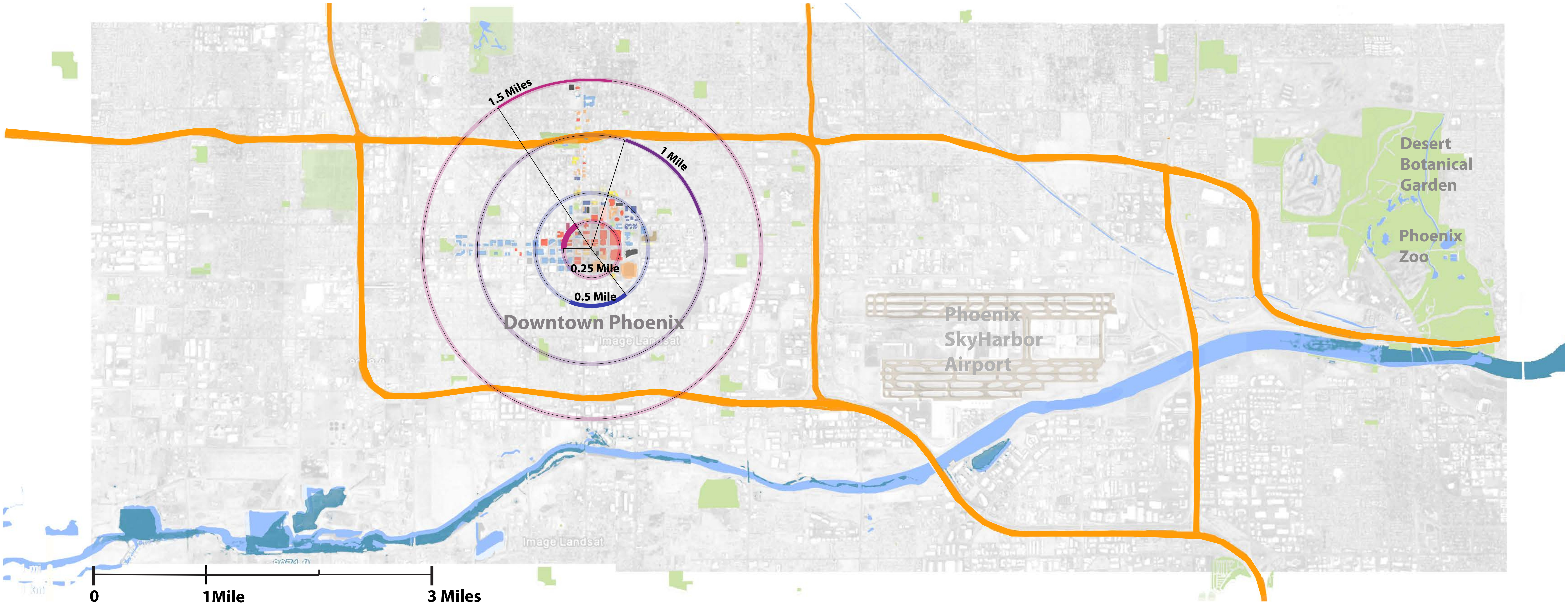
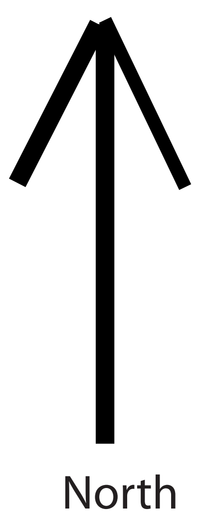
Urban Wetlands providing ecosystem services

LDE 593 / MUD 593 Thesis / Applied Project
Carol Kegley
Spring 2014 Semester / Instructor: Prof. Kenneth R. Brooks

Site -Downtown Phoenix



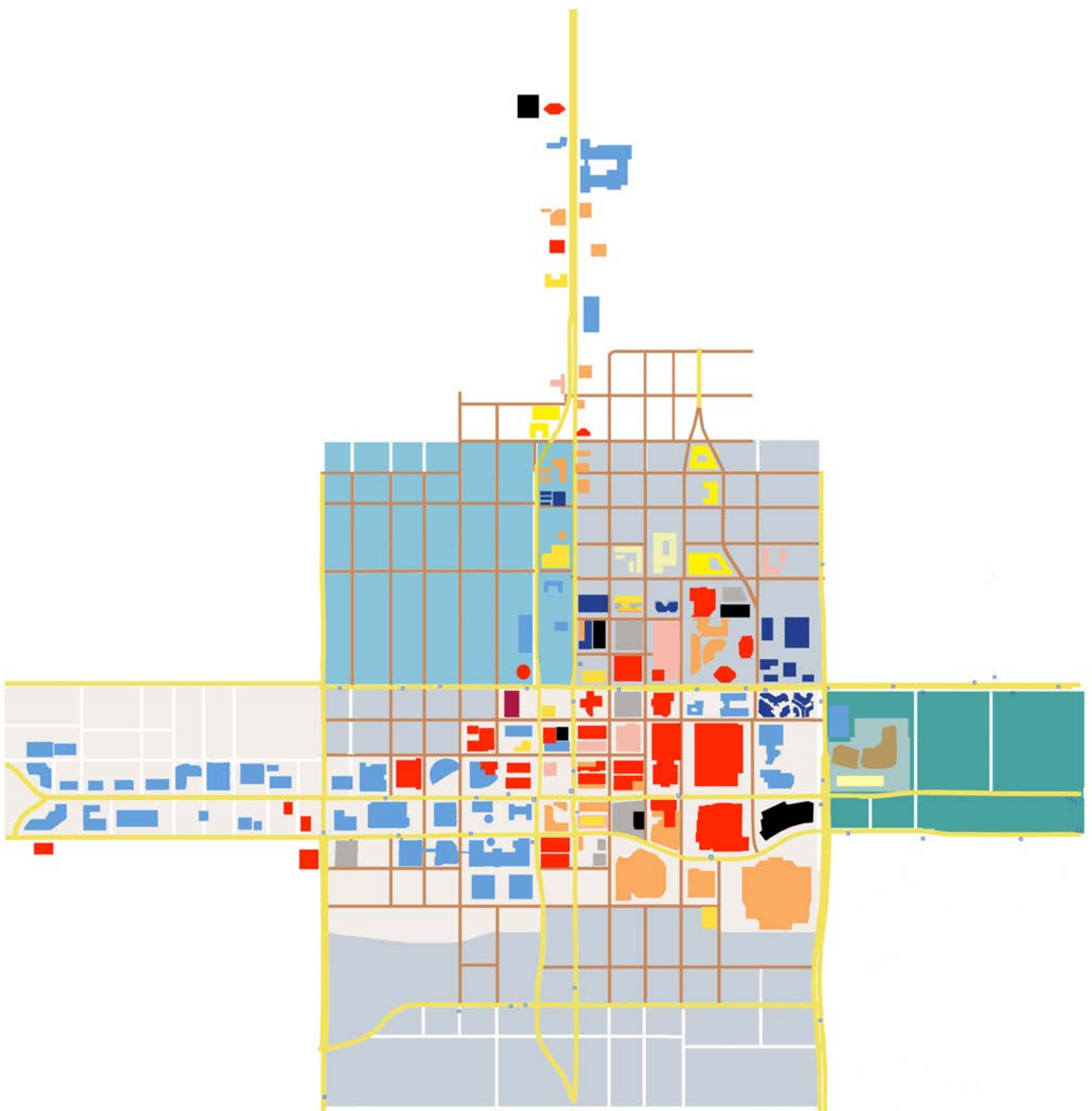


The problem and context: Preserve fresh water as a resource while recycling wastewater through urban wetlands to provide ecosystem services

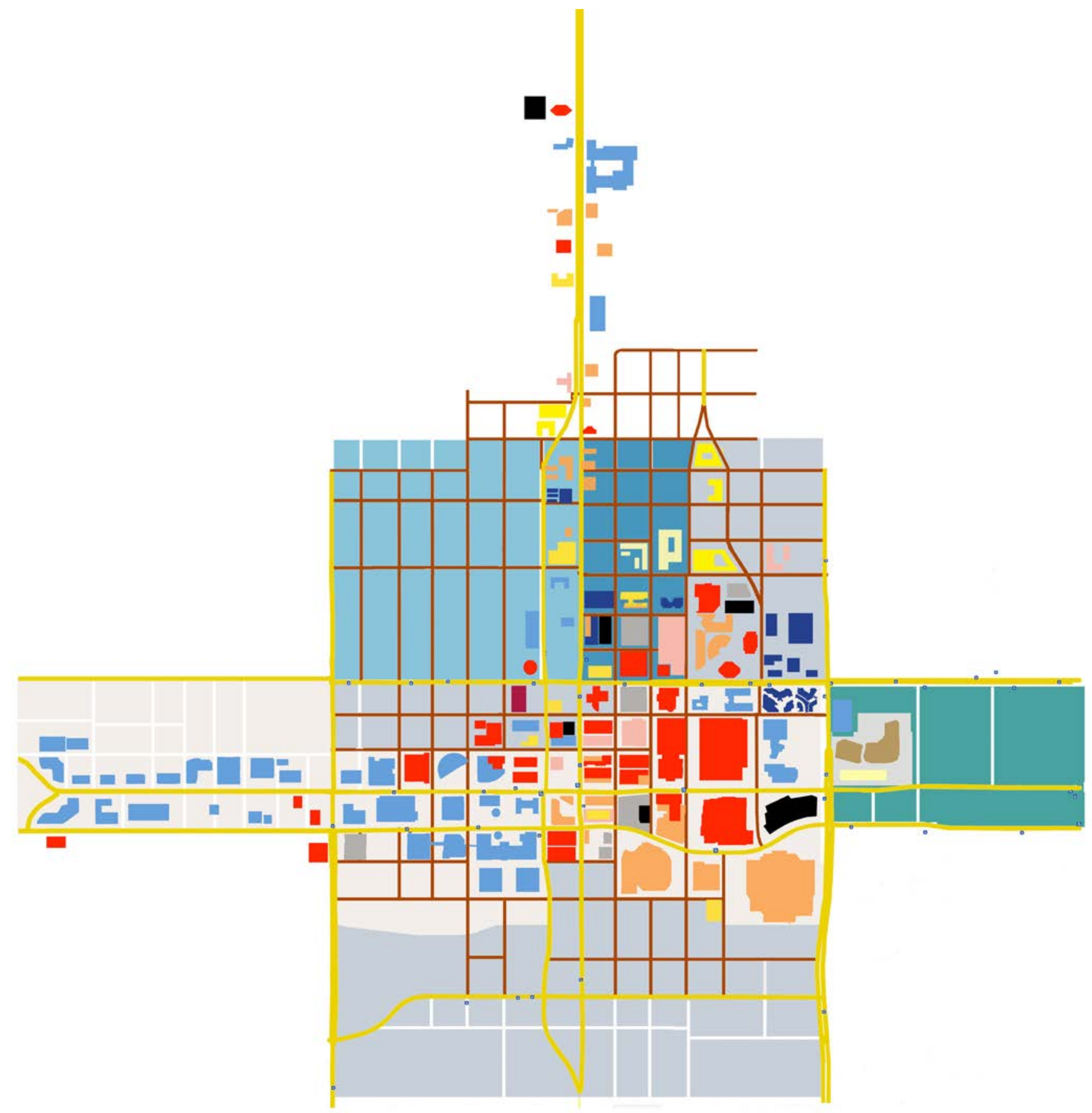
The direction of water management has taken throughout history has begun to show in severe drought conditions of groundwater and aquifer depletion while ocean levels rise. The established method of treating stormwater and rainwater in an urban environment has been to direct it off of surfaces and away from a city. As populations grew the water cycle became more manipulated. Dams, canals and large irrigation systems were built. Wastewater was isolated, collected and transferred outside of cities to be treated. This allowed for an immediate rise in standards of living for populations in urban environments. For centuries before and at the beginning of human civilization the natural hydrological cycle filtered, absorbed, transferred and balanced the distribution of water and waste through plants and soil to groundwater recharge which leads to river life and cycles which in turn flow to the oceans. Today the average flow of water into streams and reservoirs has been decreased by 37% (Sensitive Cities 2012). Climate and rainfall does play a role, however, the demand and use by civilizations can be managed and reduced while revealing how non-rainwater sources of water can play a role in delivering liveable, resilient and productive cities.

Rather than a costly and smelly waste treatment plant new industries, economic growth, and new technology can be used to generate new ways of collecting and using wastewater in a safe, and aesthetically pleasing construction. Through the Living Building challenge construction of wastewater treatment wetlands has already been included for on-site waste water treatment in the design of new buildings. Several buildings through the Living Building Challenge have been completed with constructed wetlands and awarded LEED platinum as well as Living Building Challenge credentials.

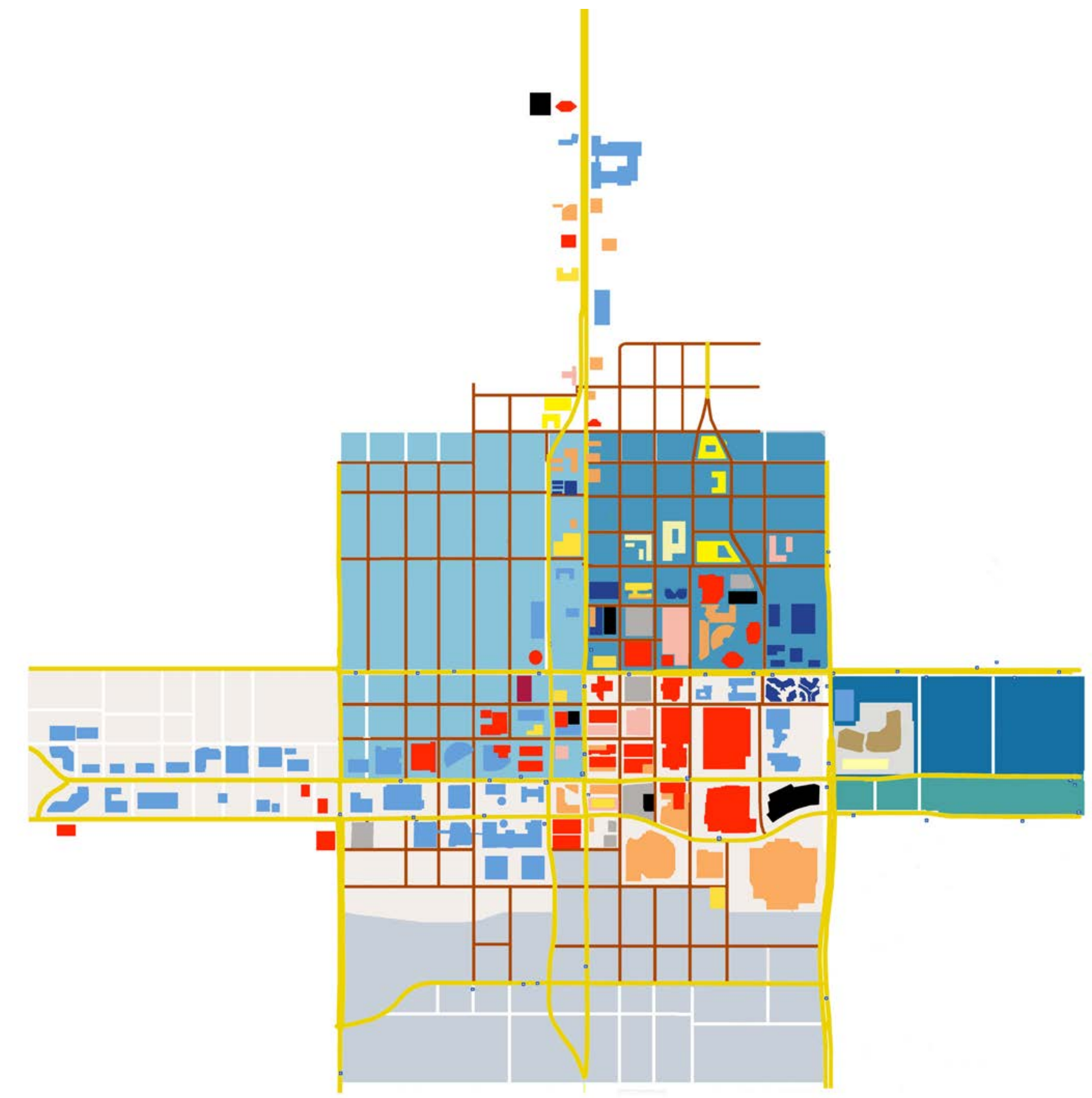
Population Growth



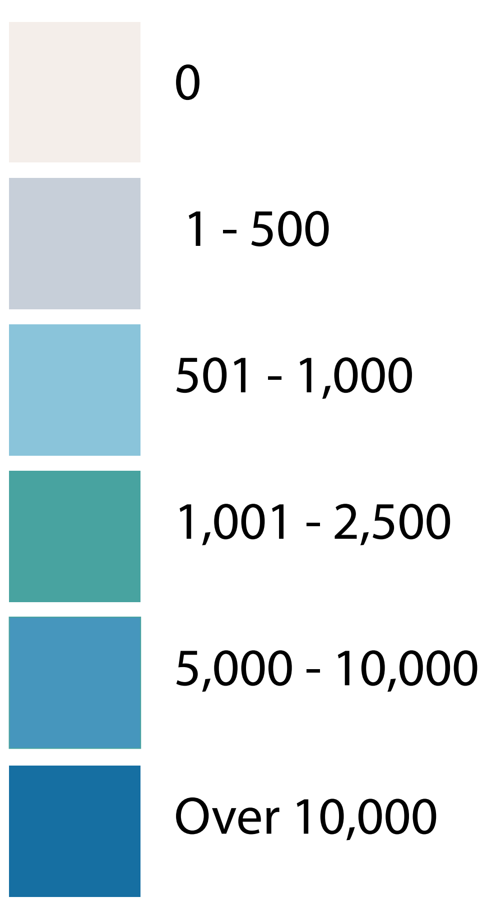
2010 Census



2030 Projected Growth



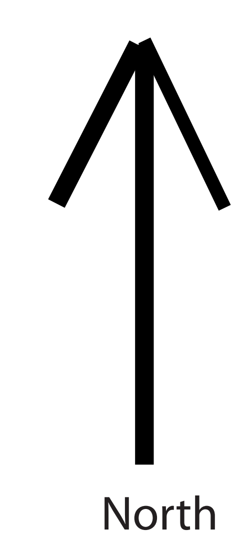
2040 Projected Growth



By 2040 the surrounding downtown areas of Phoenix will have grown

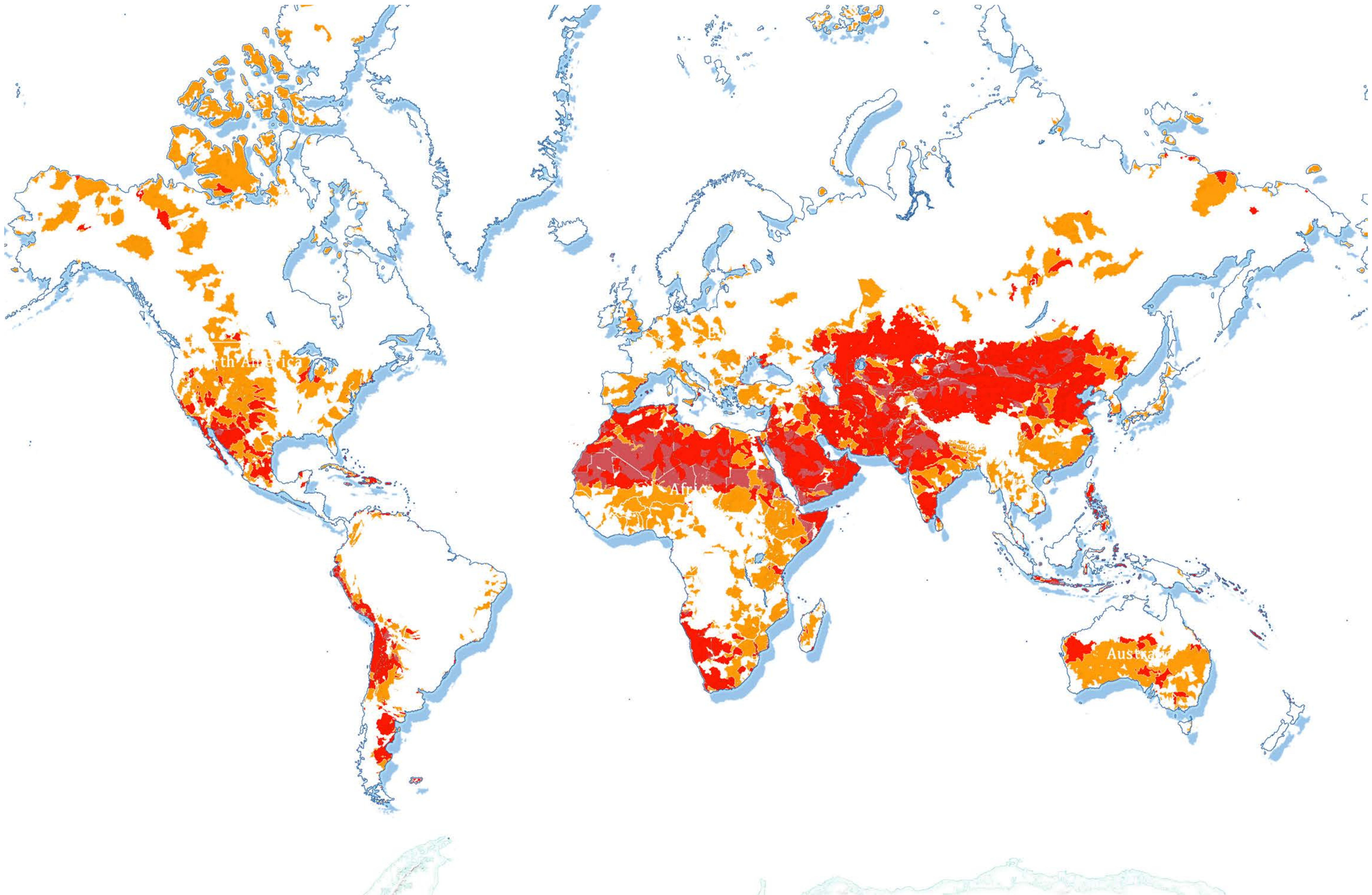
4 x current population

These areas will have 10,000 and more people per square mile.



