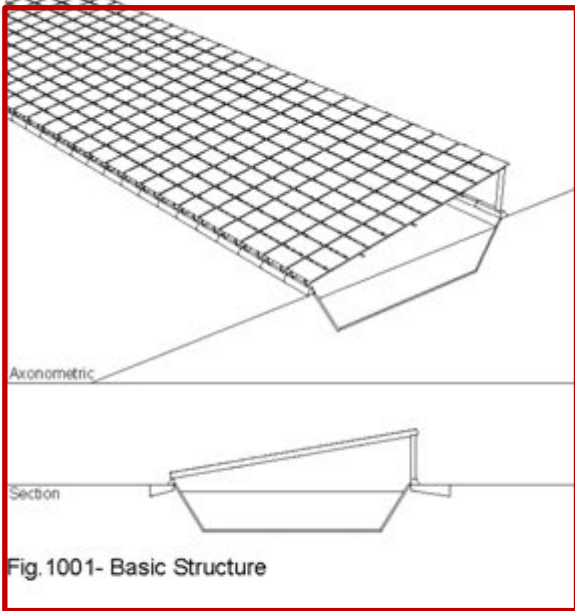


U.S. Department of the Interior
Bureau of Reclamation

May 2016

Modularity vs Lowest LCOE

'Levelized Cost Of Energy'



Construction Sequencing

modular, fast, safe

Patented

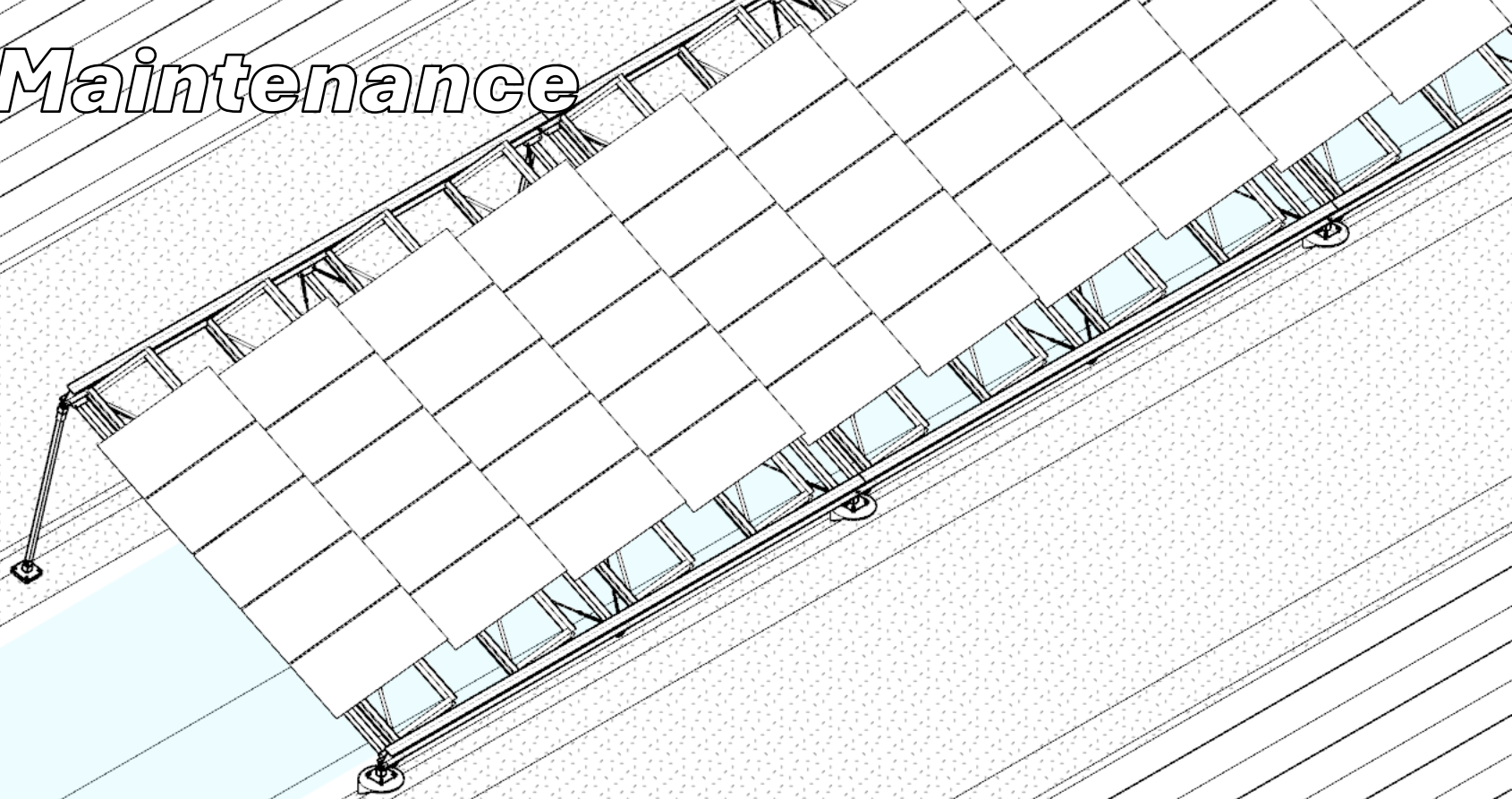
Canals Deliver Water First and Foremost

***Canal-Solar cannot get in the way
of canal operations
and maintenance***



Operations and Maintenance

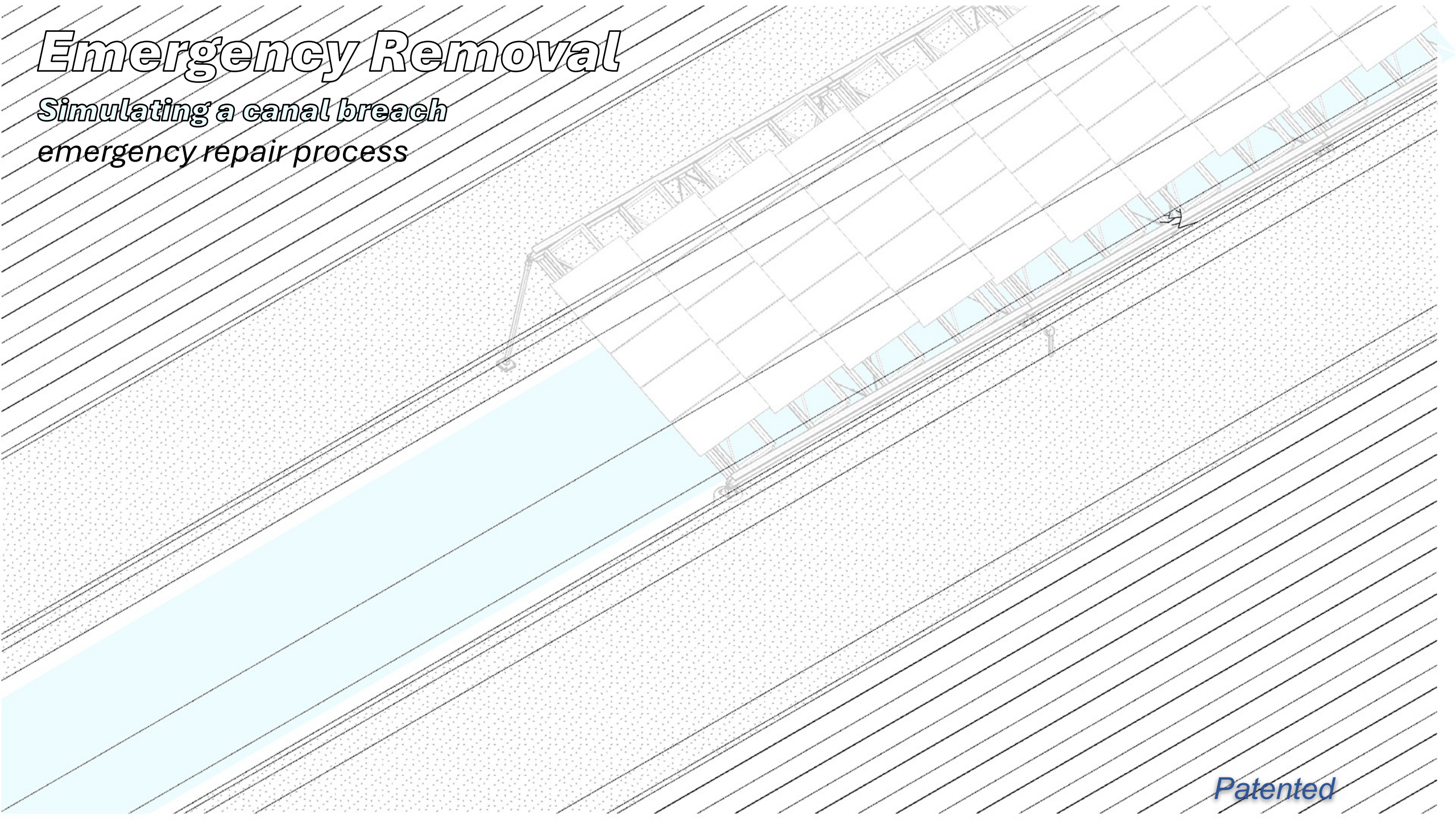
*Drag-chain sequencing
under Canat-Solar*



