"Natural Systems" for On-Site Industrial Wastewater Disposal

Leveraging Natural Processes to Solve Practical Problems

Industrial Applications

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Solid Waste Industry

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"Finding A Better Way"

Brad Granley, PE President, Founder; bgranley@ccenv.us; 720-556-4801

Topics

- "Natural Systems"
  - What does this mean?

- Introduction to Three Technologies
  - Phyto-Utilization™ Systems
  - W.A.I.V.™ – **W**ind **A**ided **I**ntensified e**V**aporation
  - Microbially Enhanced Brine Evaporation

  - Constructed / Engineered Wetlands

"Natural Systems" = ???

"A **Natural System** is one that strategically takes advantage of and **leverages the ability of natural processes…**

- Evapotranspiration
- Wind movement
- Solar radiation
- Evaporation
- Plant and biological processes

…to solve practical problems."

Natural Systems

- Trade space for "energy"
  - Energy = $$$ Money / Resources $$$
    - Electricity
    - Chemicals
    - Man power
    - Transport trucks
    - Mechanical complexity
    - O&M
- Lower Environmental Impact

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Natural Systems

- **GREEN**
- Sustainable
- Lower energy footprint
- Reduced carbon footprint
- Few moving parts
- Highly skilled labor not necessary
- Less maintenance
- Lower costs

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Natural Systems

- Phyto-Utilization™
- W.A.I.V.™
- Microbially Enhanced Brine Evaporation
- Engineered Wetlands

Natural Systems

Phyto-Utilization™ Systems

Tree-Based Phyto System

Vetiver-Based Phyto System

Natural Systems

Phyto-Utilization™

A plant-based, sustainable system that **CONSUMES** liquid (leachate) on-site (i.e. no hauling) through the evapo-transpiration process.

Highly tolerant, high water-demand plants: poplar trees (left), vetiver grass (right)

Landfill Leachate as a Resource!

Main Components are Water and Contaminants

Leachate as a **Resource**

- Hybrid Poplar and Vetiver grass = high water demand

LEACHATE = MOISTURE

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Landfill Leachate as a Resource?

Leachate Analysis (Contaminants)

- Nitrogen (ammonia)
- Phosphorous
- Potassium
- Magnesium
- Sulfur
- Calcium
- Iron
- Boron
- Manganese
- Zinc
- Copper
- Sodium
- VOCs


TestAmerica

ANALYTICAL REPORT

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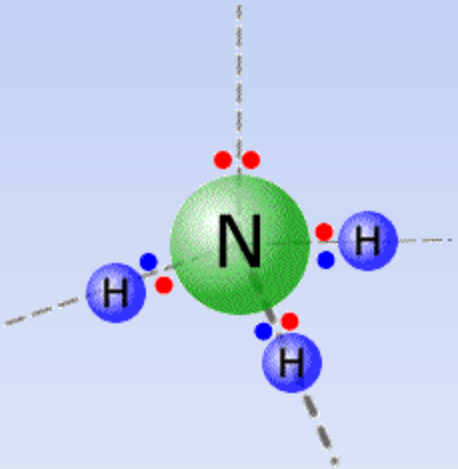
Leachate as a **Resource**

CONTAMINANTS = NUTRIENTS

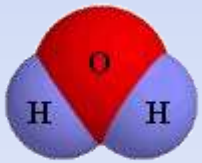
<u>Macro-Nutrients</u>

- Nitrogen (ammonia)
- Phosphorous
- Potassium
- Magnesium
- Sulfur
- Calcium
- Others



<u>Micro-Nutrients</u>

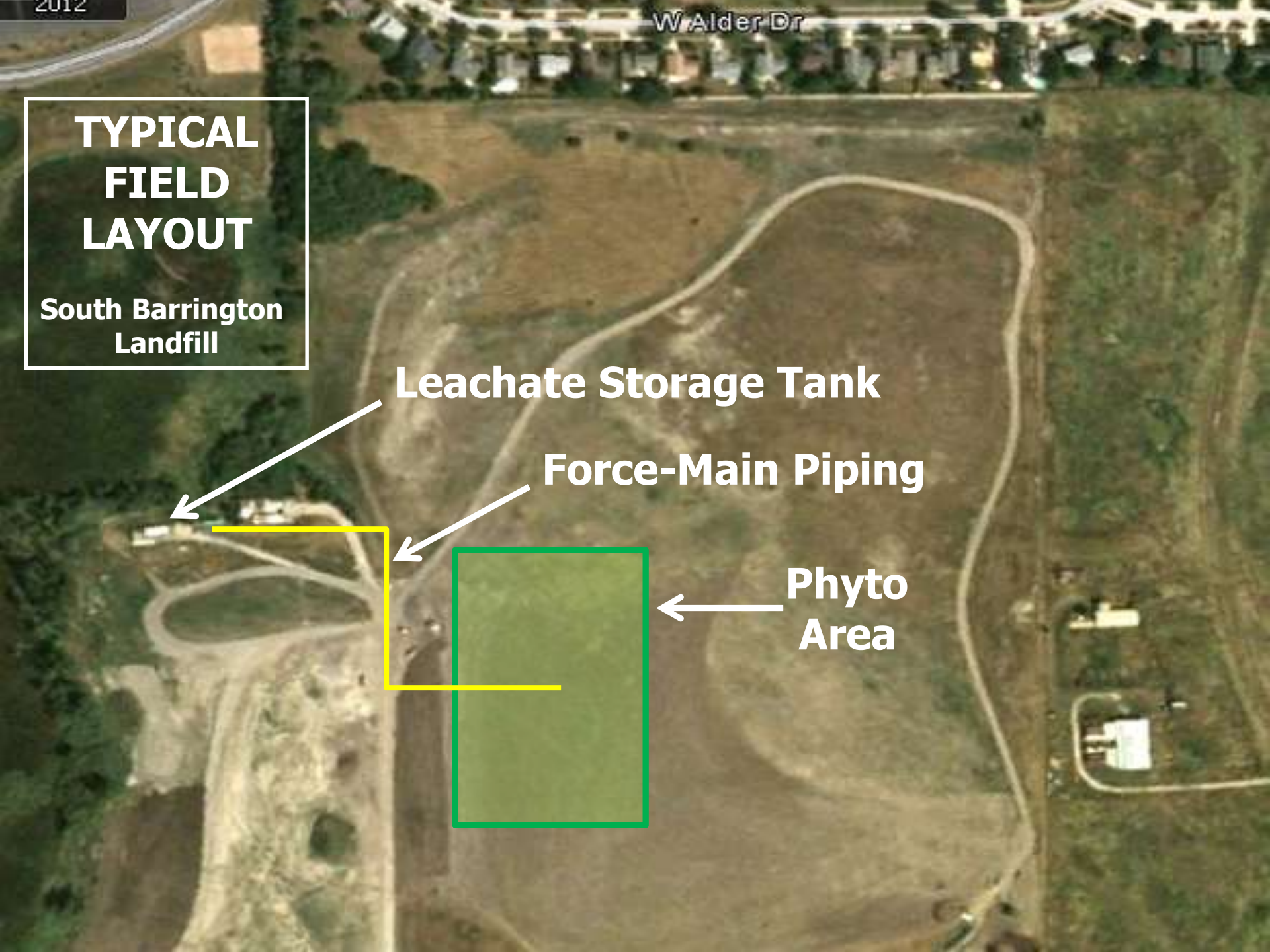
- Iron
- Boron
- Manganese
- Zinc
- Copper
- Others



Phyto-Utilization – Project Examples

Jeffco (St. Louis)
South Barrington (Chicago) and
Gulf Pines Landfills (Biloxi)

- **Project Goals**
  - Implement GREEN Technology
    - Better for the environment and reduce carbon footprint
  - Reduce Leachate Disposal Costs
  - Utilize Leachate Year Round (cold-weather climates)
  - Low O&M effort


2012
W Alder Dr
TYPICAL FIELD LAYOUT
South Barrington Landfill
Leachate Storage Tank
Force-Main Piping
Phyto Area

MECHANICAL SYSTEM

<u>Unmanned Facility</u> – System designed to be self adjusting to: leachate generation, leachate quality and changing backpressure


Easy Access, Easy Maintenance

PIPING INFRASTRUCTURE

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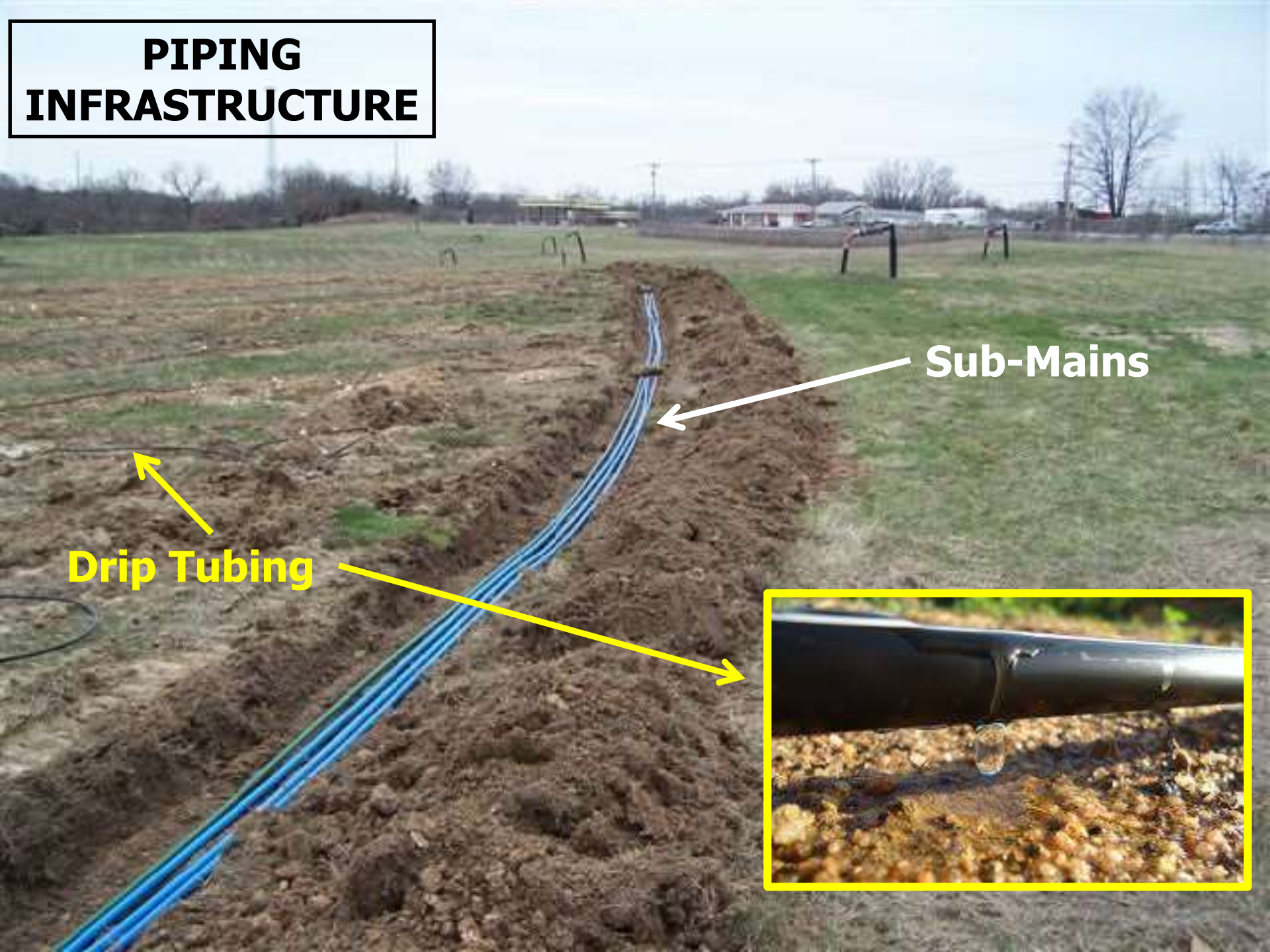
PIPING INFRASTRUCTURE

