Design and Construction of Farmers Dam

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Virginia Lakes & Watersheds Association
Virginia Water Conference
March 13 – 15, 2016

DoubleTree by Hilton, Richmond-Midlothian
‘Falkenmark indicator’ or ‘water stress index’.

- It defines water scarcity in terms of the total water resources that are available to the population of a region; measuring scarcity as the amount of renewable freshwater that is available for each person each year.
If the amount of renewable water in a country is

- < 1,700 m$^3$/p/yr, that country is said to be experiencing water stress;
- < 1,000 m$^3$/p/yr - water scarcity;
- < 500 m$^3$/p/yr - absolute water scarcity
“Water Scarce” Country

- UN Water Commission Benchmark for Water Scarcity
  - 1000m³/p/yr

- Barbados
  - 210m³/p/yr
  - Classified as Absolutely Water Scarce Country
Water Resources

- No Naturally Occurring Fresh Water Bodies/Sources
- Few Spring-Fed Streams
- Several Watersheds
- High Annual Rainfall
  - 1016 mm to 1524 mm (40 – 60 inches)
  - Generally lost to the ocean with very little water harvesting
Farmers Plantation

- Located about 12 km from Bridgetown
Farmers Plantation

16 Acres of Rolling Hillside
Farmers Plantation

- Topography Ranges from
  - EL 240m to 260m
Farmers Plantation

- Two Spring-Fed Streams
Why Dam at Farmers Plantation

- New Development to spur growth
- Source for feeding the water needs for the New Development
- Recreation
  - All Pointed to Apes Hill and other future development
Engineers

- Stantec – H&H Engineers
  - Determined Suitability for Impoundment with initial capacity of about 190,000 m³
- Stantec – Structural Engineers
  - Spillway Design
- KCI Technologies, Inc – Geotechnical Engineers
  - Embankment Design and Construction Oversight
General Geology

- Oceanic Sediment
  - Marine, highly organic Sediments
  - Coral
Subsurface Exploration Plan
Subsurface Exploration
Subsurface Exploration
Recovered Samples
Laboratory Program

- Specific Gravity
- Organic Content
- Natural Moisture Content
- Soil Classification
  - Atterberg Limits
  - Sieve Analysis
- Standard Proctor
- 1-D Consolidation
- Unconsolidated Undrained Triaxial
- USDA
- California Bearing Ratio
- Permeability
Dam Geometry

- Crest Width – 6 meters
- Dam Length – 250 meters
- Crest Elevation – EL 250 m asl (8-m high)
- Upstream Slope – 4H: 1V
- Downward Slopes – 3H:1V
- Concrete Spillway (Pipe) with Riser
  - Equipped with Non-Rising Screw Spindle
- Clay-Coral embankment with HDPE Liner
Dam Features and Appurtenant Structures

- Armored Sloped Embankment
- Dam Service Road
- Culvert No. 1 Extension
- Culvert No. 2 Extension
- Principal Spillway
- Pump Station and Water Transfer Pipe
- Existing Roadway Improvements
Evaluations

- Dam Geometry
- Seepage Evaluations
- Settlement Analysis
- Stability Evaluations
Dam Geometry
Planimetric View of Site

Legend:
- Soil Boring
- Test Pit
- Proposed Coral-Clay Removal Area
- Site Boundary of Water Impoundment
- Proposed Impoundment Area
Subsurface Profiles  Section C-C’

CROSS SECTION B-B'  
SCALE 1:200

CROSS SECTION C-C'  
SCALE 1:200
Subsurface Profiles  Section D-D’
### Estimated Settlement

<table>
<thead>
<tr>
<th>Cross Section</th>
<th>$S_i$</th>
<th>$S_c$</th>
<th>$S_s$</th>
<th>$S_{total\ (inch)}$</th>
<th>$S_{tot\ (mm)}$</th>
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<tbody>
<tr>
<td>A-A’</td>
<td>0.76</td>
<td>23.43</td>
<td>0.41</td>
<td>24.60</td>
<td>624.8</td>
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<td>B-B’</td>
<td>0.60</td>
<td>19.96</td>
<td>0.25</td>
<td>20.81</td>
<td>528.6</td>
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<td>C-C’</td>
<td>0.43</td>
<td>16.31</td>
<td>0.19</td>
<td>16.91</td>
<td>429.4</td>
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Foundation footprint to be undercut and replaced with compacted clay-coral composite
Seepage Analysis Case 1 – No Concrete Spillway
Seepage Analysis Case 2 - With Concrete Spillway and Bedding
Seepage Analysis Case 3 — Concrete Spillway, No Bedding
# Seepage Analyses - Results

<table>
<thead>
<tr>
<th>Model</th>
<th>Permeability Of Bedding Material</th>
<th>Flow Rate per Linear ft of Dam</th>
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<tbody>
<tr>
<td></td>
<td>cm/sec</td>
<td>Gals/day</td>
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<tr>
<td>Without Spillway</td>
<td>-</td>
<td>6.44</td>
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<tr>
<td>With Spillway No Bedding</td>
<td>-</td>
<td>6.59</td>
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<tr>
<td>With Spillway and Bedding</td>
<td>1.00E-03</td>
<td>22.17</td>
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<td></td>
<td>1.00E-04</td>
<td>17.29</td>
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Slope Stability  End of Construction  
Minimum FS = 1.3

<table>
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<tr>
<th>Analysis Condition</th>
<th>Minimum of FS</th>
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<tr>
<td>Two-Zone Dam A-A’, Downstream Slope</td>
<td>1.85</td>
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<tr>
<td>Impoundment Slope, D-D’</td>
<td>2.24</td>
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<tr>
<td>Impoundment Slope, E-E’</td>
<td>1.54</td>
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<tr>
<td>Impoundment Slope, F-F’</td>
<td>1.98</td>
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### Slope Stability Long-Term Steady State Conditions

**Minimum FS = 1.5**

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<th>Minimum of FS</th>
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<tr>
<td>Two-Zone Dam A-A’, Downstream Slope</td>
<td>1.48</td>
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<tr>
<td>Impoundment Slope, D-D’</td>
<td>2.33</td>
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<tr>
<td>Impoundment Slope, E-E’</td>
<td>1.89</td>
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<tr>
<td>Impoundment Slope, F-F’</td>
<td>2.22</td>
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Rapid Drawdown
Minimum FS = 1.1

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<th>Analysis Condition</th>
<th>Minimum of FS</th>
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<td>Two-Zone Dam A-A’, Downstream Slope</td>
<td>1.75</td>
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<tr>
<td>Impoundment Slope, D-D’</td>
<td>1.88</td>
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<tr>
<td>Impoundment Slope, E-E’</td>
<td>1.53</td>
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<tr>
<td>Impoundment Slope, F-F’</td>
<td>1.93</td>
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Seismic
Minimum FS = 1.1

<table>
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<th>Analysis Condition</th>
<th>Minimum of FS</th>
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<tr>
<td>Two-Zone Dam A-A’, Downstream Slope</td>
<td>1.21</td>
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<tr>
<td>Impoundment Slope, D-D’</td>
<td>1.48</td>
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<tr>
<td>Impoundment Slope, E-E’</td>
<td>1.15</td>
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<tr>
<td>Impoundment Slope, F-F’</td>
<td>1.76</td>
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