Overview of Drainage Design

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GOALS

- Basic drainage design
- Where to find MDOT drainage policy
- Look at more than the road surface
- Know what you don’t know

Hydraulics Unit

- Erik Carlson– Supervisor
- Vacant – QA/QC
- Liz McCann – Scour/Hydraulics
- Kim Moody-Holmes – Permits/Hydraulics
- Justin Logsdon - Hydraulics
- Vacant - Hydraulics
- Jim Davis – County Drain Coordination
- Ron McKee – County Drains/Apportionments

Hydraulics Unit Lead Items

- Hydraulic Analyses
  - PPMS Task 3520
- County Drains
- Bridge Scour Analyses & Countermeasures
- EGLE Permit (NREPA Part 31 - Floodplain)
- Hydraulic Connection Permits

Hydraulics Unit Assistance Items

- Hydrology
- Bridge Deck Drainage
- Drainage Agreements - Cost Participation
- Drainage Studies – PPMS task 3522
- Storm Sewer Design
- Stormwater Quantity/Quality
  - Detention basins and BMP's

Drainage Manual

- MDOT Policy and Procedure for design of Drainage Facilities
- Stormwater Program, NPDES Phase 2
  - Best Management Practices - BMPs
  - Public Education – Internal & External
- Design Contract Document
- https://www.michigan.gov/mdot/0,4616,7-151-9621_11041_91575_91583-93193--,00.html

Chapter Two – Legal

- Covers Federal, State, and local laws affecting drainage
- Perpetuate natural drainage – look outside of ROW
- State is held to a higher standard than a private citizen
- Stream vs. Drainage course
- Order of law supremacy
- Participation agreements

Not a stream

No bed, banks, or evidence of flow

Stream

Bed, banks, or evidence of flow

Chapter Two – Legal continued

- Common law drainage requirements
  - "The owner of the dominant estate has no right to divert, concentrate, or increase the velocity of the natural surface water."
  - "The owner of a lower or servient estate is obligated to receive surface water from the upper or dominant estate in its natural flow."

Chapter Three – Hydrology

- Drainage basin required information
  - Stream characteristics
  - Floodplain characteristics
  - Precipitation amounts, type, and rates
- A science and an art
  - Incorrect assumptions can lead to discharge errors of +/- 30%
- FHWA requirements for highway encroachments (FAPG 650)
  - Plans must show magnitude, frequency, and water surface elevations for 50 (2%) and 100 (1%) year floods
  - 50 year shall not overtop the road (Interstate)

Chapter Three – Hydrology continued

- Hydrologic Method Selection
  - Use the rational formula for drainage area of 20 acres or less. (Q=CIA)
  - Over 20 acres, use MDEGLE's "Computing Discharges for Small Ungaged Watersheds"
  - Over 2 square miles, determined by MDEGLE

- Design examples and rainfall intensity charts

Chapter Three – Hydrology continued

- EGLE Requirements
  - No harmful interference over a range of flows – regardless of drainage area
- MDOT Requirements
  - Culverts – 50 year design event, 100 year check for NHI
  - Bridges – 100 year design event, 500 year scour check
  - Storm sewers – 10 year design
  - Depressed roadway – 50 year design
  - Ditches – 50 year design, 100 year check for NHI
  - Ditch enclosures???

