Herbert Wertheim College of Engineering
UNIVERSITY of FLORIDA

Development of Beneficial Use and Sustainable Materials Courses ENV6932 and CGN 6525

Engineering School of Sustainable Infrastructure and Environment (ESSIE)

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POWERING THE NEW ENGINEER TO TRANSFORM THE FUTURE

Outline

- ESSIE
- Research and Course Development
- Themes for SMM
- Considerations for SMM
- Case Studies
- Future initiatives

ESSIE

- ESSIE was formed in 2013
- Civil and Coastal Engineering joined with Environmental Engineering (ESSIE)
- 48 Tenure Track / Tenured Faculty
- 700 full-time undergraduate students and over
- 300 graduate students
- ~125 are PhD students

Sustainable Materials Management (SMM)

HERBERT WERTHEIM COLLEGE OF ENGINEERING GIVING PEOPLE GRADUATE ADMISSIONS EVENING WITH INDUSTRY

UF

Engineering School of Sustainable Infrastructure & Environment

ABOUT RESEARCH PROGRAMS CENTERS & FACILITIES RESOURCES ADMISSIONS ALUMNI NEWS & EVENTS

SUSTAINABLE MATERIALS MANAGEMENT

AIR RESOURCES

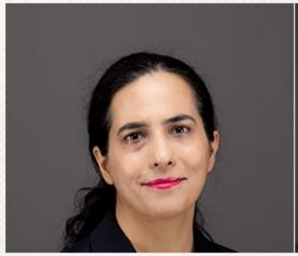
COASTAL & OCEANOGRAPHIC ENGINEERING

COASTAL ECOSYSTEM DYNAMICS

ENGINEERING EDUCATION

The sustainable materials management group is in the Department of Environmental Engineering Sciences. A combination of field and laboratory activities focus on the applied research needs of the solid waste management community. This program focuses on reduction, resource and energy extraction, recycling and beneficial reuse, and sustainable disposal of domestic solid waste streams and industrial byproducts. Undergraduate and graduate student course topics include fundamentals of waste management, landfill design, and beneficial use of waste materials.

People



SARA BEHDAD
Associate Professor

CHRISTOPHER FERRARO
Assistant Professor

TIMOTHY TOWNSEND
Jones, Edmunds & Associates, Inc. Professor

Research to Classroom

- Beneficial Reuse of Wastes (ENV 6932)
  - Created in 2012 – T. Townsend
- Sustainable Materials Course Civil Engineering CGN 6525 (2015)
  - Created in 2017 – C. Ferraro

ENV 6932 – Learning Objectives

Student is expected to learn:

- The use of a material as an effective substitute for a commercial product or commodity
- The legitimate use of a solid waste in the manufacture of a product or as a product, for construction, soil amendment or other purposes, where the solid waste replaces a natural or other resource material by its utilization
- A sustainability practice that may involve using an industrial waste in a manufacturing process to make a product or using a waste as a substitute for construction materials

CGN 6525 – Learning Objectives

Student is expected to learn:

- Sustainable use of materials used in CE and construction
- Definition of sustainability as it pertains to the built infrastructure
- Production of materials
- Recycling and beneficial use of materials
- Trade-offs with respect to sustainable use of materials
- Life cycle analysis of materials
- Sustainable engineering practices

Themes for SMM

- Defining sustainability
- Life cycle and embodied energy
- Industry metrics
- Building Material's role in sustainability
- Sustainable materials management
- Concrete's role in sustainability
- Resilience

Sustainable Materials Management (SMM)

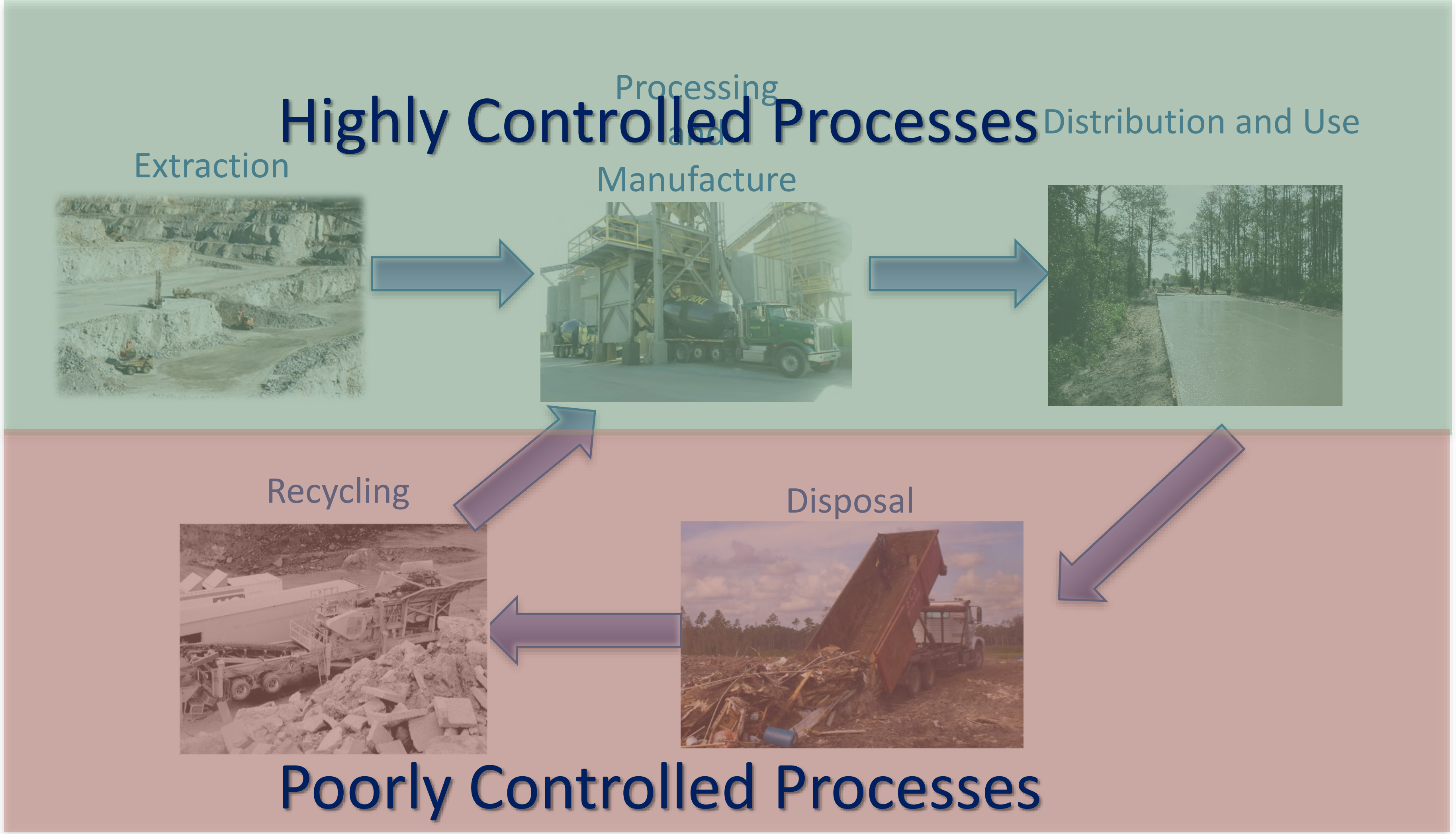
(SMM) is a key component for the development of sustainable infrastructure and an enduring society

