

TREATMENT WETLAND : A LANDSCAPE ARCHITECT'S REFERENCE

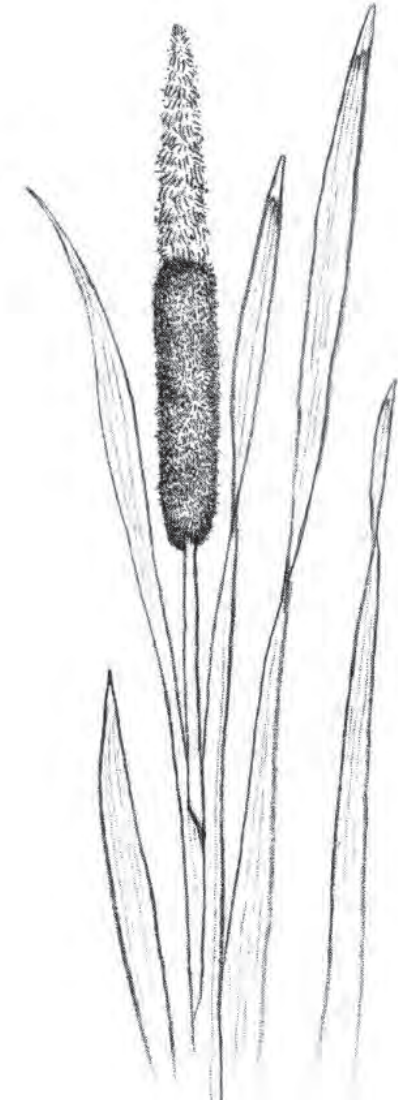
INTRODUCTION :
WHERE WE ARE NOW?

THREE COMPARTMENTS

 HYDROLOGY

 MEDIUM

 LAYOUT



3,199 projects S W A

stormwater
management
and bioswale

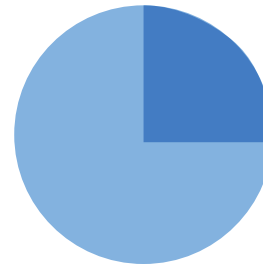
233

140

wetland
creation
restoration
preservation

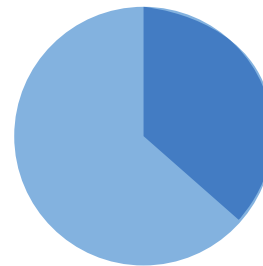
81

Within these 81 projects



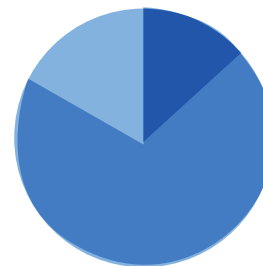
25%

Design Awarded



37% Asia

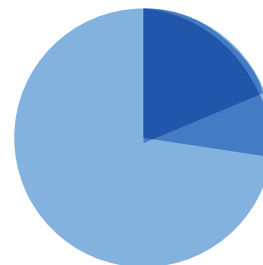
63% USA



15% 1990s

73% 2000s

12% 2010s



20% DD, CD

7% SD

73% MP

A PROGRESSION TO EXPAND OUR PROFESSION

TREATMENT
WETLAND

PORTABLE WATER PRETREATMENT
WASTEWATER TREATMENT PLANT
AGRICULTURAL WASTE AND RUNOFF
INDUSTRIAL SITE RUNOFF

QUALITY
CONTROL

ENHANCEMENT
WETLAND

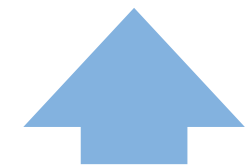
HABITAT SURFACE WATER DISCHARGE
RECREATIONAL WATER
WATER STORAGE AND REUSE
STORMWATER MEDIATION



QUALITY

DETENTION POND
RETENTION POND

STORMWATER MANAGEMENT
GROUND WATER DISCHARGE
FLOOD CONTROL



QUANTITY

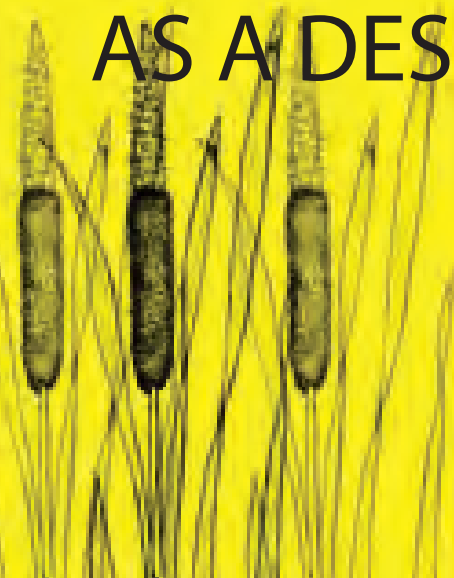
Treatment Wetland

FOR

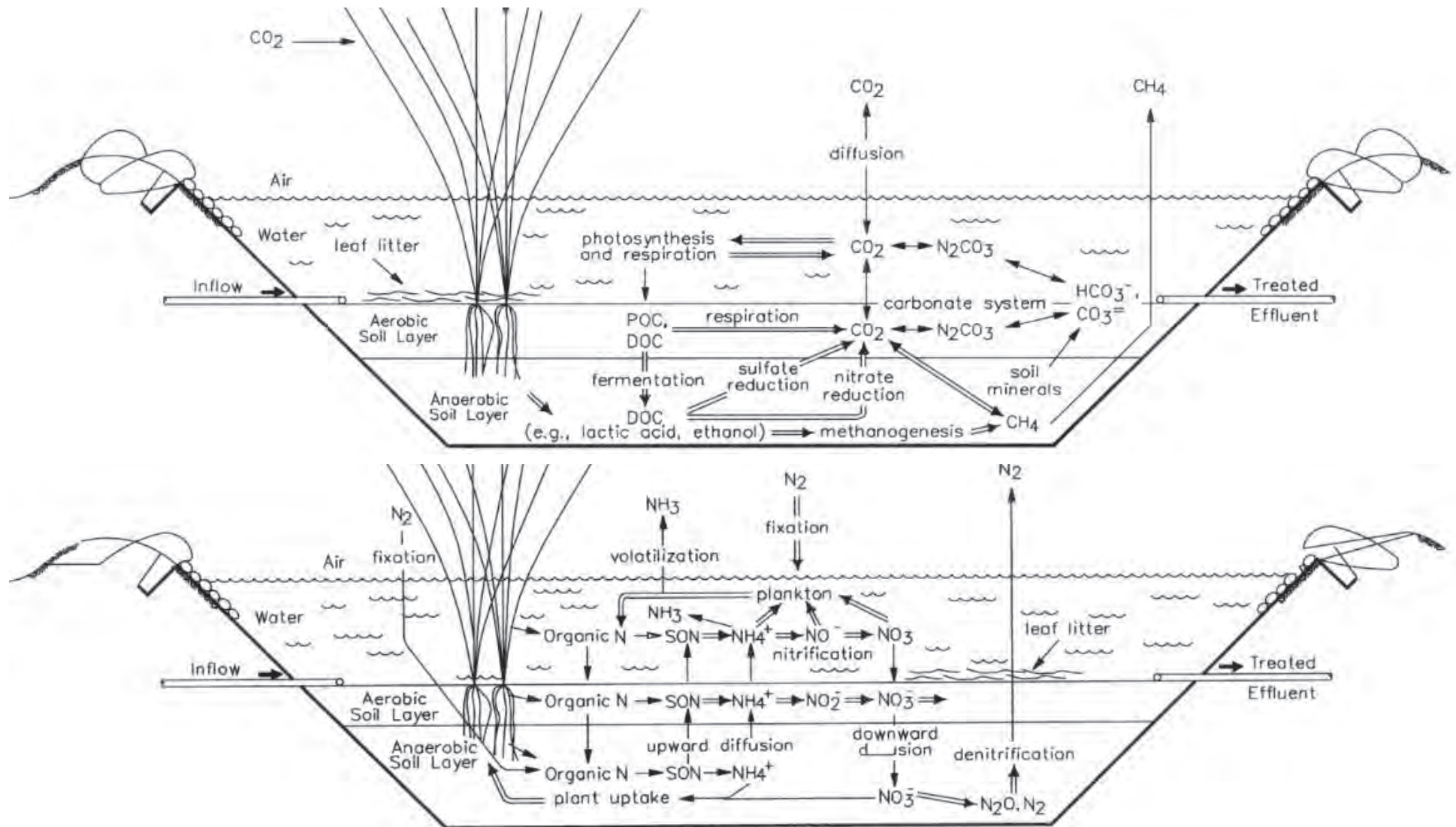
DUMMIES[®]



A REFERENCE
FOR THE REST OF US
AS A DESIGN TOOL

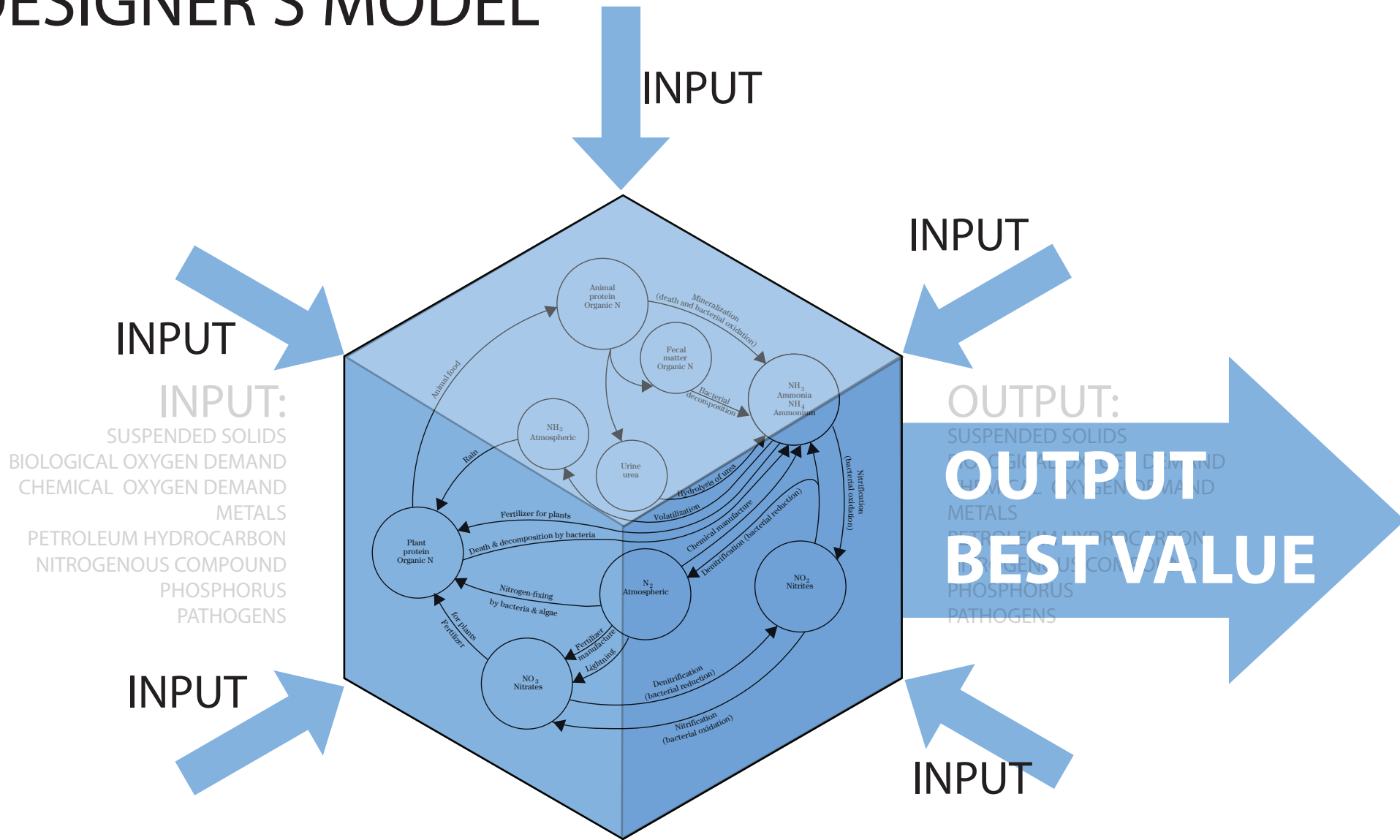


CHEMICAL AND BIOLOGICAL REACTIONS IN WETLANDS ARE INTERRELATED AND VERY COMPLICATED TO UNDERSTAND



CARBON AND NITROGEN CYCLE IN WETLANDS

A DESIGNER'S MODEL



design community's work, on the other hand, is to integrate multiple inputs and create the best appropriate solution.

[Bioremediation]

processes that use microorganisms, fungi, green plants or their enzymes to return the natural environment altered by contaminants to its original condition.

How can design create the environments that manipulate this natural return process?

THREE BASIC ELEMENTS:



HYDROLOGY



MEDIUM



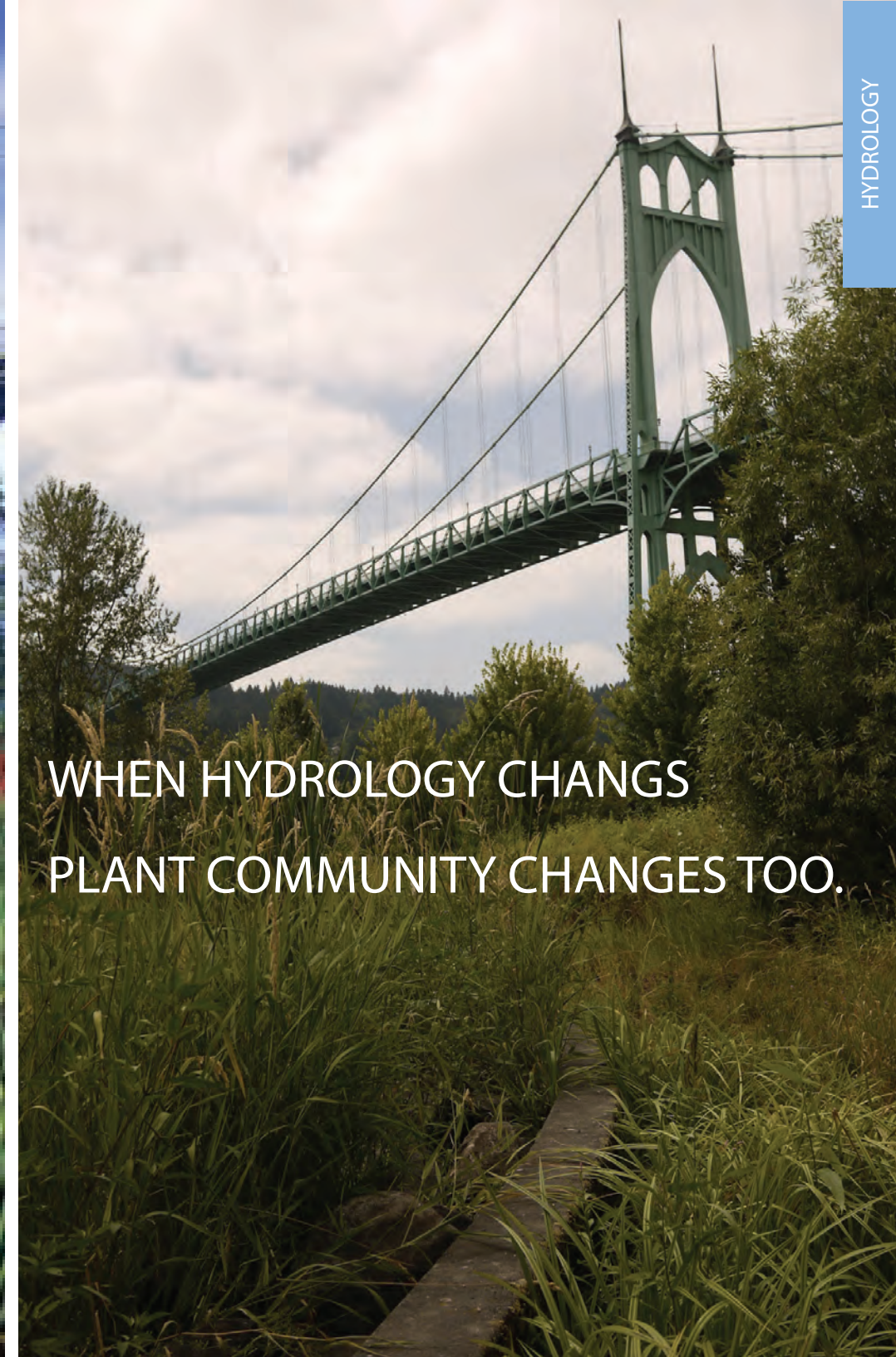
LAYOUT

HYDROLOGY

The #1 factor of success or failure



Water Pollution Control Lab, Portland, Oregon



WHEN HYDROLOGY CHANGES
PLANT COMMUNITY CHANGES TOO.



