Facing Today's Escalating Challenges and Producing Tomorrow's Solutions

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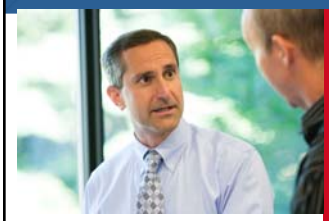
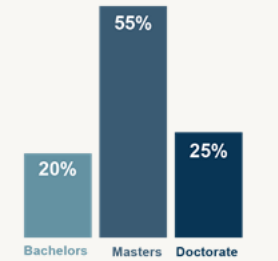
Geosyntec – Technical Consulting Disciplines



Our practitioners come from many technical disciplines

- **Engineering** - Civil, Environmental, Earthquake, Geotechnical, Hydraulic, Water Resources, Chemical, Structural, and Mechanical
- **Earth Sciences** - Geology, Hydrogeology, Geochemistry, Geophysics, and Seismology
- **Life Sciences** - Microbiology, Biology, Limnology, Zoology, Soil Science, and Biochemistry
- **Physical Sciences** - Mathematics, Physics, and Chemistry
- **Risk Management** - Toxicology, Public Health, Health Physics, Epidemiology, and Statistics
- **Construction** - Construction Management, Resident Engineering, and Quality Assurance



Professional Staff Highest Degree

We Help Create Standards & New Technologies

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We are Active in Developing New Technologies, Best Practices, Guidance Manuals, and Training Program -- Building Our Credibility with Regulators and Decision-Makers

Key Topics – Global Challenges

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- **Infrastructure and Other Needs from Population Growth**
- **Coastal Resiliency & Sea Level Rise**
- **The Need for Clean Water** - Including Emerging Contaminants
- **Waste and Wastewater Management & Treatment**
- **Environmental Awareness and Remediation**
- **Power Build Out and Conversions**
- **Sustainability & Re-Use**

Infrastructure and Other Needs from Population Growth

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The World Needs $60 Trillion in Infrastructure Improvements by 2030

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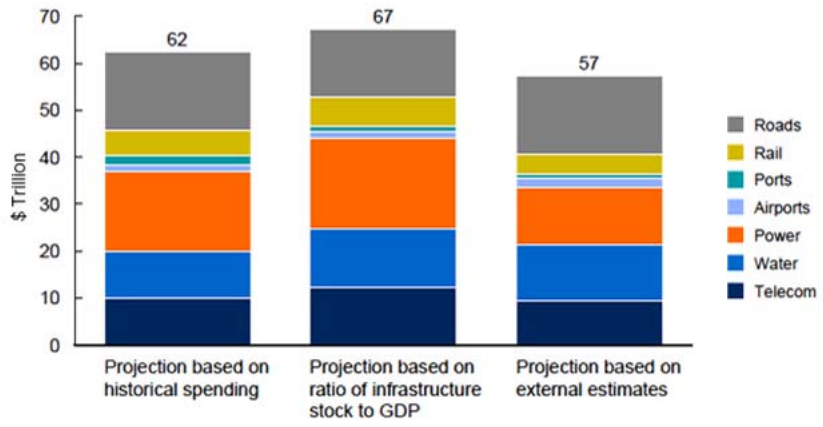

Data from McKinsey

Global Challenge – Massive Urbanization

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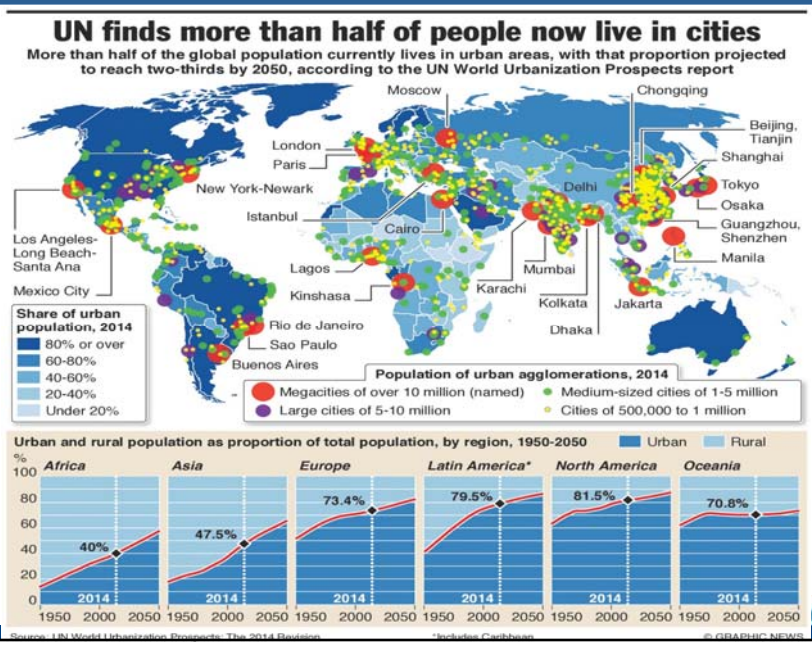

Global Challenge - Natural Disasters

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Data for 2016

Natural Disasters:

- ~11,000 people lost their lives or went missing
- Over $175 Billion in economic losses and resulted in significant re-building of infrastructure

Profound Public Health Needs in Developing Countries

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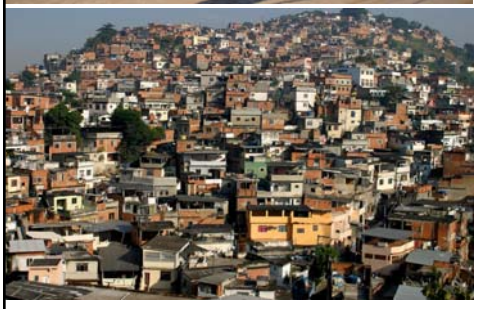

Examples of Advancements in Design

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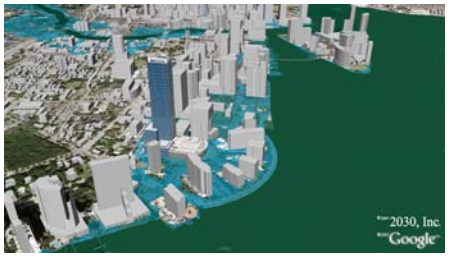
Tunnels & Rail Projects – new technologies taking us to new places

Advanced Water Treatment Plants – new contaminants and scalable for growth

Smarter Transportation Systems

Green & Sustainable Buidlings



Sea Level Rise Flood Mitigation Projects and Improved Disaster Preparedness

Coastal Resiliency & Sea Level Rise

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Coastal and Climate Change Risk

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The Bahamas is considered to be one of the most vulnerable countries to climate change due to its geographic, economic, and population characteristics.

80% of land less than one meter above sea level

"Two of the greatest challenges… are recognizing the magnitude of risk posed by flooding and motivating the public and decision-makers to make the investments and difficult policy decisions required to reduce flood risk."

ASCE Flood Risk Management Priorities

Risk - Hurricanes

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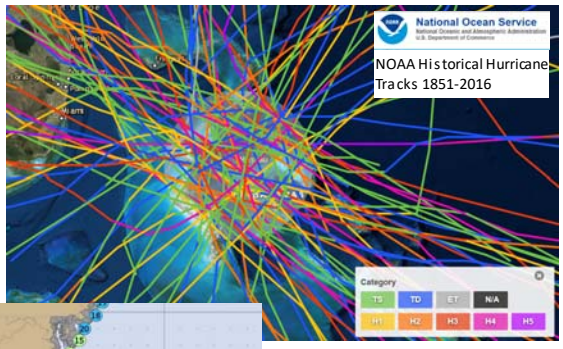
A hurricane passes near the Bahamas, on average, every two years. A hurricane makes a direct hit on the islands, on average, every four years. Two Category 5 hurricane and seven Category 4 hurricanes have struck the Bahamas since storms were first recorded in 1851.



