Stormwater Management Successes and Failures in the Prince Frederick Area

Bob Estes

Presented to Calvert County Environmental Commission

April 24, 2023

1) Good evening. My name is Bob Estes and I'm here to talk to you about stormwater management in Prince Frederick. I have quite a few slides to show you tonight but luckily there are a lot of pictures. I've limited myself to Prince Frederick but I think it's likely that what I have found here can be found all over the county. I have more failures to show you than successes unfortunately. While we can learn a lot from success it is the failures that can cause irreparable harm and directs us to do better.

Introduction

- Who is Bob Estes
- Stormwater Management (SWM) definitions
- SWM Practices and Drivers
- The Bad
- The Good
- Conclusion

2) Take a quick glance at this second slide which gives my basic outline. And no, that is not Calvert County in the background and I'm pretty sure it's not Kansas either.

DEFINITIONS 1: Bob Estes

- **Bob Estes**
  - **Retired Aerospace Propulsion Engineer**
  - **Member of Friends of Hunting Creek, Water Quality Subcommittee**
  - **Environmental Advocate Focusing On**
    - SWM facilities current and future
    - Watershed health
    - Sustainable growth

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3) I am a retired propulsion engineer but now instead of rockets I've focused the past few years on Stormwater Management, watershed health and sustainable growth. I'm a Member of the Friends of Hunting Creek group. To find out more about us and the other 3 Friends groups please visit the ACLT web site. I assure you that a 2D picture does not do justice to what I've seen and will show you tonight. Contact me via email if you would like a tour of some of the sites you'll see tonight.

Definitions 2

- **SWM Facility or System:** The aggregate of methods on a site such as culverts, ponds storage, rain gardens, etc employed to manage stormwater
- **Environmental Site Design:** First line of defense
  - Integrating site design
  - Reduce impervious surfaces
  - Mimic natural hydrology (slow runoff, increased infiltration), smaller controls, non-structural (large ponds)
  - Capture and treat runoff as close to the source as possible
  - Maintaining predevelopment runoff characteristics and protecting natural resources
- **Sheet Flow:** Pond exit → spread flow out along a line (not single stream)

☠ **Failed Systems:**

- ☠ Berms or pond walls breached
- ☠ Onsite erosion
- ☠ Outflow erosion (waterfalls, ravines, incised stream channels sediment transport)
- ☠ Sedimentation of system features
- ☠ Failure to treat (transfer to groundwater) actual water volume

4) Now for a few real definitions.
Stormwater Management Facility: Aggregate of methods on a site employed to manage rain water. The devices used including things such as ponds, storage, rain gardens, culverts, etc.
Environmental Site Design (ESD): Integrated design method which attempts to mimic natural hydrology.
The goal is to have Similar runoff characteristics to what existed before development.
Sheet flow: Spread to outflow into a sheet of water instead of a stream of water
My definition of Failed System: Pond walls breached, Onsite erosion, Erosion beyond the outflow, Sedimentation in the facility or beyond outflow, Failure to treat actual water volume

Typical SWM Design Drivers

- **Rainfall:** Quantity, Intensity, Duration of Storm
- **Soil** (Sandy, Clay, Mixed)
- **Topography** (Flat, Sloped)
- **Available Installation Space**
- **$$$**

5) There are Many design drivers but my top 5 are
Rainfall characteristics,
Soil characteristics,
Topography,
Available space for a system,
Cost

Precipitation Estimates

- Designs based on out-of-date NOAA Atlas 14 estimates
- Design 24 hour storm BUT larger storms longer than 24 hrs
- Local data collected over 16+ years
- Atlas 14 vs Local Data:
  - 1 and 2 day data
  - Meet or exceed recurrence

Duration	2 yr Atlas	2 yr Local Data	10 yr Atlas	10 yr Local Data
24-hr	3.38”	5.3”	5.27”	6.4”
2-day	3.86”	6.8”	5.99”	8.3”

LOCAL DATA

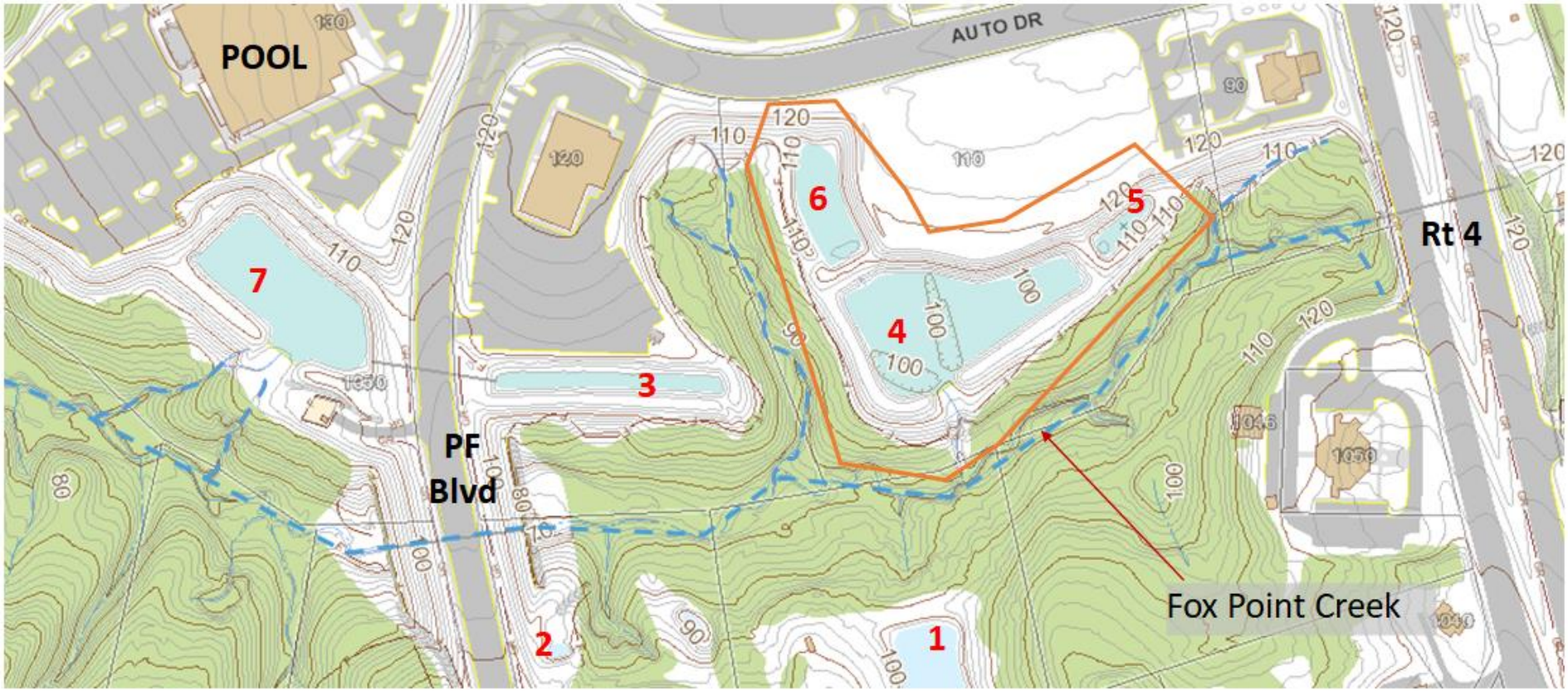
Year	1-day storm recurrences (x/16 years)	2-day storm recurrences (x/16 years)
1	22	44
2	17	34
10	8	12