Prior to 2013, the Environmental Protection Agency sought to measure the success of materials management throughout the United States by collecting data based on *waste generation and disposal*

Sustainable Materials Management (SMM)

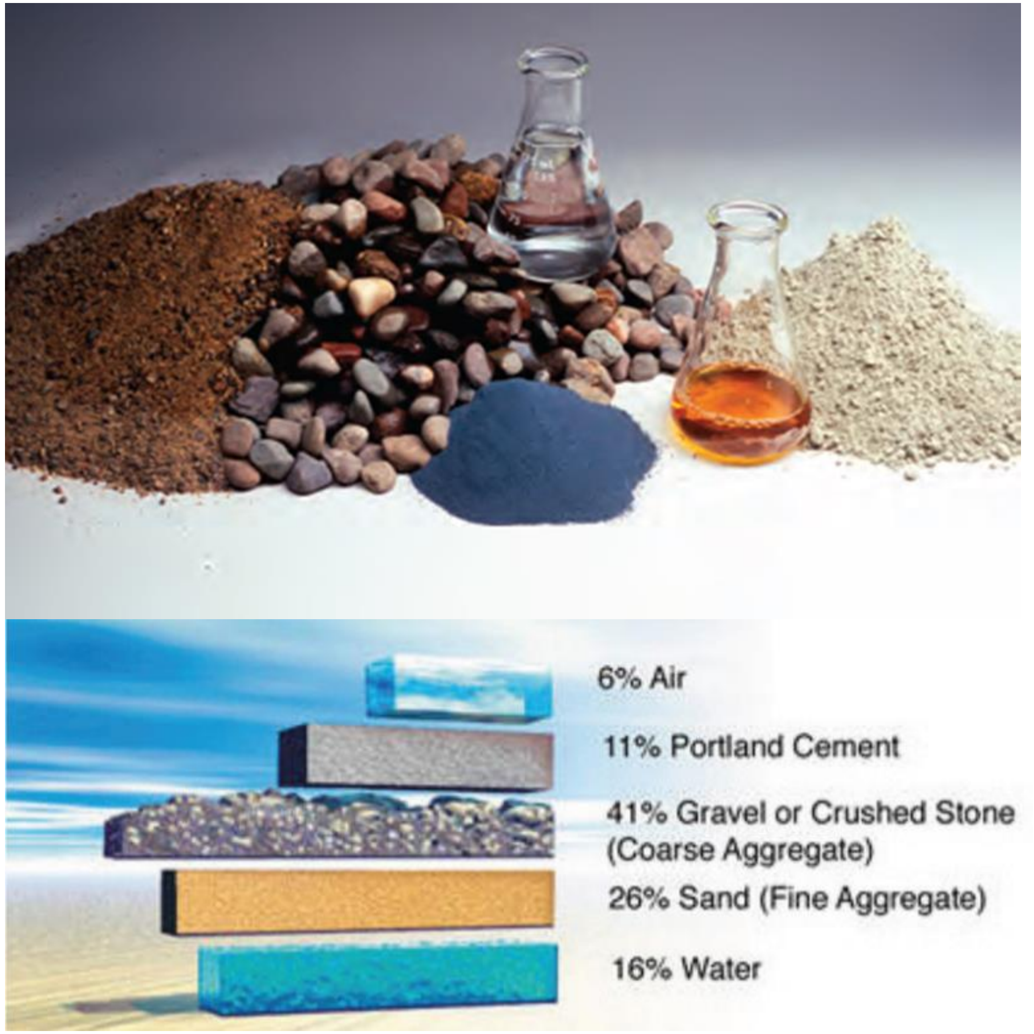
SMM is an effort to transition from waste management to materials management which focuses on use and reuse of waste materials instead of disposal.

Sustainable Materials Management (SMM)



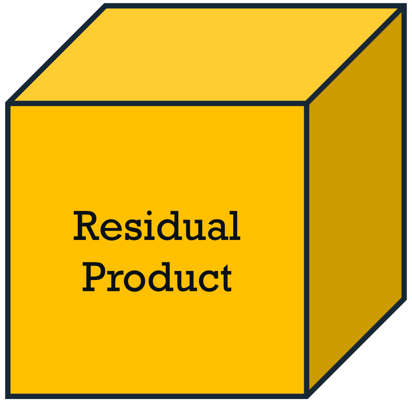
Portland Cement Concrete

- Portland cement
- Water
- Aggregates
- Supplementary Cementitious Materials (SCM / Pozzolan)
- Chemical Admixtures



