Identified Approaches

Water Resources Advisory Commission Issues Workshop
February 19, 2009

Reason to Identify Approaches

- Provide a Universal “Tool Box”
- Agreement on Definitions
- Develop Common Understanding of Advantages and Disadvantages of Each Approach
- Use Approaches to Develop Strategies and Configurations for the Phase I Planning Process

What is an Approach for Phase I Planning?

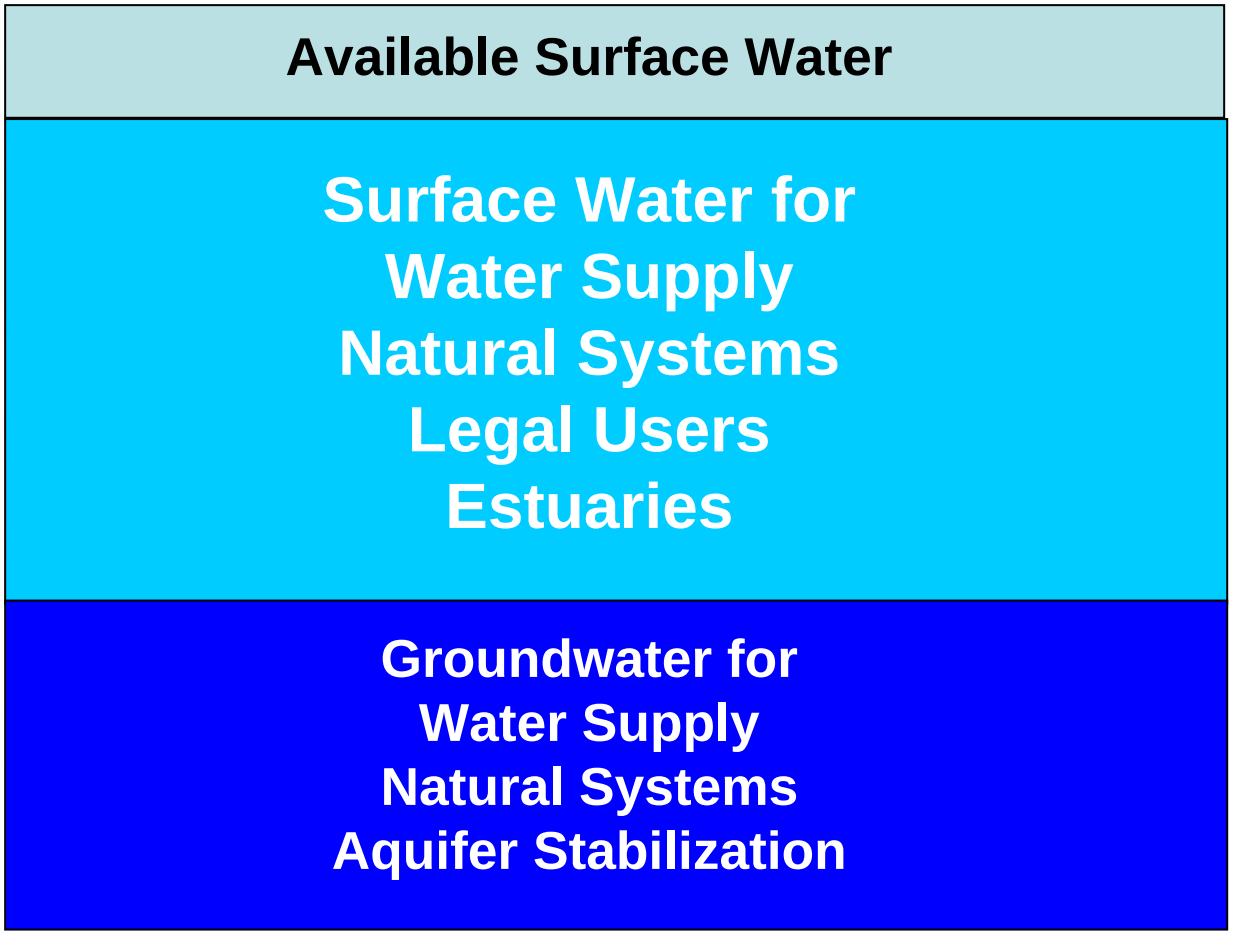
- Natural or Constructed Features or Combination of Features that Assist in Achieving the Vision, Goals, and Objectives of the Project

Approach Categories for Phase I Planning

- Storage Features
  - Store Available Surface Water
  - Utilize that Stored Water at a Later Date
- Treatment Features
  - Reduce Total Phosphorous Loads and Concentrations within the Water
    - Since Covered by Other Programs, Does Not Include Features to Initially Prevent Phosphorus from Entering the Water
- Conveyance Features
  - Convey Water Between Features

Storage Features

Water is Available to Meet the Project Goals and Objectives



Storage Features

- Vaults, Cisterns, and Storage Tanks
- Below Ground Surface
  - Aquifer Storage Recovery (ASR) Systems
  - Lakes and Ponds – Natural and Constructed
  - Below-Ground Reservoirs
- Above Ground Surface
  - Wetlands – Natural, Restored, and Constructed
  - Dispersed Storage
  - Minor Surface Water Impoundments
  - Major Surface Water Impoundments
  - Dike Existing Water Bodies

Storage Features –
Vaults, Cisterns, and Storage Tanks

Vaults, Cisterns, and Storage Tanks

- Buried or Above Ground, Man-Made Containers, Typically Made of Metal, Plastic, or Cement
- Underground Vaults are Typically Installed in a Horizontal Series of Multiple Units to Store Water to be Discharged Later
  - Average 7.7 Acre-Feet Storage Per Buried Acre
- Cisterns are Typically Smaller, Single Units
- Above Ground Storage Tanks Typically 1 to 40 Million Gallons
  - 5 to 125 Acre-Feet
- Advantages
  - If Underground, Ability to Utilize Land Above for Other Purposes
  - No Storage Loss Due to Evaporation
- Disadvantages
  - Low Volume of Storage per Vault, Cistern, or Tank

