

POND INFORMATION / VOLUME CERTIFICATION CDOT TRAINING

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NOTE: POND VOLUME AND POND INFORMATION CERTIFICATIONS REFER TO THE SAME PROCESS. THE NAME OF THE DOCUMENT WAS CHANGED TO “POND INFORMATION” TO INCLUDE VOLUME AND DRAIN TIME CALCULATIONS.



COURSE CONTENT

- › POND INFORMATION / VOLUME CERTIFICATION PURPOSE (Rachel Hansgen)
- › REQUIRED DATA (Jessie Nolle)
- › GENERAL POND VOLUME CALCULATION (PVC) (Jessie Nolle)
- › EXAMPLES (Jessie Nolle/Amy Teigen)
- › GENERAL POND DISCHARGE CALCULATION (Jessie Nolle)
- › EXAMPLES (Jessie Nolle)
- › CERTIFICATION (OR NOT) (Jessie Nolle)
- › DISCUSSION



POND INFORMATION / VOLUME CERTIFICATION

PURPOSE

- › **REGULATORY COMPLIANCE** - Water Quality Capture Volume Standard
- › **FINANCIAL RESPONSIBILITY** - Did CDOT get what it paid for?
- › **PROCESS STANDARDIZATION** - Approved design will be compared with as-builts using survey data, whether CDOT or consulting engineers complete

The Pond Certification Statement is tied to these items earlier in project delivery:

- › Design based on guidance from CDOT Drainage Design Manual - Chapter 16 - Permanent Water Quality - Water Quality Capture Volume standard
- › Survey of pond following construction, prior to project close
- › As-builts developed from survey data for pond and outlet structure



REQUIRED DATA FOR POND VOLUME CALCULATIONS

› CONSTRUCTION PLANS & WATER QUALITY REPORT

- / Construction plans may or may not contain all design information
- / Water Quality Report may be a subset of the Drainage Report
- / Must include WQCV (e.g., 0.85 acre-feet) & WQCV elevation (e.g., 5624.52)
- / UD-Detention spreadsheets in Water Quality Report should match construction plans. The reviewer may confirm consistency between the design documents and the construction plans.

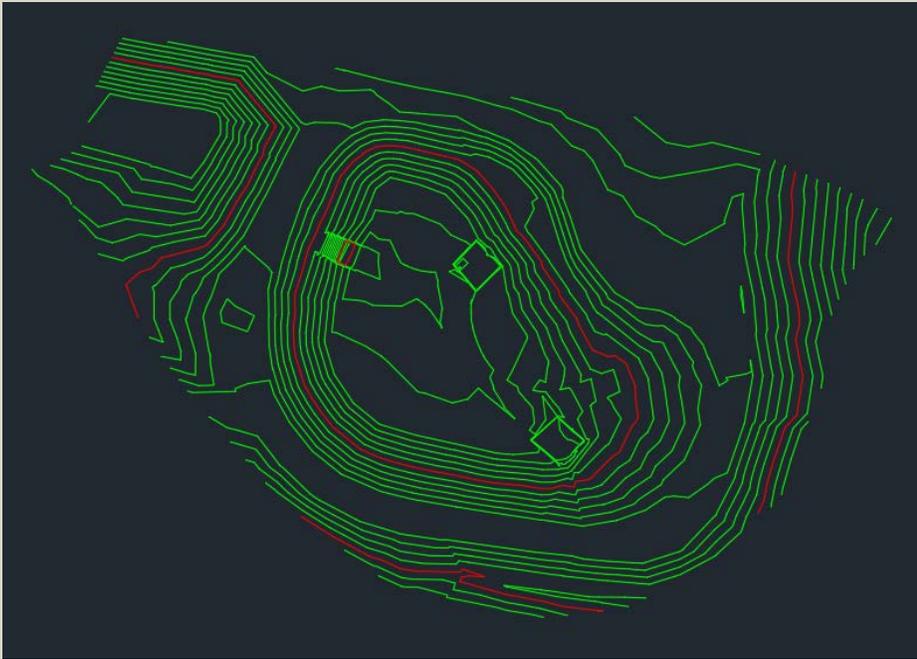
› AS-BUILT SURVEY IN CADD (MICROSTATION/AUTOCAD)

- / Closed contours to above highest design elevation (e.g., WQCV, EURV, 100-year)
- / Breaklines at the toe of pond side slopes are ideal for volume calculation within CADD but are not used for manual calculation.