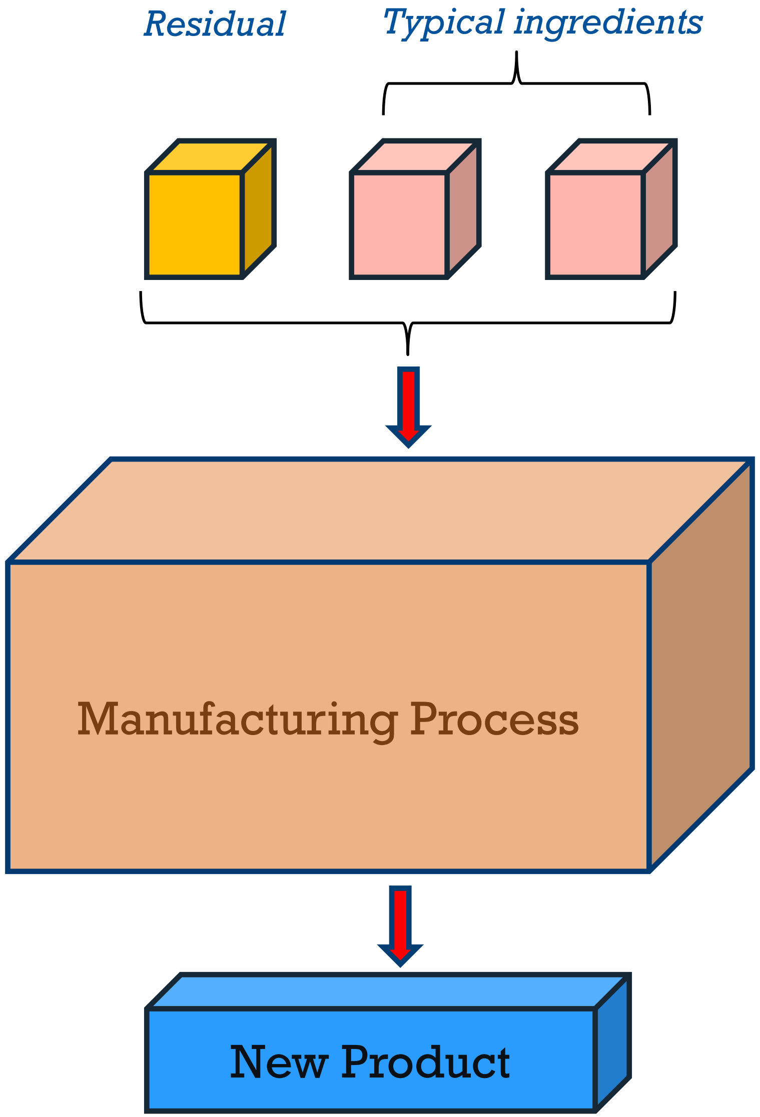
PCA - 2011

Potential Reuse Applications

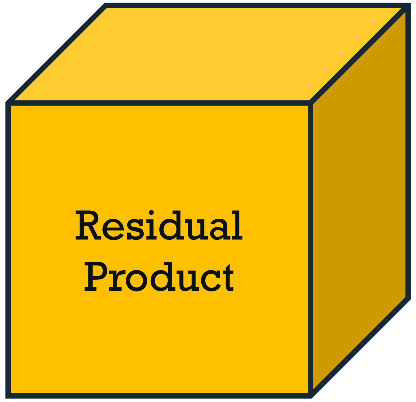


Residual is used as an ingredient in the manufacture of a new product

- Alternative kiln feed in portland cement
- SCM in concrete

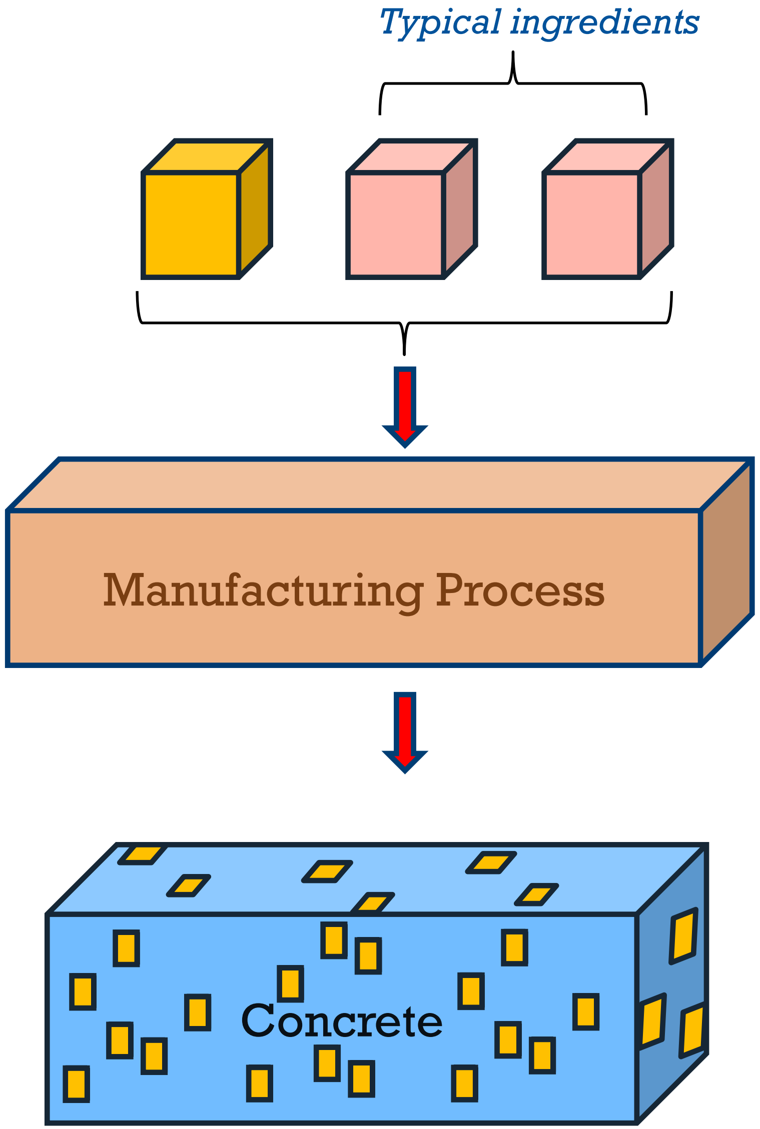


Potential Reuse Applications

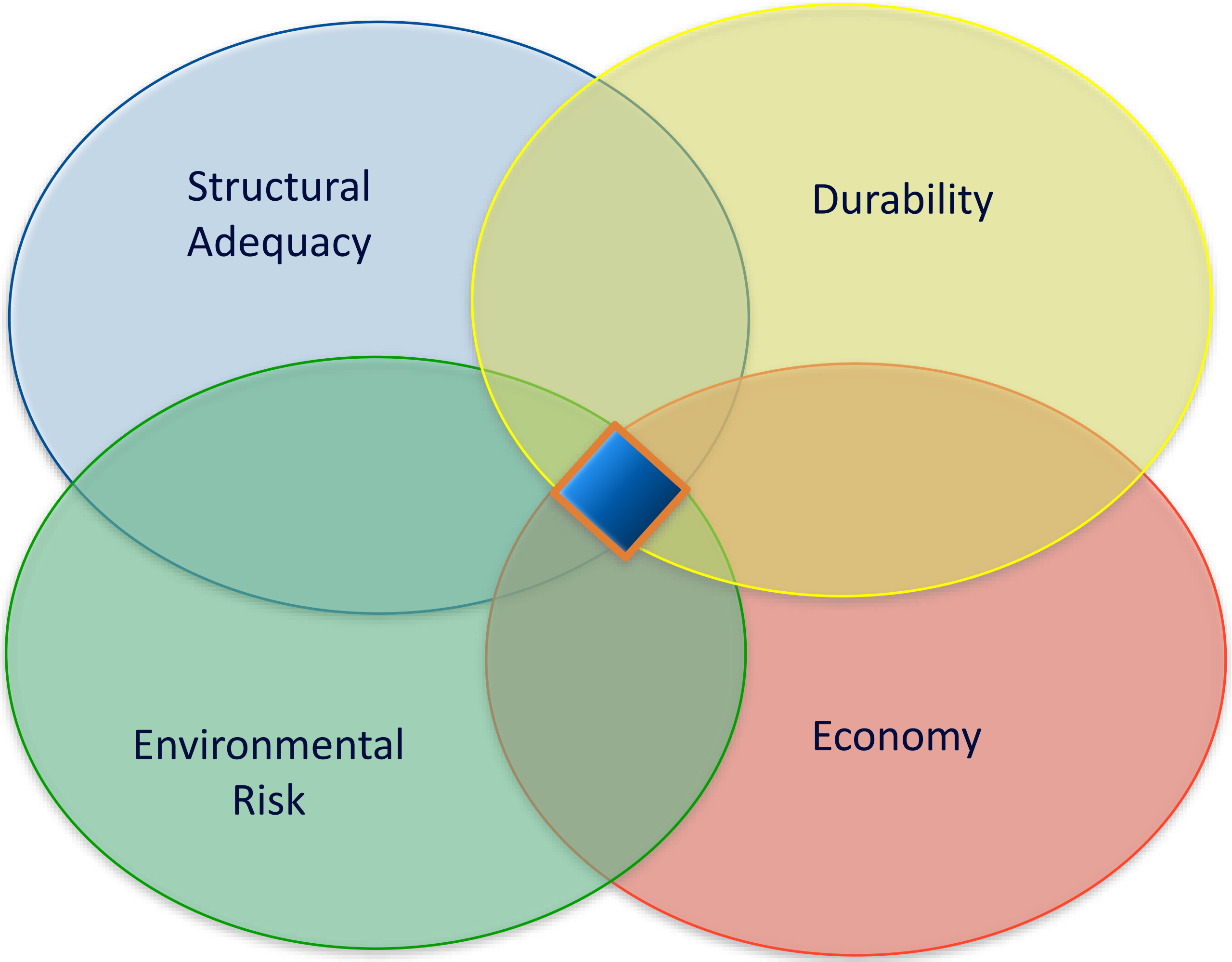


Combustion residual is used as an additive in a concrete material

- Recycled Aggregate
- Slag as Aggregate



Considerations for SMM



The impact of each will vary for different materials

SMM in the Portland Cement Concrete Industry

The Portland Cement Concrete Industry has a long history of SMM:

- Blast Furnace Slag -1900s (cement and aggregate) – *ASTM C989*
- Coal Fly Ash – 1948 – *ASTM C618*
- Silica Fume – 1950s – *ASTM C1240*