City of West Palm Beach
ASR Wellhead

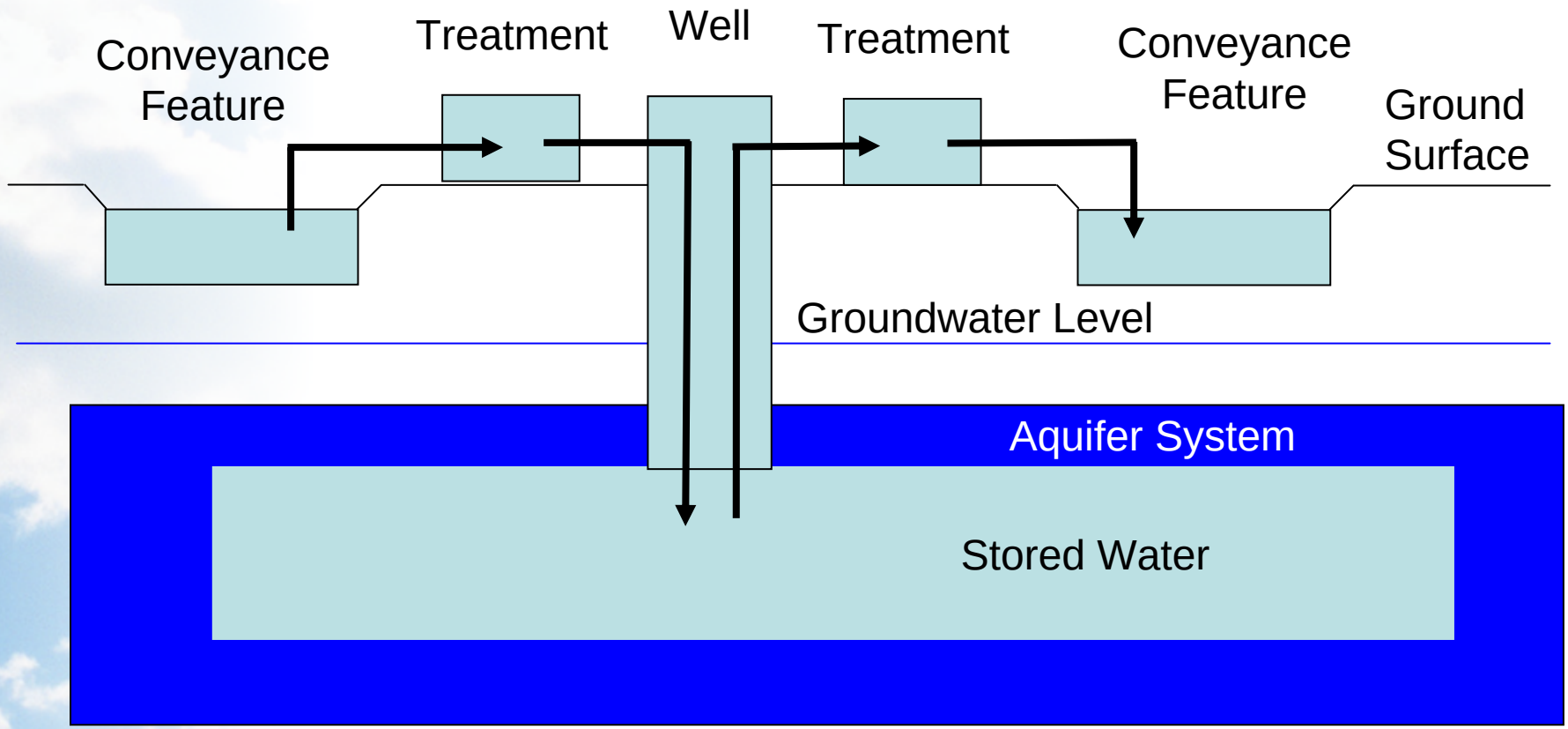
CERP Hillsboro
ASR Pilot Project

Below Ground Storage Features – Aquifer Storage Recovery (ASR) Systems

Aquifer Storage Recovery (ASR) Systems

- Recharge and Storage of Water Through a Well into an Aquifer System for Recovery of the Stored Water when Needed
- Water is Injected and Displaces Native Brackish Water in the Aquifer to Form a “Freshwater Bubble"
- One 5 Million Gallons per Day (MGD) Well Can Store 15 Acre-Feet of Water per Day

Aquifer Storage Recovery (ASR) Systems



Aquifer Storage Recovery (ASR) Systems

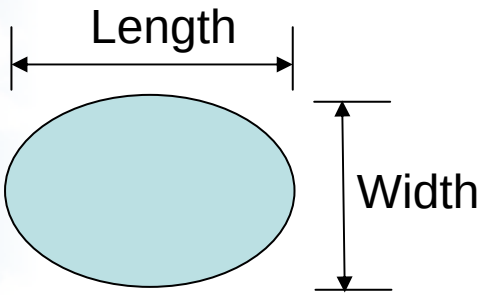
- Advantages
  - Minimal Land Requirements
  - No Storage Losses Due to Evaporation
  - Ability to Integrate with Reservoir Feature
- Disadvantages
  - Potentially Requires Both Pre and Post Treatment
  - Well Clusters Need to be Properly Sited for Hydrogeologic Conditions
  - Storage Losses Due to Diffusion or Lateral Transport

Below Ground Storage Features –
Lakes and Ponds – Natural and Constructed

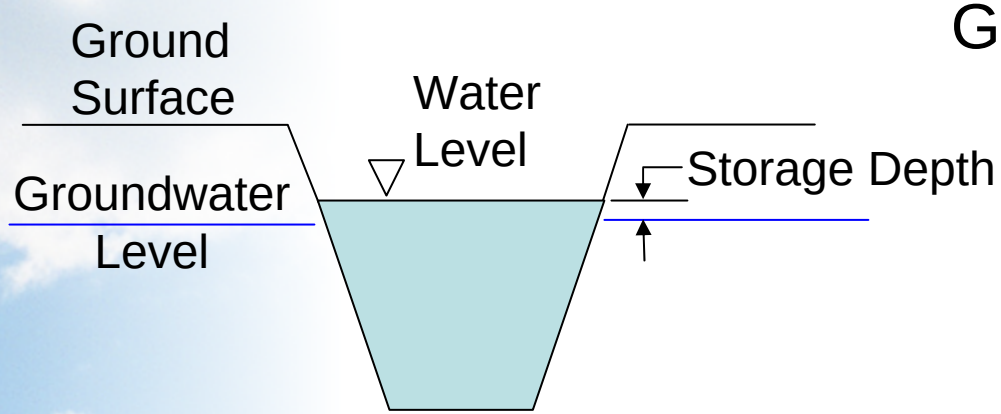
Lakes and Ponds – Natural and Constructed