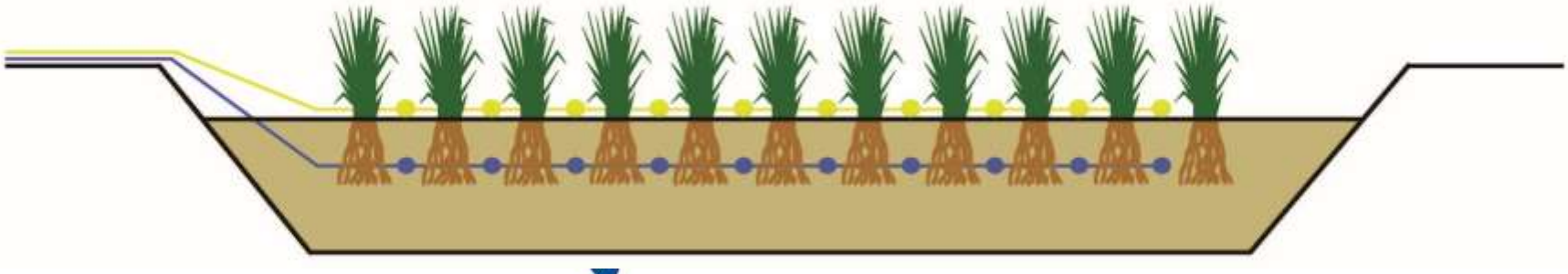
PIPING INFRASTRUCTURE



Summer 2010 – Jeffco

Fully Developed Vetiver Hedgerows Biloxi

Phyto-Cell™ System

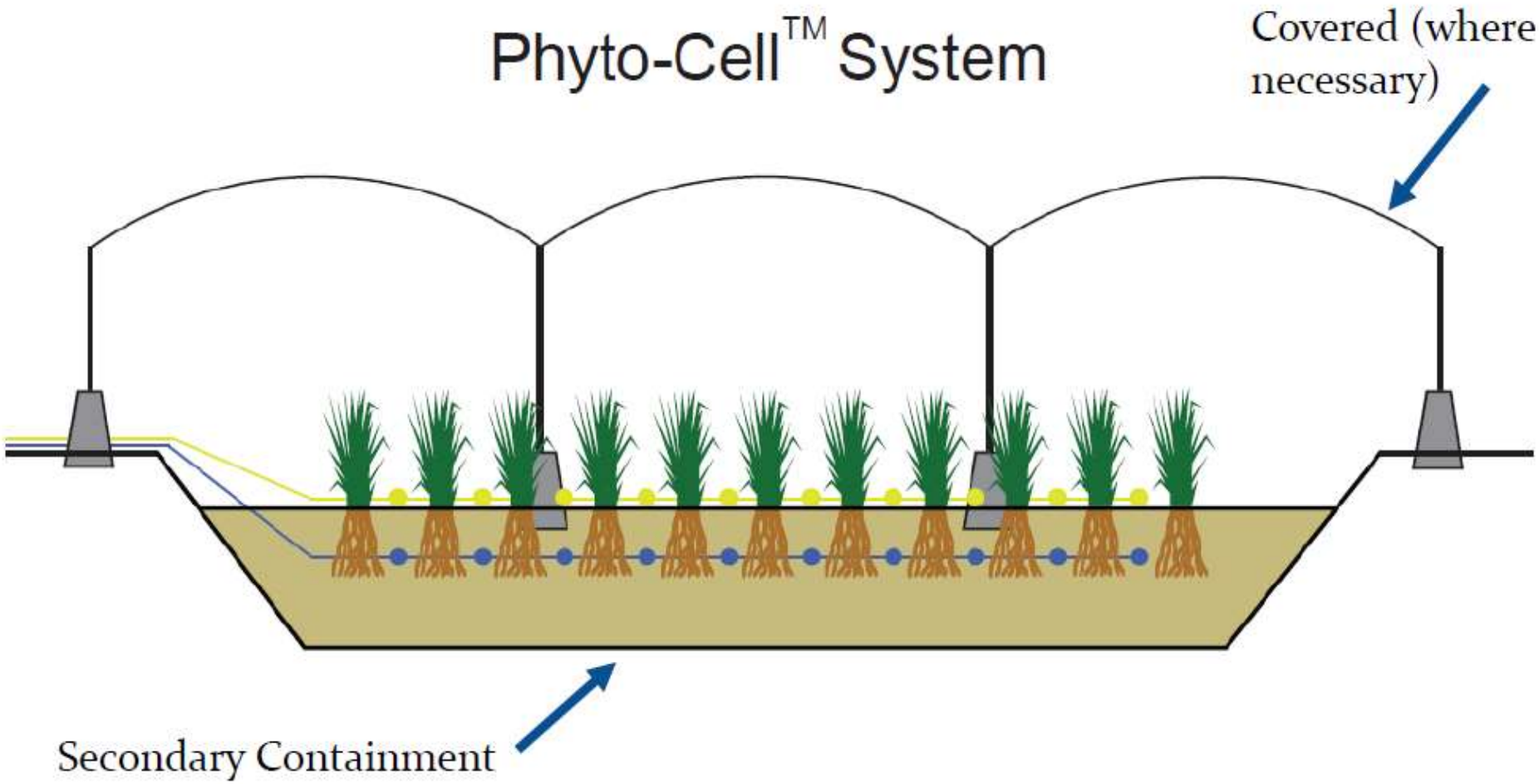


Secondary Containment

Key Components:

- Lined Area – protective of groundwater
- Influent - Distribution network (piping / coarse bedding material)
- Subsurface and/or surface distribution
- Growth Media
- Freeboard
- Rainfall Diversion
- Plants (vetiver grass)

Phyto-Cell™ System



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- Rainfall Diversion
- Plants (vetiver grass)

Benefits of Natural Systems

- **GREEN, Sustainable Technology**
  - Reduced carbon footprint
  - Corporate sustainability reports / PR opportunities
- **Significant Cost Reduction**
- **Zero Discharge Potential**
  - Not dependent on POTW
    - Changing discharge limits
    - Blamed for their problems
    - Price increases
    - Can be cut off (more and more w/ UV disinfection)
- **Year-Round Leachate Management**

Benefits of Natural Systems

- Thousands of Fewer Miles Driven by Tanker Trucks
- **Less Truck Traffic through communities**
- **Reduced Liability**
- Less Wear on Local Roads
- Habitat for Wildlife
- Aesthetic Improvement for Area
- National Award Winning Technology
- Reduce Financial Assurance Premiums
- **Newer Alternatives to Consider**

Environmental Benefits Example

<u>Natural System Solutions</u>

- 3 MGY System, over first 5 years
  - 15 million gallons total
  - Avoids 3,000 tanker trips
  - If 35 mi one-way, then **210,000 miles not driven**
  - 35,000 gal diesel not burned
  - CO_2 emissions lowered

2010 Republic Services corporate sustainability report… ***"We factor in that every trip we make and every mile of road we cover has an environmental impact of it's own."***

National Engineering Excellence Awards
In Top 25 Engineering Projects Nationally
Washington D.C.

