Civil & Environmental Consultants, Inc.

Managed Release Concept Strategy

Presented By:

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March 21 & 22, 2024

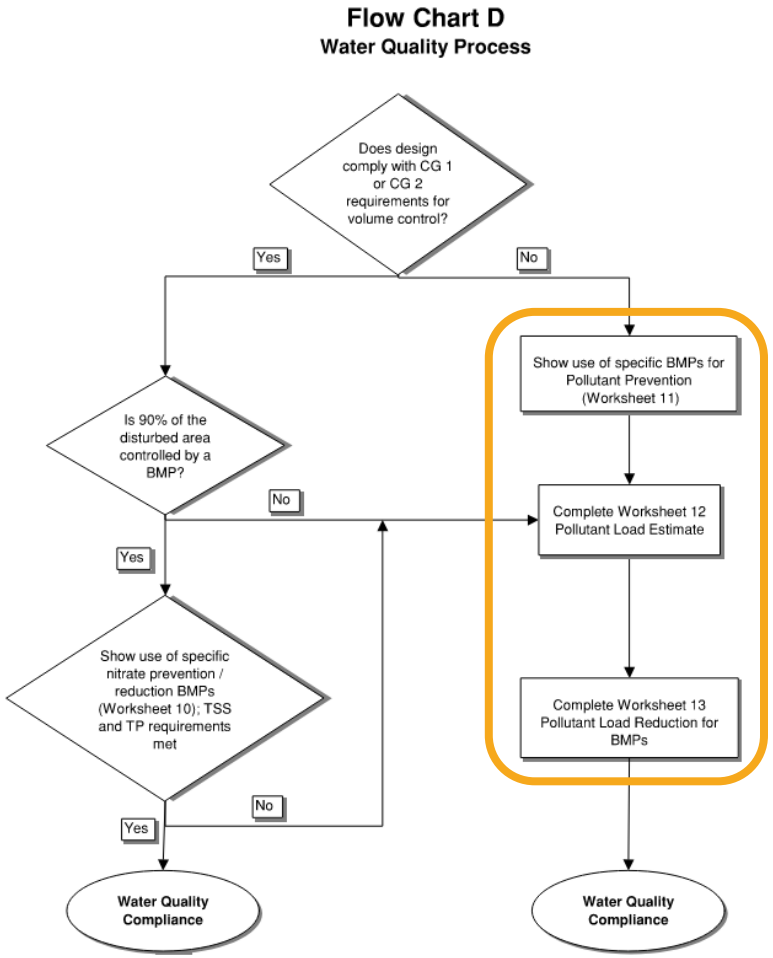
Background – Pennsylvania Stormwater Regulations

- Projects must meet **volume reduction** and **water quality requirements** specified in an applicable Department approved and/or current Act 167 Stormwater Management Plan; **or manage the net change** for storms up to and including the 2-year 24/hour storm event when compared to preconstruction runoff volume and water quality.

Background – Pennsylvania Stormwater Regulations

- Volume Control Guideline 1 (CG-1): *Very commonly used*
  - Do not increase the post-development runoff volume (2-year/24-hour event)
  - Existing non-forested pervious areas considered meadow in good condition
  - 20% of existing impervious area considered meadow in good condition (pre-development)
- Volume Control Guideline 2 (CG-2): *Not commonly used*
  - Not applicable for regulated activities with earth disturbances > 1 acre
  - Stormwater facilities sized to capture at least the first 2” of runoff from all contributing impervious surfaces
  - At least the first 1” of runoff from new impervious surfaces shall be permanently removed

Infiltration Not Feasible – Previous Process



"Management" of 2-year/24-hour storm event volume increase per 25 PA Code 102.8.(g).(2)

Infiltration Not Feasible – Previous Process

- Previously accepted approaches:
  - Underdrains
    - Controlled dewatering (between 24 and 72 hours)
    - Shutoff valve for underdrain that would only be open for the purpose of maintenance activities.
  - Wet Ponds (in certain instances)
  - Worksheets 12/13 – Water Quality (BMPs in series)

	Removal Efficiency		
	TSS	TP	NO_3
6.4.2 Infiltration Basin	85%	85%	30%
6.6.4 Water Quality Filters & Hydrodynamic Devices	60%	50%	20%
6.4.8 Vegetated Swale	50%	50%	20%
Combined Removal Efficiency for BMPs in Series (R)	97.0%	96.3%	55.2%

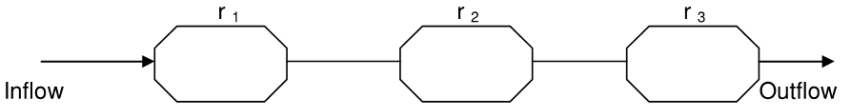


Fig. 8-1. BMPs Connected in Series

Equation for removal efficiency of BMPs in series:

$$R = 1 - \prod_{i=1}^{n}(1 - r_i)$$

R = Removal efficiency of n BMPs in series.

r_i = Removal efficiency of BMP_i

The removal efficiency R of the above three BMPS in series is,

$$R = 1 - \{(1 - r_1) * (1 - r_2) * (1 - r_3)\}$$

Infiltration Not Feasible – MRC Approach

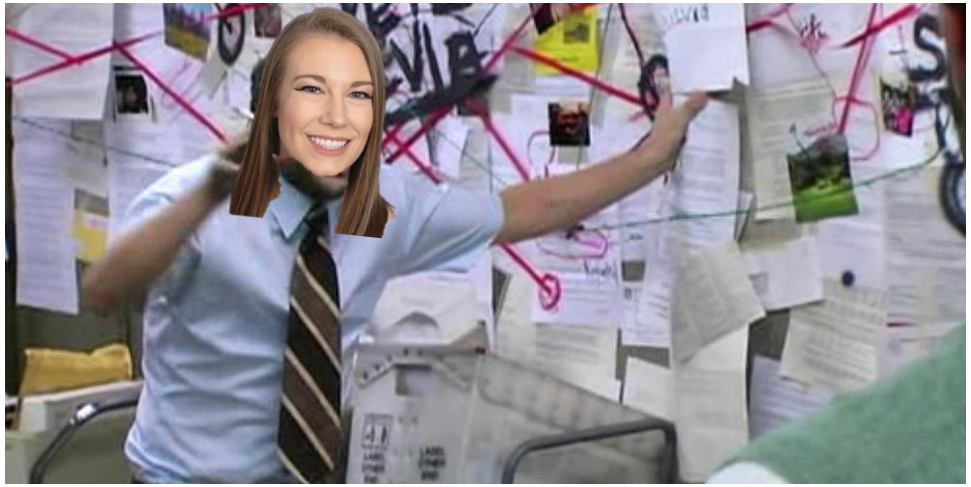
- Managed Release Concept (MRC) was introduced by the PADEP to establish guidance for project areas or subareas where infiltration is considered infeasible to meet regulatory requirements under §102.8(g)(2)
- Intention of MRC is to replicate the stormwater volume reduction and water quality benefits of conventional infiltration BMPs and to protect and improve geomorphologic processes within downstream receiving waters.

MRC – White Paper

- The MRC white paper provides design guidance and background information.
- General objectives of the MRC:
  - Manage the 2-year volume increase;
  - Provide WQ treatment (via media and/or pre-treatment); and
  - Provide means for infiltration (when conditions permit).
- Refer to the MRC white paper for more information

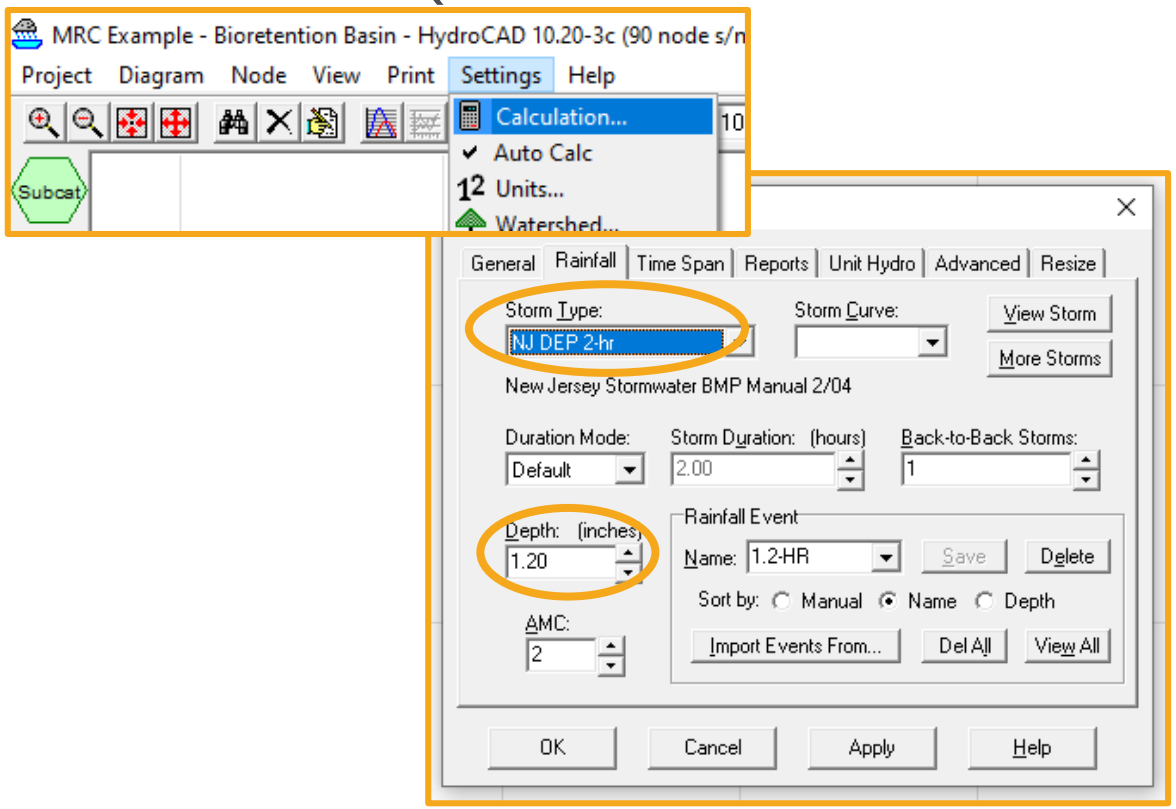
MRC Design Standards

- 1.2”/2-hour storm event
- Release Rate
- Internal Water Storage (IWS)
- Equivalent Impervious Area
- Geomorphologic Peak Flow Management
- Infiltration Testing
- Separation Distance
- Ponding Depth/Dewatering Time
- Underdrain Design



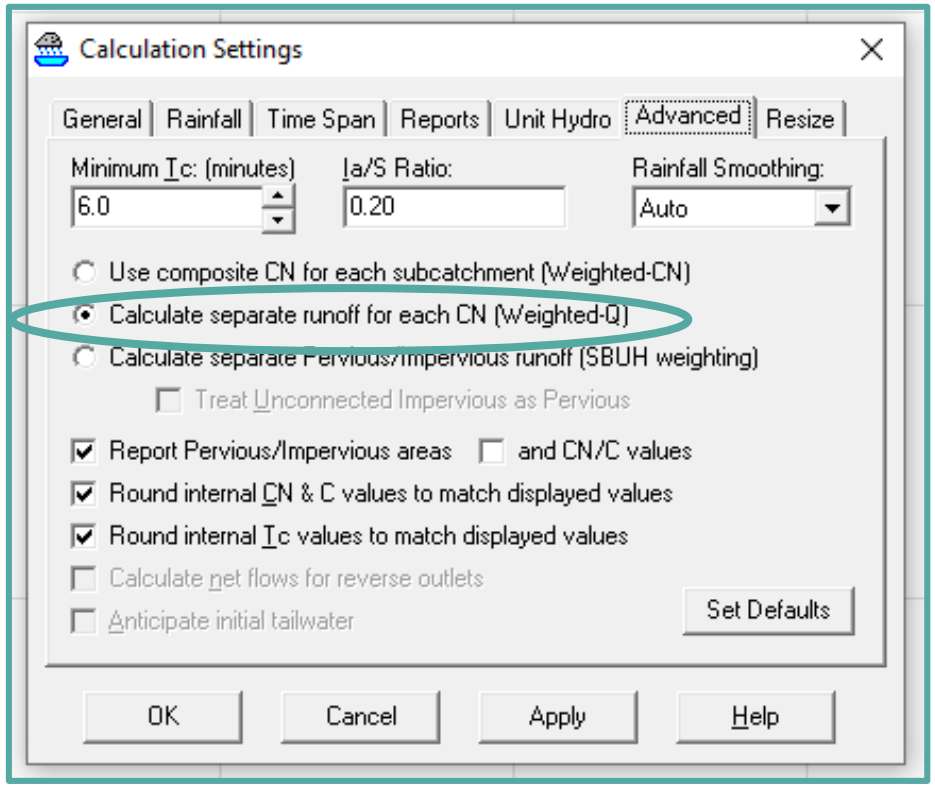
1.2”/2-Hour Storm

- Runoff from the 1.2”/2-hour storm from the *contributing watershed* should be treated by the MRC without overflow (i.e. it must flow through only the underdrain)
  - *1.2 inches of rainfall is equivalent to 1.0 inches of runoff from impervious surfaces using the NRCS curve number method.*
  - *The 2-hour distribution is a common practice used to develop a short duration rainfall pattern for analysis.*