Water Pollution Control Lab, Portland, Oregon





Water Pollution Control Lab, Portland, Oregon



Water Pollution Control Lab, Portland, Oregon

HYDRO CALC

$$\square ROV = DA * P * Rf * 3630$$

where ROV is runoff volume in cu.ft.
 DA is drainage area in acres
 P is rainfall in inches. If P is ≤ 0.05 inch then no runoff is assumed (i.e., watershed depression storage assumed = 0.05")
 Rf is the runoff coefficient, from Table 1-9 from Section 1.6.9.3 of the ECM.
 3630 is a conversion factor

$$\square Vi = P + ROV$$

Inflows to the wet pond are direct rainfall onto the pond surface (P) and runoff from the contributing watershed (ROV):

$$P \text{ (cu.ft.)} = Ap * P/12$$

Si-1 = volume of water stored in wet pond at the end of day
 Si = volume of water stored in wet pond at start of day
 Vi = inflow volume to wet pond during day
 Vo = outflow volume from wet pond during day

$$Si = Si-1 + Vi - Vo$$

$$\square ETo = Kp * PAN$$

where ETo is potential evapotranspiration for a reference crop (in.)
 Kp is the pan coefficient
 PAN is daily pan evaporation

$$\square ETc = Kc * ETo$$

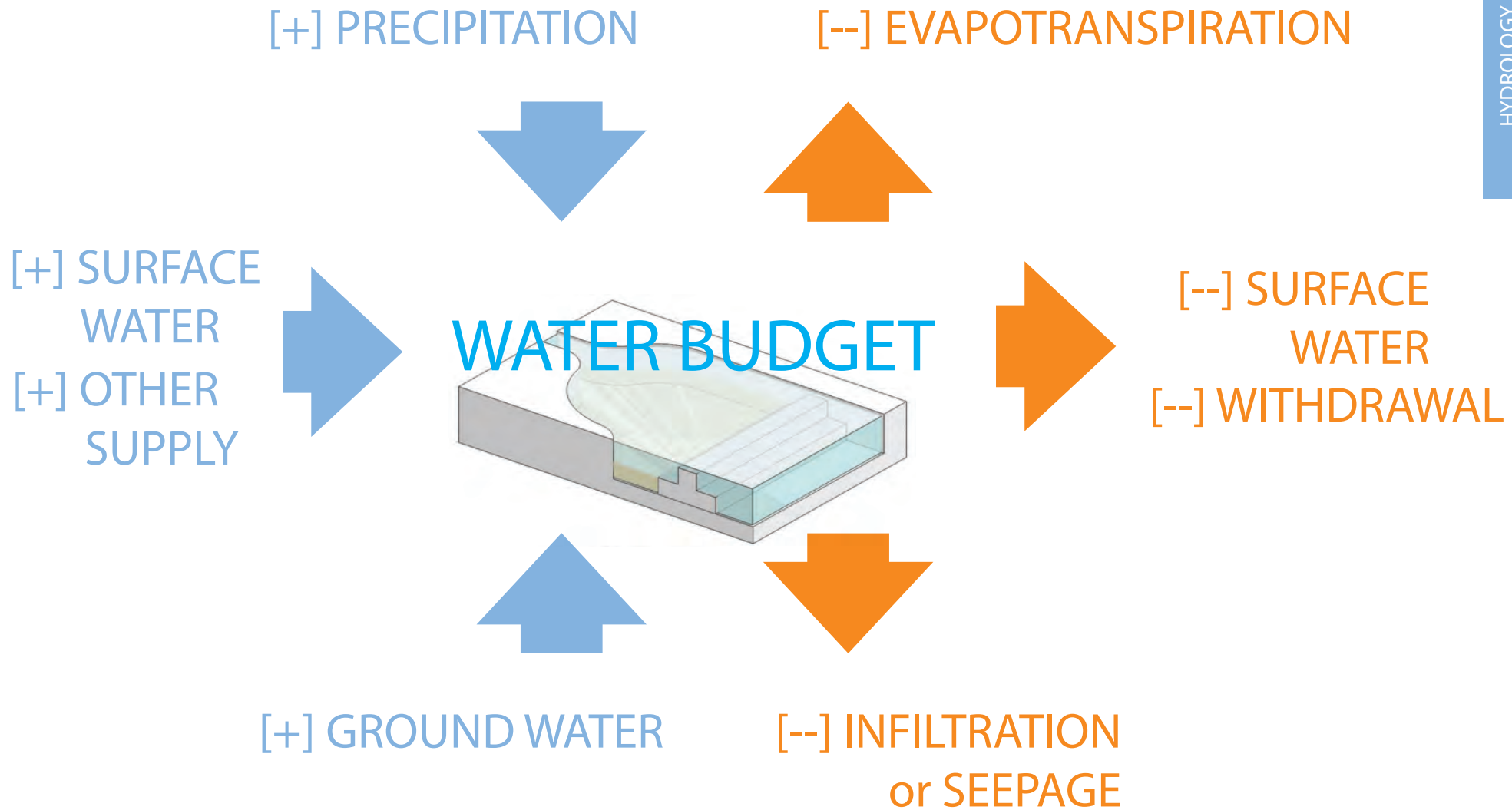
where ETc is the evapotranspiration for the crop of interest (in this case, open water and marsh vegetation)
 Kc is the crop coefficient

$$\square Vo = ETc_{ow} + ETc_{vb} + SEEP + WD$$

where Vo is the outflow volume in cu.ft.
 ETc_{ow} is the "crop" evapotranspiration from the open water
 ETc_{vb} is the "crop" evapotranspiration from the vegetated bench
 SEEP is the loss of water via seepage through the pond
 WD is the volume of water withdrawn from the pond, e.g., to irrigate landscape

Withdrawal WD - the user also has the option to input daily withdrawals (WD) in cu.ft., in column L. As stated above, there is no standard procedure

Seepage SEEP is based on the ECM value for liners of $\leq 1 \times 10^{-7}$ cm/sec, which equates to 0.00028 ft/day. Seepage is converted to cu.ft./day:



THE WATER BUDGET JUST LIKE PERSONAL FINANCE:

Flood control: How do I spend/save the money when I win a lottery?

Stormwater wetland: How can I survive in the tough time (dry season).

Wastewater wetland: I have a stable income,

BUT I WORK SO HARD FOR EVERY PENNY!

STORMWATER "WETPOND"



Central Park, Austin, Texas

Constructed: 1998
Watershed: Waller Creek
Location: Behind Central Market and the apartments at 38th Street and Lamar Avenue
Pond Watershed: 173 acres
Impervious Cover / Drainage Area: 54%
Pond Goal: Water Quality Protection
Pollutant Removal: 50,000 lbs. Total Suspended Solids (TSS) removed annually

FLOOD DETENTION LEVEL

WETLAND LEVEL

Central Park, Austin, Texas





Central Park, Austin, Texas

What is your make up water?



Mason Park Wetland, Houston, Texas

STORMWATER WETLAND SIZING

SMALL SCALE:

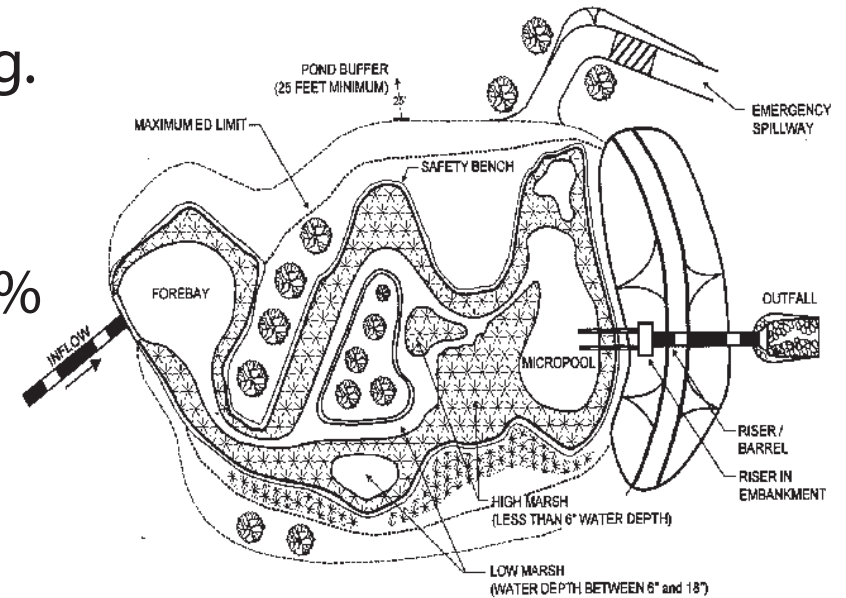
- Bioswale, Rain Garden, flexible in sizing.

MID SCALE : 1-10 HA

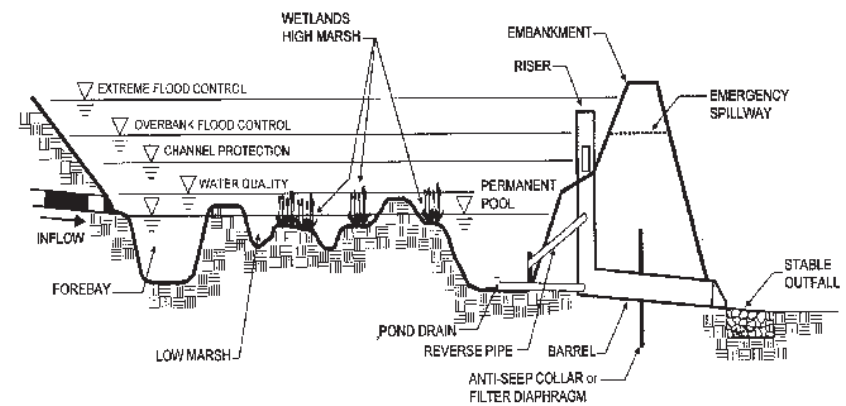
- by Wetland to Watershed Ratio : 2%-4%
- by First Flush
- by Special Discharge Standard

LARGE SCALE:

- Affiliated with flood control
- Wetland restoration or preservation
- Biological Bench Mark
- Historical Wetland Boundary



PLAN VIEW



PROFILE

WASTEWATER WETLAND SIZING

SMALL SCALE:

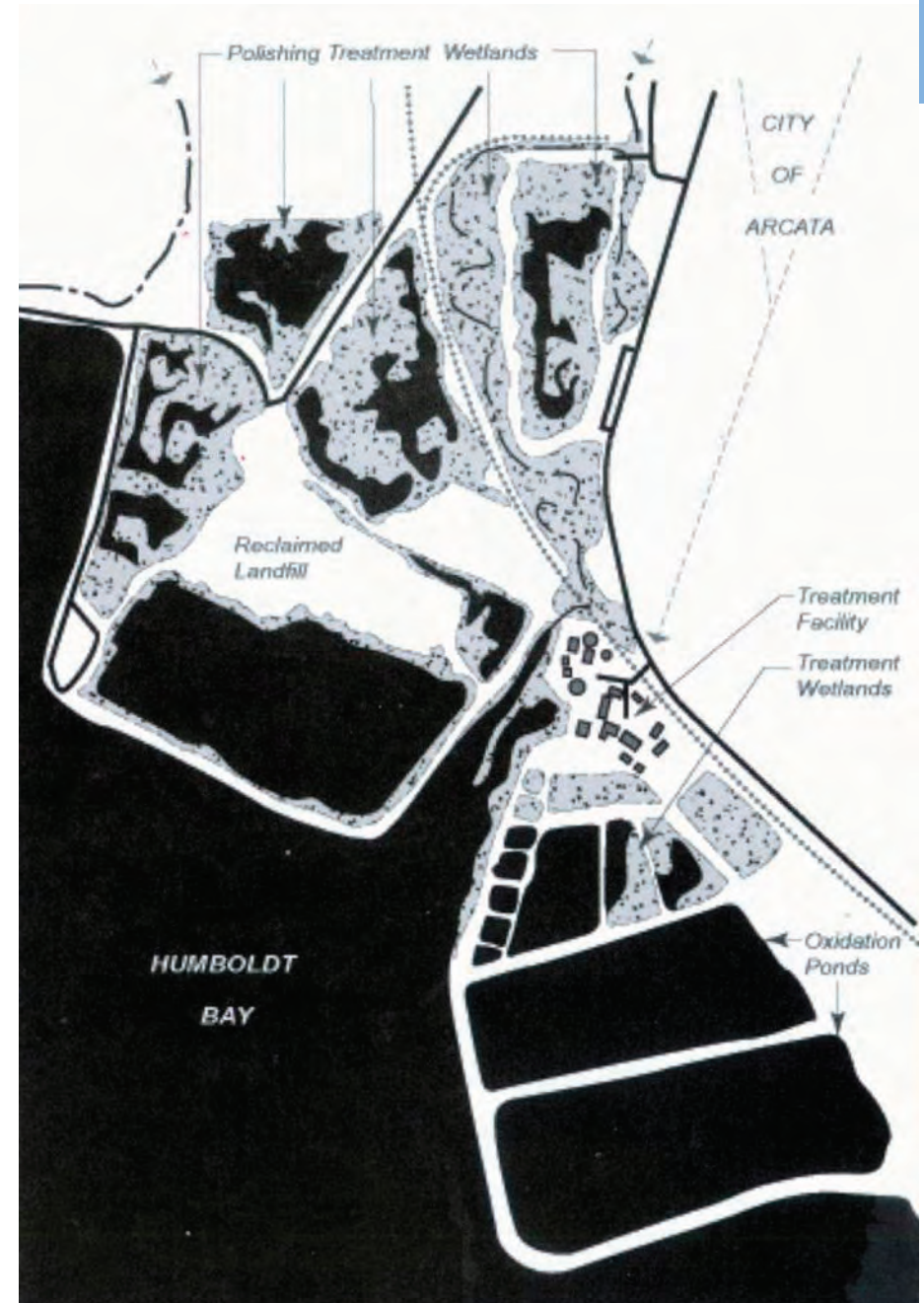
- Single Family: half of a house
- Mostly combine sub-surface flow

