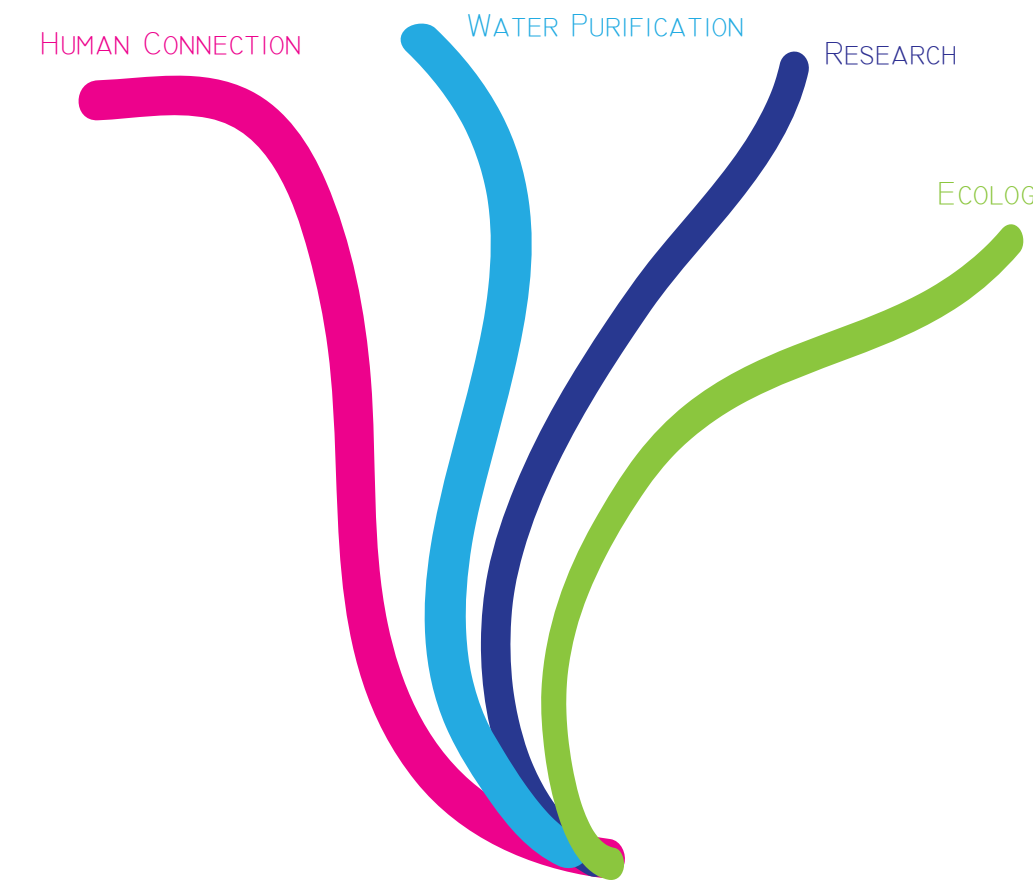


# BALTIMORE +

ASHLEY REED + PENN STATE LANDSCAPE ARCHITECTURE 414  
 BES URBAN DESIGN INITIATIVE + THE MIDDLE BRANCH  
 DESIGN CONCEPT



BALTIMORE + IS AN INNOVATIVE DESIGN THAT COMBINES ECOLOGICAL EXPERIMENTATION WITH A DYNAMIC AND VARIED EXPERIENCE THROUGHOUT THE MIDDLE BRANCH. BALTIMORE +'S PURPOSE IS TO REMEDIATE THE ROAD RUNOFF FROM THE HIGHWAYS SOARING OVER THE MIDDLE BRANCH. THE DESIGN'S EXPERIMENTS REMOVE ROAD POLLUTANTS WITH A FOCUS OF THE REMOVAL OF COPPER, LEAD, AND ZINC. THE DESIGN WAS FORMED THROUGH THESE 4 PRINCIPLES:

**HUMAN CONNECTION**

BOTH THE PHYSICAL CONNECTION TO THE SURROUNDING CONTEXT AND THE ABOVE SUPER STRUCTURE AS WELL AS AN ABSTRACT CONNECTION TO THE MICROBIAL ACTIVITY IN THE STORMWATER.

**WATER PURIFICATION**

STRIPPING THE METALS OUT OF THE STORMWATER, BUT ALSO TAKING A STEP TOWARDS REMEDIATING THE CURRENT STATE OF THE MIDDLE BRANCH WATER FOR ALL ROAD POLLUTANTS.

**RESEARCH**

THE VARIABILITY, HYPOTHESIS, AND CHANGE THAT OFFERS RESEARCH OPPORTUNITIES TO FIND THE MOST EFFECTIVE WAY TO STRIP THE POLLUTANTS FROM THE WATER.

**ECOLOGY**

CREATING HABITAT FOR LOCAL FISH, CRABS, BIRDS AND OTHER WILDLIFE. HOWEVER, MORE IMPORTANTLY CREATING INCREASED AEROBIC AND ANAEROBIC ENVIRONMENTS FOR MICROBES THAT PURIFY THE WATER AND SEDIMENTS.

ALL OF THESE FACTORS CONVERGE LIKE THE NATURAL FLOW OF THE BAY WATER, ALLOWING THE EXPERIENCES THROUGH THE SPACE TO FLOW TOGETHER CREATING ONE OVERALL DESIGN MISSION.