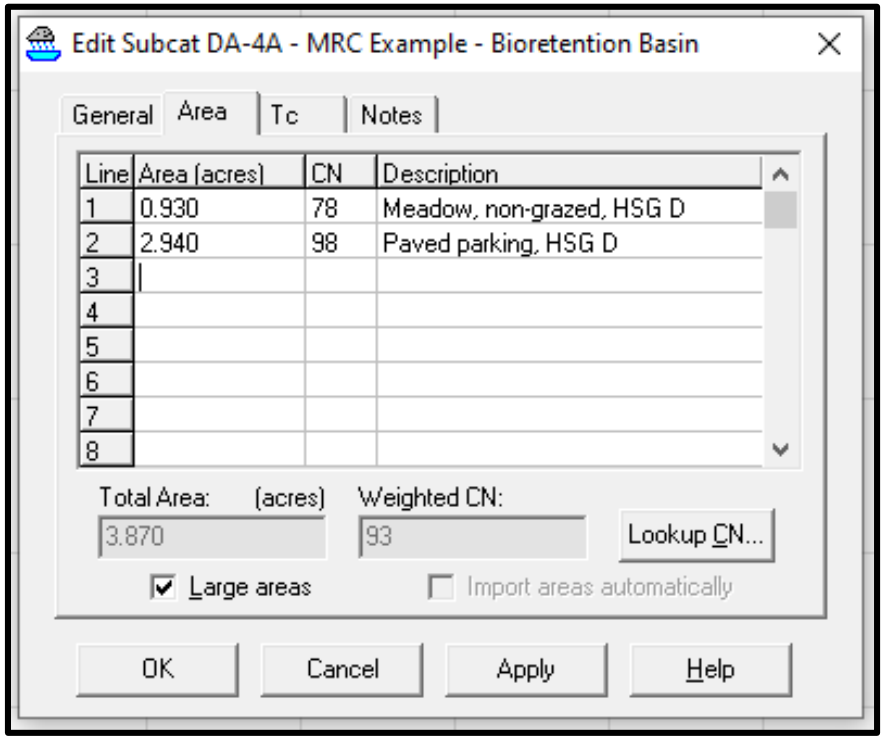
1.2”/2-Hour Storm

- The 1.2”/2-hour volume and rate must be analyzed via the *Weighted Q method*



Weighted Q vs. Weighted CN

- **Weighted Q:** Runoff is calculated for *each individual* CN
- **Weighted CN:** Runoff is calculated for the *average* CN



Weighted Q:

Cover Type	Soil Type	Area (sf)	Area (ac)	CN	S	Ia (0.2*S)	Q Runnoff[1] (in)	Runoff Volume[2] (ft^3)
Meadow	D	40510.8	0.93	78	2.82	0.56	0.12	395
Impervious	D	128066.4	2.94	98	0.20	0.04	0.99	10,519
TOTAL:		168577.2	3.87					10,914

Weighted CN:

Cover Type	Soil Type	Area (sf)	Area (ac)	CN	S	Ia (0.2*S)	Q Runnoff[1] (in)	Runoff Volume[2] (ft^3)
N/A		168,577	3.87	93	0.75	0.15	0.61	8,585
TOTAL:		168,577	3.87					8,585

1. Runoff (in) = Q = (P-0.2S)2 / (P+0.8S) where
   P = 2-Year Rainfall (in)
   S = (1000/CN) - 10
2. Runoff Volume (CF) = Q x Area x 43,560 x 1/12
   Q = Runoff (in)
   Area = Cover Type Area (ac.)

Release Rate

- The 1.2”/2-hour storm release rate *from* the MRC should not exceed 0.01 CFS per acre of **equivalent impervious area.**
- This release rate is approximately the expected rate of interflow (lateral movement of stormwater to a stream) after a 2-year/24-hour storm event.
- Releasing at this rate will produce a condition where baseflow contributions will be similar to that of an undeveloped area during and after storm events.

Equivalent Impervious Area

- **Equivalent Impervious Area** is equal to the *total volume of runoff (acre-feet)* reaching the MRC generated during the 1.2”/2-hour storm divided by 0.08333 feet

Calculating Equivalent Impervious Area & Release Rate

Rainfall: 1.20 **in**

Proposed Conditions:

Cover Type	Soil Type	Area (sf)	Area (ac)	CN	S	Ia (0.2*S)	Q Runnoff[1] (in)	Runoff Volume[2] (ft^3)
Meadow	D	40,511	0.93	78	2.82	0.56	0.12	395
Impervious	D	128,066	2.94	98	0.20	0.04	0.99	10,519
TOTAL:		168,577	3.87					10,914

0.251 Ac-ft

1. Runoff (in) = Q = (P-0.2S)2 / (P+0.8S) where
   P = Rainfall (in)
   S = (1000/CN) - 10
2. Runoff Volume (CF) = Q x Area x 43,560 x 1/12
   Q = Runoff (in)
   Area = Cover Type Area (ac.)

Calculating Equivalent Impervious Area & Release Rate

MRC Equivalent Impervious Area (Acres) = Total Volume (Ac-ft) * 12 * 0.01

0.251 Ac-ft = Total Volume of runoff generated during the 1.2-inch/2-hour storm

0.0833 ft = Conversion factor

= 0.251 Ac-ft / 0.0833 ft

3.007 acres

MRC 1.2IN/2HR Storm Event Rate = MRC Equivalent Impervious Area (Ac.) * 0.01 (cfs/Ac.)

*= 3.007 acres * 0.01 cfs/acre*

0.03 cfs

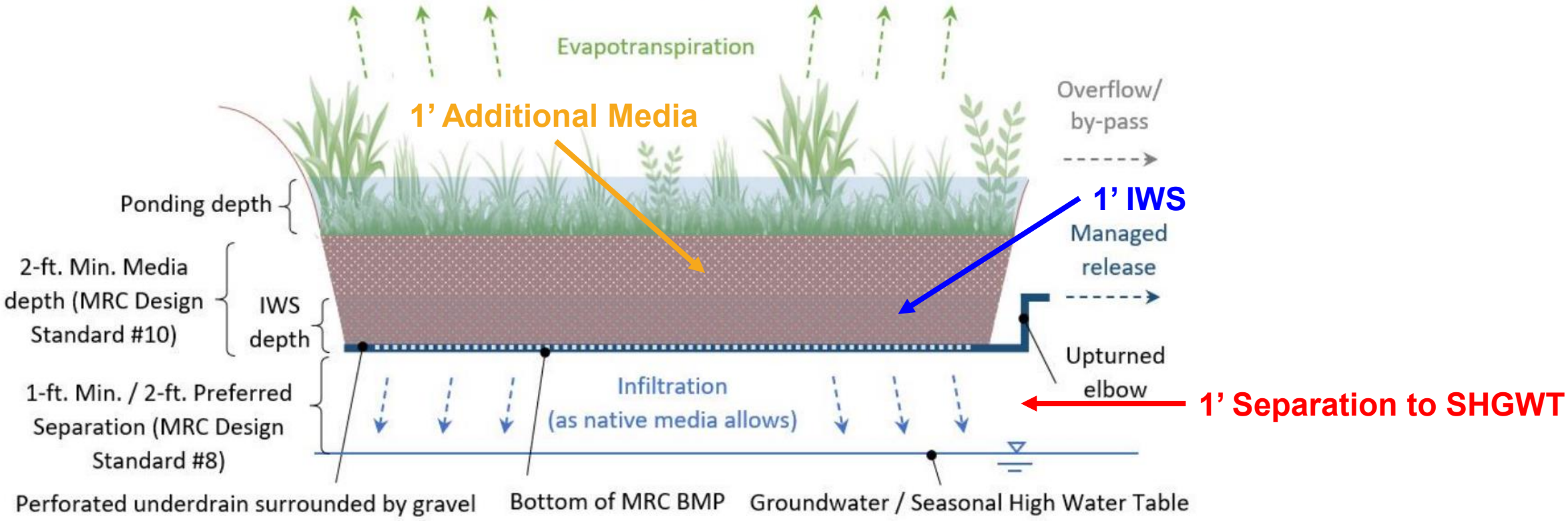
Remember – the 1.2”/2-hour rate *leaving* the MRC must be less than or equal to this rate.

Internal Water Storage (IWS)

- IWS is the material between native soil and the lowest structural outlet (i.e. the outlet for the underdrain)
  - Media Types: Soil or Gravel
- 1’ minimum / 2’ maximum depth
- 4’ maximum “total media” depth (IWS + additional media)
- If the MRC is vegetated, the IWS should be modeled as 50% of the chosen media typical void space
  - Soil media typically modeled as 30% voids. For vegetated MRC, the IWS would be modeled as 15% voids, and additional media outside of the minimum 1’ IWS would be modeled as 30% voids
- If the MRC is non-vegetated, the IWS is modeled at 0%

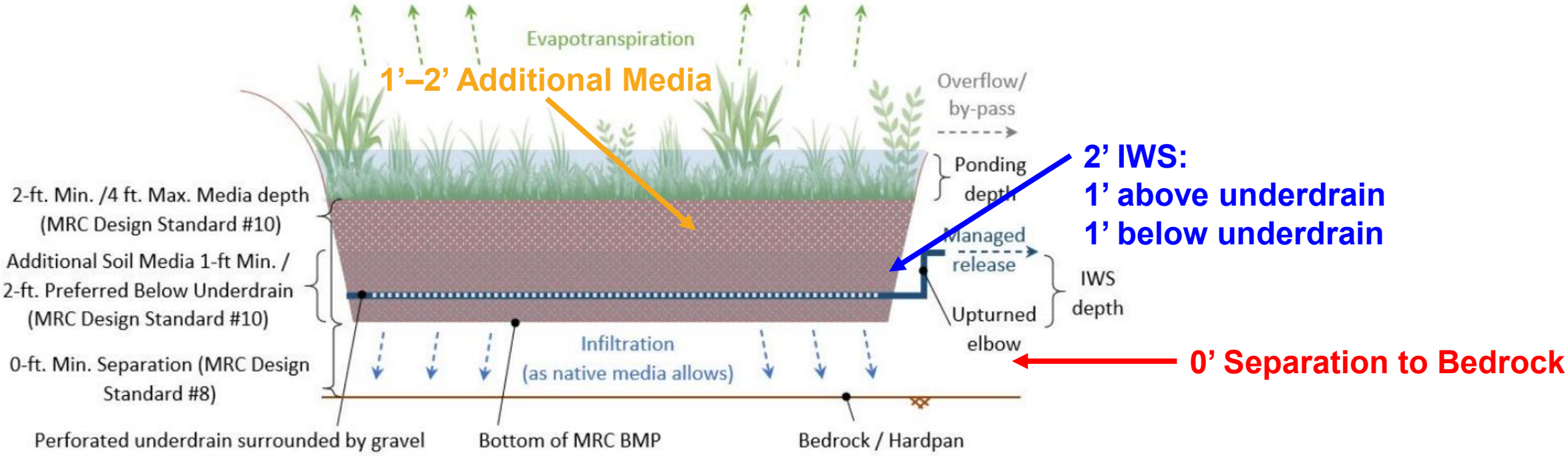
Internal Water Storage (IWS)

Figure 3: Managed Release Concept Where In-Situ Soils are Suitable in Relation to Groundwater/Seasonal High Water Table



Internal Water Storage (IWS)

Figure 6: Managed Release Concept Where In-Situ Soils <u>are not</u> Suitable in Relation to Bedrock/Hardpan



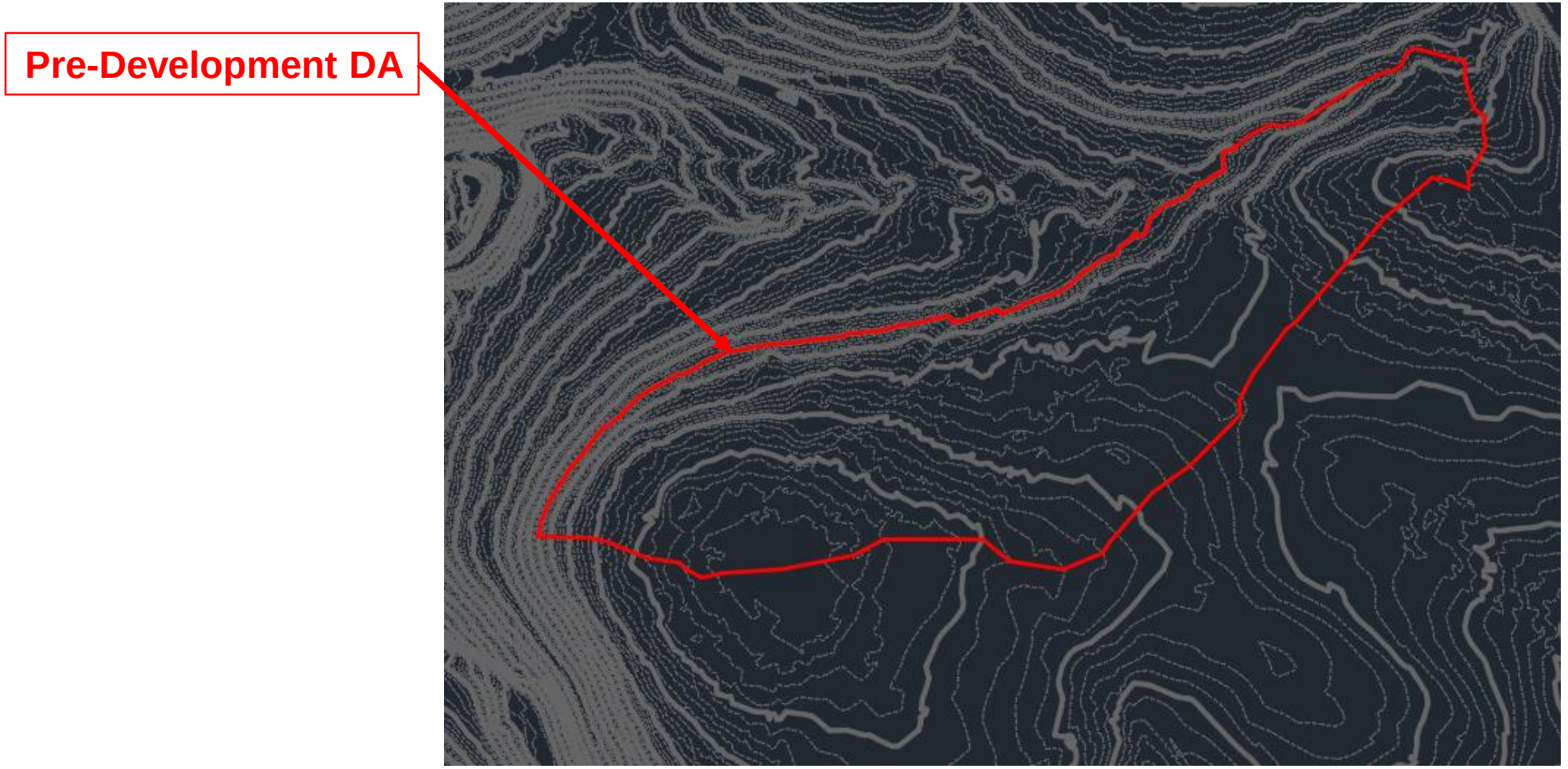
MRC Components – Liners

- *An MRC should not have an impervious liner installed unless environmental or geological conditions necessitate use of a liner, or if an existing structure would be damaged as a result of not lining the facility.*
  - *Examples include BMPs located adjacent to a constructed fill slope, BMPs located within contaminated soils, BMPs located in an area of known karst soil conditions.*
- If a system is lined – IWS starting elevations as follows:
  - Lined – start at upturned elbow (0% IWS storage)
  - Unlined & aboveground/vegetated – start at bottom
  - Unlined & belowground/non-vegetated – start at upturned elbow