6) To put on my Captain obvious hat; Stormwater management facilities are meant to manage stormwater. Need to estimate the quantity rainfall one might expect. The current quantity estimation method uses NOAA’s Atlas 14 estimates. Unfortunately, Atlas 14 underestimates the local rainfall data collected for over 16 years. The data in the two tables is for storms occurring once every 2 years and 10 years. Both the 2- and 10-year storm rainfall quantities and the frequency of occurrence of actual storms show significant discrepancies compared to actual rainfall. For example, a rainfall that should occur only once every 10 years is predicted to be 5.26” but was actually 6.4”. Rainfall amounts that should occur only 1.6 times every 16 years occurred 8 times. Underpredicting one’s primary design factor is bound to cause failures.

FAILURES

7) I'll be showing 6 facility failures in 3 areas of Prince Frederick.

North Prince Frederick Blvd



#4 System (incl ponds 4, 5, 6) = “Auto Drive” #7 = “Pool”

8) The first area is in the headwater of Fox Point Creek close to the Aquatic Center. On the map you can see the pool, Prince Fredrick Boulevard, and Rt4. We’ll first look at the #4 system seen outlined in orange. The outflow of Pond 4 flowing down to the creek is the focus. Note the steep slopes leading to Fox Point Creek.

Pond 4 (North PF Blvd)

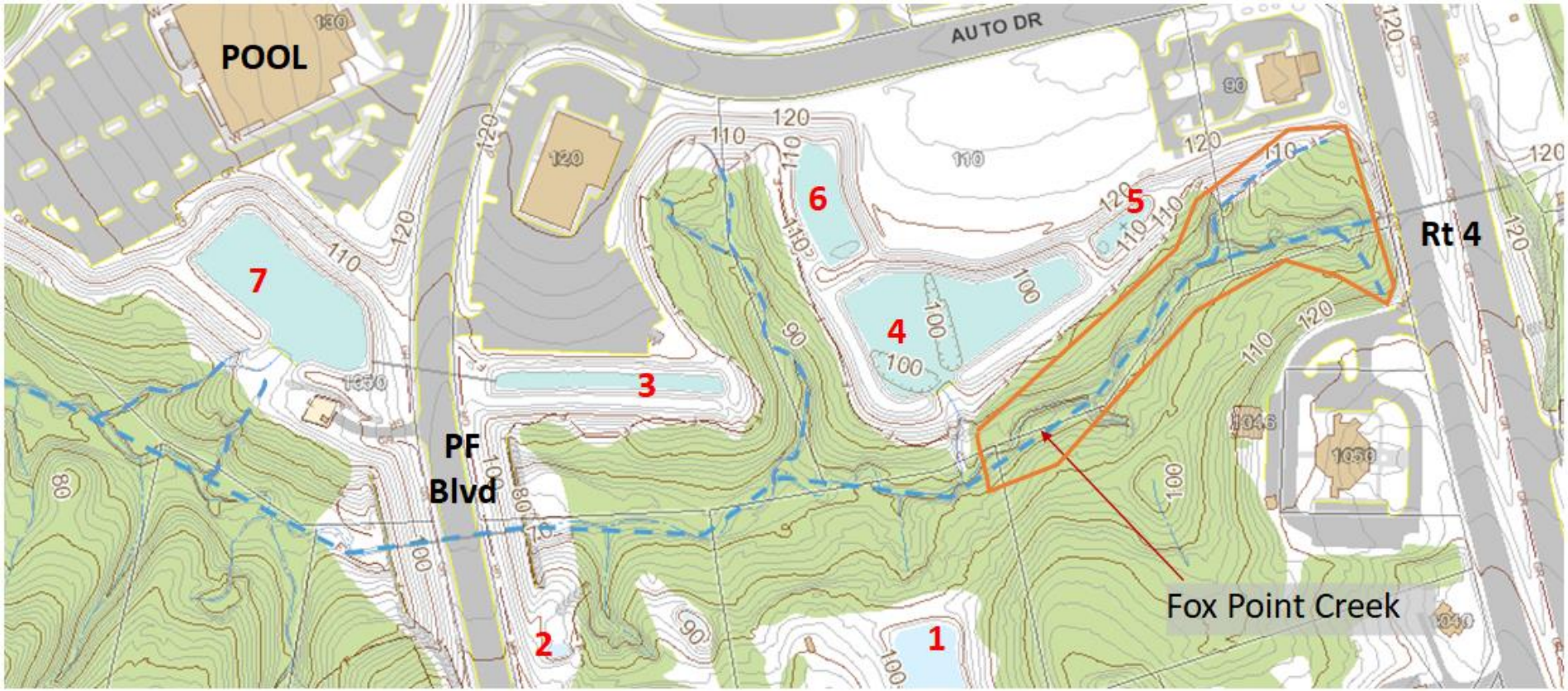
Pond 4 outlet. Designed to produce sheet flow. Land surface refocused flow.

- Just downstream of pond 4 outlet
- Eroded steep ravine. Destroyed silt barrier (black ribbons of material)
- Large sediment release into the creek

View downstream just before entrance to Fox Point Creek

9) Pond 4 has a sheet flow exit. There are 2 problems with this approach as applied here. The sheet flow is almost immediately refocused into a stream flow and more importantly the water is then dumped onto a steep slope of fragile soil without appropriate accommodations. The pictures show the result. A large amount of sediment was conveyed into the Hunting Creek watershed and on to the Patuxent.