NOAA Historical Hurricane Tracks 1851-2016

Estimated return period in years for hurricanes passing within 50 nautical miles of various locations on the U.S. Coast

Risk - Rising Seas

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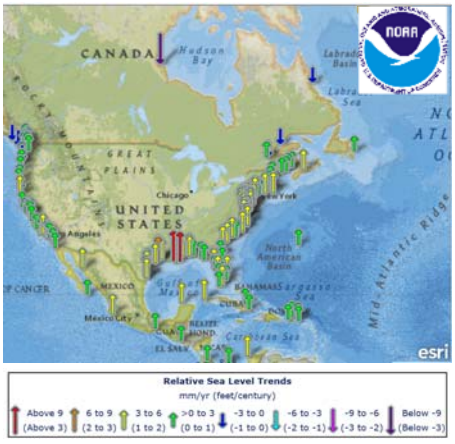
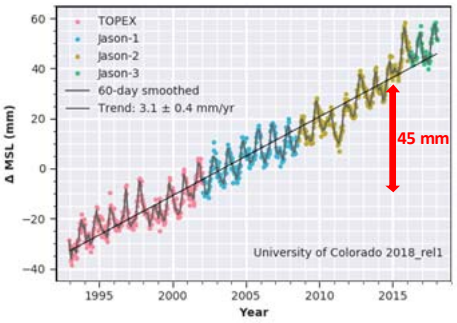
Sea Level Rise





- Science of sea level rise is continuously evolving
- Many forecasts available
- Future projections are highly variable
- Based upon models, assumptions, vigorous debate
- **BUT** no doubt sea level is rising

What are the effects of sea level rise?

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"Bahamas is one of the top three" impacted nations

The Impact of Sea Level Rise on Developing Countries (World Bank, 2007)

- Storm water/municipal drainage no longer works during high tide
- Increasing frequency of flood events
- Inundated roads (nuisance flooding)

- Salt-water intrusion
  - Rivers and lenses of fresh groundwater becoming more saline
  - Re-location of municipal drinking wells
- Coastal flooding and erosion
- Plant, tree, and habitat mortality (mangrove retreat, coral reef degradation, etc.)

Risk - Growing Coastal Populations

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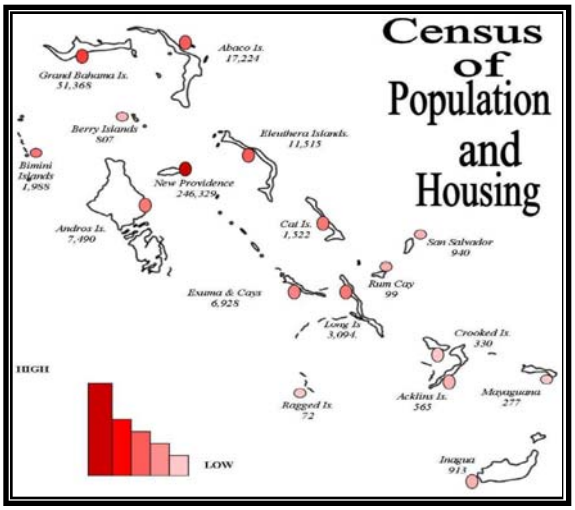
- Global coastal populations continue to rise
- People continue to be drawn to the coast to live, work, and vacation
- About 40% of the world's population live within 100 kilometers of a coastline



~400,000 total population of Bahamas

Assessing Risk

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Hazard Probability Vulnerability Consequence Criticality Risk

Sea Level Rise Estimates – Nassau, New Providence Island

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Sea Level Rise Estimates – Nassau, New Providence Island

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Sea Level Rise Estimates – Grand Bahama Island

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Sea Level Rise Estimates – Grand Bahama Island

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Resiliency and Adaptation

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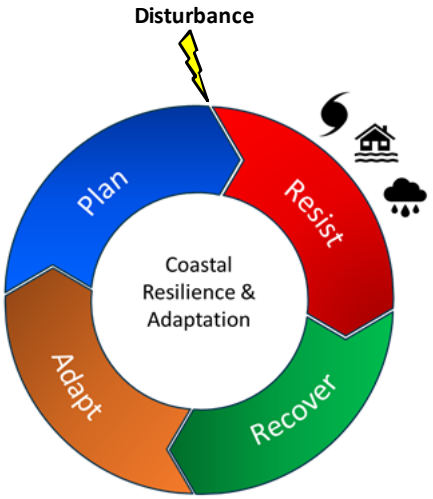
Resiliency

the ability of a natural or built system to recover from an extreme load or event

Adaption

adjustment in response to changes in the factors that impact the functionality of a natural or built system



22

Resiliency Timeline

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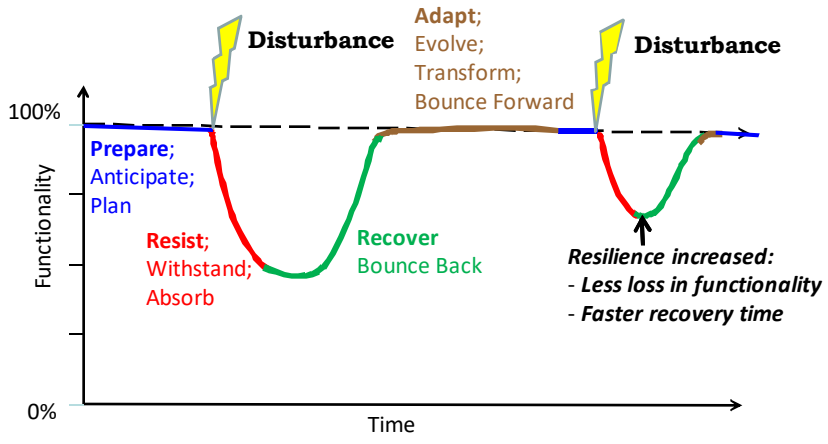

~ Adapted from USACE and Julie Dean Rosati, et al. (2015)

Resiliency Improvement

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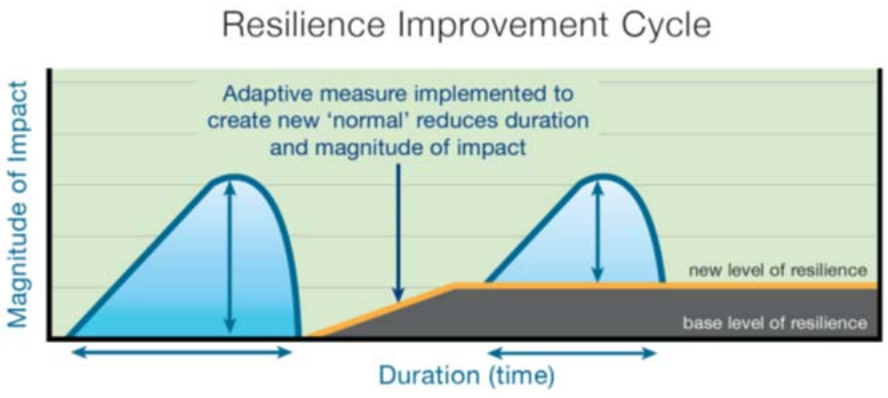