- Sugarcane bagasse ash – 1960s
- Benefits:
  - Cost
  - Durability
  - *Reduced mining footprint*
  - *Reduced carbon footprint*

Sustainability and Supplementary Materials

What is a supplementary cementitious material (SCM)?

A material that, when used in conjunction with Portland cement, contributes to the properties of the hardened concrete through hydraulic or pozzolanic activity, or both

From left to right:

Fly ash (Class C)

Metakaolin (calcined clay)

Silica fume

Fly ash (Class F)

Slag Cement

Calcined shale

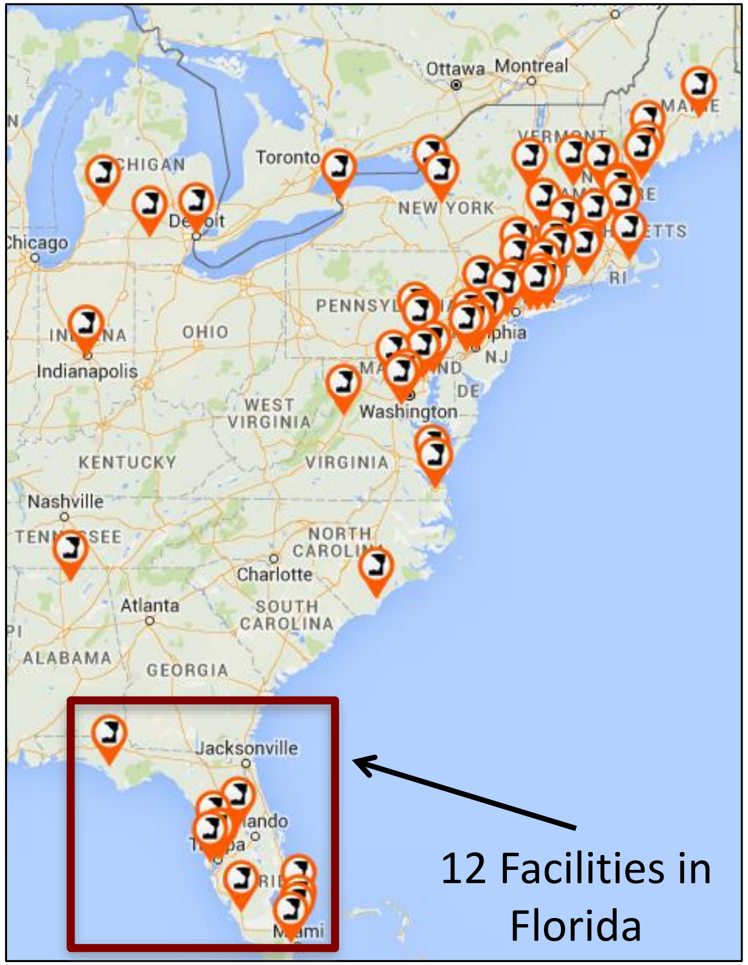
PCA - 2017

Definitions

- Municipal Solid Waste Incineration (Ash) – MSWI
- Waste to Energy (Ash) – WTE

- Both are considered to be the solid waste residual borne from the combustion of municipal solid waste – (household garbage)