- Lake is a Surface Water Body that is Below the Grade of the Surrounding Land
- Pond is a Small Surface Water Body that is Below the Grade of the Surrounding Land
- Both can be Formed by Existing Topography or Created Artificially
- Typically Both Fully Interact with Groundwater

Lakes and Ponds – Natural and Constructed



- Storage Water Level At or Below Ground Surface
- Available Storage Generally Dependent on Groundwater Levels
- Storage Volume is Only Amount of Water Above Groundwater Level



Lakes and Ponds – Natural and Constructed

- Advantages
  - May Facilitate Water Quality Improvement due to Sediment Drop Out
  - Provides Habitat and Recreational Opportunities
- Disadvantages
  - Storage Volume for Amount of Land Required Limited Due to Groundwater Influence
  - Potential Drawdown of Adjacent Groundwater when Releasing Stored Water
  - Difficult to Recover Stored Water When Needed without Potentially Impacting Groundwater Levels

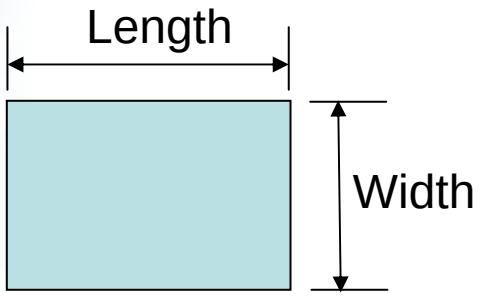
South Florida Water Management District L-8 Reservoir

Below Ground Storage Features – Below-Ground Reservoirs

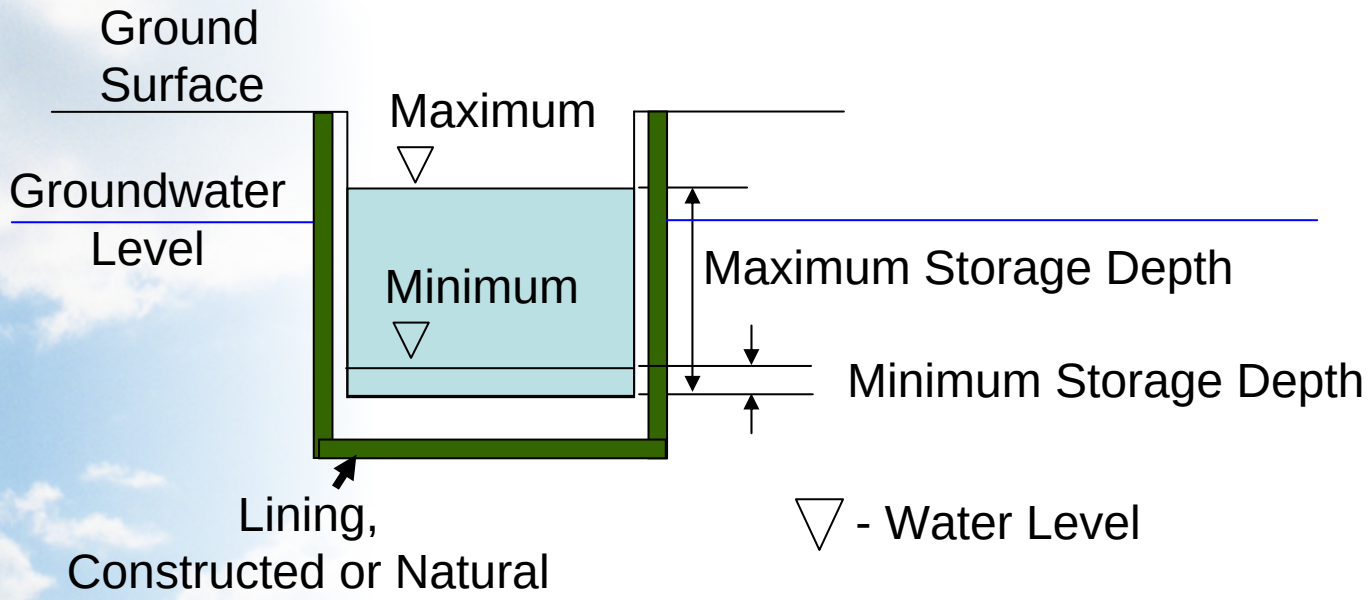
Below-Ground Reservoirs

- Natural Substrate Excavated to an Acceptable Depth, Depending on the Geology, to Create a Void to Store Water
- Storage Water Level Below Ground Surface
- Storage Water Level Independent of Groundwater Level
- Includes Active Seepage Control and Pumped Outflow

Below-Ground Reservoirs



- Lined Reservoir Interior
  - To Prevent / Reduce Reservoir Water Level from Mimicking Groundwater Levels



Below-Ground Reservoirs

- Advantages
  - Significant Storage Volume for Land Required
  - Less Water Loss due to Evaporation Compared to Surface Storage
- Disadvantage
  - May Require a Constructed Lining to Reduce the Loss of Stored Water to Groundwater
  - Requires High-head Pumps to Remove the Water from Storage
  - Ability to Detect Leakages or Other Issues with Containment
  - Reliability of Natural Geology or Liner Technology to Contain Water Over Time

Above Ground Storage Features –
Wetlands – Natural, Restored, and Constructed

Wetlands – Natural, Restored, and Constructed

- Land Areas That are Wet All or Part of the Year Due to Their Natural Position in the Landscape or Human Alteration of the Landscape
- Wetlands Can Both Convey and Store Water
  - Ability to Convey Large Quantities of Water Severely Limited by the Wetland Vegetation and Ability to Channel Flows
  - Ability to Store Large Quantities of Water Severely Limited by Requirement of Shallow Water Depths for Healthy Wetland Vegetation

Wetlands – Natural, Restored, and Constructed

- Advantages
  - High Ecological Values
  - Can Transform and Sequester Many Common Pollutants
  - Important Fish and Wildlife Habitat
- Disadvantages
  - Low Storage Volume for Amount of Land Required
  - Require Shallow Water Depths
  - Extremely Difficult to Recover Stored Water When Needed
  - Vegetation Impedes Efficient Flow of Water
  - During Dry Events, Wetlands May Become a Water User Instead of a Feature for Storage and Conveyance
  - Sensitive to Pollutant Loading

West Waterhole Pasture Florida Ranchlands Environmental Services Project (FRESP)