MID SCALE: 1-10 HA

- Combine living machine and FSW

MUNICIPAL: < 100 HA

- Tertiary treatment or polishing
- 93% of the wetland less than 100 HA
- 93% of the wetland treat less than 10,000 m³ per day
- Adding habitat value



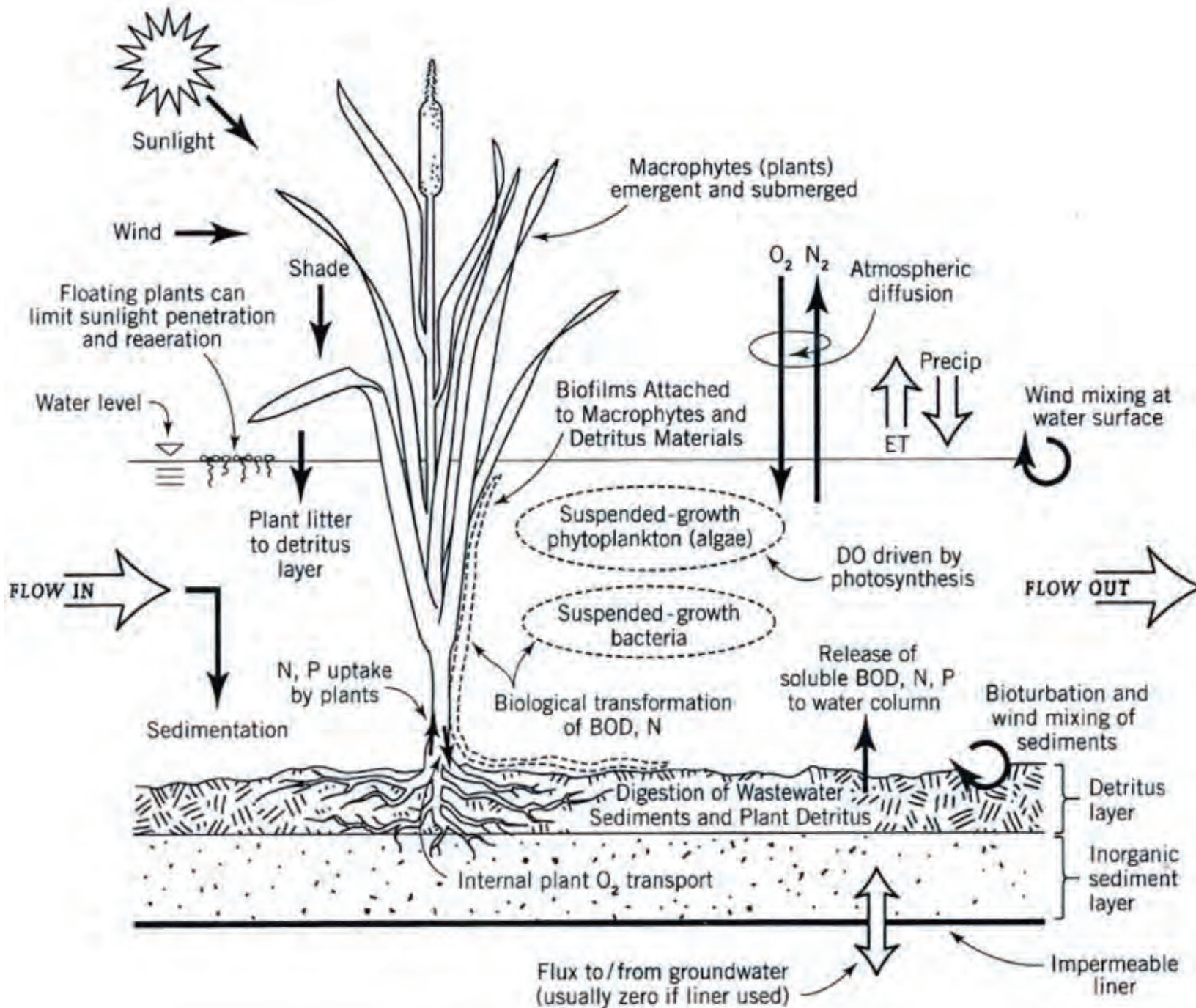
MEDIUM

Places where the magic happens

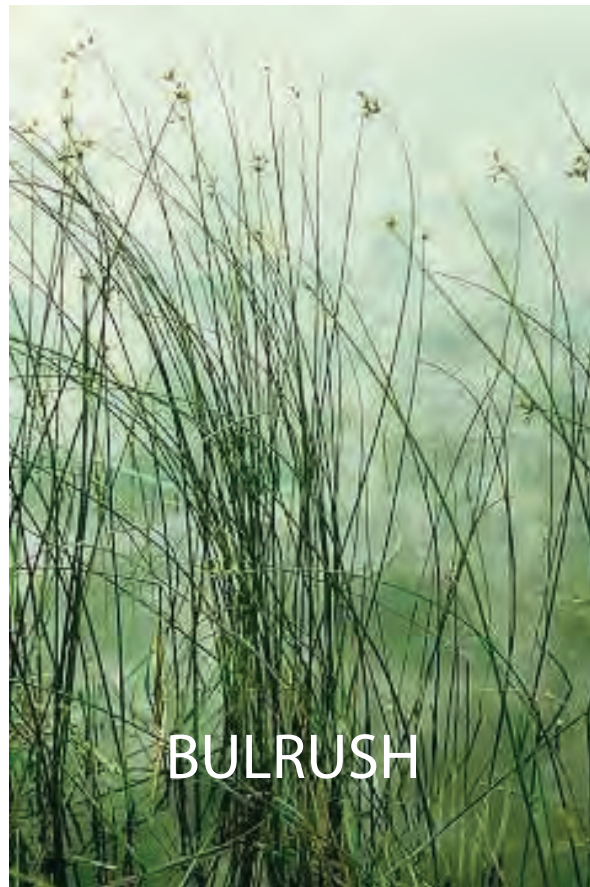
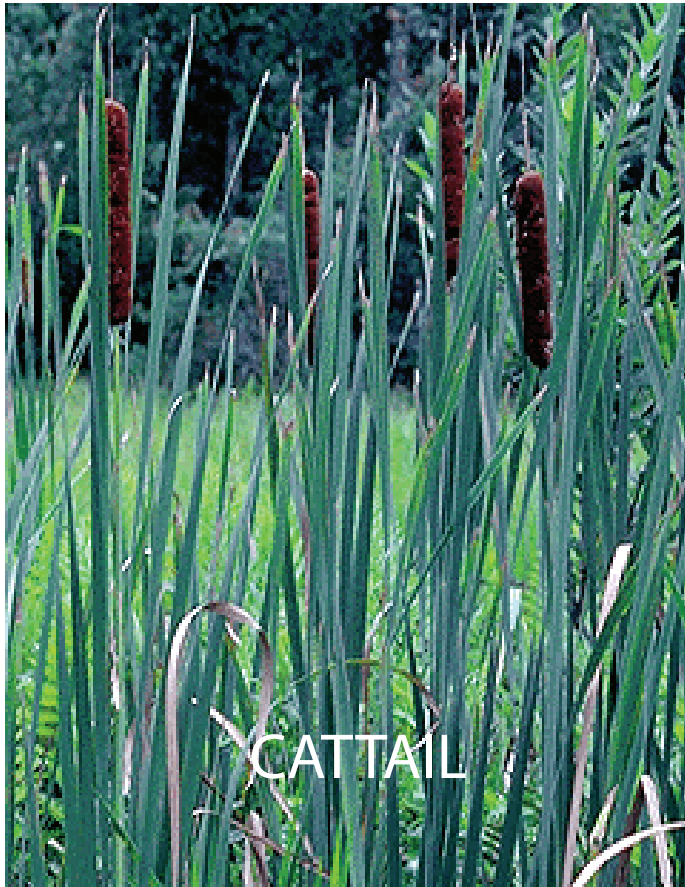
TARGET OF REMOVAL

Water Quality Parameter	Physical	Chemical	Biological
Suspended solids	<i>Sedimentation</i>	Not applicable	Microbial degradation
Biological Oxygen Demand (BOD ₅)	Sedimentation	UV radiation	<i>Microbial degradation</i>
Chemical Oxygen Demand (COD)	Sedimentation	UV radiation	<i>Microbial degradation</i>
Metals (Ag, As, Cd, Cr, Cu, Hg, Ni, Pb, Se, Zn)	Sedimentation	<i>Precipitation; adsorption; ion exchange</i>	Microbial uptake; plant uptake
Petroleum hydrocarbons (fuels, oil and grease, alcohols, BTEX, TPH)	<i>Volatilization</i>	UV radiation	<i>Microbial degradation; plant uptake</i>
Synthetic hydrocarbons (PAHs, chlorinated and non-chlorinated solvents, pesticides, herbicides, insecticides)	Sedimentation; volatilization	Adsorption UV radiation	<i>Microbial degradation; plant uptake</i>
Nitrogenous compounds (Organic N, NH ₃ , NH ₄ ⁺ , NO ₃ ⁻ , NO ₂ ⁻)	Sedimentation	Adsorption, volatilization (ammonia)	<i>Microbial uptake and transformation; plant uptake</i>
Inorganic and organic P	Sedimentation	<i>Precipitation; adsorption</i>	Microbial uptake; plant uptake
Pathogens (bacteria, viruses, protozoa, helminths)	<i>Sedimentation</i>	UV radiation	<i>Die-off; microbial predation</i>