Drought

Areas of Drought Severity

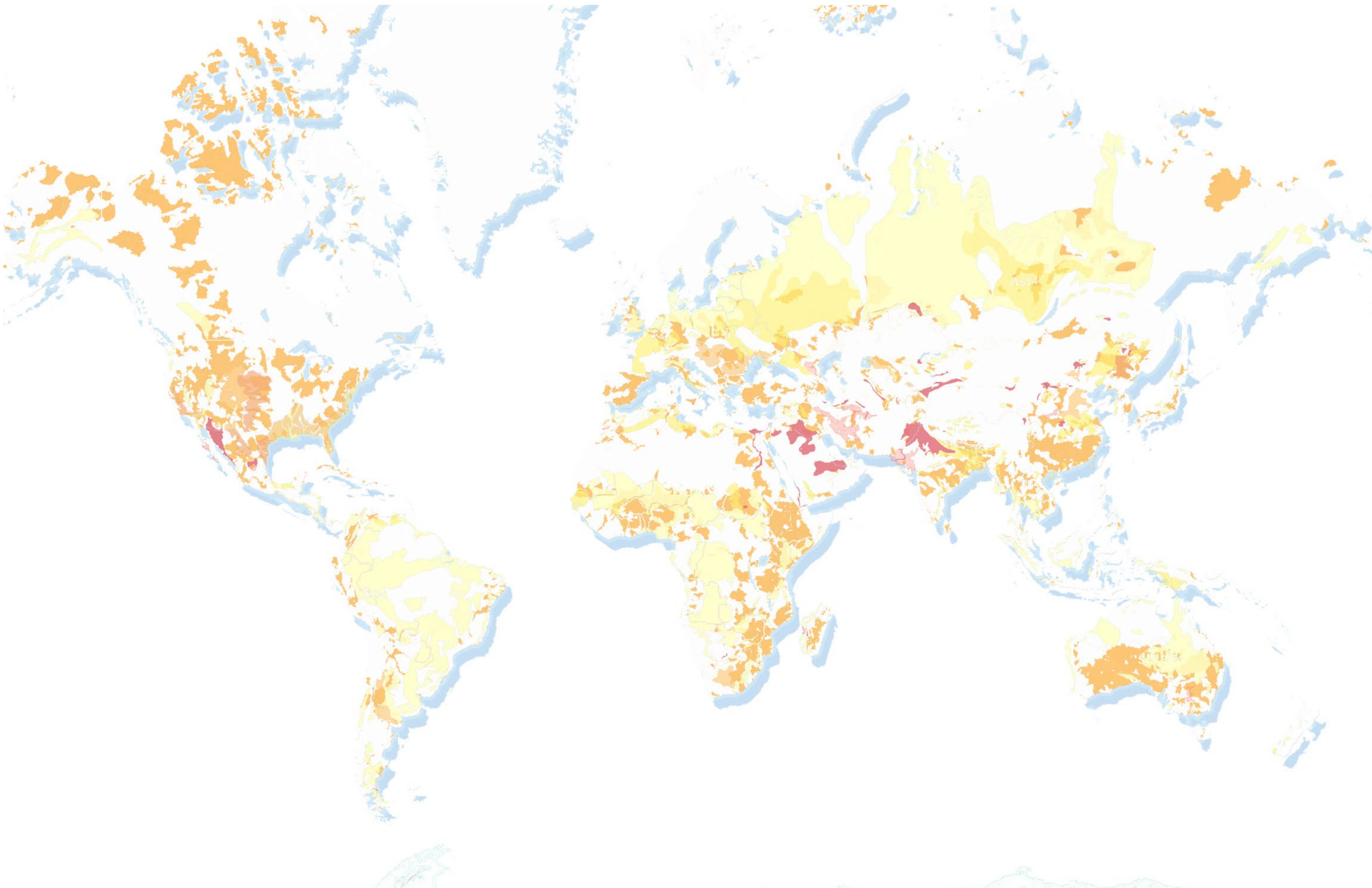


Drought severity measures the average length of droughts times the dryness of the droughts from 1901 - 2008.

Calculations: Drought severity is the mean of the lengths times the dryness of all droughts occurring in an area. Drought is defined as a contiguous period when soil moisture remains below the 20th percentile. Length is measured in months, and dryness is the average number of percentage points by which soil moisture drops below the 20th percentile. Drought data is re-sampled from original raster from into hydrological catchments.

Groundwater Stress

Areas where there is Ground Water Stress



Ground water stress measures the amount of groundwater withdrawal relative to its recharge rate over a given aquifer. Values above on indicate where unsustainable groundwater consumption could affect groundwater availability and ground-water dependent ecosystems.

Extremely High
> - 80%

High 40% - 60%

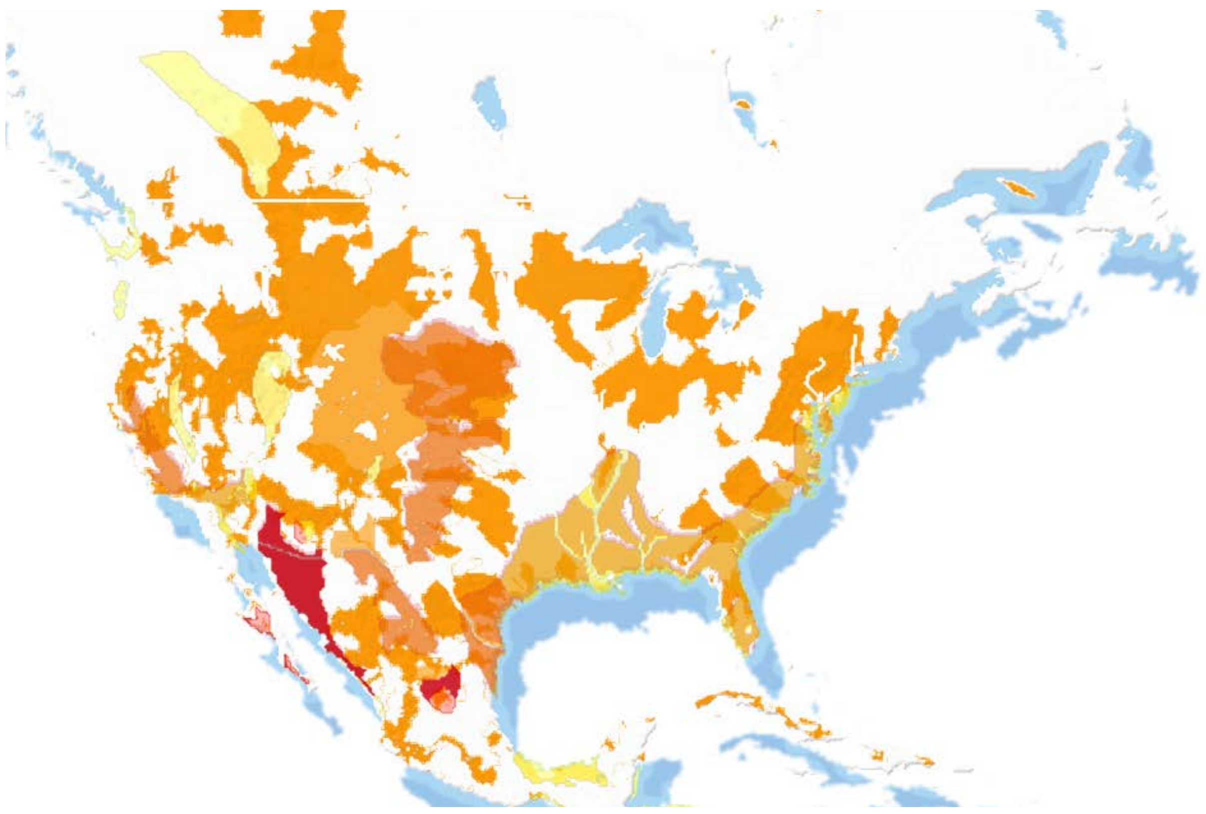
Medium to High
20% - 40%

Low to Medium
10% - 20%

Low 10%

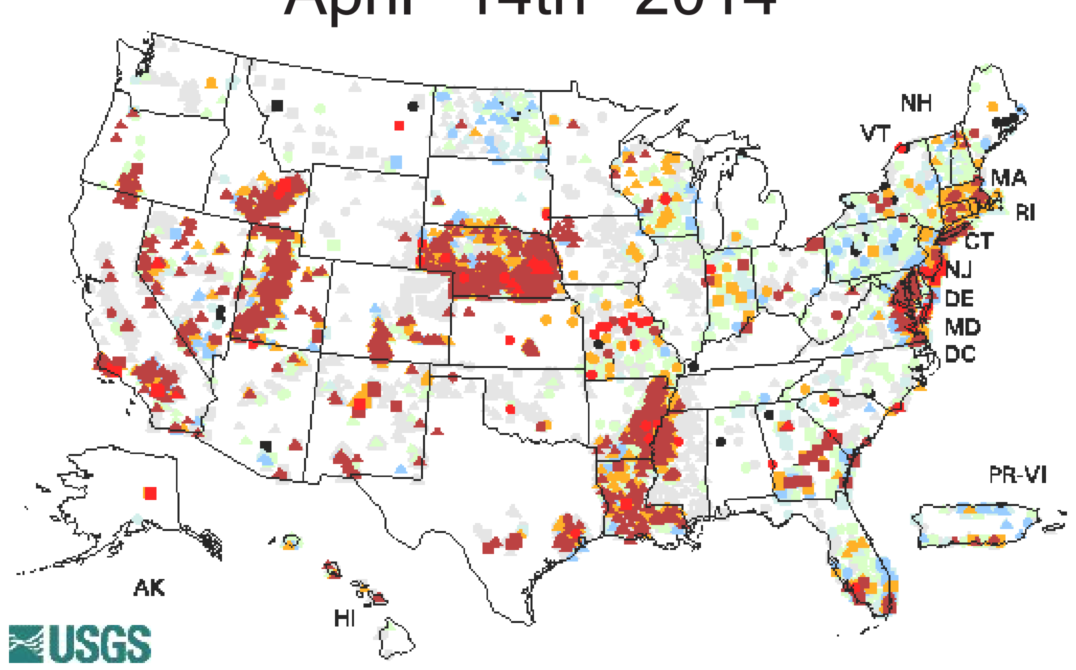
Calculations: Groundwater footprint divided by the aquifer area. Groundwater footprint is defined as A[C/(R-E)], where C, R, and E are respectively the
area - averaged annual abstraction of groundwater, recharge rate, and the groundwater contribution to the environmental stream flow.
A is the areal extent of any region of interest where C, R, and E can be defined.

Aquifer Stress



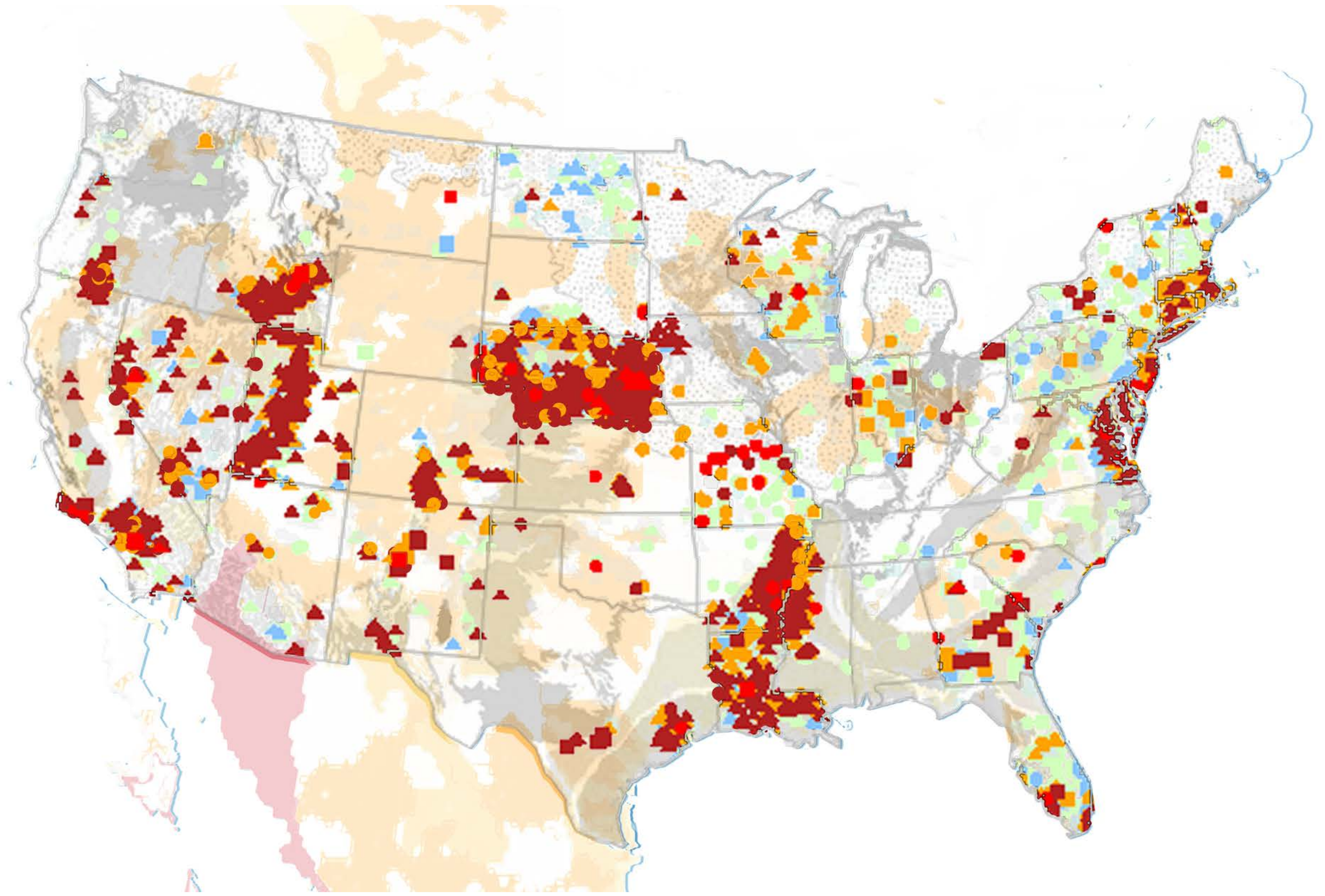
Groundwater Stress

April 14th 2014



USGS Real Time Groundwater

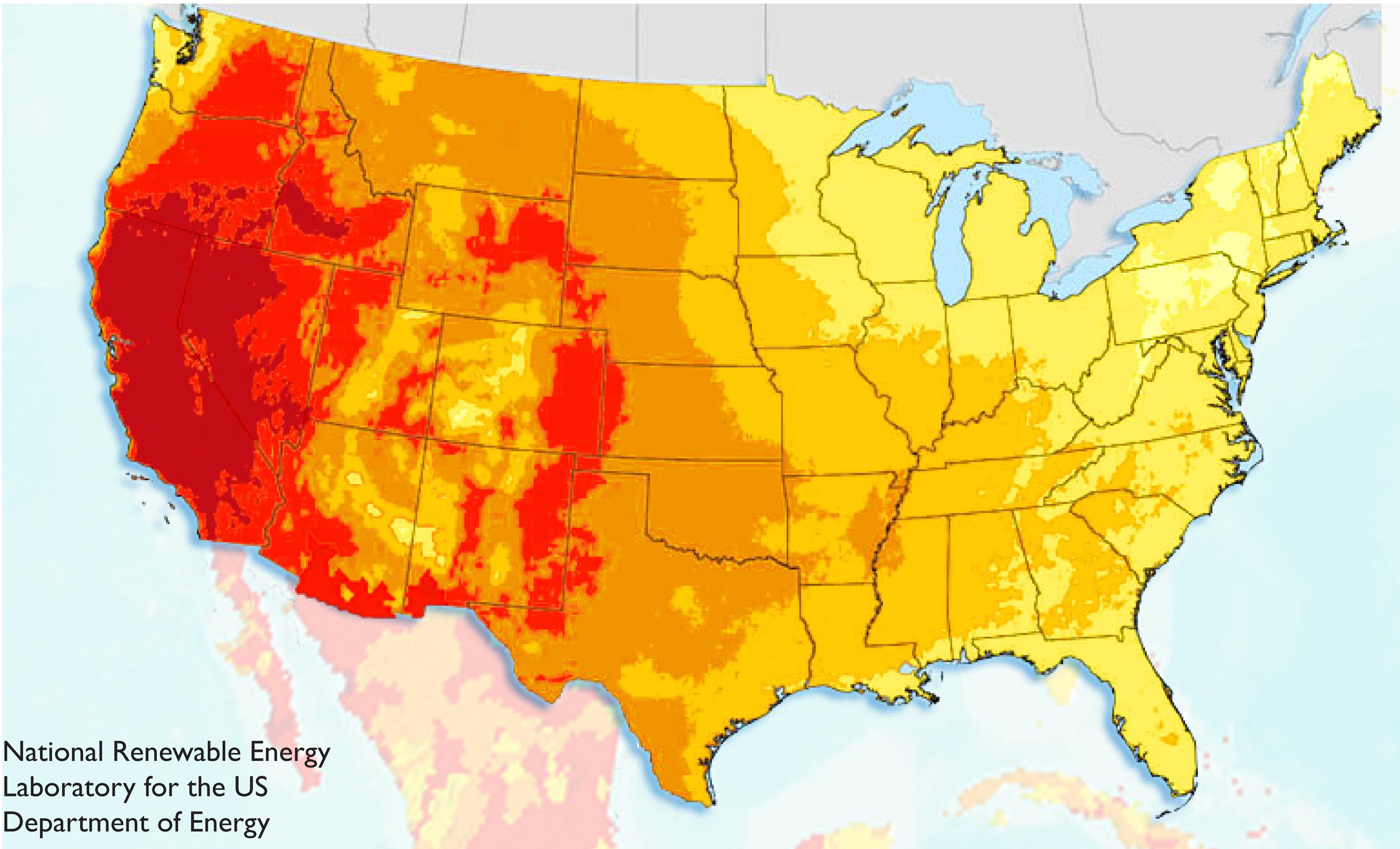
US Aquifers



N

- Low
- <10 Percentile - Much Below Normal
- 10-24 Percentile - Below Normal
- 25-75 Percentile - Normal
- 76-90 Percentile - Above Normal
- Not Ranked

Solar Radiance August 2008



National Renewable Energy Laboratory for the US Department of Energy

More than 1.8 million people live in Phoenix itself, and 22 cities surround it in the Valley of the Sun, forming the largest metropolitan landscape by area in the United States.

Each year the valley receives about Seven Inches of rainfall. Average temperatures exceed 100 degrees for three months a year, with peaks as high as 120 degrees. Global Climate change means longer sustained days of heat means more loss of water to evaporation.

Desert nights no longer cool down they way they used to, because energy from the sun is trapped in roads and buildings, a phenomenon researchers call the "urban heat island effect."