Above Ground Storage Features – Dispersed Storage

Dispersed Storage

- Land Modified with Low Intensity Constructed Elements to Store Water on Primarily Improved and Unimproved Pasture
  - Ditch Plugs
  - Berms
- Typically Existing Ground Elevation Remains Undisturbed
- Size of Individual Storage Components Vary
- Generally Quantity of Storage Components Can Be Numerous

Dispersed Storage

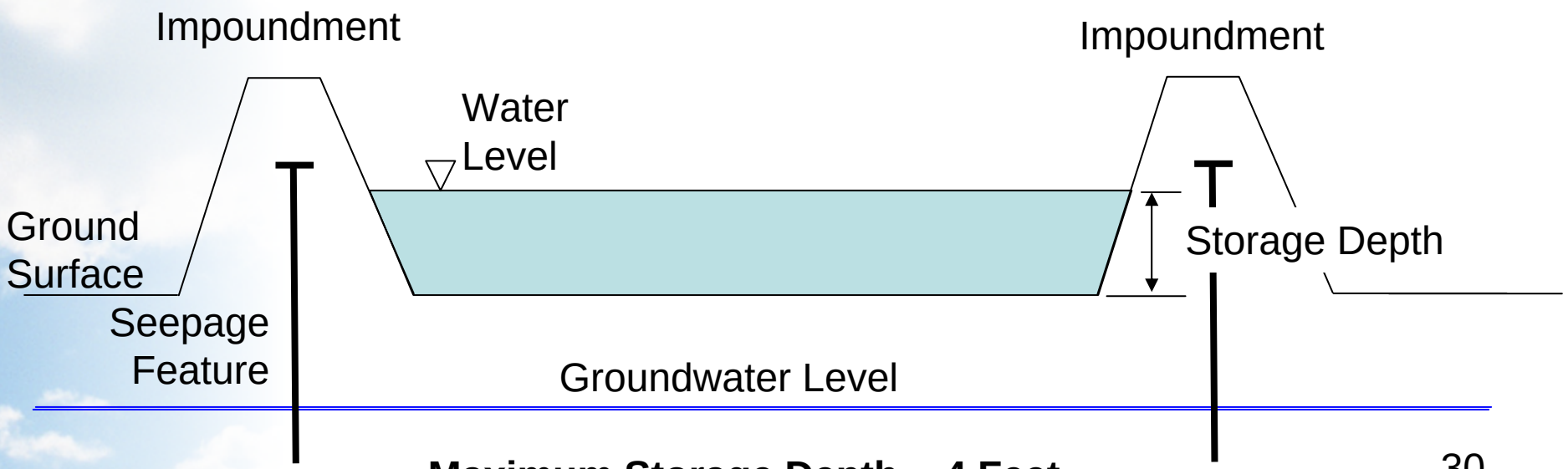
- Advantages
  - Potentially Provides an Alternative / Replacement Water Source for Existing Use by Local Land Owners which May Make Same Quantity of Water Available for Everglades Restoration Depending on Location of that Water
  - Potentially Improve Water Quality
  - Potentially Provides Habitat
- Disadvantages
  - Low Storage Volume for Amount of Land Required
    - Store 0.98 Acre-Feet Per Acre
      (Florida Ranchlands Environmental Services Project (FRESP))
  - May be Difficult to Recover Stored Water When Needed

Above Ground Storage Features – Minor Surface Water Impoundments

Minor Surface Water Impoundments

- An Above Ground Body of Water Typically Contained by Low Level Earthen Berms
- Per South Florida Water Management District Recommended Criteria in *Environmental Resource Permit Information Manual Volume IV*
  - Water Storage Depth is Generally No Greater than 4 Feet Above Surrounding Ground
  - Berm Failure Would Not Cause Significant Damage or Involve the Loss of Human Life
- Can be Designed as Both a Storage and Conveyance Feature Such as a Flowway By Increasing Impoundment Length

Minor Surface Water Impoundments



Maximum Storage Depth ~ 4 Feet

Minor Surface Water Impoundments

- Advantages
  - Medium to High Storage Volume for Land Required
  - Shallow Enough to Allow Growth of Aquatic Vegetation on the Impoundment Bottom for Water Quality Treatment
  - Earthen Levees Provide for Vegetation Growth and Habitat Support
  - Stored Water Available When Needed
- Disadvantages
  - Typically Requires Pump Stations to Deliver Water into the Impoundment
  - May Require Seepage Control Design to Maintain Storage Volume
    - Dependent on Site Geology
  - Exotic Control Required to Properly Maintain Impoundments
  - Evaporation Losses

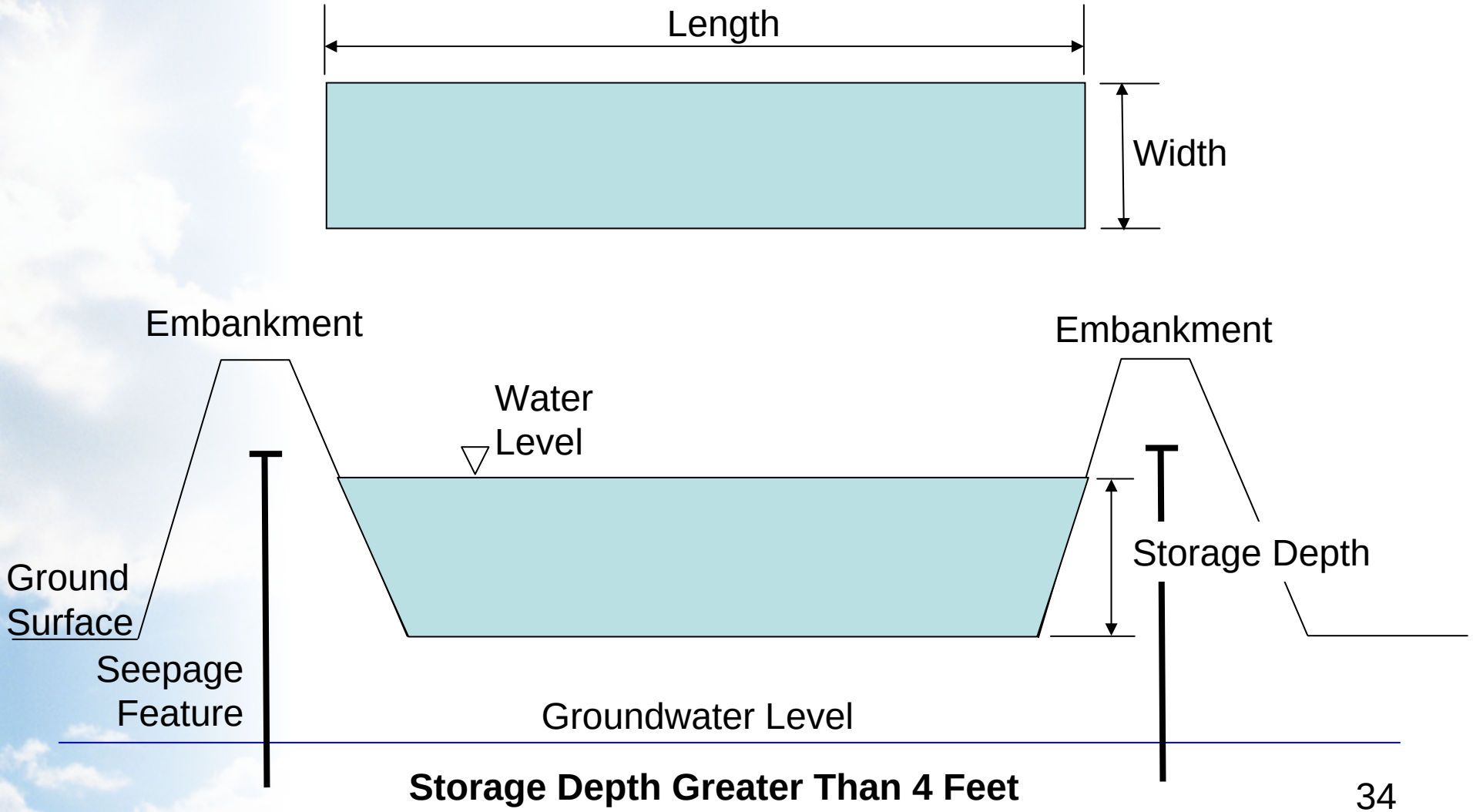
C.W. Bill Young Regional Reservoir - Tampa, Florida