North Prince Frederick Blvd



#4 System (incl ponds 4, 5, 6) = "Auto Drive" #7 = "Pool"

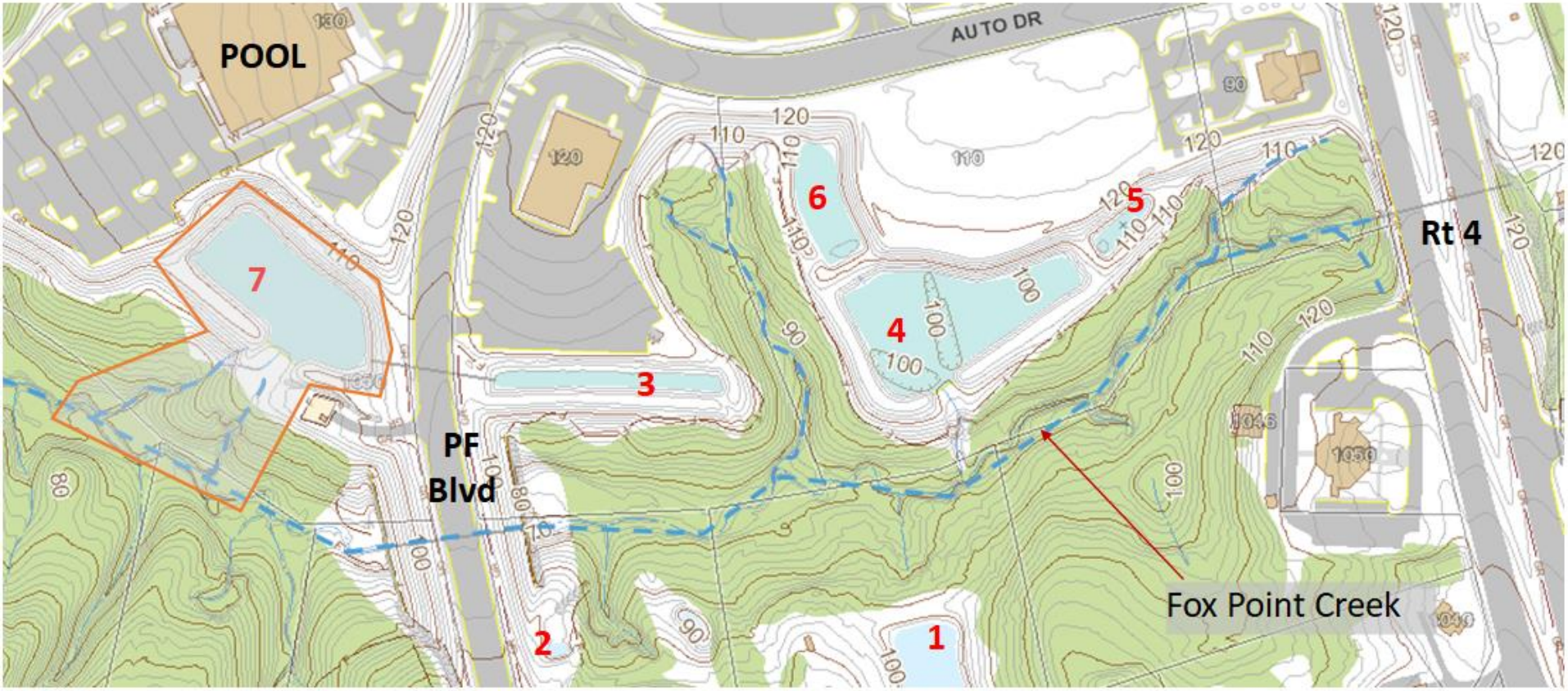
10) Next, we'll look at some pictures of the creek just upstream of Pond 4's outflow.

Stream Erosion Near Pond 4

Bounded by Islamic Center, Rt 4 Stoakley and Auto Dr Properties

11) In these photos you can see a streambed incised down to the clay layer with remnants of the failed rock lined channels and silt fences.

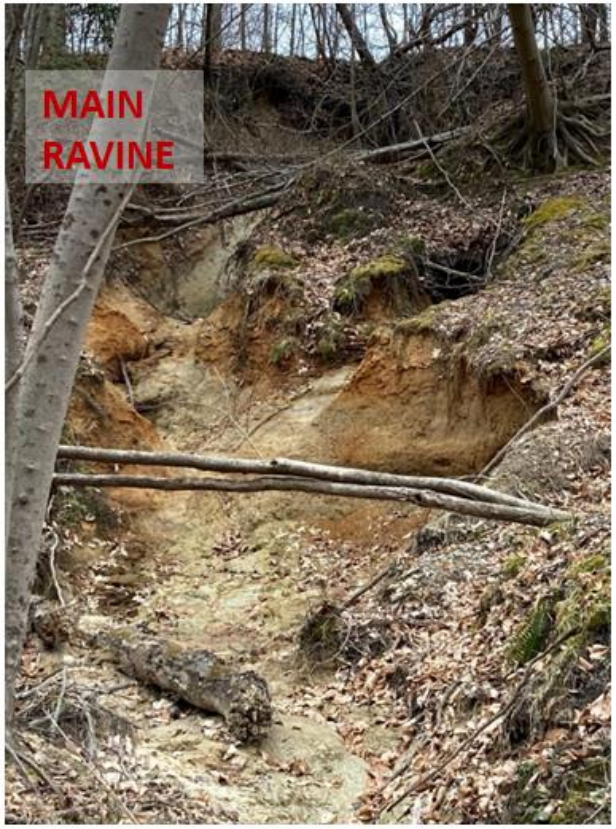
North Prince Frederick Blvd



#4 System (incl ponds 4, 5, 6) = "Auto Drive" #7 = "Pool"

12) Last for this area is the outflow from the pool's stormwater pond as seen by the orange outline. Again, note the steep slope between the pond and the creek.

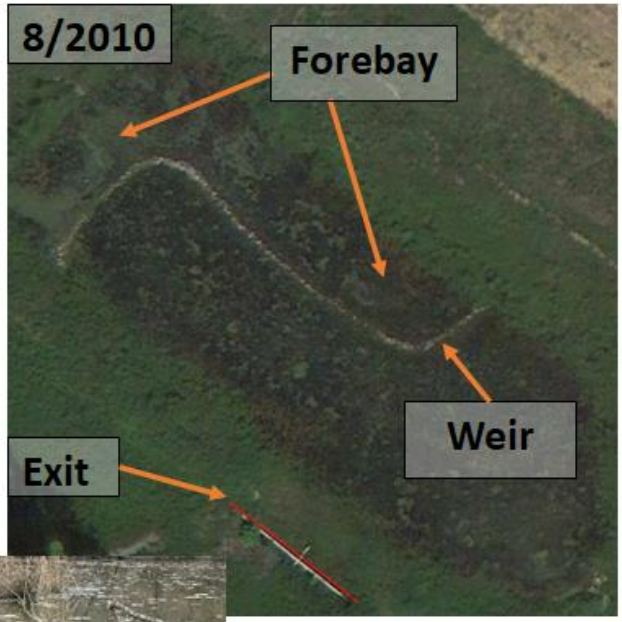
Pond 7 (Pool Pond)



13) The exit for this pond is another sheet flow wall which divides the flow in two directions and creates two ravines. The hillside is between the two ravines and is eroding at a slower rate. Eventually the entire hillside will be eroded away. The severity of the flow over top of the wall can be seen in the deflected grass of the bottom left picture.