Geomorphologic Peak Flow

- The peak flow from the post-construction 2-year/24-hour storm event should be managed to be less than or equal to the pre-construction 1-year/24-hour storm event
- *Typically* this is taken at the POI/POA – but there can be room for other approaches
  - Post-Development MRC DA analyzed with Pre-Development land covers
  - Post-Development MRC DA overlayed on and adjusted to follow Pre-Development DA (see following snips)

Geomorphologic Peak Flow



Geomorphologic Peak Flow

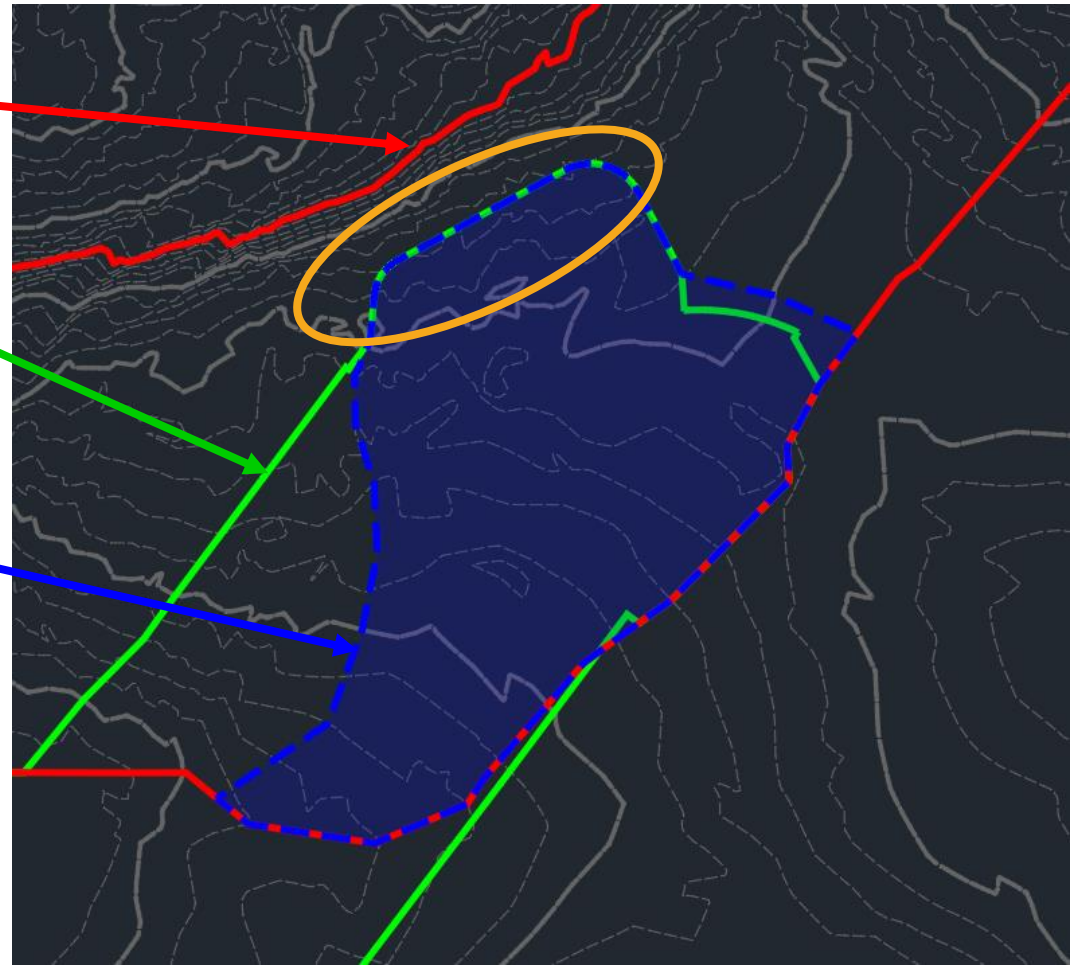
Post-Development
DA to MRC Basin

Geomorphologic Peak Flow

Pre-Development DA

Post-Development DA to MRC Basin

1-YR Pre-Development DA follows fill slope limits of MRC and then follows pre-development contours



Infiltration Testing

- *“At a minimum, one infiltration test for every 40,000 square feet (0.92 acres) of disturbed acreage should be performed with a minimum of four tests, equally distributed across the site.”*
- The minimum number of tests can be reduced if it can be demonstrated that the subsurface conditions are uniform; however, this is considered a deviation from MRC Design Standards, requiring an individual permit.
- Tests should be performed at the bottom elevation of the BMP (i.e. the bottom of the IWS)
- Test should be performed near the location of the BMP, preferably within the footprint of the BMP

Separation Distance

- 1’ minimum separation between the bottom of IWS/soil media and evidence of a Seasonal High Groundwater Table (SHGWT) (2’ preferred). This is determined during infiltration testing (i.e. mottling and/or redoximorphic features).
  - If 1’ separation cannot be provided, consider MRC with constructed wetland.
- No minimum separation between the bottom of IWS/soil media and bedrock/hardpan
- The White Paper does not specify a separation to coal/carbonaceous material, but as with other BMPs in the PCSM manual, but we typically maintain a minimum of 2’.

Ponding Depth/Dewatering Time

- Maximum ponding depth (above media) for the 2-year/24-hour storm is 2’ (1’ preferred)
- Maximum ponding depth (above media) for any event greater than the 2-year/24-hour storm is 4’
- Dewatering time is dependent on MRC type
  - Surface MRC = 72 hours (maximum)
  - Subsurface MRC = 7 days (maximum)
  - No minimum dewatering time

Underdrain Design

Vegetated

- Depending on in-situ soil infiltration capabilities, the underdrain can be located at the bottom of the IWS *or* within the IWS
- “If on-site undisturbed soils are unsuitable for the purpose of providing IWS, an additional one to two feet of suitable soil media should be provided below the underdrain.”

Underdrain Design

Non-Vegetated

- Underdrains should be located at the bottom of the IWS to promote movement of water from previous storms (i.e. to flush the water out)

PCSM SPREADSHEET EXAMPLE

Structural BMP Volume Credits: *No. Structural BMPs:* **2** *Start BMP Numbering at:* **3**

DP No.	BMP No.	BMP Name	MRC?	Discharge	Incremental BMP DA (acres)	Volume Routed to BMP (CF)	Infiltration / Vegetated Area (SF)	Infiltration Rate (in/hr)	Infiltration Period (hrs)	Vegeta-ted?	Media Depth (ft)	Storage Volume (CF)	Infiltration Credit (CF)	ET Credit (CF)
005	3	Rain Garden / Bioretention	Y	Off-Site	3.87	25,744	11,900	0.00	24	Yes	2.0	10,854	**0**	**6,259**
006	4	Rain Garden / Bioretention	Y	Off-Site	5.84	37,392	12,025	0.00	24	Yes	2.5	14,673	**0**	**7,756**
												Totals:		**14,016**

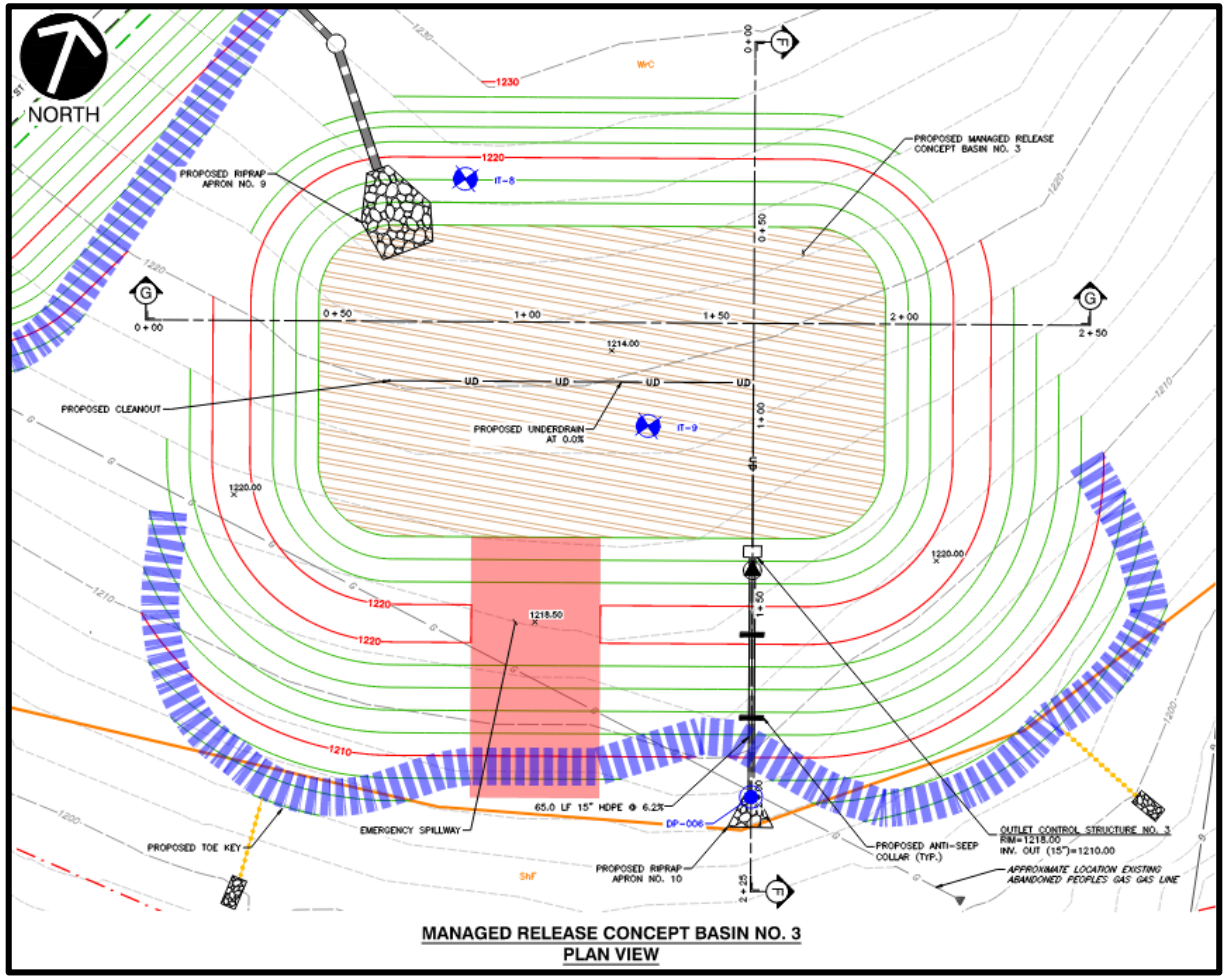
INFILTRATION & ET CREDITS (CF):	**14,016**
MANAGED RELEASE CREDIT (CF):	**49,120**
NET CHANGE IN VOLUME TO MANAGE (CF):	**46,604**
TOTAL CREDITS (CF):	**63,136**

VOLUME REQUIREMENT SATISFIED

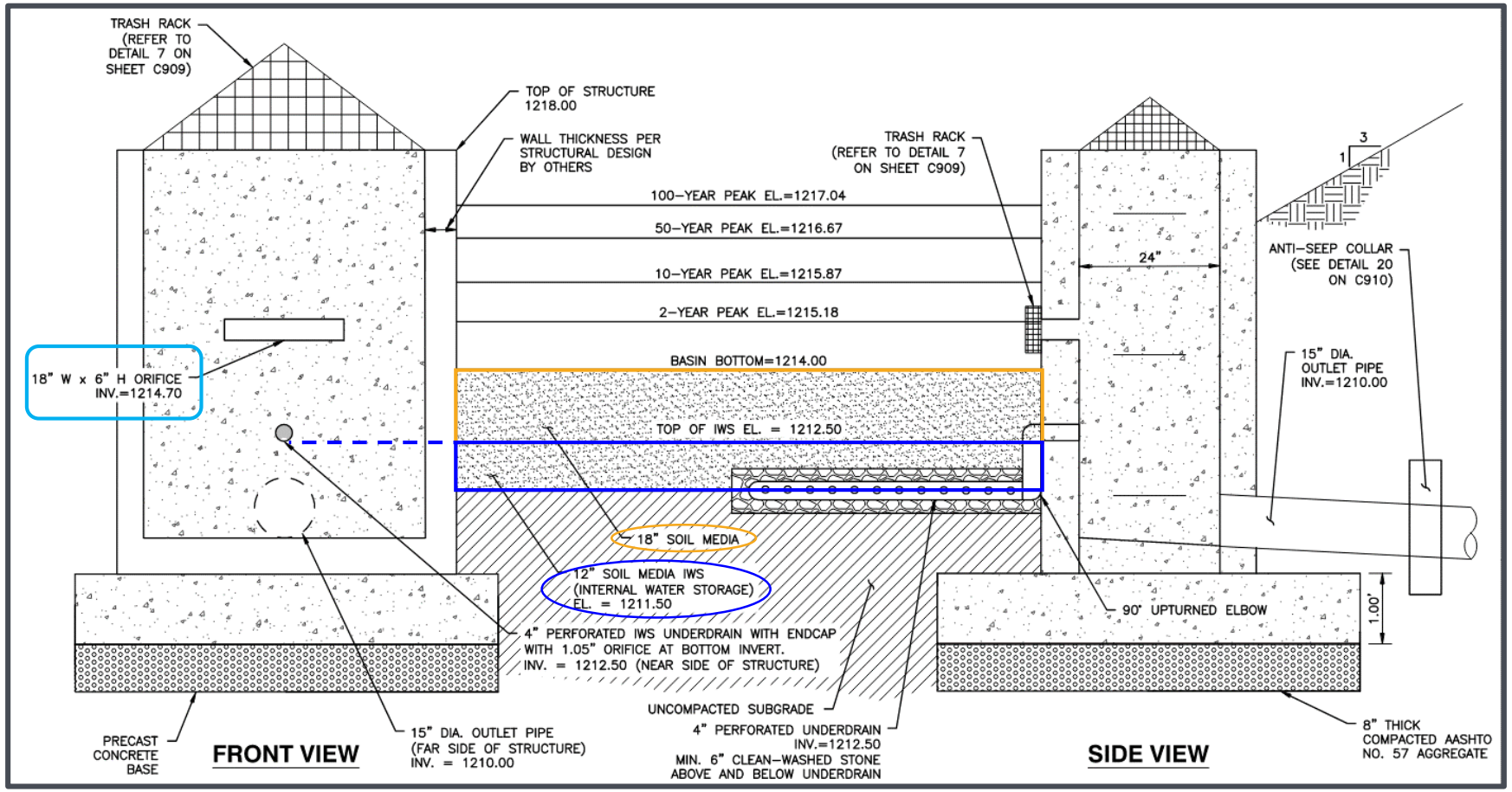
MRC Variations

- Commonly Used Applications:
  - Surface
    - Bioretention Basin/Infiltration Basin
    - Constructed Wetland
  - Subsurface
    - Prefabricated Systems
    - Perforated Pipes

