Geocell: When Nothing Else Will Do

Closure Application for Steep Slopes, Earthquake Zone 4 and Hurricane Conditions

Designer: Geo-Logic Associates, Grass Valley, CA
Solid Waste Management Consultant and Project Management:
Gershman, Brickner & Bratton, Inc. (GBB)

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Chris Lund, P.E., PSS
GBB Senior Vice President

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Agenda

1. Introduction of Guam/Dump Background
2. Existing Site Conditions and Constraints
3. Investigation/Design/Cover Evaluation/Selection
4. Cover System
5. Construction/Difficulties
6. Questions

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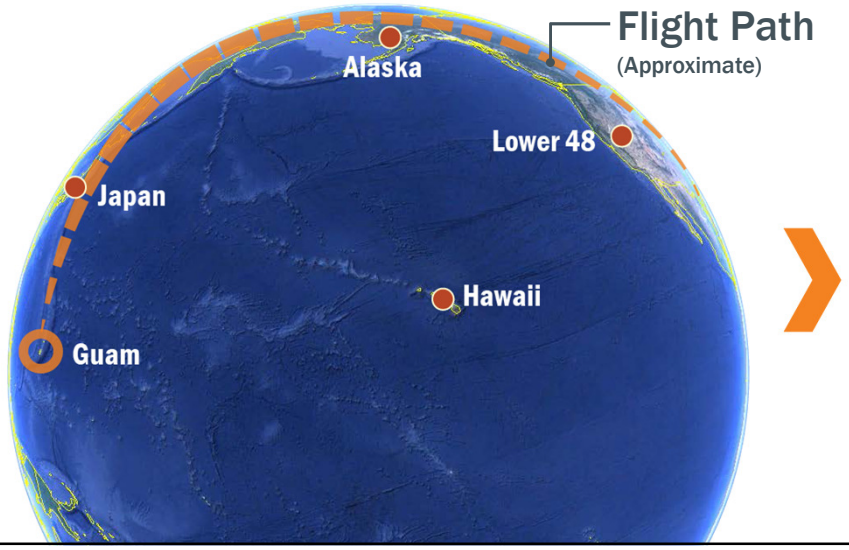
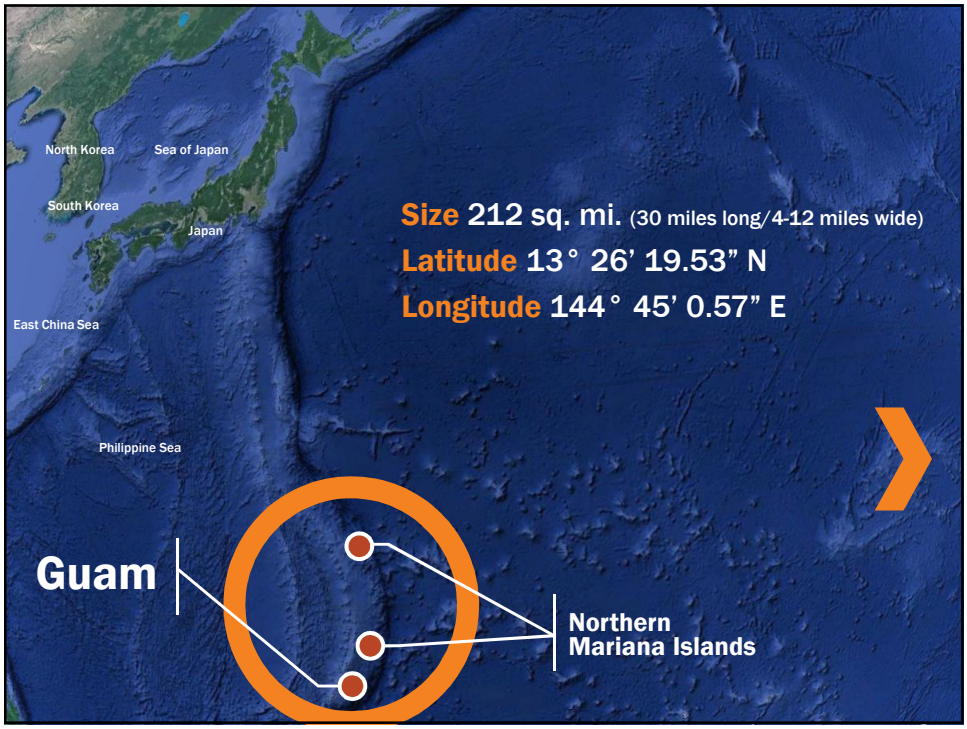
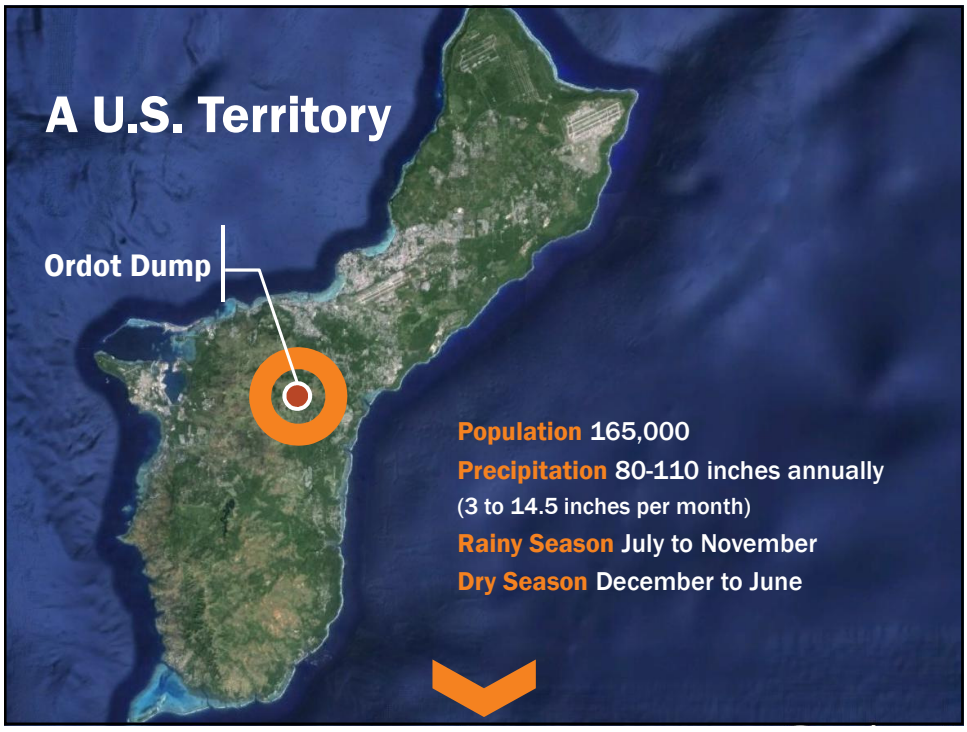
Where is Guam?