Above Ground Storage Features – Major Surface Water Impoundments

Major Surface Water Impoundments

- Above Ground Body of Water Typically Contained by Large Earthen Embankments Along with Structural Components for Erosion Control
- Also Known As Reservoirs and Dams
- Per South Florida Water Management District Recommended Criteria in *Environmental Resource Permit Information Manual Volume IV*
  - Water Storage Depth is Generally Greater than 4 Feet Above Surrounding Ground
  - Berm Failure Would Cause Significant Damage and Could Involve the Loss of Human Life

Major Surface Water Impoundments



Storage Depth Greater Than 4 Feet

Major Surface Water Impoundments

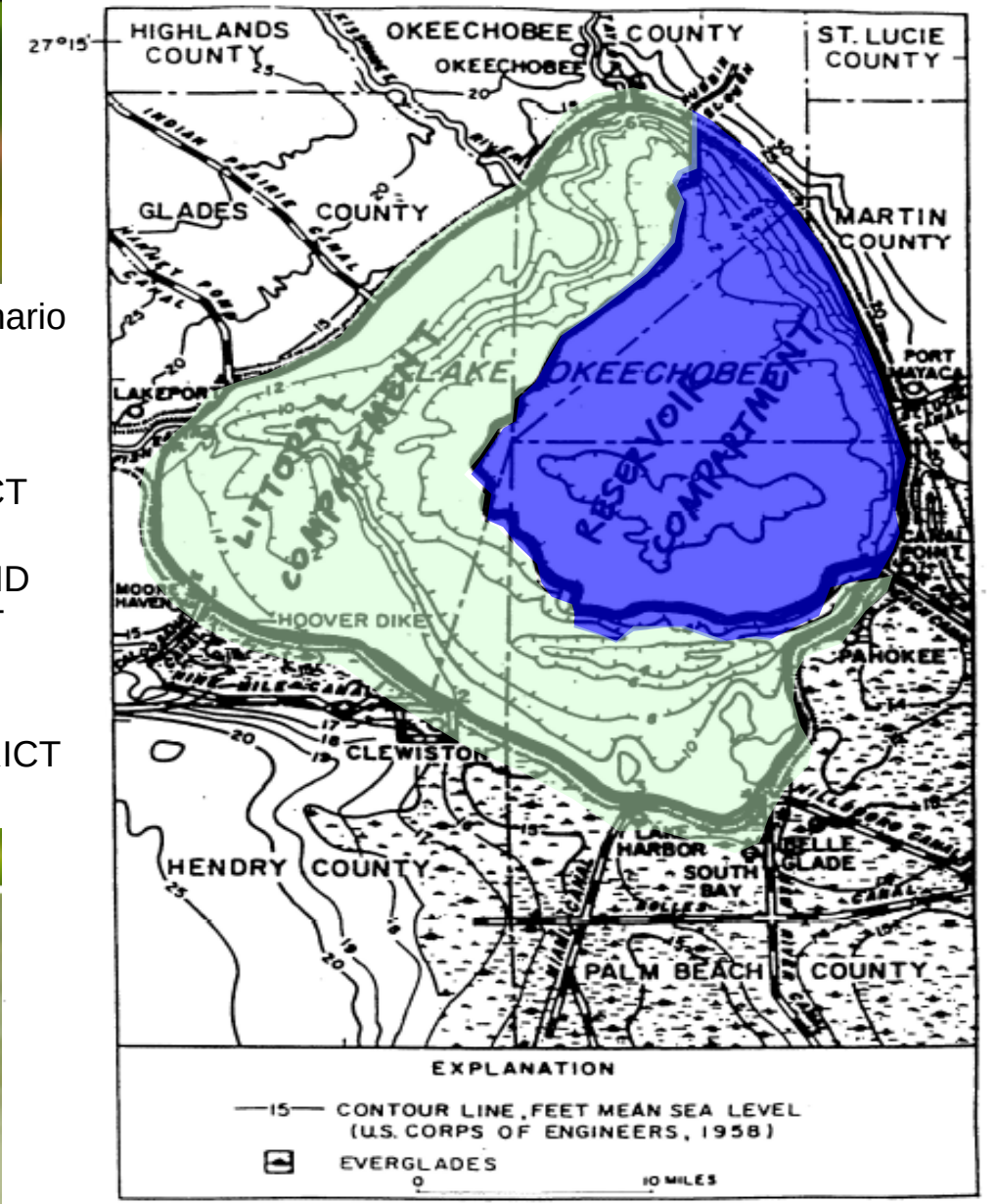
- Advantages
  - Significant Storage Volume for Land Required
  - Storage Water Level Essentially Independent of Groundwater Levels
  - Stored Water Available When Needed
- Disadvantages
  - Typically Requires Reinforcement / Protection of Interior Slopes with Minimal to No Vegetation on Interior Slopes
  - Typically Requires Structural Features to Minimize Seepage Impacts Dependent on Site Geology
  - Requires High-head Pump Stations to Deliver Water into the Impoundment
  - Evaporation Losses