Legend
kWh2/day

7.5 - 8.5
6.5 - 7.5
5.5 - 6.5
5.0 - 5.5
4.5 - 5.0
4.0 - 4.5

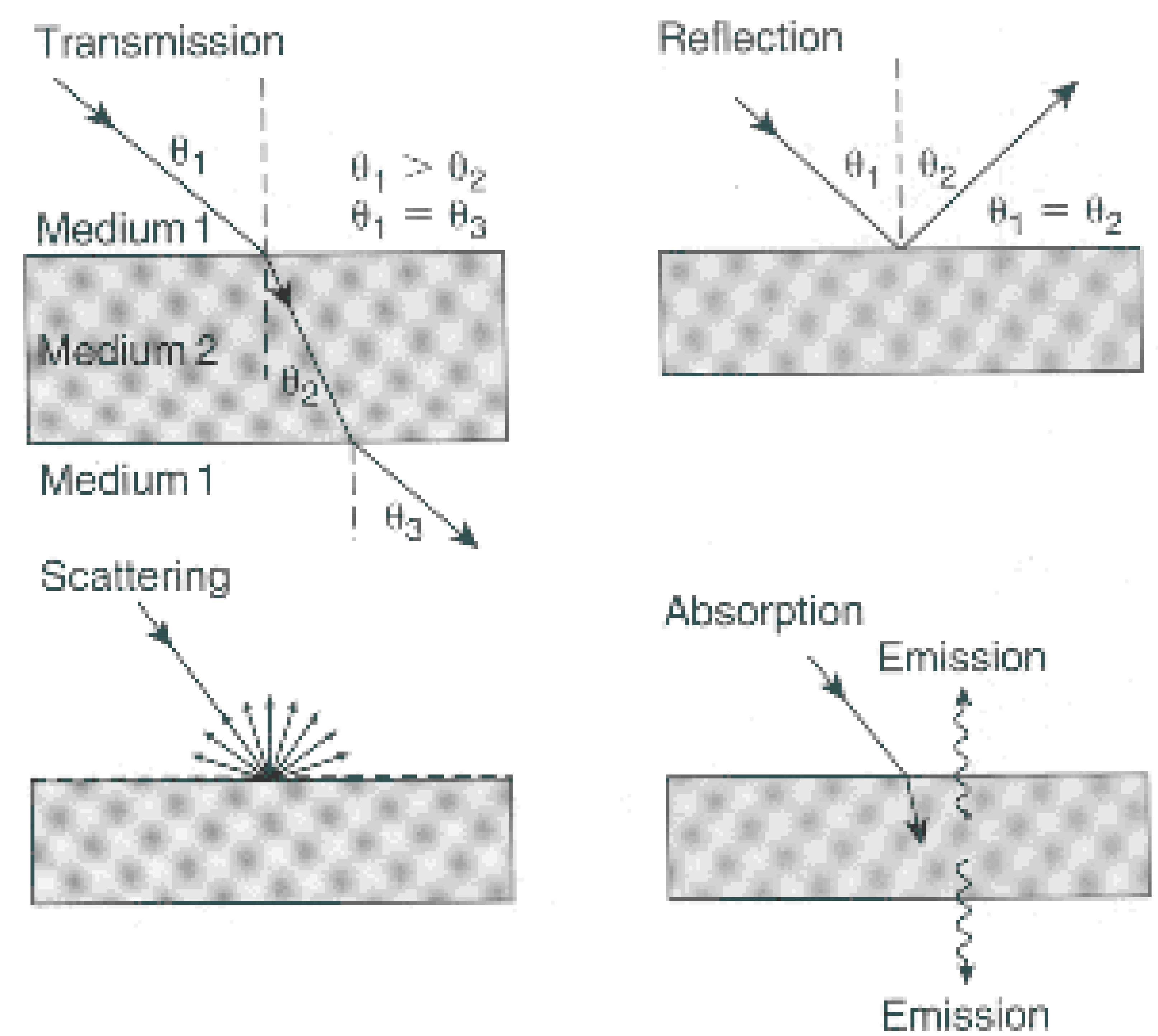
Solar Radiance /Radiation

Irradiance - The amount of electromagnetic energy incident on a surface per unit time per unit area. In the past this quantity has often been referred to as "flux".
* When measuring solar irradiance (via satellite), scientists are measuring the amount of electromagnetic energy incident on a surface perpendicular to the incoming radiation at the top of the Earth's atmosphere, not the output at the solar surface.
Solar Constant - The solar constant is the amount of energy received at the top of the Earth's atmosphere on a surface oriented perpendicular to the Sun's rays (at the mean distance of the Earth from the Sun). The generally accepted solar constant of 1368 W/m2 is a satellite measured yearly average.

Insolation - In general, solar radiation is received at the Earth's surface. The rate at which direct solar radiation is incident upon a unit horizontal surface at any point on or above the surface of Earth.
*__I will refer to insolation as direct solar radiation at the Earth's surface.__

How radiation is expressed in an urban environment with regards to materials.

Transmission	=	Filter
Reflection/Scattering	=	Reflection or Albedo
Absorption	=	Shade



Walkability

Investing in implementing an ecosystem service is securing a greener economy for the downtown not only in the ecology but in the dollars gained by **venues and services** that **benefit** from the attraction of people.

A Study: Paved with Gold; the Real Value of Good Street Design, Commission for Architecture and the Built Environment, (London 2007).
This study shows that investments in pedestrian safety and an attractive street environment brings quantifiable financial returns. Key Finding: On a seven-point pedestrian environment scale,

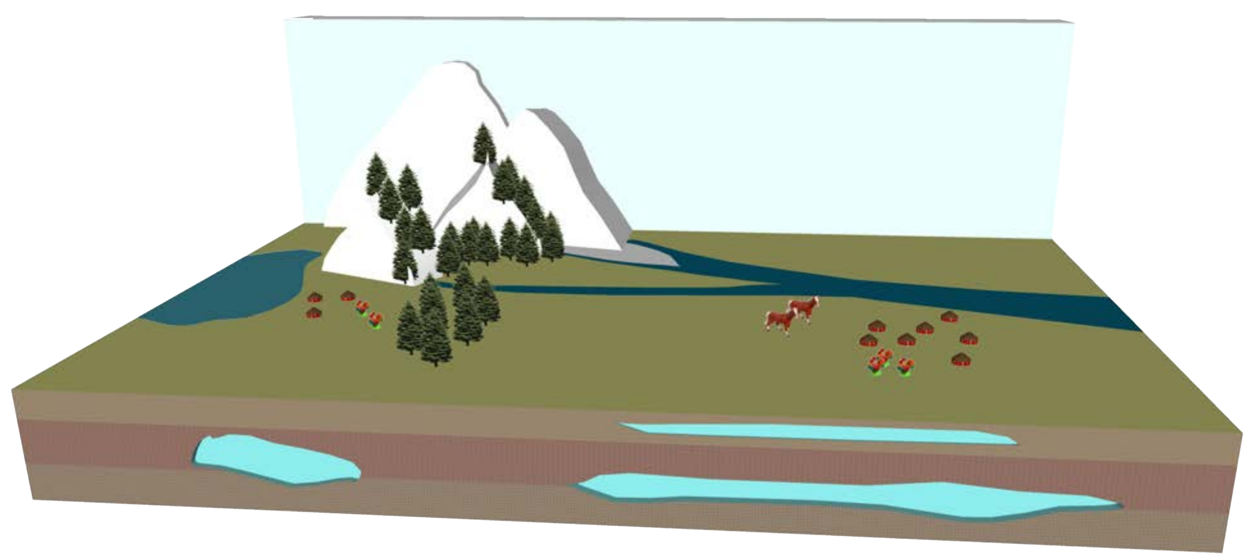
Every One Point Increase In Walkability Was Associated With 5.2% Higher Retail Prices and 4.9% Higher Commercial Rents.

Economic Value of Walkability, Victoria Transport Policy Institute, September 2009, citing a study by Accent Marketing and Research. Key Finding: This study of consumer expenditures in British towns found that customers who walk spend significantly more ($50) compared to those who drive ($40), take transit ($38), or arrive by taxi, bicycling, or other mode ($35).

“The Impact of Neighborhood Walkability on Walking Behavior” paper -
Published November 2013

The paper provides strong evidence that
Neighborhood walkability impacts the amount of time people walk.
Those who live in a more walkable neighborhood, where the infrastructure is pedestrian-friendly, walk more than those who live in a neighborhood less conducive for walking.

People will take advantage of pedestrian-friendly environments and walk more – whatever their original predispositions were towards walking.



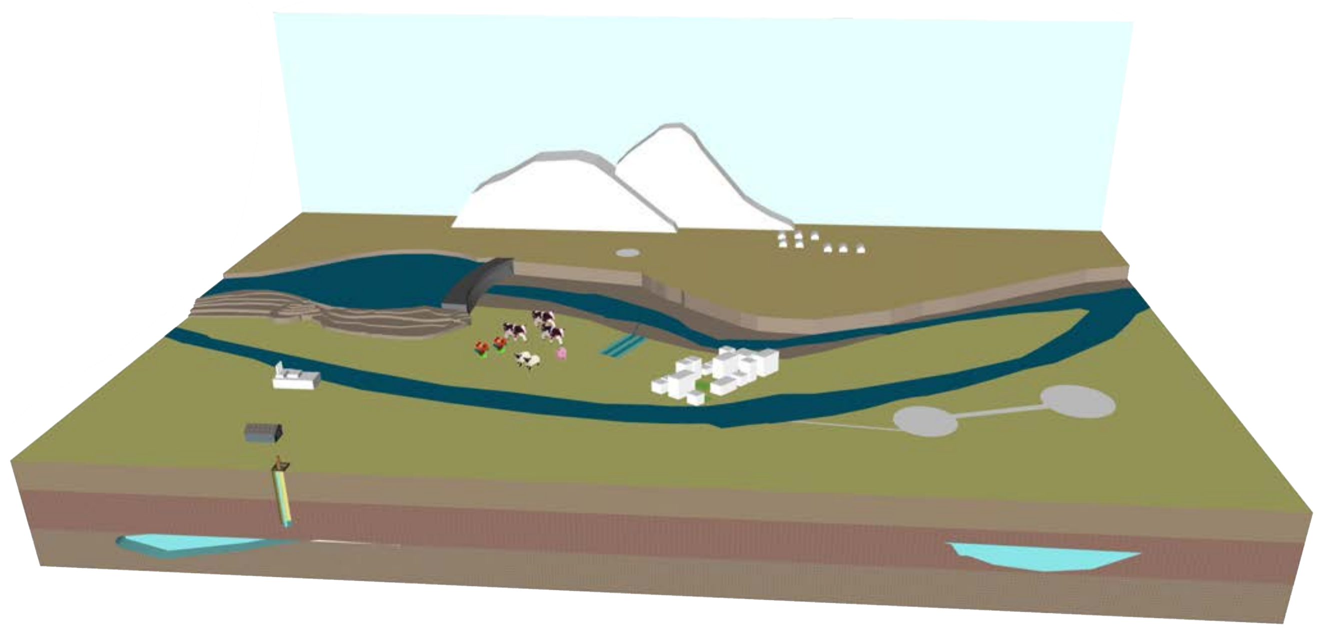
The First Era Of Water -

Relying on Nature's Sources

Hydrological Cycle- This process shows Earth's ability to filter itself through an air, land, and underground process

Dependence on Natural Water Cycle

Humans water needs were 'cleaned' by the Hydrological Cycle. Average life span of Human- 35 years.



The Second Era Of Water

Humans Manipulate Water Cycle

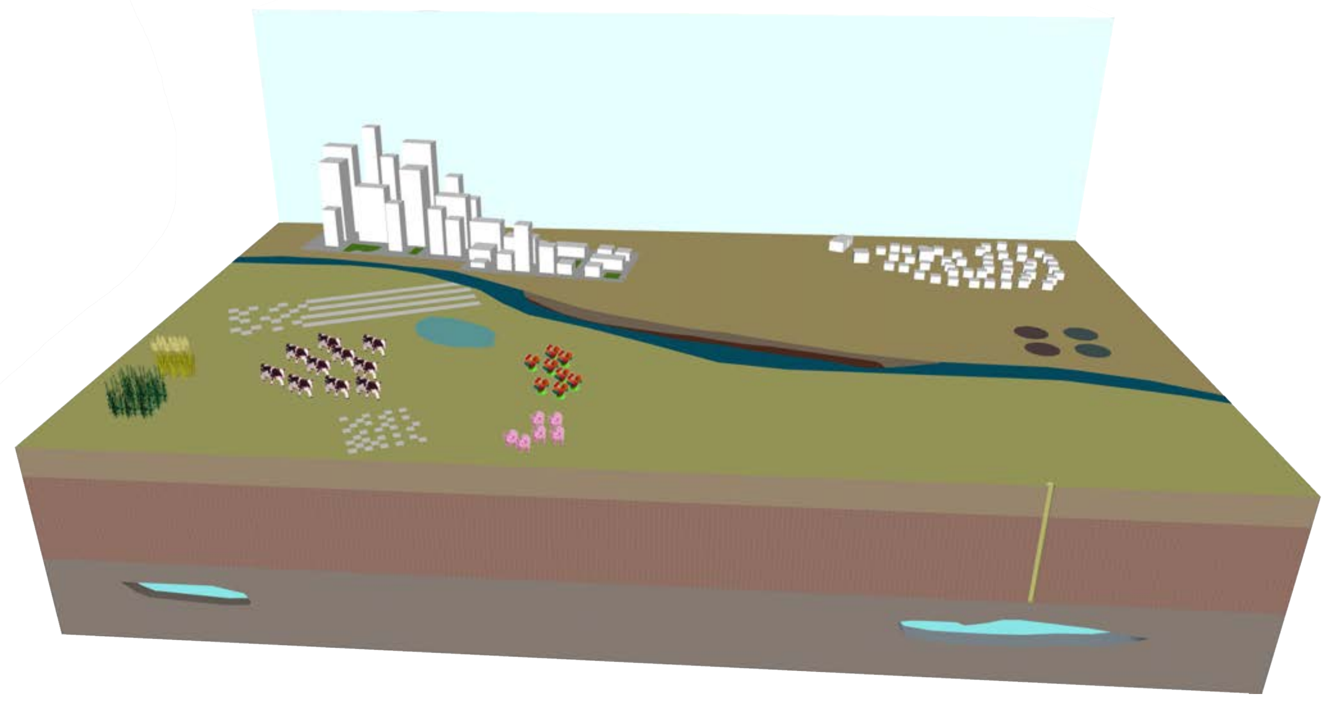
A higher standard of living is achieved through innovations in water technology such as Canals, Dams, Irrigation

Wastewater is collected and isolated

Canals strain dirty water our of tank -less water born illness and disease

Population Living Longer

With sanitation and water-related diseases reduced population growth



Third Era Of Water

Over-Development

New industries, economic growth, and new technology add to the demand of water world-wide

Failure to Integrate

Delivery of water over long distances, open storage

Lack Of Access

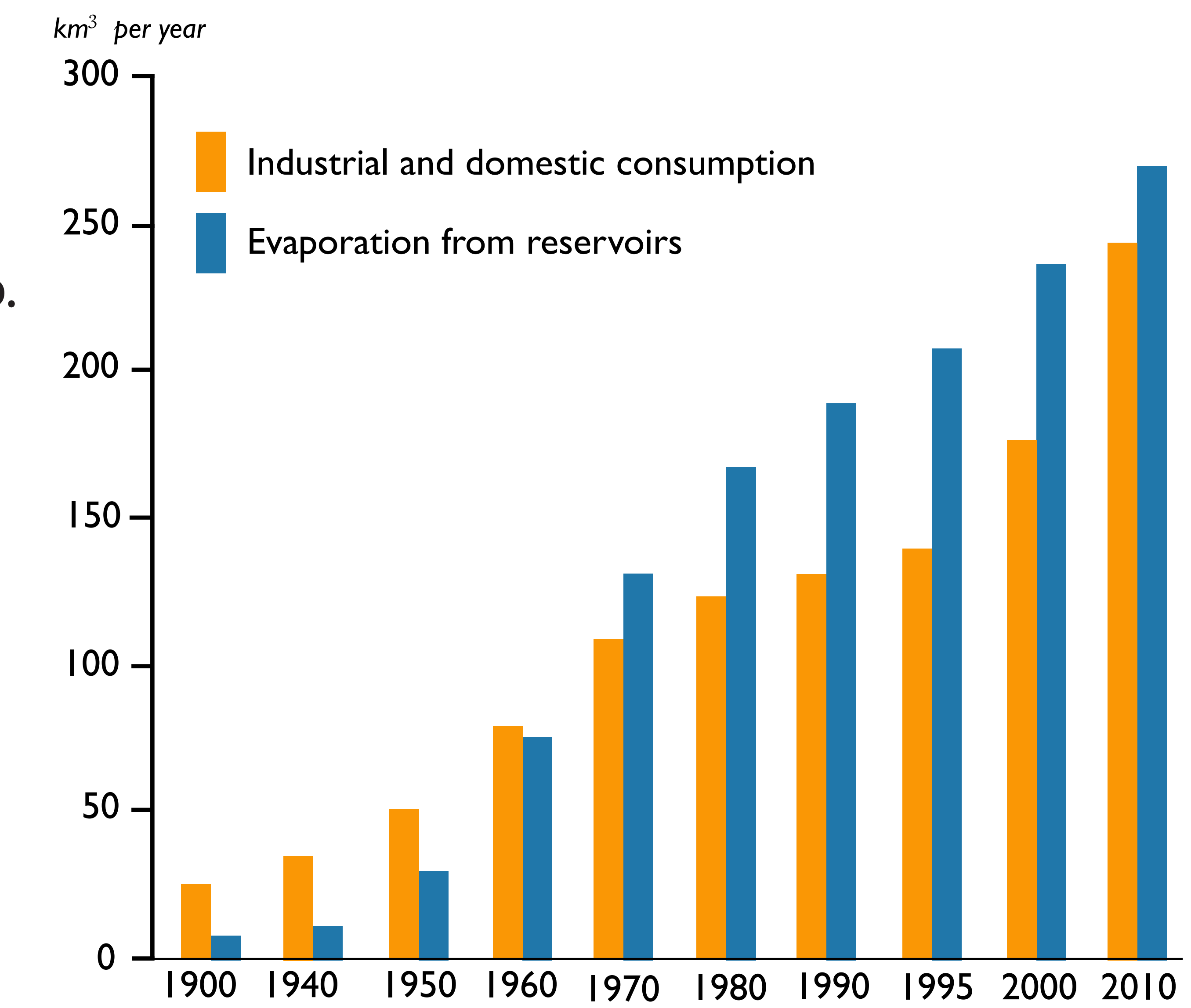
1/3rd of the world's population currently lacks access to fresh water.

Earth's Climate Is Changing

Temperatures are rising and the need for water will too.

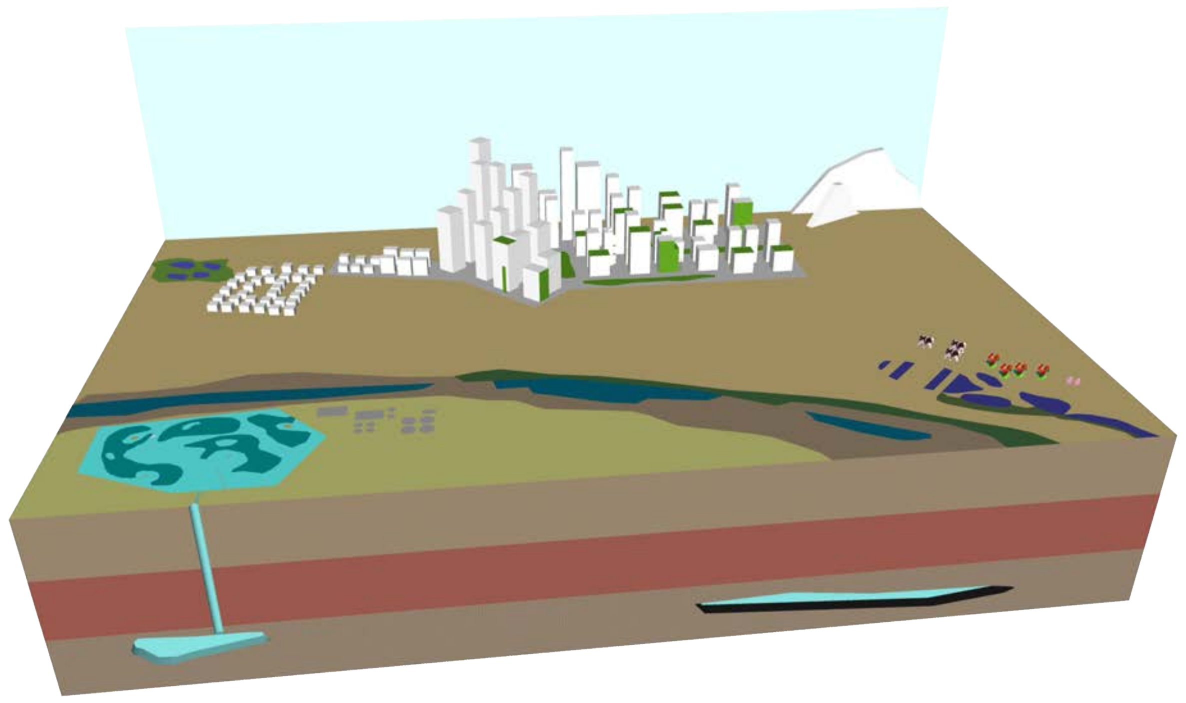
Precipitation cycle with change as a result

Based on Peter Gleik's essay " Facing Down The Hydo-Crisis" published in the World Policy Journal [(2009) World Policy Institute]



Source: Igor A. Shlklomanov, State Hydrological Institute (Shi, St. Petersburg) and United Nations Educational, Scientific and Cultural Organization (UNESCO, Paris), 1999

Fourth Era Of Water



Ecosystem Services from
Non-rainwater supply solutions
along with rainwater harvesting

To help establish a broader vision and system for a city like Phoenix to avoid committing to a growth pattern of costly augmentation of water supply and environmental damage.
This proposal has the potential to improve water management and livability in the city at the same time.