Chapter Four – Natural Channels and Roadside Ditches

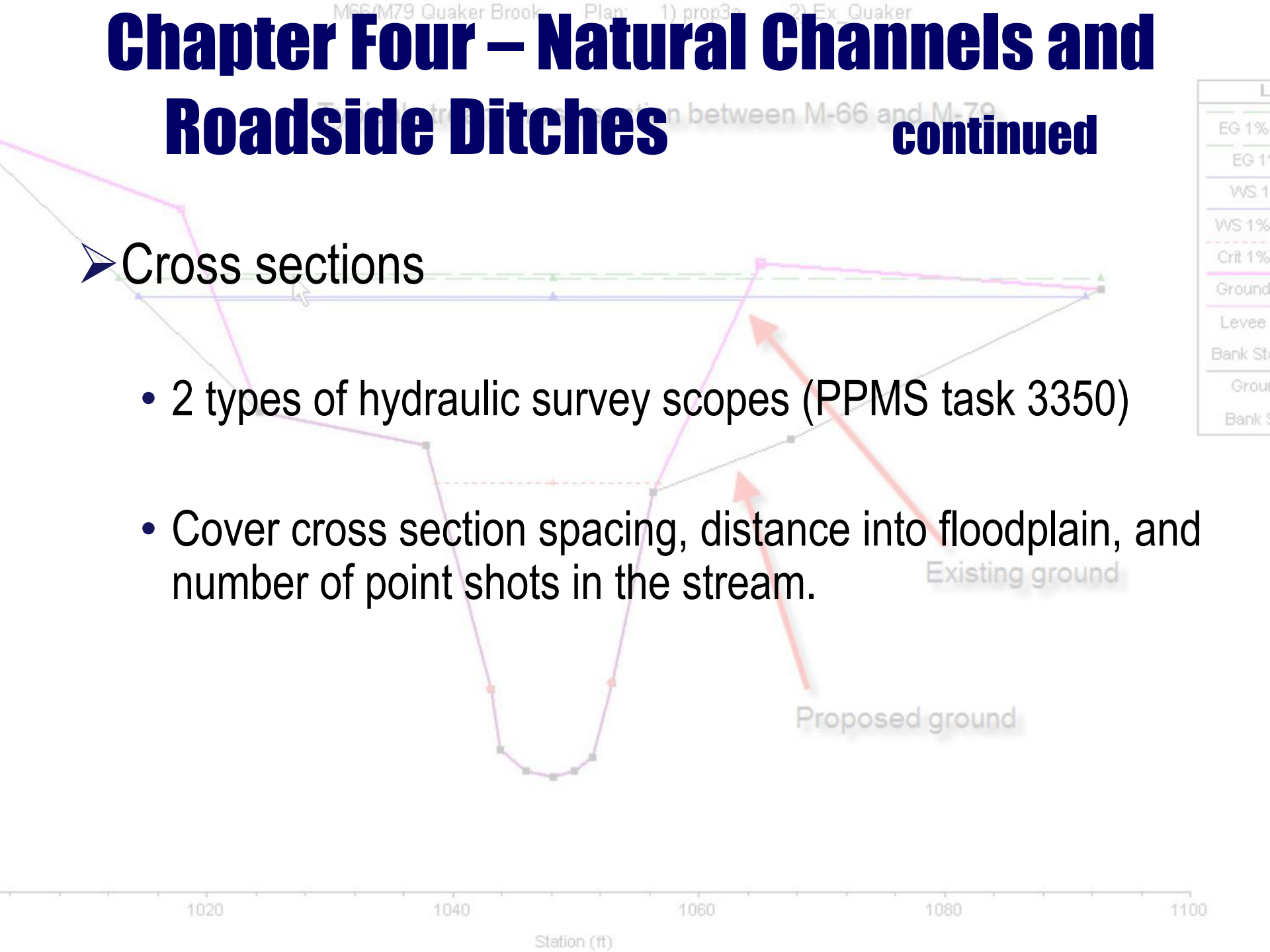
- Natural Channels
  - Evaluate hydraulic conditions over a range of flows 10 year to 100 year
  - Avoid relocation whenever possible
    - Relocated channels should mimic cross section and slope of existing
  - Stabilize stream banks with high velocity or poor angle of attack
  - Can be analyzed using HY-8 or HEC-RAS

Chapter Four – Natural Channels and Roadside Ditches continued

- Ditches
  - 50 year storm event, check harmful interference for 100 year storm event.
  - Grades from 0.1% minimum to 0.3% maximum (desirable)
  - The water in the ditch needs an 18 inch freeboard below the road's shoulder
  - If in clear zone, 2' depth at design event without guardrail can be analyzed using HY-8 or HEC-RAS

Chapter Four – Natural Channels and Roadside Ditches continued

- Cross sections
  - 2 types of hydraulic survey scopes (PPMS task 3350)
  - Cover cross section spacing, distance into floodplain, and number of point shots in the stream.



