Case Study
Sustainable Remedial Strategy for Treatment of Cement Kiln Dust

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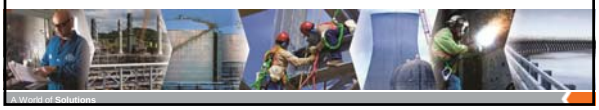


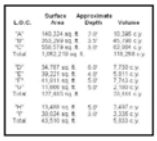
A World of Solutions

Presentation Outline

- What makes this an interesting project?
  - Local government and regulatory perspective
  - Two sustainable remedial strategies used
  - 7-year lapse in project
- Overview of presentation
  - Site background
  - What is cement kiln dust (CKD)?
  - Remedial screening process
  - Selected remedies
  - Remedial design
- Summary

Project Background

Site Conditions
- Site area approximately 160 acres
- Property undeveloped scrub bushes and trees
- Proposed site use residential and light retail
- Located next to cement plant that operated from 1951 to 1965



CKD

Cement Kiln Dust
- CKD trucked from plant to site and dumped in piles
- Piles above grade height range from 2 to 10 ft high
- Estimated volume approximately 150,000 cubic yards (CY)

What is CKD?

- Stack dust generated during cement manufacturing process
- Very fine grained, grayish white solid, becomes powder when dry, highly alkaline
- CKD initially calcium oxide reactivity, then transitions to inert substance
- Very low cohesive and shear strength
- Estimated 13 to 17 million short tons generated per year (EPA 2008)
- Potential uses in the past
  - Agricultural
  - pH buffering
  - Reused as feed material in cement manufacture

Regulatory Environment

- EPA classification
  - Solid waste
  - Exempt by Beville Amendment from RCRA Non-hazardous
  - Classified as a "Special Waste"
- Florida Department of Environmental Protection (FDEP) classification
  - Solid waste under Chapter 62-701 FAC
  - Assessment under Chapter 62-780 FAC

Site Assessment

Soil Assessment

- 23 samples collected at 20 locations for analysis aluminum, arsenic, beryllium, cadmium, copper, iron, lead, manganese, vanadium (Al, Ar, Be, Ca, Cu, Fe, Pb, Mn, V)
- AL, Cu, Pb and V exceeded Soil Cleanup Target Levels (SCTL) for direct exposure residential criteria as listed in Chapter 62-777 Florida Administrative Code (FAC)
- Leachability analysis Synthetic Precipitation Leaching Procedure (SPLP) reported AL, Fe, Pb exceedances

Groundwater Assessment

- Five shallow monitoring wells
- Analysis for 16 metals plus TDS and chlorides
- AL, Fe and Mn exceeded Groundwater Cleanup Target Levels (GCTLs) listed in Chapter 62-777 FAC
- Background well reported AL exceeding GCTL

Remedial Strategy Formulation

- Site goals
  - Cost effective strategy to manage CKD
- Strategies and technologies considered
  - Transport to Class 1 landfill as waste or blended for daily cover
  - Construct monofill and/or privacy berm
  - Blend with native soil for road base onsite/offsite
  - Offsite beneficial use
    - Bulk filler for asphalt or concrete manufacture
    - pH buffer agriculture
    - Road base
    - Waste water treatment plant buffering

Considerations

- Local government
  - "we don't want it in our county"
  - County landfill option out and neighboring landfill out
- Project coordination with FDEP (waste cleanup and solid waste)
  - Several options permissible
- Waste volume large – high transportation costs
- Low metal concentrations prohibit any agricultural use
- CKD over 50 years old has become inert, no concrete/asphalt facility would accept
- CKD in wooded area, separation from organics difficult
- Economy – housing slump
- Client change

Remedial Strategy – What's left?