ACEC
American Council of Engineering Companies
100 Years of Excellence

AMERICAN ACADEMY OF ENVIRONMENTAL ENGINEERS®

JEFFCO - POPLAR TREES

GULF PINES - VETIVER

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WAIV™

Wind Aided Intensified eVaporation

A completely new evaporative technology

What it is NOT

- No Spray
- No Mists
- No Aerosols
- No Blowers or Fans
- No Drift
- **No Fuel**

What it IS

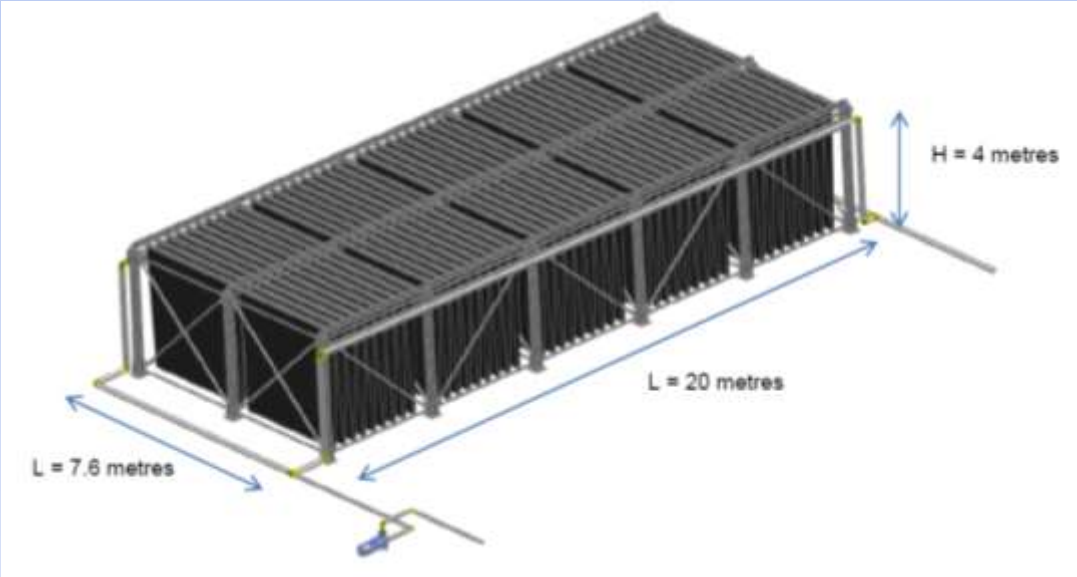
- New to the US Market
- Fundamentally Basic, Simple System
- Wind Driven
- Lower Disposal Costs than Traditional Technologies

WAIV™

Wind Aided Intensified eVaporation

- Developed for the Desalination Industry
- Adapted for Other Industries

  - Solid Waste
  - Mining
  - Chemical Producers
  - Manufacturing
  - Power Industry
  - In lieu of Injection Well
  - Metals Finishing
  - Pharmaceuticals
  - Others



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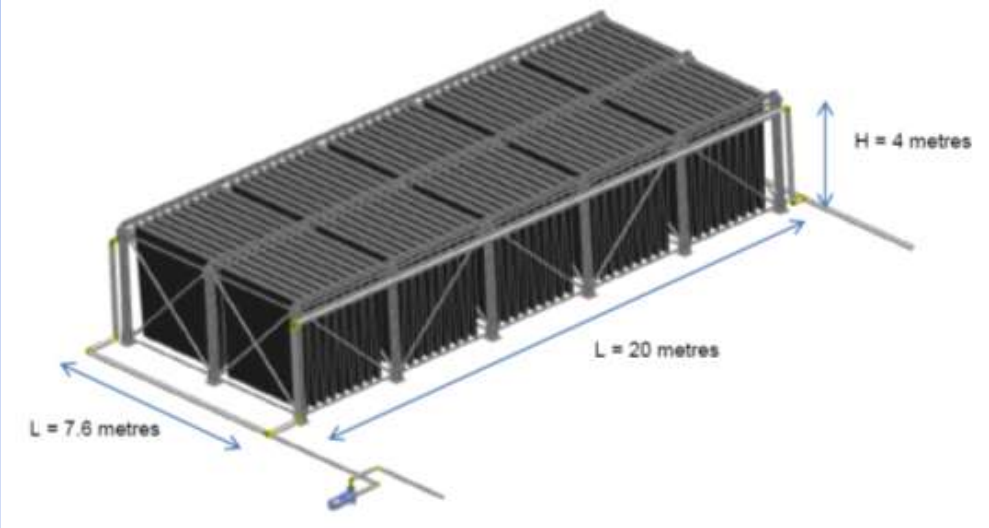
Wind Aided Intensified eVaporation

Explanation

- **High density of wetted surface area** within a **very small footprint**
- Wind causes enhanced, intensified evaporation
- Few moving parts



WAIV™

Wind Aided Intensified eVaporation

WAIV™

System Components

1. Controls (PLC)
2. Tank
3. Pump (circulation and sump)
4. Containment
5. WAIV Unit

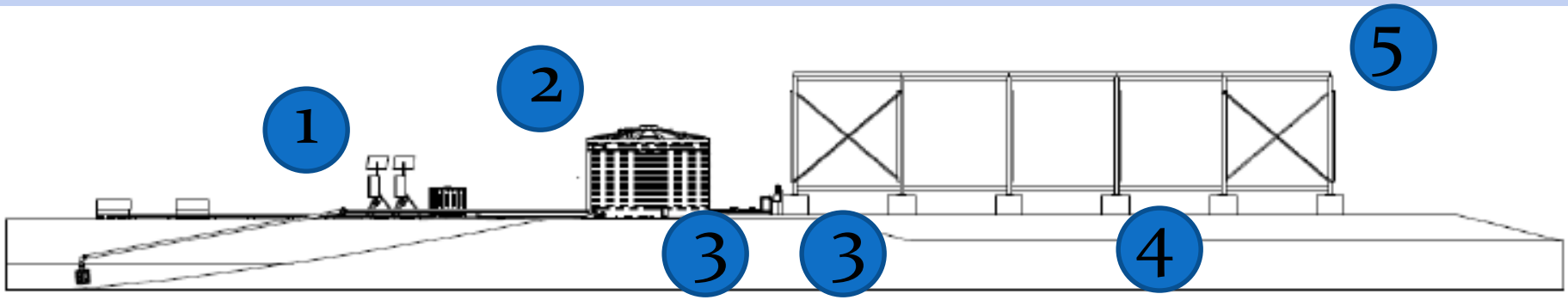
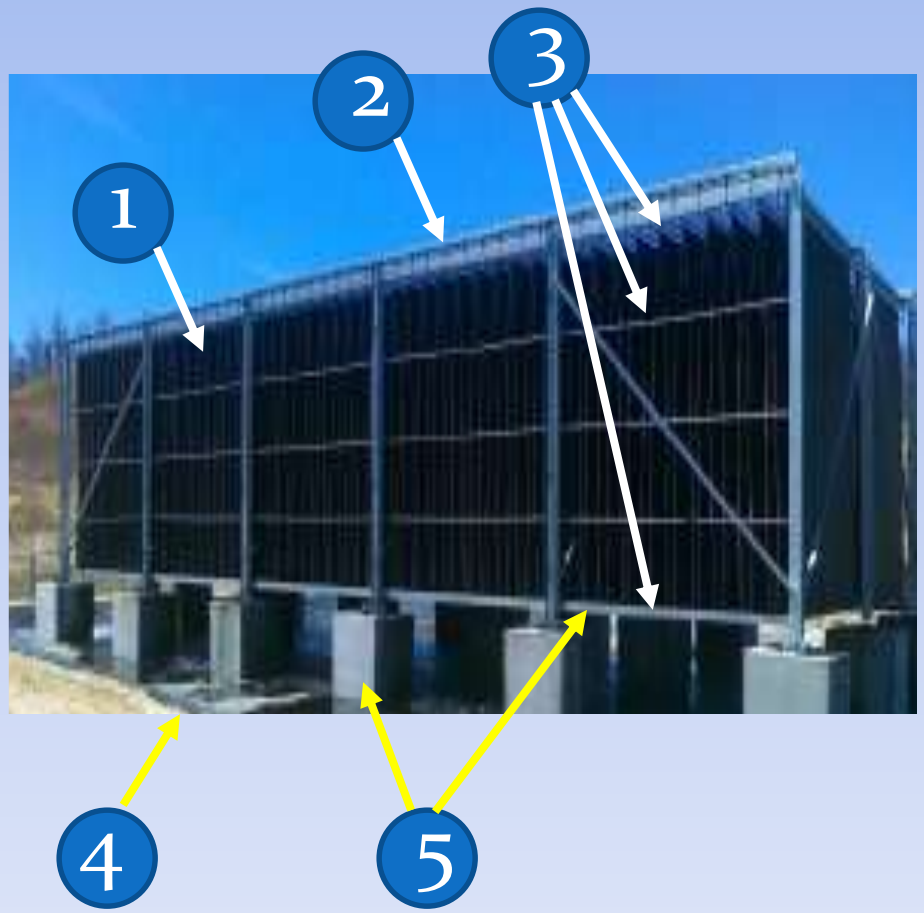