Chapter Five – Culverts

- Culvert Selection
  - Satisfy topography and budget, including maintenance
- Culvert Analysis
  - Environmental impacts
  - Harmful interference
  - Risk and costs
  - Practical site access for maintenance

Chapter Five – Culverts continued

- Culvert Design Criteria
  - All culverts require a hydraulic analysis
  - Design life = design storm = 50 years
  - Culvert material can be site specific
  - Multiple culverts should be avoided
  - Regularly inspected and maintained (2 yr. cycle)
  - Shortest length possible and aligned with channel
  - May need to be recessed into channel bottom
  - Avoid steep slopes

Chapter Five – Culverts continued

- Culvert Design Criteria
  - Maximum headwater 1.5’ below shoulder at design event
  - No harmful interference compared to existing
  - Outlet velocity < 6 fps or natural velocity
  - DA>2 sq. miles done by Hydraulics Unit
  - Culvert recess??

Chapter Five – Culverts continued

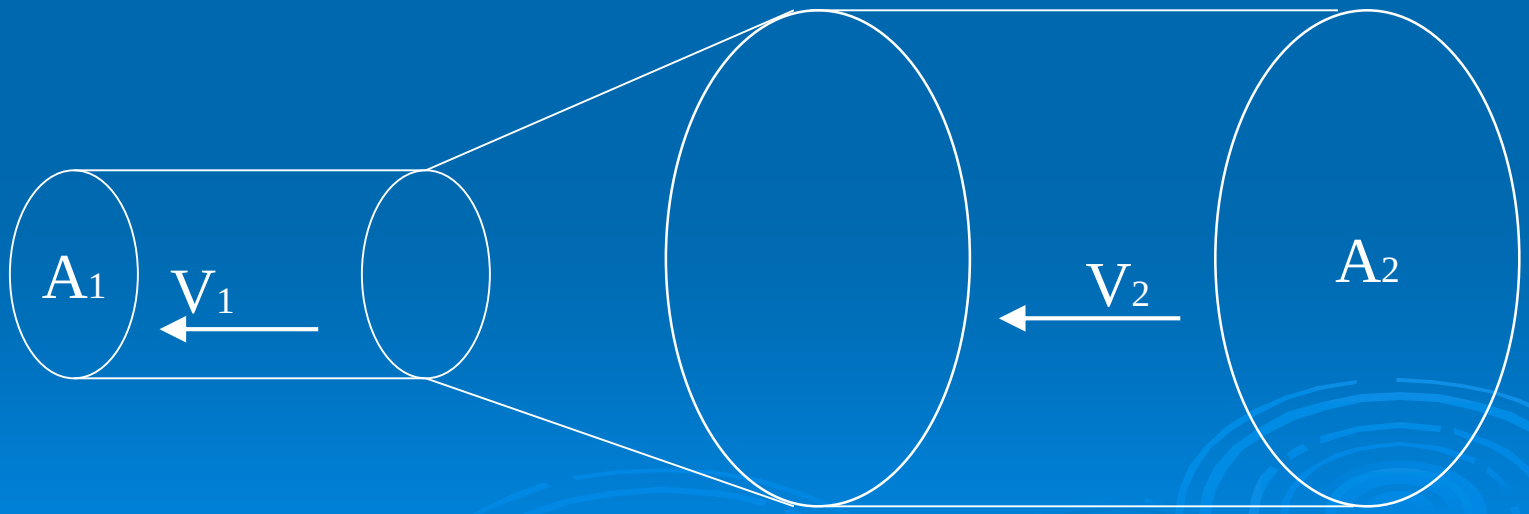
- Culvert Extensions
  - Can be done with dissimilar materials and shapes but best if consistent throughout
  - Extending slab culverts is not recommended
  - Perched culverts should not be extended
  - < 24 ft. extensions exempt from Part 31 review
    - Still have liability for harmful interference