Remaining strategies

- Blend CKD into road base
  - Bench scale testing for mix design
  - Analytical testing for leaching
  - Geotechnical testing
  - Regulatory approval
- Transport to "out of county" landfill as waste or daily cover
  - Easy regulatory approval
  - Costly - estimated over $5M

Bench Scale Testing

Objective: optimize blend of on-site material and CKD that will provide superior geotechnical properties and pass SPLP leaching test

- Mix design considerations
  - Onsite material; granular unconsolidated sand, organic sand and coquina shell
  - Limited onsite material – restricting mix ratio
  - Mix based on volumetric measurement
- Bench scale test
  - Physical properties testing
  - Initial test ratios; CKD to onsite material – 10/90, 30/70 and 50/50
    - Ratio of 50/50 appeared viable from initial testing
    - Ten additional 50/50 mixtures tested

50/50 Ratio SPLP Test Results

The table below summarizes detections above regulatory standards for the 23 metals analyzed

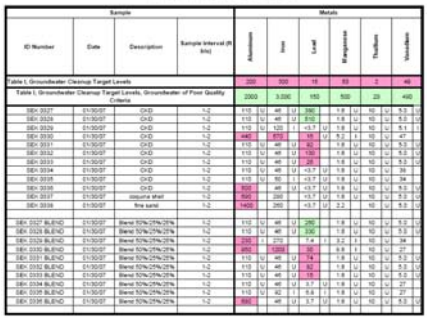
BENCH SCALE BLENDING ANALYSIS 50/50 MIX

	Aluminum	Manganese	Lead	Antimony	Thallium
Table I, Groundwater (TL (mg/L)	0.2	0.05	0.015	0.006	0.002
Table I, Groundwater (TL (GW of Poor Quality Criteria (mg/L)	2	0.5	0.15	0.06	0.02
*SCTLs for Direct Exposure Residential Criteria (mg/kg)	80000	3900	400	27	6.1
*SCTLs for Commercial/Industrial Criteria (mg/kg)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
** SCTLs for Leachability GW Leachability Poor Quality Criteria (mg/kg)	n/a	n/a	n/a	54	26
GRAND HAVEN MIX 1	1599	18.75	63.771	0.264	<1.00
GRAND HAVEN MIX 1 (TCLP)	<0.35	0.1189	<0.010	<0.010	0.0106
GRAND HAVEN MIX 2	2818	16.3	70.1	<1.65	<1.50
GRAND HAVEN MIX 2 (TCLP)	6.95	0.019	<0.10	<0.050	<0.050

Notes:
SCTLs = Selected Soil Cleanup Target Levels
* = SCTLs for Direct Exposure Residential, Chapter 62-777, Table II, Florida Administrative Code
** = SCTLs for Direct Exposure Industrial, Chapter 62-777, Table II, Florida Administrative Cod
*** = SCTLs for Leachability based on Groundwater Criteria, Chapter 62-777, Table II, Florida Administrative Code
?= Constituents have no published RfD or CSF
Shaded cells indicate SCTL or GCTL exceedances

50/50 Ratio SPLP Test Results

SPLP ANALYTICAL RESULTS



Remedial Strategy – Blending CKD

FDEP approved blending remedial strategy

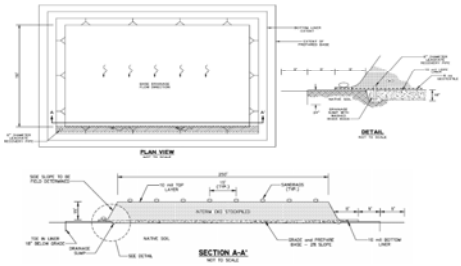
- Blend 50/50 ratio of CKD and onsite material
- Place blended material as road and retail parking base
- Lined berms account for remaining CKD
- Confirmation testing on a 50 ft grid over CKD stock pile area

DESIGNATED AREA	ROADWAY LINEAL FOOTAGE (feet)	VOLUME OF BLENDED MATERIAL(yd³)
Grand Reserve West	10,000	35,556
Grand Reserve East	7,500	30,000
Manna Village	5,000	17,778
Beach Park Village	5,000	17,778
Robert Road Reconstruction	6,000	21,333
TOTAL	33,500	122,445

Interim Storage

Extension of road through CKD

- Design interim storage cell for up to 20,000 CY storage
- FDEP approved plan and was constructed