24

Where to Improve Resiliency

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Industrial Facilities

Transportation

Water / Wastewater

Public Facilities

Utilities

Police and Fire

Schools

Hospitals

Government Infrastructure

Beaches Tourism

Tourism accounts for >40% of GDP

Bahamas generally low lying topography increases coastal vulnerability

Public assets and infrastructure at risk from coastal flooding

Need for resilient and adaptive planning and design

Multidisciplinary

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26

Many Aspects of Protection

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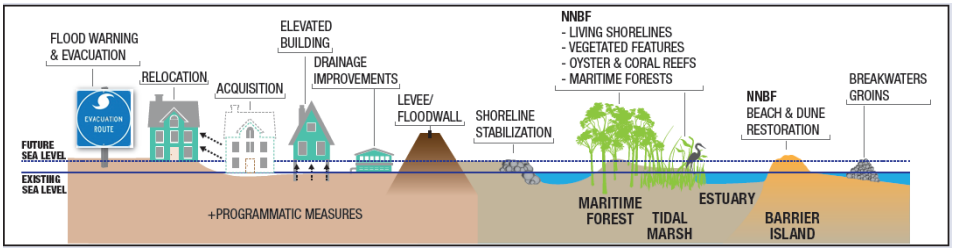

~FIGURE: North Atlantic Coast Comprehensive Study (USACE, 2015)

Inner Layer (Local)
- Smaller-scale solutions
- Protect critical infrastructure
- Integrating water management and urban planning

Middle Layer (Regional)
- "Transition" zone
- Floodwalls, marshes, levees (multifunctional) , beaches

Outer Layer (Large Area)
- Larger, engineered solutions
- Storm surge barriers, sea gates, Offshore structures, pump and levee systems

Coastal Resiliency and Adaptation Approaches

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Retreat
move infrastructure from vulnerable areas

Accommodate
modify designs to allow for periodic flooding

Protect
design defenses to reduce flooding

Everything does not have to be built now… but you have to plan for it

28

Resiliency Example

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LESSONS LEARNED
SUPERSTORM SANDY

Living Breakwaters | **REBUILD BY DESIGN**

Risk Reduction
Ecology
Culture

- Reduce wave heights and shoreline erosion
- Revive marine reef ecology and increase diversity of aquatic habitat
- Connect people to the water's edge, enhance community stewardship

design + ecology + engineering + people

Resiliency Example

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RETHINK NOT JUST REBUILD

The Big U | **REBUILD BY DESIGN**

Integrating Elements into Urban Landscape

- Berms / elevated paths
- Deployable flood walls
- Multipurpose (storm surge, sea level rise protection and park space)

Resiliency Example

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APPLYING TECHNOLOGY

Active Floodproofing

RISE:NYC

Elements at a Business Scale

- Flood risk audits
- Improve the resiliency of critical building components before, during, and after a storm
- Flood and storm surge modeling
- Flood resiliency through real time monitoring and control of pipe water levels, weather forecast and other parameters
- Controls valves automatically when conditions are indicative of a flood risk protecting building from the backflow

"NEW, INNOVATIVE, AND COST-EFFECTIVE" SOLUTIONS TO "ENABLE BUILDINGS AND INFRASTRUCTURE NETWORKS TO BETTER RESIST, ADAPT TO, AND/OR BOUNCE BACK FROM FUTURE STORMS."

Resiliency Examples

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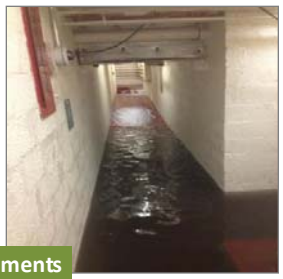
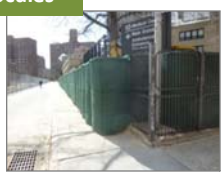
New York City Hospitals – Key Infrastructure

- Superstorm Sandy shut down 6 hospitals
- Flooded generator rooms and key utilities lost
- Wet and dry flood proofing (seal utility rooms or relocate to higher floors)
- Protecting key assets and weak points



Integrating Elements of Varying Scales



Climate Change Infrastructure Vulnerability Assessment

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Hermosa Beach, California

- Large, coastal community affected by sea level rise and salinity in coastal areas.
- Town needed to evaluate how coastal shallow groundwater elevation and salinity responds to projected increases in sea level rise in sandy, low-lying coastal soils and evaluated the vulnerability of existing sanitary sewer and storm drain infrastructure.
- Included:
  - Climate Change Vulnerability Assessment
  - Groundwater Monitoring
  - Stormwater Monitoring
  - Groundwater Elevation & Salinity Intrusion Forecasting

Coastal Resiliency Stormwater Outfall Retrofits

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St. Augustine, Florida

Goals:

- Coastal resiliency and infrastructure sustainability in the face of future sea level rise
- Protection of City assets and structures from high tide and storm impacts
- Systematic identification of critical outfalls and tide valve retrofit options

Tide Check Valve Program Flood Mitigation Project

- Great success has been documented where the valves have been installed (elimination of nuisance tidal flooding)

Next steps – Additional Resiliency Projects

- Master Stormwater Outfall Resiliency Retrofit Plan (prioritize remaining 80+ outfalls)
- Macaris Outfall Retrofit Design and Permitting (60-inch and 30-inch pipes)

OF-0142 (After): Crew installing valve into outfall pipe

OF-0142 (After): Crew securing valve with straps onto outfall pipe

Emergency & Disaster Preparedness & Response

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- Water Resources Planning
- Emergency Planning
- Risk Evaluations
- Facility/infrastructure Audits
- Emergency Response
- GIS Mapping
- Data Management
- Geotechnical/Structural Evaluations
- Health & Safety Management
- Spill Assessment/Remediation
- Natural Resource Evaluation/Response
- Regulatory Response
- Flood/Storm Resiliency

The Need for Clean Water –

Including Emerging Contaminants

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Global Challenge - Water Scarcity

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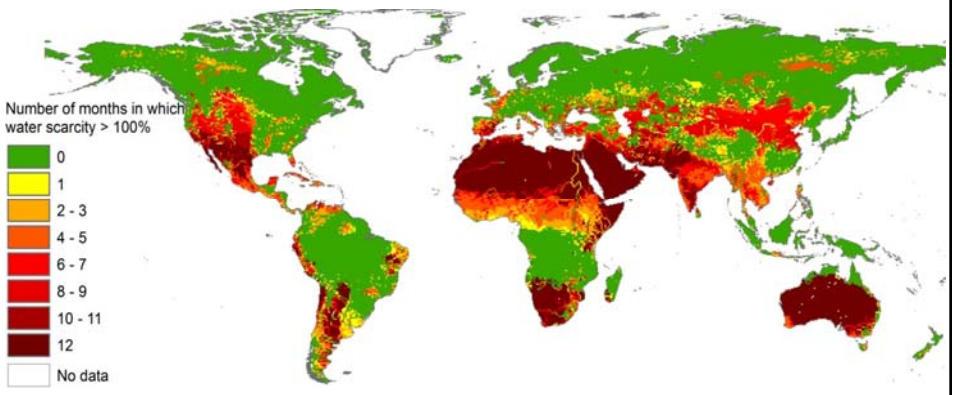
Four billion people live in regions that experience water scarcity at least one month of the year.



Emerging Contaminants in Water Supplies: Examples

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The **Flint, Michigan water crisis** began in 2014, after the drinking water source for the city of Flint, Michigan was changed from Lake Huron and the Detroit River to a less costly source of the Flint River.