Patented

Emergency Removal

*Simulating a canal breach
emergency repair process*



Patented

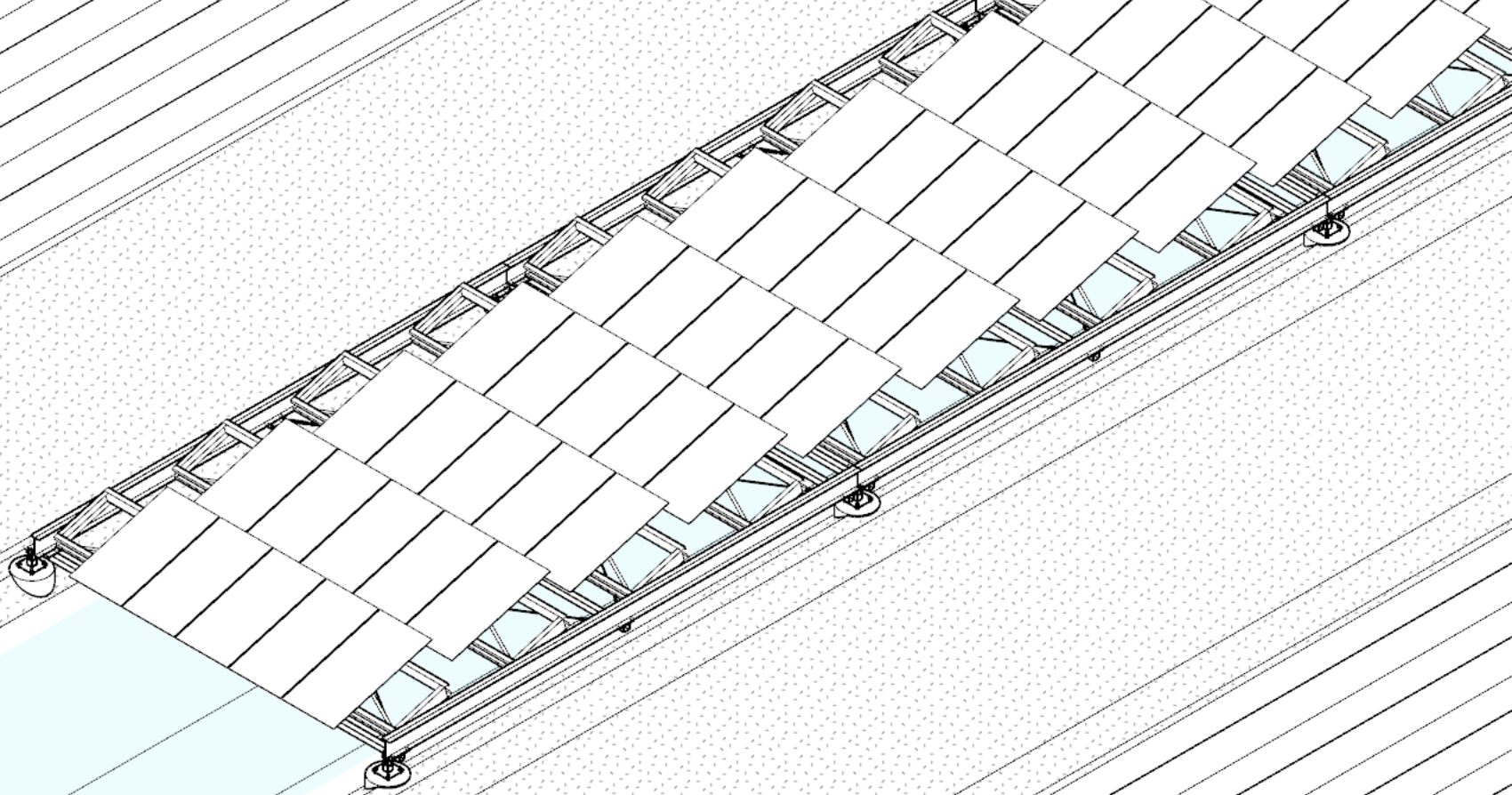
Issues



Canal Access

Emergency access

- Cows
- Couches
- Cars



Patented

Techno-Economic Research

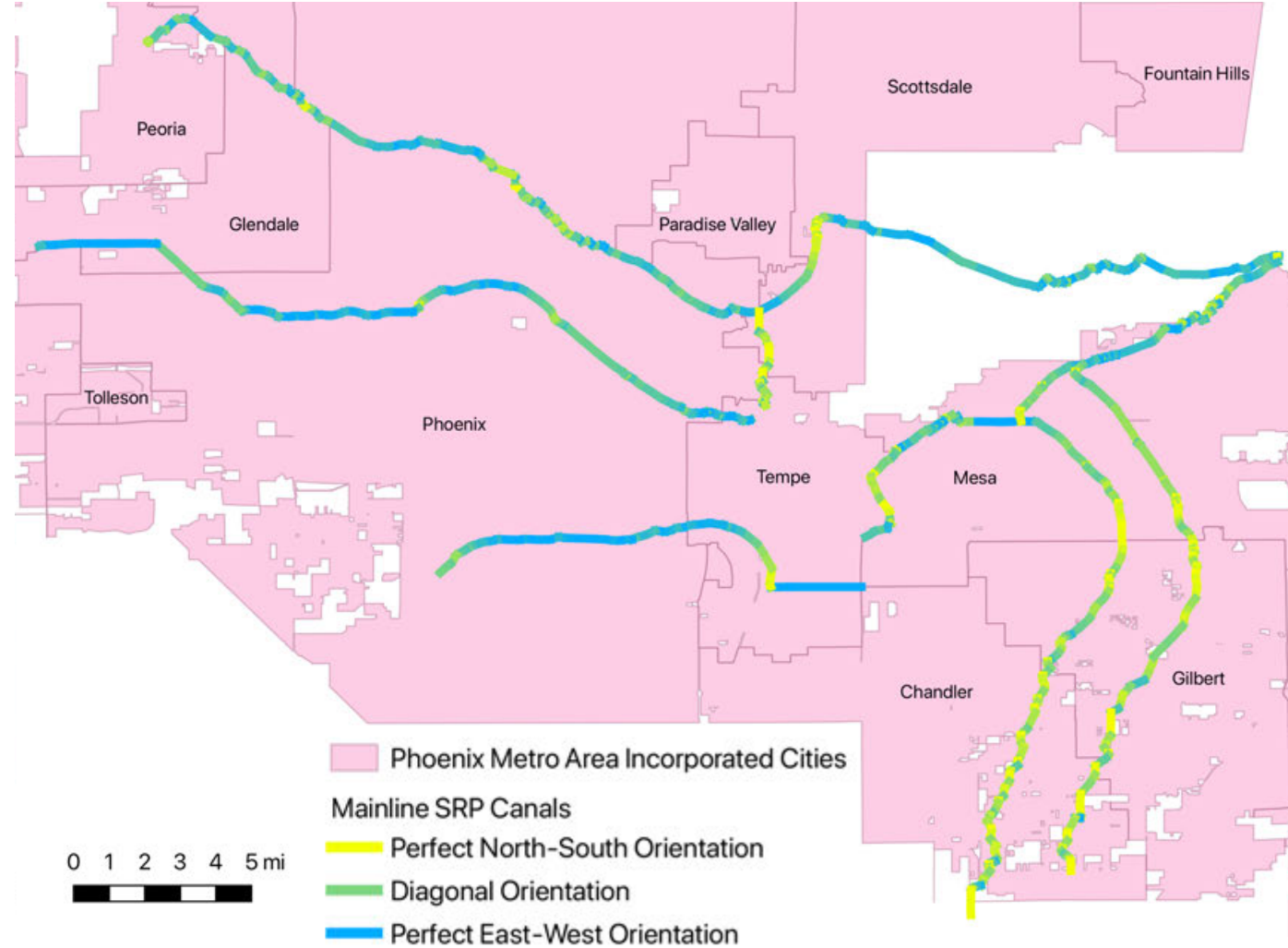
The Bisbee Science Lab Testing

+

SRP GIS Modeling and Analysis



The Bisbee Science Lab Prototype; Two sets of solar panels, one over dry land and another over a pond, with an open pond in the forefront of the image.