Figure 3-2 WAIV™ Unit

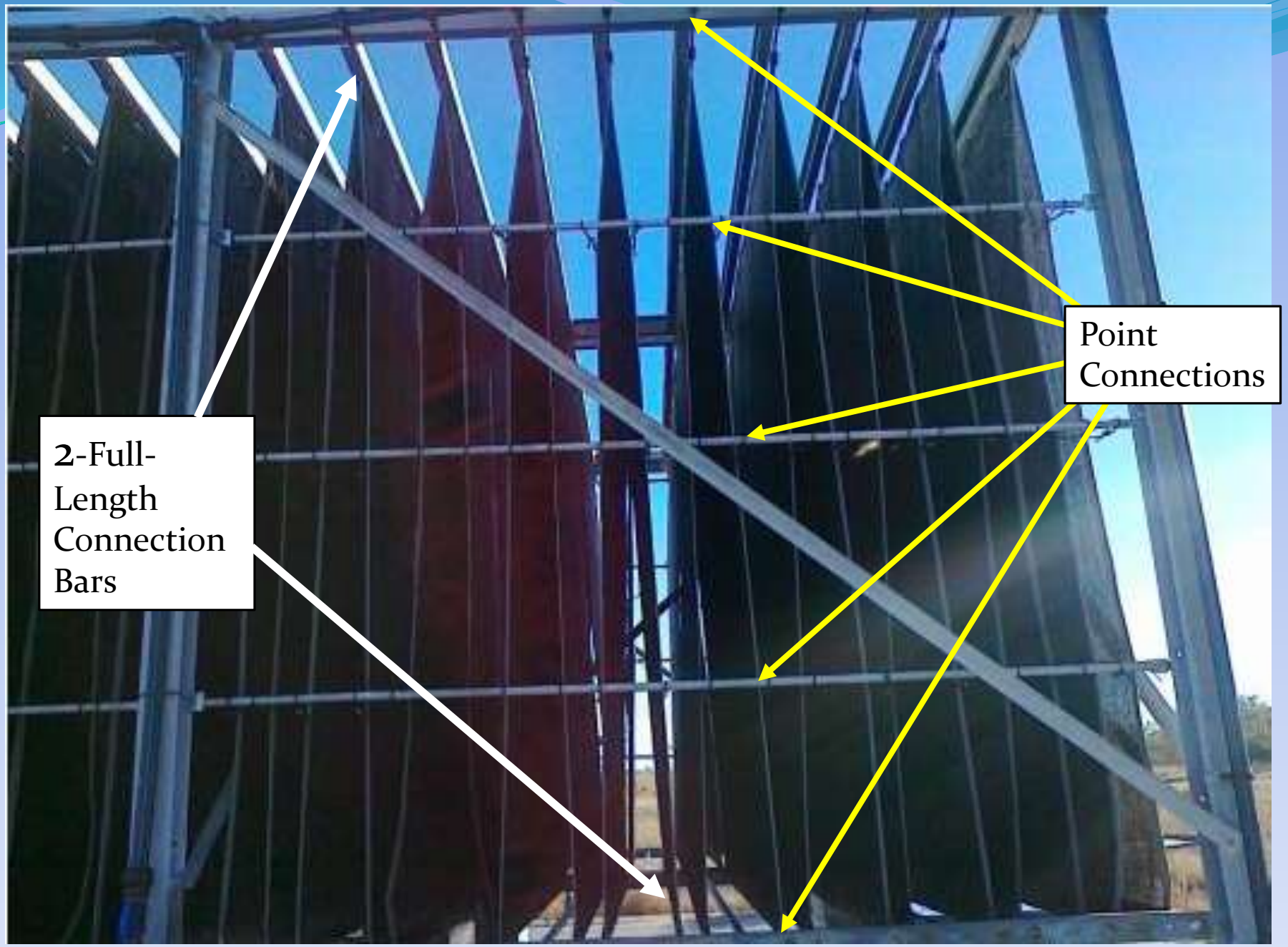
WAIV™

Wind Aided Intensified eVaporation



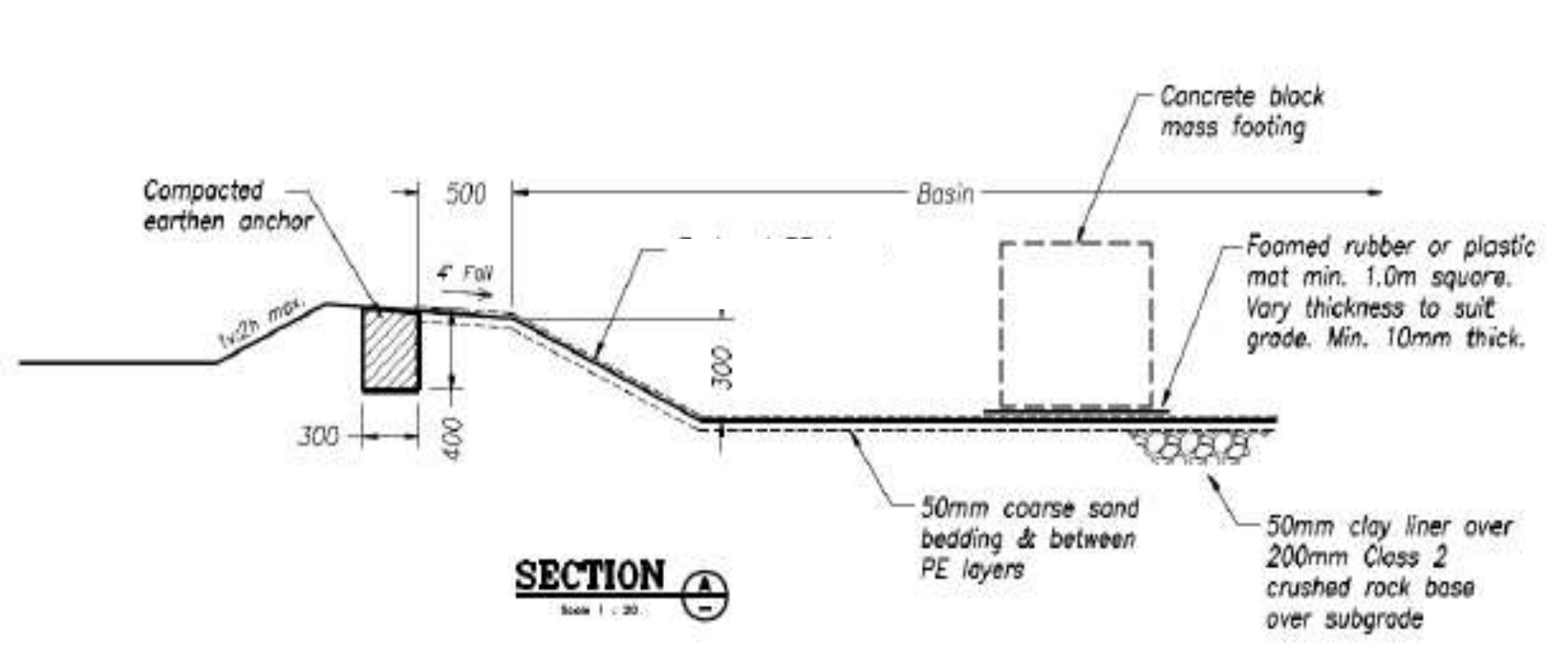
Unit Components

1. Specialized Wetted Surfaces ("Sails")
2. Liquid Distribution
3. Tensioning System
4. Containment
5. Support Blocks and Framing



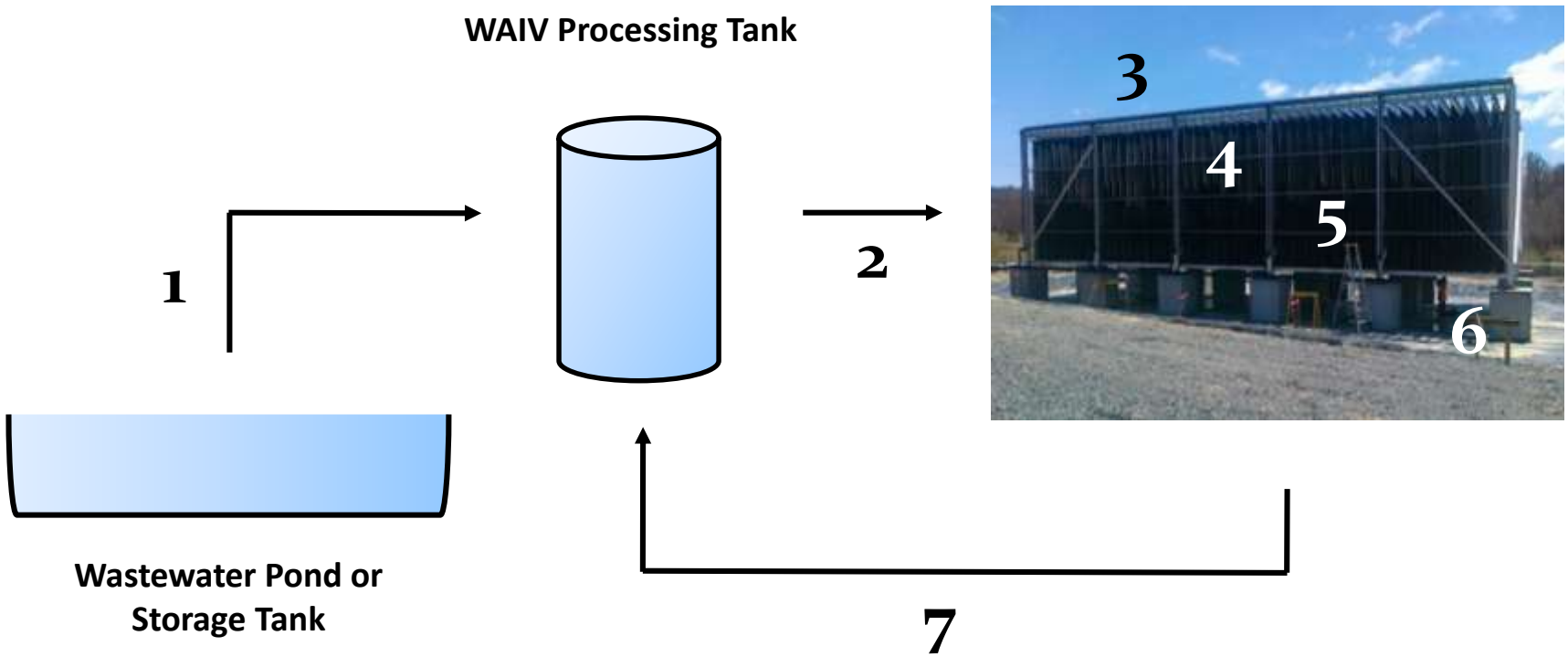
Open Flow Between Sails

Containment Cross Section



Designed to meet requirements of facility type and State requirements

Simplified Process Flow



1	=	Supply
2, 3, 4	=	Distribution
5	=	Wind / Evaporation
6, 7	=	Circulate

Repeat

WAIV™

Wind Aided Intensified eVaporation

"Unit" Information:

- Modular, scalable
- **0.6 to 1.8 MGY/unit**
- **~1,600 to 5,000 gpd/unit**
- ~25' x 65' footprint/unit
- **>62,000 ft^2 of surface area**
- 1.4 acres of surface area

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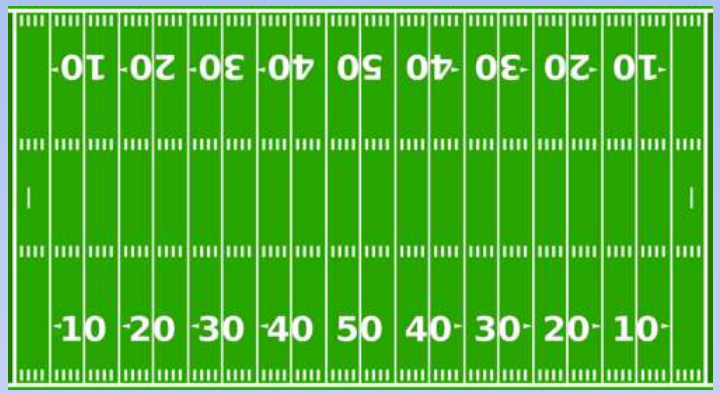
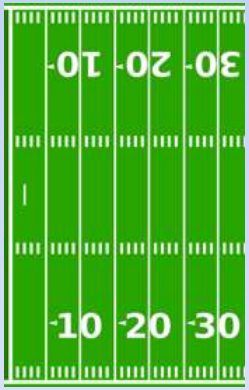
WAIV™