North Korea
Sea of Japan
South Korea
Japan
East China Sea
Philippine Sea
Size 212 sq. mi. (30 miles long/4-12 miles wide)
Latitude 13° 26' 19.53" N
Longitude 144° 45' 0.57" E
Guam
Northern Mariana Islands


A U.S. Territory
Ordot Dump
Population 165,000
Precipitation 80-110 inches annually
(3 to 14.5 inches per month)
Rainy Season July to November
Dry Season December to June

Background

- 43.5 acre unlined disposal facility
- Operated since World War II
- Ceased operations in 2011
- On the National Priorities list under CERCLA
- Came under Federal Receivership
- Guam is in US EPA Region 9

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Existing Site Conditions

- Unlined dump with minimal cover soil
- Over steepened waste slopes (as steep as ½ (horz) to 1 (vert))
- Numerous leachate seeps
- Uncontrolled landfill gas migration
- Encroachment into wetlands

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Detailed Site Investigation/Closure Design

- Site geologic/hydrogeologic evaluation
- Groundwater/landfill gas investigation and monitoring
- Waste limits evaluation
- Stormwater analyses
- Cover System Evaluation

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Cover System Evaluation

Regulatory Overview:

- Under Guam Environmental Protection Agency oversight
- Adopted CFR Title 40, Part 258 Regulations
- Prescriptive final cover to provide a $\leq 1 \times 10^{-5}$ cm/sec barrier layer
- May approve alternative cover with equivalency

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Factors Considered in the Analysis

- Final waste limits
- Dump geometry/grading
- Stormwater control and management facilities
- Highest seismicity, (Zone 4) and high winds/precipitation (175 mph/95 inches/yr)
- Erosion
- Landfill gas and leachate generation
- Costs – Long term maintenance
- End-use goals

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Final Cover Alternatives

- Prescriptive soil cover system
- Exposed geomembrane system
- Covered Geomembrane system (soil/geocell covered)

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Prescriptive Soil Cover System

From top to bottom:

- 6-inch-thick erosion layer,
- 18-inch-thick low permeability layer ($k \leq 1.0 \times 10^{-5}$ cm/sec),
- 12-inch-thick foundation layer

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Alternative Exposed Geomembrane System

From top to bottom:

- Top-deck and Benches:24-inch-thick erosion/protection layer (coral sand/gravel)
- Side slopes: Geogrid to support vegetation
- Geocomposite drainage/protection layer
- Geomembrane layer
- Geocomposite landfill gas/leachate interception layer
- 12-inch-thick soil foundation layer

Also considered Closure Turf ®

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Alternative Covered Geomembrane System (Soil/Geocell Covered)

From top to bottom:

- Top-deck:24-inch-thick erosion/protection layer (coral sand/gravel)
- Side slopes: 6- to 8-inch thick erosion/protection layer (geocell with coral sand/gravel infill)
- Geocomposite drainage/protection layer
- Geomembrane layer
- Geocomposite landfill gas/leachate interception layer
- 12-inch-thick soil foundation layer

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EQUIVALENCY DEMONSTRATION

HELP MODEL RESULTS

Simulated Cover System	Cover Percolation/Leakage Predictions (Inches/Yr.)					
	Year 1	Year 2	Year 3	Year 4	Year 5	Average Annual
Prescriptive Soil Cover	57.6	63.1	44.9	44.0	59.2	53.8
Alternative Geomembrane Cover (with Soil Cover)	2.3	2.4	1.8	1.9	2.2	2.1

Selection of Final Cover System

Selected: Soil/Geocell covered geomembrane

- Superior leakage protection versus prescriptive cover
- Superior erosion protection versus prescriptive cover
- Superior wind/puncture resistance versus exposed cover
- Lower long term maintenance versus other cover options
- Requires re-grading of existing waste slopes