Due to insufficient water treatment, lead leached from water pipes into the drinking water, exposing over 100,000 residents to elevated lead levels.

In Flint, between 6,000 and 12,000 children have been exposed to drinking water with high levels of lead and they may experience a range of serious health problems. Due to the change in water source, the percentage of Flint children with elevated blood-lead levels may have risen from about 2.5% in 2013 to as much as 5% in 2015.

Emerging Contaminates in Water Supplies: Examples

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Compound Class	Example Compounds
Industrial additives	1,4-dioxane, 1,2,3-trichloropropane
Gasoline additives	MTBE, TBA
Other industrial chemicals	Perfluoroalkyl and polyfluoroalkyl substances (PFASs) Polybrominated diphenyl ether (PBDEs)
Pharmaceuticals	Antibiotics and other drugs
Personal care products	Polycyclic musks
Volatile organics	1,1-DCA
Disinfection byproducts	NDMA
Inorganics/explosives	Perchlorate, RDX
Pesticides/herbicides	Diazinon
Surfactants/residues	Triclosan, alkylphenol polyethoxylates

Emerging Contaminants : How They "Emerge"

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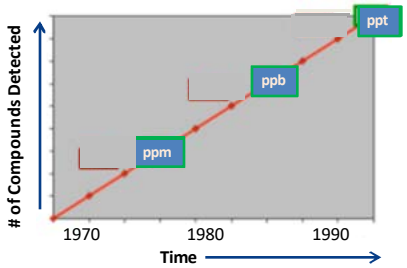
- Many contaminants are emerging just now despite 20 to 50 years of manufacturing and use
- Newly detectable using improved analytical methods
- Availability of new data (e.g., effects on endocrine system or other endpoints not previously evaluated)
- Receiving public attention, media coverage



You won't find what you don't look for!

Emerging Contaminants
Case Study

PFAS

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Per- and Polyfluoroalkyl Substances (PFOA & PFOS)

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- Unique surface-active properties, non-reactive and stable

Surface treatments/coatings
- Carpet and upholstery
- Apparel
- Paper and packaging
- Non-stick cookware

Performance chemicals
- Chromium plating (mist suppression)
- Insecticides
- Lubricants
- **AFFF**

- Most well-known compounds
  - Perfluorooctanoic acid (PFOA)
  - Perfluorooctane sulfonic acid (PFOS)

AFFF History

- AFFF = Aqueous film forming foam
  - Complex, proprietary mixtures of fluorinated and hydrocarbon surfactants, water, corrosion inhibitors, solvent
  - PFASs a few % in mixture
- Brief history
  - Mid 1960s – 1970: 3M sole source supplier of AFFF
  - 1973: National Foam
  - 1976: Ansul
  - 1994 – present: Angus, Chemguard, Fire Service Plus
- Multiple AFFFs used at most sites

PFAS – Industries with Potential Problems

Industries

- Airports
- Oil and gas industry
- Chemical
- Military sites
- Landfills
- Metal working industries
- Print industries
- Municipalities

Magnitude of the Problem from AFFF Use

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- Oil Refineries (157)
- Fire Facilities (424)
- Major Airports (51)
- Bulk Tank Facilities (1030)
- Municipal Landfills (1800)
- Large Chemical facilities (675)

Use Sector	PFOS-based AFFF, 2004 (gal)	PFOS-based AFFF, 2011 (gal)
Military and other Federal	2,100,000	1,094,700
Civil aviation (ARFF)	130,000	20,000
Oil refineries	950,000	152,000
Other petro-chemical	1,000,000	500,000
Civil aviation (hangars)	190,000	70,300
Fire departments	120,000	60,000
Miscellaneous	150,000	75,000
Totals	**4,600,000**	**1,972,000**

Amounts reported in gallons
***Source**: Estimated Inventory of PFOS-Based AFFF in the United States, Fire Fighting Foam Coalition, 2011*

Occurrence
Drinking Water

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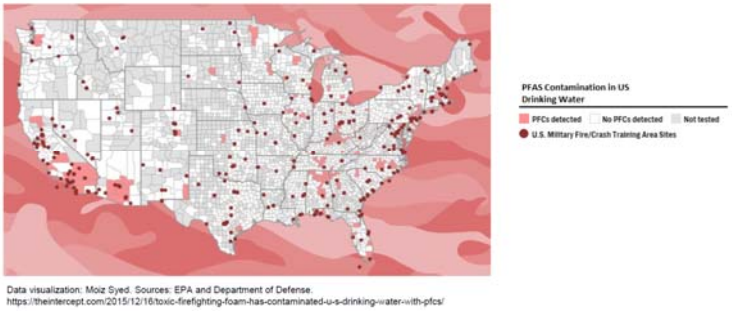
- 2012: Six PFASs added to Unregulated Contaminant Monitoring Rule 3 (UCMR 3) list, including PFOS and PFOA
- PFASs detected in 194 of 4,864 public water systems (UCMR 3 data) (Hu, 2016, ES&T)
- 2016: EPA issued a lifetime drinking water Health Advisory for PFOA and PFOS of 0.07 µg/L



Data visualization: Moiz Syed. Sources: EPA and Department of Defense.
https://theintercept.com/2015/12/16/toxic-firefighting-foam-has-contaminated-u-s-drinking-water-with-pfcs/

Regulatory Actions

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2001	3M discontinued production of PFOS
2008	PFOS phase out began in Europe
2009	PFOS listed as a persistent organic pollutant at the Stockholm Convention
2009	Australia issued guidelines for PFOS-containing wastes
2009	EPA issued Provisional Health Advisories for PFOS and PFOA (0.4 µg/L and 0.2 µg/L)
2011	Use of PFOS-containing AFFF and other PFOS applications banned in EU
2012	PFOS, PFOA added to Unregulated Contaminant Monitoring Rule 3 (UCMR 3) list
2015	PFOS, PFOA added to draft CCL4
2016	EPA issued a lifetime drinking water Health Advisory for PFOA and PFOS of 0.07 µg/L

***Note**: "…when these two chemicals co-occur at the same time and location in a drinking water source, a conservative and health-protective approach that EPA recommends would be to compare the sum of the concentrations ([PFOA] + [PFOS]) to the HA (0.07 µg/L)"*

Waste and Wastewater Management & Treatment

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Global Challenge - Adequate Sanitation is Lacking in Many Parts of the Globe

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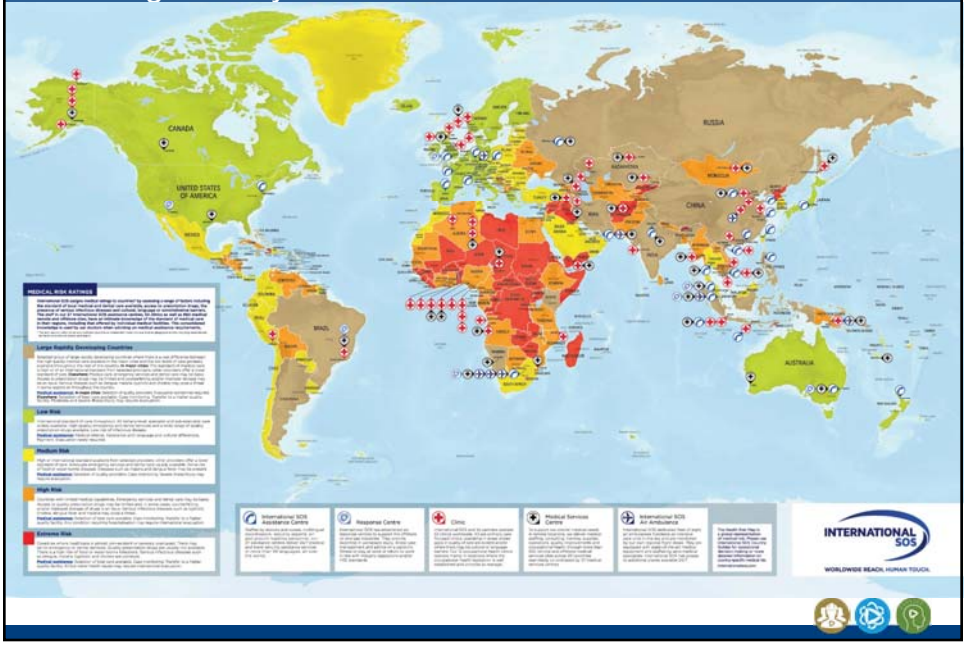