SRP mainline canal map

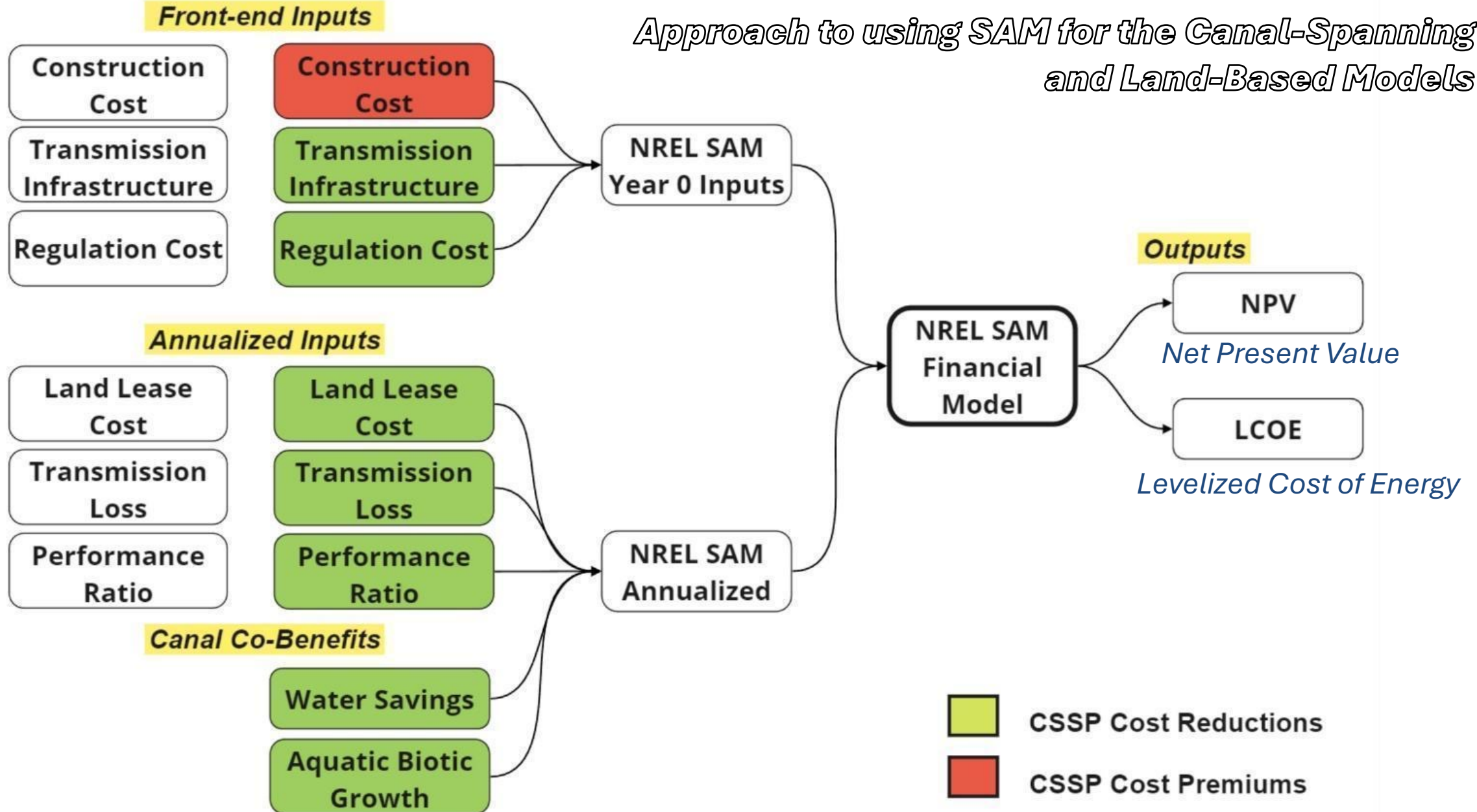
LAND-BASED

vs

CANAL-SOLAR

Techno-Economic Research








Approach to using SAM for the Canal-Spanning and Land-Based Models



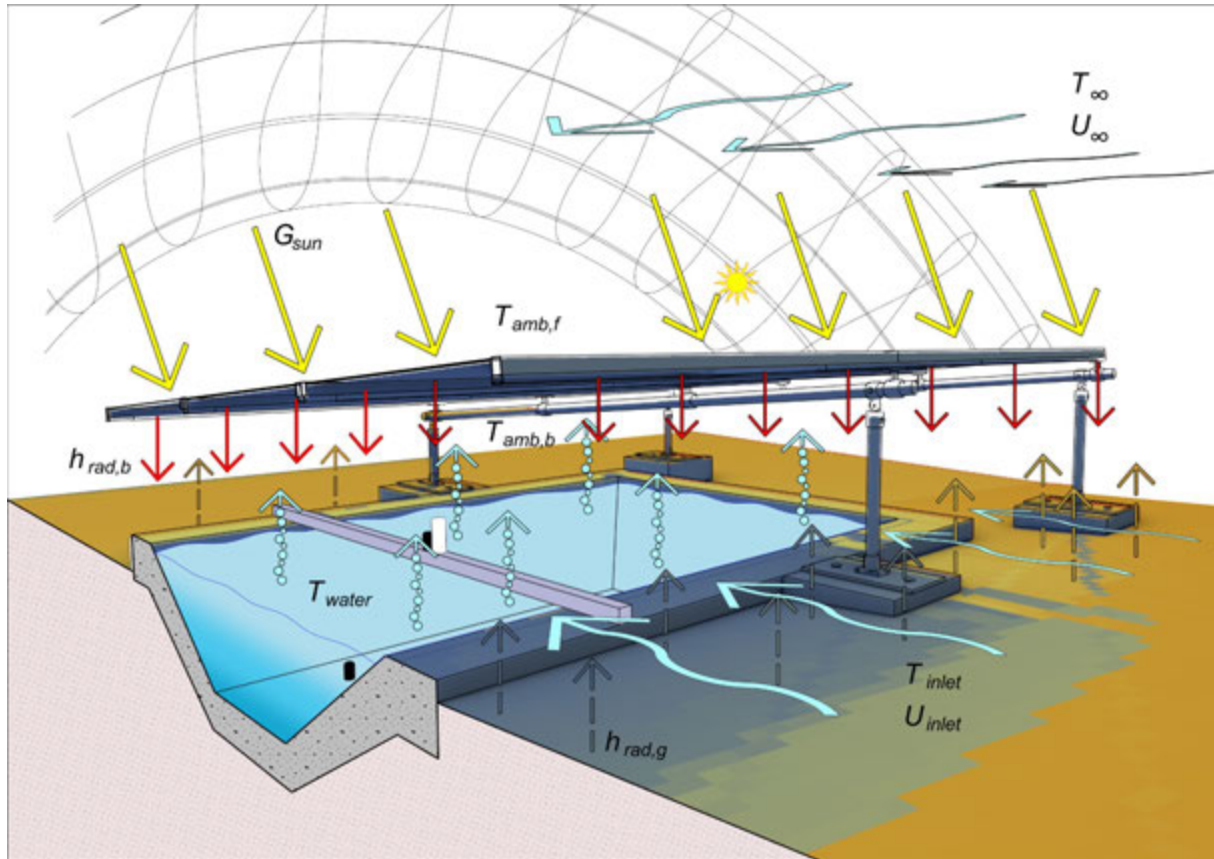
Power

1.9% boost (21 GWh) in generation
valued at approximately 2,300,000/year

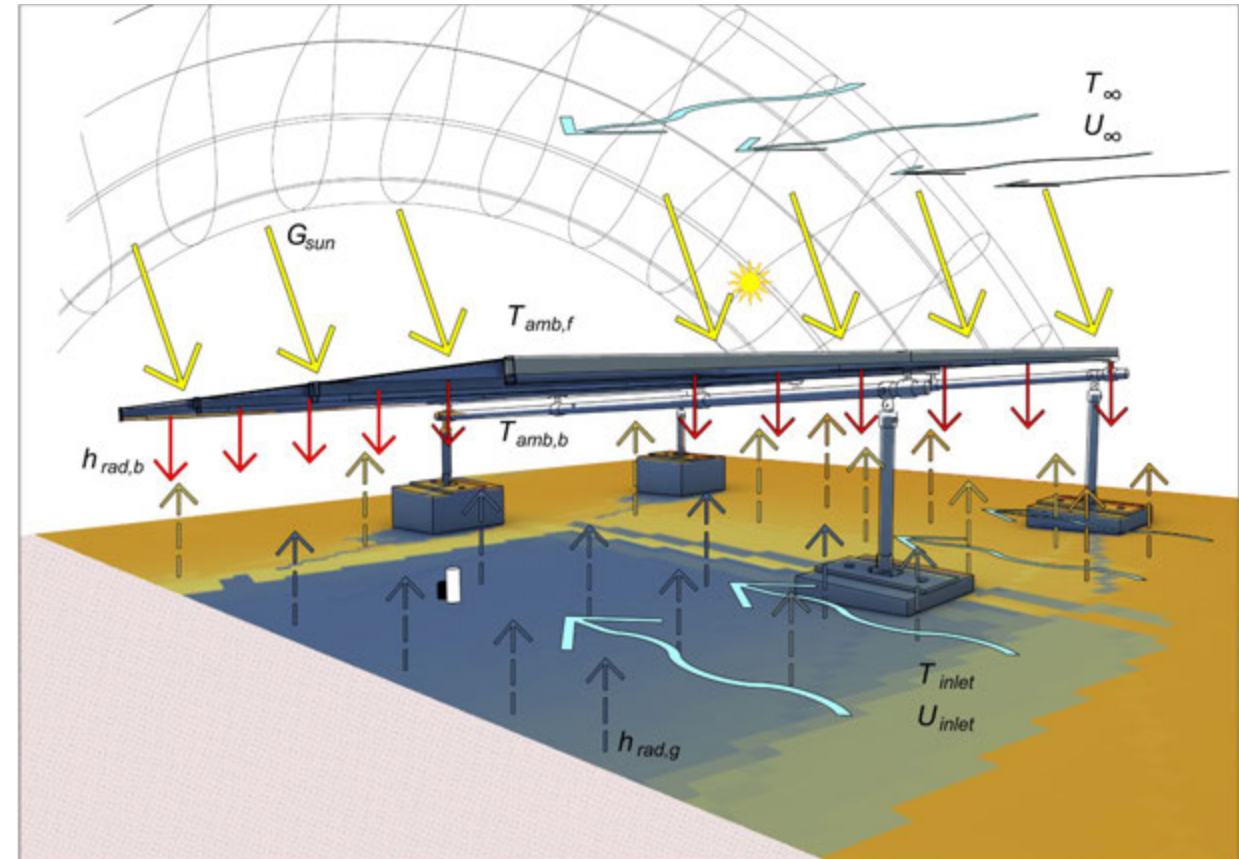
LEGEND:

-  Anemometer
-  Pyranometers
-  Wind (U)
-  Solar Radiation (G_{sun})
-  Evaporation
-  Reflected Solar Radiation ($H_{rad,g}$)
-  Back Panel Radiation ($H_{rad,b}$)
- T (inlet) = air temperature at the inlet
- T (inf) = air temperature at infinite distance from PV
- T (amb, f) = air ambient temperature just above the front of PV
- T (amb, b) = air ambient temperature just below the back of PV
- T (water) = water temperature
- U (inlet) = wind speed at the inlet
- U (inf) = wind speed at infinite distance from PV

INCIDENT RADIATION (kWh/m²):



Depiction of the thermal process for CSSP

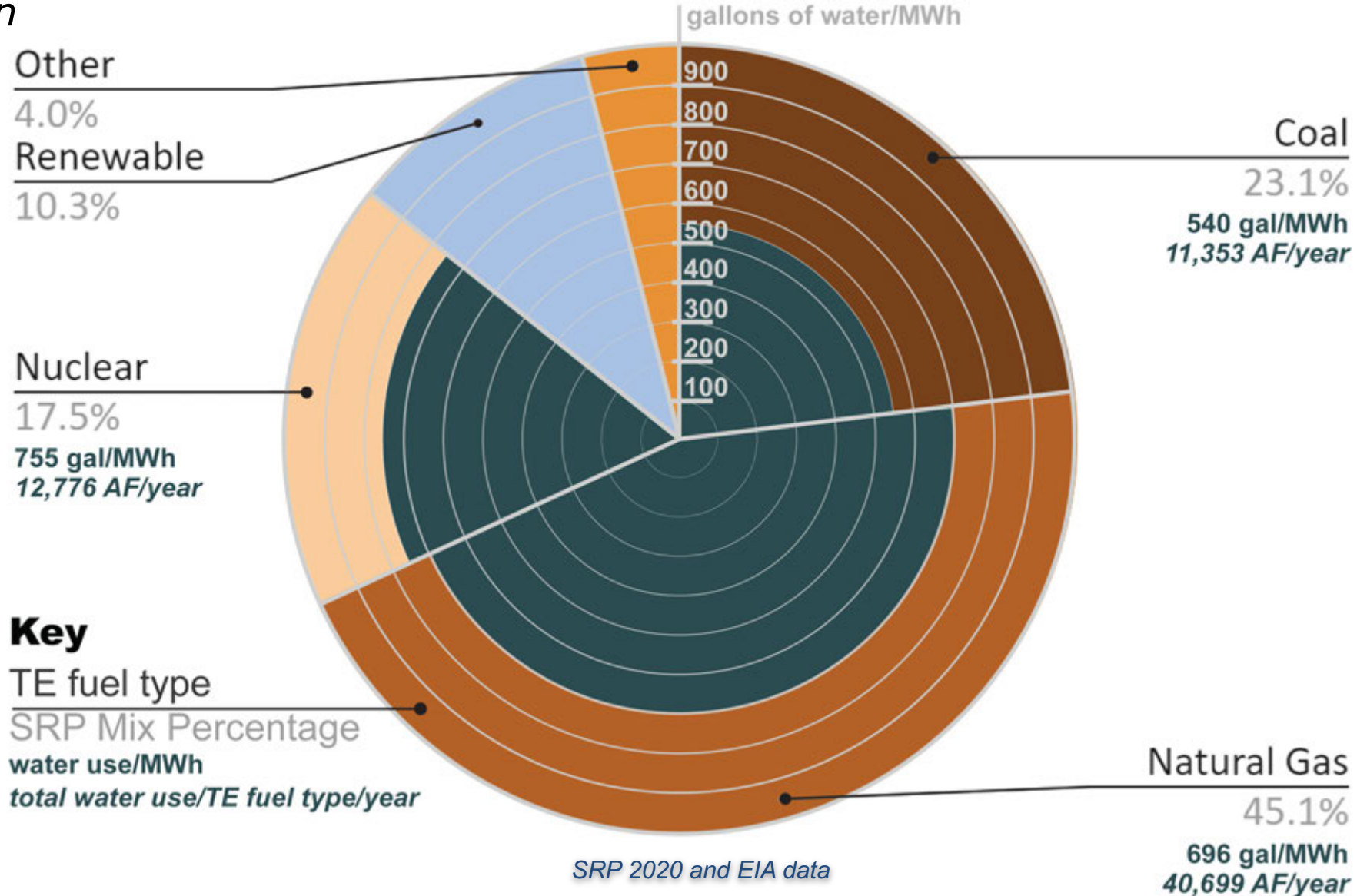


Depiction of the thermal process for LBSP

Power

2,540 AF/year of thermoelectric water consumption offset by Canal-Solar PV generation valued at approximately \$7,600,000/year

SRP's Dirty Footprint
85.7% Thermo-Electric
68.2% Fossil Fuels
31.8% Non-Fossil Fuels