Interim Storage Cell




Change of Remedial Strategy

- New client – new direction
  - Objective: design CKD monofill to become community park
  - FDEP approved CKD monofill concept, but provided several comments
    - Confirmation testing
  - Analysis required for monocell design
    - Slope stability analysis
    - Bench scale testing
      - Optimum moisture content
      - Field capacity
      - Moisture content
    - Derive field confirmatory protocol
    - Rudimentary stormwater
    - Geotechnical (shear, bearing, optimum moisture)

Bench scale Testing

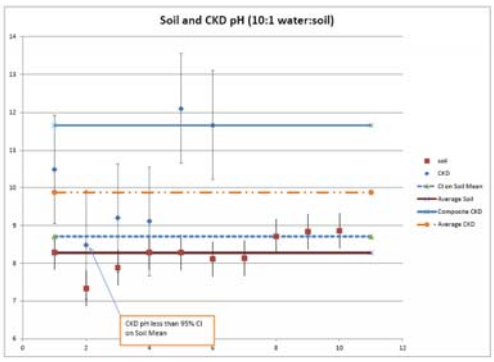
Objective: Evaluate a field test that could confirm the presence of CKD

Benefit: Reduce analysis turn-around time and costs

Procedure

- Collected CKD and site soil to determine physical properties
- Analytical testing for previously detected metals all samples
- Evaluate minimum criteria where CKD could be present
- Generate protocol for testing

Bench Scale Testing Results



Bench Scale Testing

SOIL ANALYTICAL RESULTS

Sample ID Number	Sample Type/ Description	CKD Zone	Date	Aluminum	Copper	Iron	Lead	Manganese	Vanadium
*SCTLs for Direct Exposure Residential Criteria (mg/kg)				80,000	150	52000	400	3,500	67
**SCTLs for Leachability Based Industrial Criteria (mg/kg)				*****	80,000	*****	1,400	43,000	10,000
SBX 8724	CKD 1	Fly Center	01/29/13	4320	71	5,630	274	53.1	42.5
SBX 8719	CKD 2	3	01/29/13	6010	84.4	9440	547	80.3	74.8
SBX 8718	CKD 3	2	01/29/13	1080	6.09	1270	35.2	12.2	3.14
SBX 8719	CKD 4	1	01/29/13	10800	125	12200	529	93.6	181
SBX 8725	CKD 5	3	01/29/13	6530	113	10300	306	94.9	59.4
SBX 8726	Soil 1		01/29/13	355	0.300 U		0.556	4.37	0.956
SBX 8718	Soil 2		01/29/13	414	0.39		0.330 U	6.03	1.09
SBX8717	Soil 3		01/29/13	485	0.679		1.76	4.56	0.749
SBX 8720	Soil 4		01/29/13	448	0.648		0.518	5.44	1.19
SBX 8712	Soil 5		01/29/13	574	0.631		0.758	6.54	1.27
SBX 8713	Soil 6		01/29/13	478	0.289 U		0.305	5.55	1.18
SBX 8714	Soil 7		01/29/13	303	0.440 U		2.81	2.28	0.310 U
SBX 8721	Soil 8		01/29/13	429	0.295 U		0.493	4.81	1.07
SBX 8722	Soil 9		01/29/13	456	0.295 U		0.345	5.33	1.26
SBX8723	Soil 10		01/29/13	515	0.295 U		0.445	4.64	1.14