Water & Wastewater Solutions

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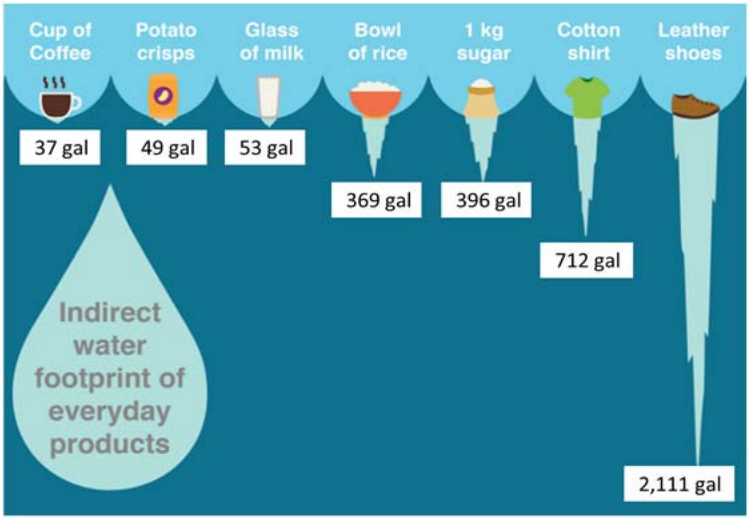
WATER FOOTPRINT ASSESSMENT



Water & Wastewater Solutions

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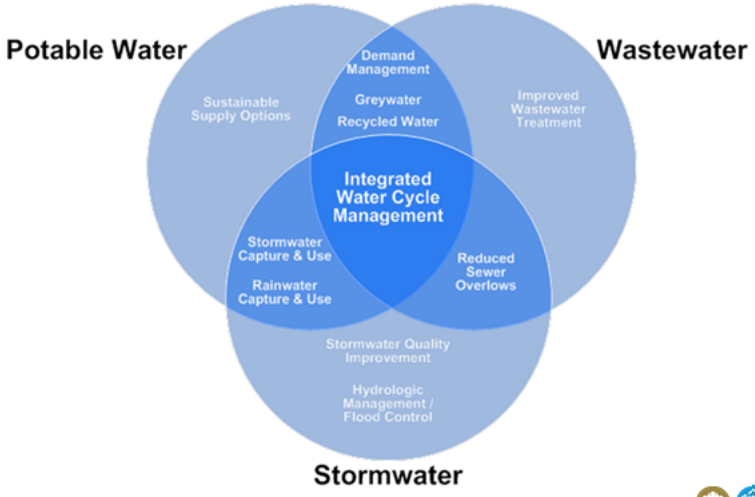
AN INTEGRATED APPROACH TO WATER TREATMENT & REUSE



Water & Wastewater Solutions

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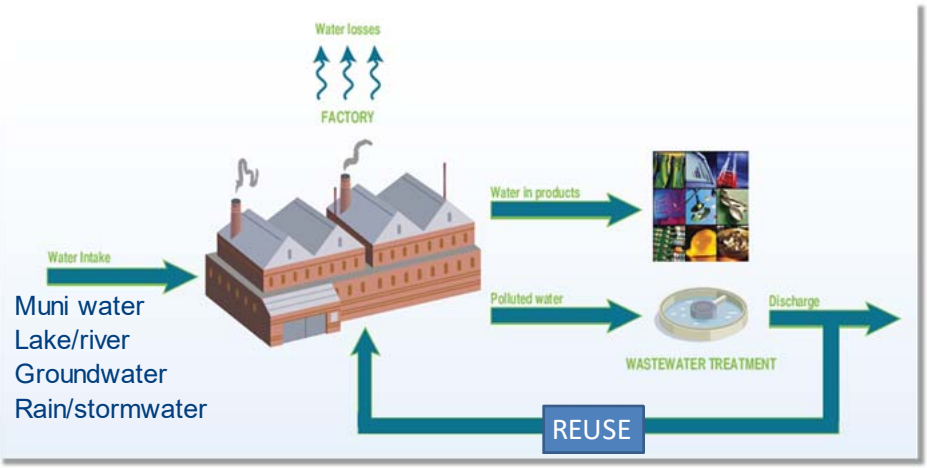
SITE-SPECIFIC EVALUATIONS



Water & Wastewater Solutions

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"TRUE COST OF WATER"

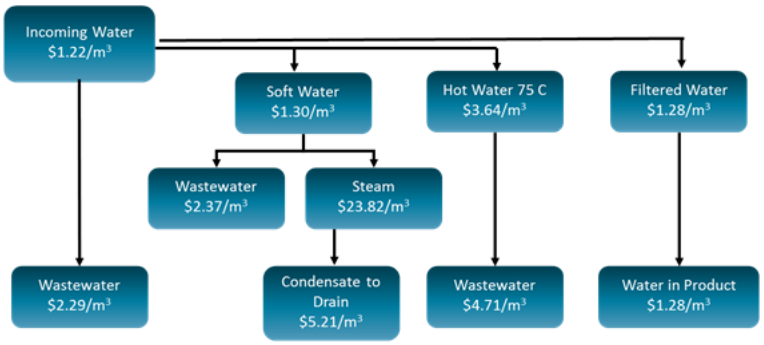

Figure 3.2: Water Cost Breakdown, Identifying the Value Stream. Water picks up value as it travels through a facility. Value (cost) streams are an important measure for impact analysis.

Source: *Water Recovery and Reuse: Guideline for Safe Application of Water Conservation Methods in Beverage Production and Food Processing, A Publication of the Center for Risk Science Innovation and Application of the ILSI Research Foundation, 2013*

Water & Wastewater Solutions

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KEY TARGET WATER USERS AT PLANTS

- Cooling Towers(most industries)
- Scrubbers for Air Pollution Control
- Chillers, Boilers and HVAC (Air Handling Condensates)
- Lawn Sprinklers/Irrigation
- Cleaning Water for Clean-in-Place Systems, etc. (e.g., tanks, bottle washing)
  - Cafeteria
  - Washrooms and showers
- Other Water Users – Laboratories etc.
- Fluming or transport (e.g., tomatoes & beans)
- Animals (e.g., spraying & cooling of livestock, scalding tubs & washing of animals)

Water & Wastewater Solutions

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ENERGY RECOVERY FROM WASTEWATER

- COD in the wastewater can be used to create energy
- 5.6 cubic meters methane per pound COD removed
- Methane has 960 BTU per cubic feet versus natural gas at 1030 and propane at 2516
- Sanitary wastewater COD around 500 mg/l
- Industrial wastewater COD can be 50,000 mg/l or 100 times
- 40,000 tons per year food waste can generate 1.2 MW of electricity and 1 Million BTUs heat

Other Waste Solutions

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FOOD WASTE TO ENERGY

Food waste is sent to to landfills where it is sent through anaerobic digesters as a slurry to create biogas which can be converted to electricity.