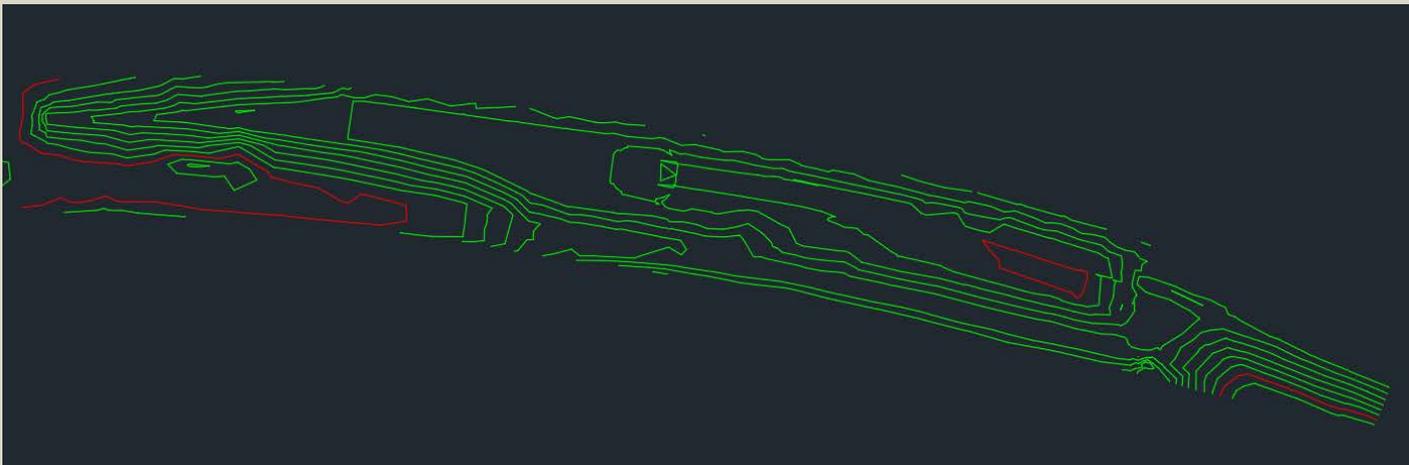
› IF ANY OF THESE ITEMS ARE MISSING, THEY MUST BE REQUESTED



EXAMPLE TOPO SURVEYS



- › The upper survey shows a clear top of bank and overflow location. Contours are closed above the overflow elevation, allowing accurate volume calculation beyond the overflow.
- › The lower survey does not include many closed contours. This may end up being acceptable, but it is worrisome at first glance.



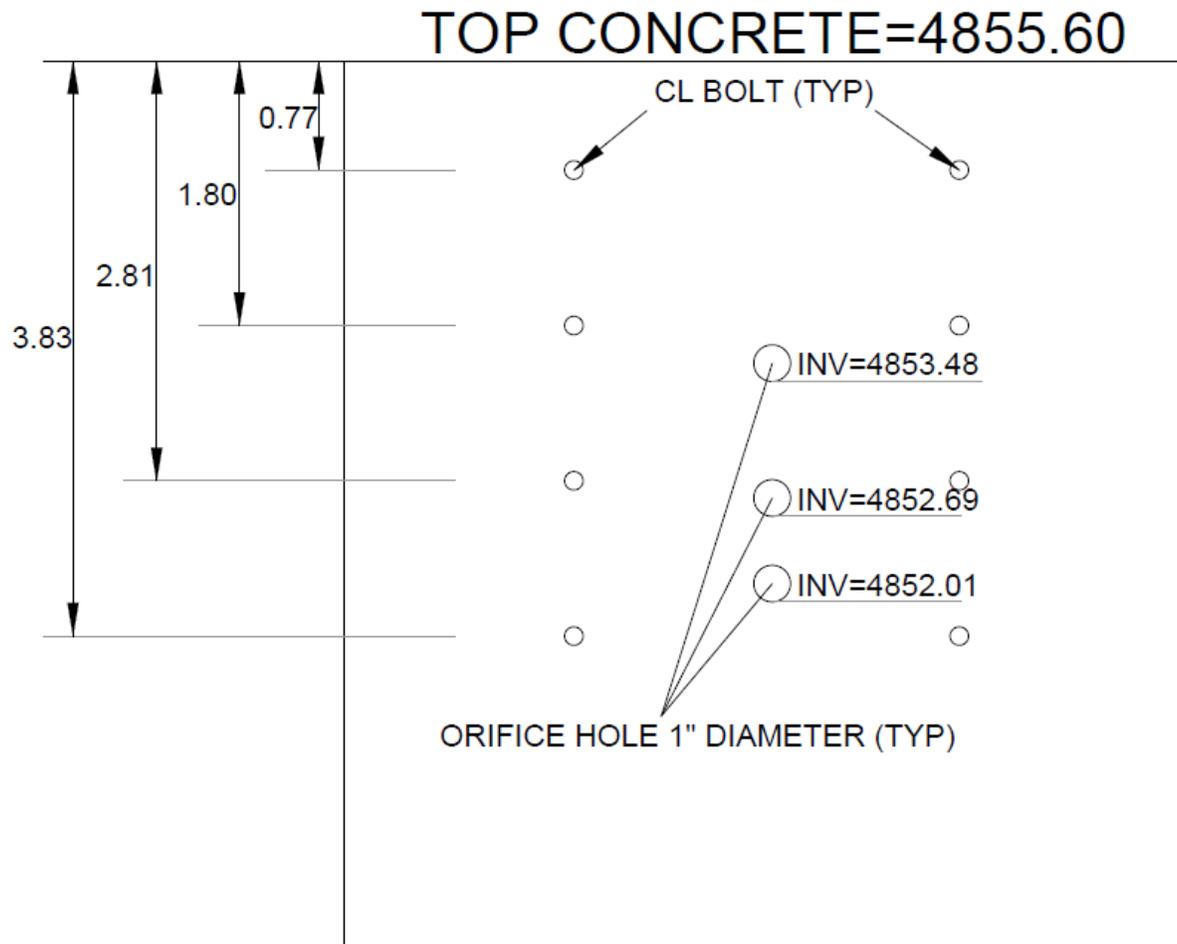
REQUIRED DATA FOR POND DISCHARGE CALCULATIONS