## EPA'S TOP ROAD RUNOFF POLLUTANTS

- SOLIDS
- METALS**
- OXYGEN-DEMANDING SUBSTANCES
- NITROGEN AND PHOSPHORUS
- PATHOGENS
- PETROLEUM HYDROCARBONS
- SYNTHETIC ORGANICS (EPA ENVIRONMENTAL ASSESSMENT)

## MARYLAND DEPARTMENT OF THE ENVIRONMENT METAL WATER ASSESSMENT



LEAD LISTING CATEGORY: 5  
 POLLUTANT: LEAD IN SEDIMENTS  
 SOURCE: UNKNOWN

CHROMIUM LISTING CATEGORY: 5  
 POLLUTANT: CHROMIUM IN SEDIMENTS  
 SOURCE: INDUSTRIAL POINT SOURCE DISCHARGE

ZINC LISTING CATEGORY: 5  
 POLLUTANT: ZINC IN SEDIMENTS  
 SOURCE: UNKNOWN

IMAGE SOURCE: [HTTP://WWW.MDE.STATE.MD.US/PROGRAMS/WATER/TMPL/INTEGRATED/0308/REPORTS/PAGES/IMP/IMPEN/IMPEN\\_ASPX](http://www.mde.state.md.us/PROGRAMS/WATER/TMPL/INTEGRATED/0308/REPORTS/PAGES/IMP/IMPEN/IMPEN_ASPX)

## METAL LEVELS

POLLUTANT	AVG IN STORM WATER	EPA WATER QUALITY	MIDDLE BRANCH SEDIMENT
	µg/L	µg/L	µg/L
AS ARSENIC	2.7	69	9988.59
CD CADMIUM	0.7	2	1997.72
CR CHROMIUM	8.6	16	79908.72
<b>CU COPPER</b>	<b>33.5</b>	<b>3.1</b>	<b>89897.31</b>
NI NICKEL	11.2	8.2	19977.18
<b>PB LEAD</b>	<b>47.8</b>	<b>2.5</b>	<b>59931.54</b>
<b>ZN ZINC</b>	<b>187.1</b>	<b>90</b>	<b>49942.95</b>

(EPA WATER QUALITY CRITERIA) (MASON, KIM, AND CORNWELL 2004) (KAYHANIANA, SUVERKROPP, RUBY, TSAYC 2007)

THE TABLE EXHIBITS THE TOP METALS RECOGNIZED BY THE EPA FOR TOXICITY IN SURFACE WATER. LOOKING AT THE AVERAGE MICROGRAMS PER LITER WITHIN HIGHWAY RUNOFF COMPARED TO THE NATIONAL EPA STANDARDS FOR AQUATIC LIFE AND FINALLY THE ACCUMULATION WITHIN THE SEDIMENT FOUND IN THE MIDDLE BRANCH. THE MOST SIGNIFICANT METALS ARE COPPER, LEAD, AND ZINC; AS THEY HAVE THE HIGHEST DIFFERENCES BETWEEN THE CURRENT STATE OF URBAN STORMWATER AND THE SUGGESTED WATER QUALITY.