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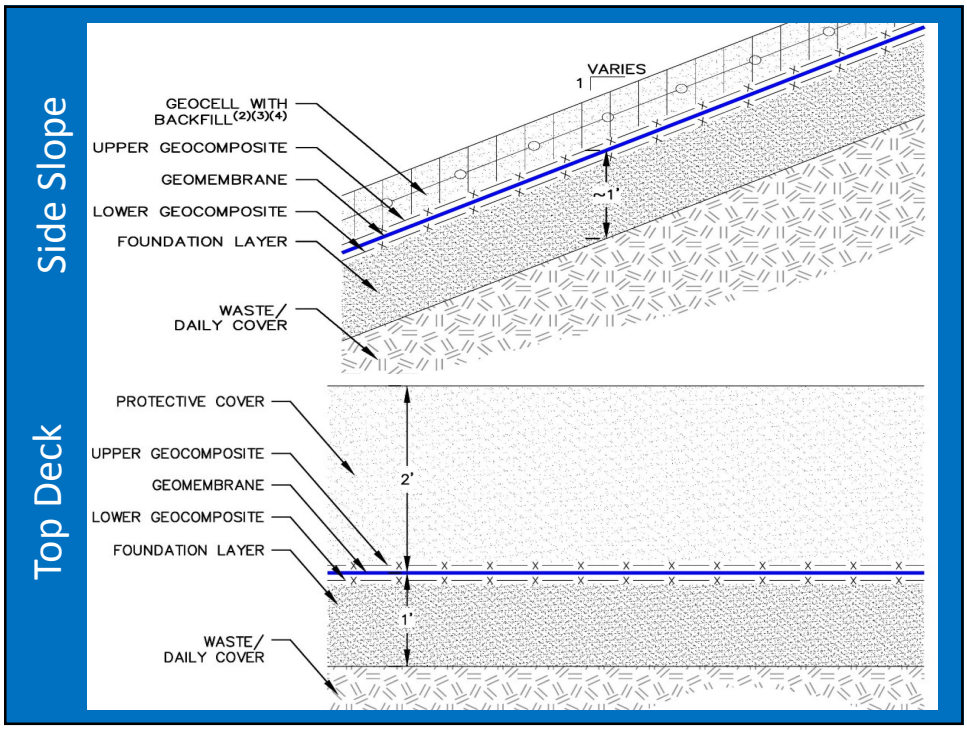

Geocell design parameters

- 8-inch thick geocell used on upper slopes for wind uplift
- 6-inch thick geocell used on lower slopes
- Kevalar® tendons used for stability on slopes steeper than 2.5 (horz) to 1 (vert)
- Polyester tendons used on slopes flatter than 2.5 to 1
- Concrete filled geocell used in stormwater collection channels for differential settlement

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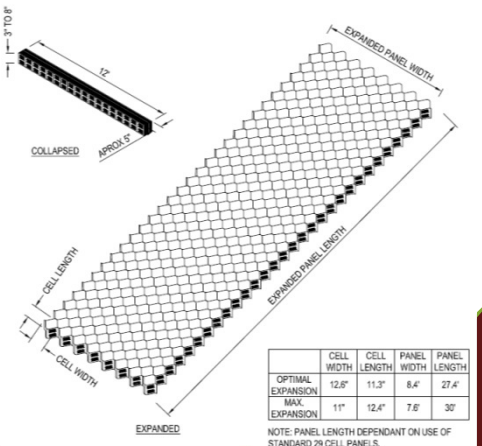
Geocell material and physical properties

- 50-60 mil thick HDPE sheets welded into panels
- 12in x 11in nominal expanded cell size
- 8ft x 27ft nominal expanded panel size



	CELL WIDTH	CELL LENGTH	PANEL WIDTH	PANEL LENGTH
OPTIMAL EXPANSION	12.5"	11.3"	8.4'	27.4'
MAX. EXPANSION	11"	12.4"	7.6'	30'

NOTE: PANEL LENGTH DEPENDANT ON USE OF STANDARD 29 CELL PANELS.

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Geocell construction aspects

- Geocell is initiated at each bench from an anchor of 2-inch schedule 80 PVC pipe to which tendons are tied. Bench geocell is infilled and then first few rows of geocell filled with concrete as anchor for geocell deployment.
- Geocell deployed in panels with tendons weaved through each panel and panels side by side stapled together with stainless steel staples.
- Geocell panels and tendons are deployed together and installed downslope to next bench.
- At each toe of slope, the terminal edge of geocell panels is concrete filled just above the stormwater channel completing the system.