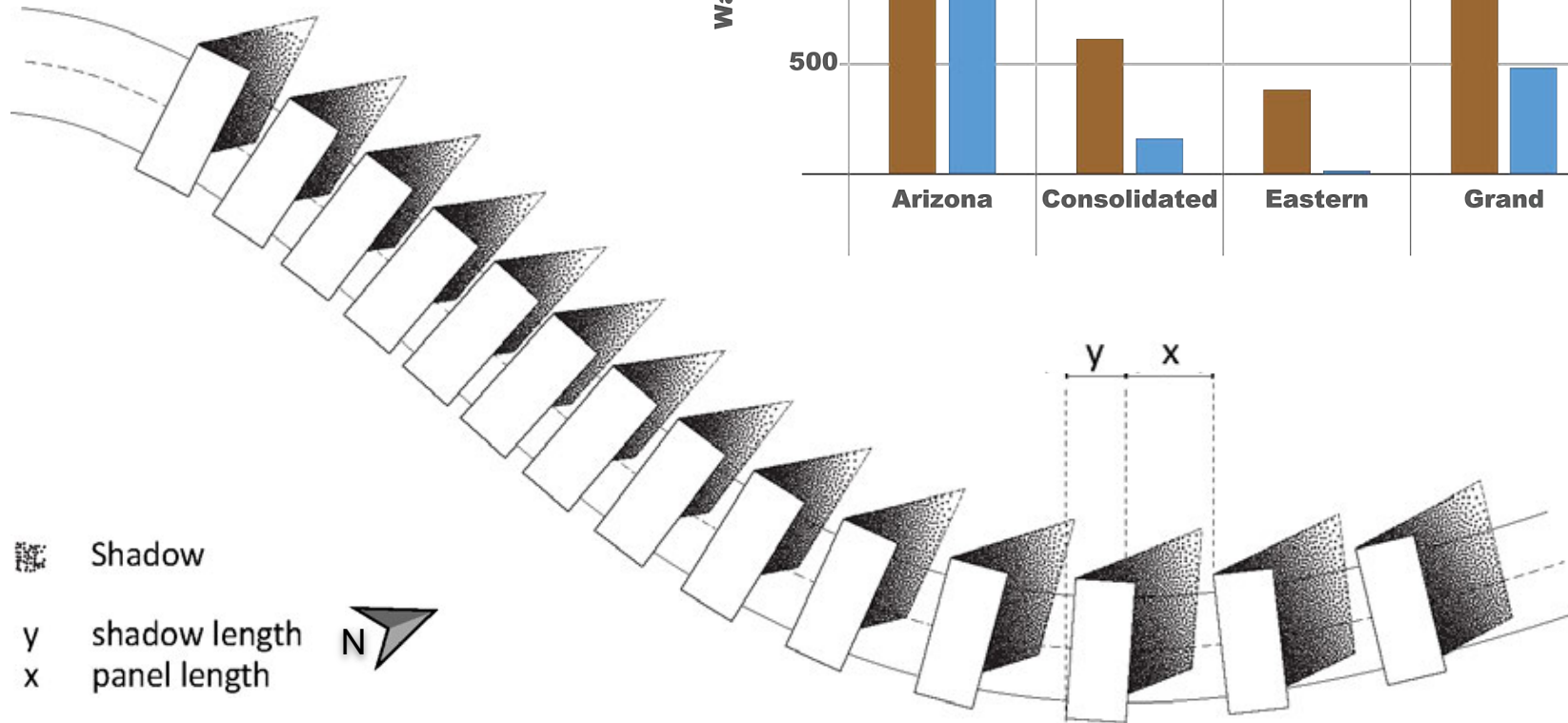
Water

80.6% shading

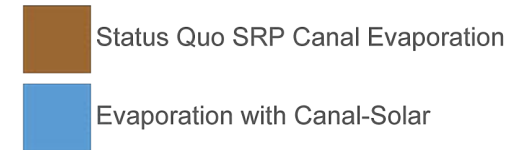
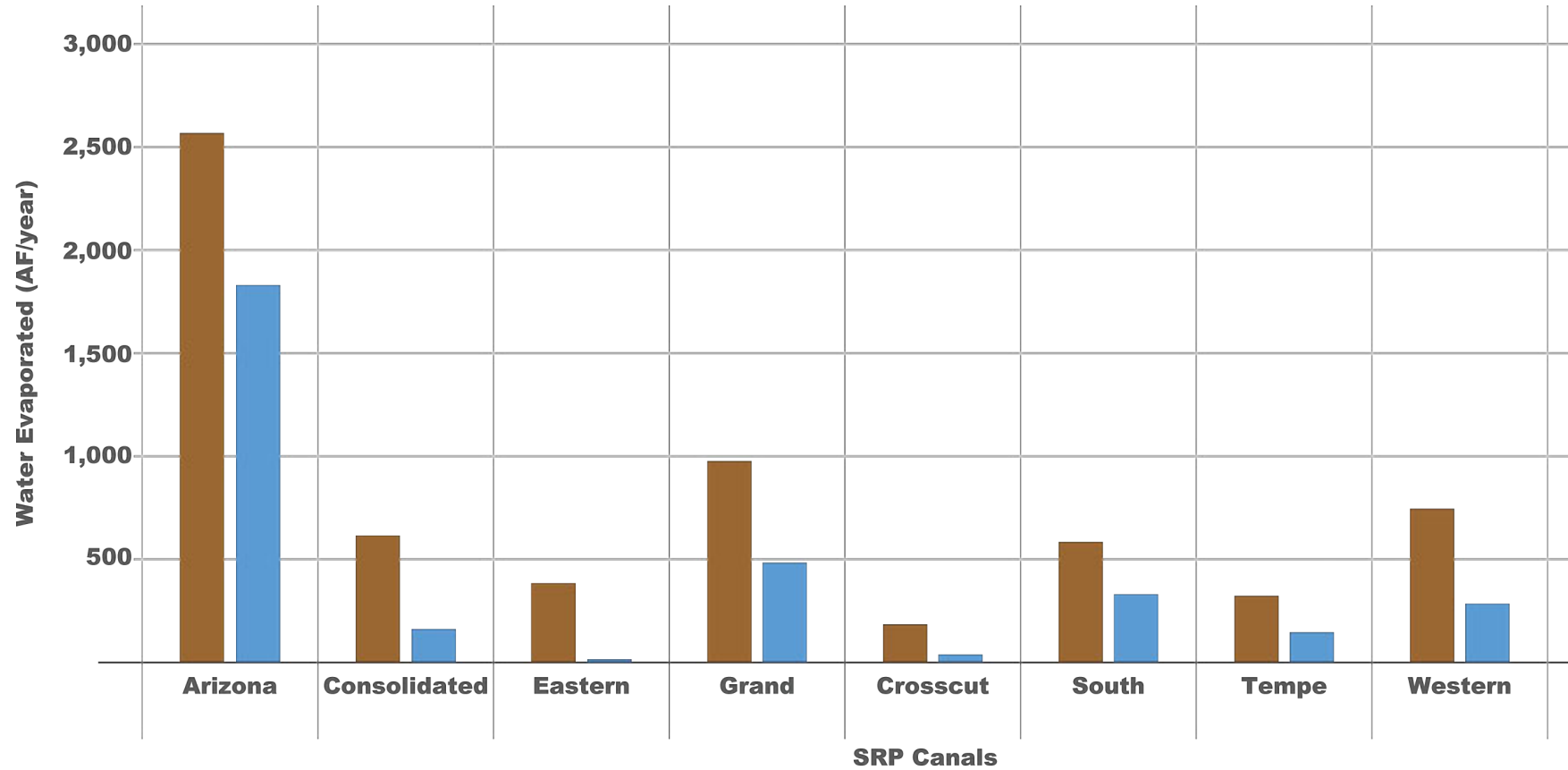
3,100 AF/year saved
valued at approximately
\$9,200,000/year

Status Quo:

6,400 AF/year water loss



Total Water Evaporation Per SRP Canal



Water

\$47,300,000 (80.6%) annual savings

Algae Treatment Budgets on SRP system for 2020

- SRP Carp Herding
- City of Phoenix
- City of Glendale
- City of Scottsdale
- City of Peoria
- City of Tempe
- City of Chandler
- Town of Gilbert

PV Chemistry

- Common Si cells won't leach heavy-metals (use these)
- Avoid Pb
- Avoid Cd Te
- Avoid CIGS (thin film)
- Avoid Perovskites



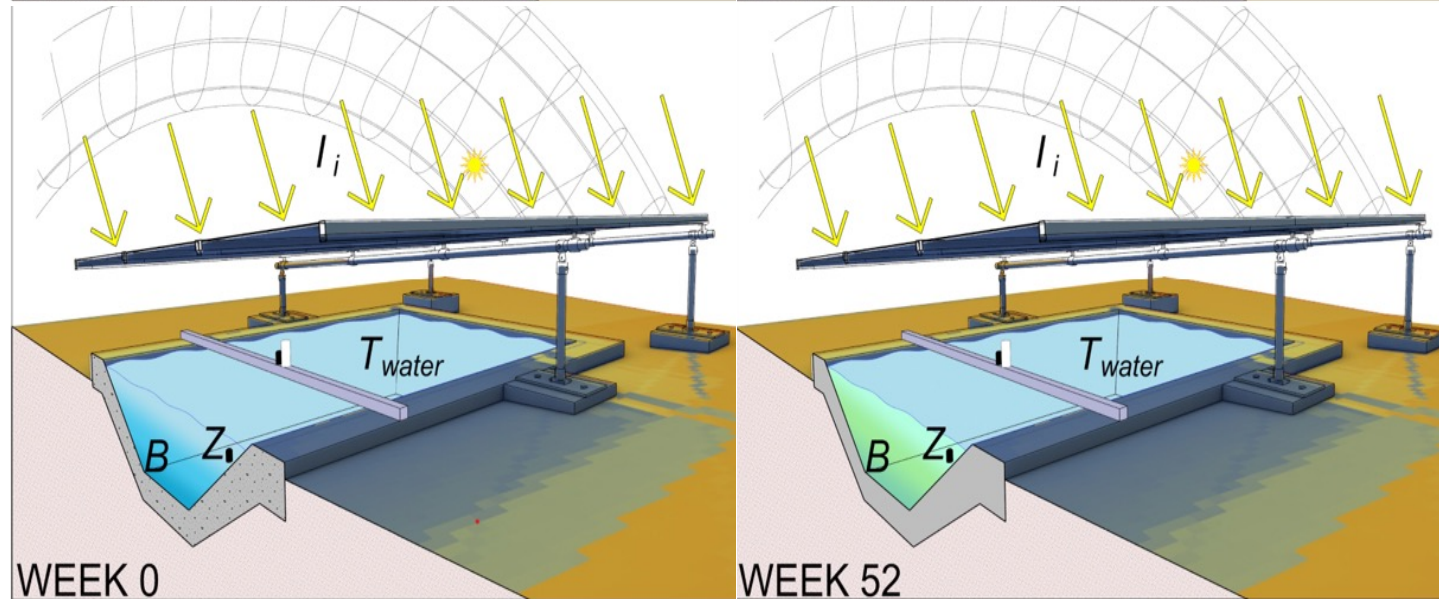
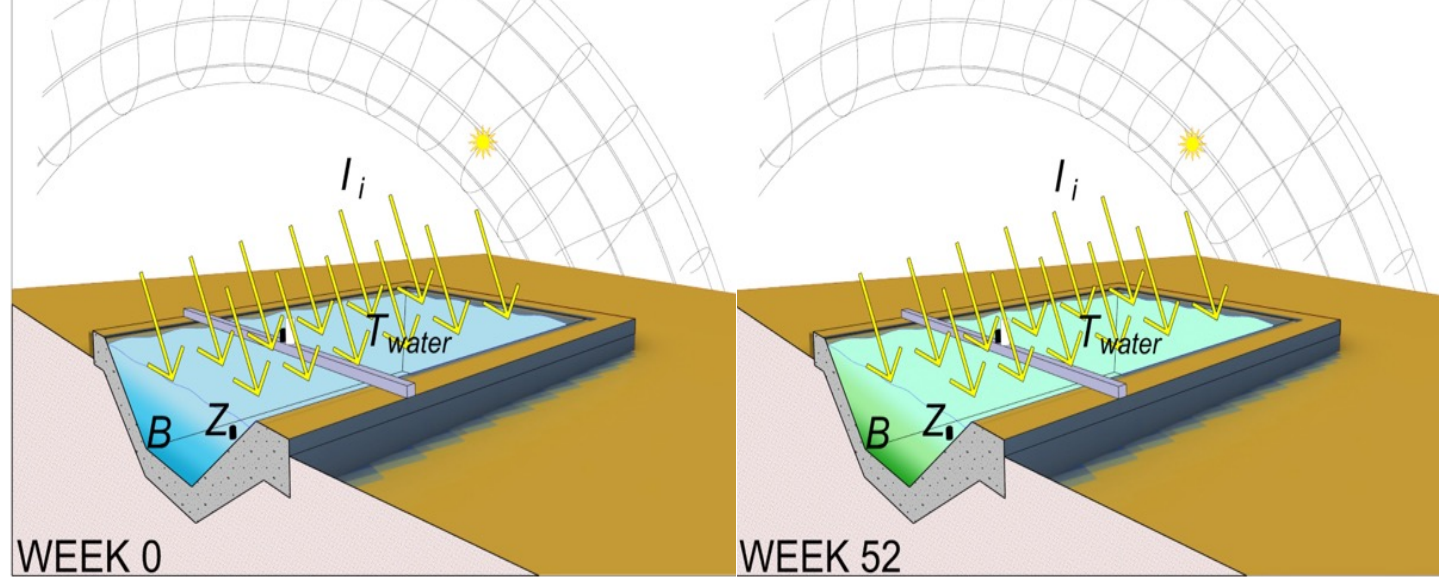
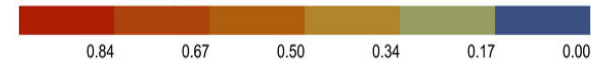
Bisbee Lab; sampling sessile algae