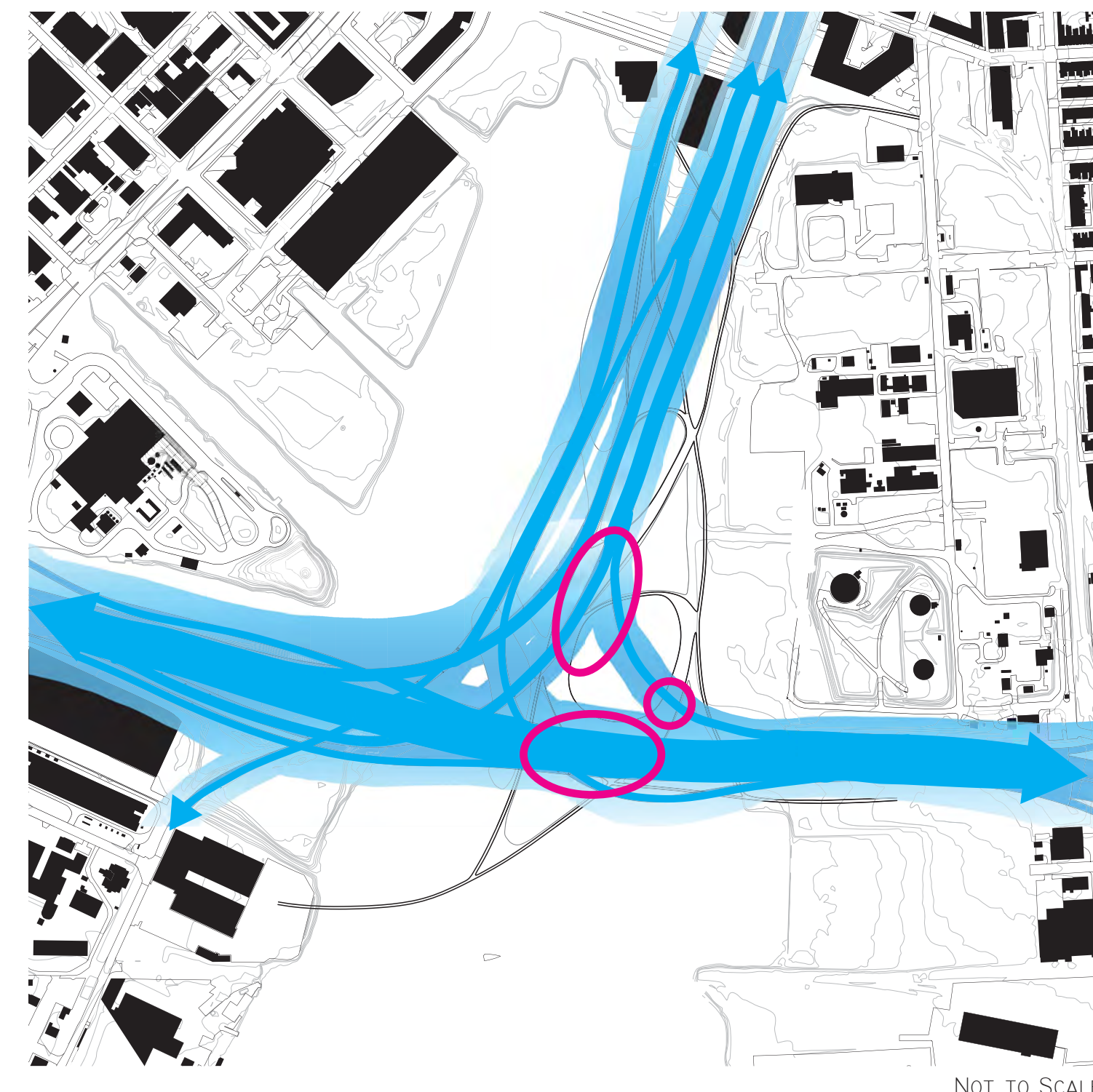
## BAY WATERFLOW SHAPING THE LANDSCAPE



THE NATURAL FLOW OF THE WATER SHAPES THE WETLANDS AND PATHWAY SYSTEM TO MOVE THE VISITOR AS IT THEY WERE FLOWING THROUGH WATER. THE FLOW WAS ALTERED SLIGHTLY BECAUSE OF PYLON PLACEMENT AND CHANNELS WERE CREATED TO KEEP A CONSTANT FEED OF WATER TO THE WETLANDS.

LEGEND:  
 - NATURAL WATER FLOW (Blue arrow)  
 - NEW WATER FLOW (Red arrow)  
 - PEDESTRIAN FLOW (Pink circle)  
 - WETLANDS (Green circle)

## SUPER STRUCTURE STORMWATER



WORKING WITH STORMWATER IS AN IMPORTANT COMPONENT OF BALTIMORE +. THE RESEARCH GOAL OF THE PROJECT IS TO COMPARE THE EFFECTIVENESS OF CLEANING THE WATER BEFORE IT IS POURED INTO THE BAY VERSUS TREATING IT IN THE BAY. TO CREATE A SYSTEM TO DO THIS THE BRIDGE WATERFLOW HAD TO BE UNDERSTOOD. THE WATER FLOWS NOT ONLY WITH THE SLOPE OF THE SUPER STRUCTURE, BUT SHEETS OFF THE SIDE WITH CONCENTRATION IN THE CURVES OF THE ROADS. THIS REVEALED IMPORTANT POINTS OF INTEREST TO CONSIDER TESTING PRE-TREATMENT.

LEGEND:  
 - WATER FLOW DIRECTION (Blue arrow)  
 - PRE-TREATMENT TEST SITES (Pink circle)  
 - SHEETING GRADIENT (Blue circle)

## PLANTING

772,250 FT<sup>2</sup> OF WETLANDS PLANTED WITH THE MIXTURE OF:  
 50% NATIVE MARYLAND WETLAND PLANTS  
 30% PHYTOREMEDIATION PLANTS  
 20% COMMON CONSTRUCTED WETLAND PLANTS  
 PLANTS SHOWN IN PALETTE ARE EXAMPLES AND NOT THE COMPLETE LIST



### PLANTS THAT PHYTOREMEDIATE METALS

- LUPINUS ALBUS - WHITE LUPIN
- CERASTIUM ARVENSE - FIELD CHICKWEED
- CLAYTONIA PERFOLIATA - MINER'S LETTUCE
- STELLARIA CALYCANTHA - NORTHERN STARWORT
- AGROSTIS CASTELLANA - COLONIAL BENTGRASS
- VICIA SPP. - VETCH
- ACHILLEA MILLEFOLIUM - YARROW
- ALLIUM SCHOENOPRASUM - CHIVES
- BRASSICA RAPA - FIELD MUSTARD
- DIGITALIS PURPUREA - COMMON FOXGLOVE
- THLASPI CAERULESCENS - ALPINE PENNYCRESS

### PLANTS FOR TEST TUBE FOREST

- VINCA MAJOR - VENCA VINE
- PTERIS VITTATA - BRAKE FERN
- POLYSTICHUM ACROSTICHOIDES - CHRISTMAS FERN
- ROSA SPP. - PAUL'S SCARLET ROSE
- VIOLA SPP. - VIOLETS

### COMMON CONSTRUCTED WETLAND PLANTS

- CAREX AQUATILIS - WATER SEDGE
- JUNCUS ARCTICUS - ARCTIC RUSH
- PHALARIS ARUNDINACEA - REED CANARYGRASS
- PHRAGMITES AUSTRALIS - COMMON REED
- IRIS MISSOURIENSIS - ROCKY MOUNTAIN IRIS