Wind Aided Intensified eVaporation

=



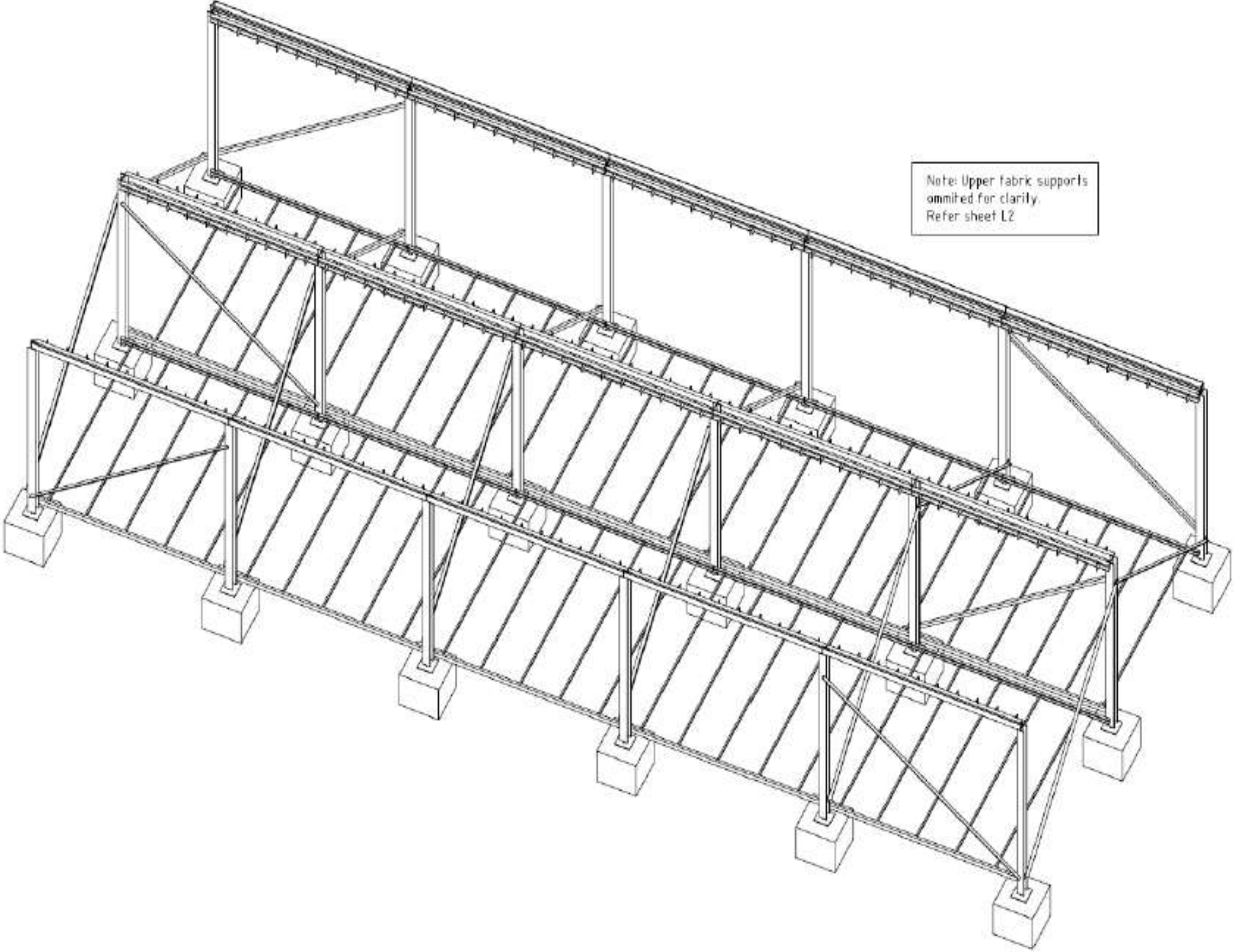


~62,000 sf (1.4 acres) of surface area
in ~62 x 25' footprint

~1.3 football fields of surface area

WAIV Construction

Copping Landfill - Australia


Note: Upper fabric supports
ommited for clarity.
Refer sheet L2

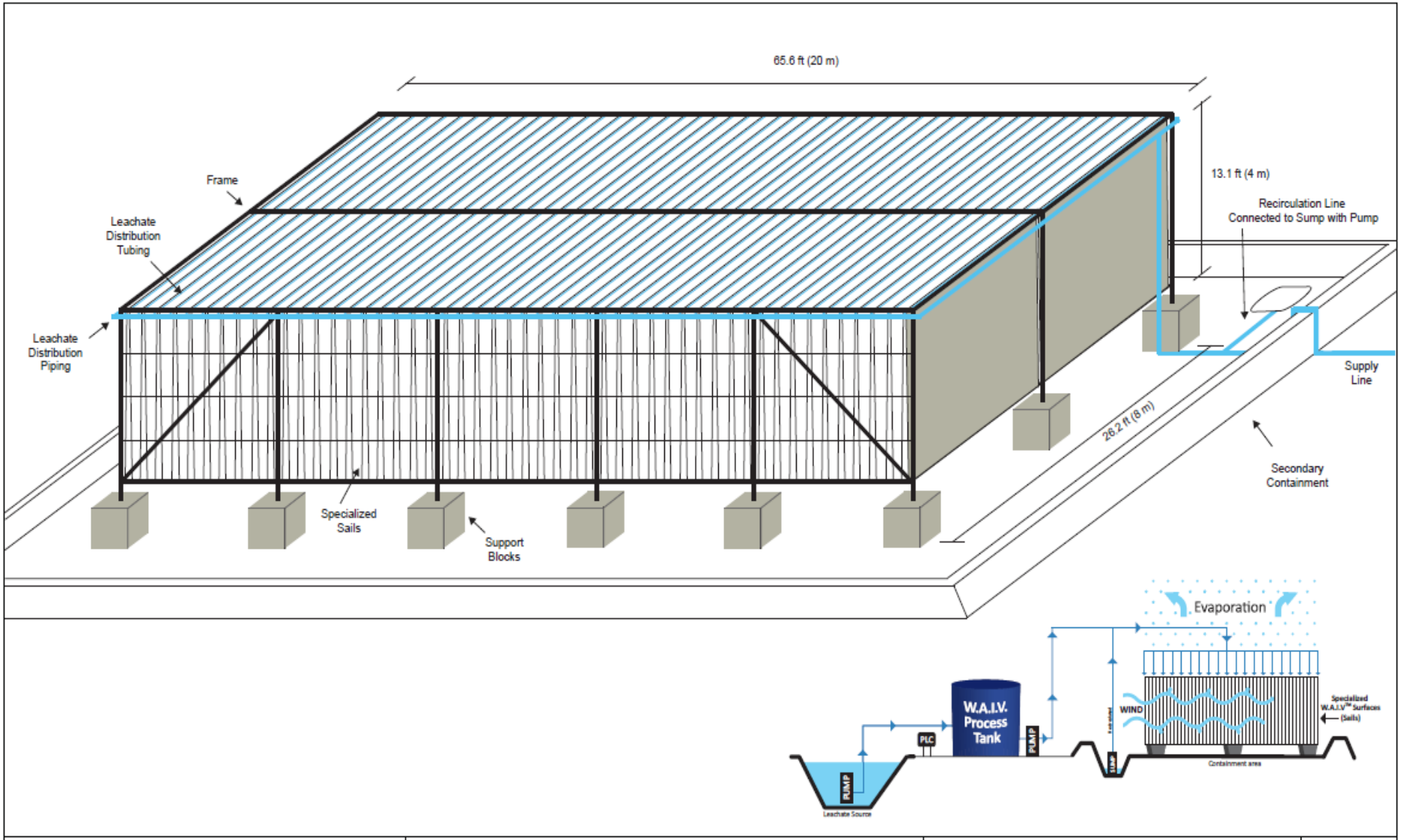
WAIV Construction

Berm, Liner and Concrete Blocks

WAIV Construction

Galvanized Steel Frame

Top cross-members installed to support sails



Clear Creek Environmental Solutions
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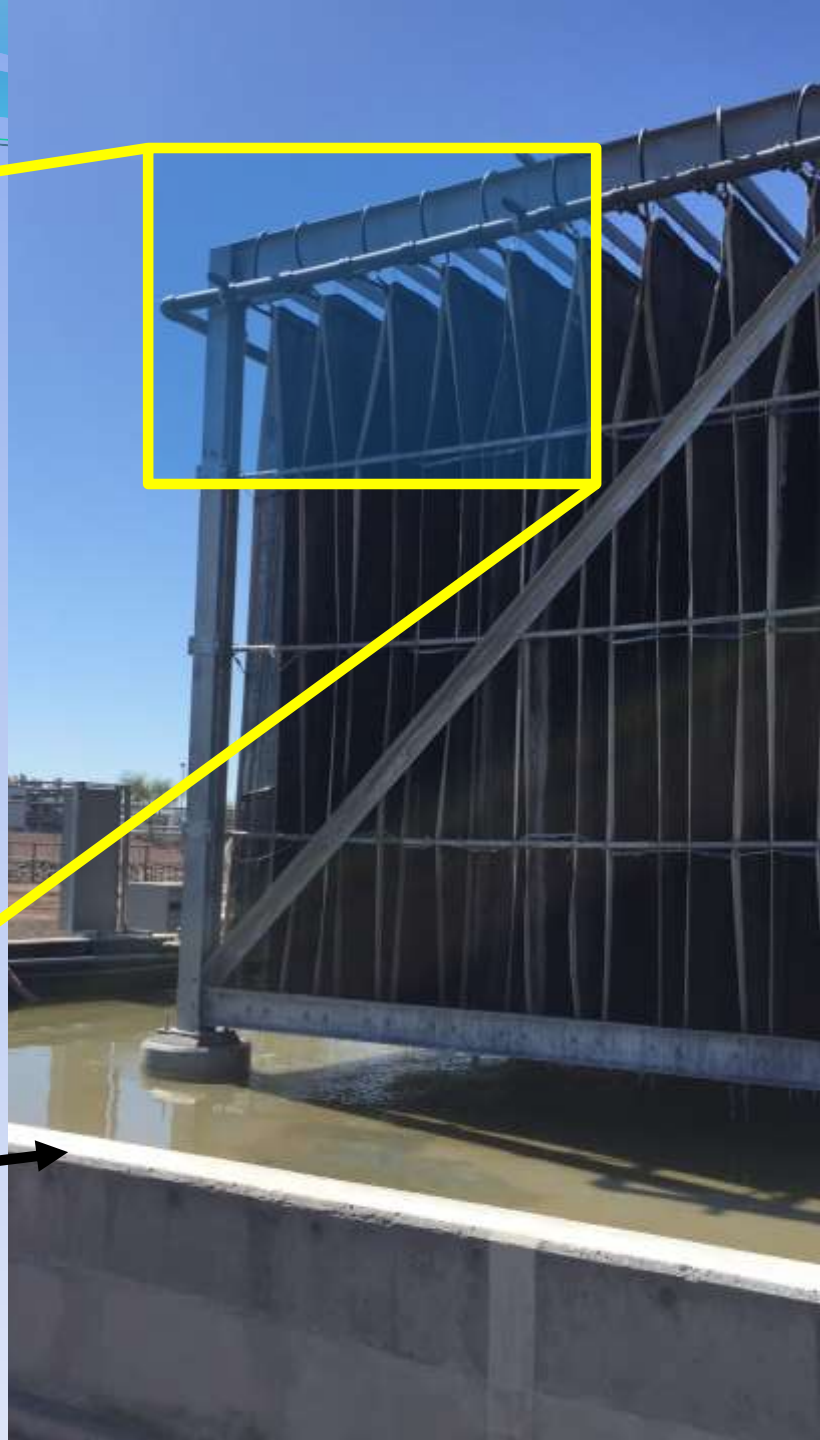
Parker, CO 80134
608-622-8900

