Overview

Modeling Approach

Outlet 1 – Rectangular Section
Outlet 2 – Trapezoidal 6 ft Bottom Width Section
Outlet 3 – Trapezoidal 2 ft Bottom Width Section
Conclusion

Agenda

- Overview
- Modeling Approach
  - Outlet 1 – Rectangular Section
  - Outlet 2 – Trapezoidal 6 ft Bottom Width Section
  - Outlet 3 – Trapezoidal 2 ft Bottom Width Section
- Conclusion
Overview
- Background
- Weir vs Channel
- Expectations
- Limitations
- Goals

Modeling Approach

Pond Configuration
- Earthen Detention Pond
  - 3:1 side slopes
  - Surface Area = 0.70 ac
- Stage-Storage Rating Curve developed
- Outlet Configurations
  - Rectangular
  - Trapezoidal
  - Trapezoidal

![Elevation Storage Curve](image)
Basic Equations

- **Weir Equation:** \( Q_{\text{weir}} = CLH^2 \)

- **Orifice Equation:** \( Q_{\text{orifice}} = CA \sqrt{2gH} \)
  
  Where \( C = 0.62 \)

  Also used for Culvert Inlet Control Condition

- **Manning’s Equation:** \( Q_{\text{manning}} = \left( \frac{1.49}{n} \right) A R^{1/2} \sqrt{S} \)

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HEC-HMS

- **Setup**
  - Hydrology Parameters
    - CN, SCS Transform
  - Detention Pond
    - Elev-Area Storage Method
    - Inflow = outflow (no tailwater condition)
  - Outlet Structures
    - Outlets
    - Spillways
    - Dam Tops

\[ I_{\text{avg}} - O_{\text{avg}} = \frac{\Delta S}{\Delta M} \]

1D Modified Puls (Level-Pool Routing)

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HEC-RAS 2D

- **Geometry**
  - Grid - 5'x5' max
  - Landuse (Concrete Structure, DS Roadside Ditch)

- **Boundary Conditions**
  - 2 inflows applied on north and east sides (Internal BC)
  - DS BC set to normal depth

- **Solution Method – Full Momentum**
  - 0.5 second time step

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D)
Outlet 1
Rectangular Section

Outlet Configuration
- Typical section
  - 14' wide rectangle section
  - Vertical Walls 4' high
  - Toe: 1488'
  - Top of Berm: 1492'
- Concrete-Lined
- 0.5% slope through outlet structure

HEC-HMS Model Setup
- Outflow Structure Approach
  - Spillway - Weir Approach
    - Weir Length = 14'
    - Crest set at flowline
    - \( C_{weir} = 2.63 \)
  - Outlet - Orifice Approach
    - Area for 14' x 4' opening
    - \( C = 0.62 \) (typical)
  - Outlet - Culvert Approach
    - 14' x 4' SBC, L = 31'
    - Typical unstratified losses
    - Slope = 0.5%
HEC-RAS Model Setup

- Geometry
  - Breakline Refinements
- Solution Method
  - Full Momentum
  - Check Courant Condition

Results

- Inflows:
  - $Q_2 = 78.55$ cfs
  - $Q_25 = 167.38$ cfs
  - $Q_100 = 214.4$ cfs

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<thead>
<tr>
<th>Section</th>
<th>$Q_2$</th>
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<td>Weir Eq.</td>
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<td>155.3</td>
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<td>Manning's Eq.</td>
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Outlet 2
Trapezoidal Section
(6 ft Bottom Width)
Outlet Configuration

- Typical section
  - Trapezoidal Section
  - 6' bottom width
  - 3.5:1 horizontal transition
  - 1.5:1 side slopes
  - Toe: 1488'
  - Top of Berm: 1462'
  - Concrete Lined
  - 0.5% slope through outlet structure

HEC-HMS Model Setup

- Outflow Structure Approach
  - Dam Top - Weir Approach
    - Wall Top Width = 14'
    - Bottom Width = 6'
    - 1.5:1 Side Slopes
    - Crest set at flowline
    - C = 2.63
  - Outlet - Orifice Approach
    - Area for section opening
    - C = 0.62 (typical)

HEC-RAS Model Setup

- Geometry
  - Breakline Refinements
  - Solution Method
    - Full Momentum
    - Check Courant Condition
Results

- Inflows:
  - \( Q_2 = 78.55 \) cfs
  - \( Q_{25} = 167.38 \) cfs
  - \( Q_{100} = 214.40 \) cfs

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§ Inflows:
Results

- Inflows:
  - $Q_1 = 78.55\ \text{cfs}$
  - $Q_2 = 167.38\ \text{cfs}$
  - $Q_3 = 214.4\ \text{cfs}$

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Outlet 3
Trapezoidal Section (2 ft Bottom Width)

Outlet Configuration
- Typical section
  - Trapezoidal Section
  - 2' bottom width
  - 2:3:1 horizontal transition
  - 1.5:1 side slopes
  - Toe - 1468
  - Top of Berm - 1482
  - Concrete-Lined
  - 0.5% slope through outlet structure
HEC-HMS Model Setup
- Outflow Structure Approach
  - Dam Top- Weir Approach
    - Weir Top Width= 14'
    - Bottom Width = 2'
    - 1.5:1 Side Slopes
    - Crest set at flowline
    - $C_{weir} = 2.63$
  - Outlet - Orifice Approach
    - Area for section opening
    - $C = 3.62$ (typical)

HEC-RAS Model Setup
- Geometry
  - Breakline Refinements
- Solution Method
  - Full Momentum
  - Check Courant Condition

Results
- Inflows:
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*Exceeded top of berm elevation.*
Results

- Inflows:
  - Q2 = 78.55 cfs
  - Q25 = 167.38 cfs
  - Q100 = 214.4 cfs

### Solution

<table>
<thead>
<tr>
<th>Solution</th>
<th>Q2</th>
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*Exceeded top of berm elevation.*
Conclusion

- Goals
  - Results showed similar trends between all three scenarios (weir types)
  - Rectangular Weir Discharge vs Depth Relationship
    - \( \text{Weir eq. (black)} \) vs \( \text{Culvert eq. (blue)} \) → produce similar results
    - \( \text{Weir eq. (black)} \) vs \( \text{Full Momentum (red)} \) → FM shows constriction to be more efficient for a given depth.
    - \( C_{\text{weir}} = 3.6 \) required to get similar \( Q \) vs \( D \) from FM results

Questions?