Chapter Five – Culverts continued

- Culvert lining only allowed for
  - Drive culverts carrying ditch flow
  - Cross culverts
  - CMP's that don't experience inlet control
- Can create other problems
  - Reduce area, increase velocity

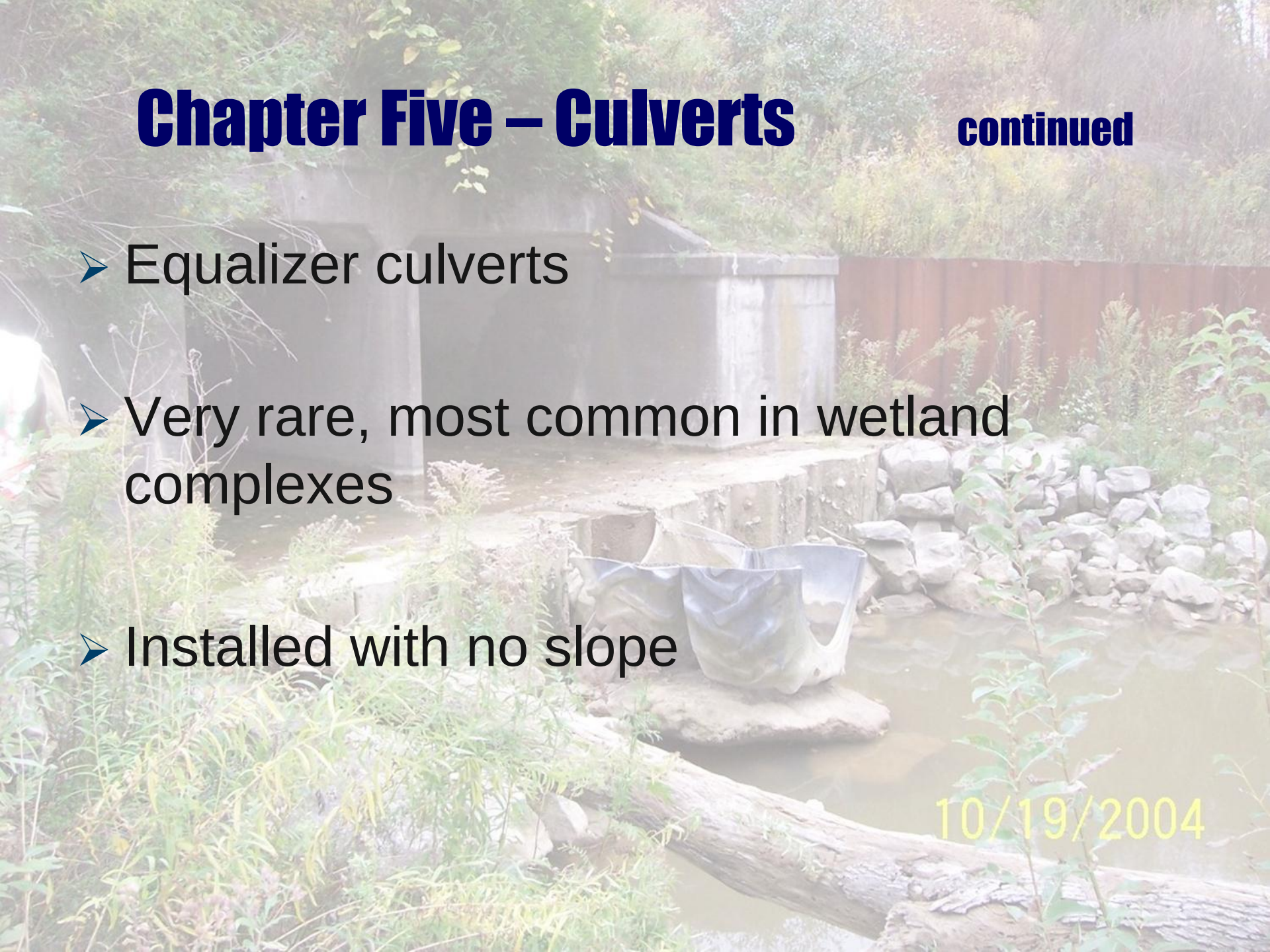
Chapter Five – Culverts continued

- $Q = V_1 A_1 = V_2 A_2$
- Discharge constant from one cross section to the next.