Bench Scale Testing Results

SPLP ANALYTICAL RESULTS

Sample ID Number	Sample Type/ Description	CKD Zone	Date	SPLP Metals ug/L Aluminum	Copper	Lead	Iron	Manganese	Vanadium
***Act TCLs for Leachability Based on Groundwater Leachability Criteria (ug/L)				200	1,000	15	300	50	49
SBX 8724	CKD 1	Fly Center	01/29/13	404	11.7	2.50 U	V	1.20 U	14.8
SBX 8719	CKD 2	3	01/29/13	7430	31.9	257	3940	26.1	62
SBX 8718	CKD 3	2	01/29/13	1630	2.40 U	73.8	880	14.3	7.40 U
SBX 8719	CKD 4	1	01/29/13	9.50 U	2.40 U	2.50 U	12	1.20 U	112
SBX 8725	CKD 5	3	01/29/13	9.50 U	2.40 U	34.0	57	1.20 U	7.40 U
SBX 8726	Soil 1		01/29/13	329	2.40 U	2.50 U		4.00 J	7.40 U
SBX 8718	Soil 2		01/29/13	454	2.40 U	2.50 U		7.7	7.40 U
SDX8717	Soil 3		01/29/13	728	2.40 U	2.50 U		4.20 J	7.40 U
SBX 8720	Soil 4		01/29/13	562	2.40 U	2.50 U		3.70 J	7.40 U
SBX 8712	Soil 5		01/29/13	1080	2.40 U	2.50 U		5.9	7.40 U
SBX 8713	Soil 6		01/29/13	556	2.40 U	2.50 U		4.90 J	7.40 U
SBX 8714	Soil 7		01/29/13	39.7	2.40 U	2.50 U		1.20 U	7.40 U
SBX 8721	Soil 8		01/29/13	468	2.40 U	2.50 U		4.10 J	7.40 U
SBX 8722	Soil 9		01/29/13	724	2.40 U	2.50 U		5	7.40 U
SDX8723	Soil 10		01/29/13	624	2.40 U	2.50 U		5	7.40 U

Bench Scale Testing Conclusions

Conclusions:

- CKD could be grouped in four categories based on results of alkalinity, density and field capacity
- Large range in pH and alkalinity in CKD
- CKD and site soil overlay in pH range
- Proposed field pH testing
  - Four tests per acre
  - pH less than 8.1 Standard Units (SU) no CKD present
  - pH greater than 9 SU assume CKD
  - pH between must be analytically tested for lead and vanadium
- Aluminum naturally occurring in site soils
- Field water capacity greater than in-situ moisture
- CKD categories will be combined according to create optimum physical properties

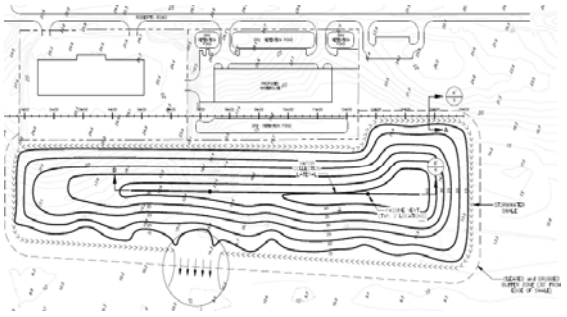
Monocell Design

Objective: Create visually appealing yet functional cell design

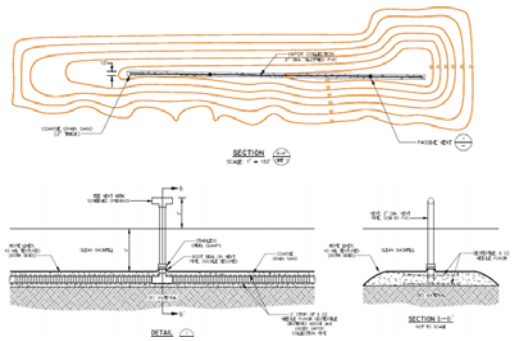
Design Considerations:

- Large enough to contain all CKD including interim storage
- Placed at least desirable location
- Optimize height and footprint
- Flowing lines and shape so activities can be performed onsite
  - General community park
  - Dog park
  - Fitness park
  - Skateboard/bike park

CKD Monocell Design



Monocell Design



Project Summary

Summary:

- Two remedial strategies developed
  - Engineered bleeding of CKD and site soil to create road base
  - Monocell encapsulation that becomes a park
- One interim management strategy – interim storage cell
- Bench scale testing to understand the impacted waste
- Analysis indicated problematic constituent (aluminum) as naturally occurring

Benefits

- Community park for multiple uses
- Reduced costs for remedial action
- Does not reduce landfill space