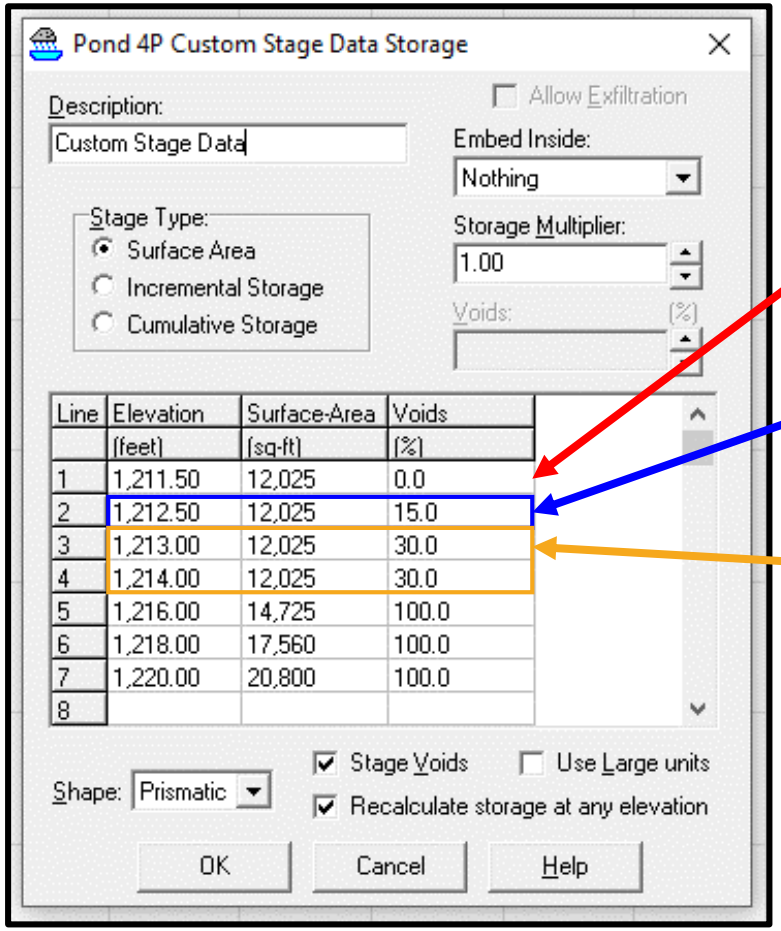
Bioretention Basin/Infiltration Basin



Bioretention Basin/Infiltration Basin



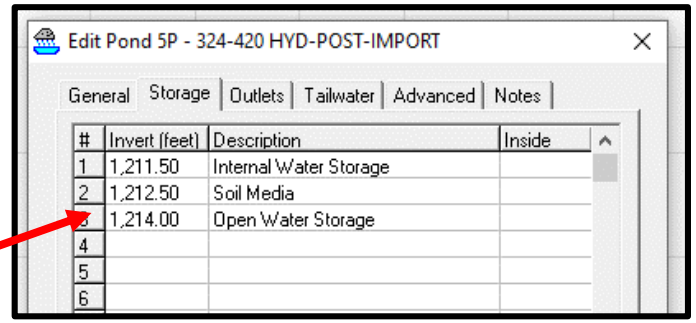
Bioretention Basin/Infiltration Basin

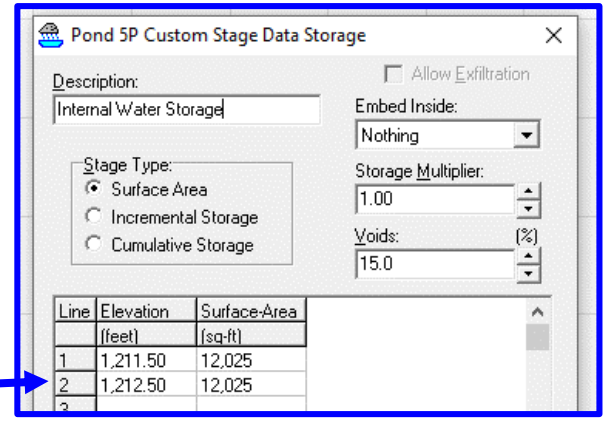


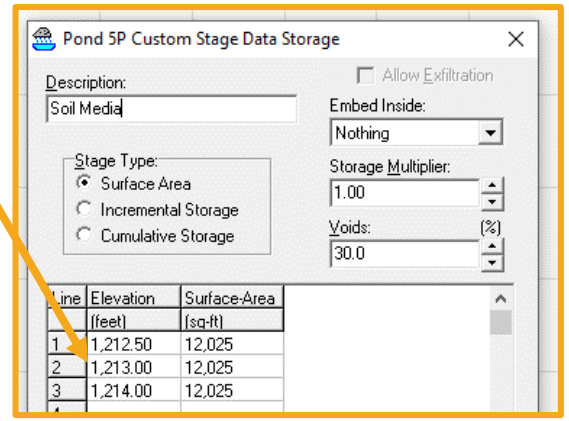
Bottom of Basin at Native Soil

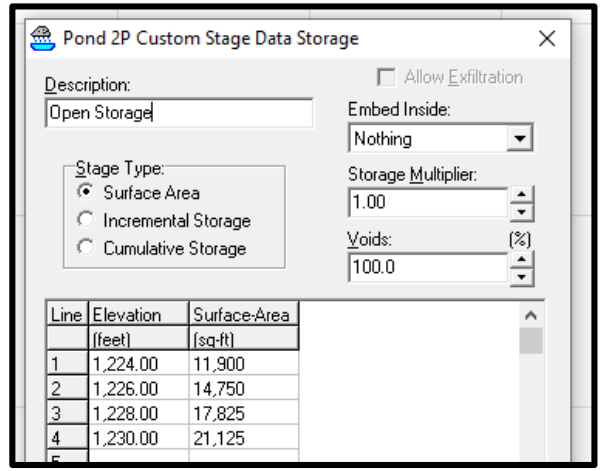
1' Internal Water Storage (IWS) at 50% media void

1.5' Additional Media at 100% media void

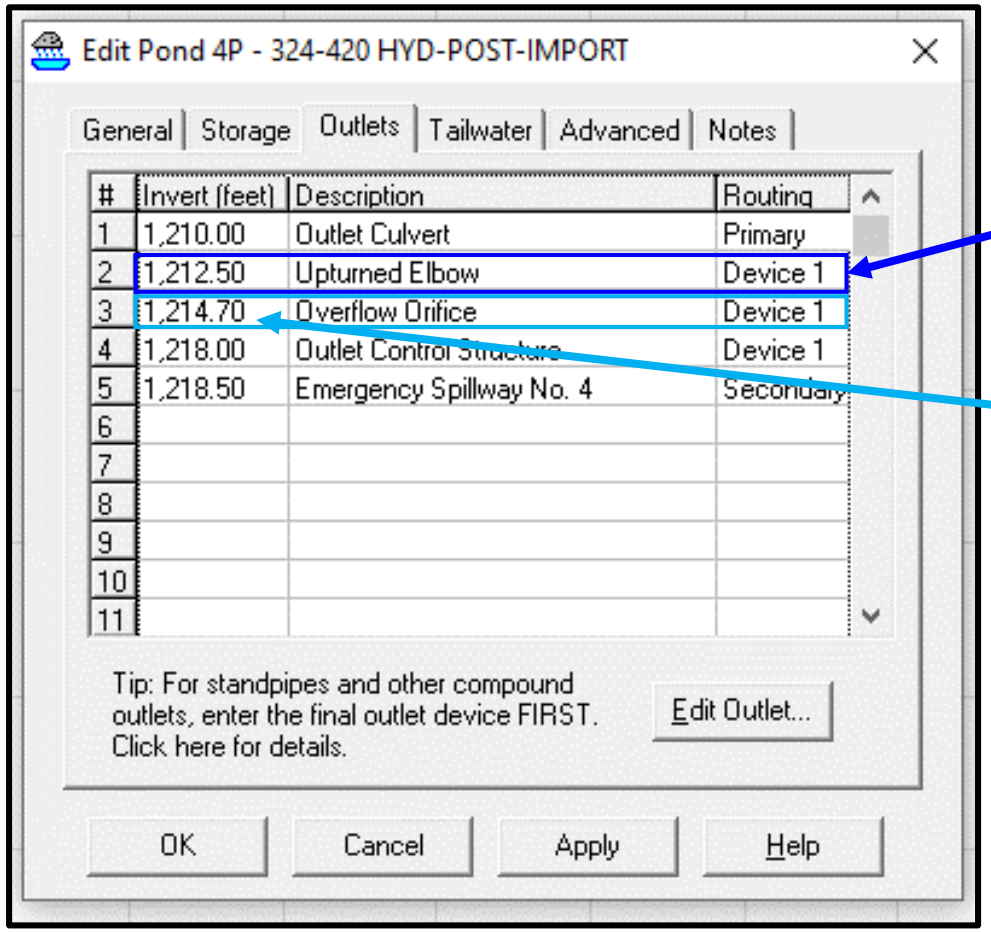








Bioretention Basin/Infiltration Basin



1' Internal Water Storage (IWS) at 50% media void

First orifice set above the 1.2"/2-HR storm water surface elevation (WSEL)

1.18' ponding depth for 2-YR storm (2' maximum)
Measured from top of media (1224.00)

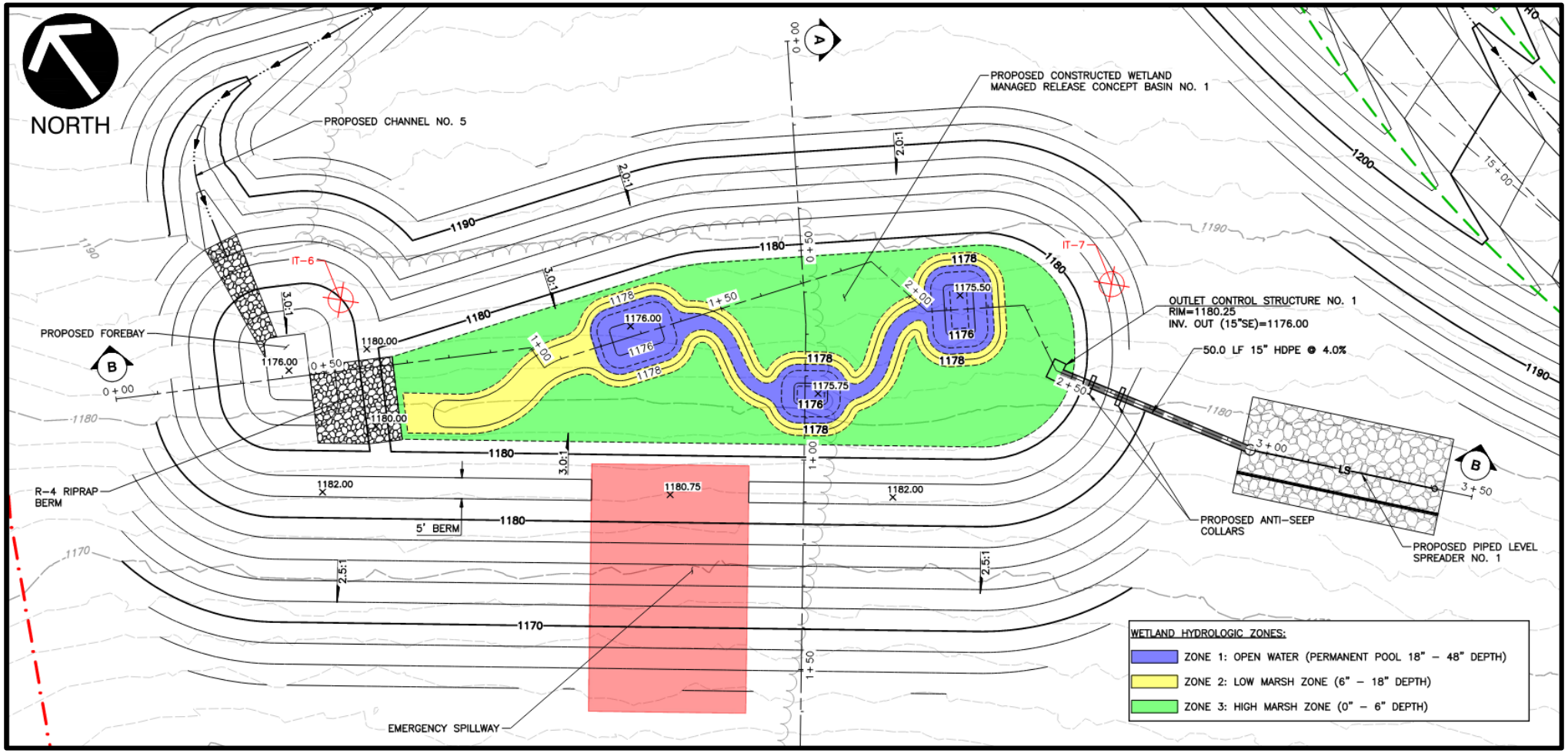
3.04' ponding depth for 100-YR storm (4' maximum)
Measured from top of media (1224.00)