Environmental Awareness and Remediation

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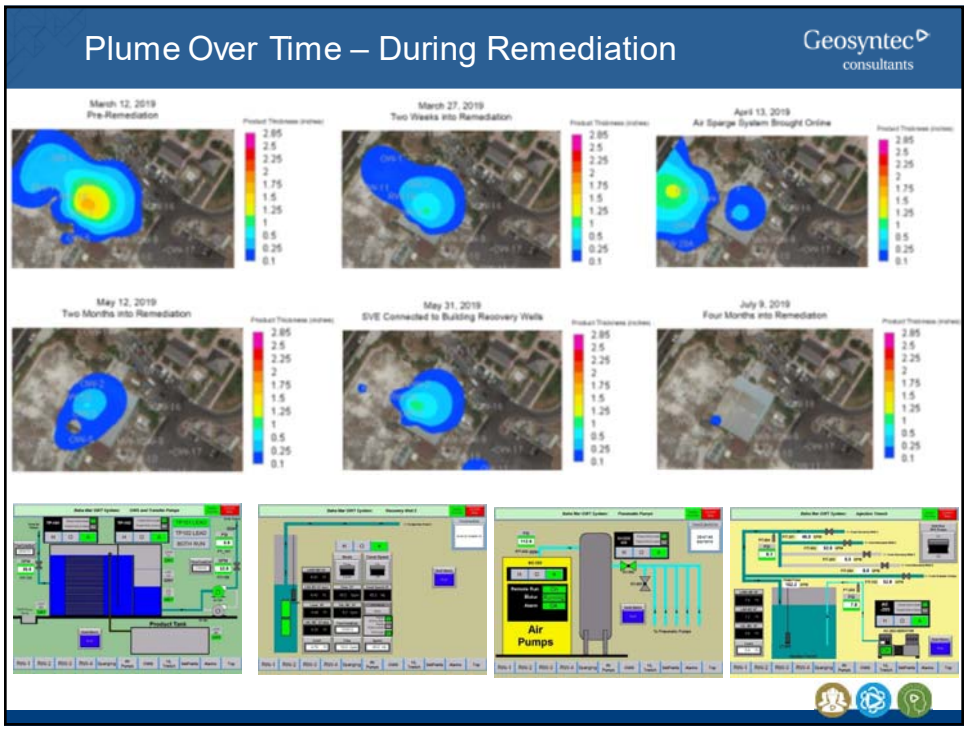
Well and Trench Network Used for Remediation and Monitoring
NEW FENCE
OIL TANK
OFFICE TRAILER
AERATION BLOWER
SYSTEM CONTAINER


Plume Over Time – During Remediation
Geosyntec consultants
March 12, 2019
Pre-Remediation
March 27, 2019
Two Weeks into Remediation
April 13, 2019
Air Sparge System Brought Online
May 12, 2019
Two Months into Remediation
May 31, 2019
SVE Connected to Building Recovery Wells
July 9, 2019
Four Months into Remediation
Air Pumps

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Remediation of Soil and Groundwater at the NASA Kennedy Space Center in Florida

Geosyntec
consultants
Radiological Waste Management
Design and Construction of a Low-Level Radioactive Material Treatment and Final Disposal Facility in Malaysia

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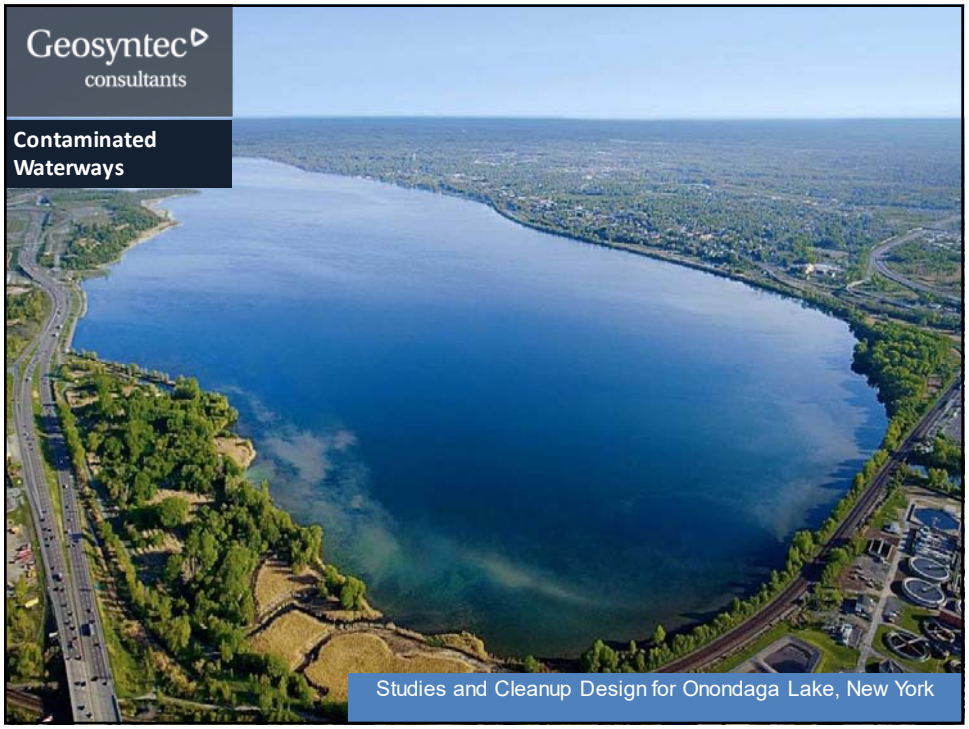
Contaminated Waterways



Studies and Cleanup Design for Onondaga Lake, New York

Contaminated Sediment Investigation & Remediation

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Development of cost-effective, practical solutions

- Feasibility Studies
- Dredging and Associated Sediment and Water Management
- Capping and Active Cap Design
- In Situ Treatment with Amendments
- In Situ Stabilization (ISS)
- Waterfront Infrastructure
- Monitored Natural Recovery
- Enhanced Monitored Natural Recovery
- Design Constructability Review

Sediment Technical Trends

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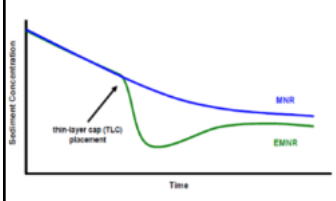
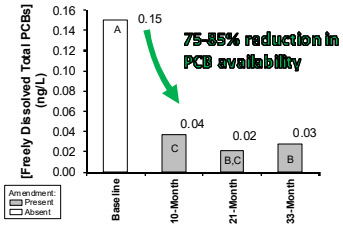
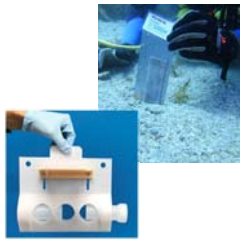


Enhanced Monitored Natural Recovery (EMNR)
Addition of a thin layer of material to surface to augment deposition rates and advance MNR route (i.e., natural deposition of clean material).



Active Capping Technologies
Application of chemically reactive amendments (e.g., AquaBlok™, apatite, carbon, etc.) directly to the sediment surface (or via thin-layer cap) for permeability control or to reduce porewater concentrations and biouptake of metal and organic contaminants.