Recycling and Wastewater , Greywater Condensate

Urban Wetlands

Uses for Recycled Water

Landscape
Public parks
Golf course irrigation
Cooling water air conditioning
Toilet flushing
Dust control,
Construction activities
Concrete mixing
Artificial lakes or water feature

Downtown Wetlands

The full use of water ecosystem services in an urban environment can shift and combine the image of water from a resource focus to a service focus. Water supplies will be stressed because of the growth in demand. Bringing water out into public spaces in a manner that demonstrates a recyled use demonstrates the importance and needs on water. It will take a coevolution of technological and mutually reinforcing institutional and sociocultural goals and values. This project looked at ecosystem services as the catalyst for the shared goals and values in society and how these ecosystem services can be delivered through constructed urban wetlands.

Lessons learned from current construction demonstration sited and already existing models allow for diversity of configuration of constructed wetlands to adapt to growth and continue even distribution of recycled wastewater.
A decentralized water system not only has landscape design and construction mitigating stormwater runoff and providing rainwater harvesting it creates re-uses for non rainwater sources such as HVAC condensate and wastewater wetlands. Wetlands are permanently waterlogged areas populated by hydrophytic plants such as reeds, They comprise a variety of sub-surface micro-habitats of differing oxygenation and redox potential. Constructed wetland systems are increasingly being employed for treatment of wastewater, sewage sludges and industrial effluents as a cost-effective, low energy and robust alternative to traditional engineered biological treatment such as the activated sludge process.

Constructed wetlands are classified according to their mode of operation as free water surface-flow, horizontal flow, vertical downflow or vertical upflow type. They have been used successfully in the treatment of domestic sewage, urban, highway and stormwater runoff, acid mine drainage, agricultural wastewater and industrial effluents (including landfill leachate). Biological oxygen demand (gases) and solids reduction occurs through microbial activity and removal of nitrogen and phosphorus through the processes of filtration, denitrification, plant uptake and absorption. This project is focused on the subsurface flow wetlands which through its construction allows for integration within a streetscape or urban space of a city.

Design structure of a new water management system

Use of water ecosystems and integrated wetlands develops multifunctional urban spaces

Conventional Wastewater Treatment

Single purpose to process and treat large volumes of wastewater on small parcels of land

Secondary benefits not considered

Process involves application of chemicals and energy for pumping, agitating and aerating

High cost of electricity /feul to operate waste treatment facility

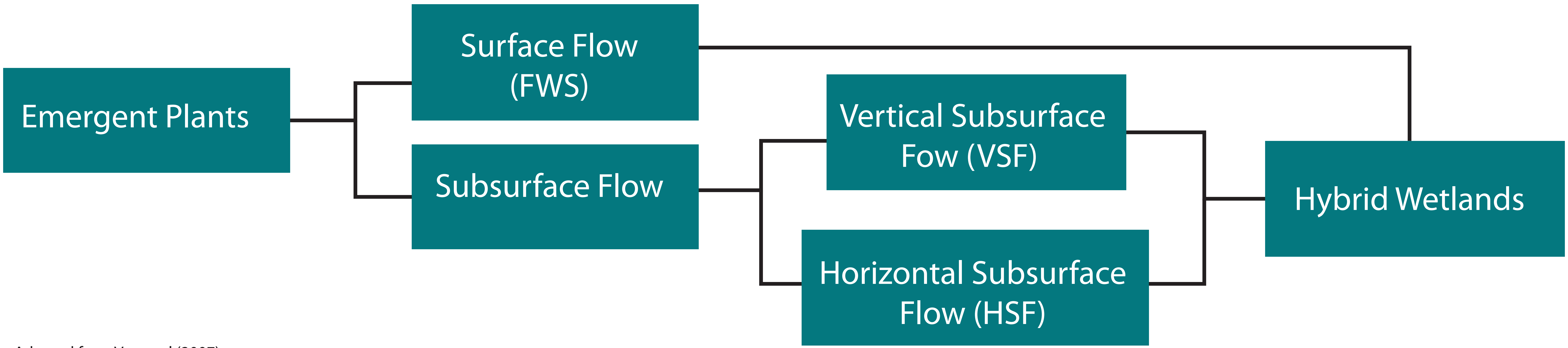
Constructed Emergent plant Wetlands

Scaled to neighborhood and can be distributed throughout the watershed

Secondary benefits in conservation of water and ecosystem services that contribute to the landscape network

Byproducts can be used to augment landscape, natural areas and contribute to species and habitat diversity.

Wetland Process Diagram

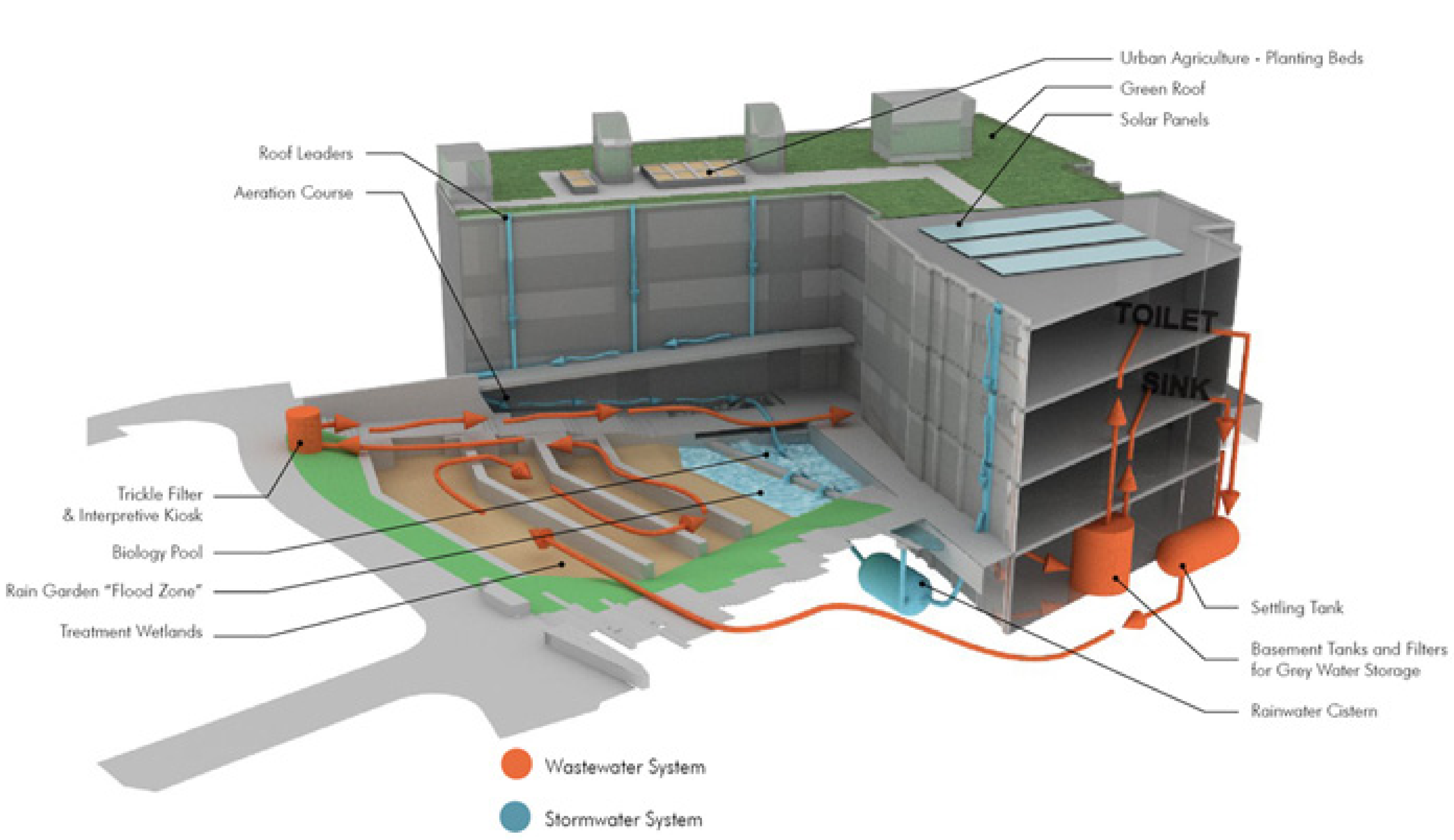


Adapted from Vymazal (2007)

Wetlands ecologies are both complex and stable and the root systems of the plants are adapted to thrive all the while submerged in water. Wetlands have continuous water flow, thus the plants are adapted to filter out nutrients very quickly. Plants do not take up the waste contaminants to their tissue the submerged root system is where nutrients are broken down so no portion of their leaves or stems contain contaminants.

Constructed Wetlands are differentiated by vegetation type and flow regime. A new function to wetlands is below ground treatment of wastewater. The benefit to this is a multifunctional green infrastructure that can be scaled to the neighborhood as well as a city block and distributed throughout the watershed.
The (HSF) horizontal subsurface flow wetland and the (VSF) vertical subsurface flow wetland are the two options for below-ground treatment stages. A hybrid of the two allows for more compactness and higher performance of treatment.

Case Study Sidwell Friends Middle School- Living Building



90% Reduced Municipal Water Use

60% Less Energy Demand

Dashboard Information Access

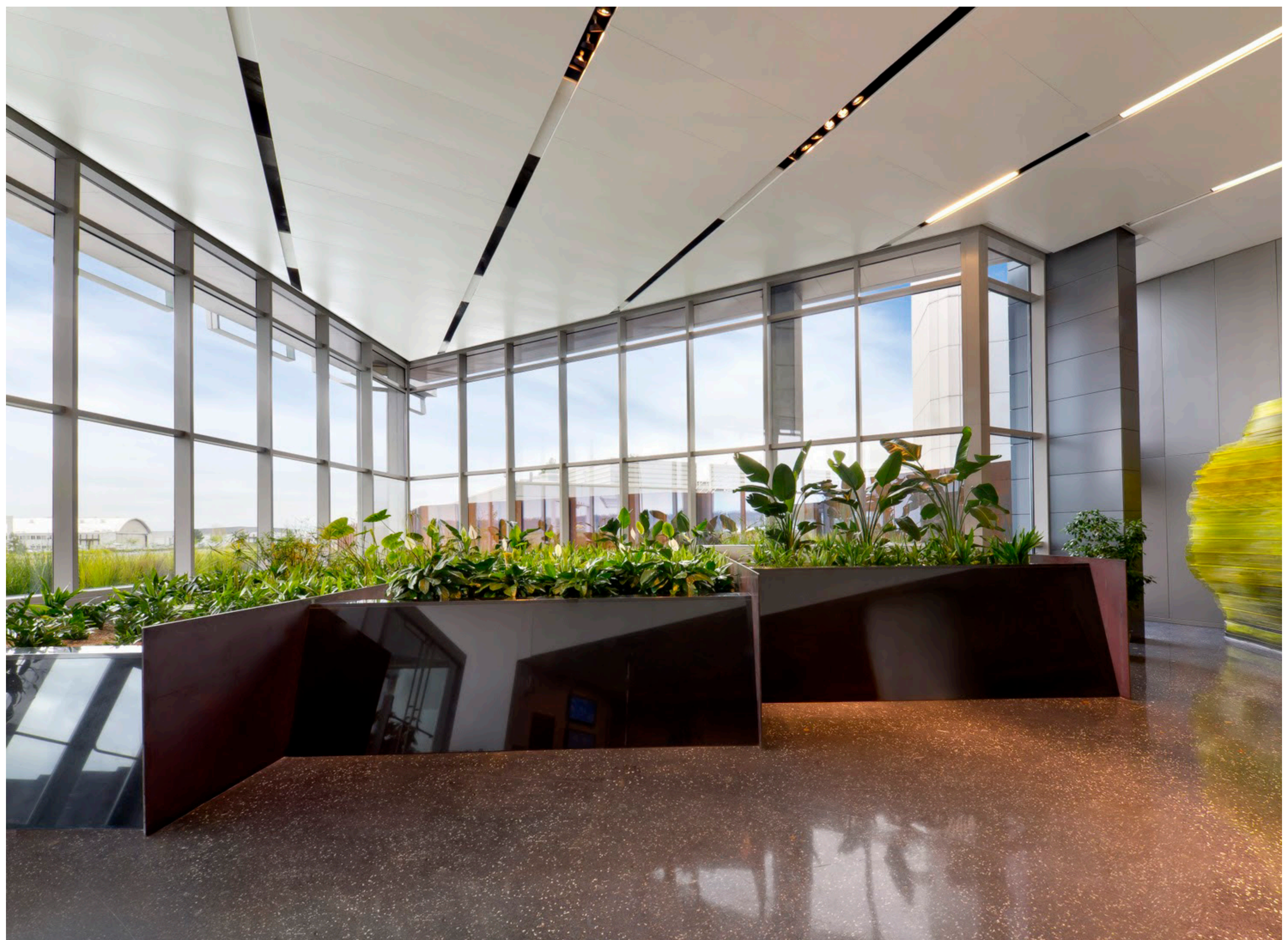
Biodiversity

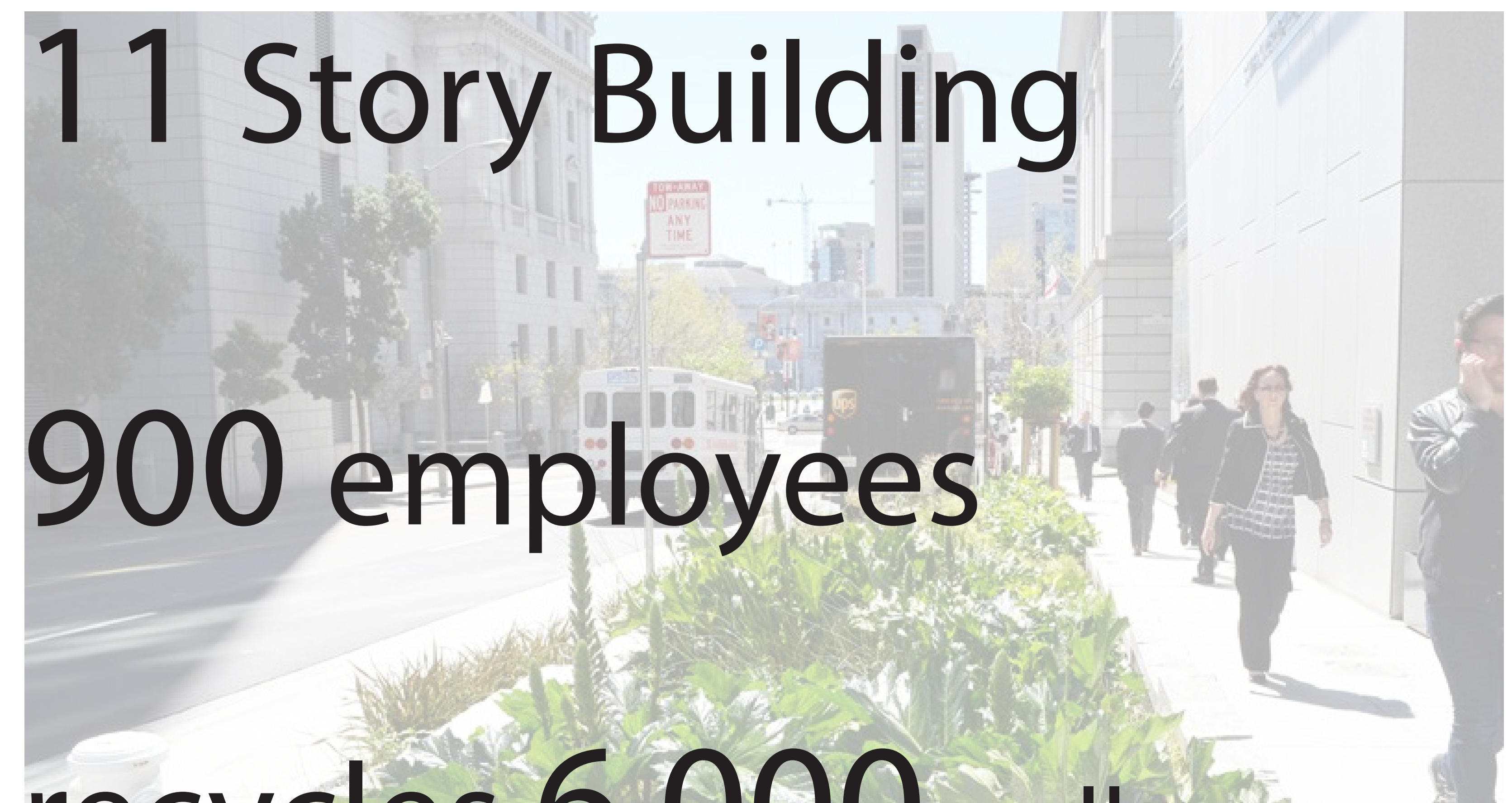
Over **80** Native Plant Species established on the campus

Learning Life Sciences in Landscape

Case Study San Francisco
Living Building

These Living Buildings clean wastewater through a living wetland system that moves from outside to inside the building.

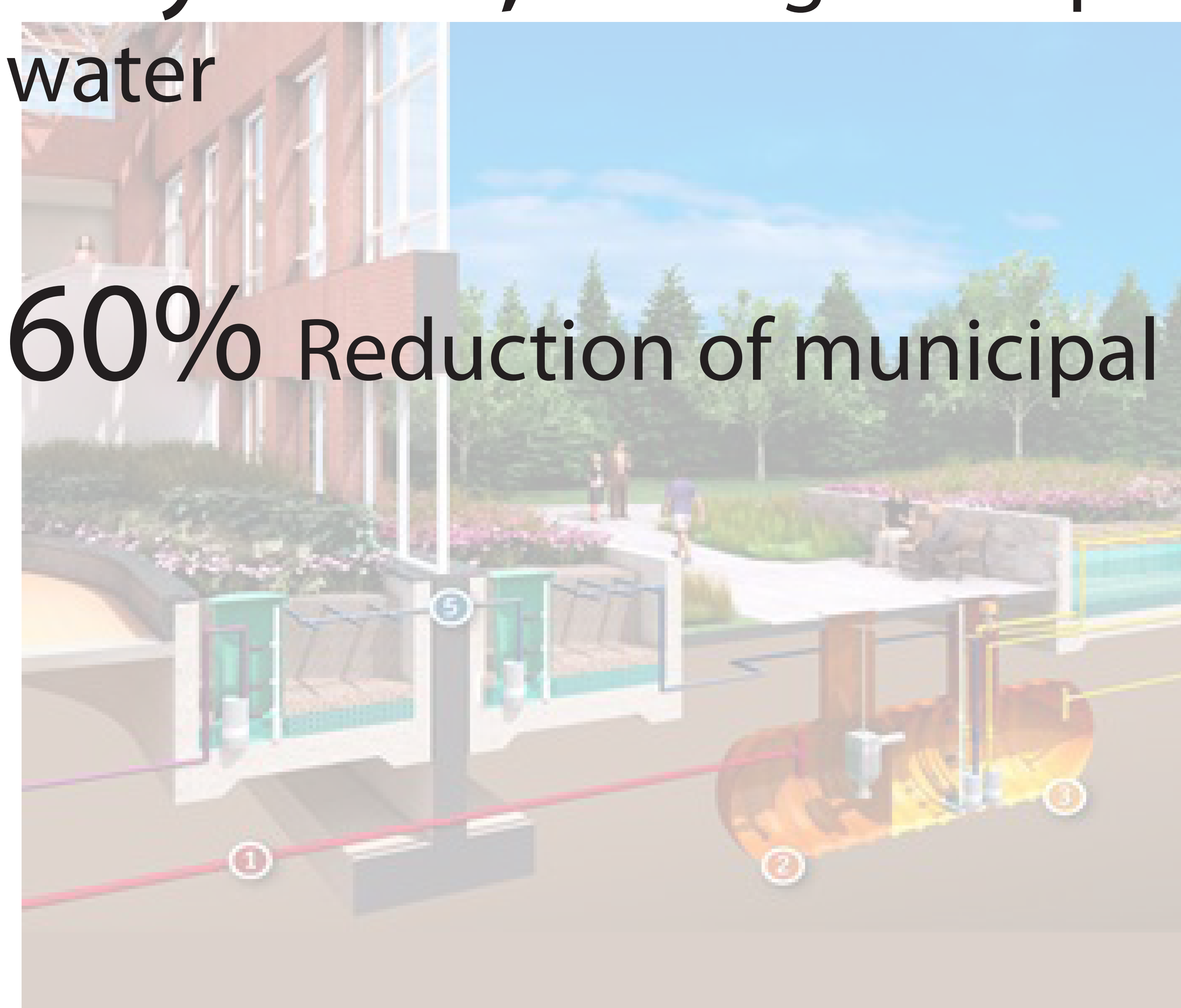




11 Story Building

900 employees

recycles 6,000 gallons per day of waste water



60% Reduction of municipal waste cost.