Compartmentalizing Lake Okeechobee

Section B.3.5.9 Partitioning Lake Okeechobee Scenario
Hydrology and Hydraulics Modeling
Appendix B April 1999

CENTRAL AND SOUTHERN FLORIDA PROJECT
COMPREHENSIVE REVIEW STUDY
FINAL INTEGRATED FEASIBILITY REPORT AND
PROGRAMMATIC ENVIRONMENTAL IMPACT
STATEMENT
U.S. ARMY CORPS OF ENGINEERS
SOUTH FLORIDA WATER MANAGEMENT DISTRICT
APRIL, 1999

Dike Existing Water Bodies



Map of Lake Okeechobee area showing topography and principal drainage.

Figure B.3-97

Dike Existing Water Bodies

Compartmentalizing Lake Okeechobee

- Subdivide Lake Okeechobee into Compartments Utilizing Embankments
- Compartments Managed to Provide for Varying Water Levels to Achieve Lake's Multiple Purposes
- Utilize Water Control Structures within the Interior Dam to Provide Optimal Water Levels in Each Compartment and to Allow Commercial and Recreational Navigation

Dike Existing Water Bodies

- Advantages
  - Increased Lake Water Storage
  - Increased Lake Water Supply Capability
  - Increased Ability to Manage Lower Lake Stages
  - Periodic Drawdown More Feasible to Manage Lake Health
  - Internal Dam Reduces Wind Fetch Length for Improved Navigation and Reduced Turbidity
  - Improve Recreational Access
  - Lessen Effects of Storm Surge on Perimeter Herbert Hoover Dike
- Disadvantages
  - Complex Design and Construction
  - Impact to Lake Circulation Patterns are Unknown
  - Ecological impacts are unknown

Treatment Features

Goal of Treatment Features for River of Grass Project

- Reduce Total Phosphorous Loads and Concentrations within the Water Stored and Water Eventually Routed South to the Everglades

- Does Not Include Features to Initially Prevent Phosphorus from Entering the Water
  - Included in Other Projects

Treatment Features

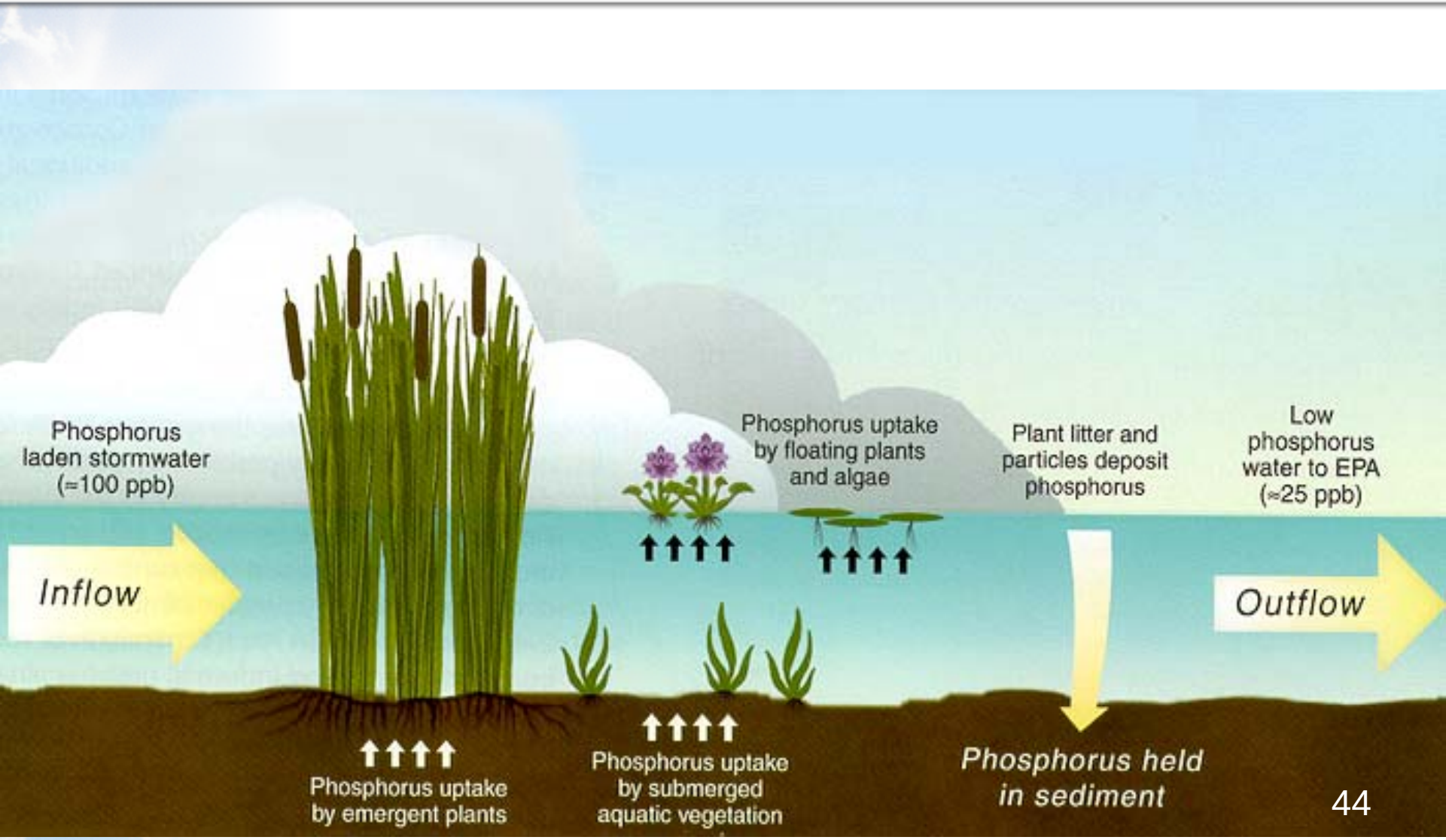
- Stormwater Treatment Areas (STAs)
- Chemical Treatment
- Hybrid Wetland Treatment Systems
- Managed Aquatic Plant Systems