› AS-BUILT MARK-UP OF OUTLET STRUCTURE

- / The outlet structure as-built should be a separate viewport in CADD or more likely a red-lined construction plan in PDF.
 - / Outlet structure data must answer the question, “How does water leave the pond?”
 - » Orifice sizes (L, W, Dia.) and elevations (WQCV orifices, EURV orifices)
 - » Overflow weir elevation(s) and sizes (L, W) (EURV overflow, 100-year overflow)
 - / If there are no PDF mark-ups of the orifice plate in the as-built set, it was not surveyed – It is a near impossibility that a single orifice was built to the 0.01’, let alone more than one.
 - / In this case, request that it be surveyed to ensure it was not installed upside down or otherwise incorrectly. This has happened.
- › EARLY IN THIS PROCESS IT MAY TAKE A FEW ROUNDS OF REQUESTS TO GET THE DATA YOU NEED.



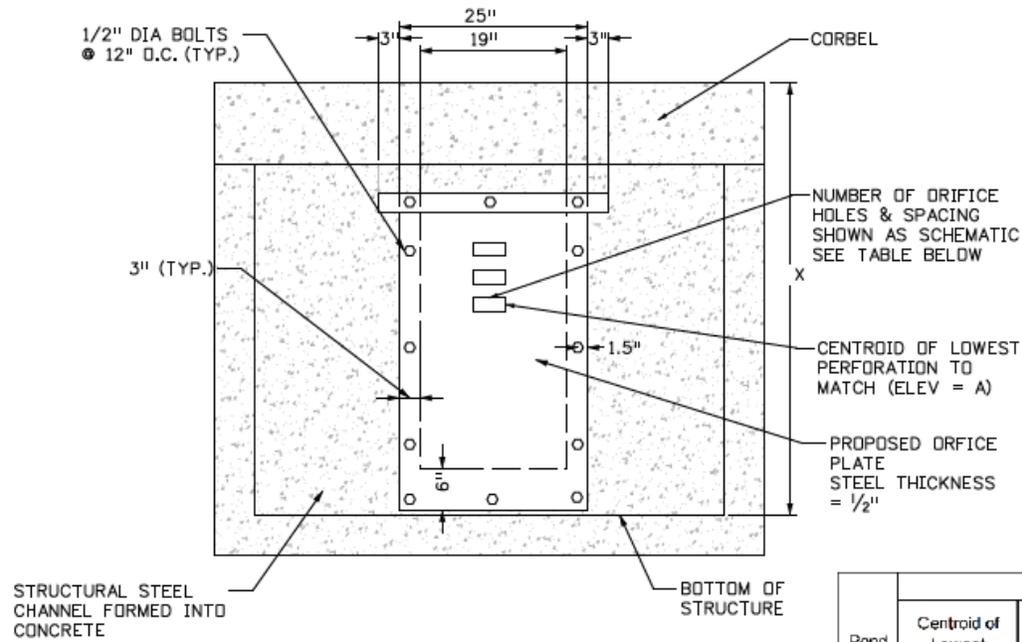
EXAMPLE 1 OUTLET STRUCTURE SURVEY



- › This AB survey shows each hole diameter, invert elevation (which can be converted to centroid), and overflow weir elevation in a separate document.
- › The bolt hole locations show that the surveyor is not clear on what he is being asked to survey or why.
- › This AB required the surveyor to be sent back because the initial survey provided only bolt hole locations.