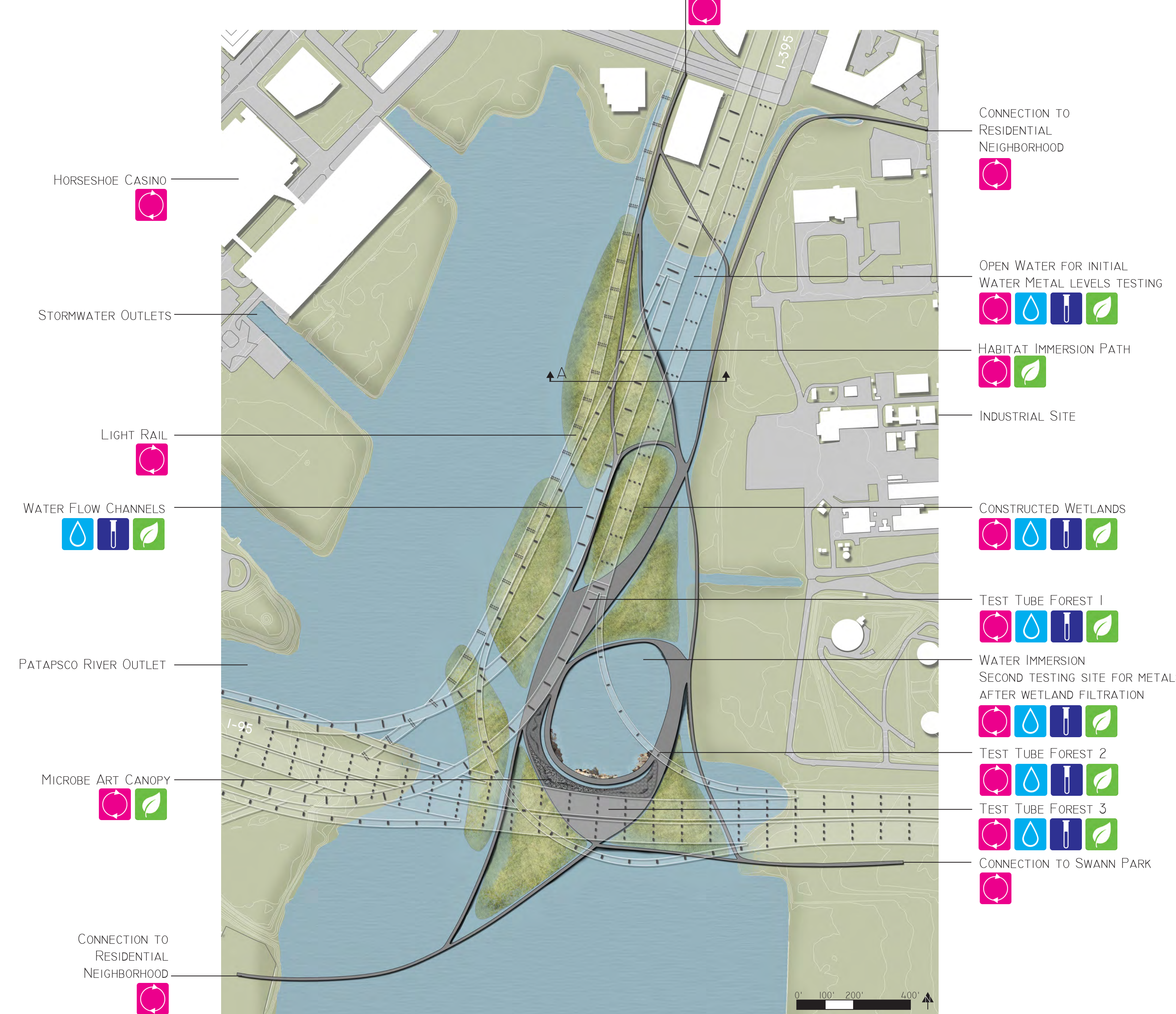
### PLANTS THAT REMEDIATE OTHER ROAD POLLUTANTS

- CYNODON DACTYLON - BERMUDA GRASS
- PANICUM VIRGATUM - SWITCH GRASS
- TRIFOLIUM REPENS - WHITE CLOVER
- BRASSICA JUNCEA - INDIAN MUSTARD
- HELIANTHUS ANNUUS - SUNFLOWER

### NATIVE MARYLAND WETLAND PLANTS

- CAREX CRINITA - FRINGED SEDGE
- ACORUS CALAMUS - SWEETFLAG
- CALTHA PALUSTRIS - COMMON MARSH-MARIGOLD
- TYPHA LATIFOLIA - BROAD-LEAF CATTAIL
- ANDRIPOGON GERARDI - BIG BLUESTEM
- ASTER PUNICEUS - SWAMP ASTER
- HELIANTHUS ANGUSTIFOLIUS - SWAMP SUNFLOWER
- RUDBECKIA LANCEOLATA - CUT-LEAF CONEFLOWER
- THELYPTERIS THELYPTEROIDES - MARSH FERN
- OSMUNDA CINNAMOMEA - CINNAMON FERN

## MASTERPLAN



- HORSESHOE CASINO
- STORMWATER OUTLETS
- LIGHT RAIL
- WATER FLOW CHANNELS
- PATAPSCO RIVER OUTLET
- MICROBE ART CANOPY
- CONNECTION TO RESIDENTIAL NEIGHBORHOOD

- CONNECTION TO RESIDENTIAL NEIGHBORHOOD
- OPEN WATER FOR INITIAL WATER METAL LEVELS TESTING
- HABITAT IMMERSION PATH
- INDUSTRIAL SITE
- CONSTRUCTED WETLANDS
- TEST TUBE FOREST 1
- WATER IMMERSION SECOND TESTING SITE FOR METALS AFTER WETLAND FILTRATION
- TEST TUBE FOREST 2
- TEST TUBE FOREST 3
- CONNECTION TO SWANN PARK

