# Groundwater Flooding in Residential Subdivisions

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# Introduction

- Basement flooding from groundwater seepage
- Out of the ordinary for floodplain managers
- Two good things that don't always go good together:
  - Stormwater infiltration
  - Basements in the Midwest
- Potential issues to consider
  - Groundwater levels fluctuate slowly/hard to predict
  - Soils usually not homogeneous
  - Mass grading and other changes can impact groundwater flows
  - Building elevations unknown at due diligence stage
- Names were changed

# A Tale of Two Subdivisions

- Subdivision No. 1 – Phreatic Farms
  - 160 Acres; 205 single-family lots
  - Preliminary plat filed in 1989
  - No records of soil borings, field tile investigation
  - NRCS soils maps:
    - Well-drained soils
    - More than 80" to groundwater
  - Not far from floodplain
    - 500 feet from edge of subdivision to SFHA
    - BFE:  2' below ground surface

# Phreatic Farms

- Property filled for grading and drainage
- Detention ponds constructed in granular soils with normal gravity outlets
- No groundwater issues observed in construction
  - Mass grading
  - Underground utilities
  - Basement construction
- Sump pumps discharge to storm sewer system
- Homes built and occupied from 1993 to last year

# Phreatic Farms

- First concerns voiced in Fall 2004
- Low rainfall in 2005; concern abated
- Adjacent development began due diligence
- Concerns resurfaced in 2006
  - Sump pump run times
    - Up to 12 cycles per hour for 10 days after rain
    - Continuously for 14 days after rain
    - Continuously year-round
    - Never run
  - Loss of power
  - Lowering pond normal water level

# Phreatic Farms

- So, what did we do?
  - Preliminary investigation Fall 2004
    - Researched old plans, calculations and reports
    - Water surface observation/recording
      - Detention ponds
      - Natural water bodies
      - High groundwater level approximately 594
    - Solution:  Convey water away from subdivision by gravity
      - Extend conveyance to nearby River
        - Large-diameter storm sewer:  $780,000
        - Swale with road culvert:  $580,000
      - Needed ROW/easements
      - Too expensive/public expense vs. private nuisance
      - Concerns abated with lower groundwater levels
      - Wait for downstream development

# Phreatic Farms

- Renewed investigation in 2007
  - Worked with adjacent development
    - Soil borings
      - 3-4 feet of clay under topsoil
      - Loose to firm sand and gravel to end of borings
      - Groundwater levels at 590.5 to 592.5
    - Drawdown test
  - Additional ground surveying
    - Basement elevations:  inconsistent with sump pump run times
  - Exploratory excavation in specific areas
    - Looked for field tiles in subdivision
    - Found porous soils and rapid groundwater movement
  - Traced/repaired downstream field tiles
  - Balance against pond size/depth reduction
  - Resident survey
  - Required minimum basement elevations

| House | Drain Tile Invert | Pumping – Dry | Pumping – Wet |
|---|---|---|---|
| 1 | 590.35 | 12/hour | Constant |
| 2 | 590.63 | Seldom | Constant |
| 3 | 591.76 | Constant | Constant |
| 4 | 591.79 | Constant | Constant |
| 5 | 591.82 | Constant | Constant |
| 6 | 592.17 | 12/hour | Constant |
| 7 | 592.40 | Constant | Constant |
| 8 | 592.56 | Seldom | Seldom |
| 9 | 592.61 | Seldom | Seldom |
| 10 | 592.74 | Seldom | 6/hour |
| 11 | 592.81 | Seldom | 12/hour |
| 12 | 592.88 | Seldom | 6/hour |
| 13 | 592.89 | Seldom | Seldom |
| 14 | 592.91 | Seldom | Seldom |
| 15 | 592.99 | Constant | Constant |
| 16 | 593.25 | Seldom | Constant |
| 17 | 593.32 | Seldom | Constant |

# Phreatic Farms

- Developed alternative solutions
  - Public groundwater wells through subdivision
  - Private groundwater wells near homes
  - Infiltration pipe or trench through subdivision
  - Piped outlet at end of subdivision
  - Back-up power
  - Convert basements to crawlspaces
- Hired Hydrogeologist
  - Used data from adjacent development
  - Developed and ran Winflow groundwater model
  - Tested alternative solutions

# Phreatic Farms

- Results
  - Public groundwater wells (11) through subdivision
    - Limited benefit at basements
    - Lowering of water level in existing ponds
    - Public responsibility for construction, operation and maintenance
    - $300,000 cost
    - Needs outfall:  additional $780,000
  - Infiltration pipe or trench ("French drain") through subdivision
    - Needs gravity outfall ($780,000); would be below BFE
    - Lowering of water level in existing ponds
    - Public responsibility for construction and maintenance
    - Not considered further
  - Piped outlet at south (downstream) end of subdivision
    - Lowering of water level in existing south pond
    - Decreasing benefit at basements going north
    - Public responsibility for construction and maintenance
    - Not considered further