EXAMPLE 2 OUTLET STRUCTURE SURVEY

AS BUILT



ORIFICE PLATE
NOT TO SCALE



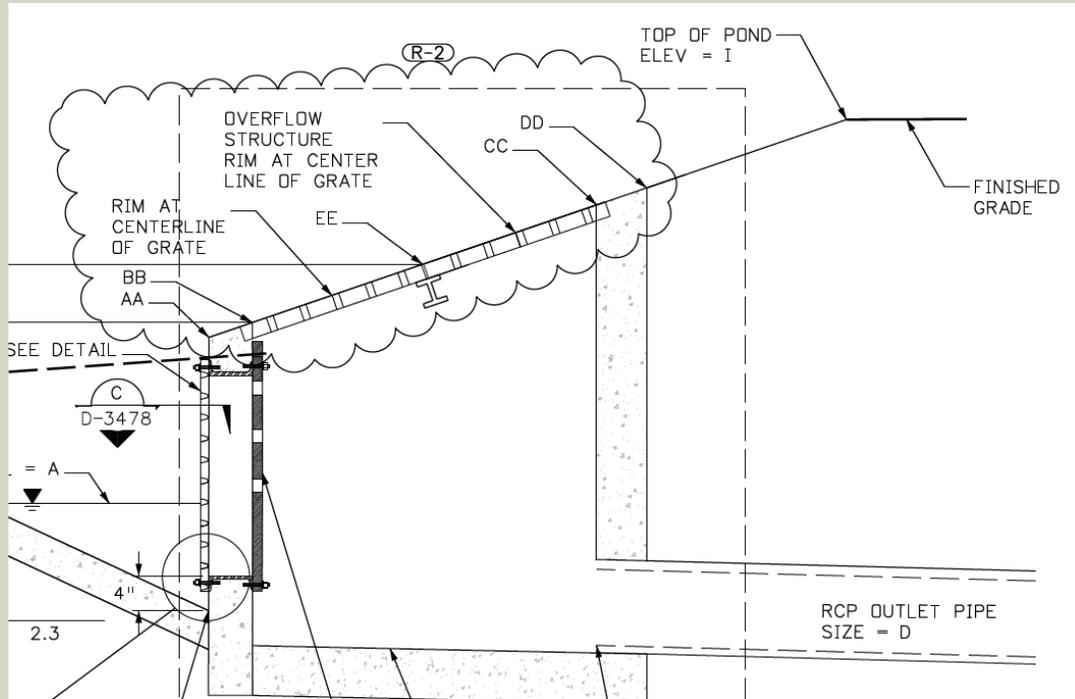
Pond	Orifice Plate						
	Centroid of Lowest Perforation	Number of Rows of Orifice holes	Number of holes per Row	Height of holes (in)	Width of holes (in)	Spacing of holes (in O.C.)	Height (ft)*
1185S	5723.12	3	1	3.00	3.00	43.00	13.22

* HEIGHT TAKEN AT FRONT FACE OF STRUCTURE

- › This AB survey does not appear to include revised orifice elevations.
- › The surveyor must be sent back to get true AB information.



EXAMPLE 2 OUTLET STRUCTURE SURVEY



- It's not clear if this AB survey is showing a redesign with R-2 or actual AB elevations.
- Check the design plans to see if the elevations match exactly.
- If they do, send the surveyor back for the overflow weir elevation.

(R-2)

all (ft)	Structure				Center of Both Grates	Overflow Structure			
	Rim	Grate Slope	Outside Front Face	Inside Front Face		Rim	Grate Slope	Inside Back Face	Outside Back Face
			AA	BB				CC	DD
	5735.30	2.17:1	5733.53	5733.84	5737.07	5738.03	4:1	5738.82	5738.99

Sheet Revisions			
	Date:	Comments	Init.
○	02/10/17	RFC SEGMENT 3	WJC
○ (R-1)	05/18/18	NDC #65	WJC
○ (R-2)	03/25/20	FDC - 109	WJC
○			



GENERAL POND VOLUME CALCULATION

› 12.7.2 OF THE DRAINAGE DESIGN MANUAL NOTES 3 WAYS TO CALCULATE VOLUME

- / Average end area: $\text{Volume} = [(A_1 + A_2)/2] * (El_1 - El_2)$
- / Frustrum of a pyramid: $\text{Volume} = [(El_1 - El_2)/3] * [A_1 + (A_1 A_2)^{0.5} + A_2]$
- / Prismoidal formula is for perfectly trapezoidal basins only (see DDM if interested)

› NOTES ON METHODOLOGY

- / Average end area method will result in a higher calculated volume, but it is acceptable per the CDOT Drainage Design Manual.
- / Frustrum of a pyramid method is the most common in the metro area, but the more $(El_1 - El_2)$ is reduced, the more the result mimics average end area.
- / This training will use frustrum of a pyramid as it is considered more accurate.



GENERAL POND VOLUME CALCULATION

› WHAT ABOUT CADD TERRAIN MODELING AS AN OPTION?

/ PROS AS IT RELATES TO POND VOLUME CERTIFICATION

1. Interesting and fun technology to use.
2. Time savings of approximately 15 minutes.
3. May be used to corroborate Excel-calculated values.