## HABITAT IMMERSION PATH



## SECTION A



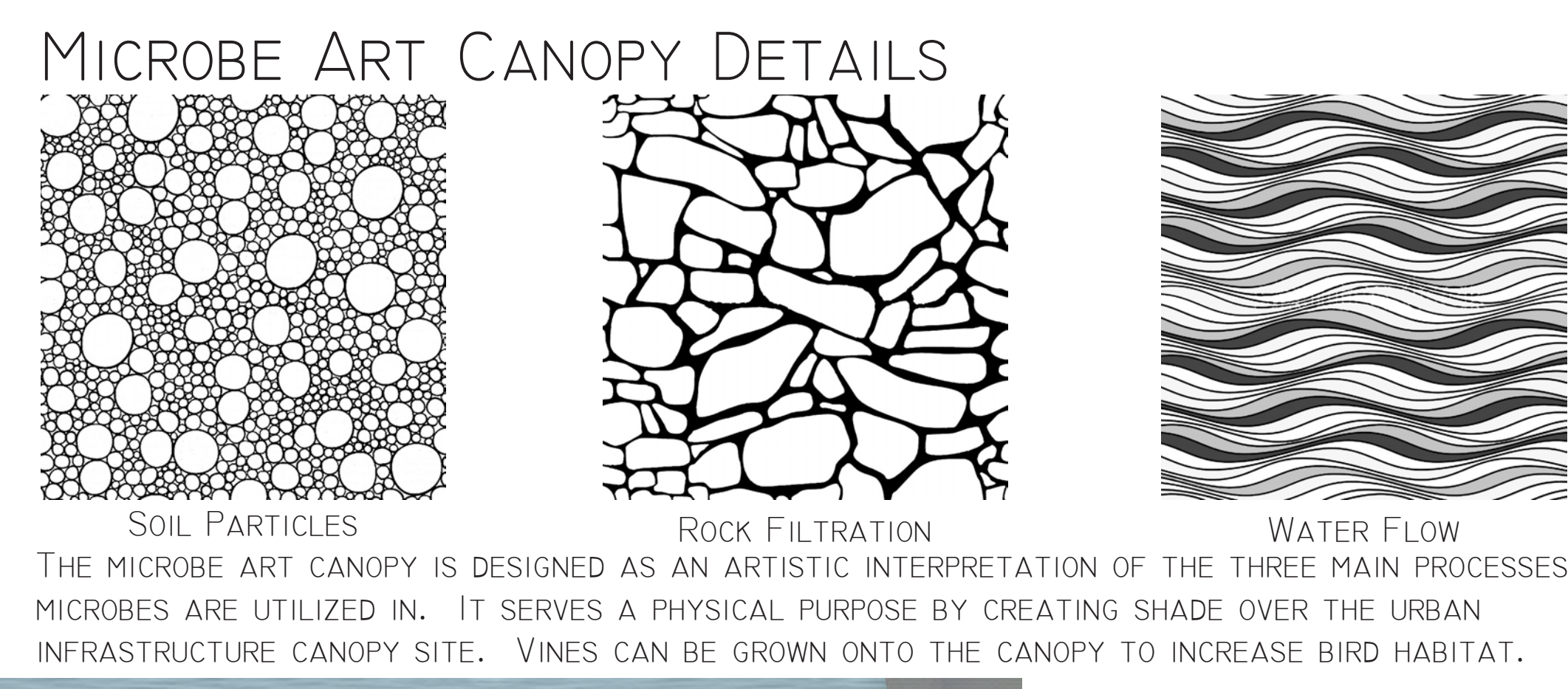
- MIDDLE BRANCH
- HABITAT IMMERSION
- BOARDWALK
- INITIAL TESTING WATER
- BOARDWALK



# BALTIMORE +

ASHLEY REED + THE PENNSYLVANIA STATE UNIVERSITY  
THE MIDDLE BRANCH + BALTIMORE ECOLOGICAL STUDY

## URBAN INFRASTRUCTURE CANOPY



## TEST TUBE FOREST 3



## TEST TUBE EXPERIMENT

LOOKING AT EXAMPLES OF STUDIES INCLUDING TESTING SALT ENRICHED STORM WATER IN MICROBIAL TUBES (ENDRENY, BURKE, BURCHARDT, FABIAN, AND KRETZER 2012), I CAME UP WITH THE BALTIMORE TEST TUBE THAT COMBINES 4 DIFFERENT FILTRATION SYSTEMS TO REMOVE THE METALS AND OTHER ROAD POLLUTANTS THROUGH THE TUBES.