FIND AN APPROPRIATE STRATEGY



MOST COMMONLY USED PLANTS



YOU CAN'T SEE THE MICROBES

MEDIUM

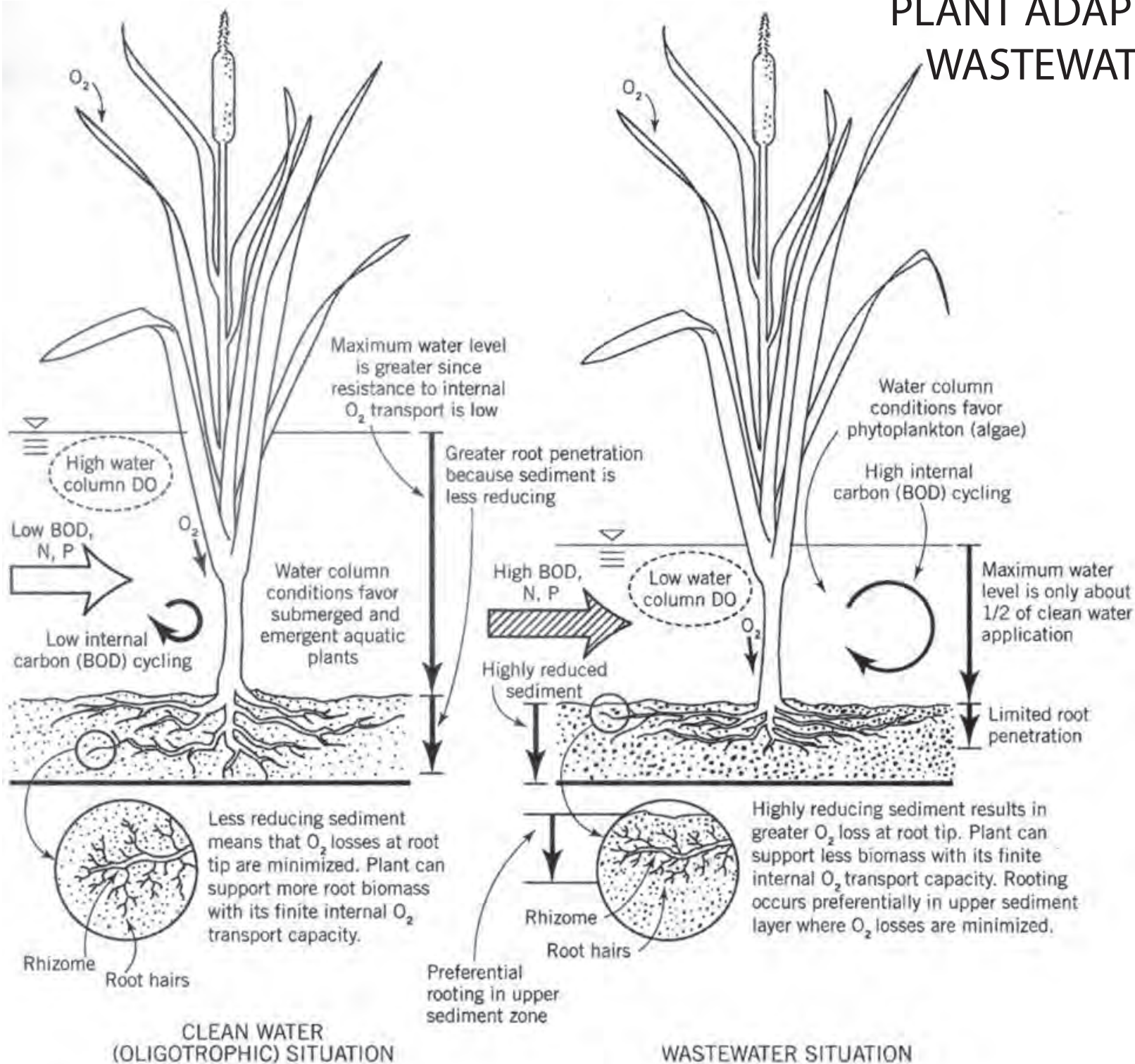


BUT THE MONSTERS ARE ALL THERE WORKING

MEDIUM



PLANT ADAPTATION TO WASTEWATER STRESS





Arcata Marsh, Arcata, California



MEDIUM



THE THICK ROOT LAYER AND BIOMASS



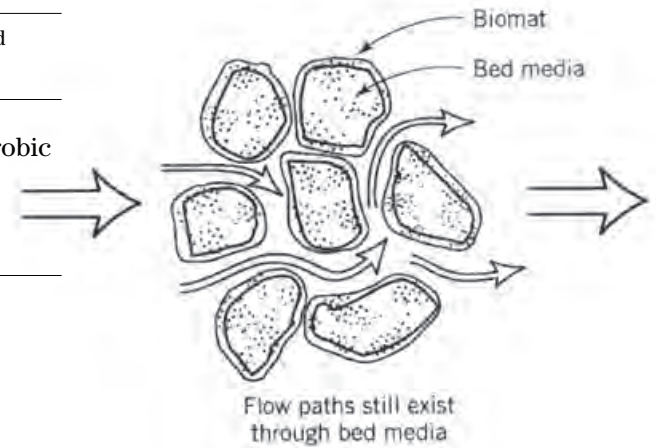


MEDIUM



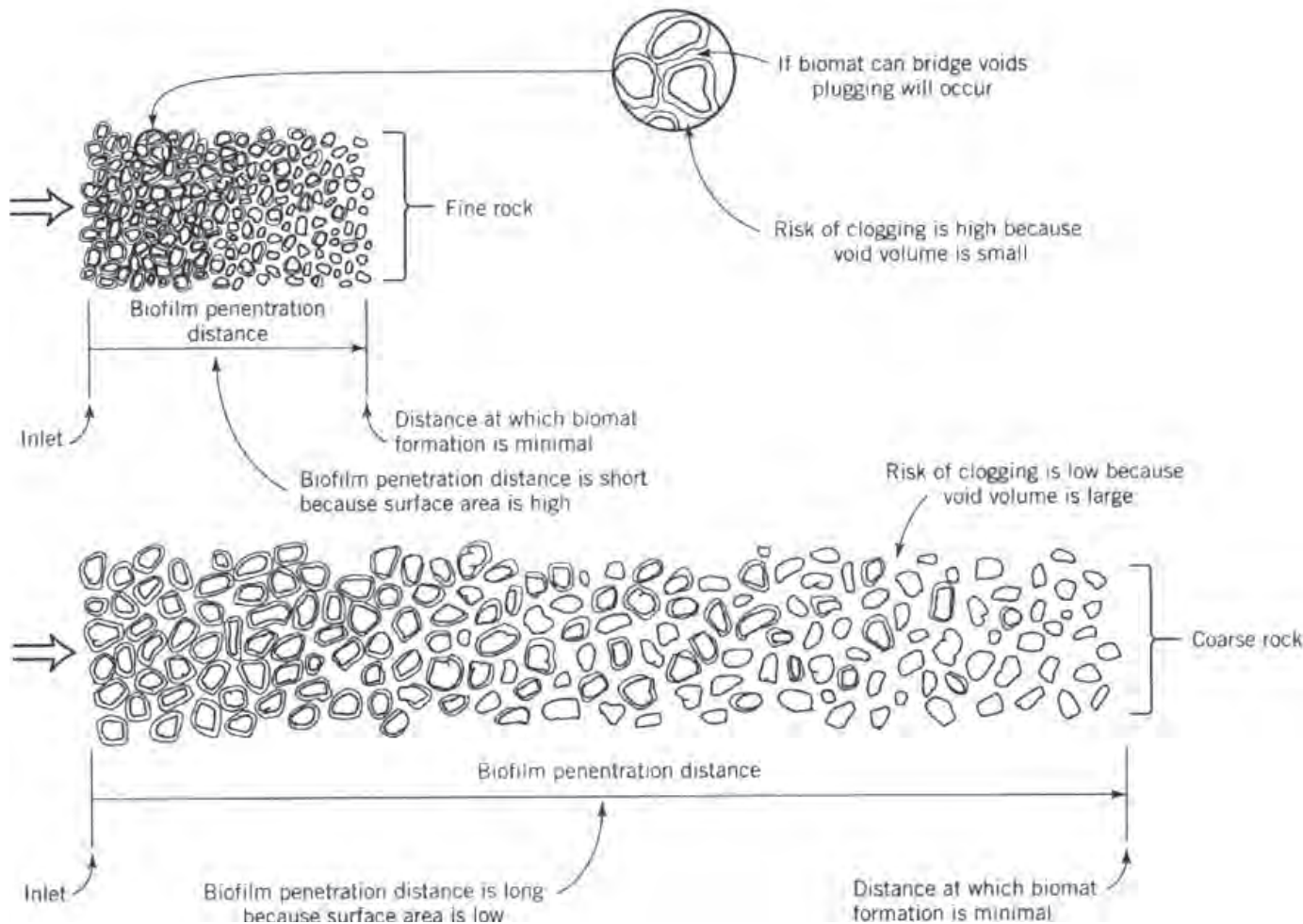
Table 3-5 Processes involved in the conversion of organic and ammonia N to nitrogen gas

Process	----- Conversion of N -----	Condition required
	from to	
Ammonification	Organic N (Org-N) to Ammonia (NH ₃ + NH ₄)	Anaerobic or aerobic
Nitrification	Ammonia (NH ₃ + NH ₄) to Nitrite (NO ₂) and Nitrate (NO ₃)	Aerobic
Denitrification	Nitrate (NO ₃) to Nitrite (NO ₂) and N gas (N ₂)	Anaerobic



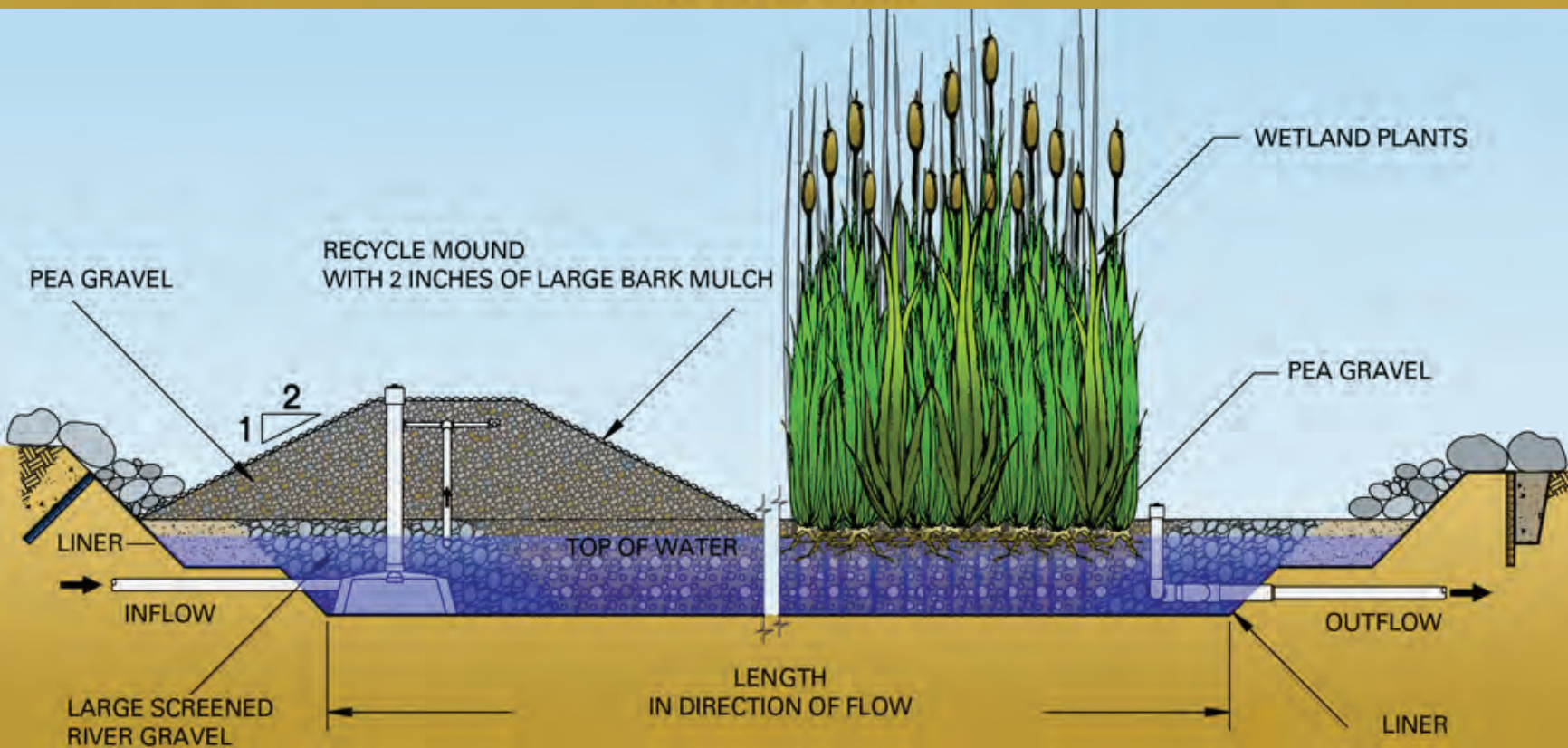
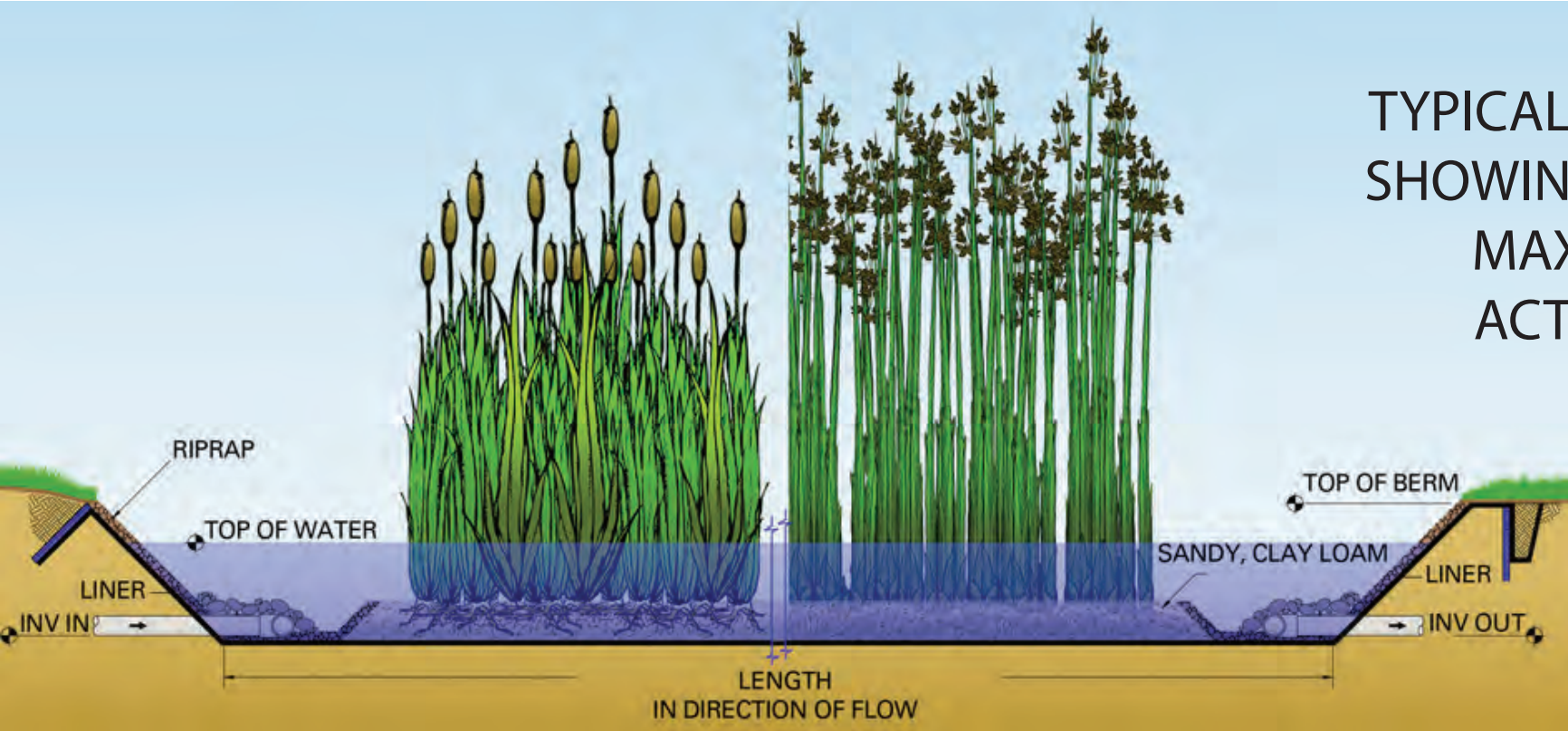
3-18

(210-VI-NEH, September 2002)



**GRAVEL:
SURFACE BIO-FILM**

TYPICAL SECTIONS SHOWING HOW TO MAXIMIZE THE ACTIVE ZONES

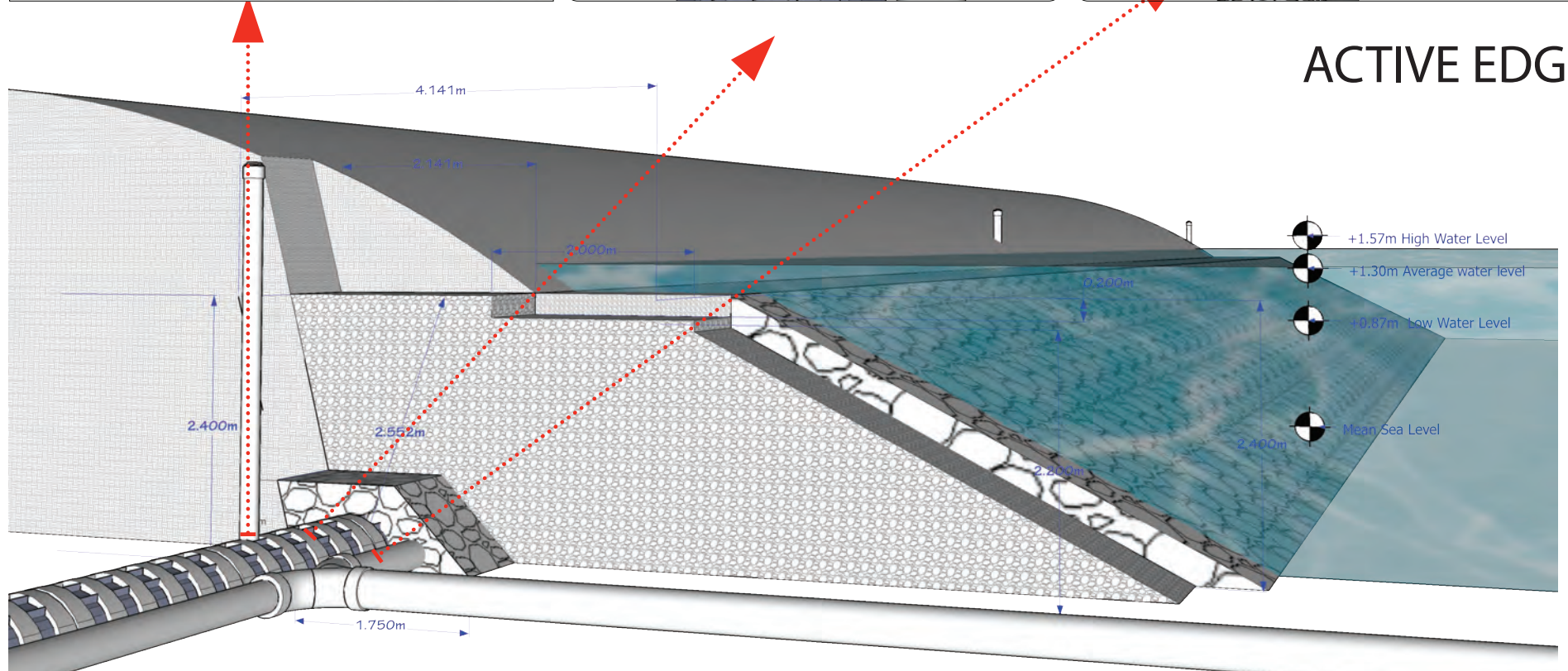
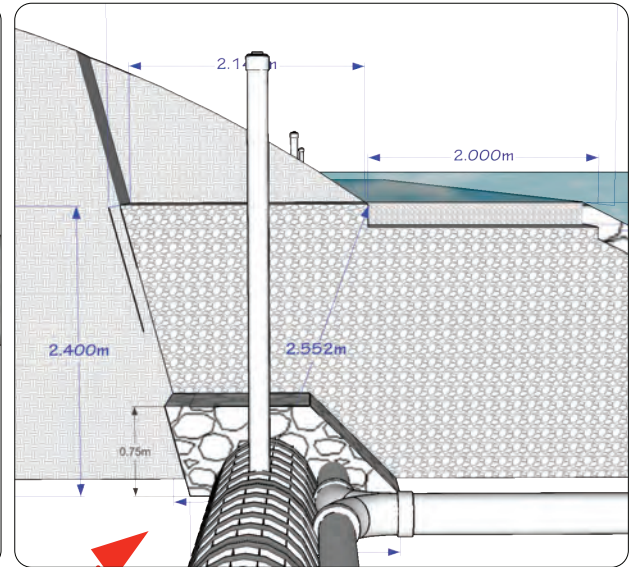
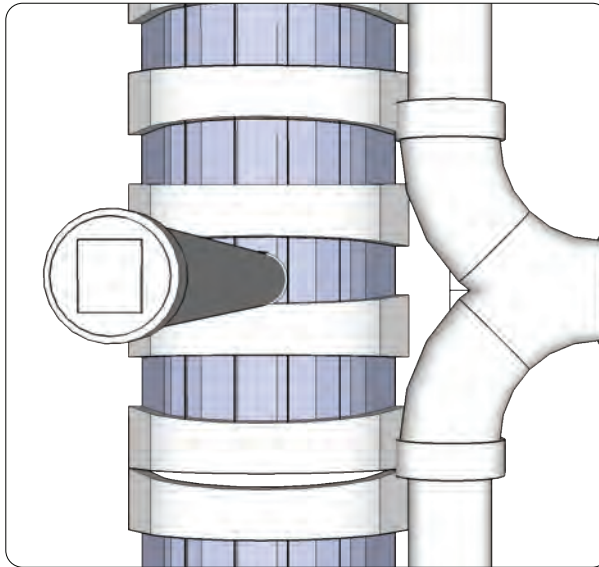