WAIV™ EVAPORATION SYSTEM DESIGN - 1 UNIT			FIGURE
Site			3
File: WAIV Design.pdf	Drawn: EJW	Checked: BAG	Date: 1-15-2018

WAIV Setup – 1 Unit

WAIV Surfaces and Distribution Piping Installed

Distribution Piping

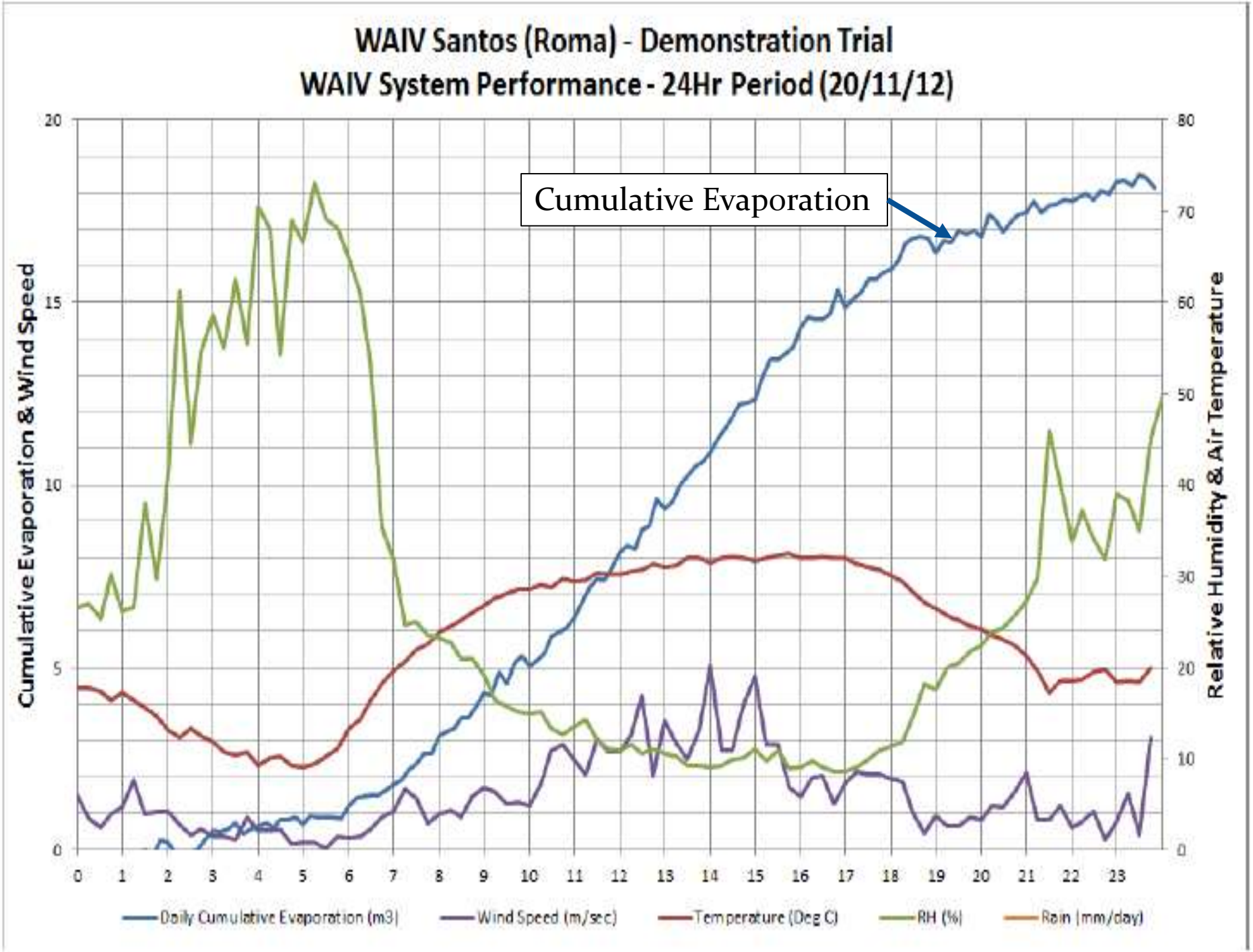


Secondary Containment
(can be simple HDPE)

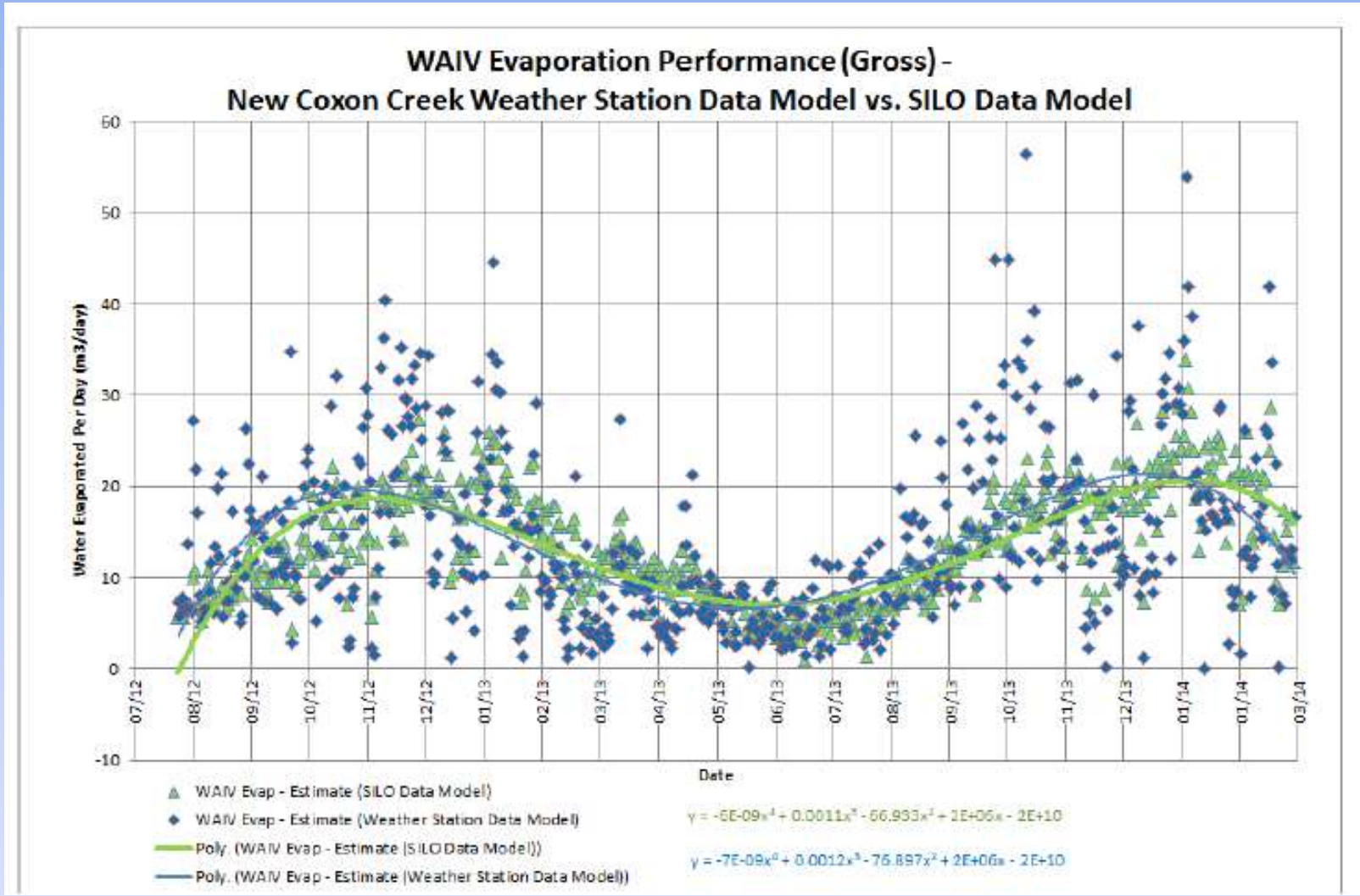
Extensive Research and Validation

Ben-Gurion University of the Negev

Backed by Science


WAIV Santos (Roma) - Demonstration Trial
WAIV System Performance - 24Hr Period (20/11/12)
Cumulative Evaporation
Cumulative Evaporation & Wind Speed
Relative Humidity & Air Temperature
0
5
10
15
20
0
10
20
30
40
50
60
70
80
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Daily Cumulative Evaporation (m3)
Wind Speed (m/sec)
Temperature (Deg C)
RH (%)
Rain (mm/day)

Extensive Research and Validation



Validation of Evaporation Modeling with Actual Evaporation Data

Examples of WAIV™ Systems Around the World

1. **Leachate: Copping Landfill - Tasmania, Australia**
2. **Produced Water - Coal: Santos - Queensland, Australia**
3. **Concentrated Brine: GM– Ramos Arizpe, Mexico**
4. **Desalination: Pettavel Winery – Victoria, Australia**
5. **Desalination: Mekorot – Ketziot, Israel**

Wind Aided Intensified eVaporation

Final WAIV Comments

- High degree of applicability
- Developed with science
- Proven in field w/ many improvements
- Beneficial for the environment
- Beneficial to community
- Lower costs

Natural Systems

Microbially Enhanced Brine Evaporation of Highly Saline Solutions

Halophile = salt loving micro-organism

A Biologically Sustainable System to Eliminate Highly Saline Concentrates

Background

- Top 5 Halophilic Microbiologist in the World

Rankings – Confirmed!!