Pond 4P: MRC Basin No. 3 - 324-420 HYD-POST-IMPORT

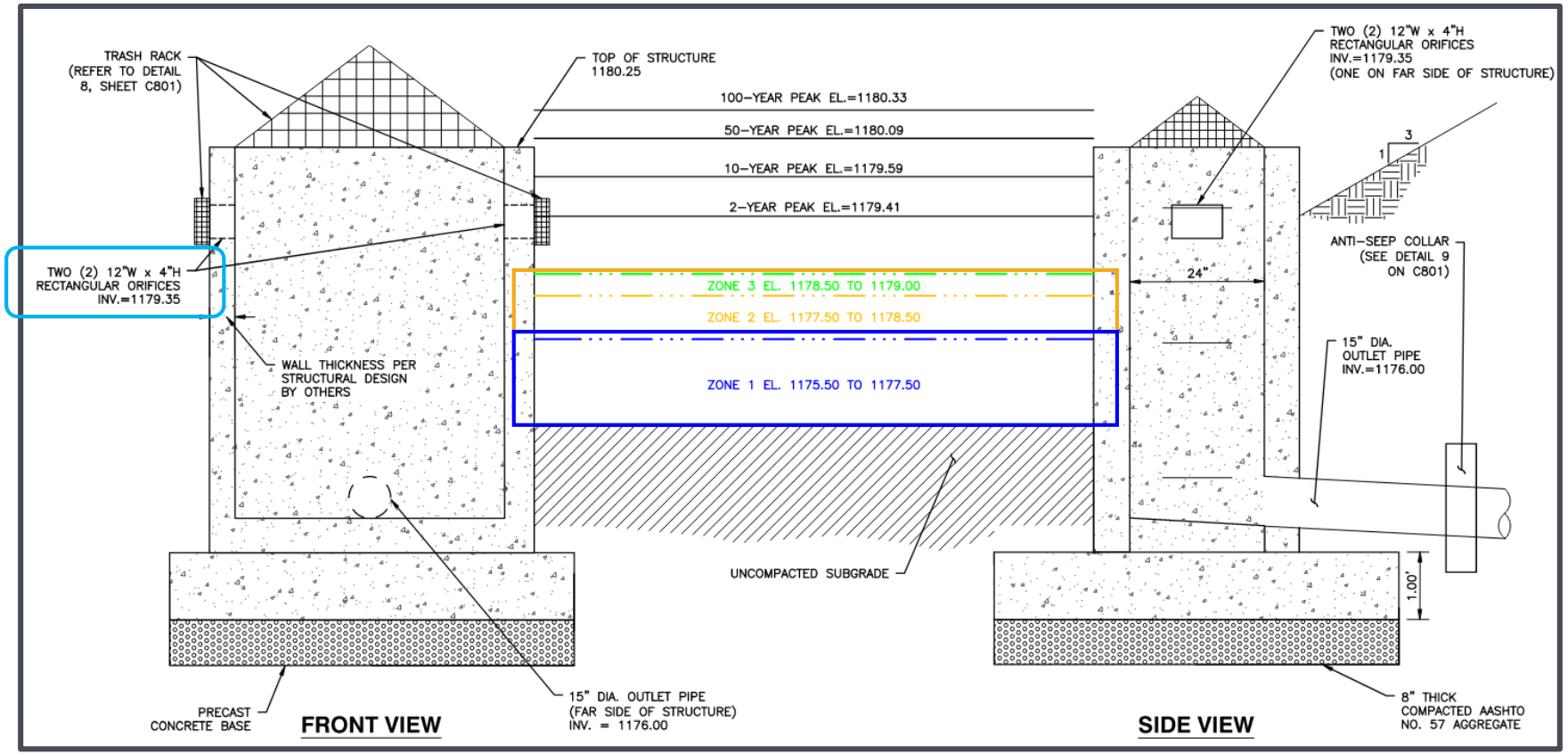
Summary | Hydrograph | Discharge | Storage | Profile | Events | Sizing

Event	Inflow (cfs)	Outflow (cfs)	Primary (cfs)	Secondary (cfs)	Elevation (feet)
1-YR	12.91	0.71	0.71	**0.00**	1,214.97
1.2-HR	11.83	0.04	0.04	0.00	1,214.66
2-YR	16.00	1.65	1.65	0.00	1,215.18
10-YR	23.98	3.50	3.50	0.00	1,215.87
50-YR	33.42	4.80	4.80	0.00	1,216.67
100-YR	**37.97**	**5.28**	**5.28**	0.00	**1,217.04**

Constructed Wetland



Constructed Wetland



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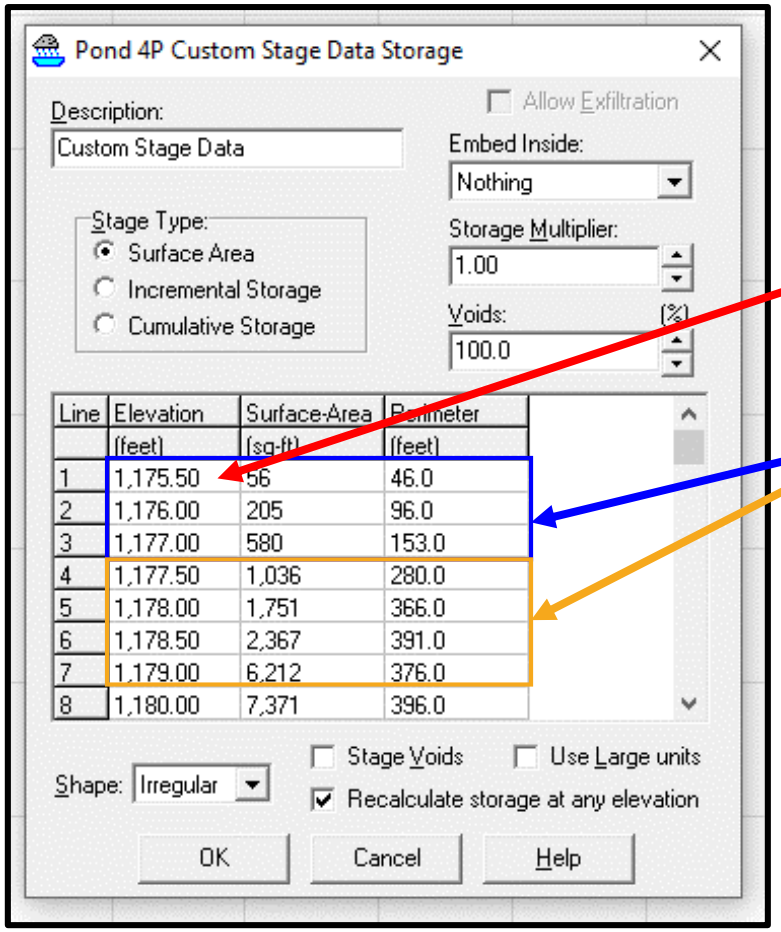
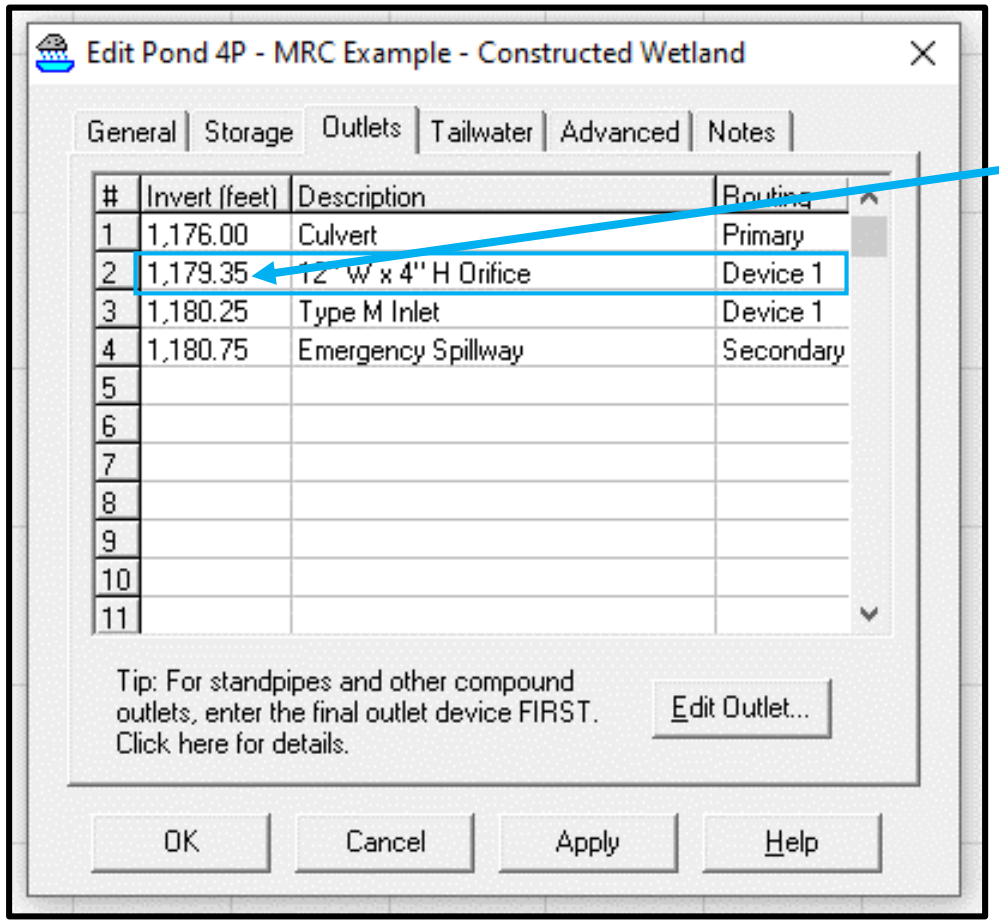


Bottom of Basin at Native Soil

3.5' Permanent Pool = Internal Water Storage + Additional Media

Notice – There are no actual *voids* applied to the storage data. Due to the nature of the constructed wetland and the required permanent pool, the IWS/additional media is assumed to *be* the permanent pool.

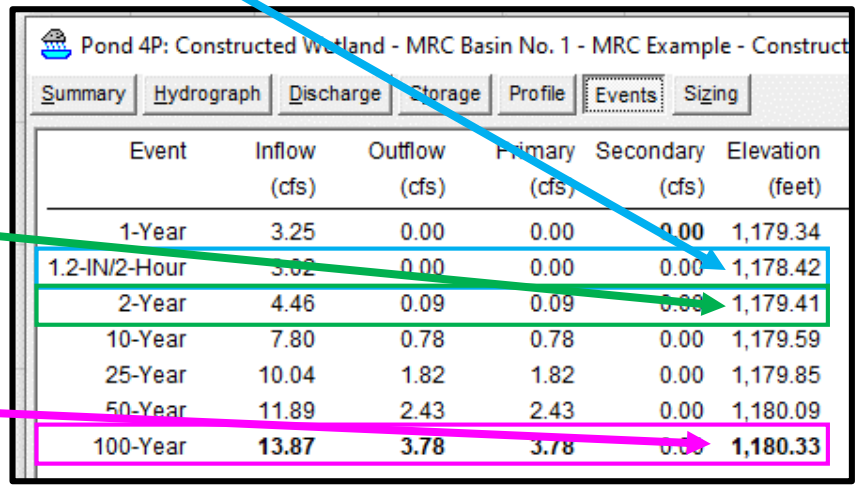
Constructed Wetland



First orifice set above the 1.2"/2-HR storm water surface elevation (WSEL)

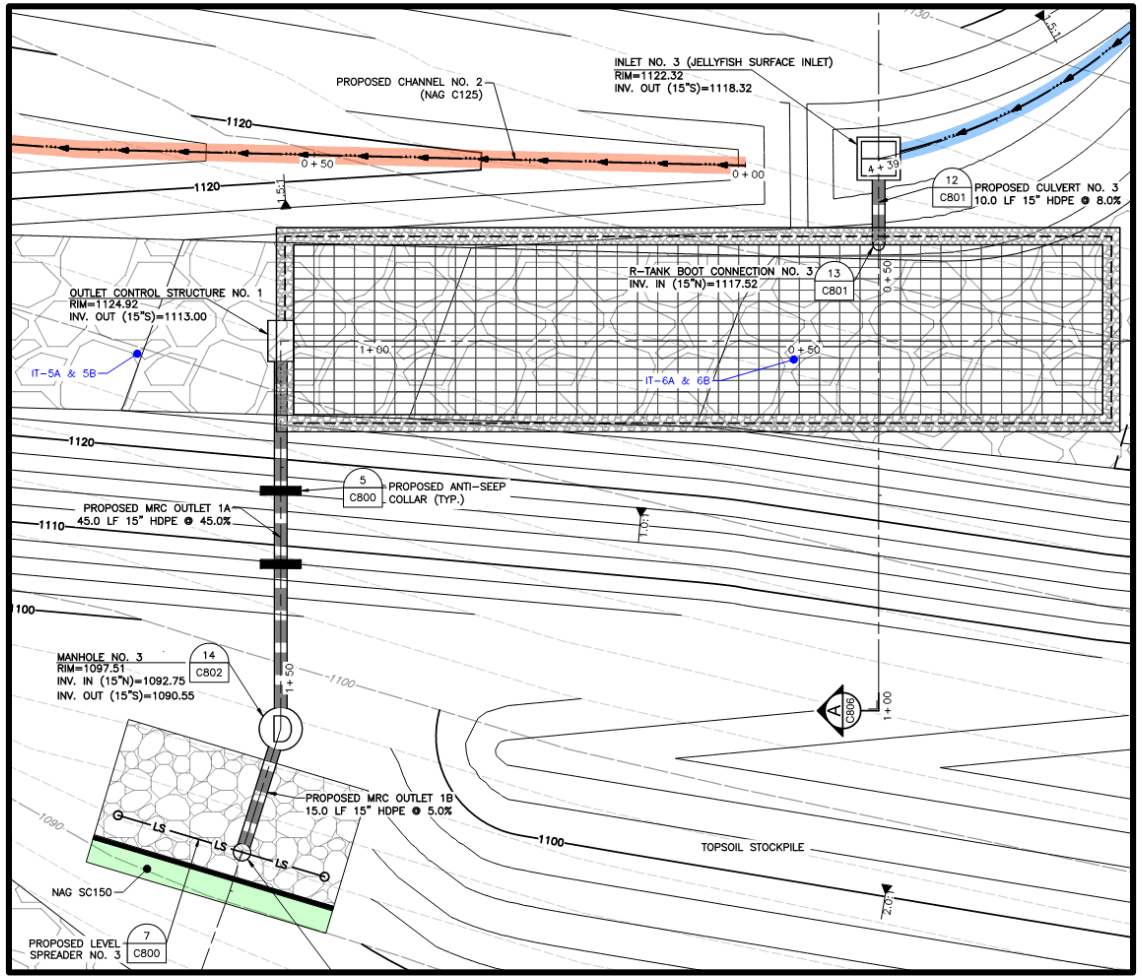
0.41' ponding depth for 2-YR storm (2' maximum)
Measured from top of media (1779.00)

1.33' ponding depth for 100-YR storm (4' maximum)
Measured from top of media (1779.00)



Event	Inflow (cfs)	Outflow (cfs)	Primary (cfs)	Secondary (cfs)	Elevation (feet)
1-Year	3.25	0.00	0.00	0.00	1,179.34
1.2-IN/2-Hour	3.02	0.00	0.00	0.00	1,178.42
2-Year	4.46	0.09	0.09	0.00	1,179.41
10-Year	7.80	0.78	0.78	0.00	1,179.59
25-Year	10.04	1.82	1.82	0.00	1,179.85
50-Year	11.89	2.43	2.43	0.00	1,180.09
100-Year	**13.87**	**3.78**	**3.78**	0.00	**1,180.33**