WTE / MSWI Continental United States

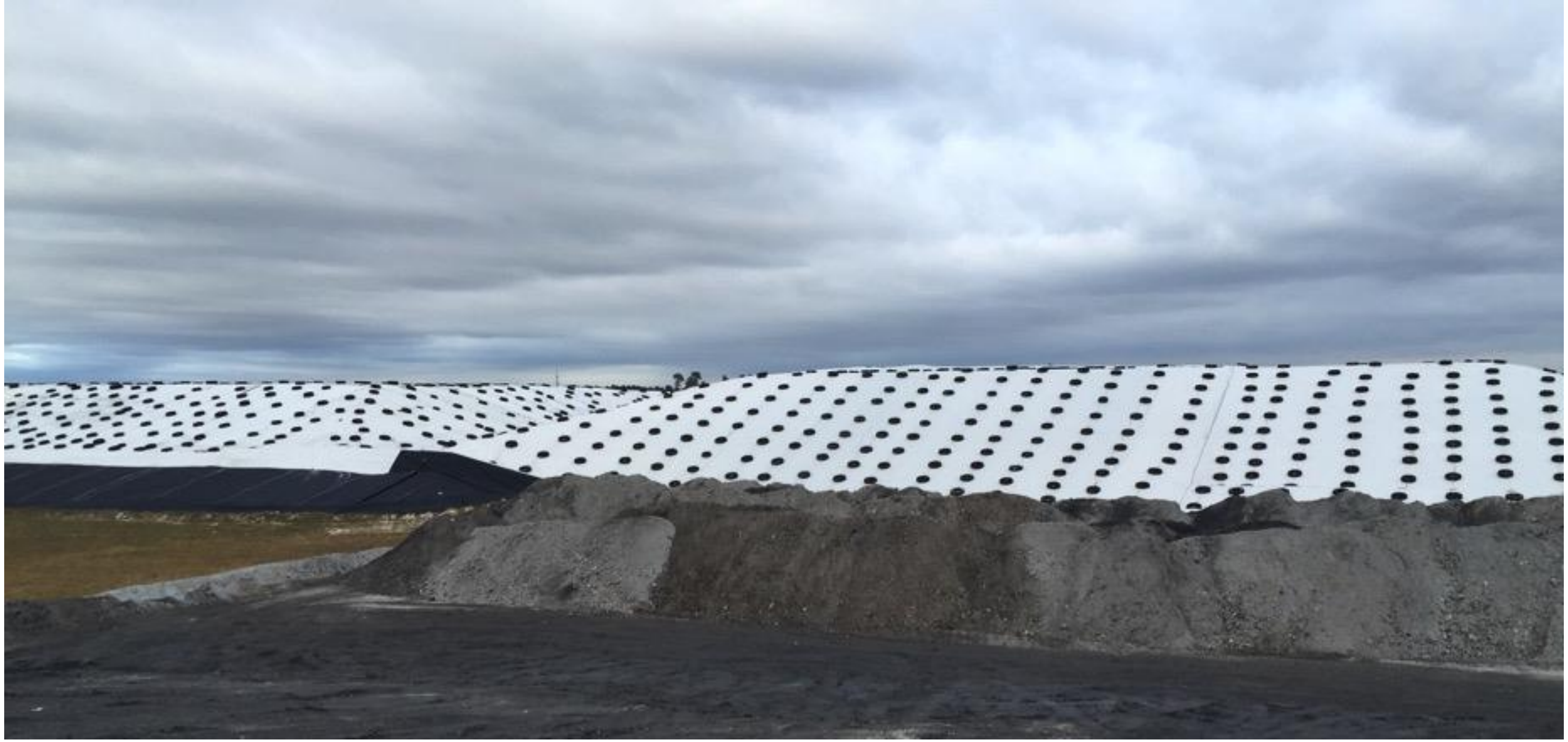


- Florida most of any state in U.S.
- Majority of plants active since early 1990's
- Represents 15-25% of MSW waste management in Florida
- Concentrated in areas of higher population with elevated land cost
- Approximately 1 million tons per year of ash residue produced
  - Landfilled/monofilled

Case Studies

Exploring Pathways Toward the Beneficial Use Applications of WTE / MSWI Ash

Pasco County Landfill

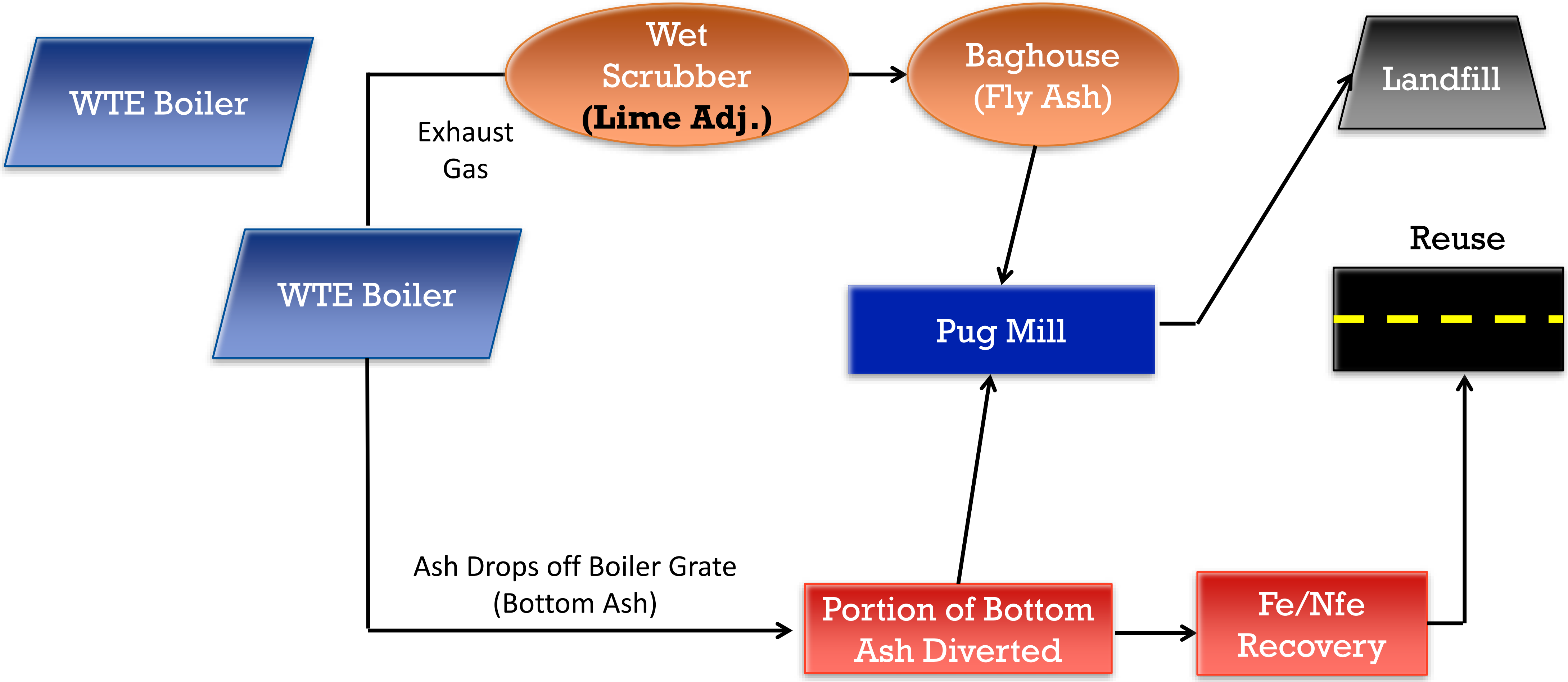


Background – WTE / MSWI

- Thermal treatment of waste:
  - Volume reduction (80%)
  - Power generation
  - Material recovery
  - Stable residues for reuse

- Waste-to-Energy (WTE) ash is the residual from the burning of municipal waste

Modified WTE Process – Ash Reuse



What are the benefits?