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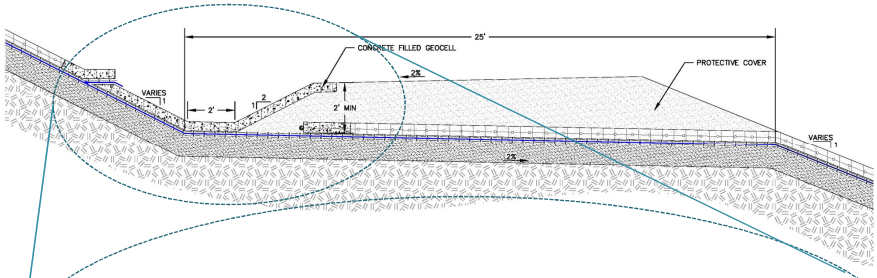
Geocell Details



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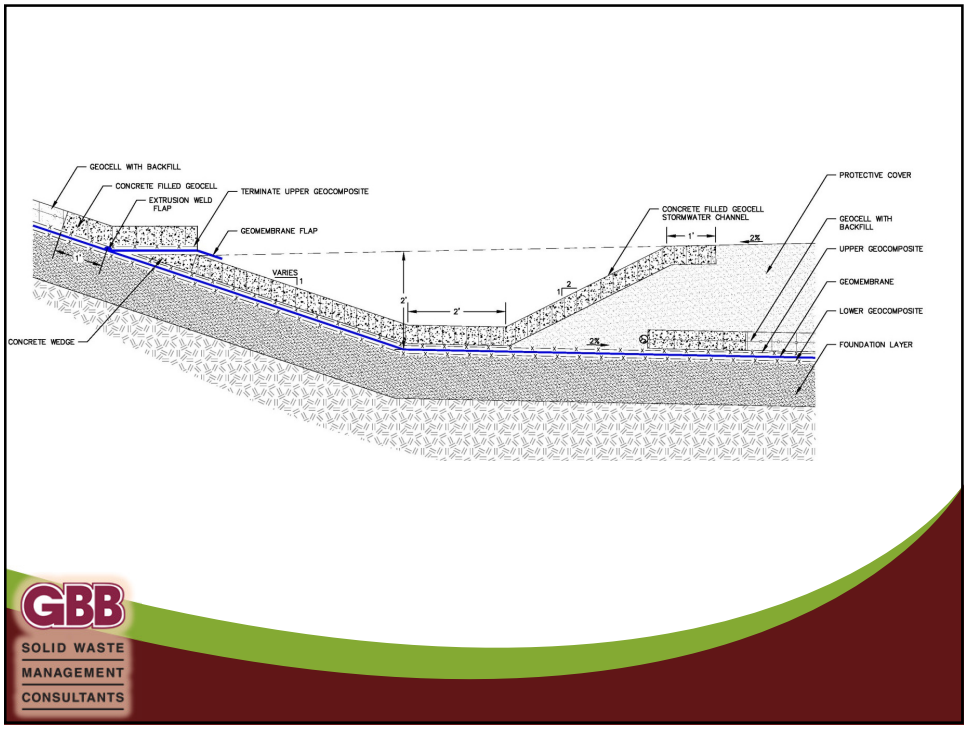
GEOCELL WITH BACKFILL
CONCRETE FILLED GEOCELL
EXTRUSION WELD FLAP
TERMINATE UPPER GEOCOMPOSITE
GEOMEMBRANE FLAP
VARIES
CONCRETE WEDGE
CONCRETE FILLED GEOCELL STORMWATER CHANNEL
PROTECTIVE COVER
GEOCELL WITH BACKFILL
UPPER GEOCOMPOSITE
GEOMEMBRANE
LOWER GEOCOMPOSITE
FOUNDATION LAYER
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Benefits of using Geocell in Final Cover

- Enhanced erosion control
- Steeper waste slopes acceptable
- Use of tendons enhance veneer stability
- Protection of geomembrane from wind uplift/damage
- High tolerance to differential settlement
- Ability to mitigate high precipitation/pore pressure build-up in cover soil

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Geocell construction difficulties

- Placing coralline infill on long slopes
- Anchoring geocell on downslope ridges
- Width of access benches made installation more difficult
- Forming geocell at toe of benches to construct concrete filled stormwater channels

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QUESTIONS

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