/ CONS AS IT RELATES TO POND VOLUME CERTIFICATION

1. Not designated as a methodology in the Drainage Design Manual.
2. Modeling may give unreliable results without user realization (ex: vertical sides assumed at the limits of the model where no data exists). This technology requires a skilled user that is cognizant of the limitations of the software.
3. It is a black box; there is no way to “show your work.”
4. Files are not usable by as many people; limited ability to duplicate results.
5. Time savings is less applicable to volume below a flat surface.



GENERAL POND VOLUME CALCULATION

› CALCULATED POND VOLUME AT DESIGN WQCV ELEVATION MUST MATCH CONSTRUCTION PLANS & DESIGN REPORT, *WITHIN REASON*

1. Reasonable Tolerances:

- › Straightforward percentage (e.g., 5%, 6%, 7% - use your engineering judgment)
- › Section 203.04 Construction Requirements of 203 Excavation and Embankment in the Standard Specifications says, “Variation from the subgrade plan elevations specified shall not be more than 0.08 foot.” What does this mean?

2. Weir (or orifice) elevation that marks the top of the WQCV is different than plan:

- › If the overflow weir set at the top of the WQCV is 3 inches higher than the plans, the elevation at which the WQCV is calculated could be raised that same amount.
- › Before allowing that assumption, consideration needs to be given to what other kinds of detention is intended at the site (e.g., EURV, 100-year) and if that will be accommodated.

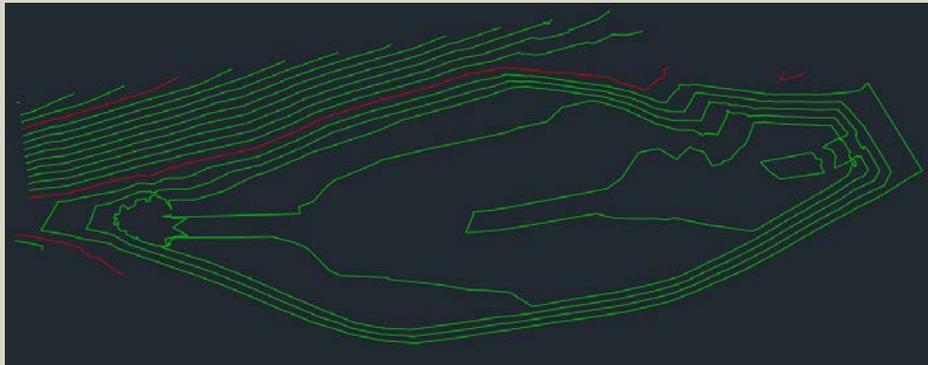


GENERAL POND VOLUME CALCULATION

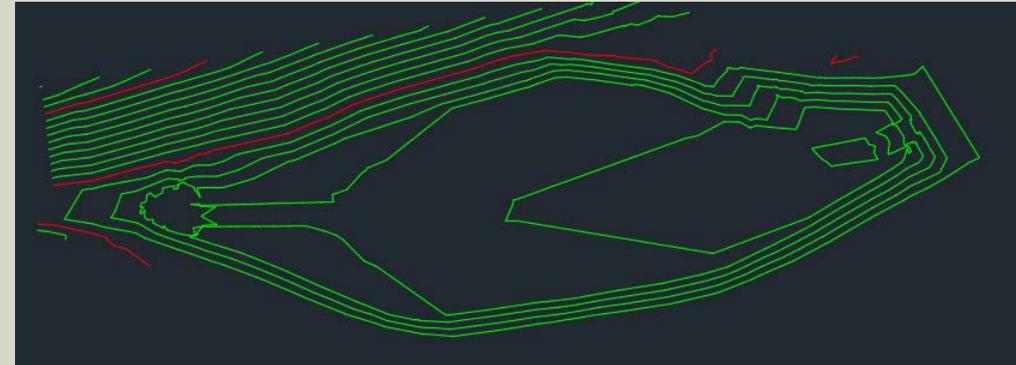
› OTHER CONSIDERATIONS

1. Volume within the Trickle Channel and Forebays:

- › If the survey does not capture these volumes, they may be added, although this is normally not worth the effort.
- › Volumes are typically minimal but accounting for them may be helpful in justifying *not* certifying.



Survey above may account for the trickle channel.



Survey above likely does not account for trickle channel volume.

GENERAL POND VOLUME CALCULATION

- › THE DESIGN DOCUMENTS MAY HAVE TO BE REVIEWED TO UNDERSTAND THE INTENT OF THE CONSTRUCTION PLANS. EXAMPLE: SOMETIMES THE WQCV OR THE WQCV ELEVATION MAY NOT BE IN THE PLANS.
- › WHAT IF REVIEWER NOTES THAT DESIGN DOCUMENTS (UD-DETENTION, WATER QUALITY REPORT) DO NOT MATCH CONSTRUCTION PLANS?
 1. This process does not include questioning the validity of the design, but the design should match the construction plans, which then should match the as-built, all within reason.
 2. Reviewer may ask for clarification from the design engineer as to which documents are correct and to provide any updates.
 3. Reviewer may provide the corrected documentation to the CDOT project engineers responsible for the design and construction of the project to be filed with the project.
 4. Continue with the certification process.