**1 ROCK FILTRATION:** SUGGESTED MEDIA IN THE TUBES THAT HAVE BEEN PROVEN TO REMOVE METALS ARE:

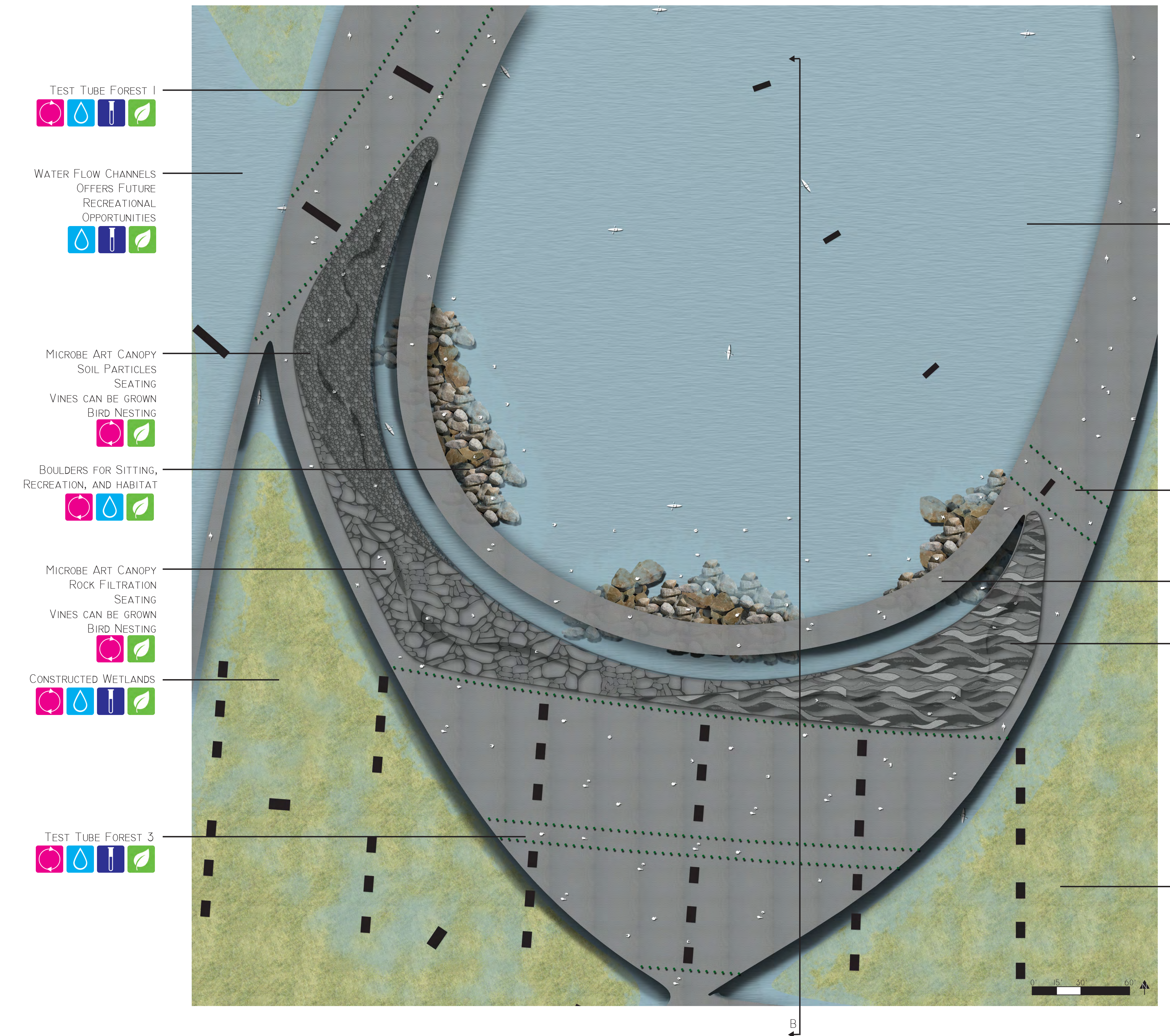
- LIMESTONE- NATURAL ROCK REMOVES UP TO 89% OF HEAVY METALS (GRAY, BURNS, GRIFFITH 2012)
- BIOBALLS- INCREASE MICROBIAL ACTIVITY
- CLINOPTILOLITE-HIGH HOLDING CAPACITY FOR COPPER, LEAD AND ZINC (GRAY, BURNS, GRIFFITH 2012)
- ZEOLITES- HIGH HOLDING CAPACITY FOR COPPER, LEAD AND ZINC (GRAY, BURNS, GRIFFITH 2012)