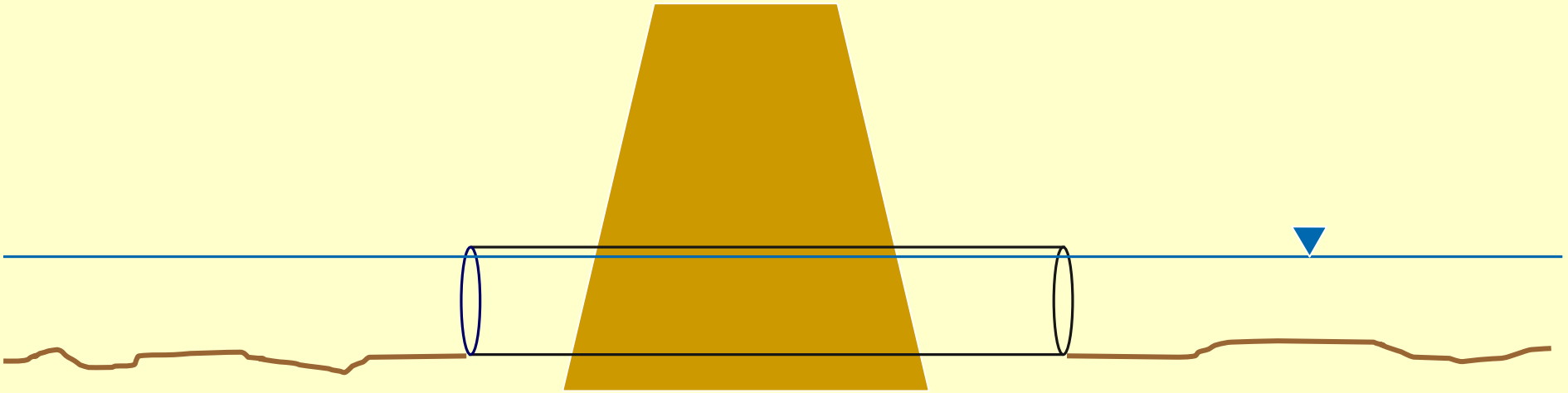


Chapter Five – Culverts continued

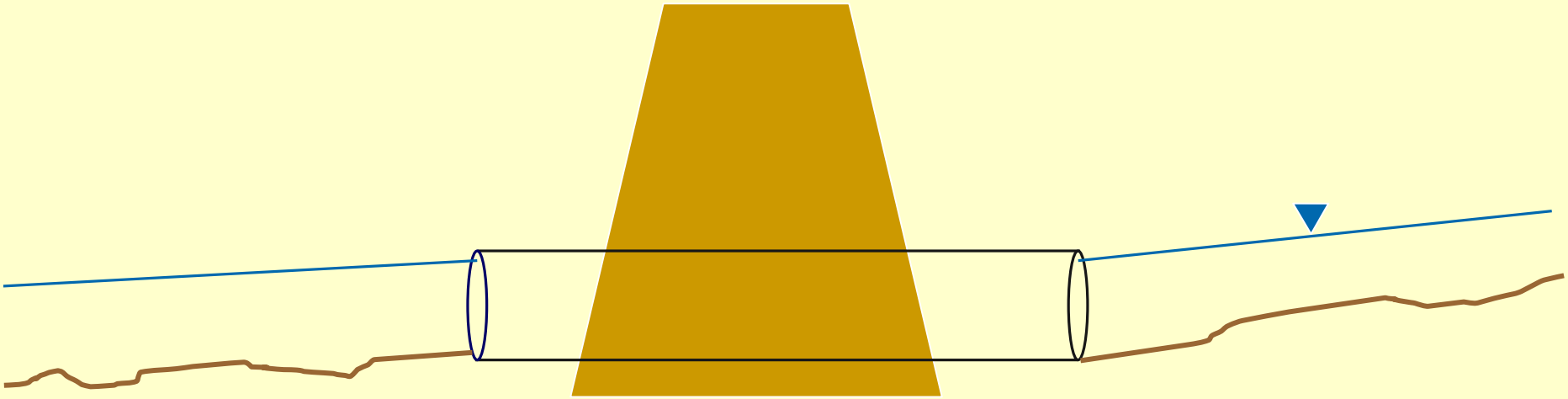
- Equalizer culverts
- Very rare, most common in wetland complexes
- Installed with no slope