#7 (Pool Pond) Notes

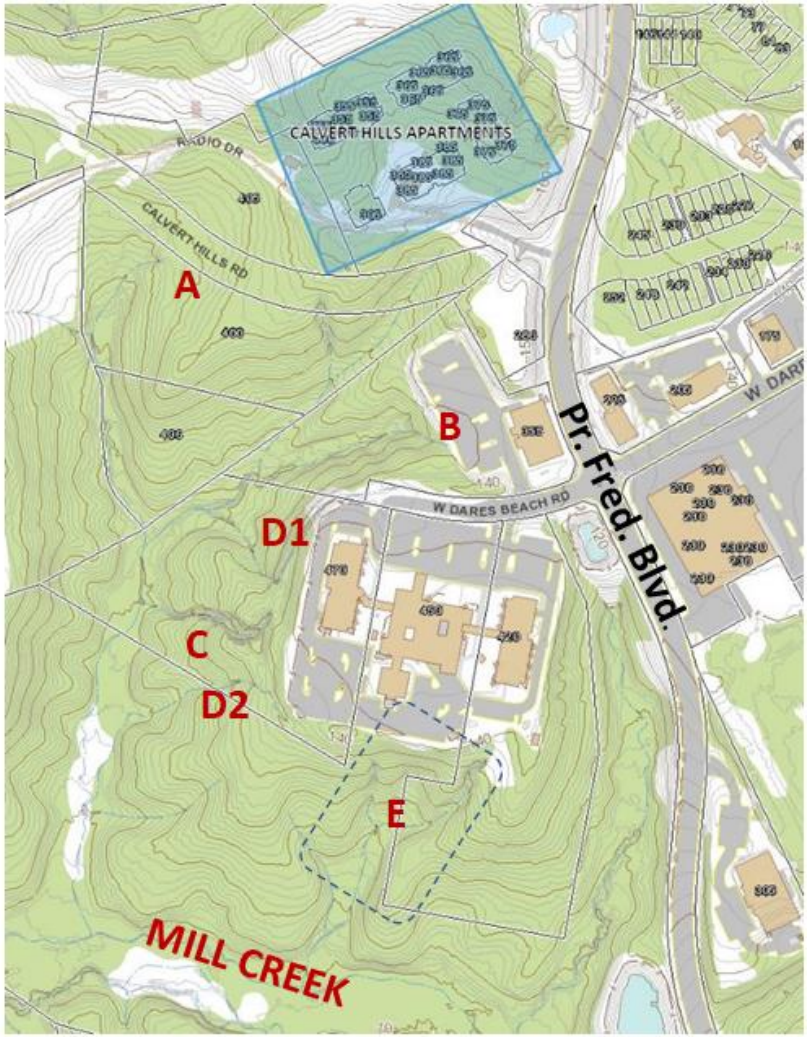
- Image Shows a Weir (Rock Wall) Early in the Life of the Pond
- Purpose
  - Separates forebay and extended storage area
  - Forebay captures most sediment
- Rarely seen → High Water in Pond
- High Water in pond Due to Sediment
- Remediation Scheduled for Out-Years in Budget
- During Wetter Times of Year Pond Routinely Overflows



14) The pool pond is actually divided into 2 parts separated by a rock weir. The Forebay at the top of the picture is supposed to capture most of the sediment. The section beyond the forebay holds most of the water for more extended periods of time. The sediment does not come from the parking lot and the hillside and pond walls are heavily vegetated. The pond overflows more frequently than it should which magnifies the erosion beyond the outflow. The excess sediment in the pond was likely deposited into the pond early in its life. Public works has outyear plans to remove sediment from the pond but …..

South Prince Frederick Blvd

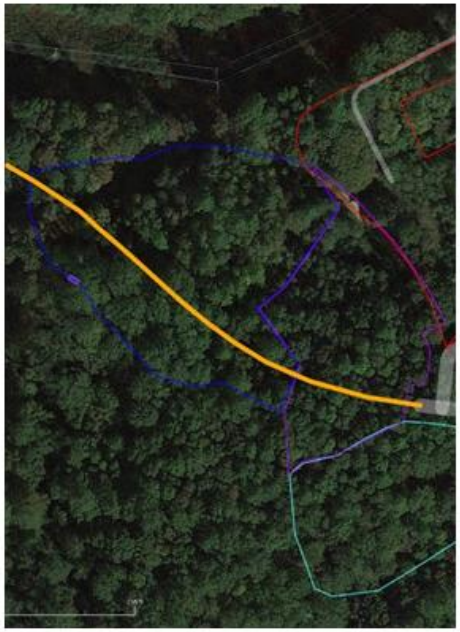
- A = Calvert Hills Apartments
- B = ARC Parking Drainage
- C = Senior Center, Main Ravine
- D = Senior Center Secondary Ravines
- E = Senior Center, Area B
  - Not covered in presentation
  - Eroded ravines
  - Destroyed silt fencing
  - Significant sediment conveyance
  - Included in proposed remediation



15) Next, we'll go to another region I call South Prince Frederick Boulevard. We will look at the Calvert Hills Apartments just north of Dares Beach Road, the damage downhill of the ARC parking lot and the undeveloped area around the Calvert Pines senior center. There are three ravines on the west side of the Senior Center which I have labeled C, D1 and D2. I will not present Site E but it features eroded ravines and destroyed super silt fences. It empties into a Mill Creek floodplain.

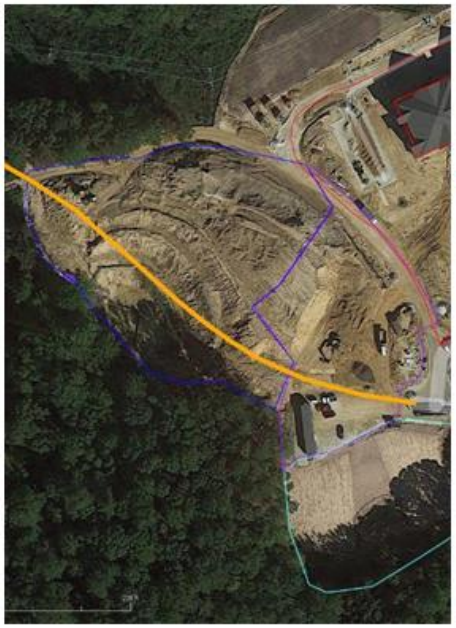
Evolution of Calvert Hills (A) Stockpile