AP Top 25

RK	TEAM	REC	PTS	TREND
1	Alabama (57)	13-1	1521	- 2
2	Georgia	13-2	1454	+ 1
3.	 Our Halophilic Microbiologist			
4	Clemson	12-2	1292	- 2
5	Ohio State	12-2	1236	—

Coaches Poll

RK	TEAM	REC	PTS	TREND
1	Alabama (57)	13-1	1550	- 2
2.	 Our Halophilic Microbiologist			
3	Georgia	12-2	1416	- 1
4	Clemson	12-2	1328	- 2
5	Ohio State	12-2	1304	—

A Biologically Sustainable System to Eliminate Highly Saline Concentrates

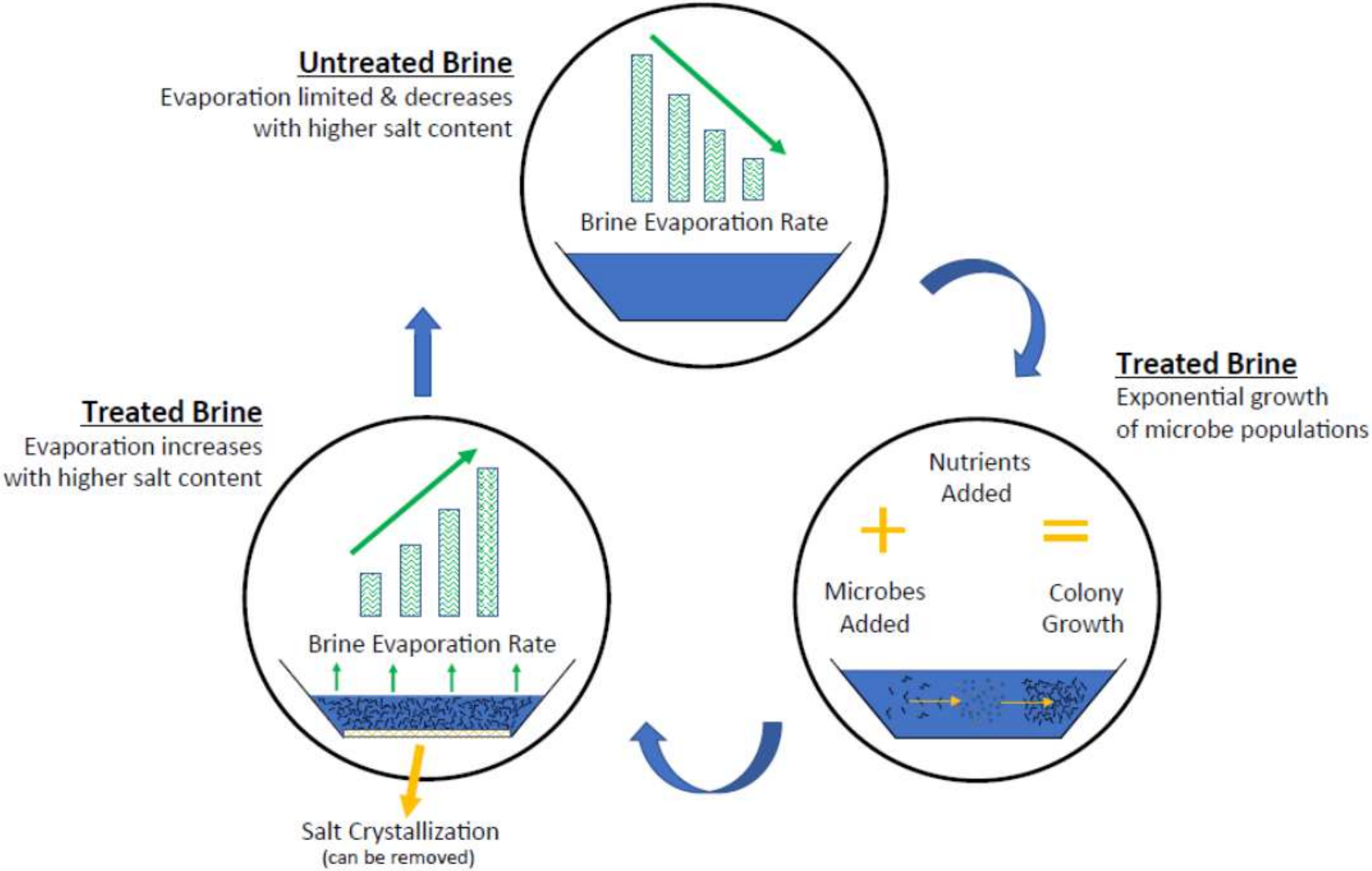
Background

- Top 5 Halophilic microbiologist in the world
- 35-year career, retired professor
- Discovered 30+ years ago
- >1,300 microbes isolated
- Projects in US and Canada
- Awarded US Bureau of Reclamation Grant for 2020

(looking for participants)

- Applicable for use in evaporation ponds with TDS 80,000 mg/L and up. 100,000 mg/L, 200,000+ mg/L

How Does It Work?



How Does It Really Work?

- Increased temperature
  - Microbial metabolism
  - Color change
- Increased opacity / sunlight penetration

How Does It Really Work?

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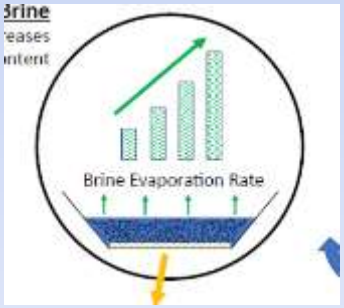
- Increased "Activity" of the microbes
  - (proprietary information / our 'special sauce')

How Does It Really Work?

- Increased temperature
  - Microbial metabolism
  - Color change
- Increased opacity / sunlight penetration
- Increased "Activity" of the microbes
  - (proprietary information / our 'special sauce')
- Partially unknown
  - Do microbes 'sweat' the water?
  - Increased surface area from micro disruption of surface



What Results Can be Expected?

- Increased evaporation rates
  - **The greater the salt content, the <u>better</u> the results**
- Degradation of VOCs
- Degradation of some fats and oils
- Utilization of nutrient compounds

- **Meet or exceed evaporation rates of fresh water**

Steps to a Project

- **Step 1 – Viability Testing.** We ensure that there are no major bio-inhibitors and that we can efficiently grow cultures in your brine

- **Step 2 – Customization.** We determine what combination of microbes and nutrient mix works best with your brine

- **Step 3 – Implementation.** We grow cultures and mix nutrients which are shipped to your site for pouring into your brine pond

- **Step 4 – Long Term.** Continued addition of inoculum and nutrients for inflow volume

Applications

- End Game for Zero Liquid Discharge (ZLD)
  - Post volume reduction processes
    - High recovery RO
    - Mechanical / thermal

Photo source: Water Online

- Existing disposal options
  - Crystallization
  - Haul to WWTP
  - Deep-well injection
  - NPDES discharge
  - Land application

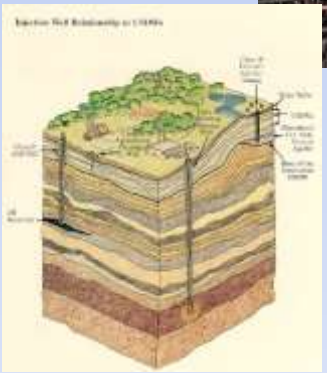


Photo source:
LA DNR

Photo source: scienceabc.com

Applications

Photo source: businesstimes.com

Industries

- Mining & solution mining wastewaters
- Electric power generation
- Oil and Gas industry
- Manufacturing
- Hide (leather) brines
- Many others

Photo source: clui.org

- Recovery of valuable salts / beneficial reuse

Characteristics and Advantages

- No external energy input
- No mechanical equipment
- No additional infrastructure or buildings are required
- No sprays or mists
- No drift or odors
- No pretreatment required
- No control systems, plumbing, or electricity