Subsurface – Modular System



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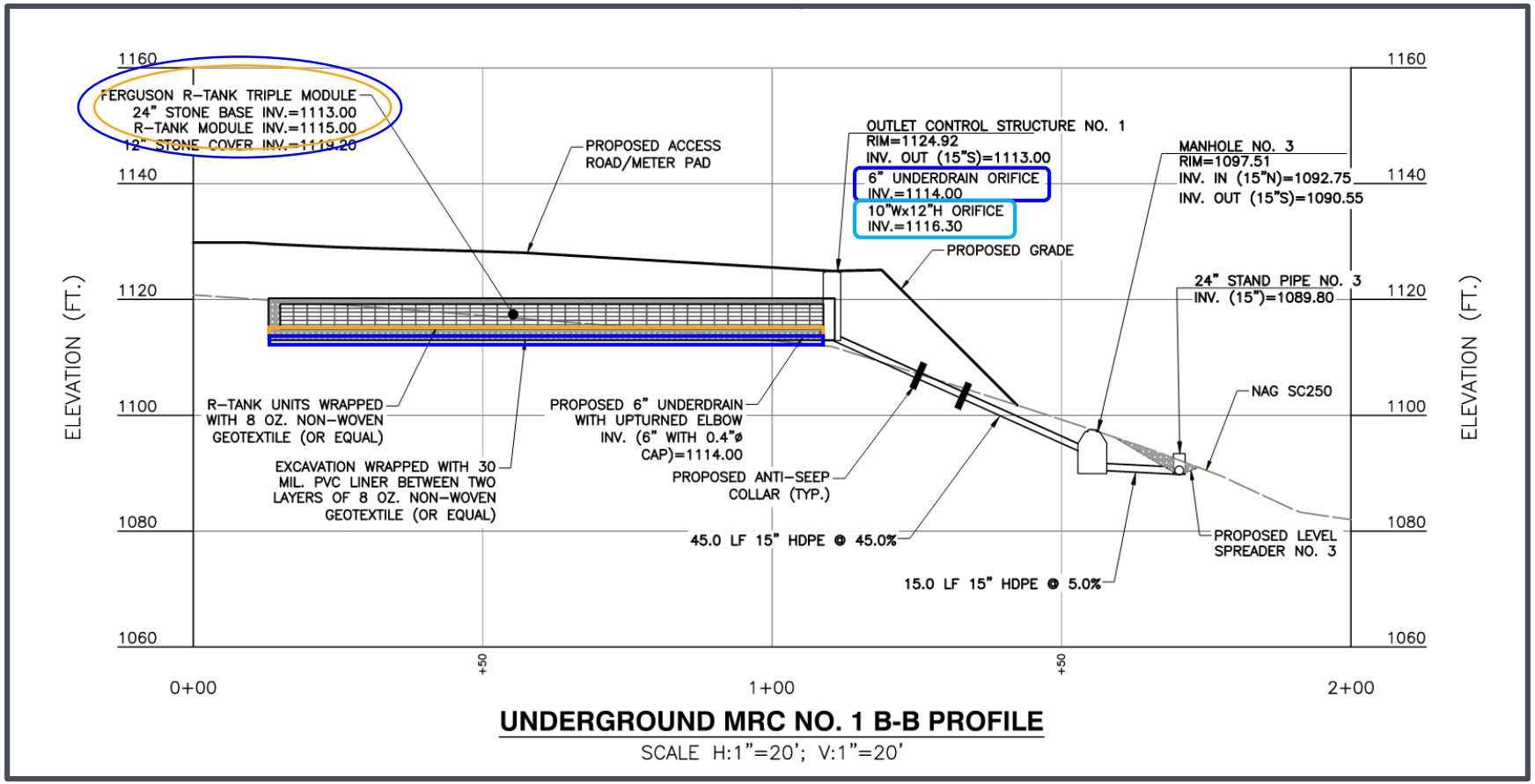
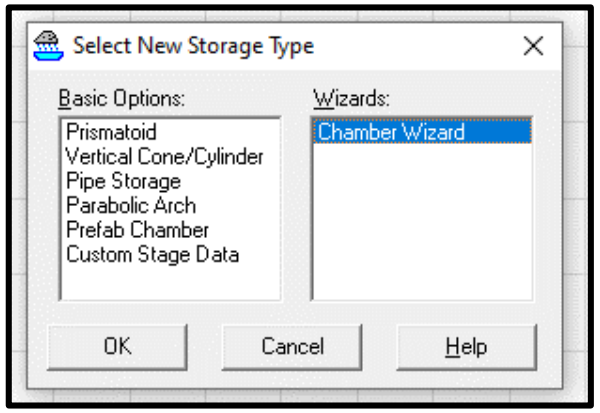
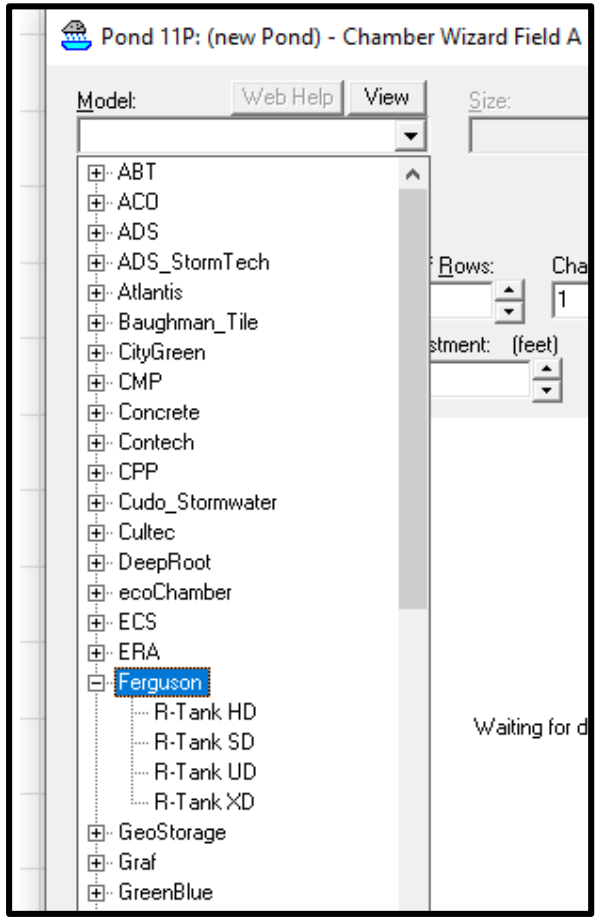


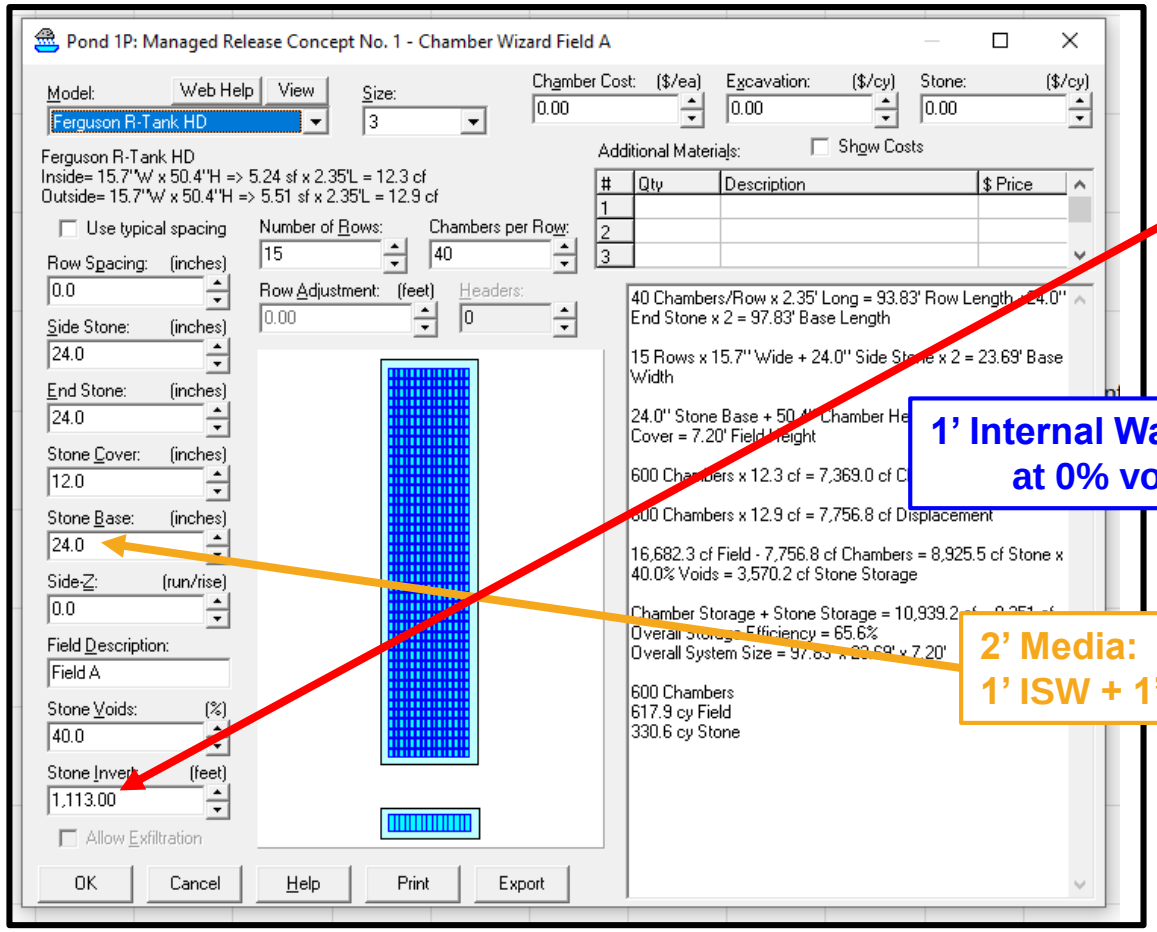
Subsurface – Modular System

- HydroCAD has a handy built-in feature that allows the user to select from a variety of manufacturers and their systems





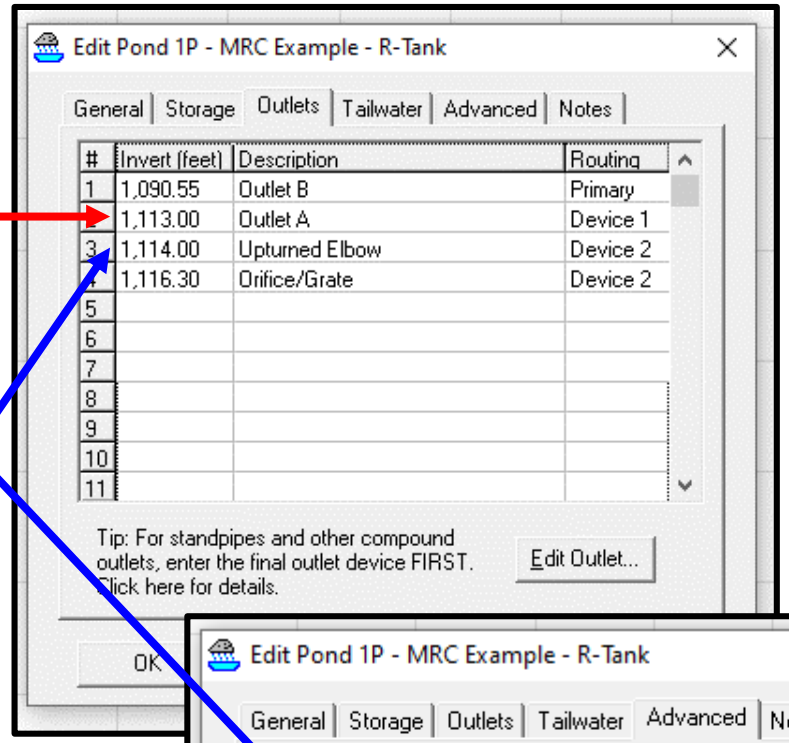
Subsurface – Modular System

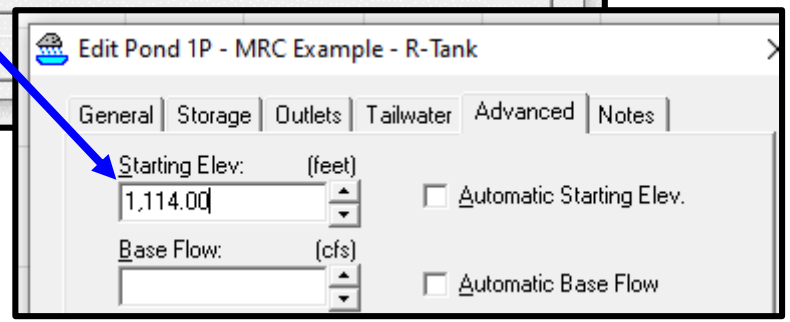


Bottom of Basin at Native Soil

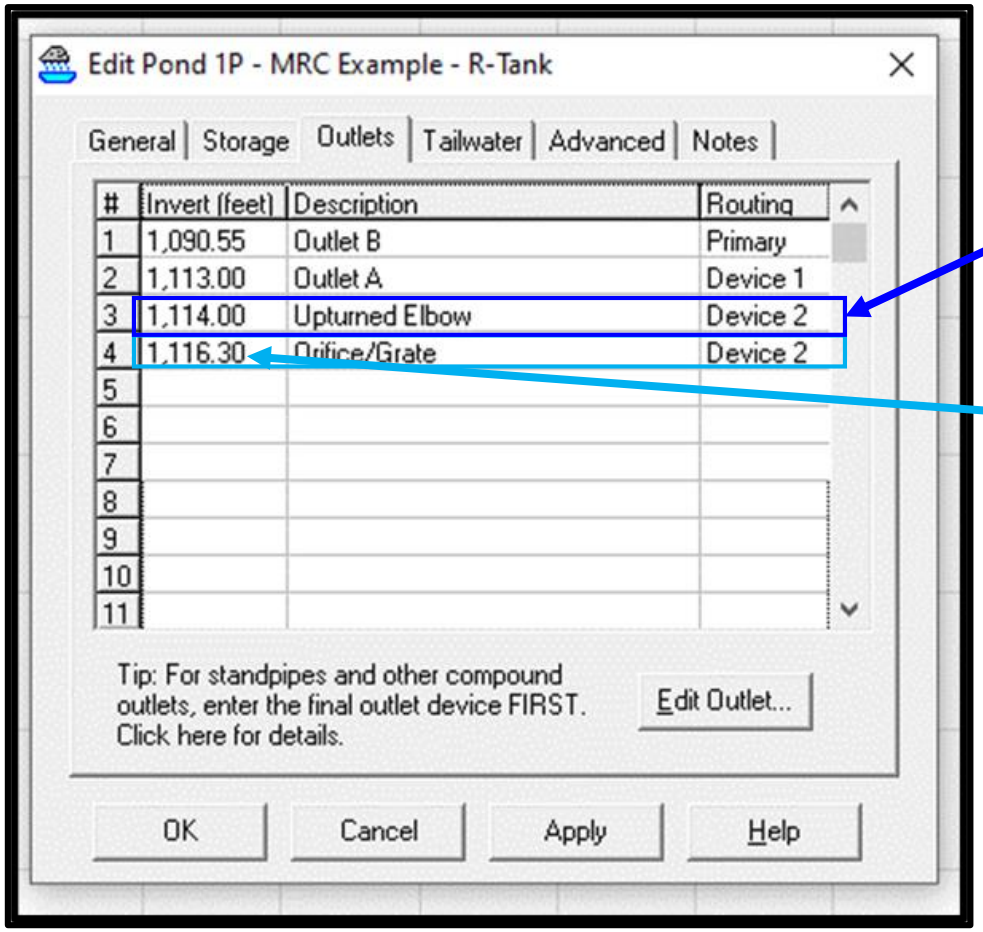
1' Internal Water Storage (IWS) at 0% voids (unvegetated)