Passive Porewater Samplers to Measure Amendment Performance
Commercial development of passive samplers for organics (e.g., LDPE) and metals (e.g. peepers). Porewater provides a direct means to monitor amendment performance based on what is bioavailable to biota.

Berry's Creek Superfund Site

Geosyntec consultants

- Tidal waterway and marsh in Hackensack Meadowlands, NJ
- Industrial discharges of PCBs, mercury, PAHs, metals
- Complex interaction between marsh and waterway

Work Scope

- RI characterization of waterway sediments, marsh sediments, surface water, porewater, volatile emissions, *Phragmites*, aquatic biota, terrestrial biota
- Pilot Study design and implementation of thin layer placement in marshes and waterway
- Feasibility Study resulting in phased remedy implementation

Berry's Creek Superfund Site

Geosyntec consultants

- Phase 1 ROD
  - Dredge 2 ft of soft sediments from upper portion of site
  - Backfill with sand
  - Marsh Demonstration Project to confirm recovery in marshes and preserve stability
- Work scope:
  - Remedial design Engineer of Record
  - Design of Marsh Demonstration Project
  - Baseline Monitoring

Gowanus Canal Superfund Site

Geosyntec consultants

- Industrial waterway constructed in mid-1800s
- 1.8 miles long, 100' wide with 3 turning basins
- CSOs and stormwater discharges, failing bulkheads
- Multiple industries adjacent to canal
- NAPL and dissolved PAH, sheen events
- Mandated Remedy ~
  - Dredge of soft sediments
  - ISS of native sediments with NAPL
  - Active cap to address dissolved and NAPL phase migration
  - Bulkhead support as needed

Gowanus Canal Superfund Site

Geosyntec consultants

- Work Scope:
  - Project Coordinator & Engineer of Record
  - Pre-Design Investigations
  - Remedial Design
- Pilot Study
- Design and remedial action through 2020s

Portland Harbor Superfund Site

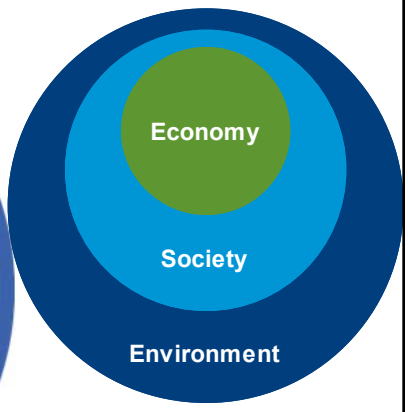
Geosyntec consultants

- 10-mile-long Superfund site on the Lower Willamette River near downtown Portland, Oregon
- 3 million CY dredging, 176 acres engineered cap
- Geosyntec is co-leading the pre-remedial design and baseline sampling program
- Field staff collected 2,000+ data points, including surface grabs, sediment cores, surface water, sediment traps, fish tissue, background porewater, fish tracking and bathymetry studies, all in a fast-track 12-month period
- Results will be used to establish baseline conditions, revise the CSM, and refine the remedial footprint size, volumes, and costs estimates

Sustainability and Re-use

Geosyntec consultants

Look at Minimizing Impacts to the Environment, Society, and the Local Economy



Sustainability: Integration

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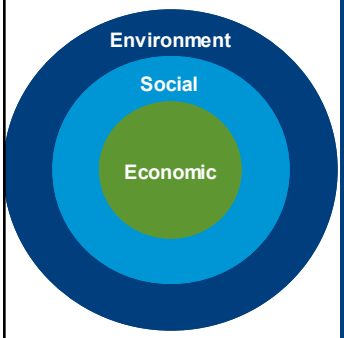

Environmental Stewardship

- Good environmental practices
- Transparency
- Energy efficiency
- Eco-friendly and energy performance technologies
- Carbon footprint
- Compliance with requirements
- Sustainable materials in supply chain
- Habitat protection and improvement
- Strategies to reduce risk and cost

Social Responsibility

- Safety and security at work
- Improved health and occupational health
- Human factors
- Organization structure, leadership, compensation
- Community service, involvement and development
- Stakeholder identification and engagement
- Human rights, labor practices, consumer issues and protection
- Employee benefits, hiring and retention
- Promoting diversity, equity and inclusion

Economics & Governance

- Employee benefits and compensation
- Financial viability of organization (profitability)
- Transparency and ethics
- Executive compensation
- Dissemination of new technologies
- Good business practices, including procurement
- Relations between economic actors
- Supporting local economies
- Cost effective strategies
- Risk reduction strategies

Sustainability & Environmental Management Systems

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Renewable Energy
- o Landfill Gas to Energy (LFGTE)
- o Solar
- o Wind & Water

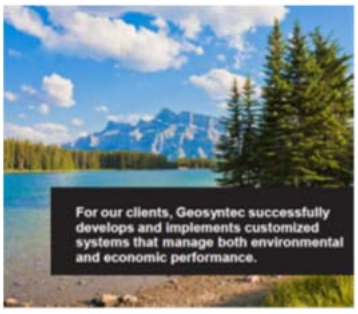
Climate Change and Greenhouse (GHG) Management
- o Baseline GHG Surveys
- o Carbon Credits
- o Carbon Capture and Storage

Sustainable Development
- o Site Revitalization (Brownfields)
- o Low Impact Development
- o LEED Certification
- o Water Resources

Sustainable Waste Management
- o Waste Reduction
- o Bioreactors
- o Landfill Mining

Sustainable Remediation
- o Constructed Wetlands
- o Passive Soil and Groundwater Technologies
- o Water Reuse

Environmental Management
- o Environmental Management Systems (EMS) and Ecoefficiencies
- o Pollution Prevention and Product Stewardship
- o Environmental Liability Evaluation



United Nation Sustainable Development Goals (SDGs)

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Local Government Examples

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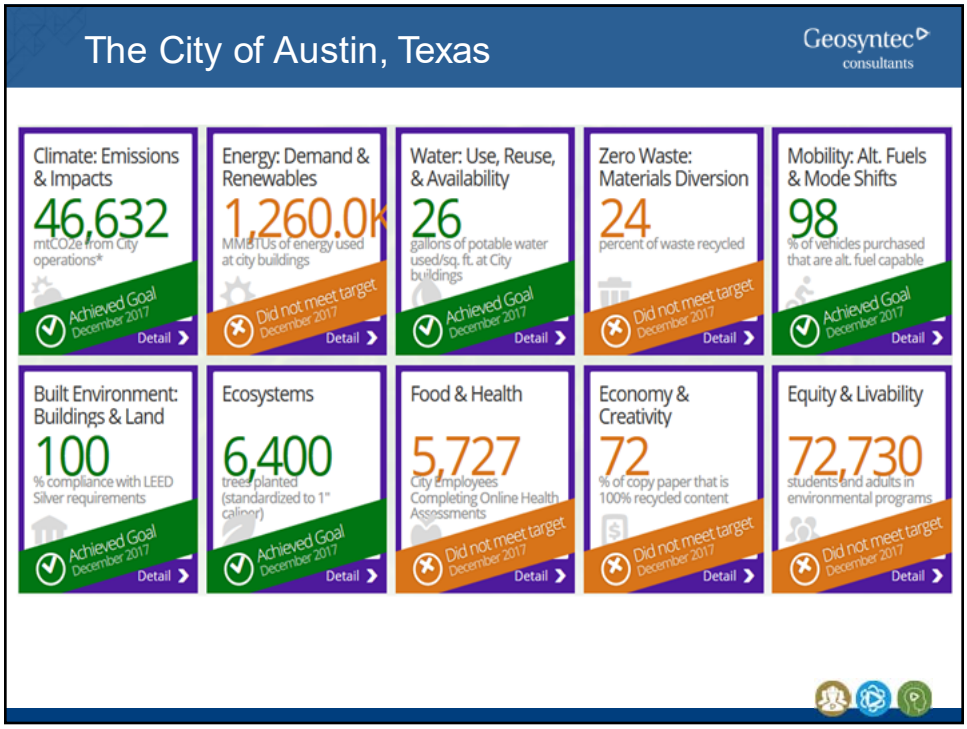
The City of Austin, Texas
Geosyntec consultants
Climate: Emissions & Impacts
46,632
mtCO2e from City operations*
Achieved Goal December 2017
Detail
Energy: Demand & Renewables
1,260.0k
MMBTUs of energy used at city buildings
Did not meet target December 2017
Detail
Water: Use, Reuse, & Availability
26
gallons of potable water used/sq. ft. at City buildings
Achieved Goal December 2017
Detail
Zero Waste: Materials Diversion
24
percent of waste recycled
Did not meet target December 2017
Detail
Mobility: Alt. Fuels & Mode Shifts
98
% of vehicles purchased that are alt. fuel capable
Achieved Goal December 2017
Detail
Built Environment: Buildings & Land
100
% compliance with LEED Silver requirements
Achieved Goal December 2017
Detail
Ecosystems
6,400
trees planted (standardized to 1" caliper)
Achieved Goal December 2017
Detail
Food & Health
5,727
City employees Completing Online Health Assessments
Did not meet target December 2017
Detail
Economy & Creativity
72
% of copy paper that is 100% recycled content
Did not meet target December 2017
Detail
Equity & Livability
72,730
students and adults in environmental programs
Did not meet target December 2017
Detail