**2 SOIL MIXTURES:** SUGGESTED SOIL TYPES TO TEST IN TUBES

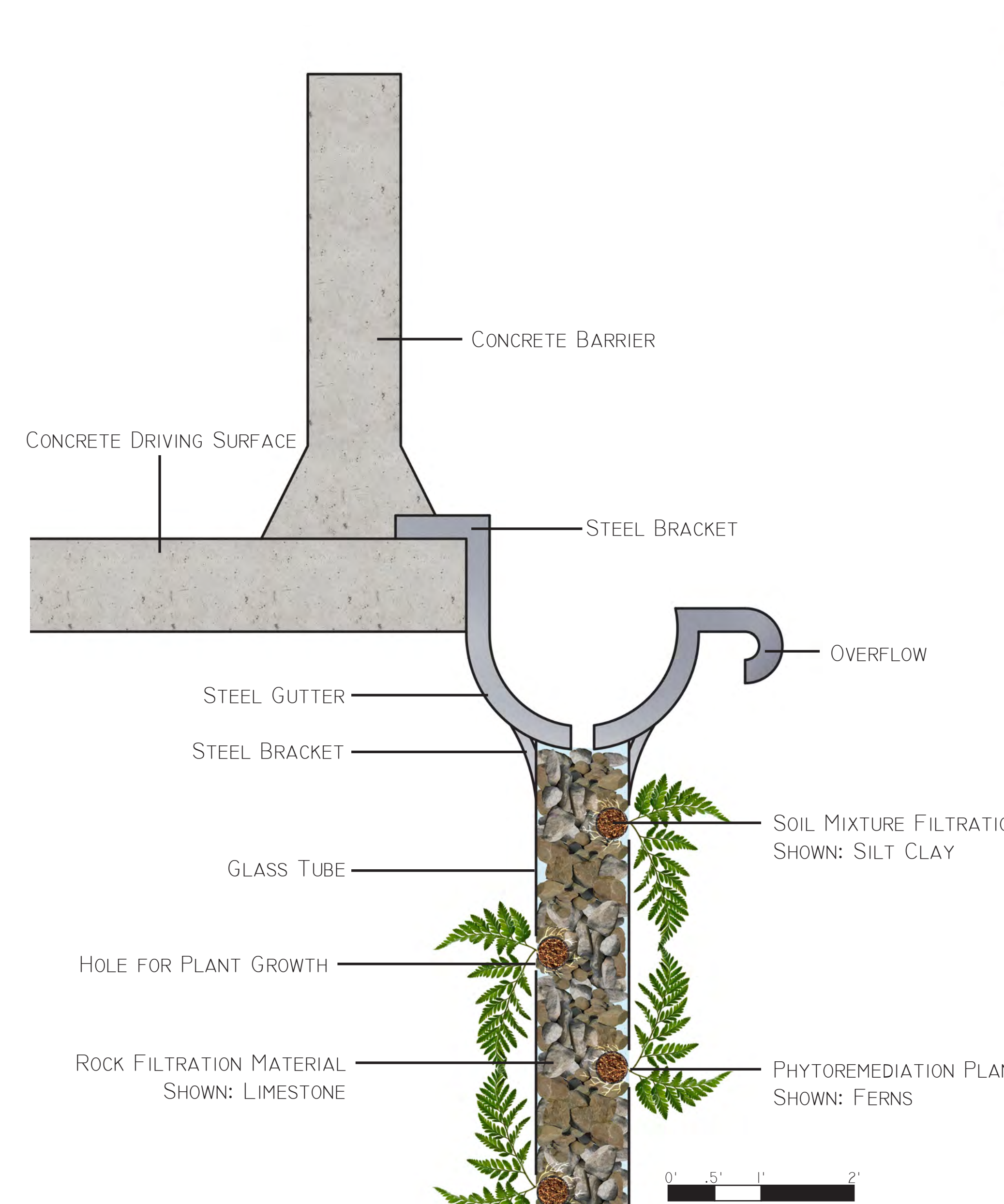
- SAND FILTERS - REMOVES UP TO 87% OF METALS
- CLAY/SILT MIXTURES - CLAY CHEMICALLY BINDS TO THE METALS HOLDING THEM IN THE FILTER SPIRAL (GRAY, BURNS, GRIFFITH 2012)

**3 MICROBIAL SYSTEM:** BIOFILMS OF BACTERIA FORM ON THE ROCKS, IN THE SOIL, AND THE ROOTS OF THE PLANTS TO HELP BREAK DOWN THE WATER SOLUBLE METALS FOR PLANT UPTAKE. IN THE AFOREMENTIONED STUDY ON BACTERIAL COLUMN TESTS THEY WERE SUCCESSFUL IN INCREASING MICROBIAL ACTIVITY AND ITS EFFECTS ON THE URBAN STORMWATER. (ENDRENY, BURKE, BURCHARDT, FABIAN, AND KRETZER 2012)

**4 PLANT UPTAKE:** IT HAS BEEN PROVEN THAT CERTAIN PLANTS ARE BIOINDICATORS AND BIOACCUMULATORS FOR CERTAIN TYPES OF METALS. IN A STUDY OF PROCESSING STORMWATER RUNOFF THROUGH A PLANT FILTRATION SYSTEM, THEY WERE ABLE TO REMOVE 94% OF LEAD AND 42% OF COPPER AND ZINC. PLANTS THAT UPTAKE METALS WILL BE ROTATED IN THE TUBES AND PATCHES THROUGHOUT THE WETLANDS TO TEST THEIR EFFECTS ON REMOVING LEAD, ZINC, AND COPPER. (LEGRET AND PAGOTTO 1999)



## TEST TUBE DETAILS



## TEST TUBE WATER TREATMENT

**486 TUBES** 1FT DIAMETER WITH AVERAGE OF 60 FT HIGH (3.14)(.5FT)(60FT)=94.2 FT<sup>2</sup>=704 GALLONS /HALF FOR ROCK SPACE=352 GALLONS X 486 TUBES= **171,072 GALLONS TREATED**

**3.9 INCHES** IS BALTIMORE'S PER HOUR AVERAGE RAINFALL INTENSITY (FINDTHEBEST.COM)

**125,327 FEET<sup>2</sup>** IS THE AREA OF BRIDGE THE TUBES ARE TREATING 125327FT<sup>2</sup> (3.9IN)(.7 RUNOFF COEFFICIENT FOR CONCRETE)= 342,142.71 GALLONS PER DAY/50% FOR EVAPORATION COEFFICIENT= **171,072 GALLONS PER DAY BEING TREATED**