10/2019, Google Earth



2020, Calvert GIS

10/2020, Google Earth



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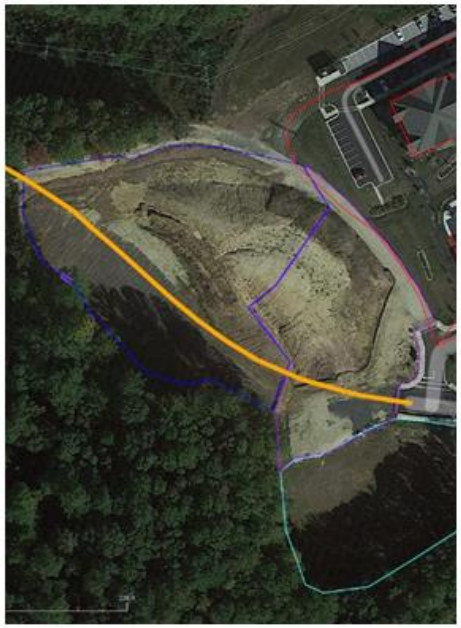
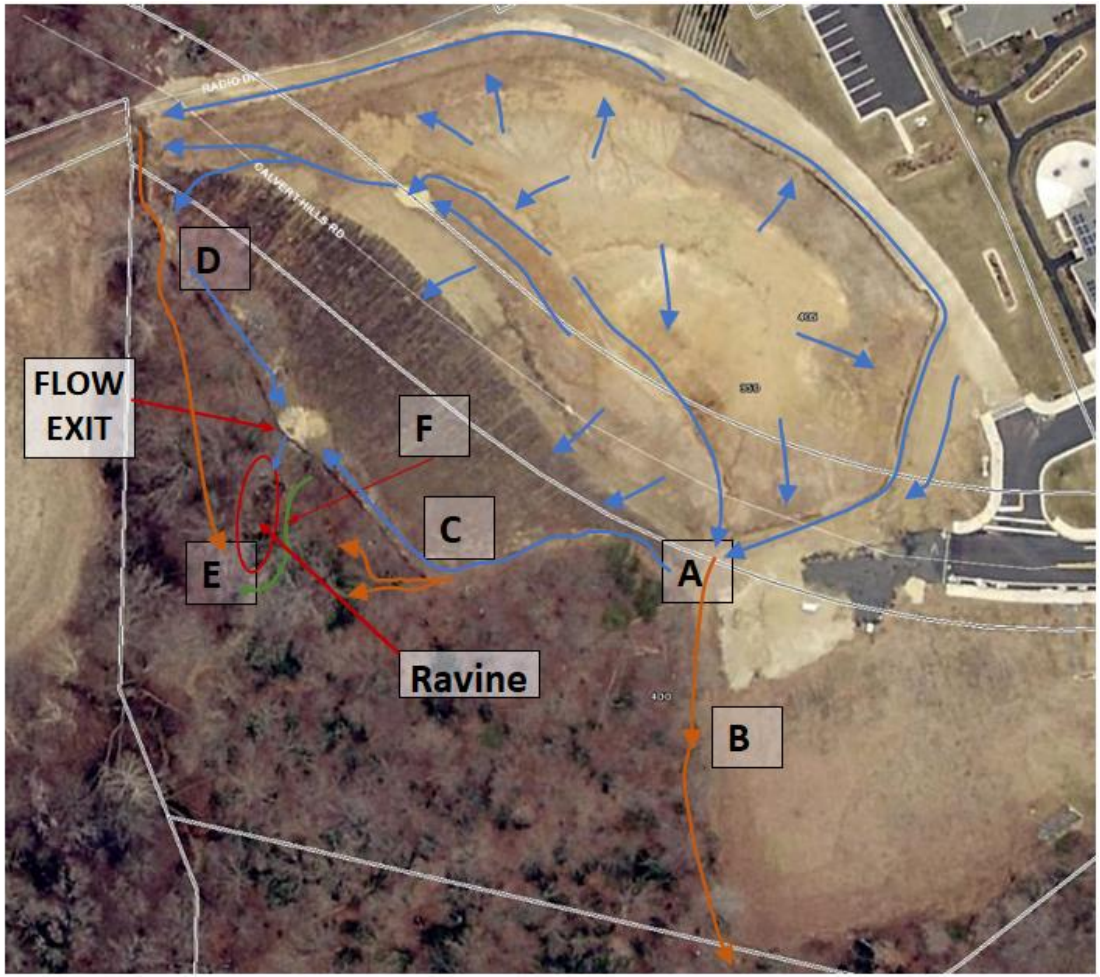


Pre-Development Forest
→No Eroded Streambeds

16) I will first talk about the Calvert Hills Apartments and specifically the large stockpile which is still on the property. In the 4 pictures I have retained the same outlines throughout. The October 2019 picture shows the undisturbed forest where the stockpile currently exists. From topographic maps one can see the location of pre-disturbance streams. The old streambeds were found during an onsite examination and they were NOT eroded. The erosion occurred after construction began. During the stockpiles evolution large amounts of sediment washed away. An eroded ravine formed and the streambed beyond the exit also eroded.

Calvert Hills Stockpile Flows

- **Original Design: All flow Through Flow Exit Shown**
- **Current**
  - 2/3 of Flow (B and E) bypasses exit
  - Bypass flow is NOT filtered through silt fences
  - Flow through ravine reduced
  - Ravine is still growing
- **Stockpile Graded Slope Was Forest→ No Eroded Streambeds**



17) I've included the flow path picture here to point out some details. The actual stockpile covers 1.2 acres. The area drained including the contoured slope down to the main exit covers 2.6 acres. The stockpile only has silt fencing on the right side of the pile as seen by the dark line. Super silt fencing can be seen on both sides of the flow exit at the bottom of the contour. The original designed flow path followed C and D to the flow exit and out through the super silt fencing. This overloaded paths C and D and there was severe erosion. The current design bypasses 2/3 around the exit and flows along paths B and E. This eased the growth of the ravine and the erosion of paths C and D but NONE of the flow along B and E goes through a silt fence.

Calvert Hills (A)

Mill Creek Tributary

Eroded Ravine Beyond Exit

18) These are some pictures at various stages of the stockpile's evolution. The most telling is the accumulation of sediment downstream in a Mill Creek tributary. Note the dead tree. It was likely killed by the thick layer of sediment piled on top of its root area.