PASSIVE GRAVEL WEIR

MEDIUM

Houtan Park, Shanghai, China





ACTIVE EDGES

Ningbo Eco-corridor, Ningbo, China

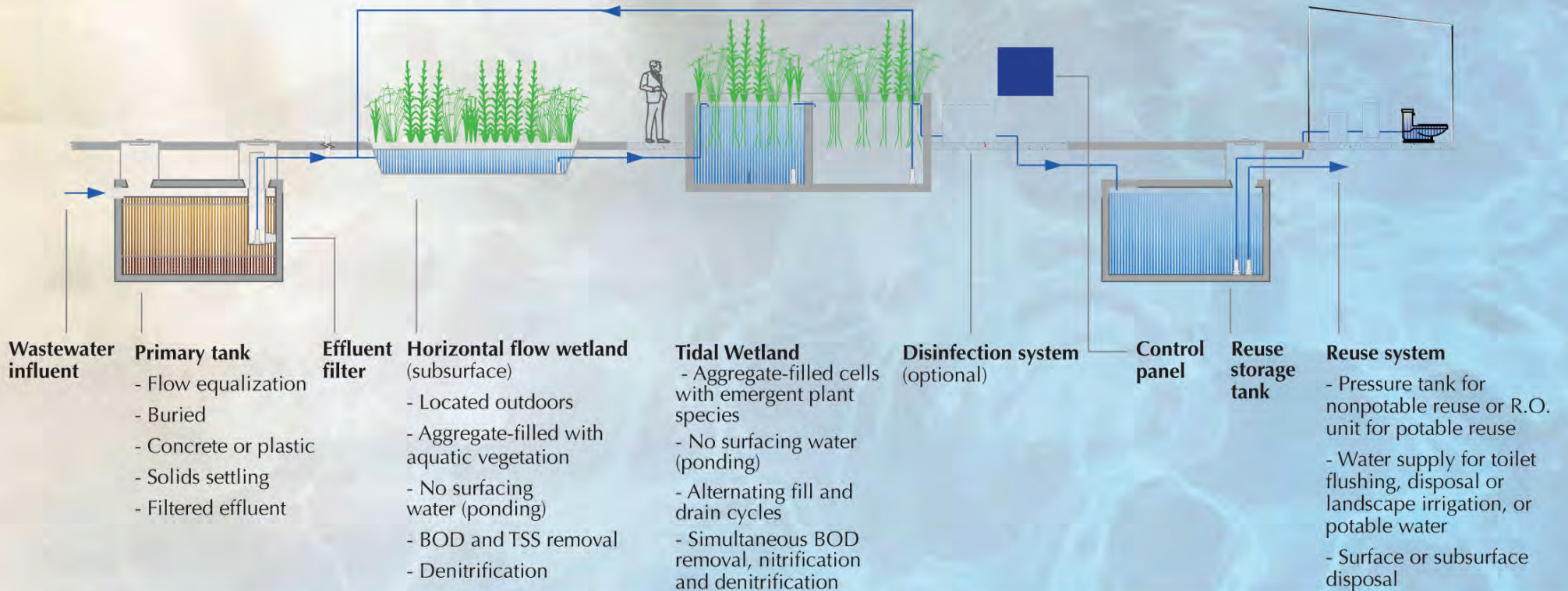
TECHNOLOGY APPLICATION

MEDIUM



BWW Eco Pool

HYBRID WETLAND LIVING MACHINE



INFLUENT

PRIMARY TREATMENT

FILTRATION

WETLAND

TIDAL WETLAND

DISINFECTION

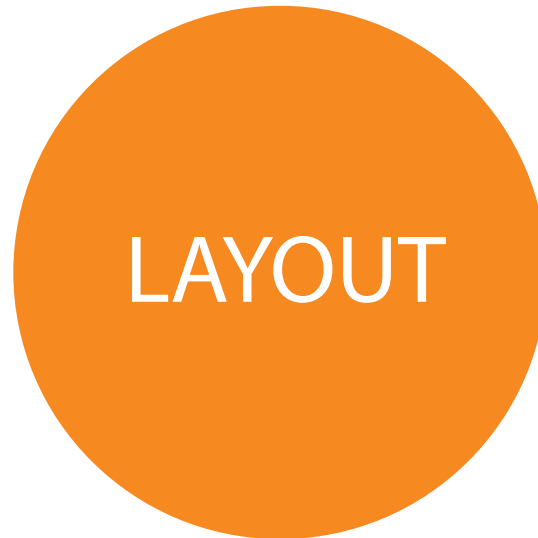
REUSE STORAGE

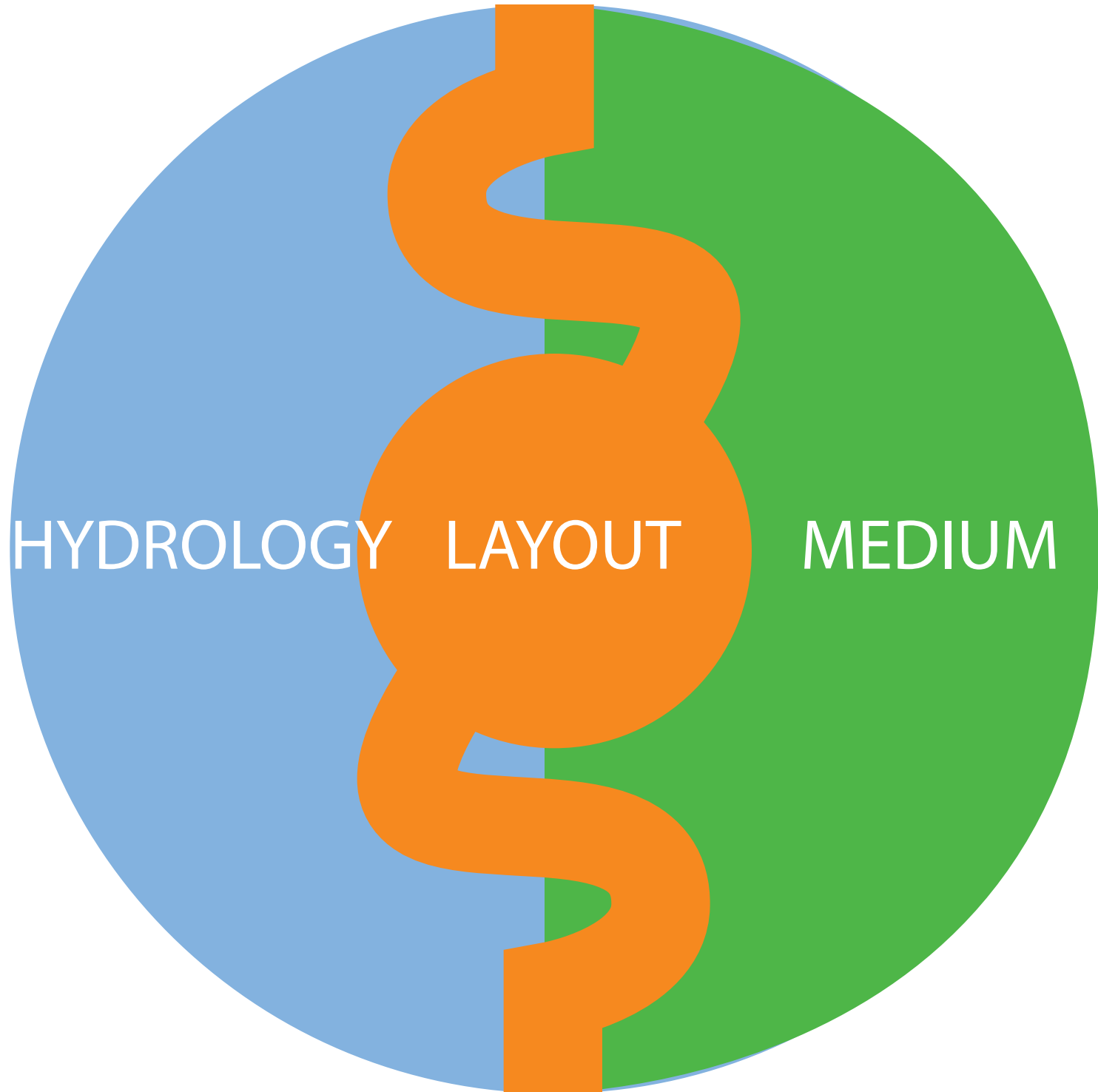
WATER SUPPLY

LAYOUT

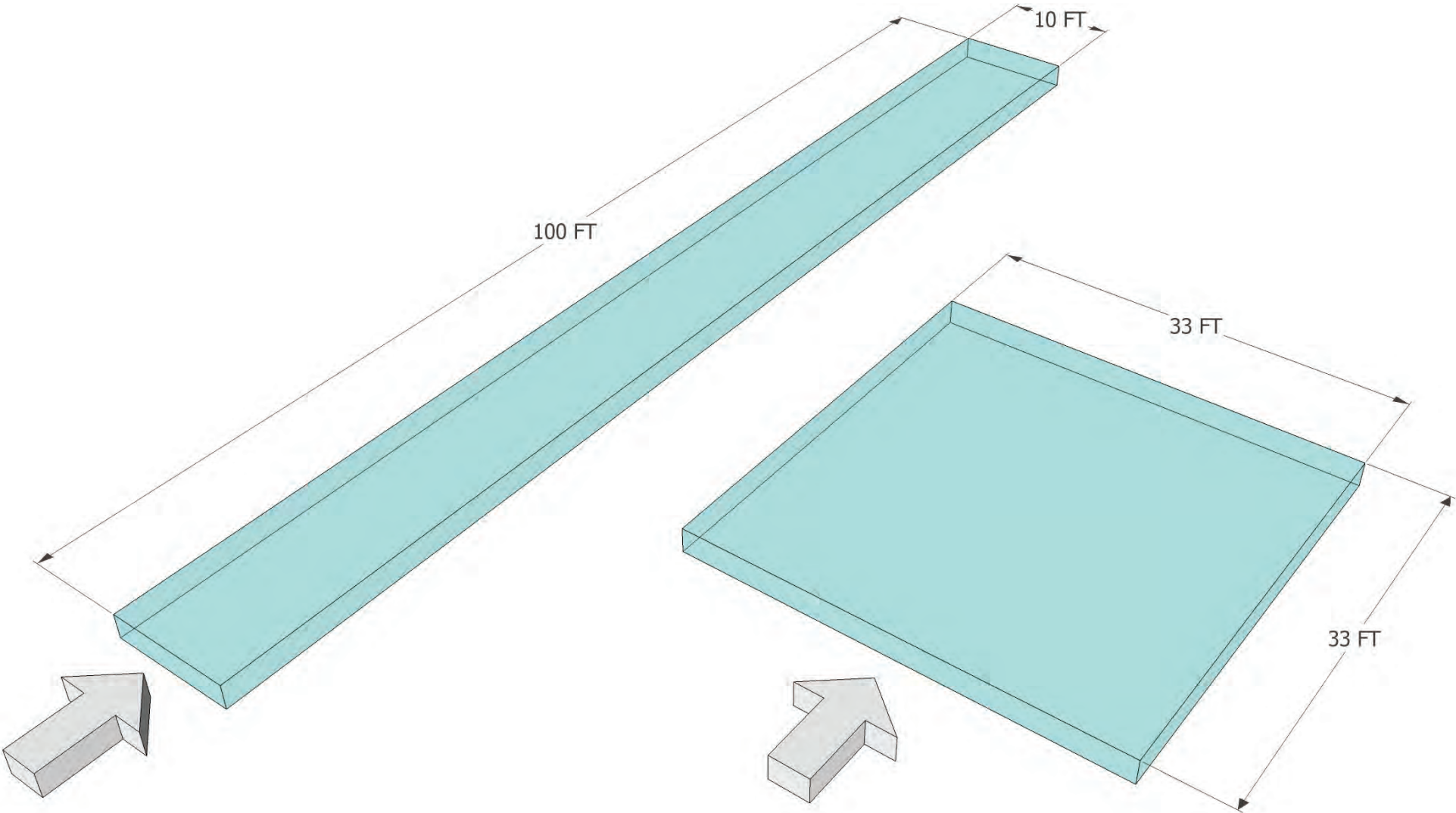
Finding the Best Arrangement

THREE BASIC ELEMENTS:

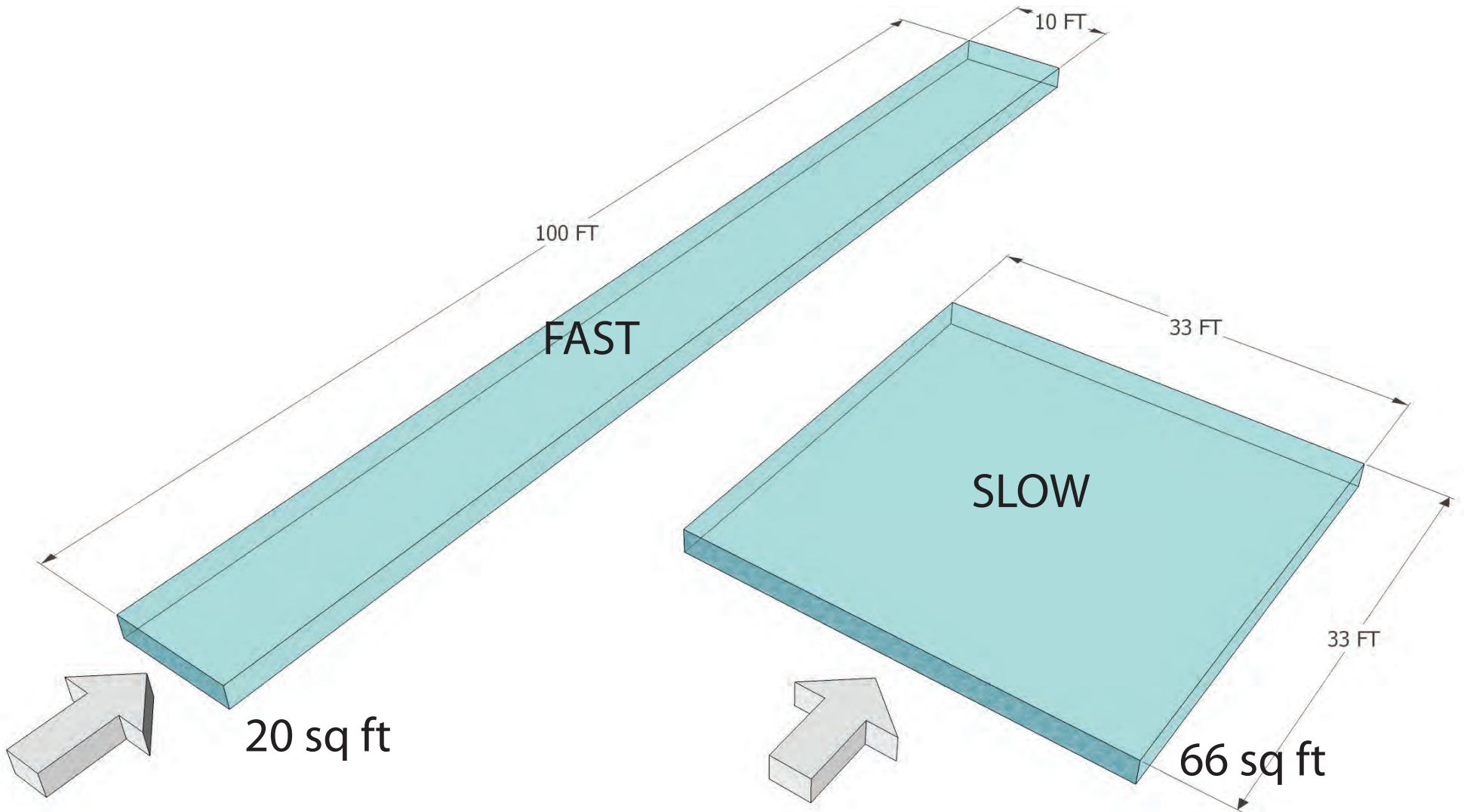




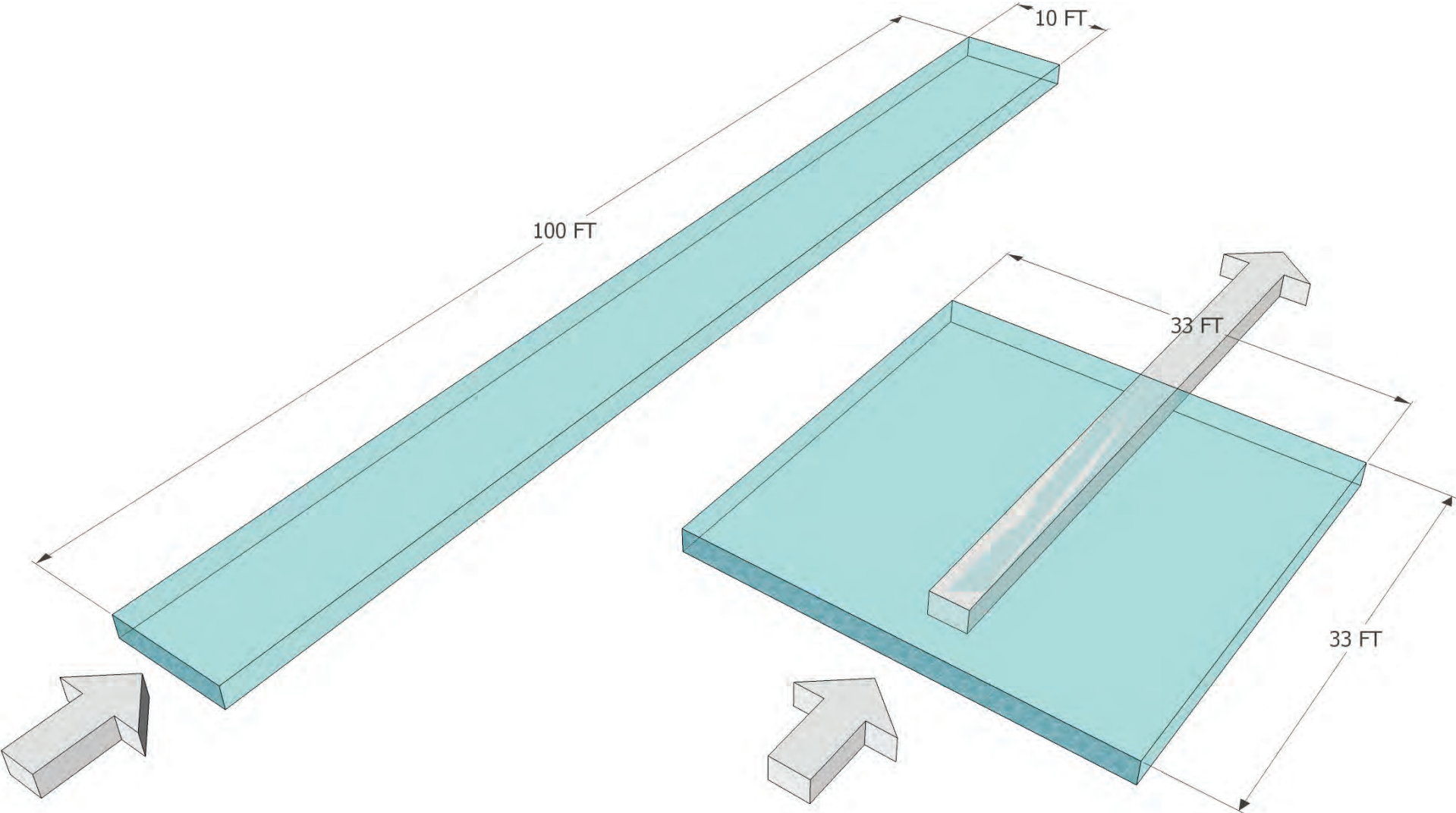
GEOMETRY AND HYDRAULICS



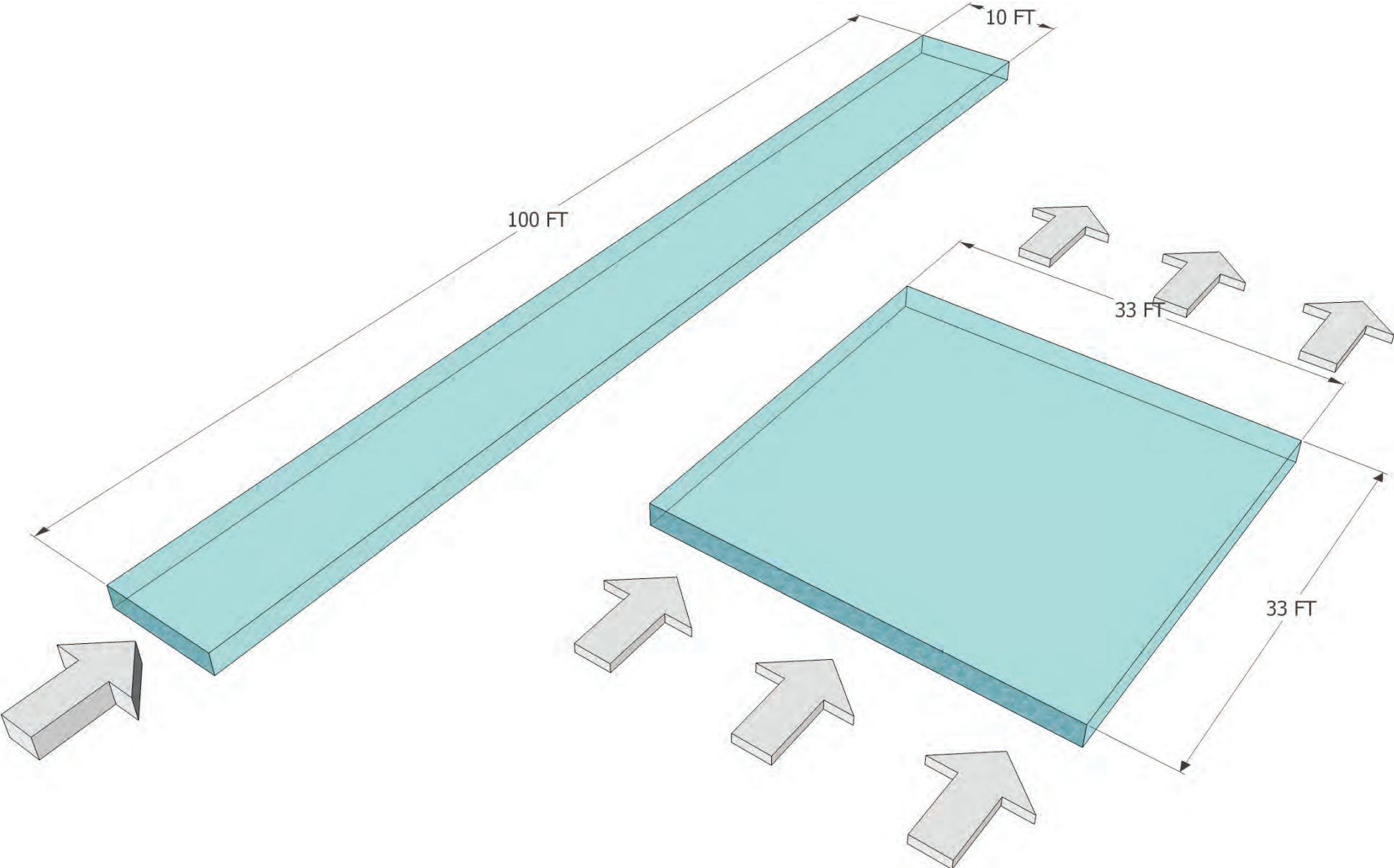
VERTICAL CROSS SECTION AREA
VERTICAL HYDRAULIC LOADING RATE
VELOCITY OF FLOW



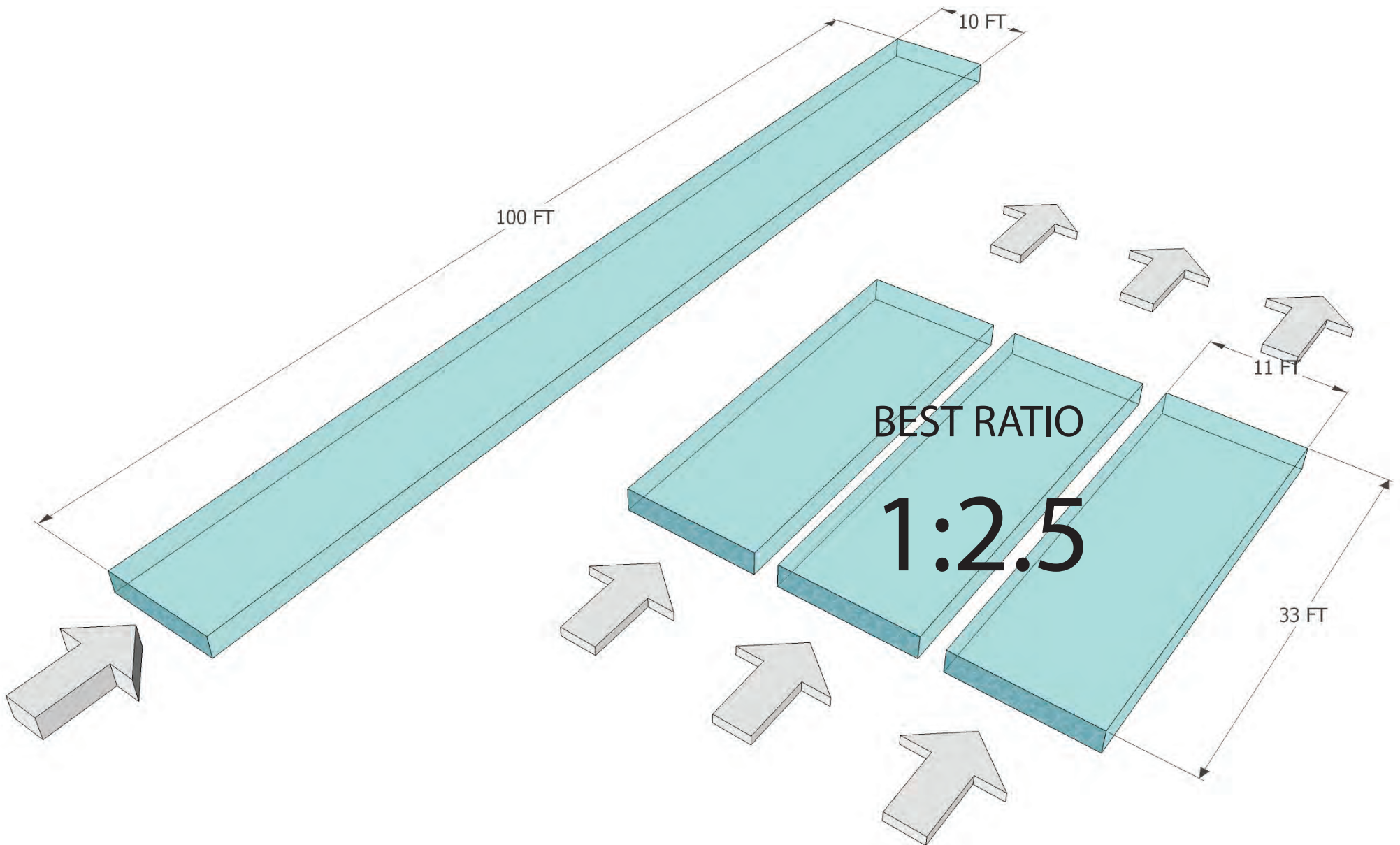
PROBLEM OF SHORT CUT



DISTRIBUTION UNIFORMITY