EXAMPLE 1 – VOLUME

› CONFIRM THE VOLUME OF POND 1082S

- / Determine the design WQCV and the associated design WQCV elevation
- / Open AB plans and note that neither is noted, only the EURV elevation
- / Searching the Drainage Report for 1082S yields the UD-Detention spreadsheet
 - / WQCV = 1.542 AF at a Zone 1 stage of 4.37 feet
 - / EURV = 2.506 AF at a Zone 2 stage of 6.12 feet
 - / Note that zones begin at the top of the micropool elevation, **5640.72** per plan, but the AB condition is unknown. For now, proceed in determining volume at design elevations.
 - / Design WQCV EI = $5640.72 + 4.37 = \underline{\underline{5645.09}}$
 - / Design EURV EI = $5640.72 + 6.12 = \underline{\underline{5646.84}}$
- / Why bother with the EURV?
- / Now that we have defined the grading goals, we can evaluate the AB contours in CADD.



EXAMPLE 1 – VOLUME

› CONFIRM THE VOLUME OF POND 1082S

- / Complete spreadsheet by starting with the AB elevation of the centroid of the lowest orifice and the area of the micropool at this elevation if known. If area is unknown use 0.00.
- / If the AB orifice elevation is missing, use the design until surveyor can provide an AB orifice plate survey. Design elevation of lowest orifice is **5640.72**.
- / Enter the area of each contour above the starting elevation and note the increasing cumulative volume.
- / Insert the WQCV and/or EURV elevation into the spreadsheet and interpolate the surface area at each elevation.
- / Determine if pond provides the WQCV at the WQCV design elevation.
- / Note that if the design overflow weir at which the WQCV elevation is set has a higher AB elevation, the WQCV elevation may be raised to that level as well.



EXAMPLE 2 – VOLUME

- › CONFIRM THE VOLUME OF POND WQ56L / 3056L
 - / Determine the design WQCV and the associated design WQCV elevation
 - / AB plans note the **WQCV=0.137 AF** at elevation **4853.73** (a stage of 1.73 above the design lowest orifice centroid of at 4852.00)
 - / But next page of plans notes a different *ultimate* condition and the *ultimate* WQCV is not defined in the plans
 - / Searching the Drainage Report yields UD-Detention spreadsheets & helpful text
 - / Ultimate condition **WQCV = 0.599 AF** even though UD-Detention says 0.689 AF
 - / The stage is 3.86 feet or elevation **4855.86**
 - / Why bother with the Ultimate Condition?
 - / Now that we have defined the grading goals, we can evaluate the AB contours in CADD.