Alcoa
Geosyntec consultants
Alcoa Sustainability Performance 2017
10.9% reduction in carbon dioxide equivalent emissions
5.7% reduction in energy consumption
75% of electricity consumed by our smelters was from renewable sources
1.01:1 ratio for new active mining disturbance to mine rehabilitation
4.9% increase in landfilled waste
2% improvement in bauxite residue storage efficiency
382,000 metric tons of scrap recycled
3% increase in freshwater-use intensity
100 (perfect) score on the Corporate Equality Index 2018
14.5 percent of our global employees were women
3 contractor fatalities
0.66 days away, restricted and transfer rate per 100 full-time workers
US$9.5 billion in purchased goods and services
US$5.8 million in community investments
5,600 employee volunteer hours in the community

Mars Drinks

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HOW

Customer Focused

Workplace Expertise

Associates as Ambassadors

WHAT

SUSTAINABLE AGRICULTURE

SUSTAINABLE OPERATIONS

SUSTAINABLE SOLUTIONS

WHY

Our Commitment to Sustainability

Automating Workflow – Data and Information Management

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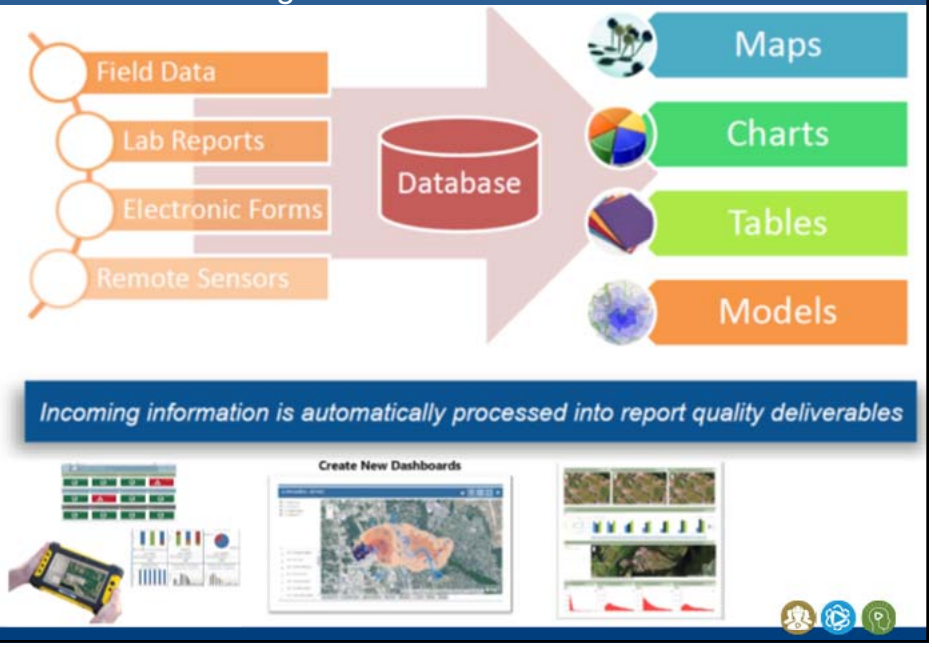

Other Examples

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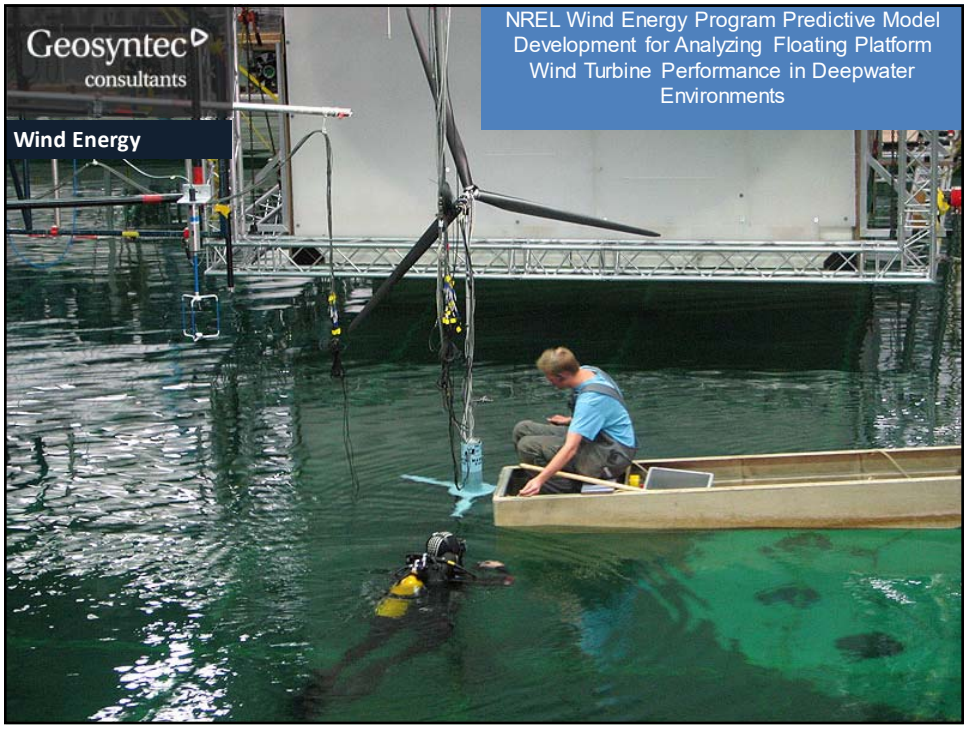
Comprehensive Evaluation of Seismic Stability of Blue Ridge Dam in Fannin County, Georgia

California Department of Water Resources
FERC Part 12 Independent Review Board, Oroville Dam and Thermalito Forebay/Afterbay Complex, California
84



Facing Today's Escalating Challenges and Producing Tomorrow's Solutions

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consultants