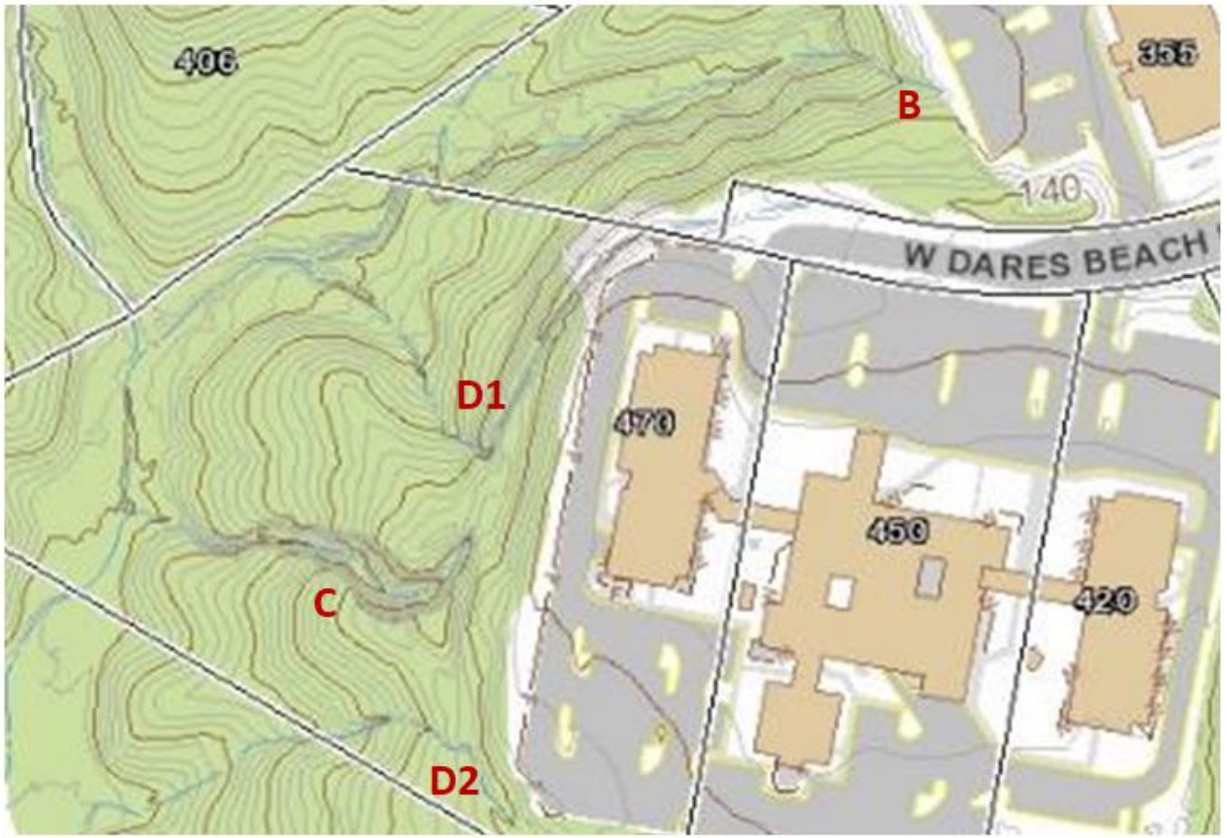
Calvert Hills (A) Conclusions

- **Apartment area has good SWM**
  - Pervious pavers
  - Extensive rain garden/micro bioretention ponds
  - Underground infiltration
- **Forested Area Cleared for Large Semi-permanent Stockpile**
- **No Site design for SWM of Stockpile**
  - Flawed SWM focuses runoff
  - Inadequate rock dams, silt fences, slope vegetation and sediment settling ponds
  - Flawed installation
- **MDE Understaffed for Prescribed Oversight**
- **Significant Ravine and Stream Incising**
- **Hundreds of Yards of Sediment Transported Into Watershed**
- **Consequences Not Consistent with Damage**

19) The apartment area has modern ESD and structural methods applied effectively. The stockpile area is another story. 3 acres of forest was stripped to make room for a significant feature which had no design details on the development's site plan. At the time the stockpile was evolving the MDE was severely understaffed and essentially no inspections were performed on the stockpile. The result was hundreds of yards of sediment being sent into the watershed. I filed a complaint with MDE during this time which resulted in renewed oversite, redirection of the design, and fines. I'm sorry to say that the consequences placed upon the developer were not consistent with the damage caused. The developer also chose to not implement a number of MDE recommendations.

ARC (B) and Senior Center Canyons (C, D)

- ARC Has Eroded Head Near Parking Lot



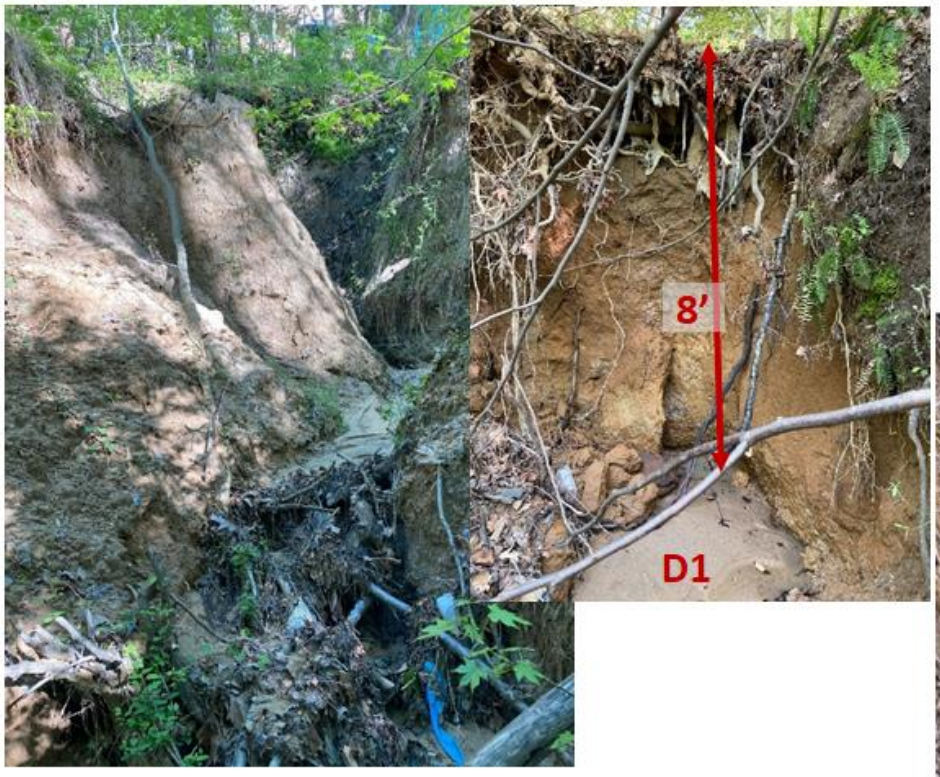
20) I'll not dwell on the ARC site but it also contributes to the sediment deposited into the same Mill Creek tributary. Once again drainage from impervious surfaces was dumped onto a steep fragile slope and severe erosion was the result. Note the rocks in the picture which were no match for the volume of water released. Also note the locations of Senior Center C, D1, and D2.

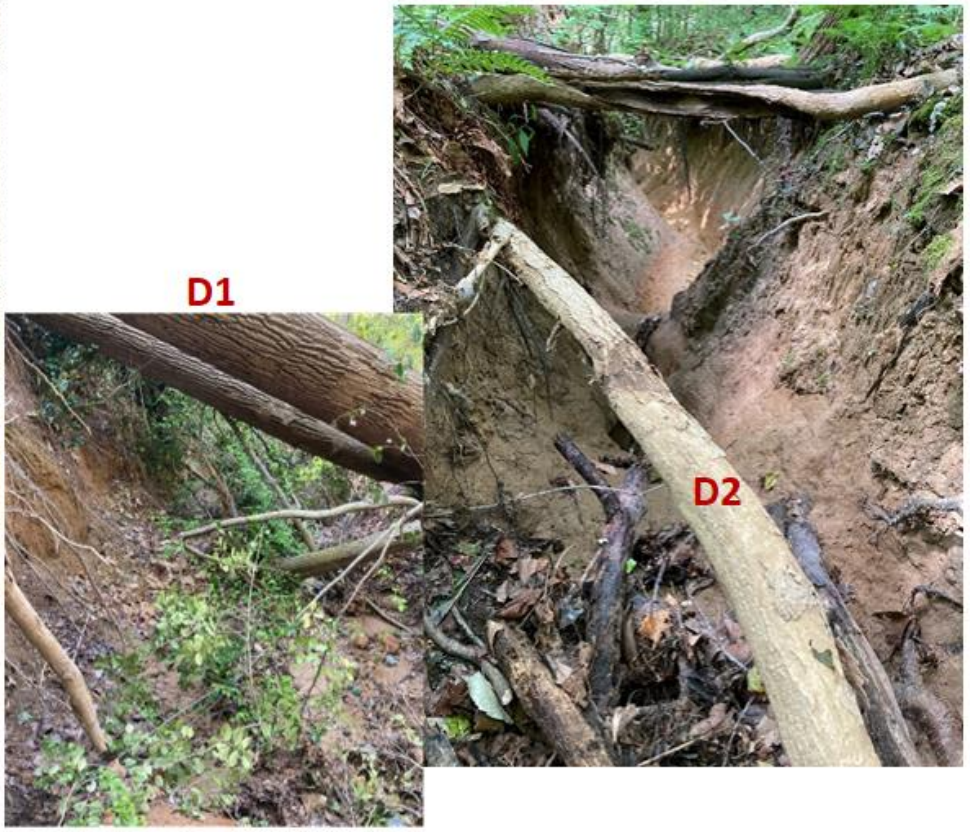
Senior Center Canyons (C, D)