Treatment Features – Stormwater Treatment Areas (STAs)

Stormwater Treatment Areas (STAs)

- Constructed Shallow Marshes / Wetlands for Reduction of Phosphorus in Water Through Uptake and Long-Term Soil/Peat Accretion
- Typically Require More Land than Chemical Treatment Facilities
- Typically Require Less Land than Wetlands
- Provide Less Storage than Impoundments

Stormwater Treatment Areas (STAs)



Stormwater Treatment Areas (STAs)

- Advantages
  - Proven 80%-90% phosphorus removal
  - Uses natural biological processes
  - Limited residuals management
  - Attracts wildlife and provides recreational opportunities
- Disadvantages
  - Significant Land Acreage Required for Treatment
  - Highly-managed systems with structures and vegetation control
  - Hurricanes can damage vegetation and re-suspend sediments/nutrients
  - During dry periods can become “water users”

South Florida Water Management District Constructed this Chemical Treatment Facility to Test the Technology for Treating Everglades Agricultural Area Runoff

Treatment Features – Chemical Treatment

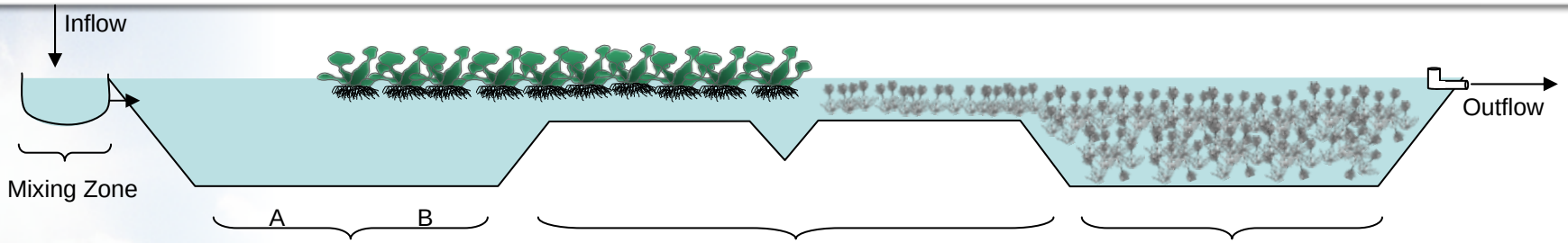
Chemical Treatment

- Injection of Liquid Chemicals such as Aluminum Chloride Into the Water to Flocculate and Settle-Out Pollutants and Phosphorous
- Other Chemicals, such as Ferric Chloride and Aluminum Salts, Can Also be Used
- Two Methods
  - Incorporated Directly with Storage Features (Injection of Chemicals Into the Water While it is Being Stored) or Other Treatment Features
  - Separate Chemical Treatment Plant With an Upstream Flow Equalization Basin
    - Plant Located Before or After the Storage Feature

Chemical Treatment

- Advantages
  - Reduces Phosphorus Concentrations Consistently by 85%-90%
  - Demonstrated to Consistently Achieve 10 Parts Per Billion (ppb) Phosphorus Treatment of Everglades Agricultural Area Runoff
  - Low Land Acreage Required for Treatment
- Disadvantages
  - Additional Mixing May Be Required of Treated Water to be Compatible with Everglades Marshes
  - Treatment Plant May Require an Upstream Flow Equalization Basin
  - May be difficult to Implement on Large Scale
  - “Residual” Disposal
  - Does Not Provide Habitat or Recreational Opportunities

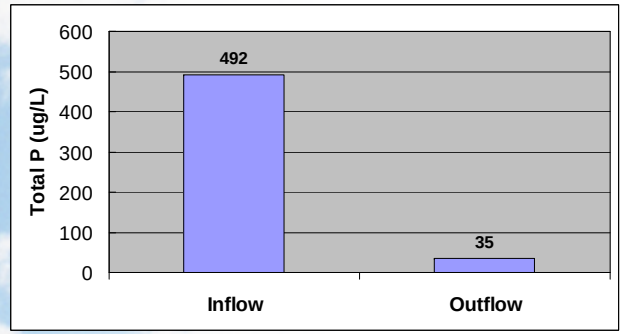
Treatment Features – Hybrid Wetland Treatment Systems

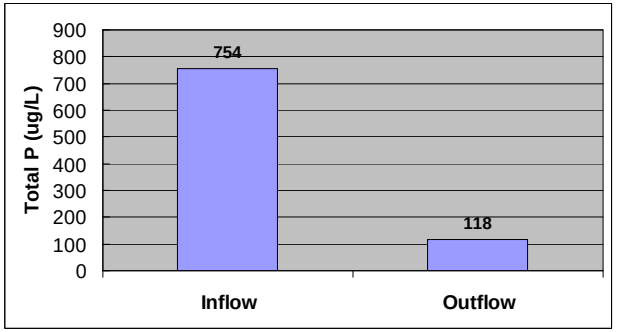


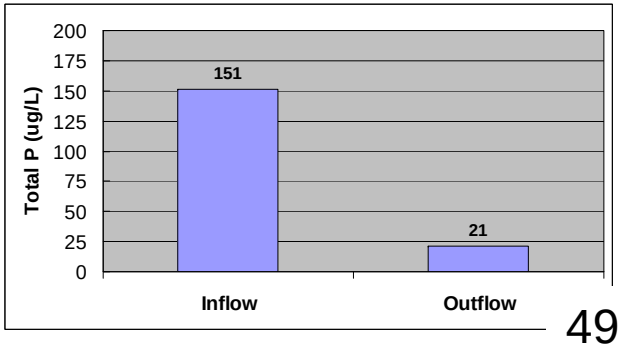
Mosquito Creek – 3 sites

Nubbin Slough

Ideal 2 Grove - Ft. Pierce







Hybrid Wetland Treatment Systems

- Combines Chemical Treatment with Managed Wetlands
- Requires Less Acreage Than Stormwater Treatment Areas (STAs) Only to Achieve Same Treatment Level