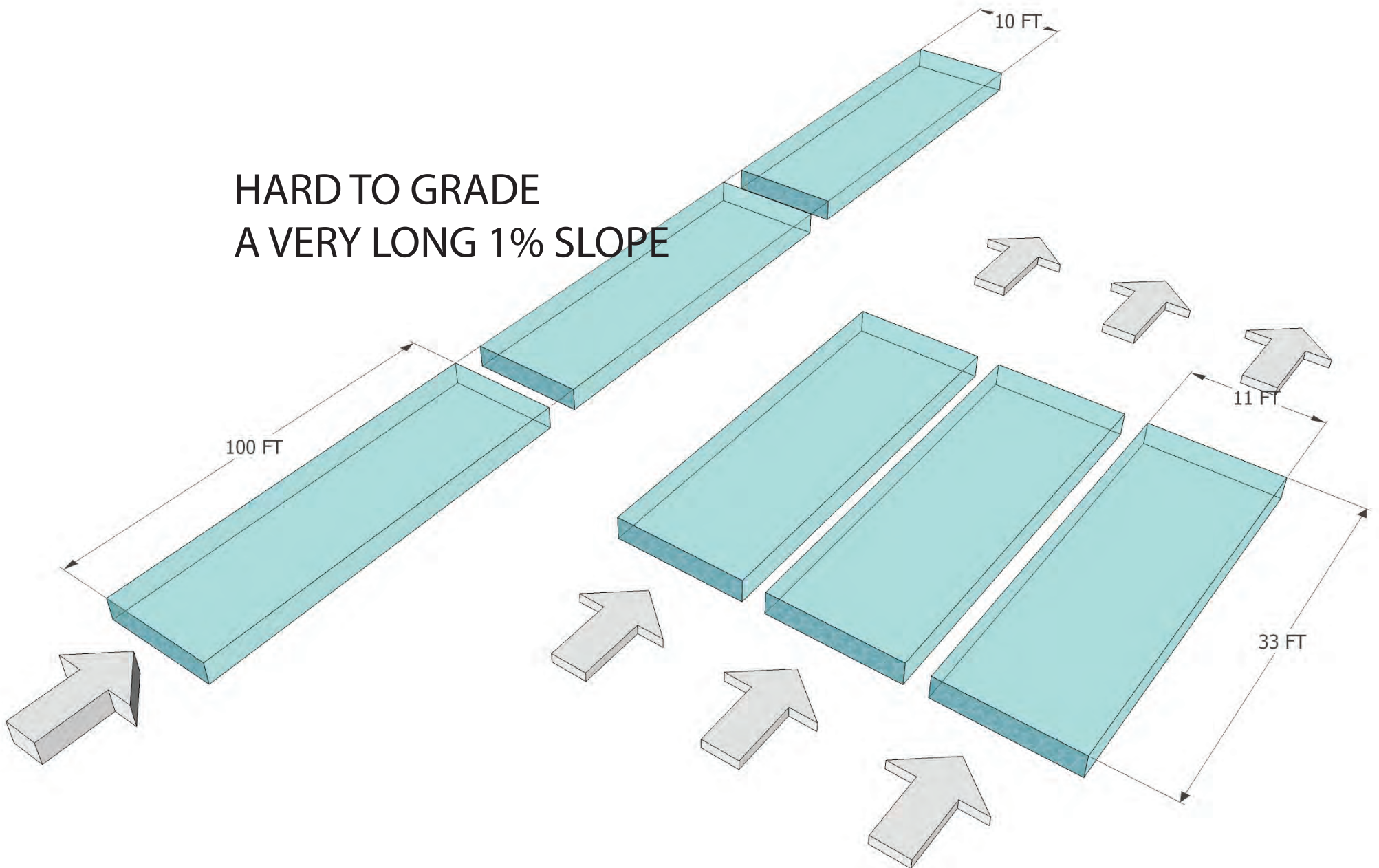


FURTHER SEPARATION OF CELLS



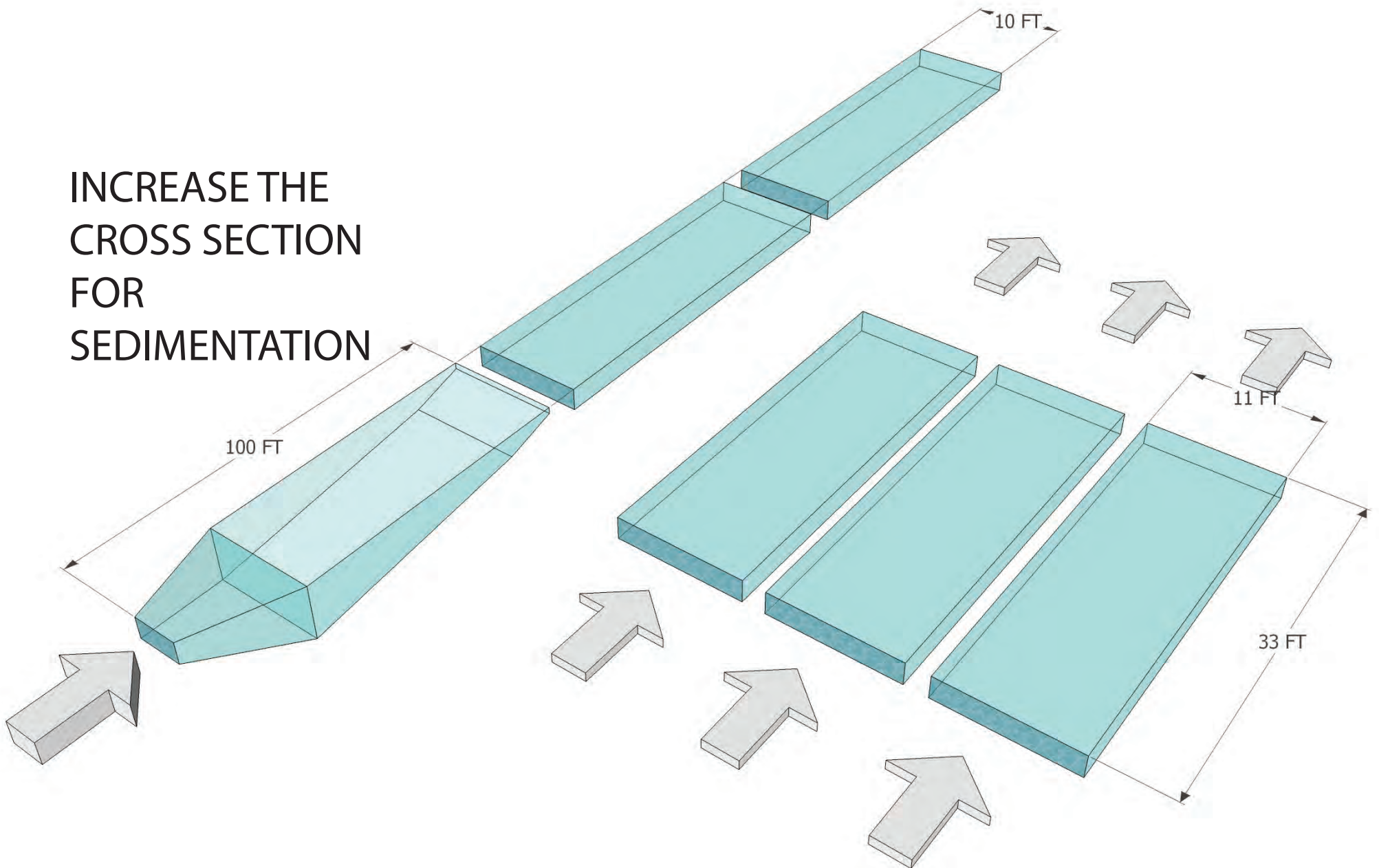
WATER LEVEL CONTROL SEGMENTS

HARD TO GRADE
A VERY LONG 1% SLOPE

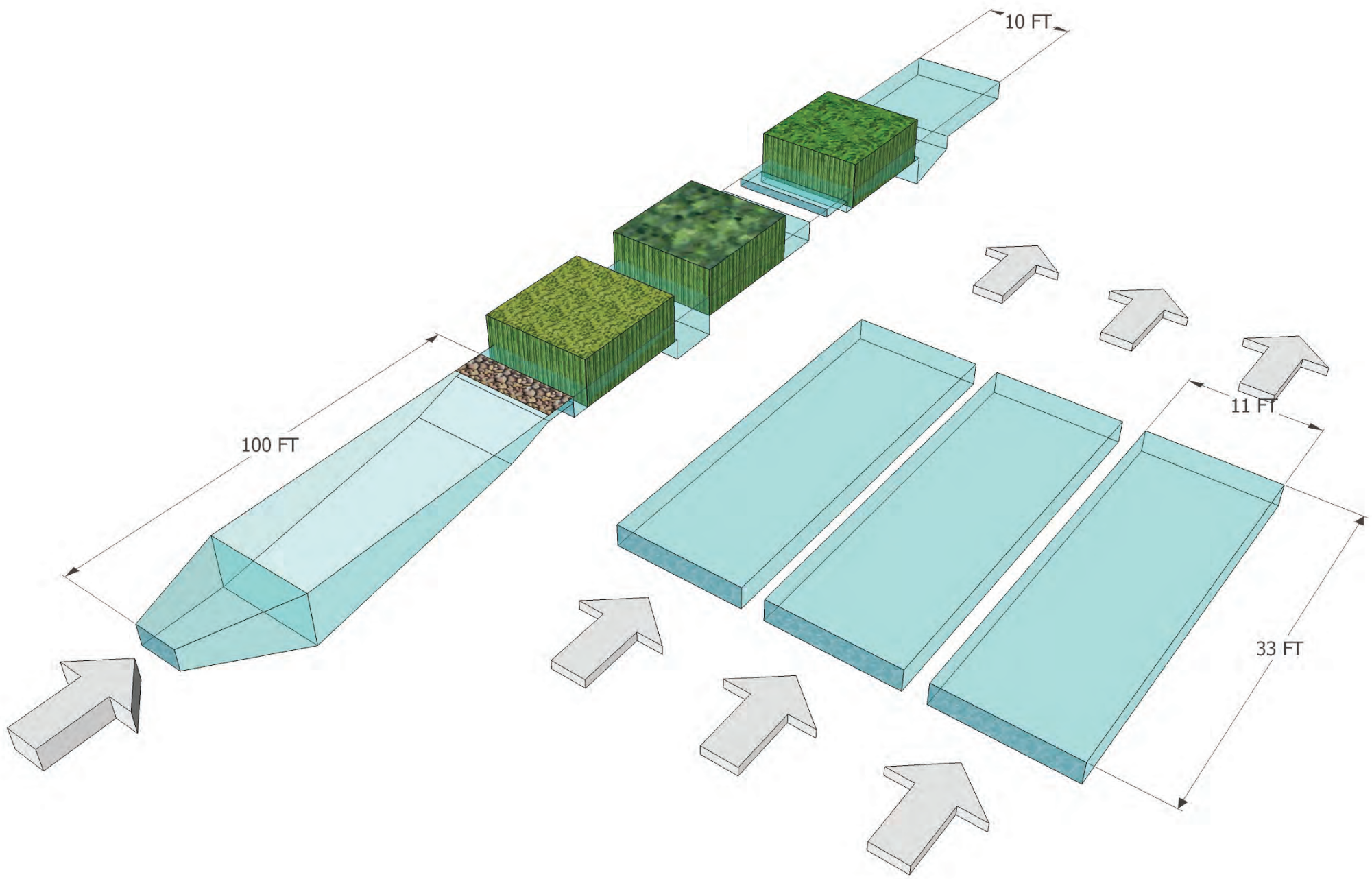


VELOCITY BY CROSS SECTION

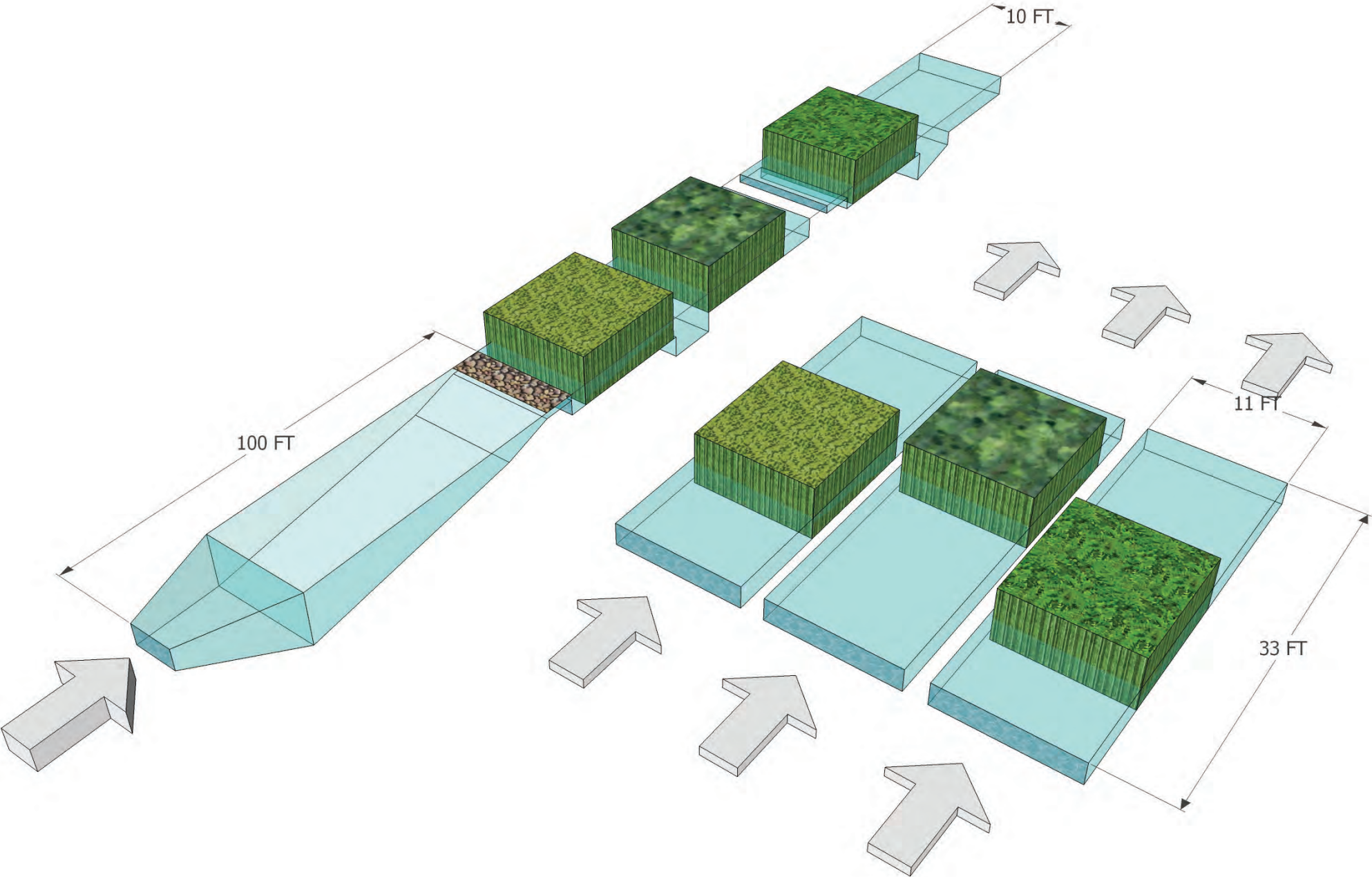
INCREASE THE
CROSS SECTION
FOR
SEDIMENTATION