- **Built in Early 1990's**
- **NOT a SWM Facility – Direct Water Away From Buildings**
- **Severe Erosion Began Shortly After Construction**
- **Present:**
  - Hill cut in half (C)
  - D1, D2 deeply incised side canyons
  - Site plans and grant funding
  - SWM NOT part of rework

21) As I mention before, I will only cover the three ravines near the west side of the Center. The original features for conveying runoff away from the building were built in the early 1990's. The system began failing almost immediately. The result was the 30' deep canyon that cut a hill in half and created two deeply incised side canyons D1 and D2. The pictures of this site as well as others I have shown do not do justice to the damage one sees in person. Public works has $600,000 in grant money to repair the damage but the repair does not include stormwater management upgrades.

Senior Center Canyons (C, D)

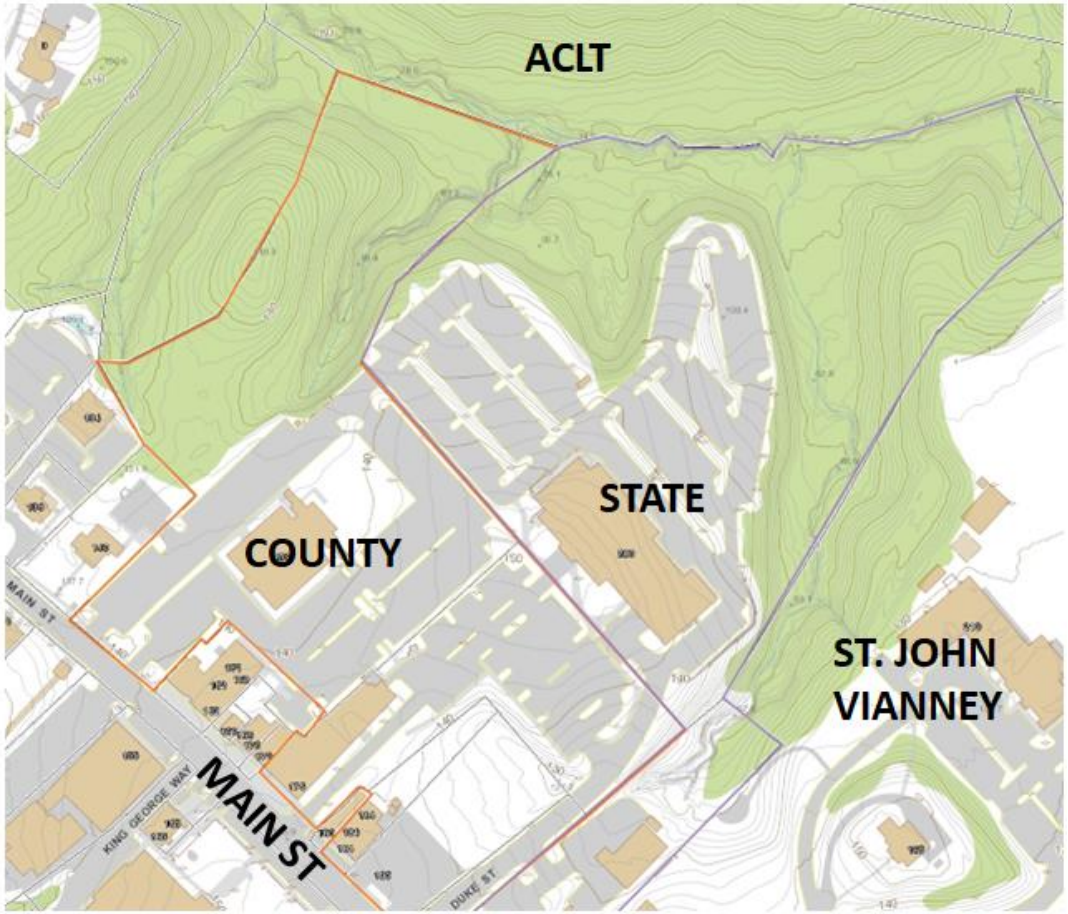




22) These are the two side ravines D1 and D2. They are deep with steep walls and are lined with clay. Oddly, these two side canyons now intercept and divert a majority of the flow that formed the 30’ canyon away from the canyon.

Government Plaza

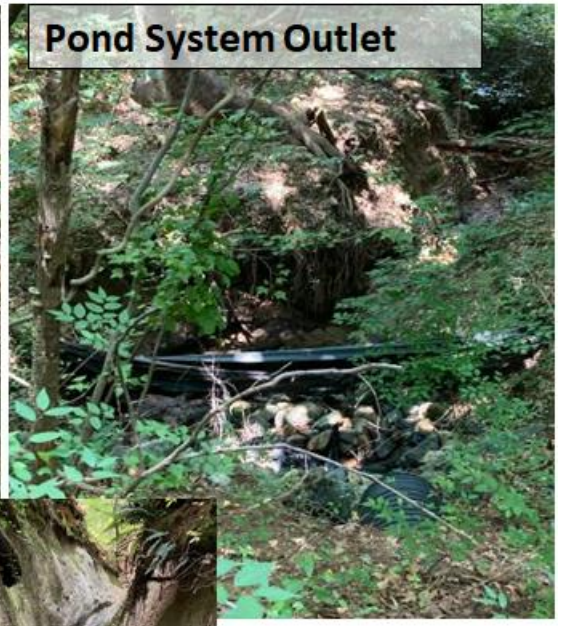
- State and County Facilities
- Each Have Contributed to Significant Erosion and Sediment Production and Transport
- Old Designs (dump over the side of the hill)
- Little or No Maintenance or Repair



23) Now onto my last failure site located at the government plaza in downtown Prince Frederick. The land downhill of the parking lots is steep and fragile. It is owned by a combination of the State, the County and a small part by St. John Vianney. The drainage off of the parking lots is essentially just dumped over the hill. The result is again spectacular eroded features and destruction of the minimal stormwater management features employed. The flow off of the plaza makes its way into Parkers Creek and then into the Bay. As with many of the failed systems there is little maintenance provided and no plans for remediation.