2' Media:
1' ISW + 1' Additional Media





Subsurface – Modular System

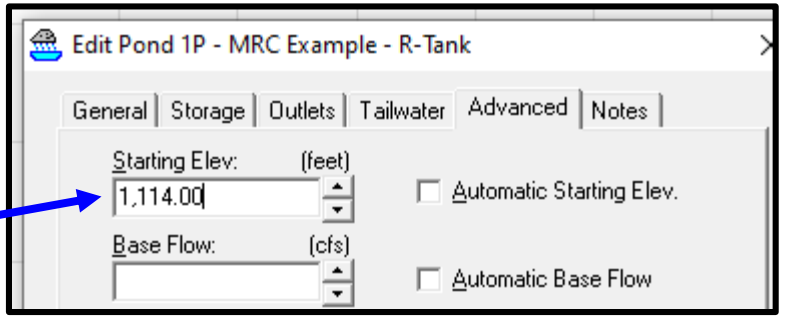


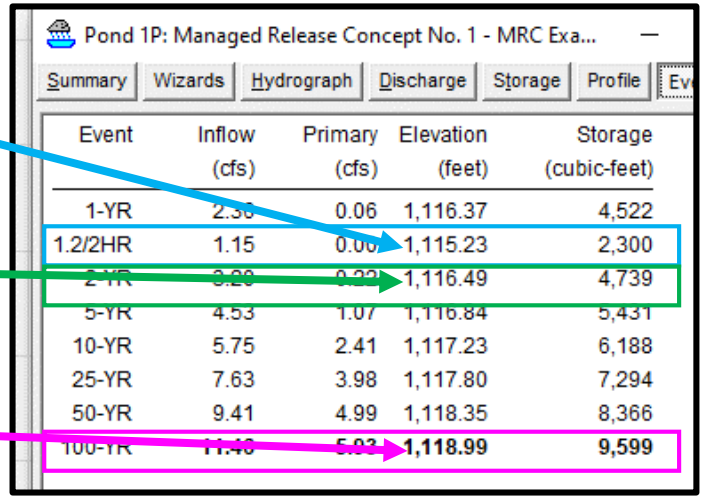
1' Internal Water Storage (IWS) at 0% media void

First orifice set above the 1.2"/2-HR storm water surface elevation (WSEL)

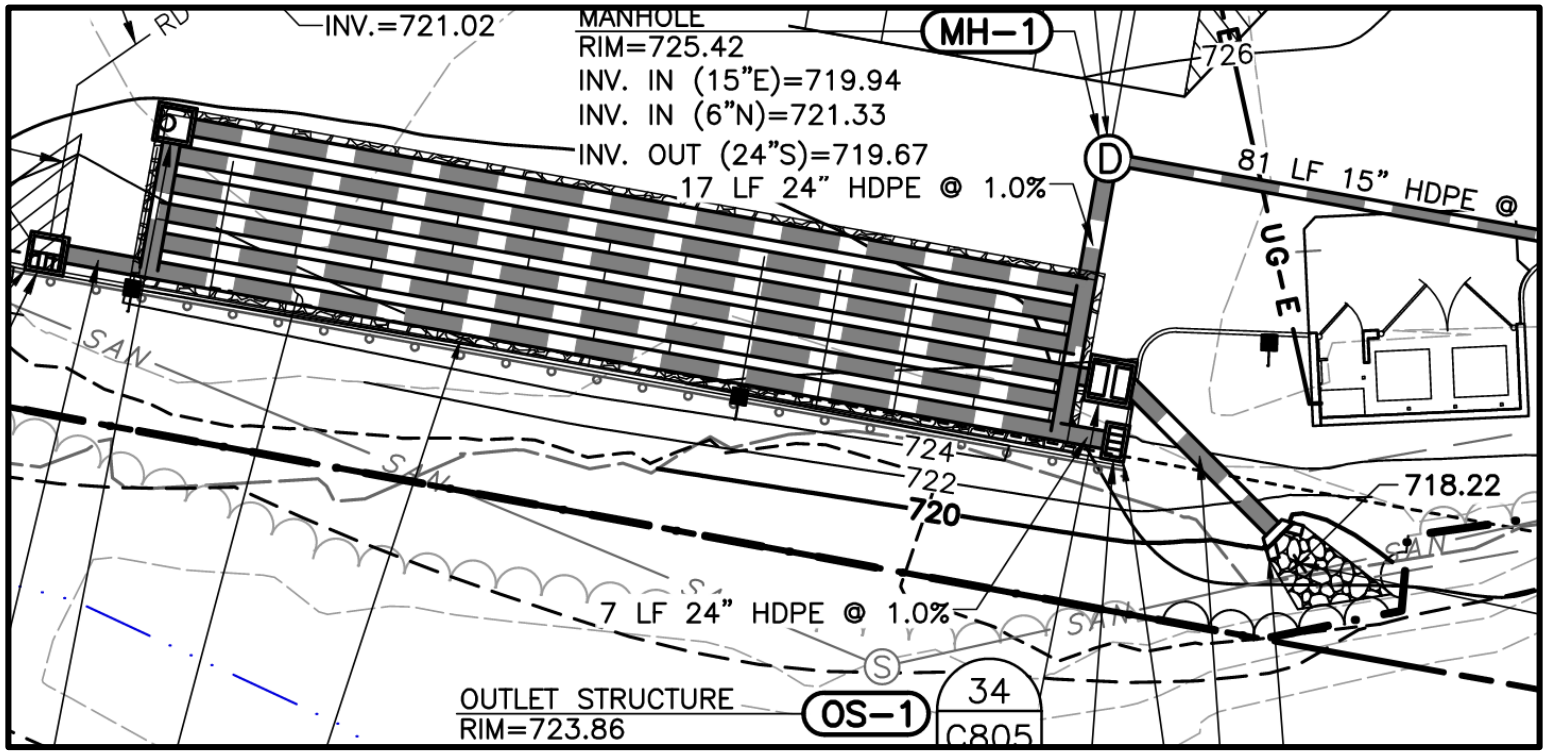
1.49' ponding depth for 2-YR storm (2' maximum)
Measured from top of media (1115.00)

3.99' ponding depth for 100-YR storm (4' maximum)
Measured from top of media (1115.00)