# Phreatic Farms

- Private groundwater wells (external sump pumps) at affected homes
  - Highest benefit at basements
  - Re-use existing drainage system within subdivision
  - Private construction, operation and maintenance cost
  - $12,000 per home
  - Village agreed to fund 13 individual pumps
- Private improvements
  - Back-up power
  - Basement conversion
- Downstream field tiles
  - Repair/replace by Village
  - Ongoing monitoring and maintenance
- Adjacent development
  - Changed housing product to eliminate basements
  - Clay liner proposed for detention pond
  - Utility installation not as difficult as expected

# Phreatic Farms

- What's happening now?
  - Most (internal) sump pump run times reduced significantly
  - Village maintaining field tiles
  - Residents monitoring adjacent development
  - Detention pond normal water level still an issue
  - One home still has sump pump issues

# Subdivision No. 2 - Infiltration Acres

- Preliminary Plat filed in 1992
- 60 Acres; 153 single-family lots
- Soil borings indicated
  - Granular soils at 1 to 8 feet below grade
  - Various groundwater levels throughout site
- No evidence of field tile survey
- NRCS maps
  - Well-drained soils
  - More than 80" to groundwater
- Upstream of floodplain
  - 2,000' from edge of subdivision to SFHA
  - BFE 5' below ground surface
- Minimal mass grading
- Sump pumps discharge to storm sewer system

# Infiltration Acres

- Stormwater planned to infiltrate
  - Open-bottom drainage structures
  - Detention ponds
    - Primary outlet through infiltration
    - Overflows above ground
  - Homes built and occupied from 1994 to 2000
  - No concerns voiced by residences until Spring 2008
    - Little sump pump usage until September 2007
    - Rainfalls in March 2008 triggered significant sump pump run times
    - Rainfalls in May 2008 increased sump pump run times
      - Head in storm sewer system against sump pumps
      - Sump pumps ran continuously, but:
        - Sumps backed up into basements
        - Seepage from walls and floors

# Infiltration Acres

- Residents:
  - Purchased and installed additional pumps
  - Disconnected pumps from storm sewer system
  - Contacted Village for assistance
  - Concerned about lowering pond level
- Village:
  - Inspected storm sewers for blockages
  - Observed detention pond water levels
  - Bypass-pumped storm sewers to reduce head against sump pumps
  - Concerned about downstream impacts of pumping

# Infiltration Acres

- So, what did we do about it?
  - Met with residents to assess specific problems
  - Researched old plans and reports
  - Ground survey:
    - Top of foundation
    - Pond levels and storm sewer inverts
  - Hired soils consultant
    - Installed five groundwater observation wells
    - Installed one well logger
    - Checked wells monthly
    - Downloaded daily logger readings
  - Sealed bottoms of open drainage structures

# Infiltration Acres

- Investigated field tiles
  - Records from adjacent work
  - Field tile installer/locator
- Reviewed information and options with Village Staff
  - Groundwater levels vs. drain tile inverts
  - No gravity outfall readily available
  - Maintain existing pond normal water level
- Pursued implementation of limited improvements
  - Surface conveyance improvements
  - Field tile extensions and repairs
  - Opinion of cost for groundwater pumping station:
    - Pump station and local drainage improvements: $230,000
    - Downstream conveyance improvements: $380,000
    - Total: $610,000

# Infiltration Acres

- So, what's happening now?
  - Monitored groundwater through November 2009
  - Groundwater responds quickly to rainfall events
  - Groundwater subsided over time
  - No concerns since May 2008
  - Groundwater pumping station unfunded

# Lessons Learned

- Ordinance Amendments
  - Reviewed other agencies' requirements
  - Will County, Illinois:
    - Lowest floors above seasonal high groundwater
      - Reportedly, 2/3 of County becomes unbuildable
      - Ordinance not passed
    - Eau Claire County, Wisconsin
      - New ordinance
      - No enforcement experience
    - Waukesha County, Wisconsin
      - Relatively new ordinance
      - Limited enforcement experience
      - Staff concerned about veracity of reports
  - Field tile survey requirements
    - Clarified as requirements, not recommendations

# Lessons Learned

- Considered local ordinance modifications
  - Resident protection vs. development time/cost
  - Met with development community
    - New regulations considered too harsh
      - Time and cost required to complete studies
        - Historical data difficult to obtain; monitoring periods excessive
      - Data inconclusive:
        - Local vs. global
        - Perched groundwater tables
      - Variables hard to mandate
        - Ground elevations (existing vs. proposed)
        - Rainfall patterns/groundwater levels
        - Building styles/elevations
        - Soil types/locations
    - Most developers perform adequate due diligence

# Lessons Learned

- Ordinance amendments currently being considered
- Formalize soils report requirements
  - Minimum number of borings
  - Appropriate locations for borings
  - Groundwater information
  - Development plan:
    - Ground/groundwater/building elevations
    - Soils strata
  - Soils consultant requirement
    - During concept plan, ideally
    - Prior to preliminary plat, minimally
    - Consultation during final plat and plan preparation
- Basements are not a requirement
  - Option between builder and homeowner
  - Entail risk
- Whose problem is it?

# Lessons Learned

- Due Diligence:  There is no substitute.