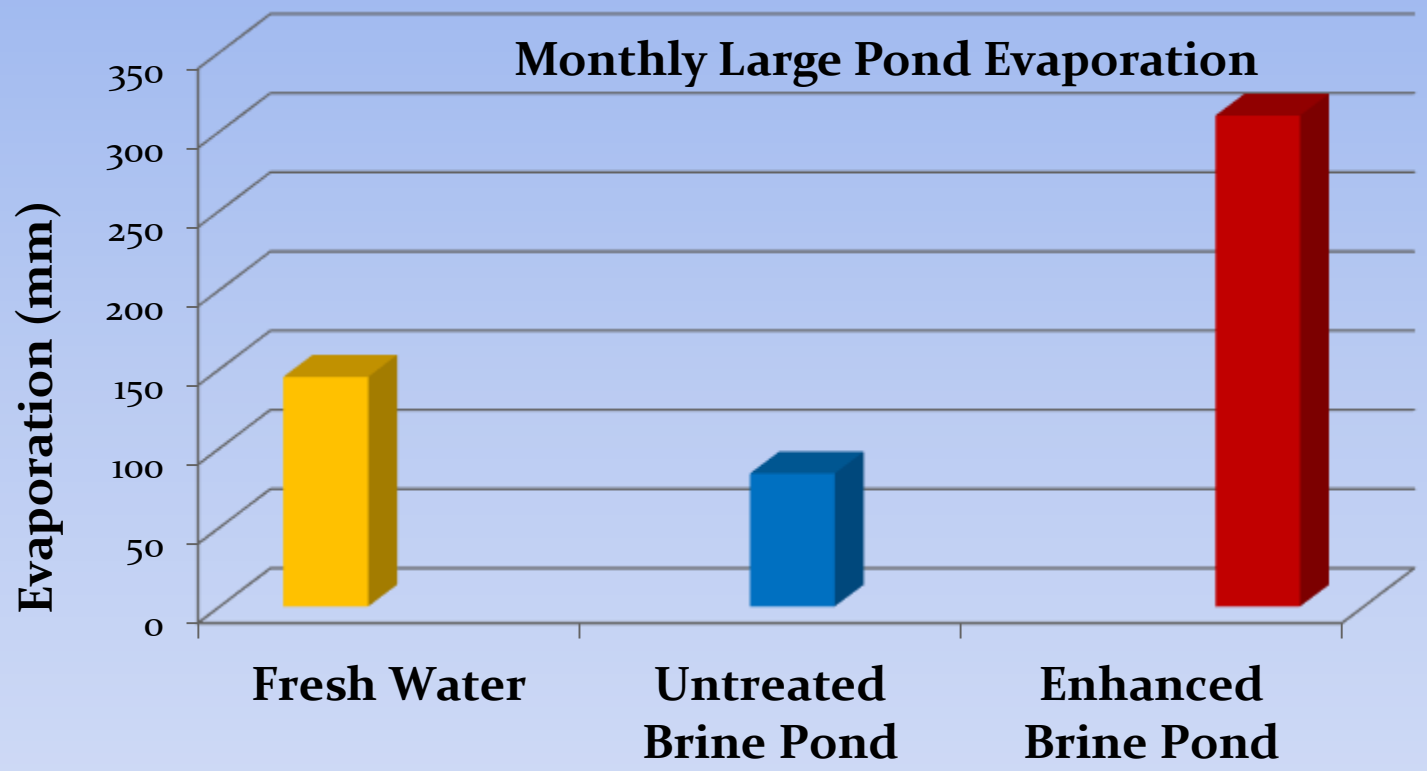
- All energy used is FREE
- Adaptable and Flexible – works in salt concentrations where others techniques fail

Characteristics and Advantages

- Proprietary microbe and nutrient mixes
- Non-pathogenic and not genetically modified
- Quickly die outside of highly saline environment

CASE STUDIES

Brine Disposal in Alberta, Canada December 1995



- Evap of untreated brine = ~85 mm
- Evap of fresh water = ~145 mm
- Evap of treated brine = ~300 mm

Case Study
Cargill Meat Packing Facility

- Hide curing process
- **Project Objective: eliminate off site disposal**
  (deep well injection, discharge and/or hauled away to WWTP)
- In lab testing / Class A pan evaporation units
- Full lagoon treatment
  - 36,000,000 gallon volume in a 4.5 acres
  - Began 8/16/2019

Sequence of events in treatment #1

Fat layers begin to degrade (2 - 3 weeks)

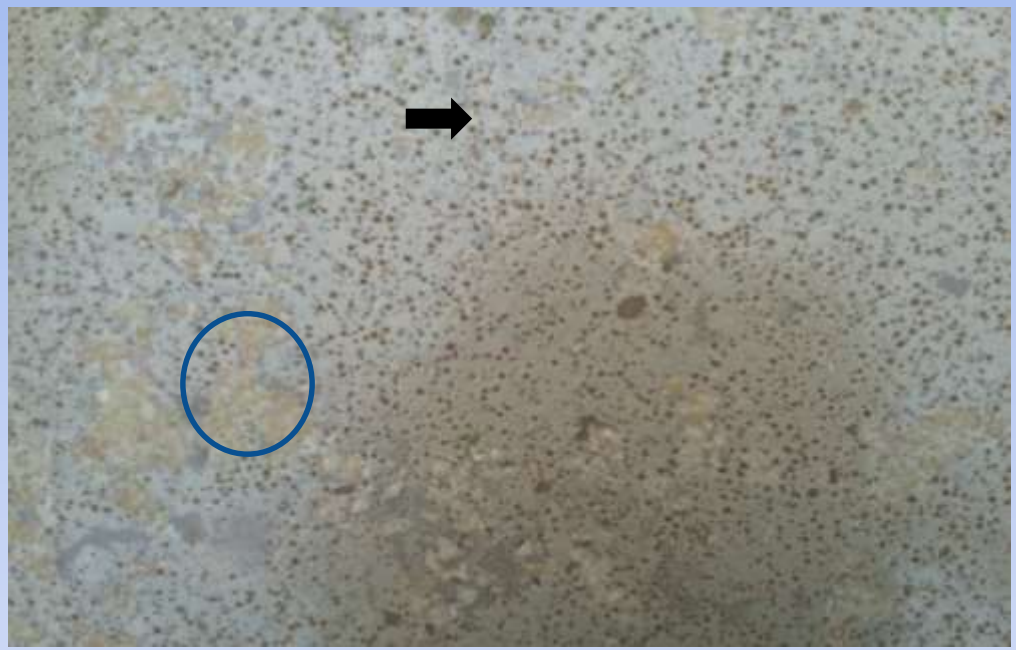
Untreated

Treated

Note color changes and larger open areas

Appearance of small crystals on surface 3 weeks of treatment

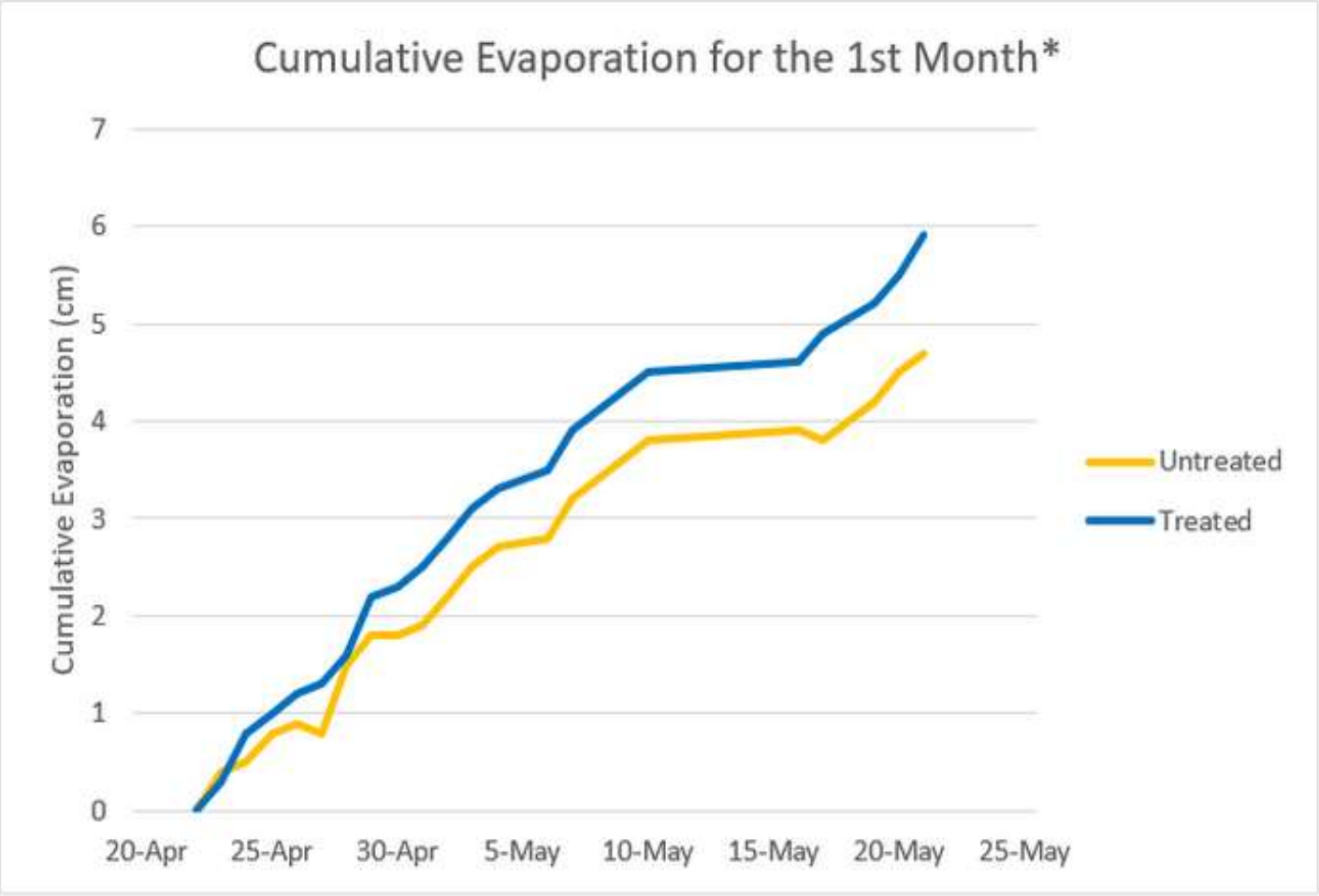
Un-treated



Treated close-up

Note ➡ Surface dimples are floating crystals

Some fat ◯ is still present but is being degraded



Evaporation of treated brine increased >25% over first month

Crystal Production to date

67% Increase in Salt Production

Brine Clarity
6 weeks of treatment

Un-treated Treated

Un-treated Treated

Current Status

- Working as designed
- Microbial population still climbing
- Evaporation rates still increasing

Main Takeaway

- **Natural Systems** can solve **Big Problems**

Add them to your list

- Phyto-Utilization™ Systems
- W.A.I.V.™ – **W**ind **A**ided **I**ntensified e**V**aporation
- Microbially Enhanced Brine Evaporation
- Constructed/ Engineered Wetlands

Industrial Wastewater Disposal with Natural Systems

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THANK YOU

Clear Creek
ENVIRONMENTAL SOLUTIONS

"Finding A Better Way"

Brad Granley, P.E. bgranley@ccenv.us