Plant Choices For and Urban Setting

Exterior wetland plants


Eleocharis *palustris*


Calex *species*


Acanthus *mollis*


Chrondropetalum *tectorum*


Junicus *effusus*


Acorus *gramineus*


Cyprus *alternifolius*

Interior wetland plants


Rumohra *adiantiformis*


Agapanthus *Preacox*


Zantedeschia *aethiopica*


Cyprus *alternifolius*

Adopting An Adaptive Regime

Attributes	Traditional Regime	Adaptive Regime
System Boundary	Water supply, sewerage and flood control for economic and population growth and public health protection	**Multiple** purposes for water considered over long-term time frames including waterway health, transport, recreation/amenity, micro-climate, energy, etc.
Management Approach	Compartmentalization and optimization of single components of the water cycle.	**Adaptive,** integrated, sustainable management of the total water cycle (including land-use)
Expertise	Narrow technical and economic focussed disciplines	**Transdisciplinary,** multi-stakeholder learning across, technica design, economic, social and ecological spheres, coordination across all levels and usually with social engagement.
Service Delivery	Centralised, linear and predominantly technologically and economically based	**Diverse,** flexible solutions at multiple scales via a suite of approaches (technical, social, economic, ecological etc.)
Role of Public	Water managed by government on behalf of communities	**Co-management** of water between government,business and communities
Risk	Risk regulated and controlled by government	**Risk shared** and diversified via private and public instruments

Wastewater design characteristics are used to determine size and design of the treatment system components. Design mass load of chemical oxygen demand (COD) and Total Kjeldahl Nitrogen (TKN) ar the primary water quality indicators or characteristics for sizing treatment components. The following table shows selected design influent concentrations that would be cleaned based on a flow rate of 5,000 gallons per day. The system is designed to provide for maximum treatment capacity in the space available in the wetland cells. If the flow of wastewater has sifnificantly higher concentrations of the key constituents listed in the Table 1. the treatment capacity will be reduced to less than 5,000 GPD. The flow into the system can be monitored by a control system and set manually by an operator that will allow overflow to the city sewer.

Table 1. Tidal Wetland Design Influent Wastewater Characteristics [(a)]

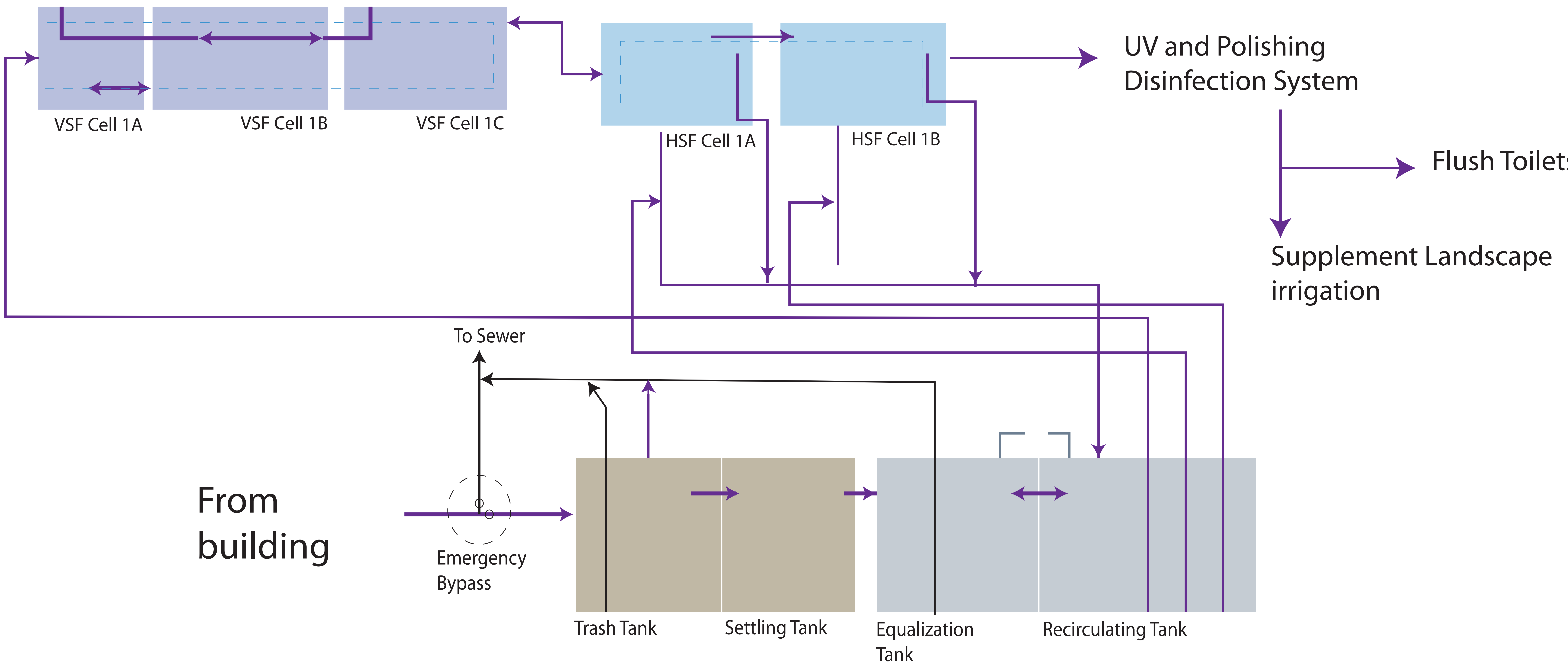
Parameter	Concentration mg/L	Mass Load [(b)]	
		kg/d	lb/d
Design Flow, gallons per day	5,000	N/A	N/A
BOD (Biological Oxygen Demand)	260	4.92	10.83
COD (Chemical Oxygen Demand)	545	10.32	22.71
TSS (Total Suspended Solids)	90	1.7	3.75
Total Kjeldahl Nitrogen as N [(c)]	170	3.22	7.08
pH, standard units	6.5–8.5	N/A	N/A

(a) Wastewater pumped to the Living Machine System after primary treatment

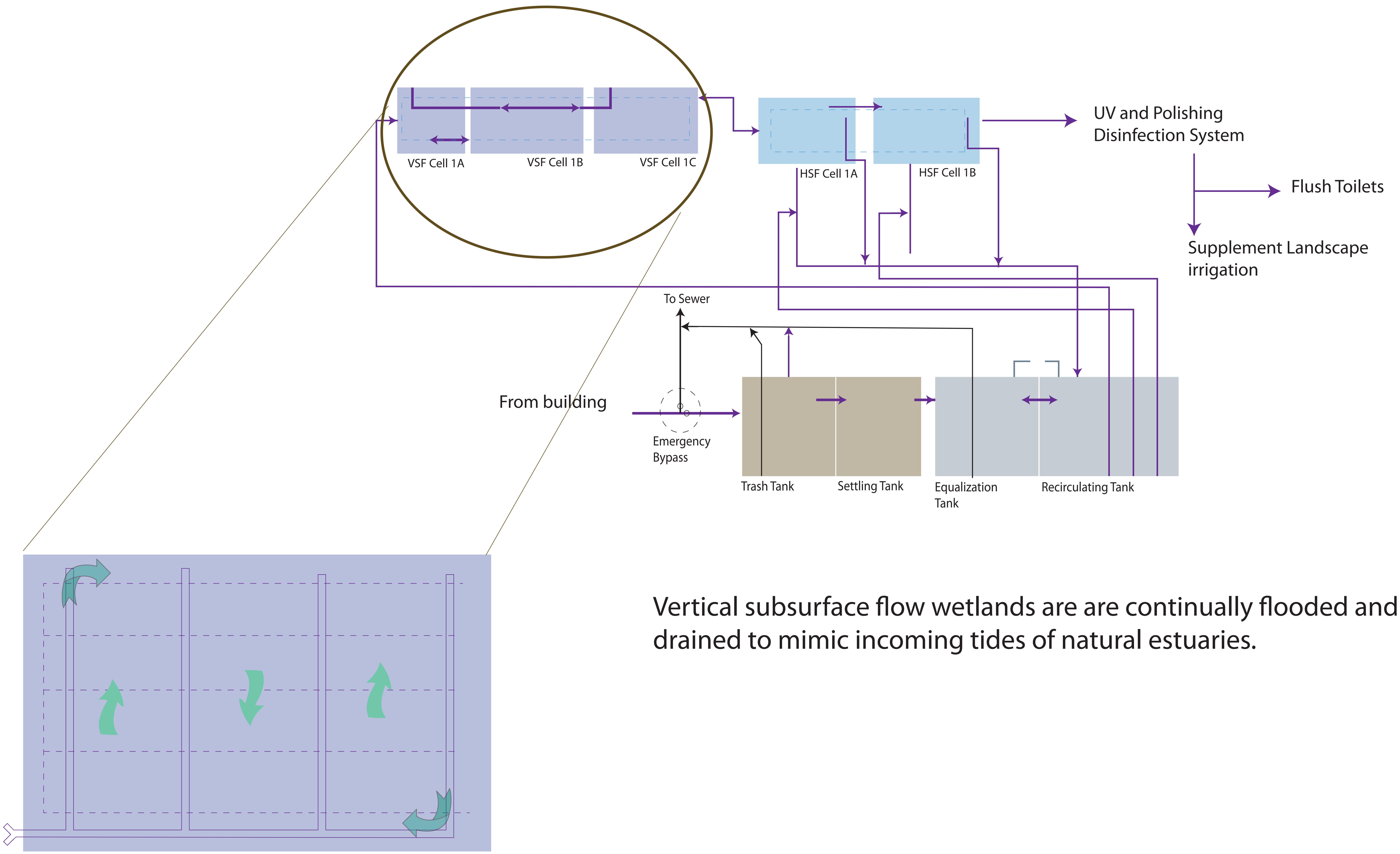
(b) Mass load based on stated design flow multiplied by the listed parameter concentration

(c) Total Kjeldahl Nitrogen (organic + ammonia)

Process Schematic

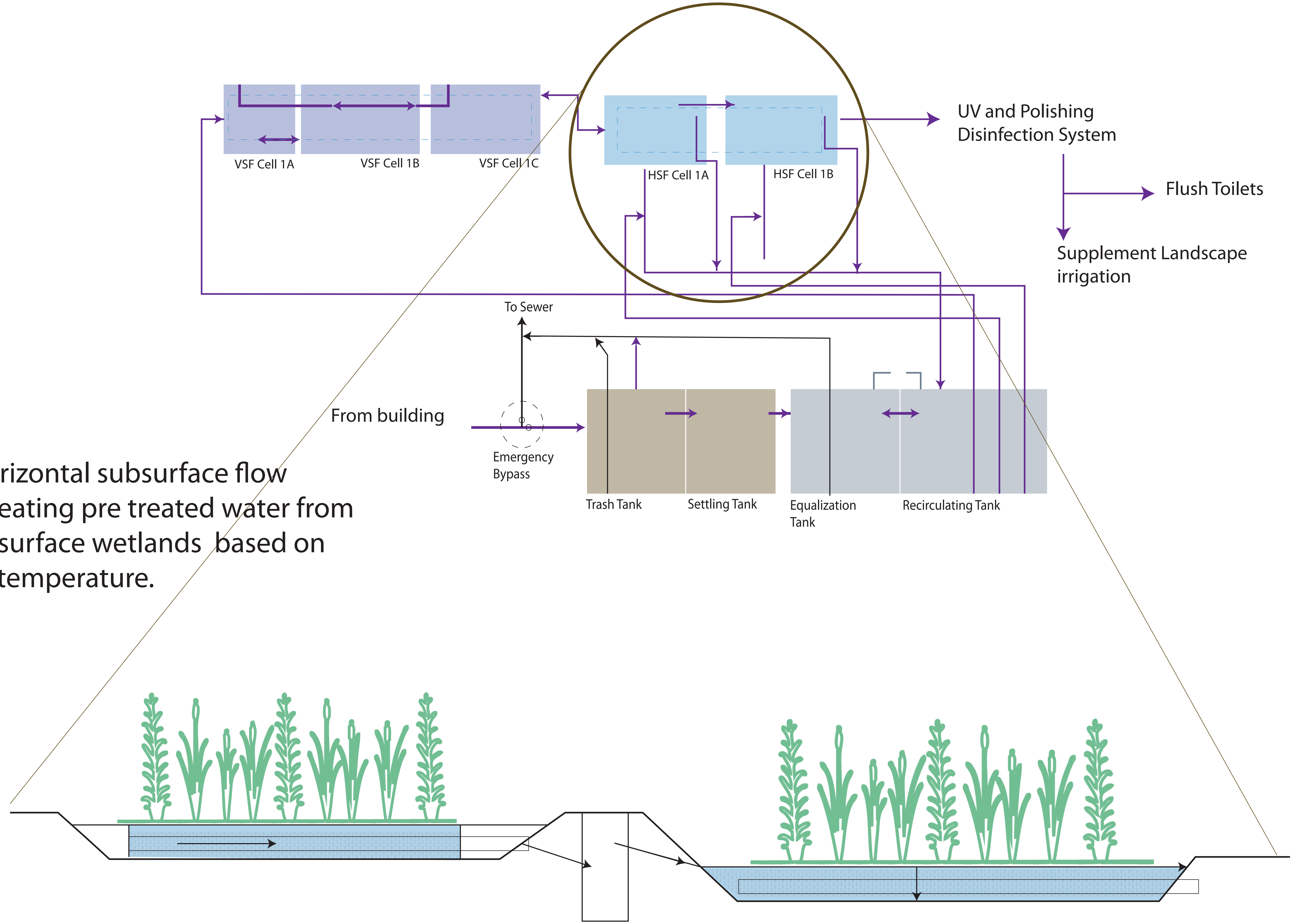


Vertical Subsurface Flow Schematic



Vertical subsurface flow wetlands are are continually flooded and drained to mimic incoming tides of natural estuaries.

Horizontal Subsurface Flow Cell Schematic



Constructed horizontal subsurface flow wetlands are treating pre treated water from the vertical subsurface wetlands based on gravel size and temperature.

Economic

Maximize Economic Value

Minimize Capital Costs
Planning and Design
Land
Phasing
Existing Treatment
Existing Collection
Financing

Operating Costs/ Value Added
Financing cost
Labor-Job Creation
Power /Energy
By-products
Life Cycle costs

Environmental

Optimize Environmental Benefit

Water Quality
Waste Decomposition
Re Purification

Water Quantity
Water Balance
Sustain Flow

Natural Environment
Biodiversity
Disturbance
Global Warming

Social

Fulfill Community Objectives

Quality of Life
Health
Respitory
Outdoor Environment
Built Environment

Stability
Dependable
Resilient
Safe

Equitability
Serves all equally

Aesthetics

Return on Perception

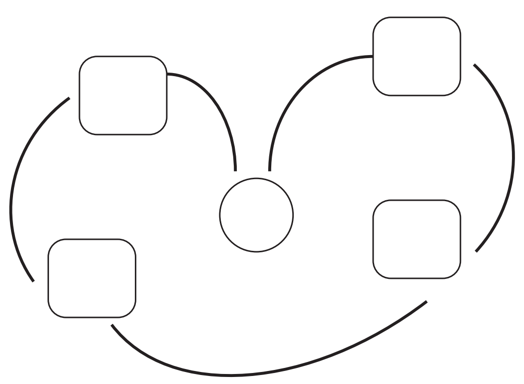
Place-Making
Identity
Walkability
Well Being

Productivity / inspiration
Learning Visually
Attraction

Social value /Legacy
Future Generations

Decentralized Wastewater Stakeholder Decision Model adapted using quadruple-bottom-line approach to help users determine what is most important to the community and How can decentralized wetlands in create these in urban environments through ecosystem services.

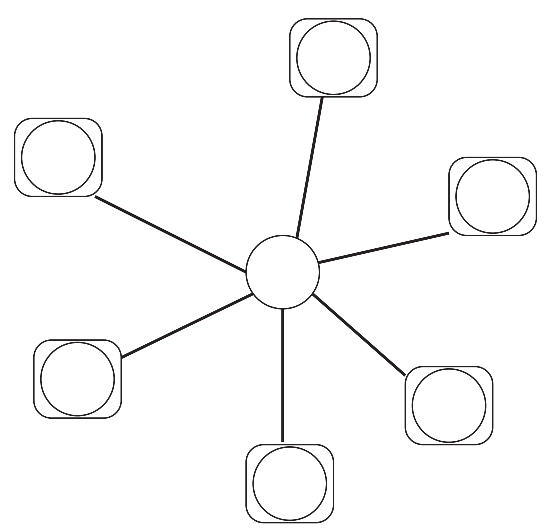
Designer as "one-man band."



The design is lead by a single learner of the discipline, who specializes and executes the design in isolation from other disciplines. Community and Stakeholders are represented. Coordination by standardization

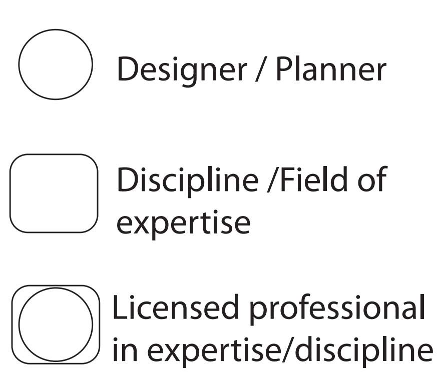
System wide investment (management) by one party into the whole system.

Designer as an "orchestra conductor"

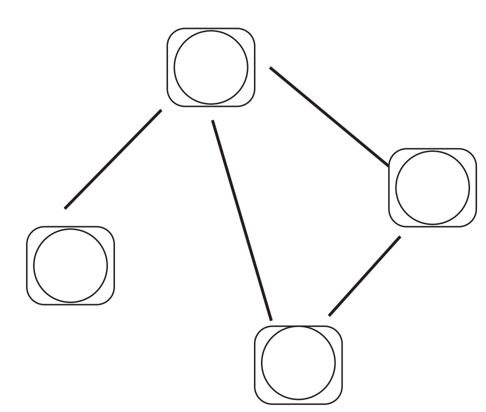


Multidisciplinary where the lead designer examines from other perspective and through their own discipline how to integrate and staple together the results from the other disciplines. Stakeholders and other disciplines contribute and synthesized by single party.

System wide management of multi-disciplines within the single party, multi -closed loops systems. Pooled interdependence.



Designer as part of an "ensemble"



Interdisciplinary where there is coordination from the design concept for a unified guide to the problem solving and shared methods. Community and Stakeholders can contribute to the process

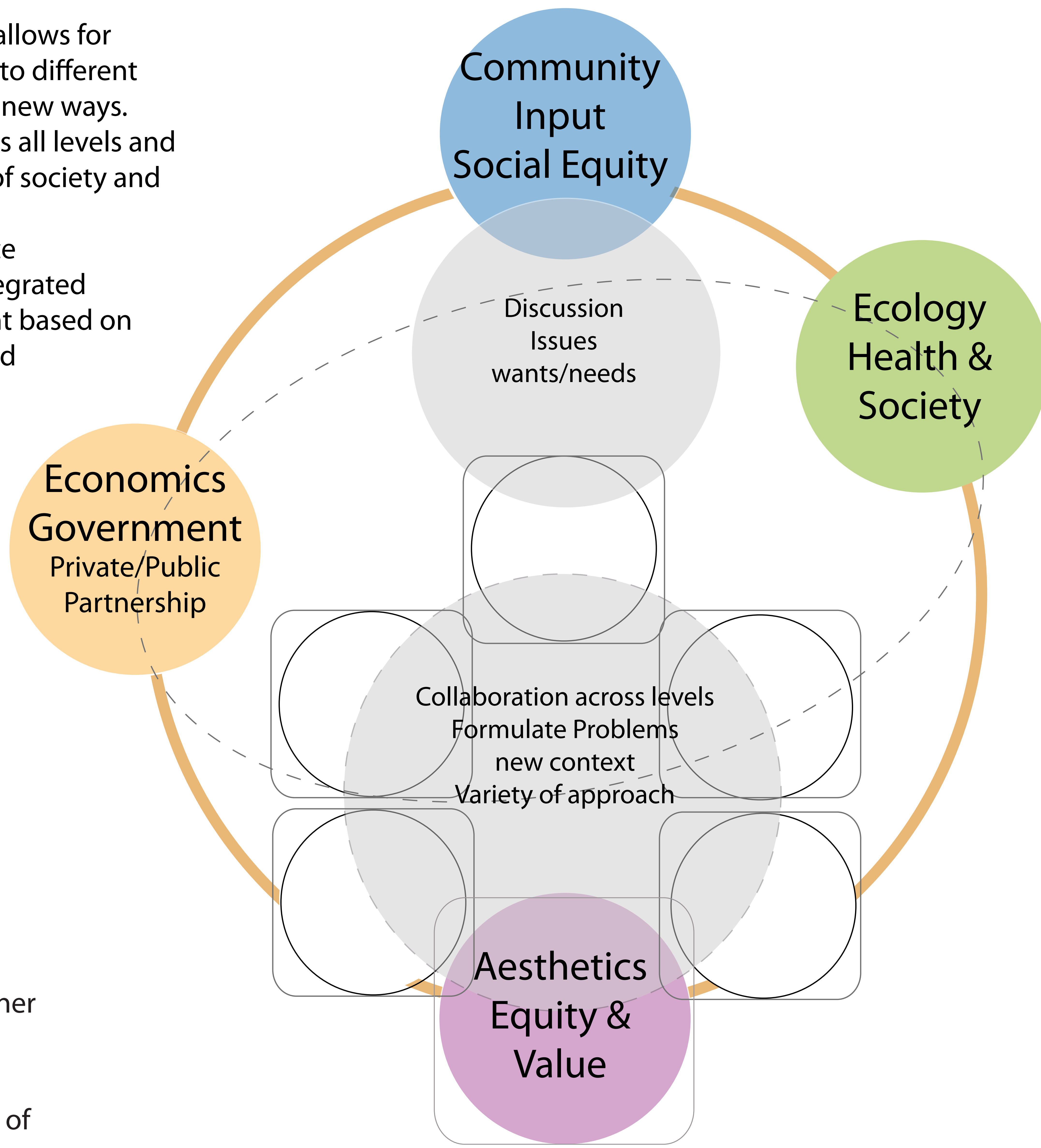
Coordination by planning. Sequential interdependence

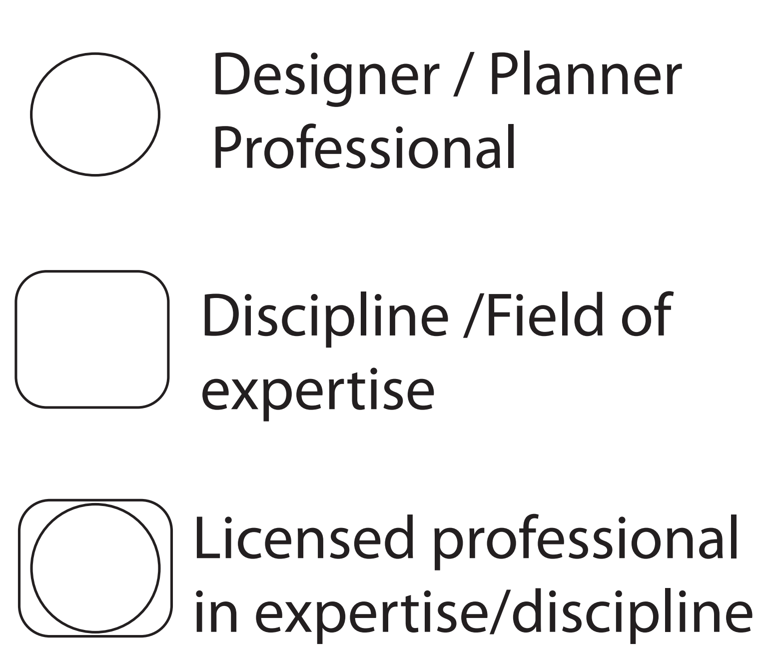
Adapted from Urban Ecological Design Plate #9 -The designer as part of an ensemble. Showing progression of management and collaboration towards a method that would include the quadruple bottom line.