LEGEND:

- Anemometer
- Pyranometers
- ↖ Wind (U)
- ↘ Solar Radiation (G sun)

- B = algae concentration
- $i(i)$ = solar irradiation at pond surface
- T (water) = water temperature
- Z = downward distance measured from pond surface

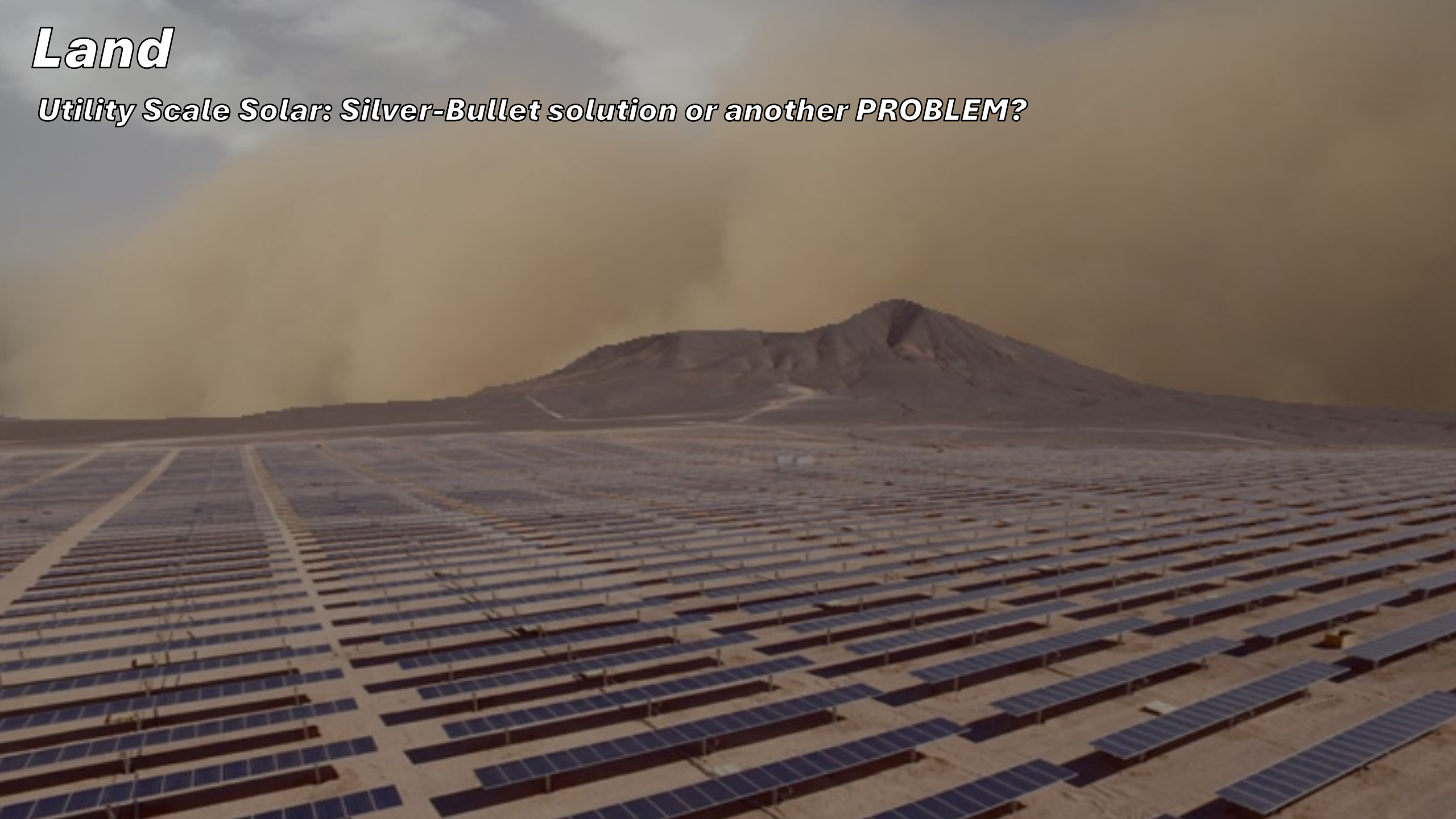
INCIDENT RADIATION (kWh/m²):



Comparison of the algae growth between shading and sunny conditions

Land

Utility Scale Solar: Silver-Bullet solution or another PROBLEM?



Land

Utility Scale Solar: Silver-Bullet solution or another PROBLEM?



New Utility-scale solar between multiple new neighborhoods, Valencia Rd, Tucson.

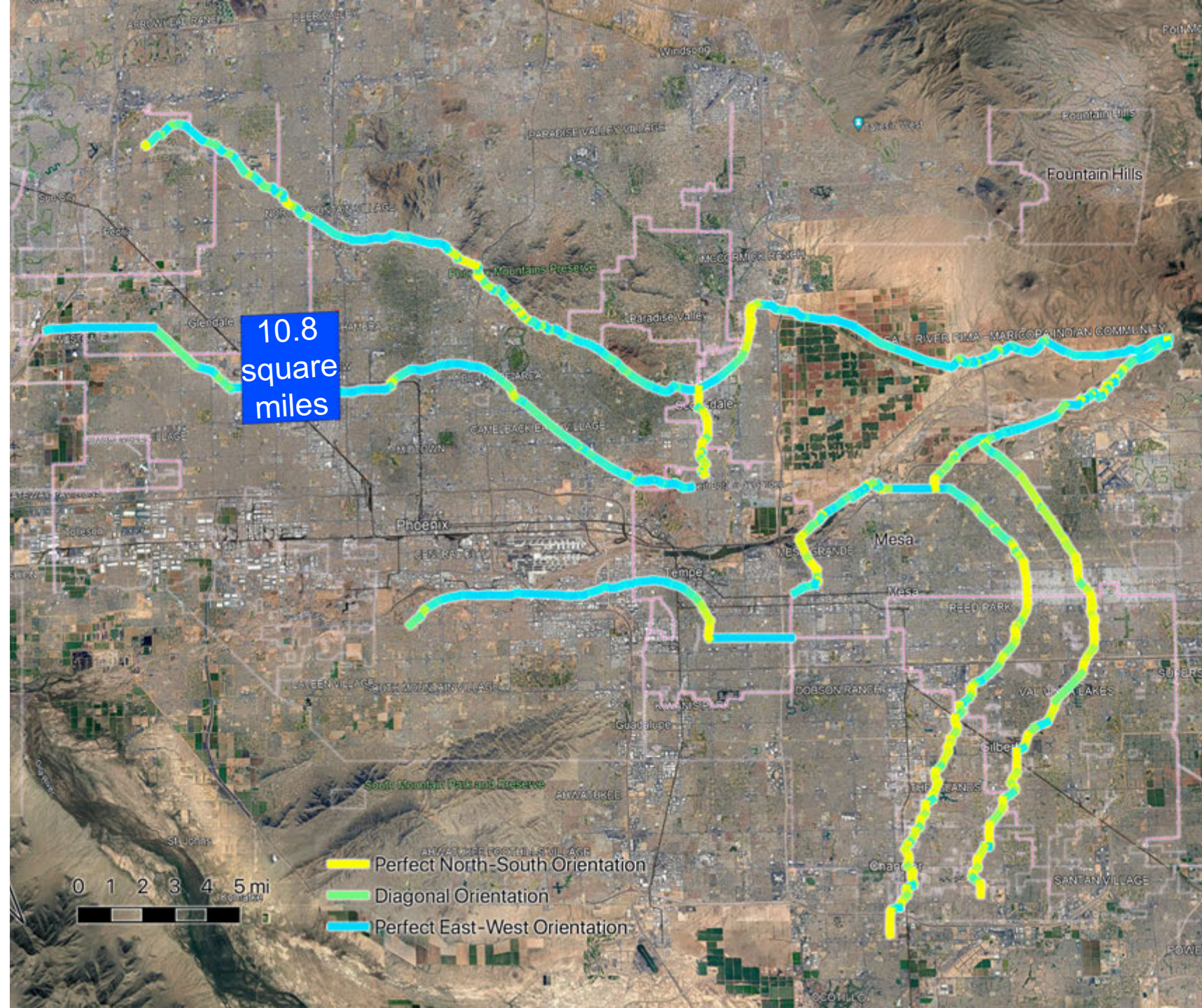
Land

716 MW

nameplate PV capacity

1.12 ac/MW Canal-Solar
on dual use land versus
8.8 ac/MW Land-Based
on virgin land