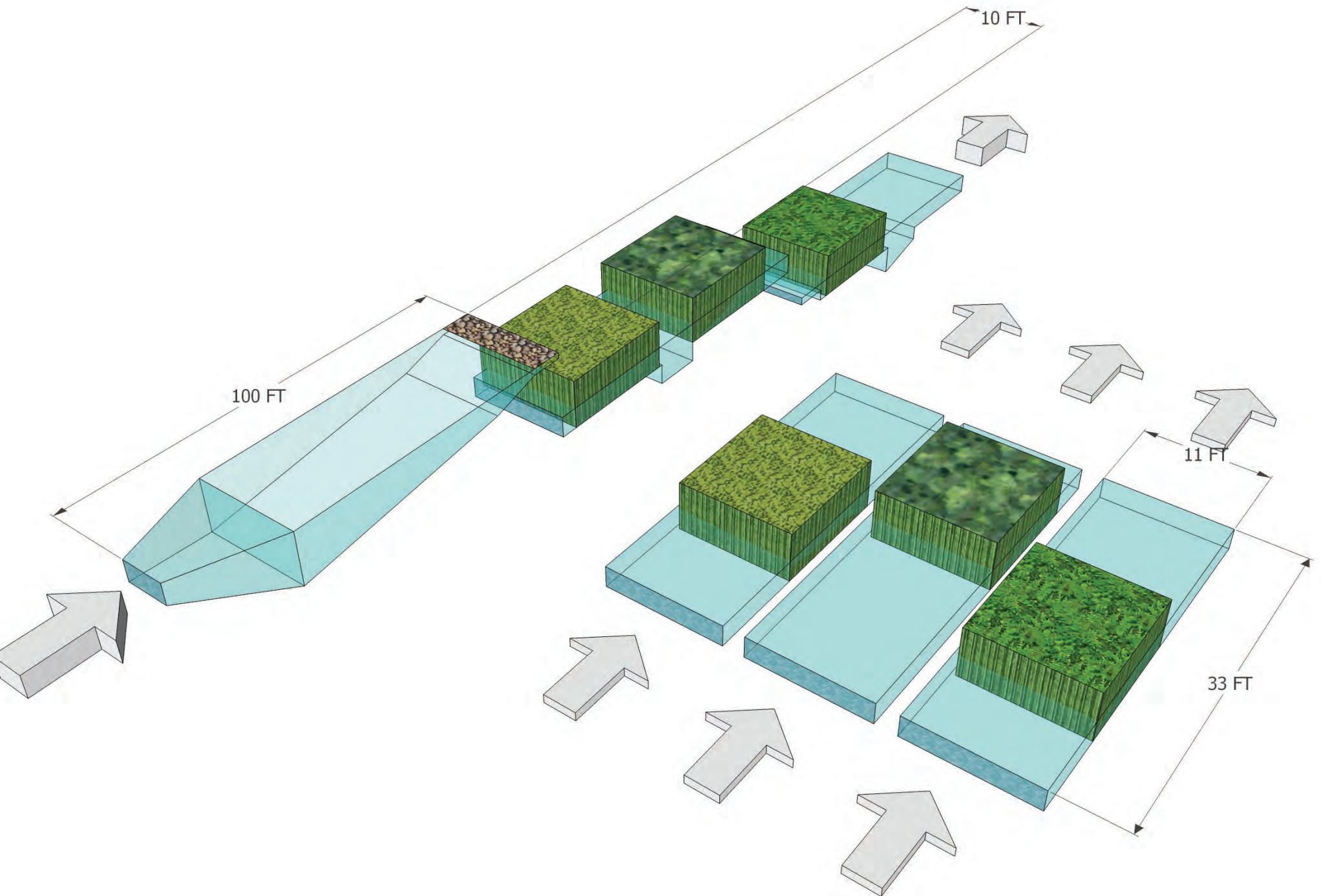
VERSATILITY OF SERIES CELLS



VERSATILITY OF PARALLEL CELLS



ADAPTATION TO GRADE CHANGES





EFFICIENCY OR



DIVERSITY?



PUBLIC ACCEPTANCE





Water Work Garden, Renton, Washington

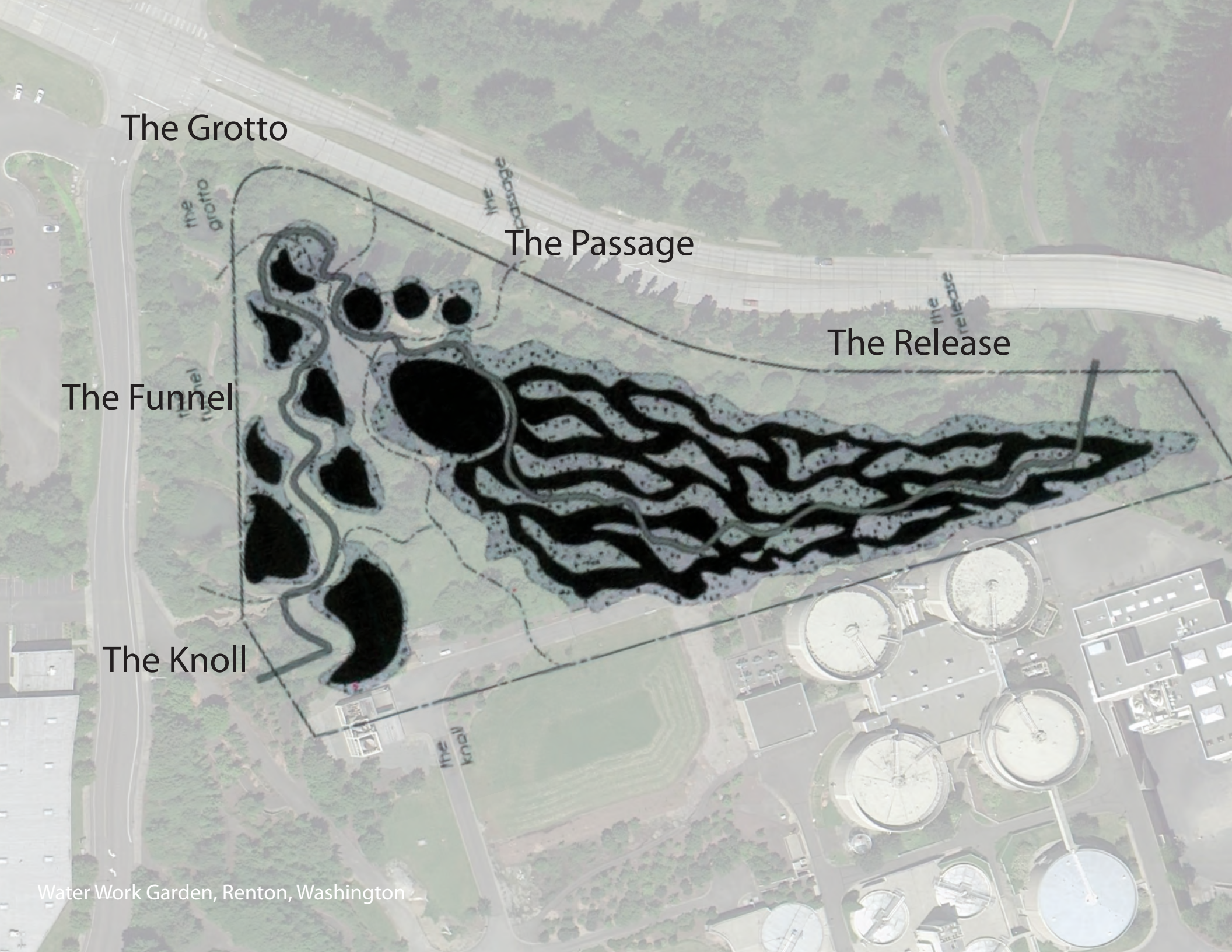
The Grotto

The Passage

The Release

The Funnel

The Knoll





Water Work Garden, Renton, Washington





Water Work Garden, Renton, Washington

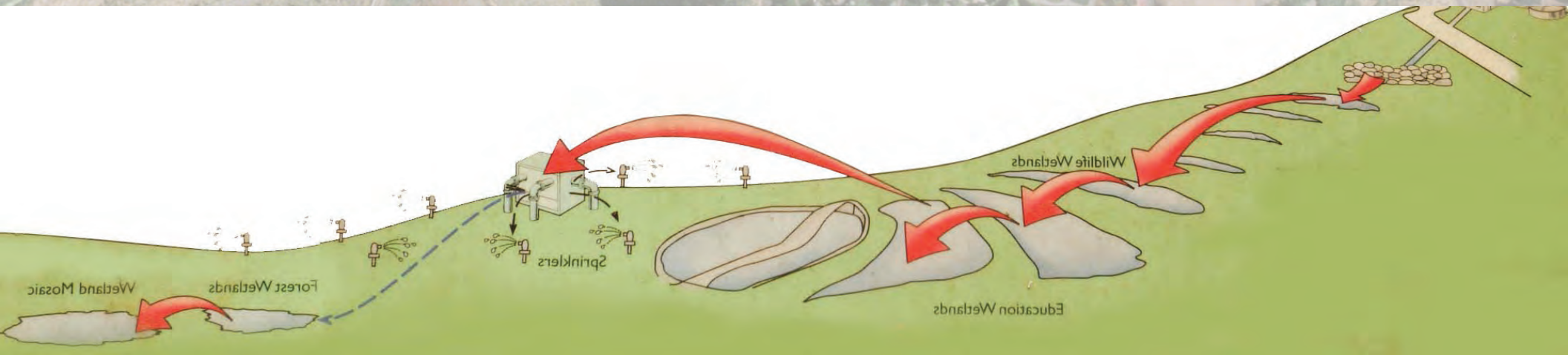


Water Work Garden, Renton, Washington





Oregon Garden, Silverton, Oregon





Water Work Garden, Renton, Washington



Water Work Garden, Renton, Washington



Water Work Garden, Renton, Washington

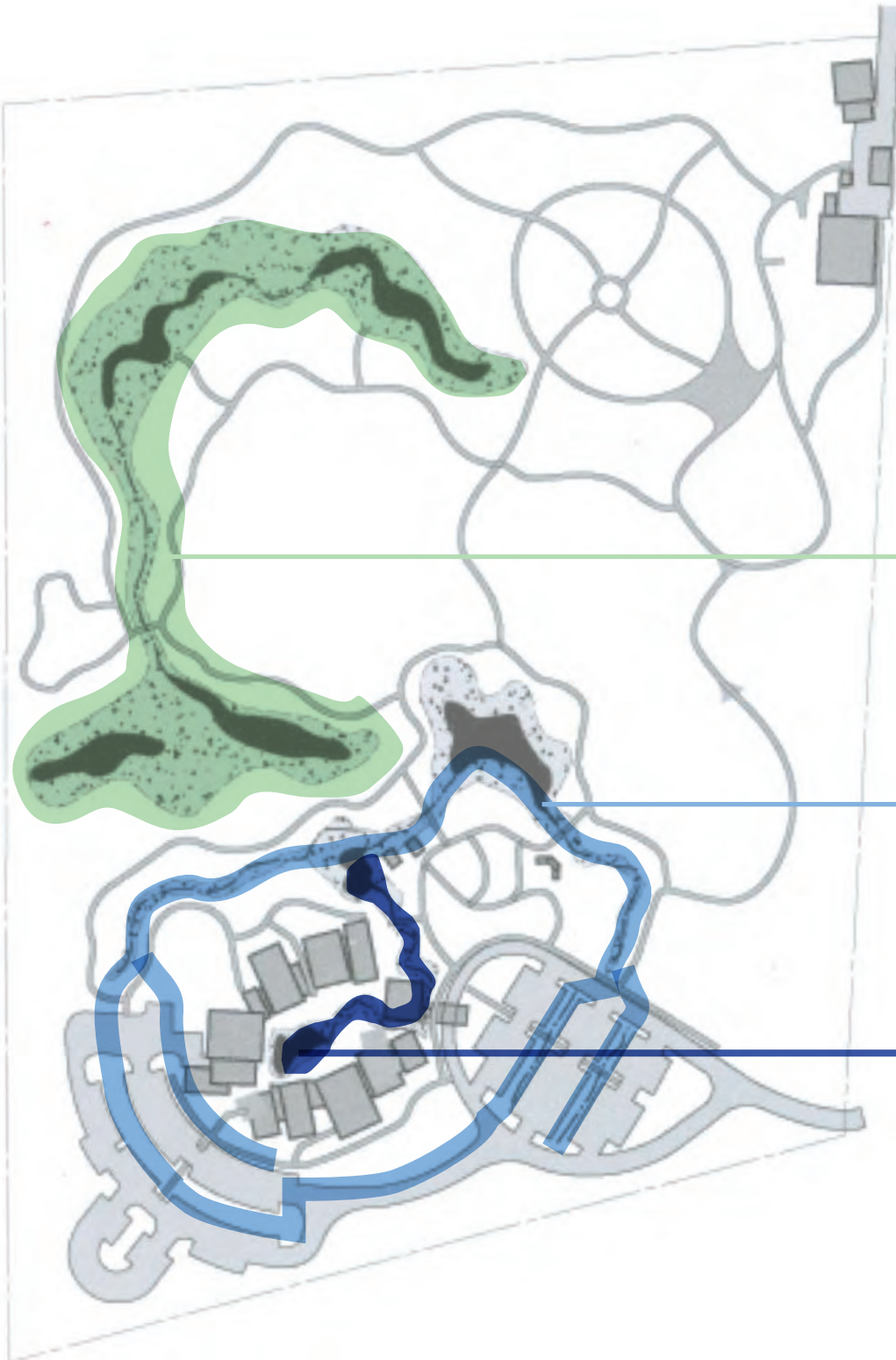


Water Work Garden, Renton, Washington

POTAWOT HEALTH VILLAGE

LOCATION: Arcata, California

Category: Wetland Restoration, Stormwater Treatment



SEASONAL WETLAND

Historical oxbow wetland restoration
Wetland Cultural Outdoor classroom

SITE RUNOFF TREATMENT

Parking Lot Runoff bio-remediation
Site Stormwater Management

COURTYARD WETLAND

Exhibition Wetland with Pump Circulation
Collection of Rain Water from the Roof



Potawot Health Village, Arcata, California



Potawot Health Village, Arcata, California



Potawot Health Village, Arcata, California



Potawot Health Village, Arcata, California



SCIENCE IS THE ART OF KNOWING,
ART IS THE SCIENCE OF FEELING.

WE MUST KNOW TO BE ABLE TO DO,
BUT WE MUST FEEL TO KNOW WHAT TO DO.

C.P. SNOW