Transdisciplinary model and the quadruple bottom

Transdisciplinary, allows for formulation of problems into different context and learn to see in new ways. There is coordination across all levels and usually with engagement of society and stakeholders.
Reciprocal interdependence
Coordination based on integrated input/output. Development based on shared values and goals and

uncertainty and reorientation





Ecosystem Service Defined in the quadruple bottom line & Transdisciplinary model

Aesthetics	Social Equity	Economic Government & PPP	Ecology Ecosystem Services
Cultural	Education & Lifestyle	Social Capital	Habitat Endangered species
Planting pallet Habitat Provision	Civic Space	Material & Energy	Soil & Nutrient Cycling
Appealing to the Senses Attraction	Mental Physical Health	Partnerships Growth and savings	Rivers Groundwater Lakes Oceans
Recreation	Accessibility Walkability	Increase Property Value	Waste Decomposition
Climate & Radiation Regulating	Improve Living & Working Conditions	Employment	Air & Water Purification

Aesthetics

Scale: Human, Ecological, Local, City, Regional.
Relevance, appropriateness, Proportions
Color, texture, light, moisture, water, materials
Habitat, productive soils

Social Equity

Human Uses
Benefits and Experiences
Mental Health, Spiritual inspiration
Physical Health, Walkability, Access
Civic Attraction and community building
Educational

Economic Government & PPP

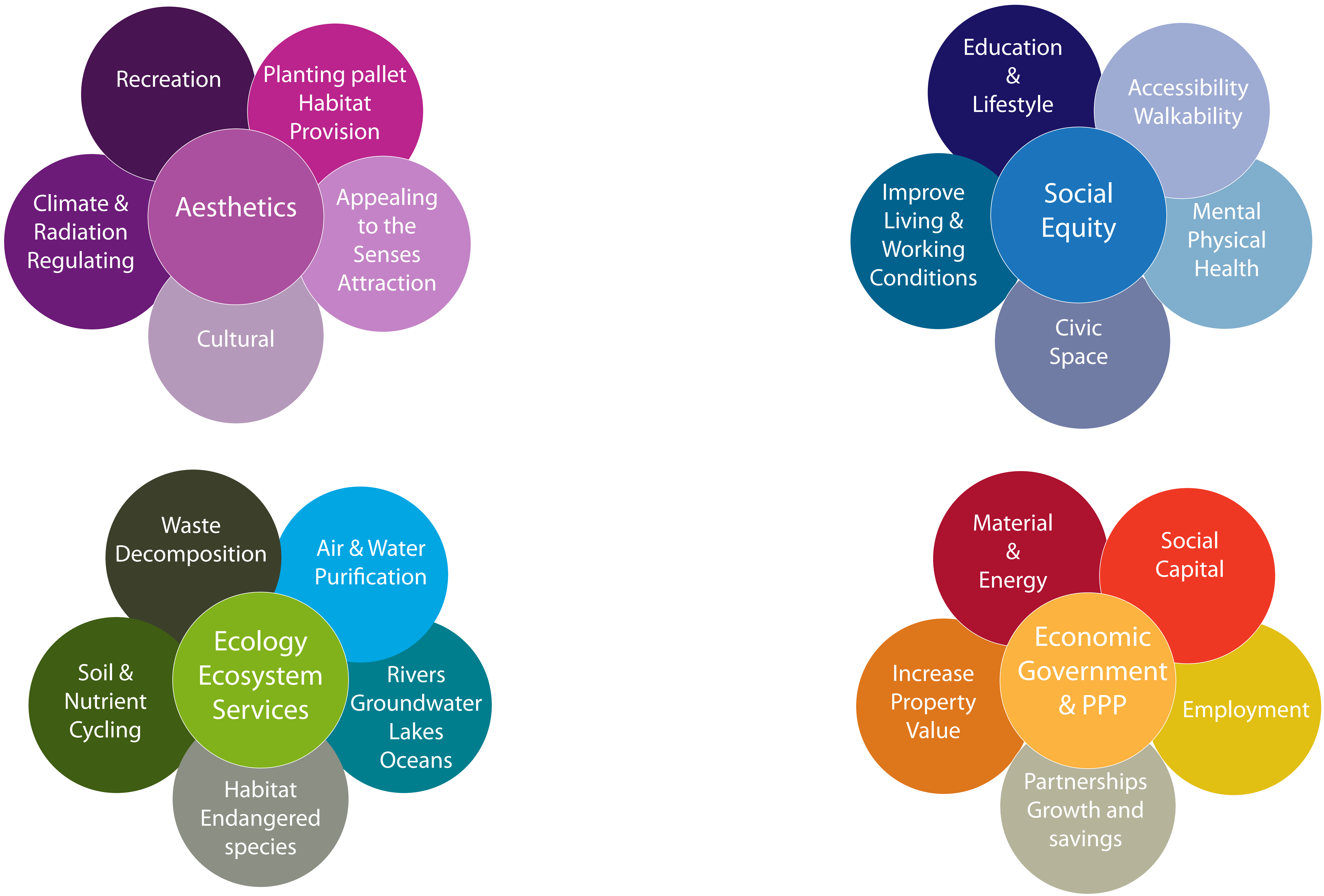
Securities and Goods
Arable lands, crops
Drinking water, energy
Natural fibers, pharmaceuticals
Seafood, textiles, timber
Industrial products

Biodiversity, food production
Future genetic materials,
Pollination protection

Ecology Ecosystem Services

Processes / Functions
Air pollution, CO2 absorption, carbon storage
Disturbance regulation, drought mitigation, dust particle capture
Erosion control, climate mitigation on different scales, groundwater recharge
Nitrogen removal / fixation, photosynthesis, seed dispersal, self-purification
Storm protection, UV protection, water purification
Water recycling pollination protection

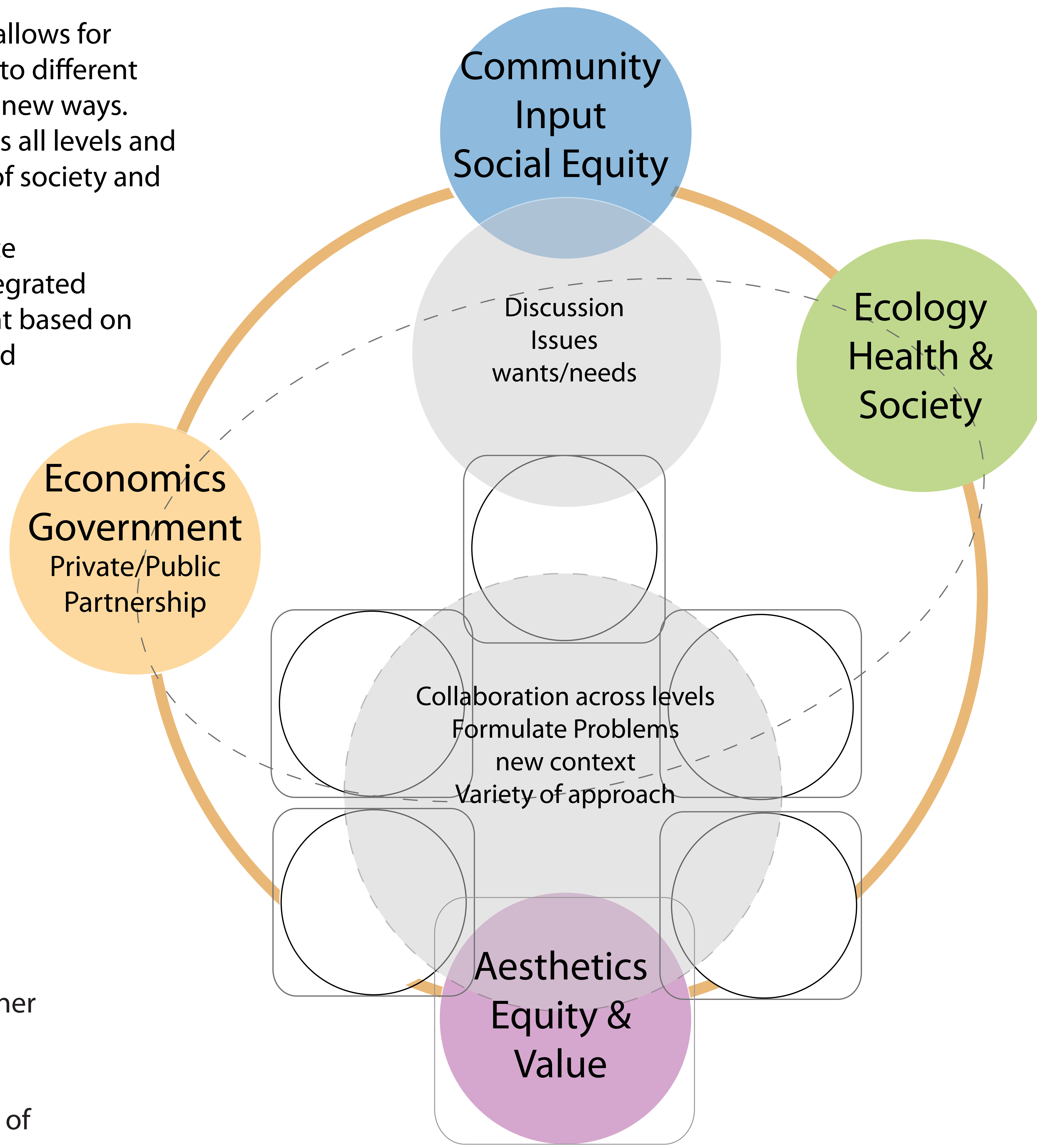
Ecosystem services out of the quadruple bottom line



Transdisciplinary model and the ecosystem services

Transdisciplinary, allows for formulation of problems into different context and learn to see in new ways. There is coordination across all levels and usually with engagement of society and stakeholders.
Reciprocal interdependence
Coordination based on integrated input/output. Development based on shared values and goals and

uncertainty and reorientation



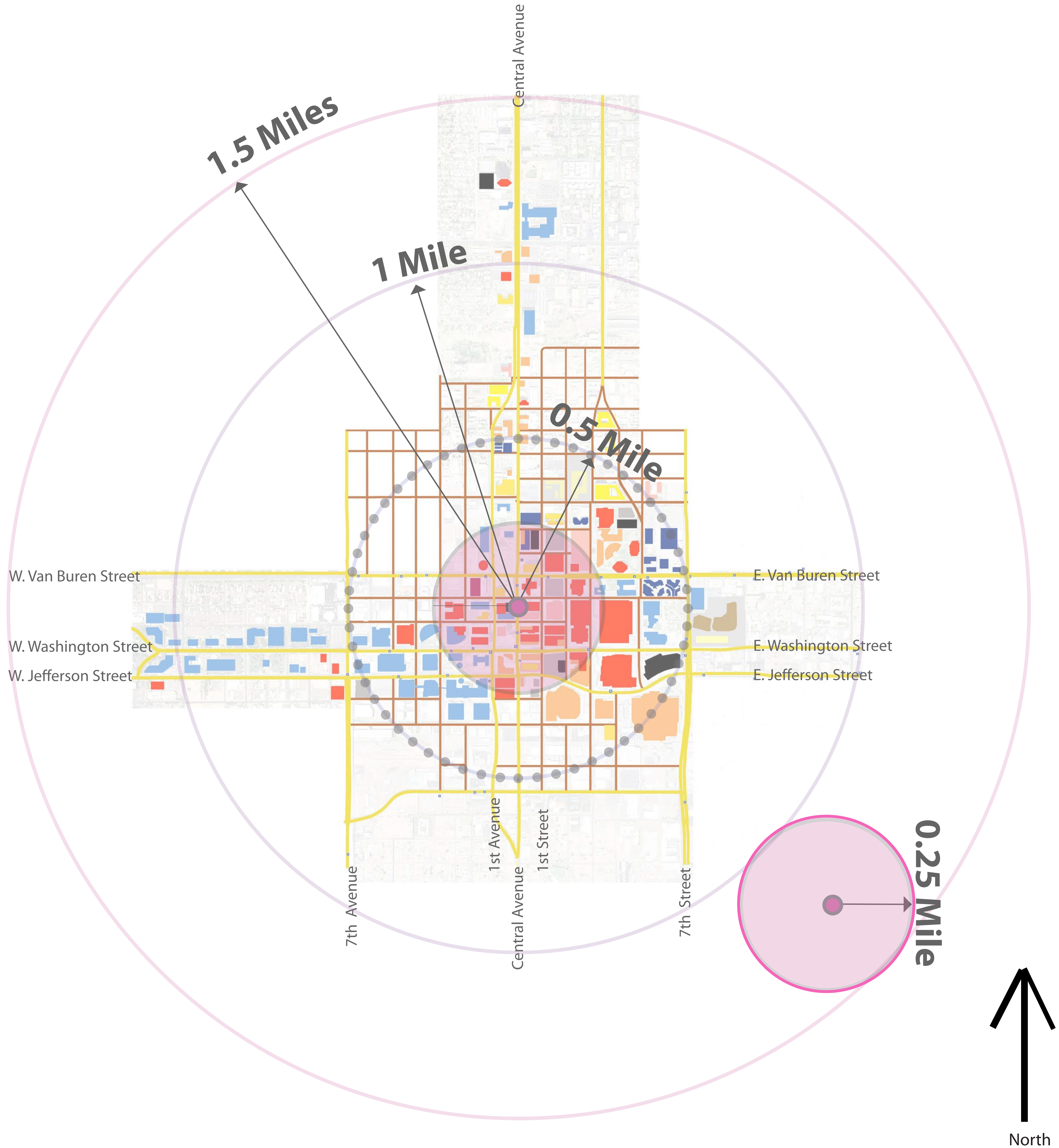
Aesthetics	Social Equity	Economic Government & PPP	Ecology Ecosystem Services
Cultural	Education & Lifestyle	Social Capital	Habitat Endangered species
Planting pallet Habitat Provision	Civic Space	Material & Energy	Soil & Nutrient Cycling
Appealing to the Senses Attraction	Mental Physical Health	Partnerships Growth and savings	Rivers Groundwater Lakes Oceans
Recreation	Accessibility Walkability	Increase Property Value	Waste Decomposition
Climate & Radiation Regulating	Improve Living & Working Conditions	Employment	Air & Water Purification

Designer / Planner Professional

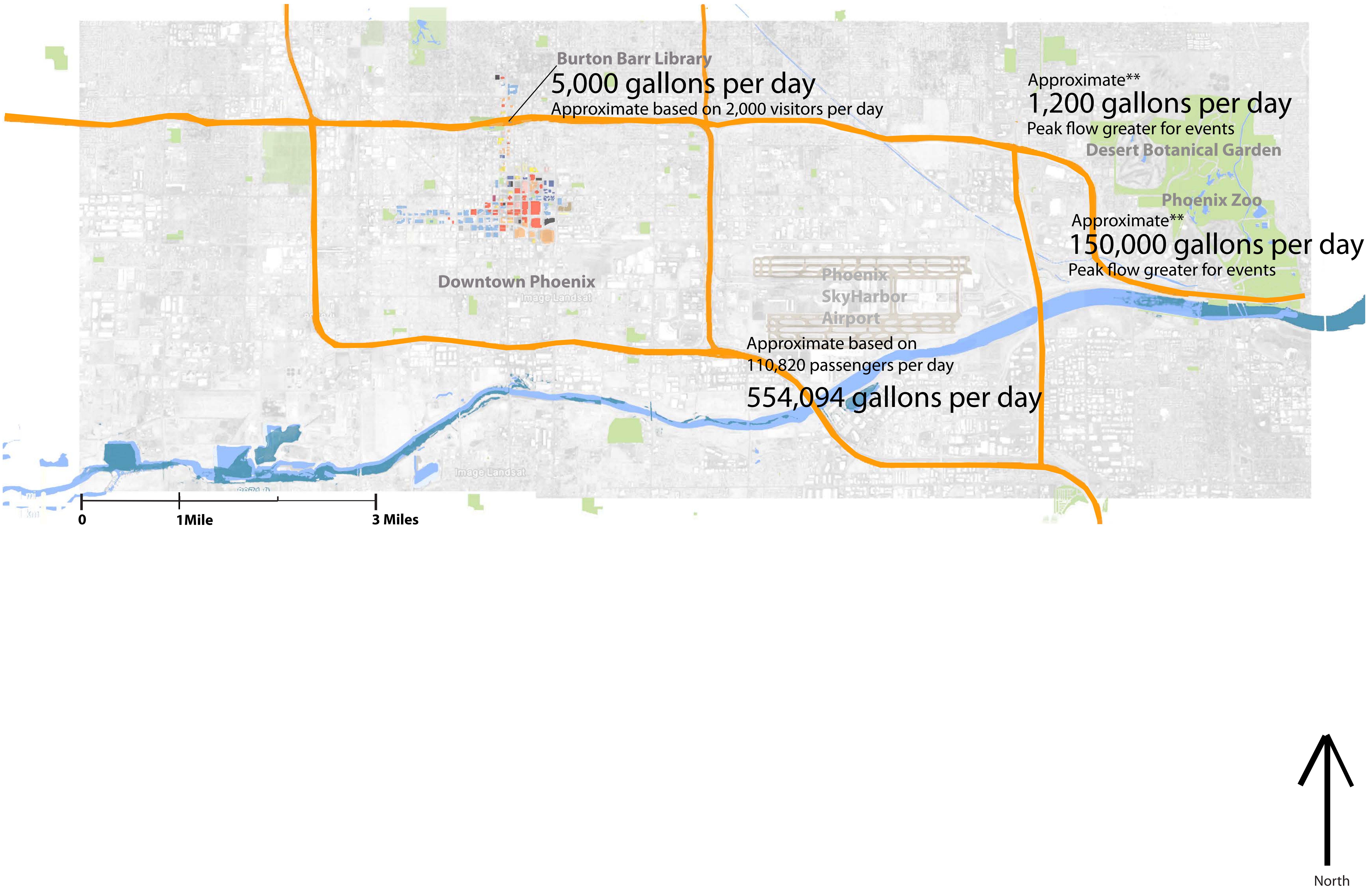
Discipline /Field of expertise

Licensed professional in expertise/discipline

A **healthy** downtown Phoenix core is what is essential to the growth and health of the surrounding municipalities.