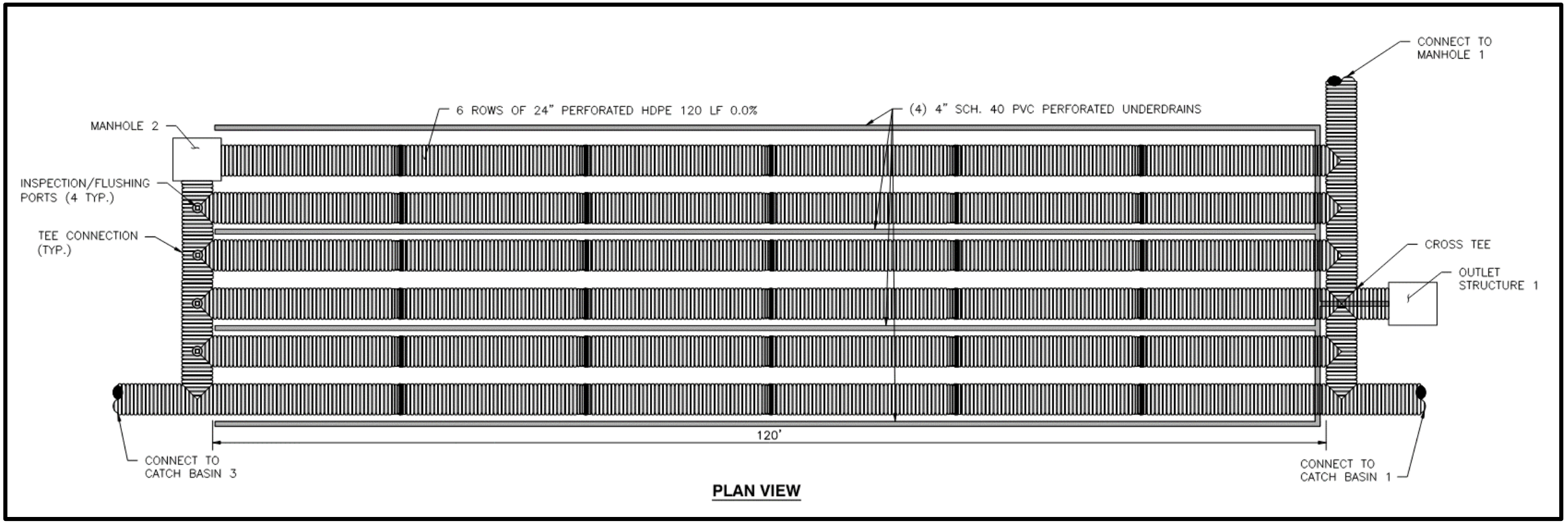




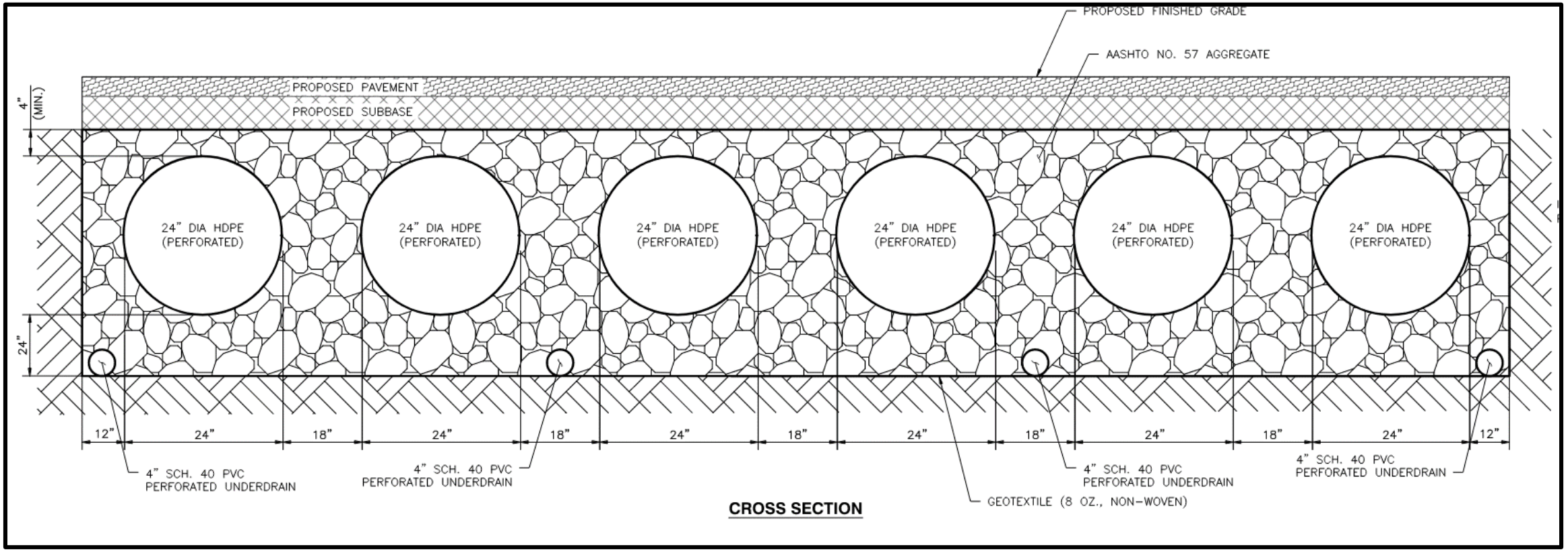
Subsurface – Pipe System



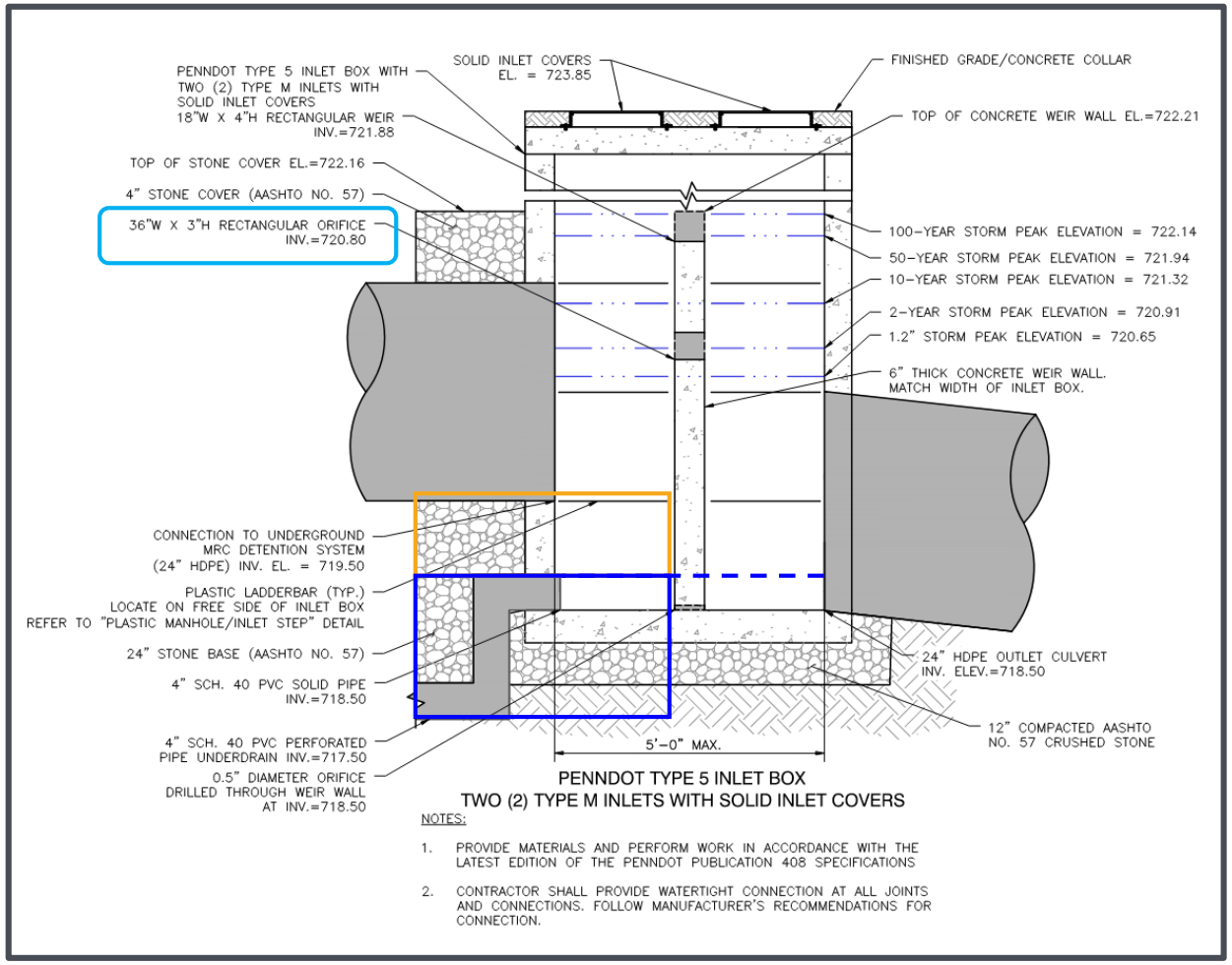
Subsurface – Pipe System



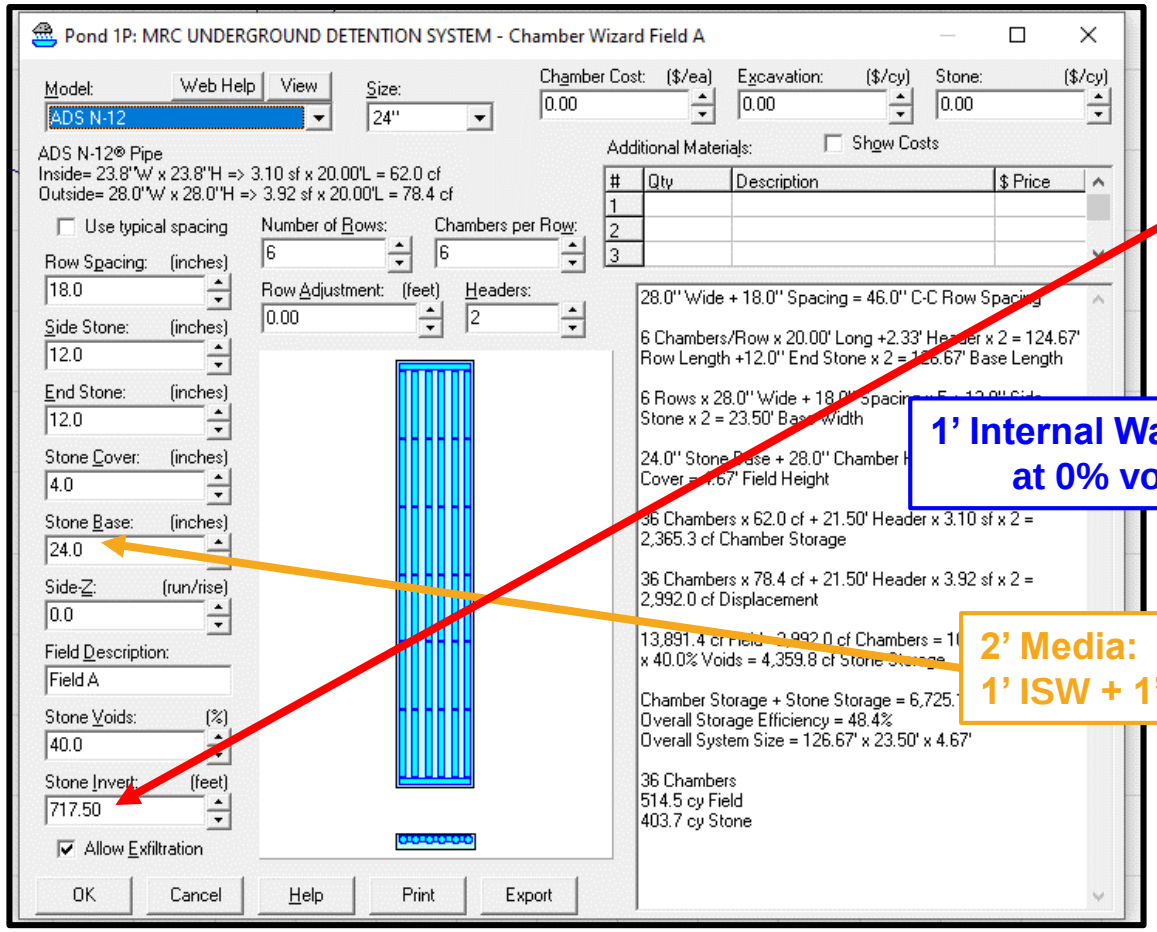
Subsurface – Pipe System



Subsurface – Pipe System



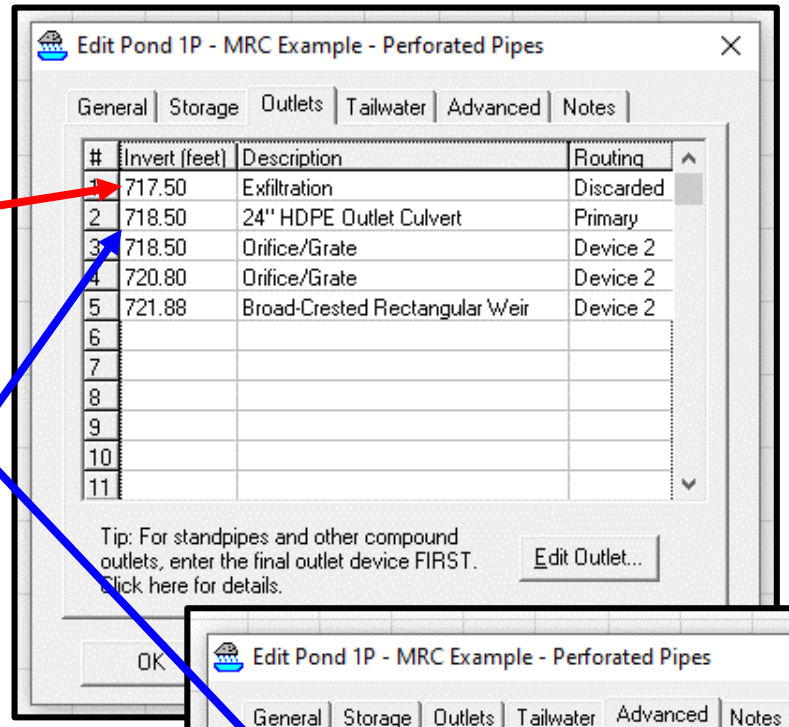
Subsurface – Pipe System

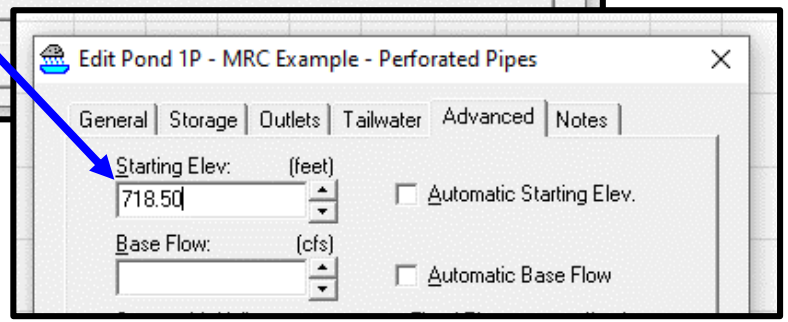


Bottom of Basin at Native Soil

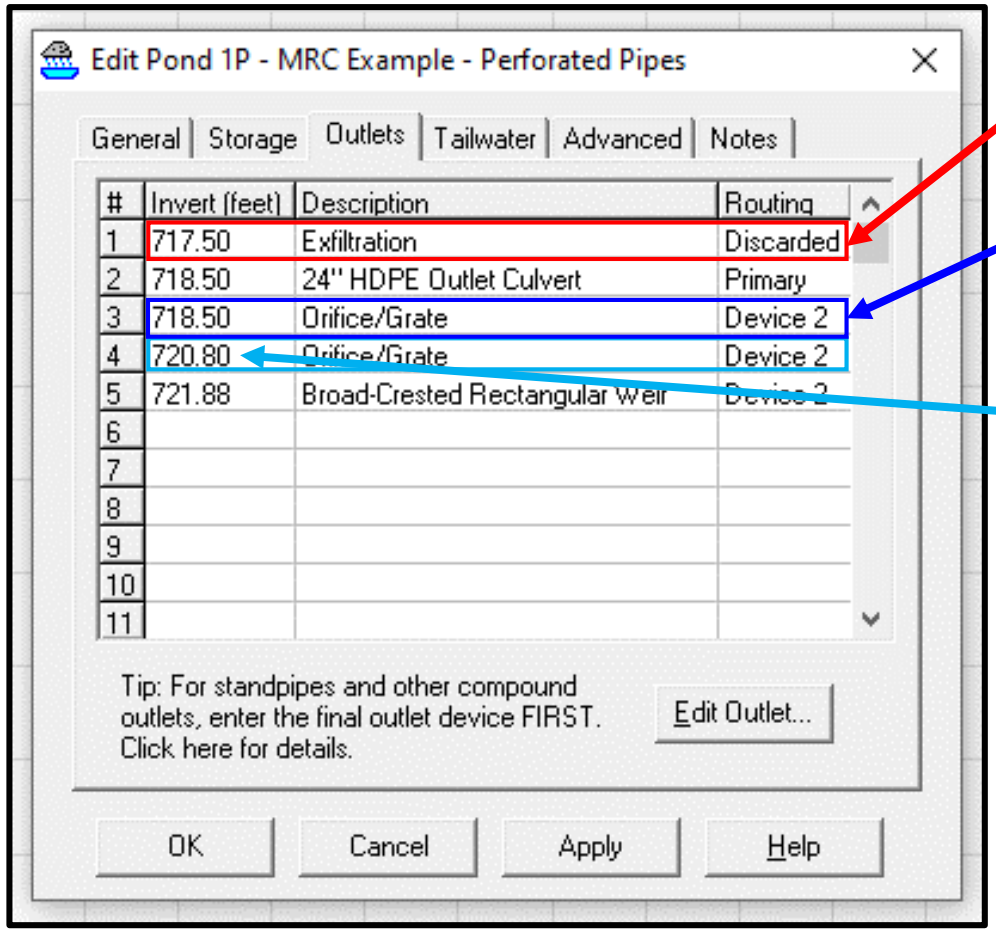
1' Internal Water Storage (IWS) at 0% voids (unvegetated)

2' Media: 1' ISW + 1' Additional Media





Subsurface – Pipe System



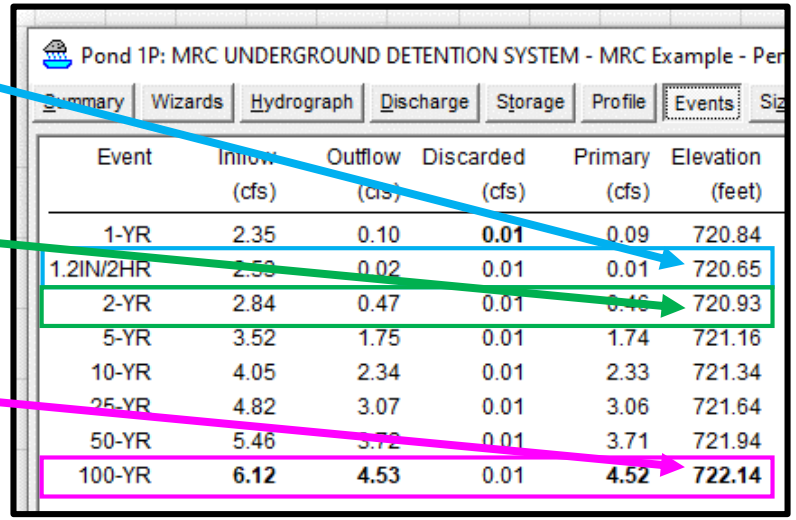
Infiltration at Bottom of Basin (Native Soil)

1' Internal Water Storage (IWS) at 50% media void

First orifice set above the 1.2"/2-HR storm water surface elevation (WSEL)

1.43' ponding depth for 2-YR storm (2' maximum)
Measured from top of media (719.50)

2.64' ponding depth for 2-YR storm (4' maximum)
Measured from top of media (719.50)



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Questions?

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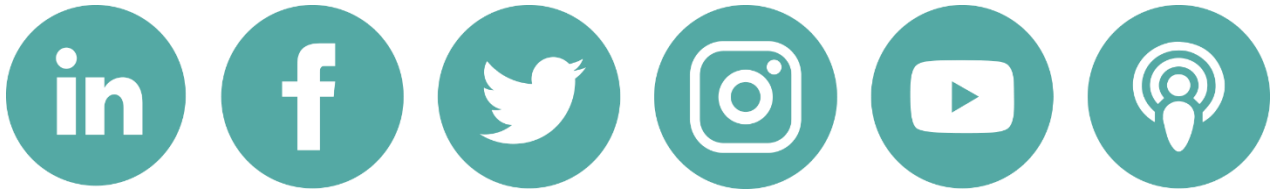

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