WTE Process

- Similar process to conventional fossil fuel power generation
- Waste heated in rotary grate boiler
- A bottom ash and an air pollution control residue are generated
  - 80% Bottom Ash
  - 20% Fly Ash
- Residues typically mixed and disposed
- Partitioning of heavy metals to fly ash
  - Goal is to characterize fly ash as non-hazardous

Bottom Ash

Fly Ash

WTE Process - Size Fractions

>3/8" Fraction

"Greater Than" Bottom Ash

< 3/8" Fraction

"Less Than" Bottom Ash

3/4” - 3/8” Aggregate Fraction

Elemental Composition – WTE / PC

Element	Portland Cement (Weight %)	WTE BA (Weight %)
Al	5-8	5-13
Ca	60-65	0-5
Cl	<1	0-4
Fe	0-5	0-5
Hg	<1	0-2
K	<1	0-4
Mg	<1	0-4
Na	<1	0-5
Si	20-25	5-20

Risk Analysis and Element Release

Toxicity Characteristic Leaching Procedure (TCLP)US EPA Method 1311

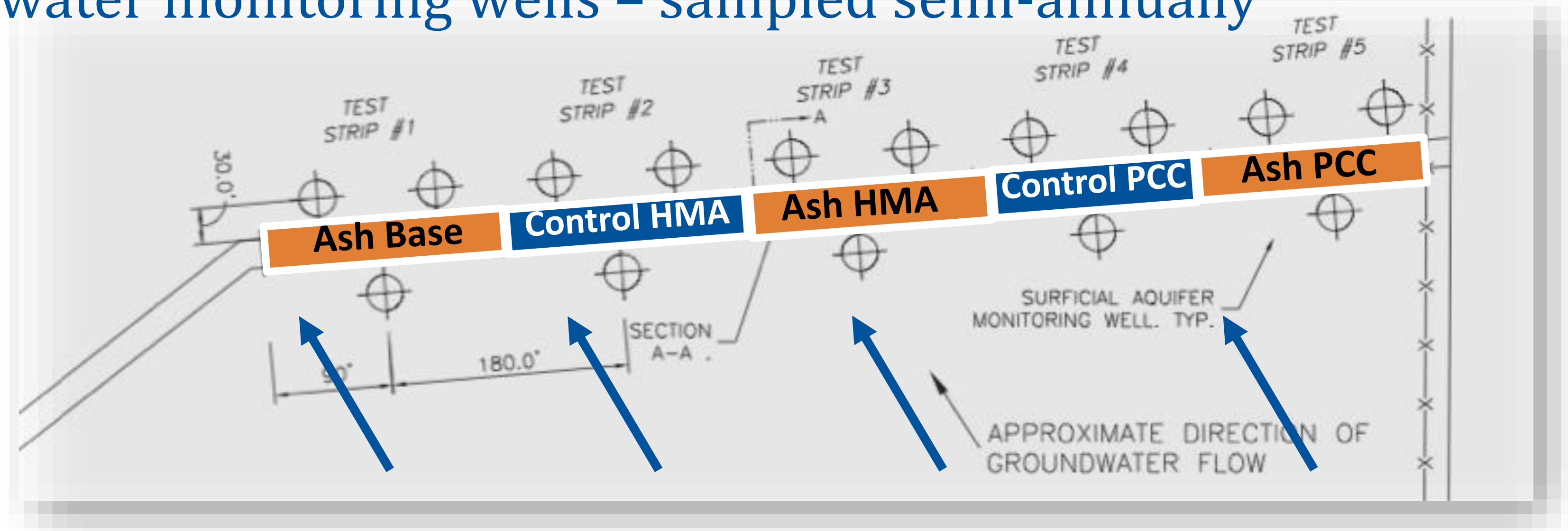
- Test to determine the mobility of both organic and inorganic analytes present in liquid, solid, and multiphasic wastes

- Basic Procedure
  - Separate Solid and Liquid Phases (no liquids present)
  - Particle size reduction to less than 10mm (if necessary)
  - Extraction fluids as determined by EPA method 1311 used.
  - Analyze using Ion Chromatography (IC-ICP-MS)

Pasco. Co Pilot Project – Test Strips and Monitoring

- Series of roadway test strips produced using processed bottom ash from the Pasco Co. WTE facility
  - Graded aggregate base
  - Aggregate in Hot Mix Asphalt (HMA)
  - Aggregate in Portland Cement Concrete (PCC)