Wastewater Use



Urban Wetlands providing Ecosystem Services

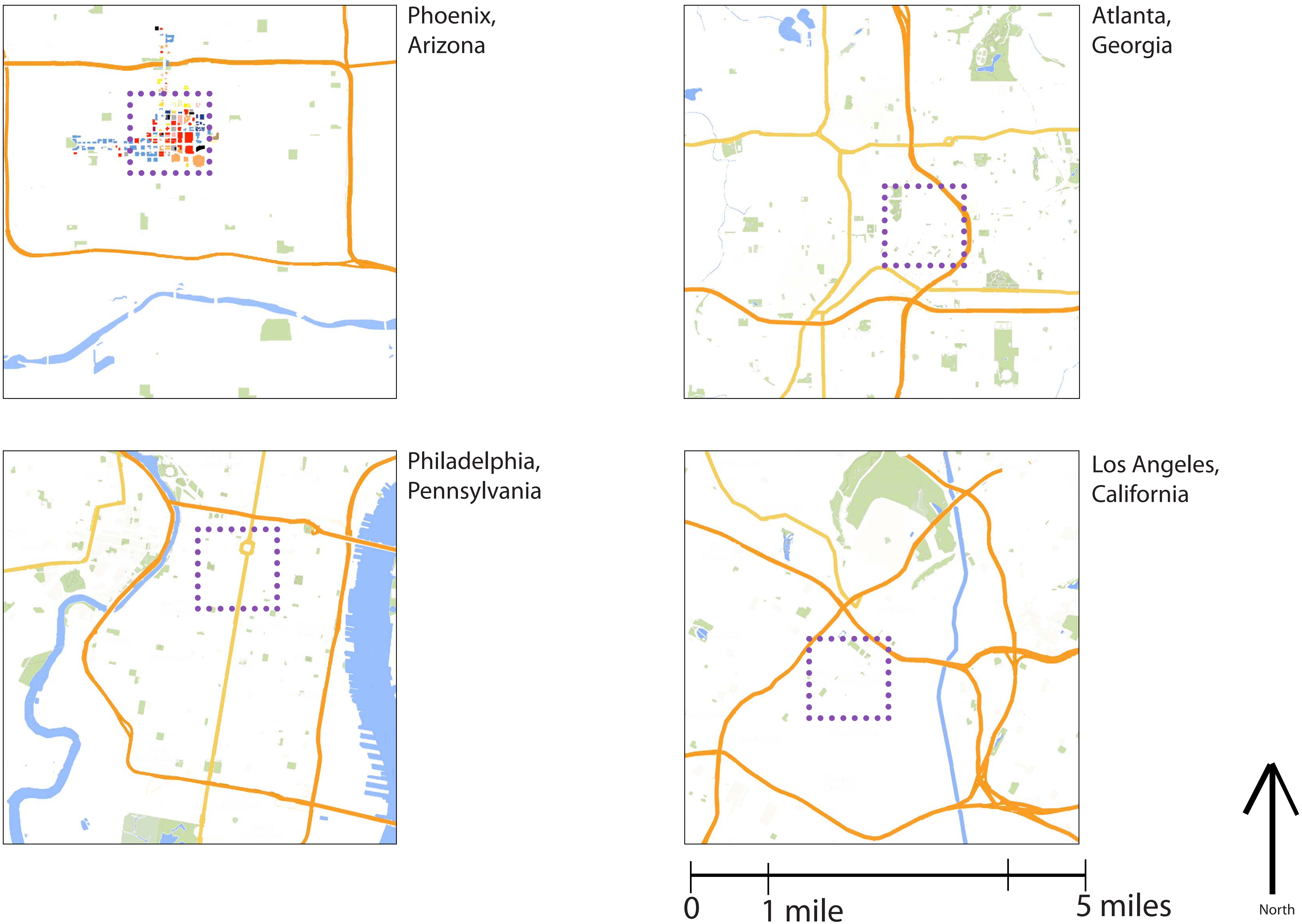
The Climate of Phoenix

To Improve the quality of living in the urban city

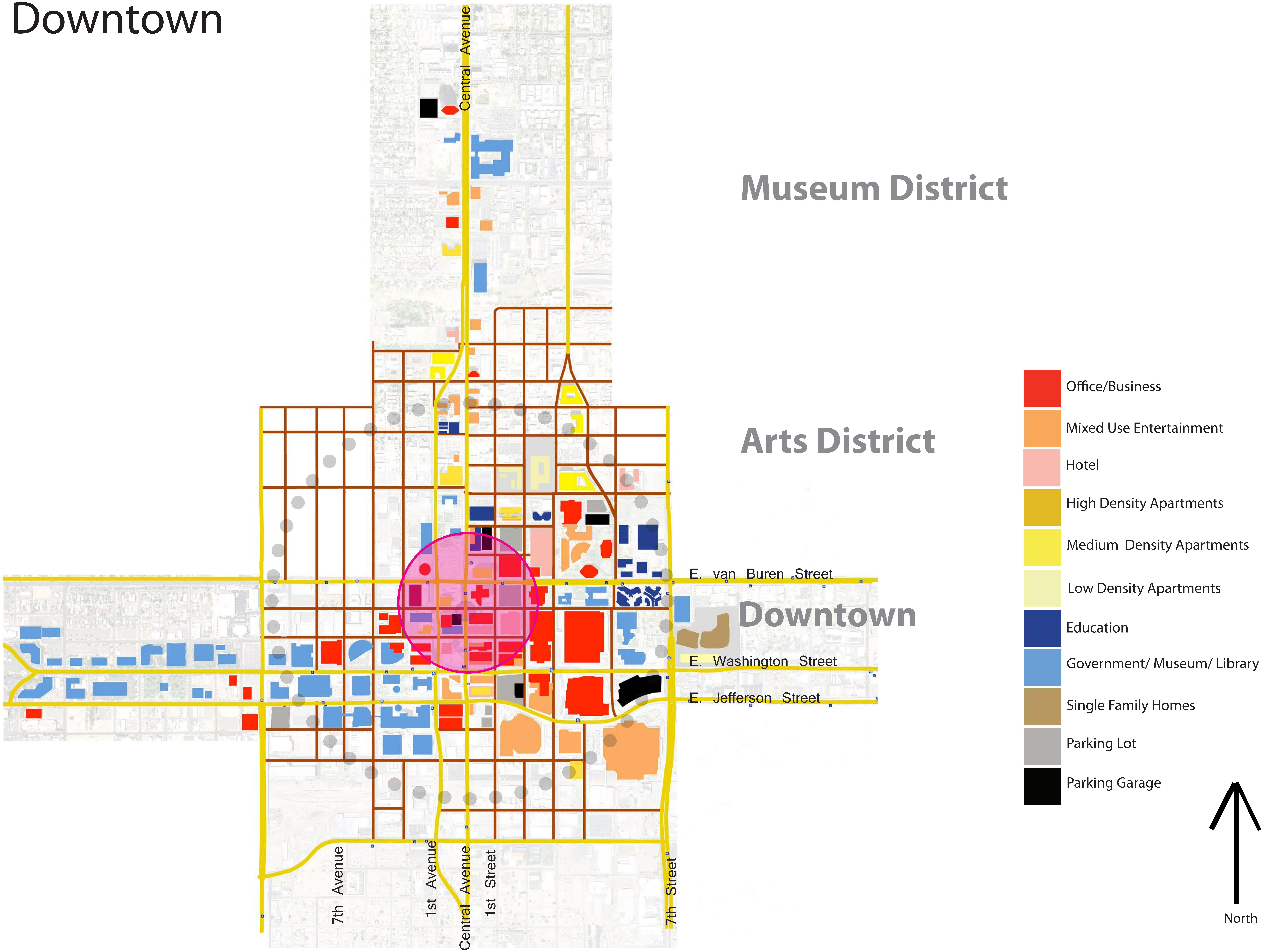
While providing Non Rainwater and Rainwater supply solutions
For the vibrant landscapes, cooling micro-climates, walkability in the urban city

Current Issues
Drought
Stressed Groundwater Resources
Population Growth
Heat and Heat Island
Lack of aesthetics in the urban downtown

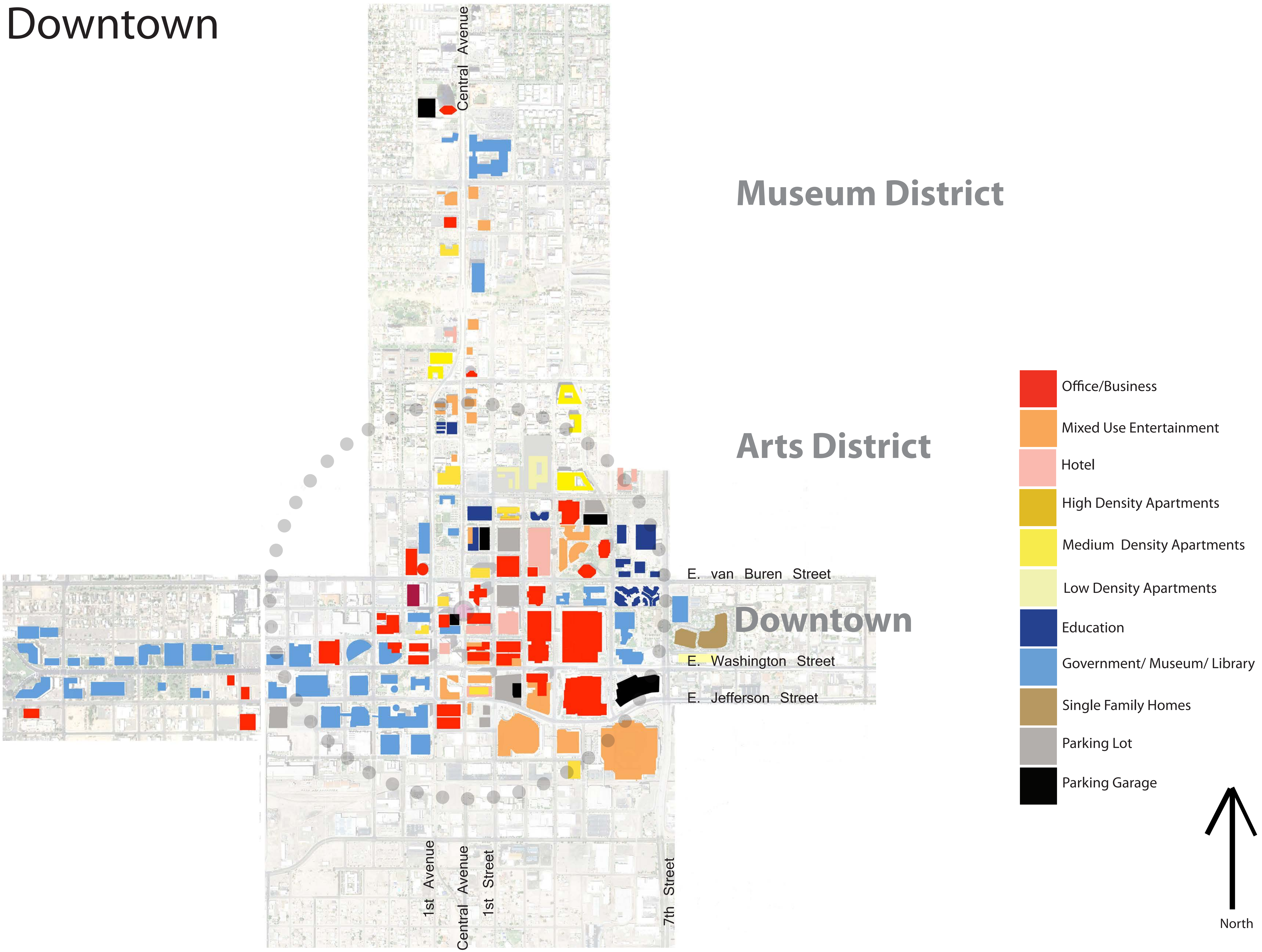
Downtown city one square mile comparison



Downtown


Museum District
Arts District
Downtown
Central Avenue
E. van Buren Street
E. Washington Street
E. Jefferson Street
7th Avenue
1st Avenue
Central Avenue
1st Street
7th Street
Office/Business
Mixed Use Entertainment
Hotel
High Density Apartments
Medium Density Apartments
Low Density Apartments
Education
Government/ Museum/ Library
Single Family Homes
Parking Lot
Parking Garage
North

Downtown



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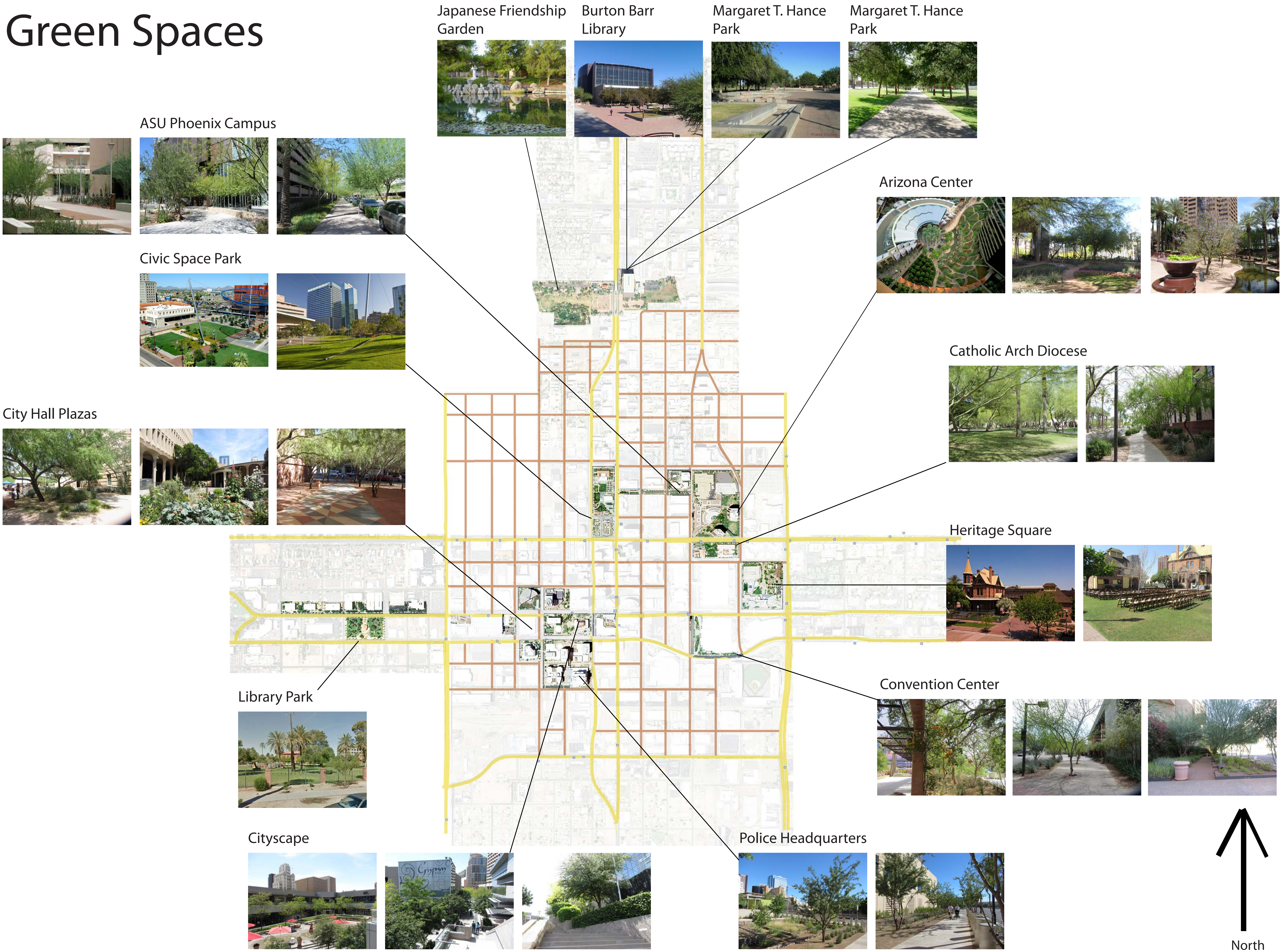
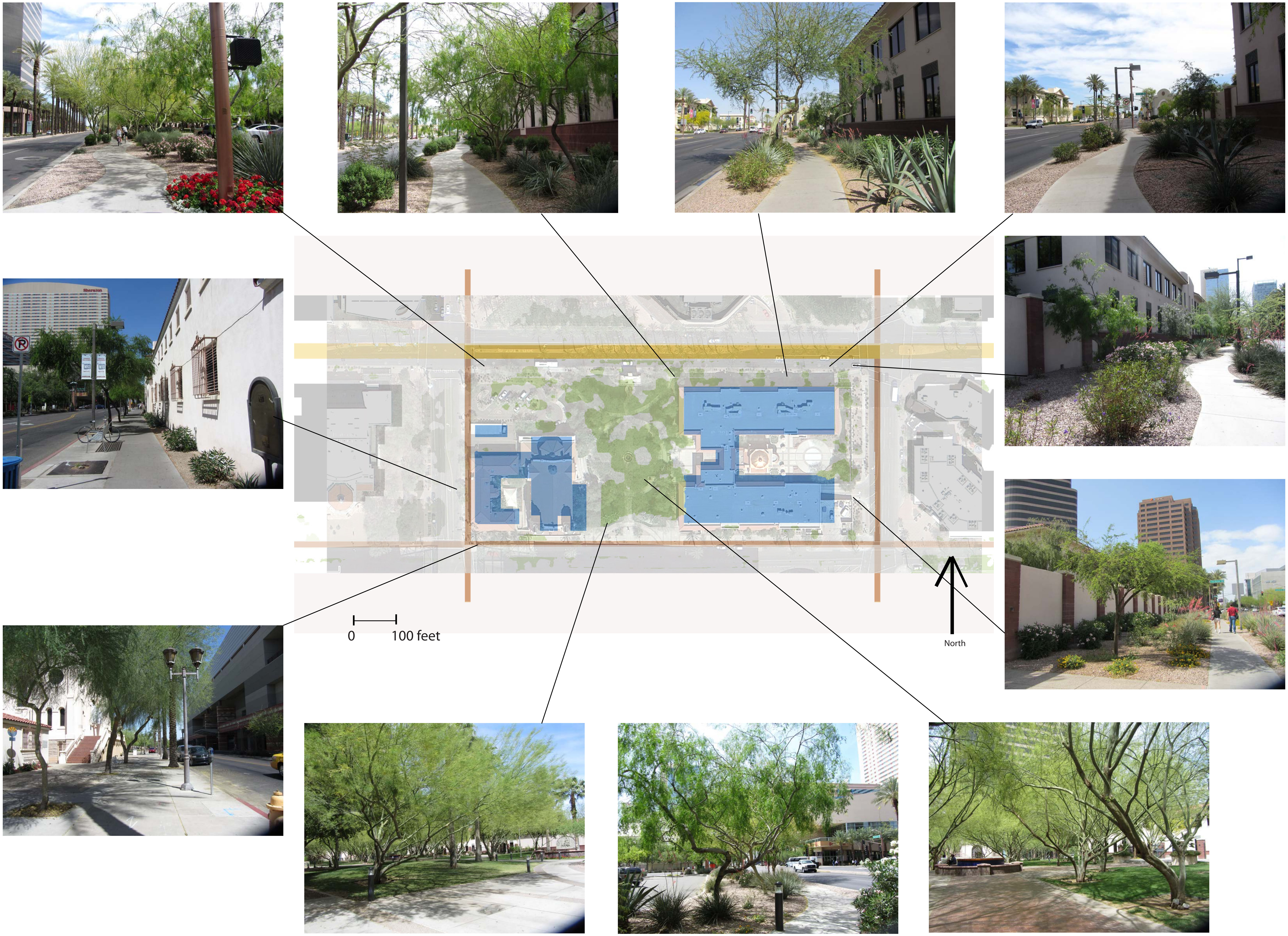
Office/Business
Mixed Use Entertainment
Hotel
High Density Apartments
Medium Density Apartments
Low Density Apartments
Education
Government/ Museum/ Library
Single Family Homes
Parking Lot
Parking Garage
North

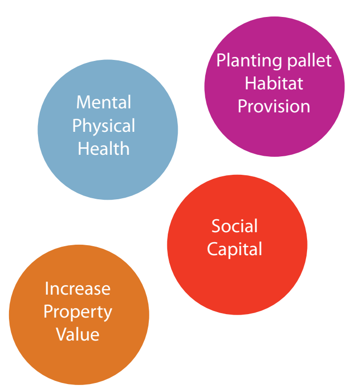
Green Spaces



Catholic Arch Diocese

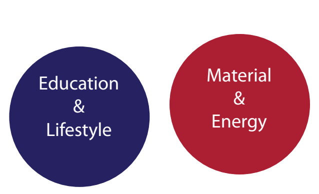


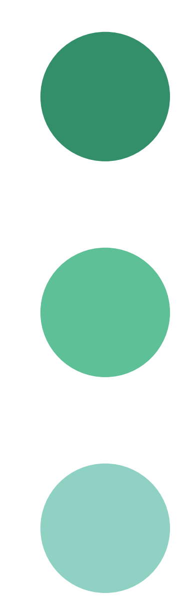
This is the process of defining what are the elements of landscape design which contribute to the ecosystem services in the quadrupal bottom line and begins to look at placing an importance or priority on them base on the site specific conditions and use.