This is an equalizer culvert



This isn’t



Culverts and the Scoping Process

- Important to look at all existing culverts
  - Condition
  - Watershed changes
- Including them later impacts schedule and budget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Chapter Six – Bridges

- Bridge Design Criteria
  - Design storm = 100 years
  - No harmful interference compared to existing
  - 2 ft. freeboard where practical but avoid pressure flow
  - Require scour calculations
  - Foundations must be stable for a 500 yr. scour event
  - Blend with environment
  - Analyzed with HEC-RAS

Chapter six – Bridges continued

- Chapter also covers

  - Hydraulic analysis using HEC-RAS
  - Scour analysis using FHWA HEC-18
  - Bridge Deck Drainage / Maintenance
  - Hydraulic Report format

Chapter Seven – Storm Drainage Systems

- Design for 10 year storm, use 50 year for depressed roadways
  - Design life is 70 years
  - Rational method Q=CiA for most drainage to catch basins
  - 15 minute Tc, 10 minute Tc for depressed roadways
  - Use all contributing drainage area, not just ROW
  - Pipes most efficient at 90% full
  - Velocities < 12 fps in pipe, 6 fps at outlet
  - Pipe slope minimums given in chapter
  - Inlets not further than 300’ – meet design spread
  - Avoid placement of trunks in traffic lanes

Chapter Seven – Storm Drainage Systems
continued

- Spiral ribbed cmp or concrete – same Manning's "n" value
- 20 years future development
- Surcharge only allowed when caused by high tailwater
  - Keep HGL 1' below gutter grade
- Can be analyzed by hand or computer program (GEOPAK Drainage)

Chapter Seven – Storm Drainage Systems

continued

- Water does not acknowledge jurisdictional, property, ROW lines
- Laws/Permits/Agreements/Litigation – Chapter 2
- Receiving Waters
  - Drainage Course
  - County Drain
  - Intermittent Stream
  - Inland Lake, Stream

Chapter Eight – Storage Facilities

- Used to meet NPDES and MS4 permit requirements
  - Reduce direct discharges
  - Reduce runoff velocity
  - Potential changes upcoming to MS4 – Water Quality/Water Quantity
  - Design by hand or computer model (HYDRAIN)
- Routing requires stage/storage and stage/discharge curves and inflow hydrograph
- Need borings for groundwater elevations in ponds. No storage to be included below groundwater table.
- Detention vs. Retention