- 15 groundwater monitoring wells – sampled semi-annually



Construction – Ash in Asphalt

Construction – Ash in PCC

Construction – Ash as a Road Base

Pasco. Co Pilot Project - Application

LEED & US GBC

Leadership in

Energy and

Environmental

Design

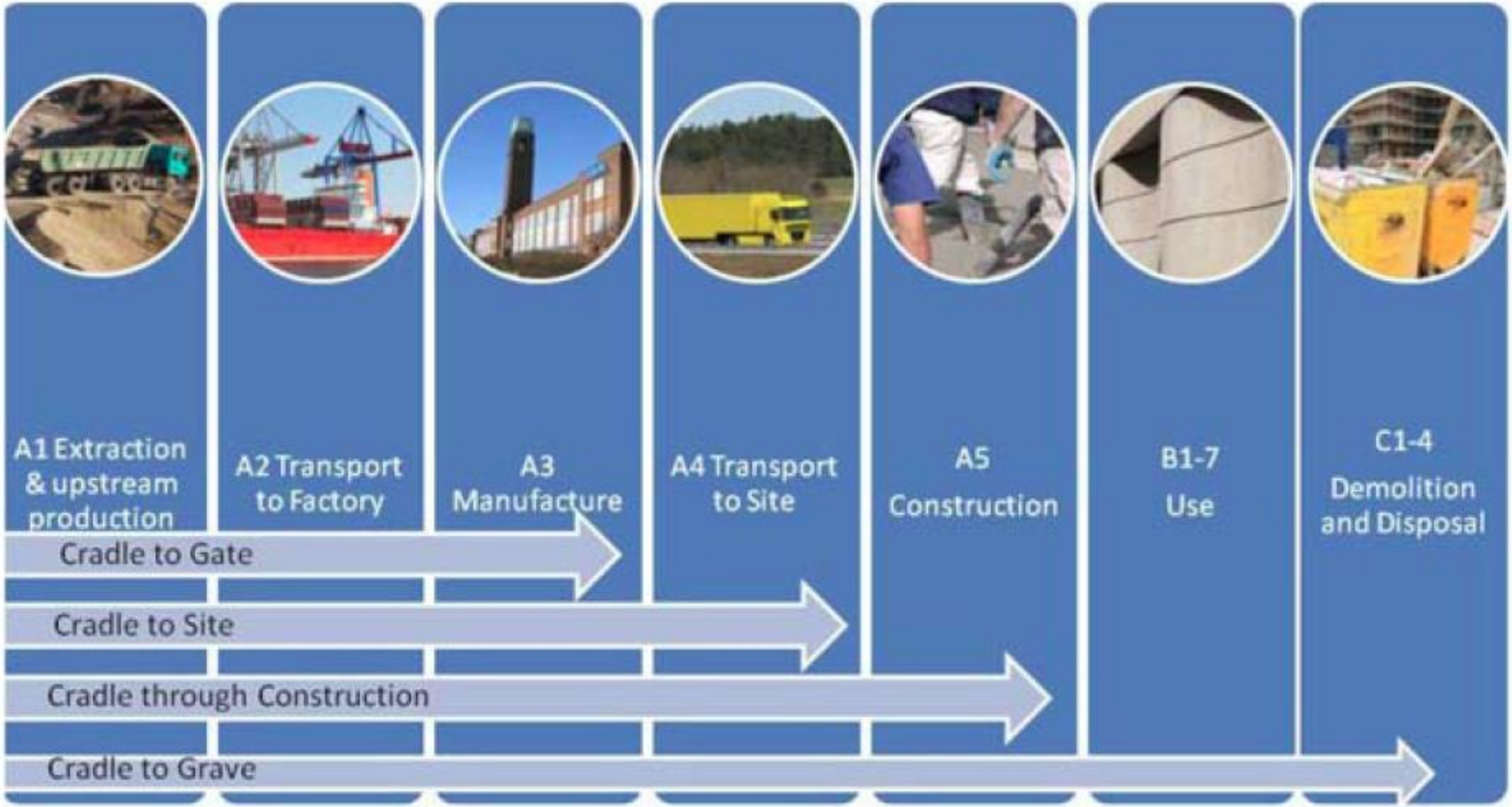
Basic Certification	Silver Certification	Gold Certification	Platinum Certification
40 -49 points	50 – 59 points	60 – 79 points	80 – 110 points

Major “Green” Marker Driver

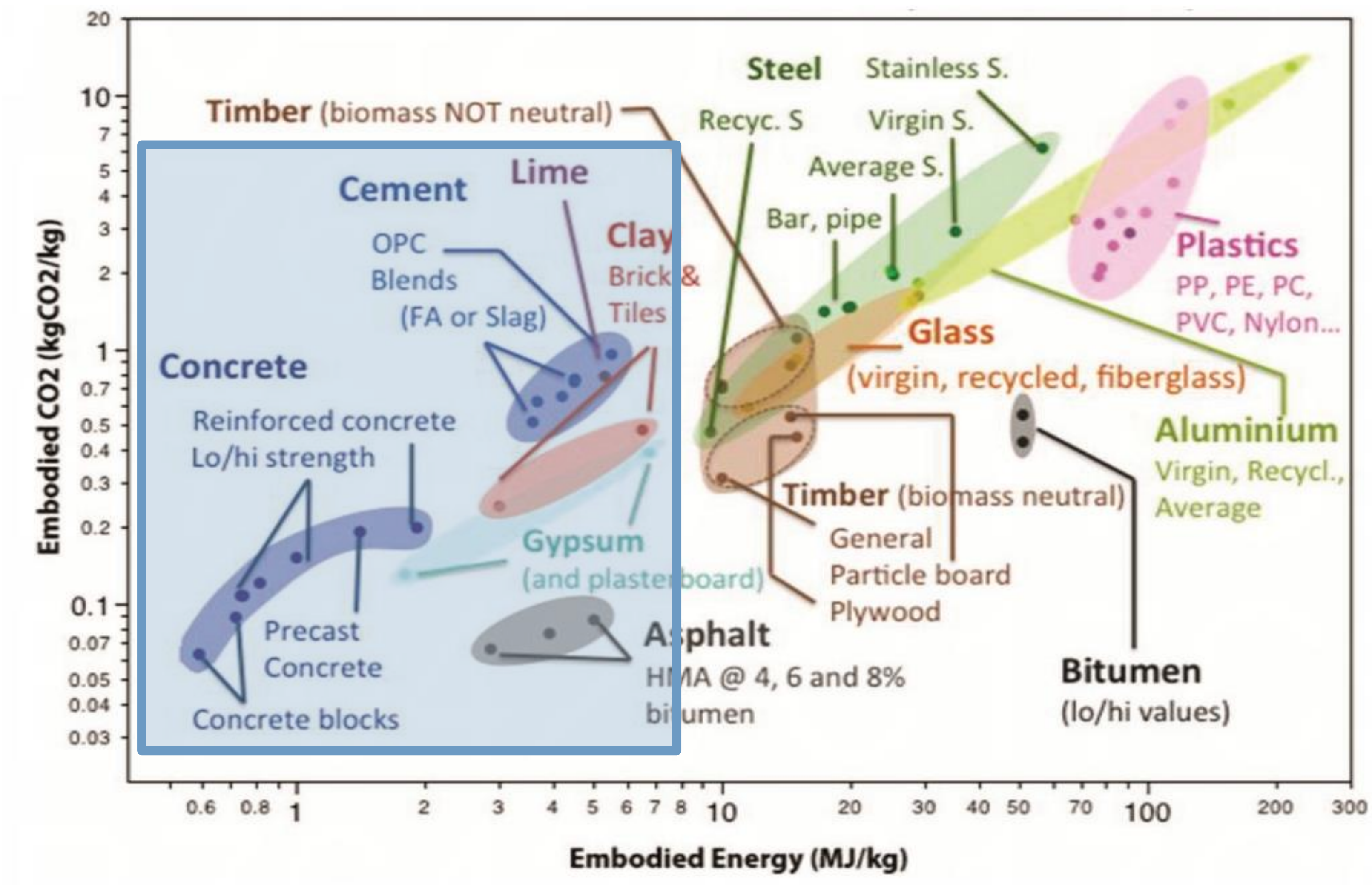
US Green Building Council

Mission: to promote the design and construction of buildings that are environmentally responsible, profitable, and healthy places to live and work.