Techniques	Micro Climate	Water Management	Air Quality	Physical Health	Mental Health	Energy Consumption	
Trees & sidewalk planting, ground cover	●		●		●		
Seat walls & Raised planters Site furniture	●						
Vertical and horizontal vine systems for shade							
Constructed Wetland							
Rainwater Harvesting							
Pollinator Plants	●						
Pocket Park	●		●	●	●		
Soil health, moisture	●						
Water Feature		●			●	●	
Shade Structure							

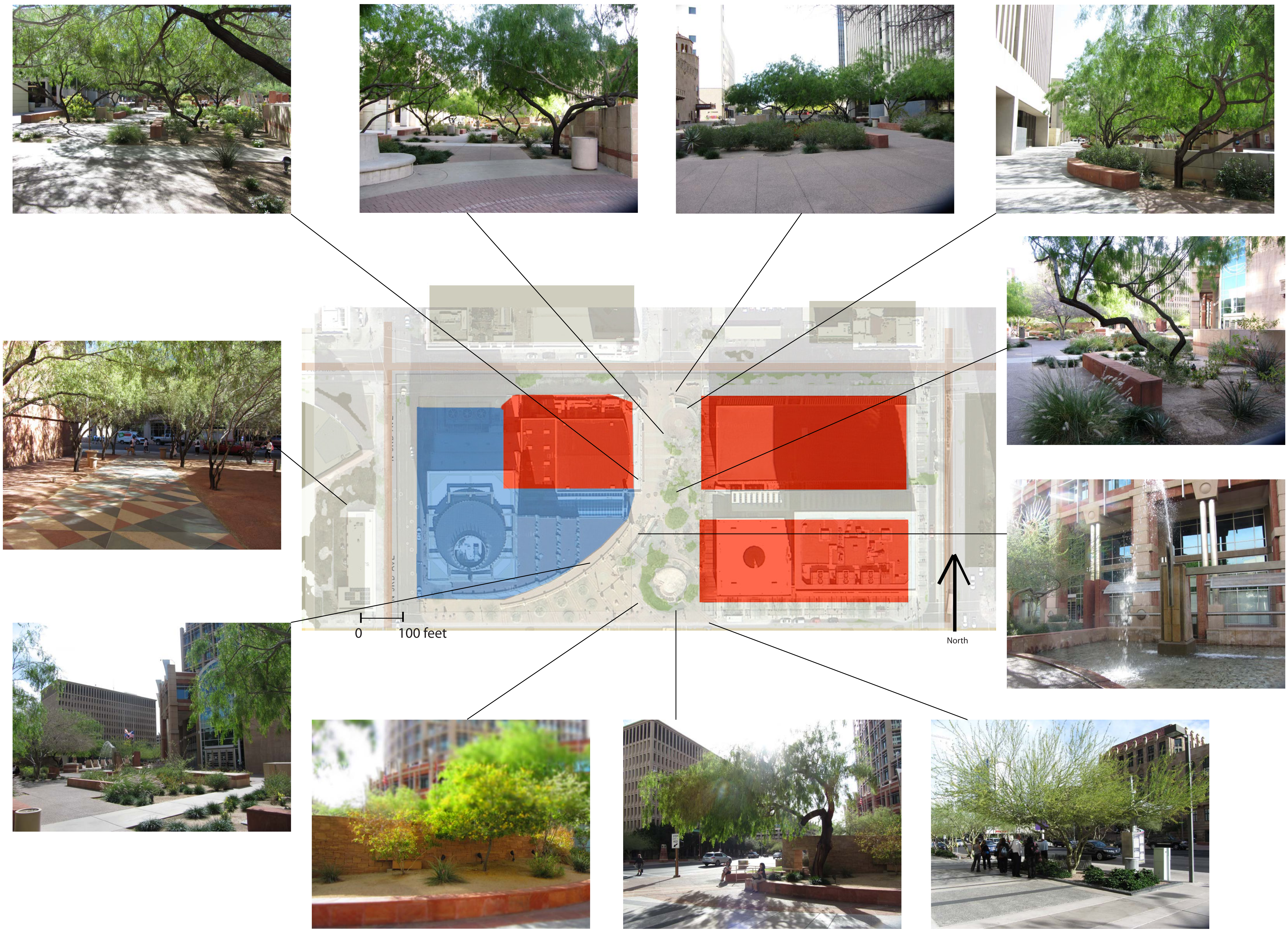
EXAMPLE





Convention Center

City Hall Plaza



Site


Image Landsat
1264 ft
Google earth

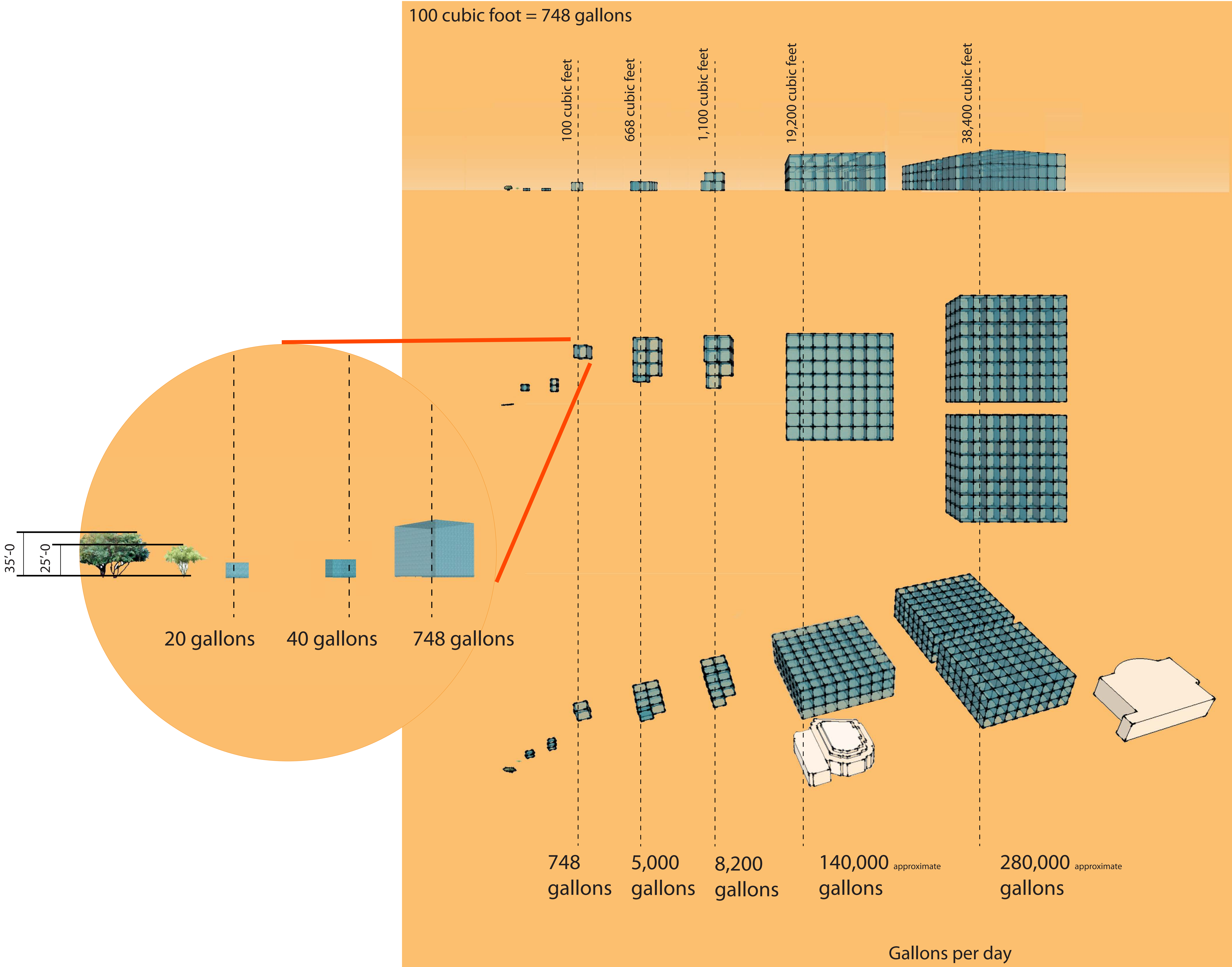

100 cubic foot = 748 gallons
100 cubic feet
668 cubic feet
1,100 cubic feet
19,200 cubic feet
38,400 cubic feet
35'-0
25'-0
20 gallons
40 gallons
748 gallons
748 gallons
5,000 gallons
8,200 gallons
140,000 approximate gallons
280,000 approximate gallons
Gallons per day


Image Landsat
1593 ft
Google earth

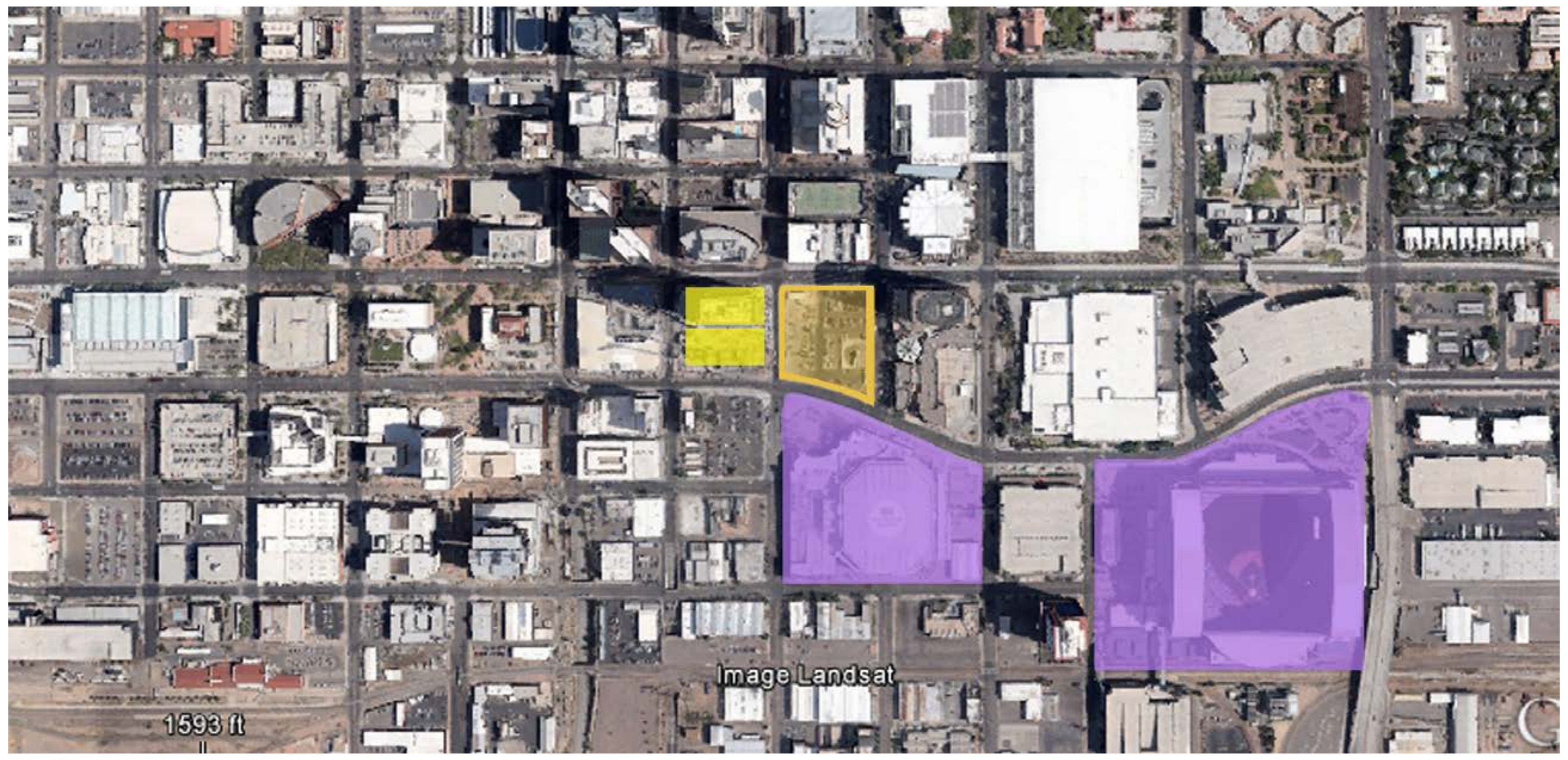
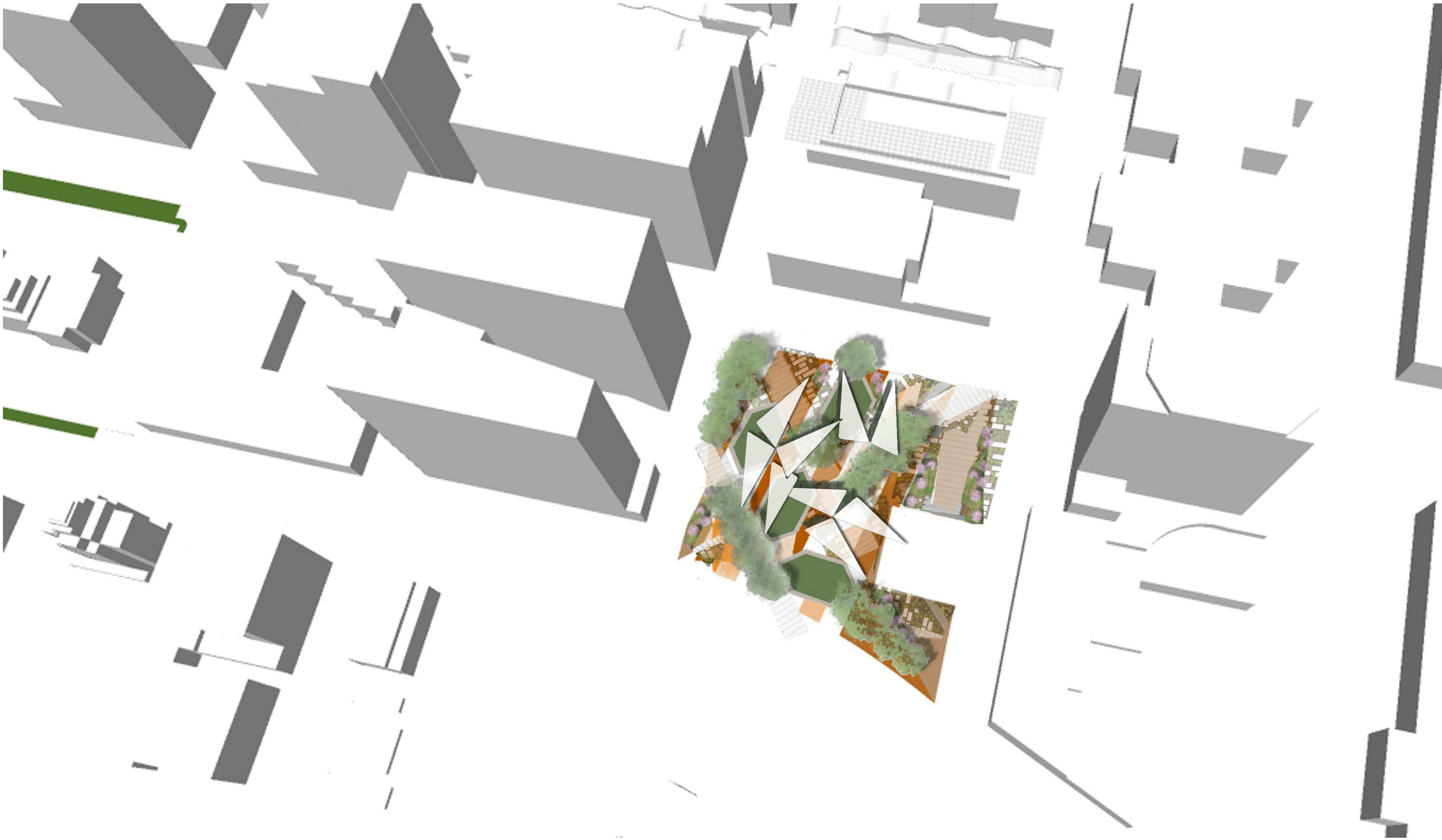


Image Landsat
1593 ft



First life, then spaces, then buildings
The other way around never works.

Jan Gehl

References

Menzel, S., & Buchecker, M. (2013). Does Participatory Planning Foster the Transformation Toward More Adaptive Social-Ecological Systems?. Ecology & Society, 18(1), 1-15. doi:10.5751/ES-05154-180113

Petter, M., Mooney, S., Maynard, S. M., Davidson, A., Cox, M., & Horosak, I. (2013). A Methodology to Map Ecosystem Functions to Support Ecosystem Services Assessments. Ecology & Society, 18(1), 1-36. doi:10.5751/ES-05260-180131

Ahern, J., Cilliers, S., & Niemelä, J. (2014). The concept of ecosystem services in adaptive urban planning and design: A framework for supporting innovation. Landscape and Urban Planning, 125(0), 254-259. doi: http://dx.doi.org.ezproxy1.lib.asu.edu/10.1016/j.landurbplan.2014.01.020

Buranen, Magaret (2009). Stormwater as Entertainment. Integrating stormwater management with the urban landscape. In: Stormwater, issue May 2009.

Ashley, R., Brown, R., Farrely, M.)2011) Political and Professional Agency Entrapment: An Agenda for Urban Water Research, Water Resources Management ,December 2011, Volume 25, Issue 15, pp 4037-4050

Vymazal, Jan, (2006) Removal of nutrients in various types of constructed wetlands, Science of the Total Environment, 380 (2007) 48–65doi:10.1016/j.scitotenv.2006.09.014

Vymazal J., Brix, H., Cooper P. F., Green M. B and Haberl R. (Eds.): Constructed Wetlands for Wastewater Treatment in Europe. - Backhuys Publishers, Leiden, 366 pages. ISBN 90-73348-72-2. 1998

Bartell, S., Childs, R., McNair, D., Ozment, S., Shaikh, S., (2013) Creating Value Through Ecosystem Services Management in Urban and Suburban Landscapes, World Resource Institute, wri.org

Middle,A, Hab, K., Brazel, A.. Martin, C. Guhathakurta, (2014) Impact of urban form and desing on mid-afternoon microclimate in Phoenix Local Climate Zones, Landscape and Urban Planning, 122, pp 16-20

Sustainable Development in a Desert Climate, Re-invent Phoenix

Kent, Eric, (2011) Wind Patterns and the Heat Island in Phoenix, Arizona: 1993–2008, Journal of the Arizona-Nevada Academy of Science, 42(2):92-103. 2011.
The Arizona-Nevada Academy of Science http://dx.doi.org/10.2181/036.042.0205

International Living Building Institute, (2010) Documentation Requirements, Living Building Challenge 2.0 Renovation, Landscape + Infrastructure, and Building Typologies, www.ilbi .org

Skancke, Jennie R. (2007), Evaluation of Constructed Wetland Performance in New Mexico, University of New Mexico

Raven, Jeffrey, (2011) , Cooling the Public Realm: Climate-Resilient Urban Design
Resilient Cities, Local Sustainability Volume 1, 2011, pp 451-463. doi 10.1007/9778-94-007-07-0785-6-45

Websites

California Sustainability Alliance, California on-site water recycling: policy brief
A Navigant Consulting Program, Sponsored by Southern California Gas Company,
Funded by California utility customers under the auspices of the California Public Utilities Commission
http://www.sfwater.org/index.aspx?page=497
World Resource Institute, wri.org
United Nations, Global Desert Outlook, unep.org/geo/gdoutlook/045.asp
United Nations, Ecosystems and their services, http://www.unep.org/maweb/documents/document.300.aspx.pdf
United States Geological Society, usgs.org

Bibliography cont.

Websites, cont.

Yale University Ecological Performance index, epi.yale.edu
New York City Government, Pedestrian Plazas, http://www.nyc.gov/html/dot/html/pedestrians/public-plazas.shtml
Applied Water Management Group, Case Study Gillette Stadium, www.amwater.com
University of New Mexico, Section5 wastewater flows
http://www.septic.umn.edu/prod/groups/cfans/@pub/@cfans/@ostp/documents/asset/cfans_asset_131281.pdf
San Francisco Water Power Sewer http://www.sfwater.org/
Reference, San Francisco Water Power Sewer Living Building
Sidwell Friends School Constructed Wetland
http://www.sidwell.edu/about_sfs/environmental-stewardship/green-buildings/ms-green-building/index.aspx

Books

Jerke,D., Porter, D., Lassar, T., Urban Land Institute (2008), Urban Design and the Bottom Line, Optimizing the Return on Perception

Speck, Jeff, Walkability, North Point Press (201 2), How Downtown can save America One Step at A Time

Pallazzo,D., Steiner F., Island Press (2011) Urban Ecological Design, A Process for Regenerative Places

Howe, C, Mitchell, C. , IWA (2012),Water Sensitive Cities

Brown, G.Z., DeKay, M., Wiley (2001),Sun, Wind & Light Architectural Design Strategies, second edition

Austin, G.,Routlege (2014), Green Infrastructure for Landscape Planning, Integrating human and natural systems

Dannenberg, A., Frumkin, H., Jackson,R.J., Island Press(2011) Making Healthy Places, Designing and Building for Heallth, Well-being, and Sustainability