Chapter Eight – Storage Facilities
continued

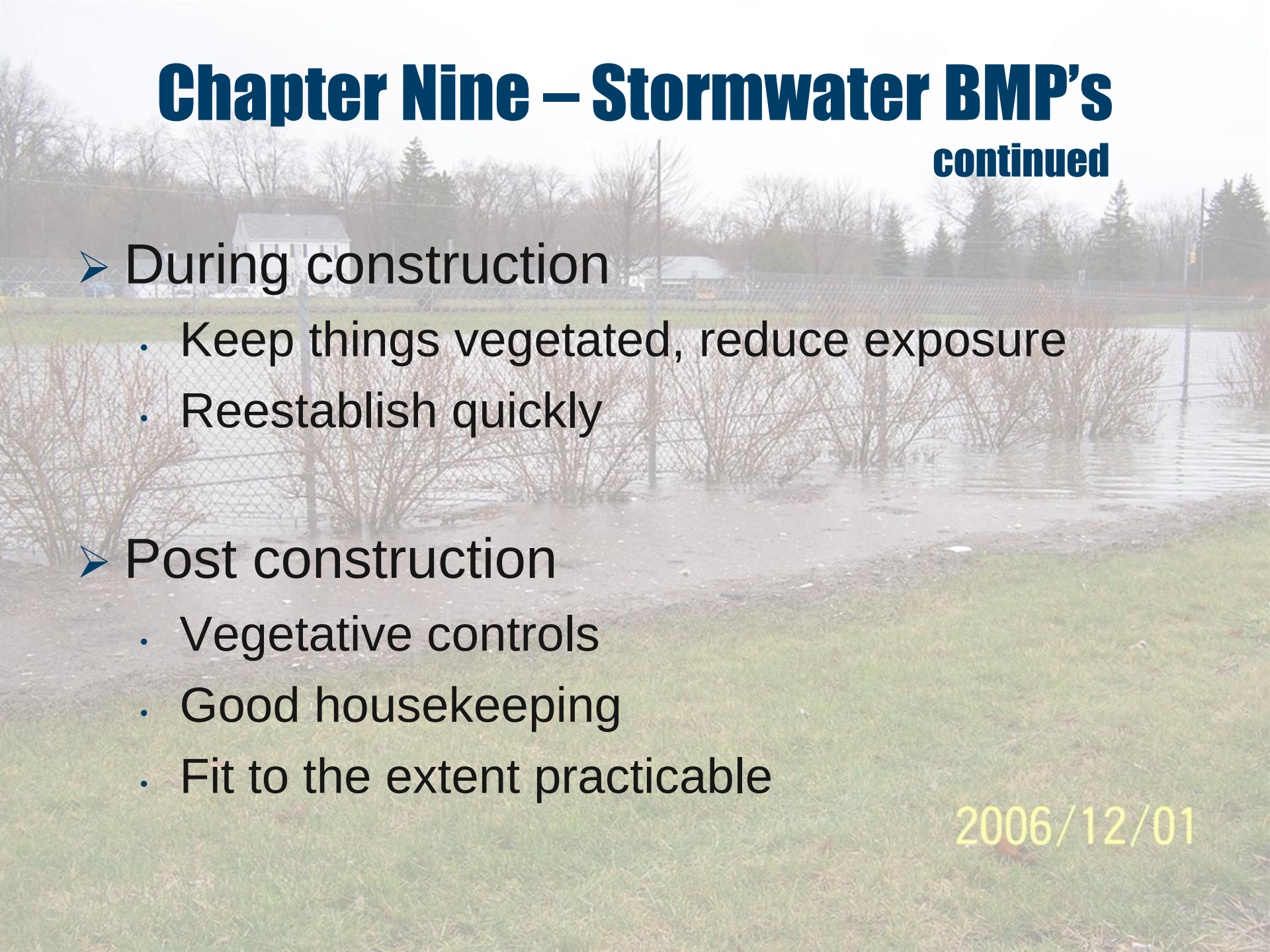
- Design Criteria
  - Design outlet rate: 10% to 4% existing peaks
  - Design volume: 10% to 4% post development
  - Spillway design: 1% post development, 1.5’ freeboard
  - 2’ maximum depth if located in clear zone
  - Spillway preference of weir over perforated riser
  - Requirements for side slopes, fencing, and embankment

Chapter Nine – Stormwater BMP's

- Stormwater Quality
  - SESC (Soil Erosion and Sedimentation Control)
    - Water quality during construction
  - MS4 (Municipal Separate Storm Sewer System)
    - Water quality post construction

Chapter Nine – Stormwater BMP's
continued

- During construction
  - Keep things vegetated, reduce exposure
  - Reestablish quickly
- Post construction
  - Vegetative controls
  - Good housekeeping
  - Fit to the extent practicable



Chapter Nine – Stormwater BMP's
continued

- Development of future stormwater manual to be independent of the Drainage Manual.