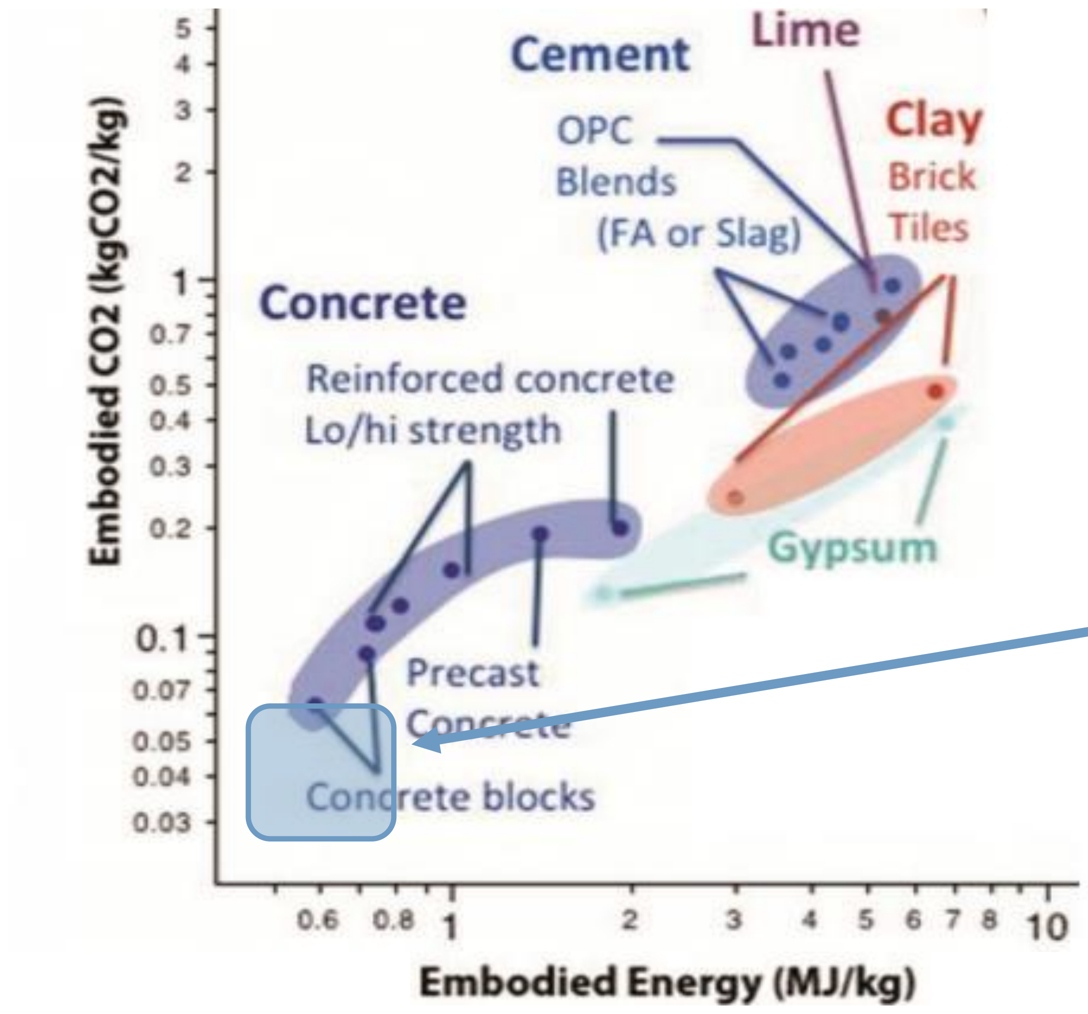
Product Category Rules – Functional Unit



Revisiting Embodied Energy – and Green Materials – ACI 130



Embodied Energy and Concrete's Role

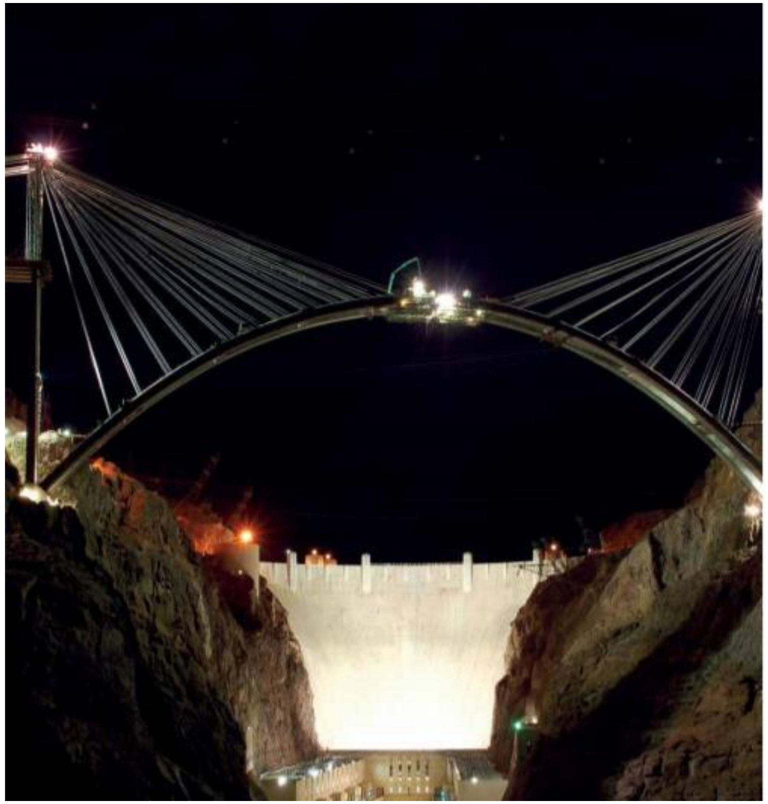


Approximate range for aggregates

ACI – 2019, Mitchell 2012

Resilience

Once the concrete is placed – what do we say about sustainability?



Resilience

Among the Ruins of Mexico Beach Stands One House, Built 'for the Big One'

The elevated house that the owners call the Sand Palace, on 36th Street in Mexico Beach, Fla., came through Hurricane Michael almost unscathed. Johnny Milano for The New York Times

Dr. Lackey said he and Mr. King, who jointly own the Mexico Beach house. They built the sand palace to withstand 250 mile-an-hour winds.
The house was fashioned from **poured concrete,** reinforced by **steel cables and rebar**, with additional concrete bolstering the corners of the house. The space under the roof was minimized so that wind could not sneak in underneath and lift it off.

"We're thinking that we need to build a house that would survive for generations," Dr. Lackey said.

https://www.nytimes.com/2018/10/14/us/hurricane-michael-florida-mexico-beach-house.html

Resilience

How much additional embodied energy will be required to rebuild the rest?

How much additional embodied energy was required to build this house?

https://www.nytimes.com/2018/10/14/us/hurricane-michael-florida-mexico-beach-house.html