7.8x increased density
over Land-Based Solar



Land

716 MW

nameplate PV capacity

*1.12 x greater
nameplate capacity
than Apache Coal Plant
in Willcox*



Land

10.8 square miles equivalent utility-scale Land Use

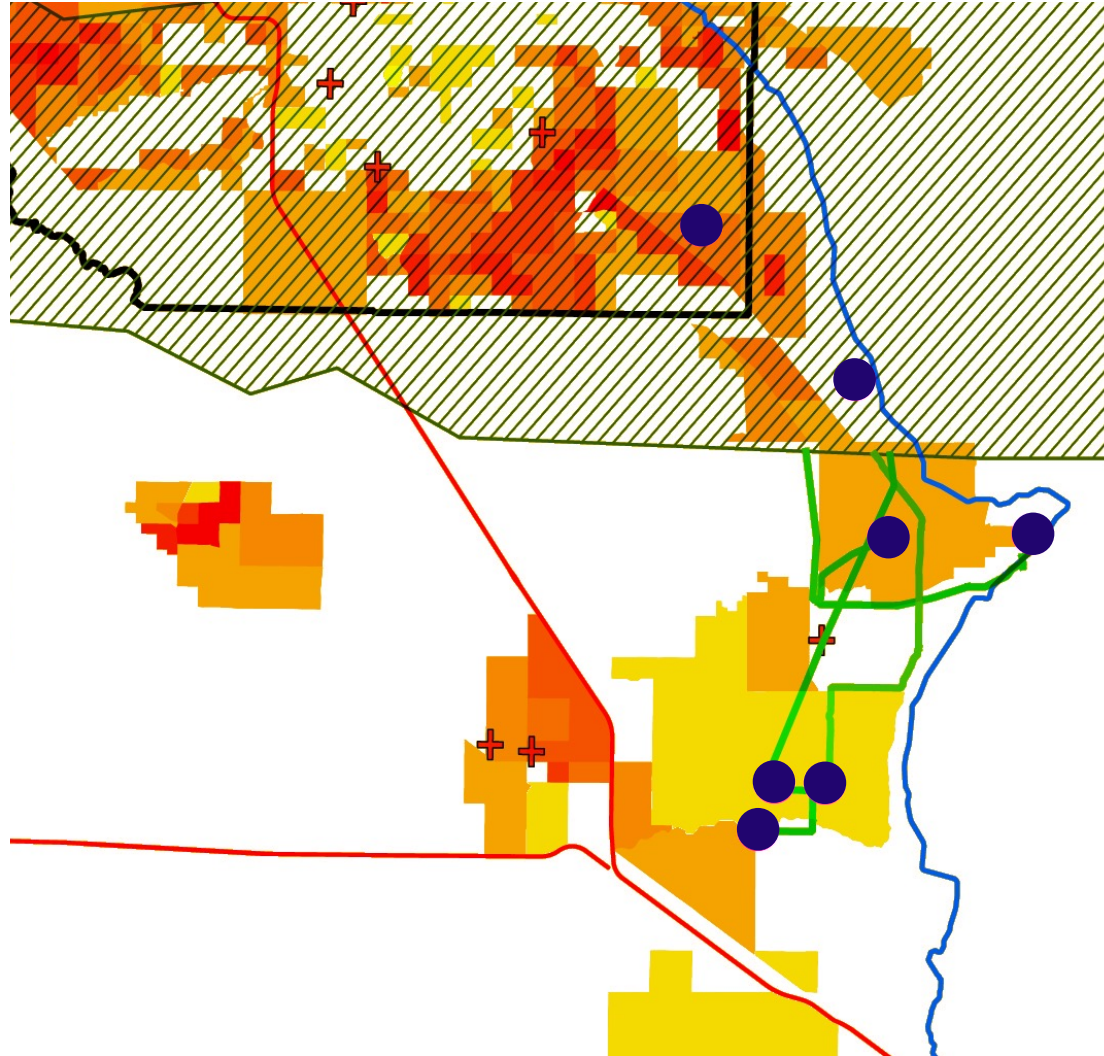


Land

7.4% transmission loss

approximately 90,000,000 kWh/year | \$9,800,000/year

@ SRP's average retail electricity rate of \$0.1092/kWh



Legend

- CAP Canal
- Interstate Highways
- ▭ Arizona State Boundary
- Urban Percent Change 2008 - 2018
 - ≤ -0.0588
 - ≤ -0.0067
 - ≤ 0.0074
 - ≤ 0.0231
 - ≤ 0.0445
 - ≤ 0.0723
 - ≤ 0.1149
 - ≤ 0.1827
 - ≤ 0.3059
 - ≤ 0.4700
- Utility-Scale Solar
- ▨ SRP service area
- SRP transmission line

Summary

SRP Canal-Spanning Solar Panels

Power

- *132 miles of canal = 716 MW*
- *Generates nearly 1,300 GWh/year (Power for approximately 240,000 people annually)*
- *900,000 metric tons of Co2 emissions offset per year*

Water

- *Saves 2,580 AF/year of water from TE offset*
- *Saves 3,070 AF/year of water from evaporation reduction*
- *Water for 34,500 people annually*
- *Algae treatment savings of \$47m/year to water ratepayers*

Land

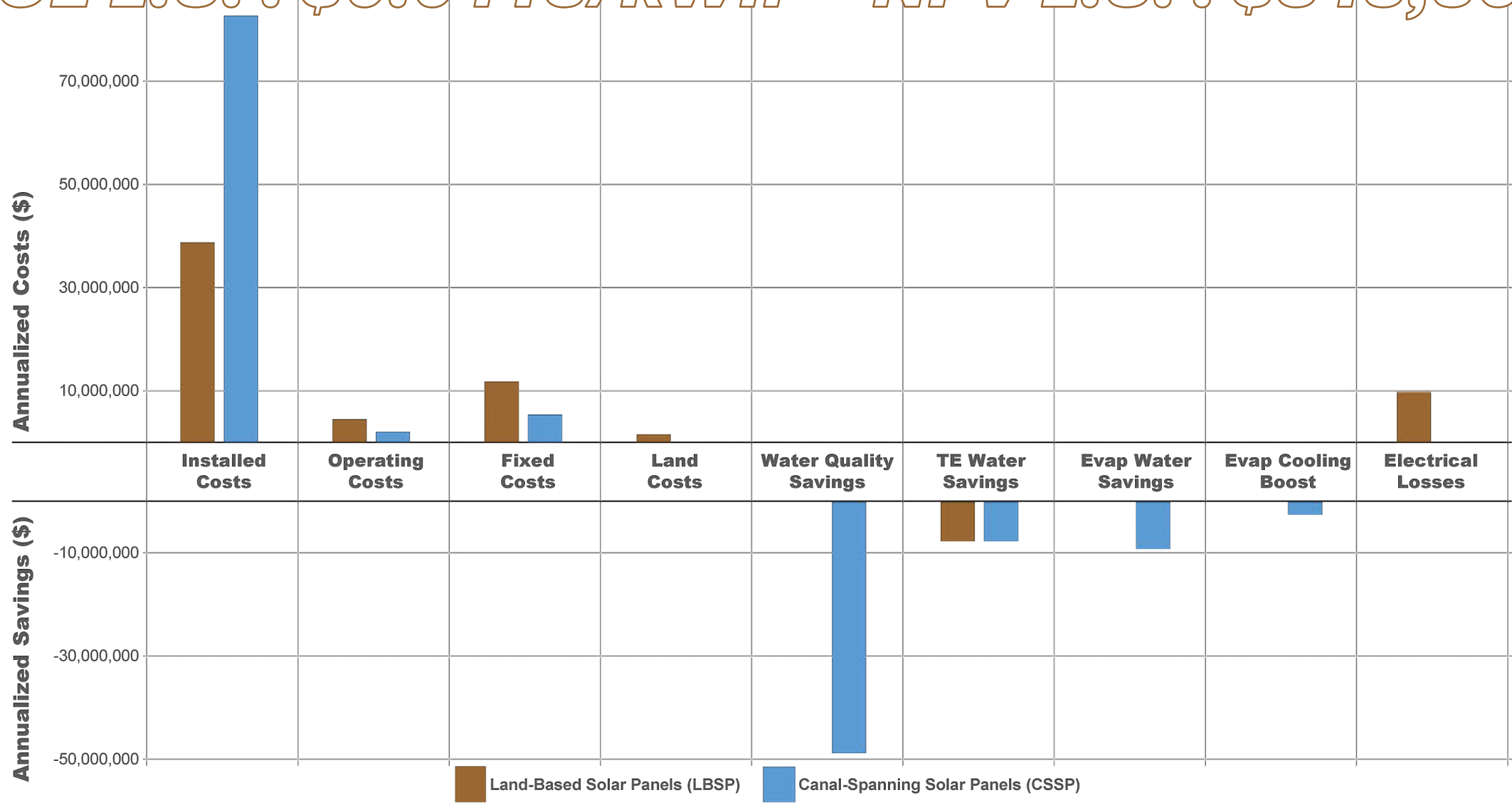
- *6,900 acres (10.8 square miles) virgin land saved compared to utility-scale solar*
- *Density ratio: 8.8 ac/MW average for six SRP LBSP projects vs. 1.12 ac/MW for CSSP (7.8x area)*

LCOE C.S. : \$0.0206/kWh

NPV C.S. : \$7,034,299

LCOE L.S. : \$0.0418/kWh

NPV L.S. : \$845,562



The figures stated in this presentation are estimates based off of models and lab data and are prospective in nature and may change as the science improves and our climate changes. Many of these models are novel to this project and still a work in progress. Research funded in part from DoE cooperative agreement DE-SC0020022 and have SBIR protected rights.