Hybrid Wetland Treatment Systems

- Advantages
  - Proven 80%-90% Phosphorus Removal
  - May be Improved with Further Research
  - Most Promising for “Edge of Farm Treatment”
  - Good for “Load Removal”
- Disadvantages
  - May be Difficult to Implement on Large Scale
  - “Residual” Disposal
  - May Not be Good for Low Phosphorus Outflow Targets Below 20 Parts Per Billion (ppb)
  - Medium Land Acreage Required for Treatment

Treatment Features –
Managed Aquatic Plant Systems

Managed Aquatic Plant Systems

- Consists of a Suitably Sloped Substrate, Typically a Plastic Geomembrane, Overlain with an Attachment Grid, Upon Which Nutrient Enriched Waters are Discharged and Aquatic Plant Systems are Cultured
- Such Systems can be Effective at Removing Carbon Dioxide, Nutrients and a Variety of Pollutants Found in Natural or Waste Water

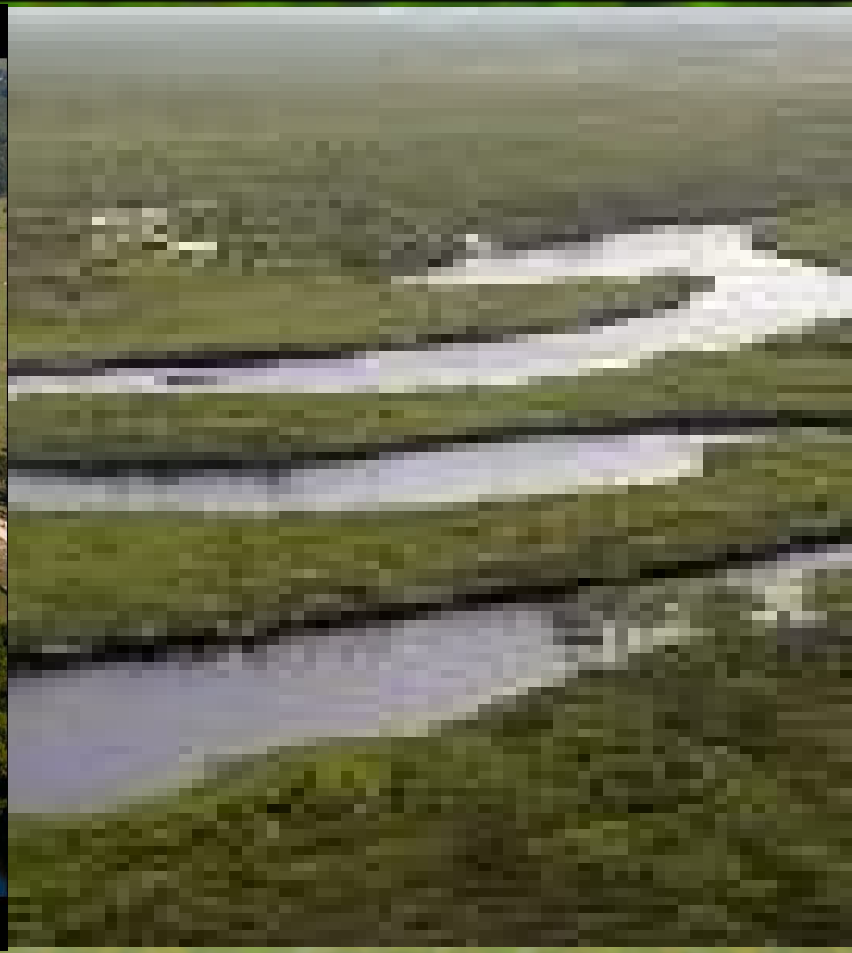
Managed Aquatic Plant Systems

- Advantages
  - Most Applicable as “Edge of Farm Treatment”
  - Can Effectively Remove Phosphorus in Some Instances
  - Low to Medium Land Acreage Required for Treatment
- Disadvantages
  - May be Difficult to Implement on Large Scale
  - “Residual” Disposal
  - Performance can be Negatively Impacted by Perturbations and Unknown Constituents in the Inflow Water

Conveyance Features

Conveyance Features

- Below Ground Canals and Rivers
- Above Ground Canals
  - Flowways
  - Aqueducts
- Pipelines – Buried and Above Ground



Conveyance Features –
Below Ground Canals and Rivers

Below Ground Canals and Rivers

- Water Conveyance Feature Carved Out of the Earth to Allow Water to Travel from One Place to Another
- Water Level Below Ground Surface
- Canal – Man-Made Conveyance
- Rivers – Natural Stream of Water that Flows Through Land and Typically Empties into another Body of Water

Below Ground Canals and Rivers

- Advantages
  - Potentially Minor Impacts to Transportation Corridors and Utilities
  - Can be Created to Mimic Natural Waterways
  - Riverine Habitat
- Disadvantages
  - Potential Seepage Issues Depending on Groundwater Levels
  - Inability to Control Volume and Timing
  - Need for a Constant Source of Surface Water
  - During Drought will Drawdown Adjacent Groundwater

Conveyance Features –
Above Ground Canals

Above Grade Canals

- Constructed Entirely Above Ground with Earthen Berms to Allow Water to Travel from One Place to Another
- Can be Designed as Both a Conveyance and Storage Feature Such as a Flowway or Aqueduct
- May Require Seepage Control Design Dependent on Site Geology to Maintain Conveyance Ability, Storage Volume, and Minimize Interaction with Groundwater

Above Grade Canals

- Advantages
  - Changes in Elevation not as Critical to Conveyance
- Disadvantages
  - Potential Impacts to Transportation Corridors and Utilities
  - Cannot be Created to Mimic Natural Waterways
  - May Require Seepage Control Design to Maintain Storage Volume And Not Impact Surrounding Properties
    - Dependent on Site Geology

Conveyance Features –
Pipelines – Buried and Above Ground

Pipelines – Buried and Above Ground

- Enclosed Concrete or Steel Pipes to Allow Water to Travel from One Place to Another
- Buried Below Ground Pipeline or Exposed Above Ground Pipeline
- Geologic Soil Conditions Significantly Impact Installation Design and Maintenance Requirements

Pipelines – Buried and Above Ground

- Advantages
  - Buried Pipelines Provide Minor and/or Short Term Impacts to the Environment
  - No Impact to Transportation Corridors and Utilities
  - Changes in Elevation not Critical to Conveyance
  - Seepage not an Issue
  - Move Water in Faster Time Frames than Canals
- Disadvantages
  - More Maintenance and Replacement Issues Compared to Canals
  - Requires a Pumping Water Transfer System for Pipeline

Questions?