Chapter Ten – Pump Stations

- Prefer gravity drainage
  - Long term maintenance costs

- Design Criteria
  - 50 year design event
  - Storage in station 2’ below gutter line low point
  - When upgrading, can’t increase capacity
  - Need to evaluate storage upstream of the pumpstation if inflow greater than outflow.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Mt Pleasant


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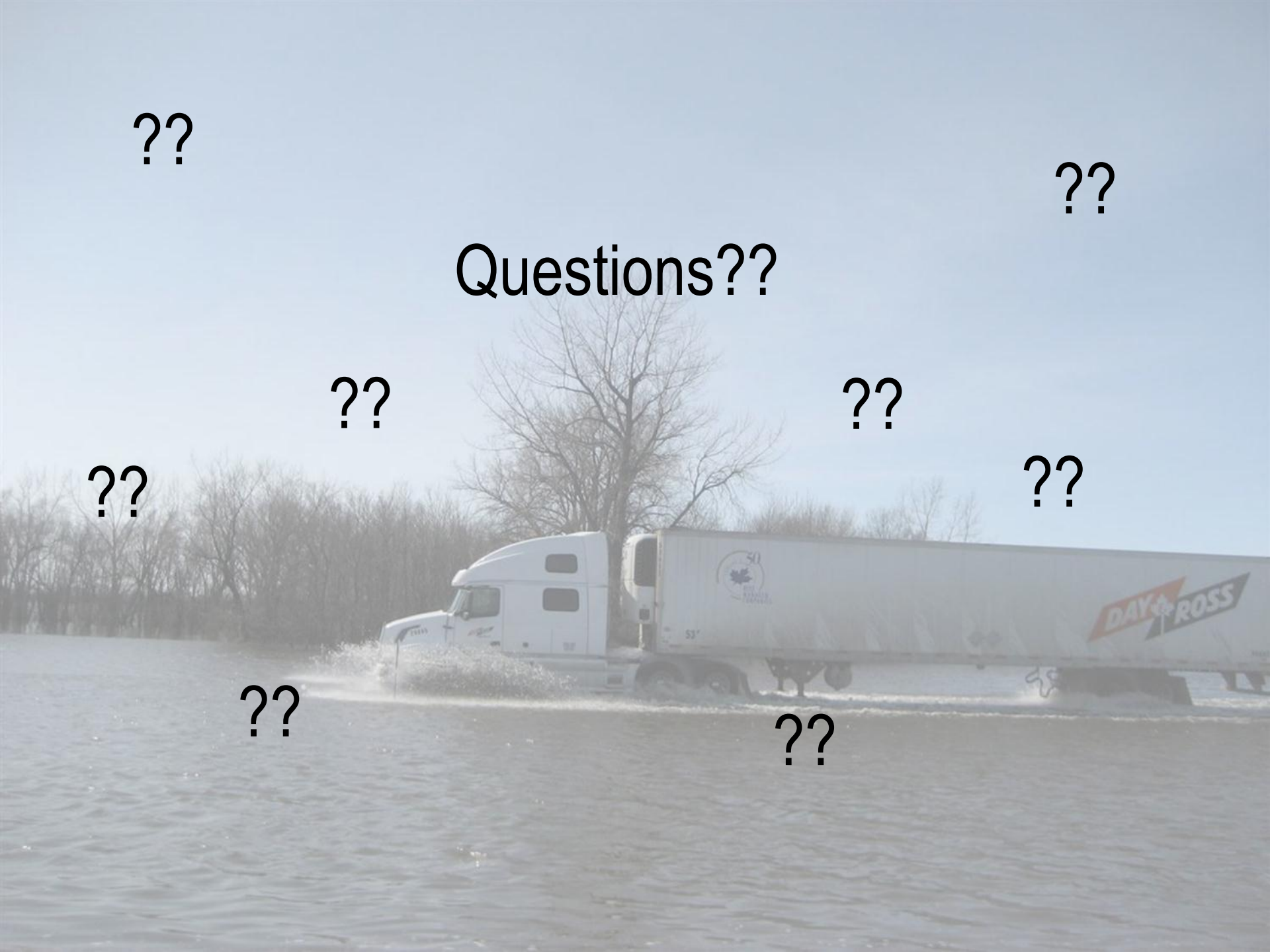
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Questions??
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