ben@tectonicus.com

solar-river.info

waterxience.com



Computer Rendering



Gila River Indian Community: Innovation in Water Management



David H. DeJong, Ph.D.
Director, Pima-Maricopa Irrigation Project

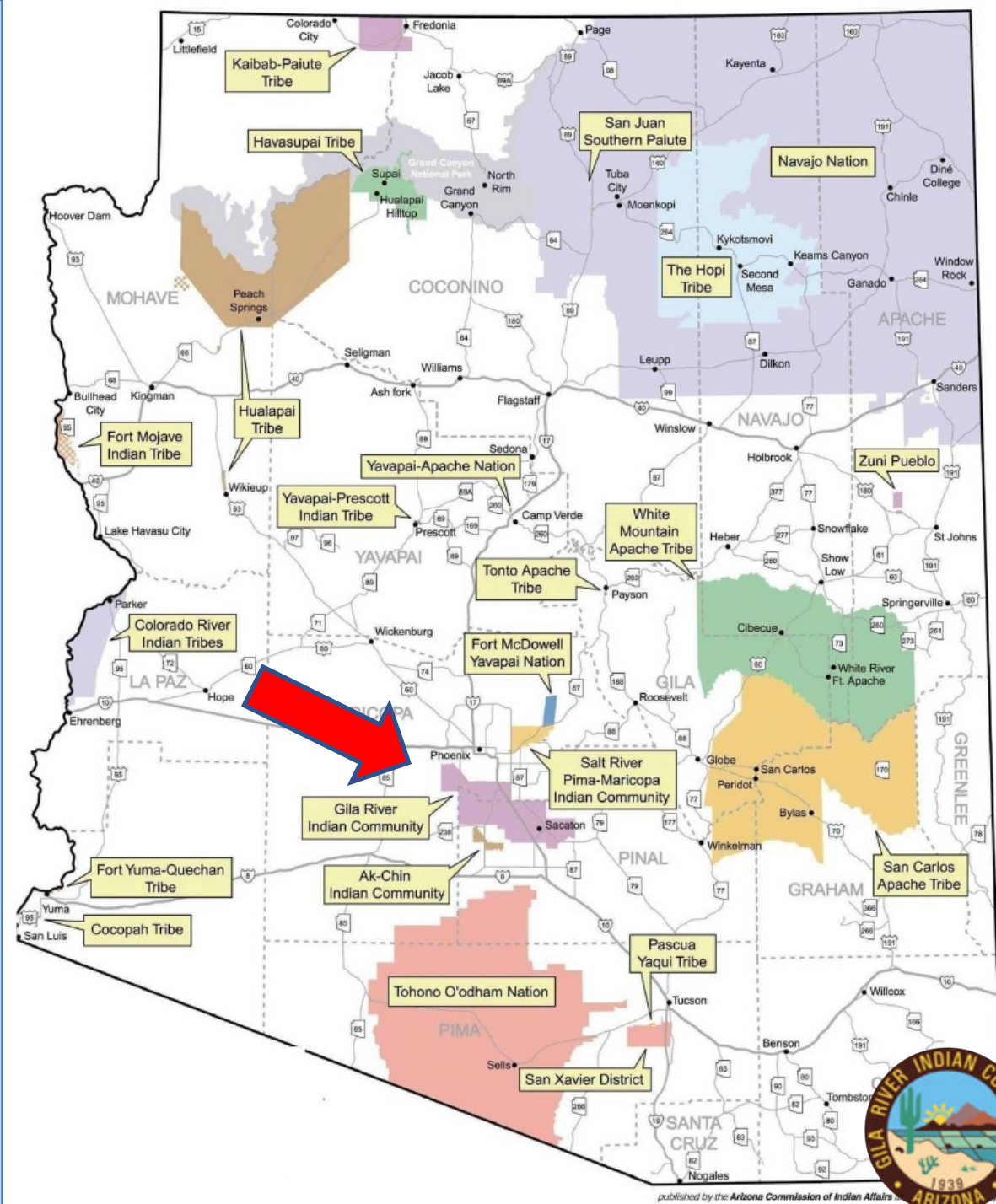


The Gila River Indian
Community in central
Arizona:

Akimel O'otham
(Pima)

and

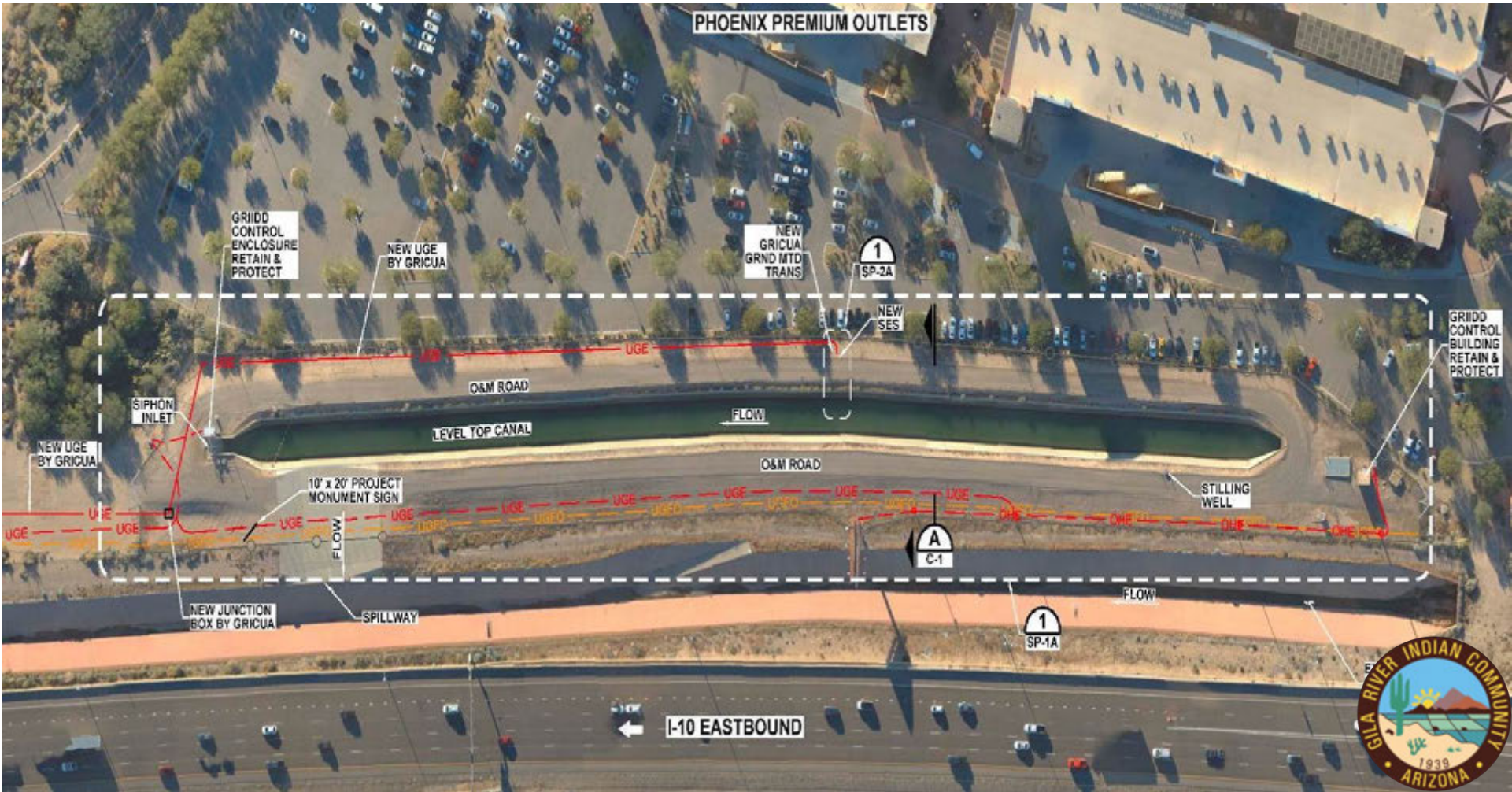
Pee Posh (Maricopa)



GRIC has developed innovative water partnerships and management



make GRIIDD the first green irrigation district in the world



I-10 Solar over Canal Project:

Army Corps of
Engineers (Tribal
Partnership Program
agreement), GRIC, &
Bureau of Reclamation
funded



I-10 Solar-over-Canal Project

Design

- 1,624 solar panels covering 50,896 SF (962' x 53')
- 29 frames each with 56 panels
- Designed to minimize O&M impacts
- Generate 876 kW or 1,677,460 kWh (1,667 MWh) generating power valued at **\$174,456**

Water savings

- Limited evaporation losses (5.4 AF/YR)
135 AF over 25 years
- Thermoelectric water savings (2.57 AF/YR)
64 AF over 25 years
- Total is 7.98 AF/YR or 199 AF over 25 years



Casa Blanca Canal Solar Project

Canal Width (FT)	Canal Length (FT)	Area (SF)	DC OUTPUT based on 14W per SF (KW)	DC OUTPUT based on 16W per SF (KW)	DC OUTPUT based on 17W per SF (KW)	AC OUTPUT based on 14W per SF (KWH) per year	AC OUTPUT based on 16W per SF (KWH) per year	AC OUTPUT based on 17W per SF (KWH) per year	AC OUTPUT based on 14W per SF (KWH) dollars/per year (\$)	AC OUTPUT based on 16W per SF (KWH) dollars/per year (\$)	AC OUTPUT based on 17W per SF (KWH) dollars/per year (\$)
24	2167	52,008	728	832	884	1,275,652	1,457,888	1,549,006	\$132,668	\$151,620	\$161,097
24	1443	34,632	485	554	589	849,454	970,804	1,031,479	\$88,343	\$100,964	\$107,274
Totals		86,640	1,213	1,386	1,473	2,125,106	2,428,692	2,580,486	\$221,011	\$252,584	\$268,371



Purpose:

To restore an economically-
viable agricultural economy

and

With the smallest carbon
footprint