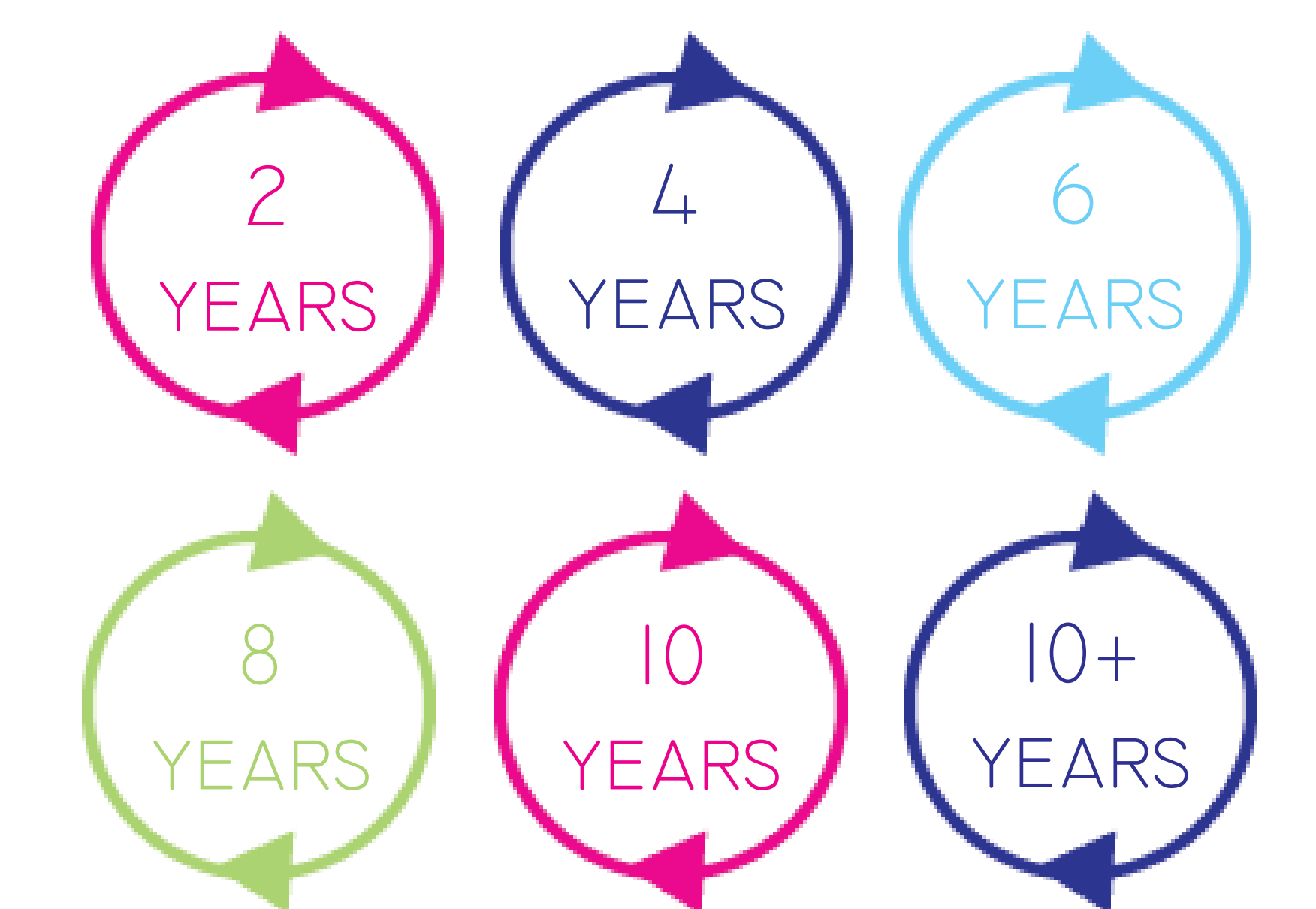
THE REST OF THE WATER WILL CONTINUE ITS NORMAL RUNOFF INTO THE WETLANDS AT THE BASE OF THE SUPERSTRUCTURE TO BE TREATED BY THE BIOACCUMULATORS. THE PURPOSE OF THE EXPERIMENT IS TO TEST THE EFFECTIVENESS OF TREATING THE WATER THROUGH THE CONVENTIONAL CONSTRUCTED WETLANDS COMPARATIVE TO THE PREVENTATIVE METHOD OF TRAPPING IT BEFORE IT HITS THE WATER. ON DRY DAYS OR DURING DROUGHT SEASON IT WOULD BE PLAUSIBLE TO INSTALL A PUMP TO NOT ONLY KEEP THE TUBES RUNNING BUT TO ACT AS CONTINUAL FILTRATION FOR THE BAY EVEN WHEN IT IS NOT RAINING.

## SECTION B



## EXPERIMENTING INTO THE FUTURE

WATER QUALITY ASSESSMENTS ARE REQUIRED BY THE EPA EVERY 2 YEARS. (EPA WATER QUALITY ASSESSMENT) FOR THE FIRST 10 YEARS THE TUBE CONTENTS AND WETLAND PLANTS WILL BE ROTATED EVERY TWO YEARS TO TAKE SAMPLES ON THEIR EFFECTIVENESS IN DIFFERENT COMBINATIONS.



AFTER 10 YEARS THE ROTATIONS WILL BE DETERMINED BY THE SOIL TESTS FOR MAXIMUM METAL LOADS THAT THE TUBES CAN HOLD. ONCE THE TESTS ARE CONCLUSIVE, THE TUBE MATERIAL WILL BE ROTATED WHENEVER THE TUBES REACH MAXIMUM LOAD IN AN ATTEMPT TO COMPLETE LONG TERM STUDIES AS WELL.