Downhill of Government Plaza

Clay Canyons



24) We see the same sorts of damage as with other sites but the fact that neither the State nor the County will take responsibility for fixing the damage is distressing. The runoff from the State owned parking accounts for much of the damage. Only about a third of the state parking is actually used with the least used parking just uphill from the damaged areas. I would like to see these areas of unused parking turned into viable stormwater management features. What do you think?

SWM System Causes of Failure

- **System not sized for local rainfall volume and intensity**
- **Soil fragility (including slope) not properly accounted for**
- **Excess outflow**
- **Outflow released onto steep slopes**
- **MDE inspection corps understaffed (getting better)**
- **Design implementation issues**
- **Inadequate fines for violations**
- **Fixed inspection schedule, Not accounting for heavy storms**
- **Lack of maintenance (and $$ for maintenance)**
- **Older systems not upgraded**
- **Damage repair not timely**

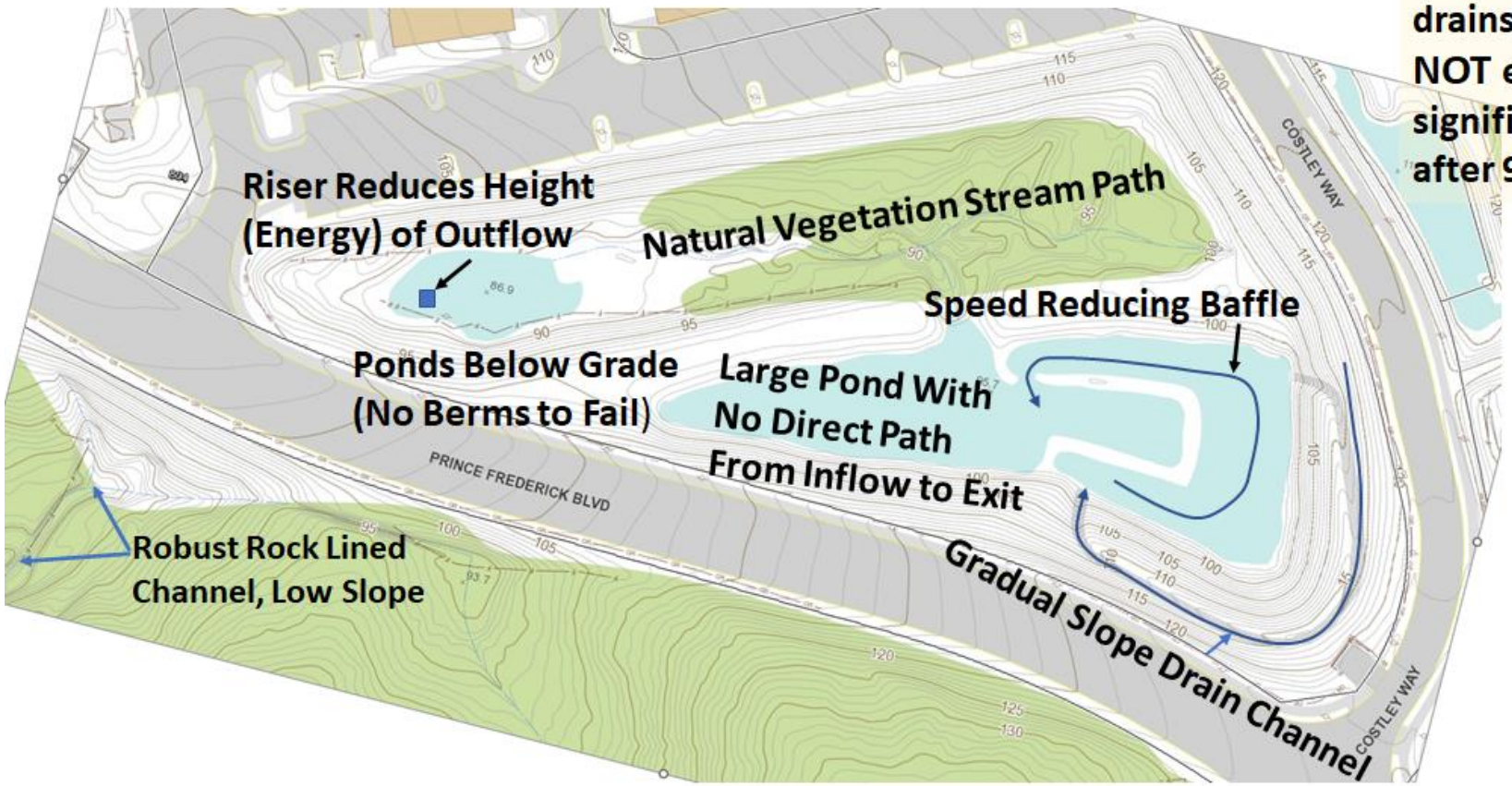
25) My conclusions regarding the causes of failures. Others might have their own list. I won't read the whole list but my key causes would be
1. Systems not sized for actual local rainfall,
2. Soil fragility and slope not properly accounted for
3. Insufficient maintenance and timely repair

SUCCESSES

26) Don’t worry; I don’t have as many examples of success; or maybe you should worry. I think the reason is that sometimes successes are harder to detect – they are out there though just doing what they do without trouble.

SUCCESSES – LIBRARY SYSTEM

NOTE: The stream that the system drains into did NOT exhibit significant erosion after 9” rainfall.



27) The library system is rare in that even the last hurricane with its 9” rainfall did not damage it nor cause significant downstream damage. I found out in talking with the designer that extra resilient features were built into the design. None of these features are revolutionary on their own but the combination of the features ensured success even when faced with an extreme event. Pull over some time and take a look. I especially like the baffle and the gradual slope drain channel.

New Systems Likely to Succeed

- **New Pond Near Theater**
  - Robust Pond with Riser to Lower Effluent to Stream Level
  - Settling Pond Prior to Stream
- **Behind Fox Run Shopping**
  - Newly refurbished
  - Heavy duty Construction
- **Calvert Hills Apartments (NOT Including Stockpile)**
  - ESD and BMP Combination
  - Extensive Rain Gardens
  - Pervious Pavers

28) There are 3 other systems I'd like to highlight as likely to succeed. It takes time and the tests of high rainfall amounts to tell.
1. There is a new large pond system just to the southwest of the theater. It replaces a failed system that was responsible for dumping huge amounts of sediment downstream.
2. The system behind Fox Run shopping center was repaired and improved recently.
3. The apartment portion of the Calvert Hills property uses a promising mix of ESD and structural features

Hunting Creek, Twirly Hole

Thank you for your time and attention.

Please remember why it is important that we do stormwater management right.

Questions?