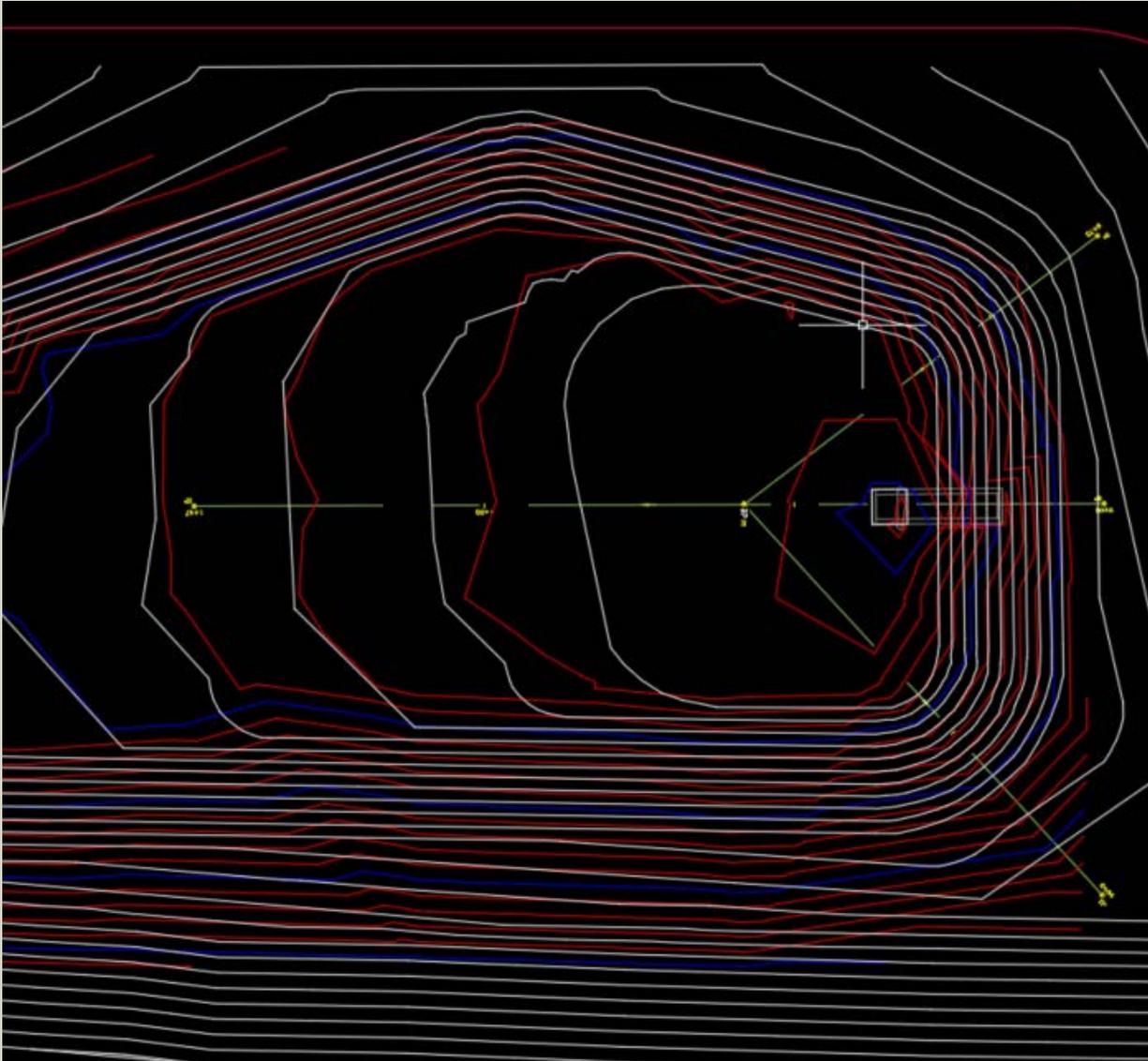


EXAMPLE 2 – VOLUME

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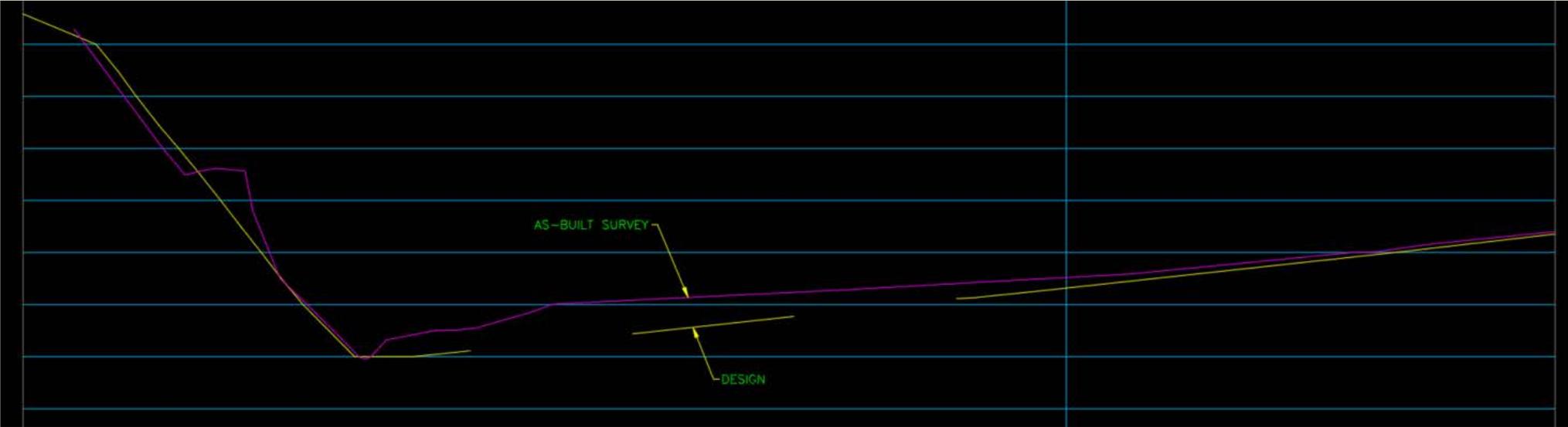
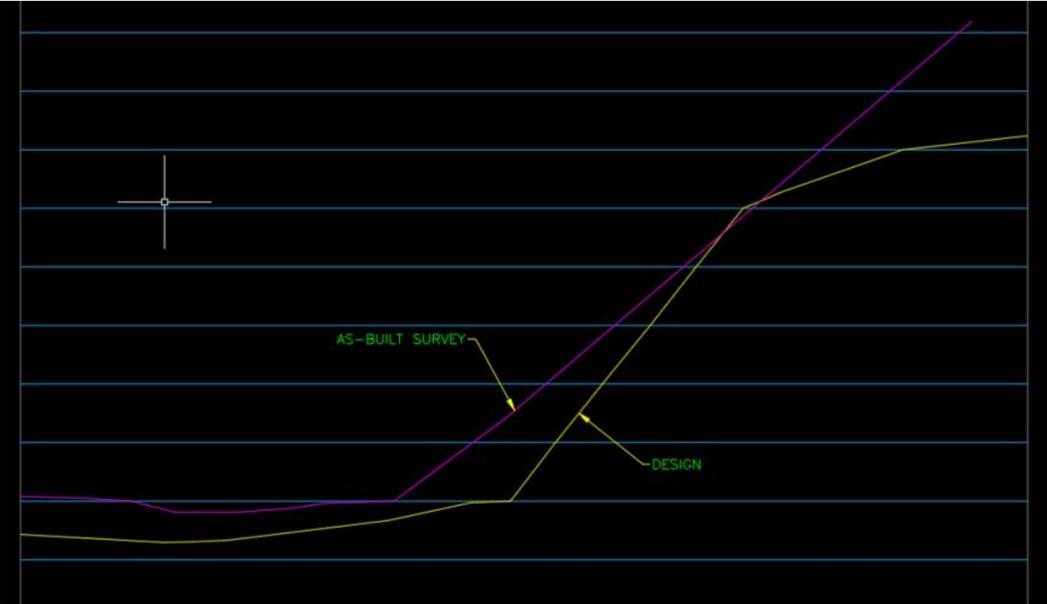
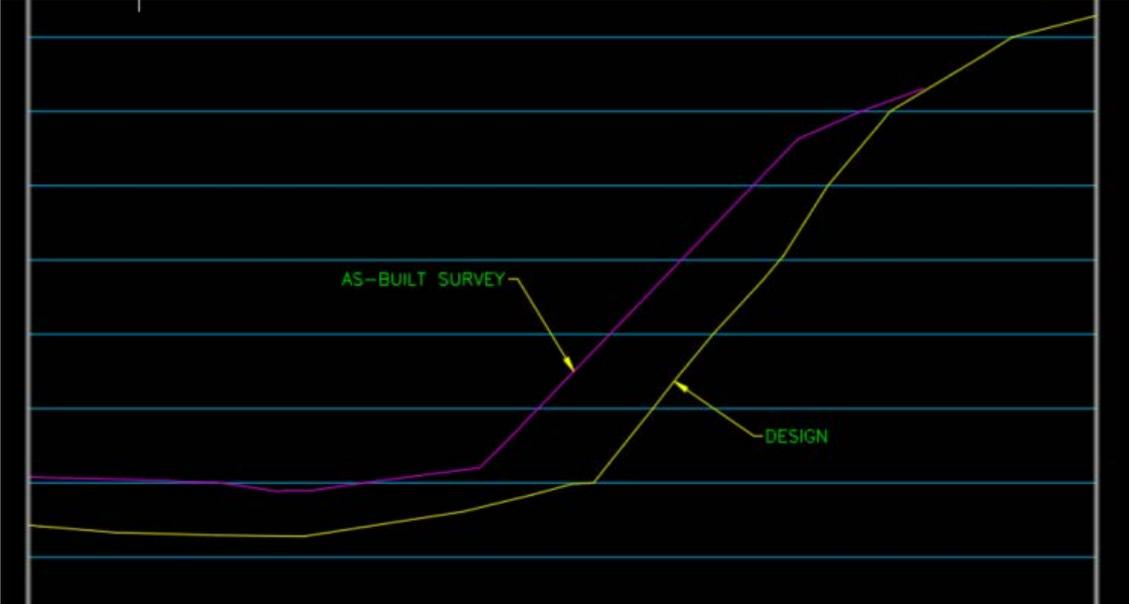


EXAMPLE 2 – VOLUME



- Contractor insisted that pond was constructed correctly.
- / An initial glance at the design contours overlaid on the AB contours appears somewhat close.
- / A closer look shows the lowest contour is closer to the outlet structure than as designed, and that the backslope of the pond is more interior to the pond than designed.
- / Sections were cut along the three alignments to better convey the issue.

EXAMPLE 2 – VOLUME



TAKE-AWAYS

- › A DETAILED AS-BUILT SURVEY OF THE OUTLET WILL HELP DEFINE THE TOP AND BOTTOM OF THE WQCV.
- › IT IS POSSIBLE FOR A CONTRACTOR TO GRADE A POND TO PLAN.
- › ALTERNATIVE BUT DEFENSIBLE EVALUATIONS MAY BE USED TO CERTIFY POND VOLUME AS NECESSARY IF PROFESSIONAL ENGINEERING JUDGEMENT ALLOWS IT TO BE CALLED SUBSTANTIAL CONFORMANCE.
- › REFUSAL TO CERTIFY MAY RESULT IN THE NEED TO DEFEND YOUR EVALUATION.



GENERAL OUTLET CONFORMANCE

› UD-DETENTION IS THE MOST COMMON OUTLET SIZING CALCULATION

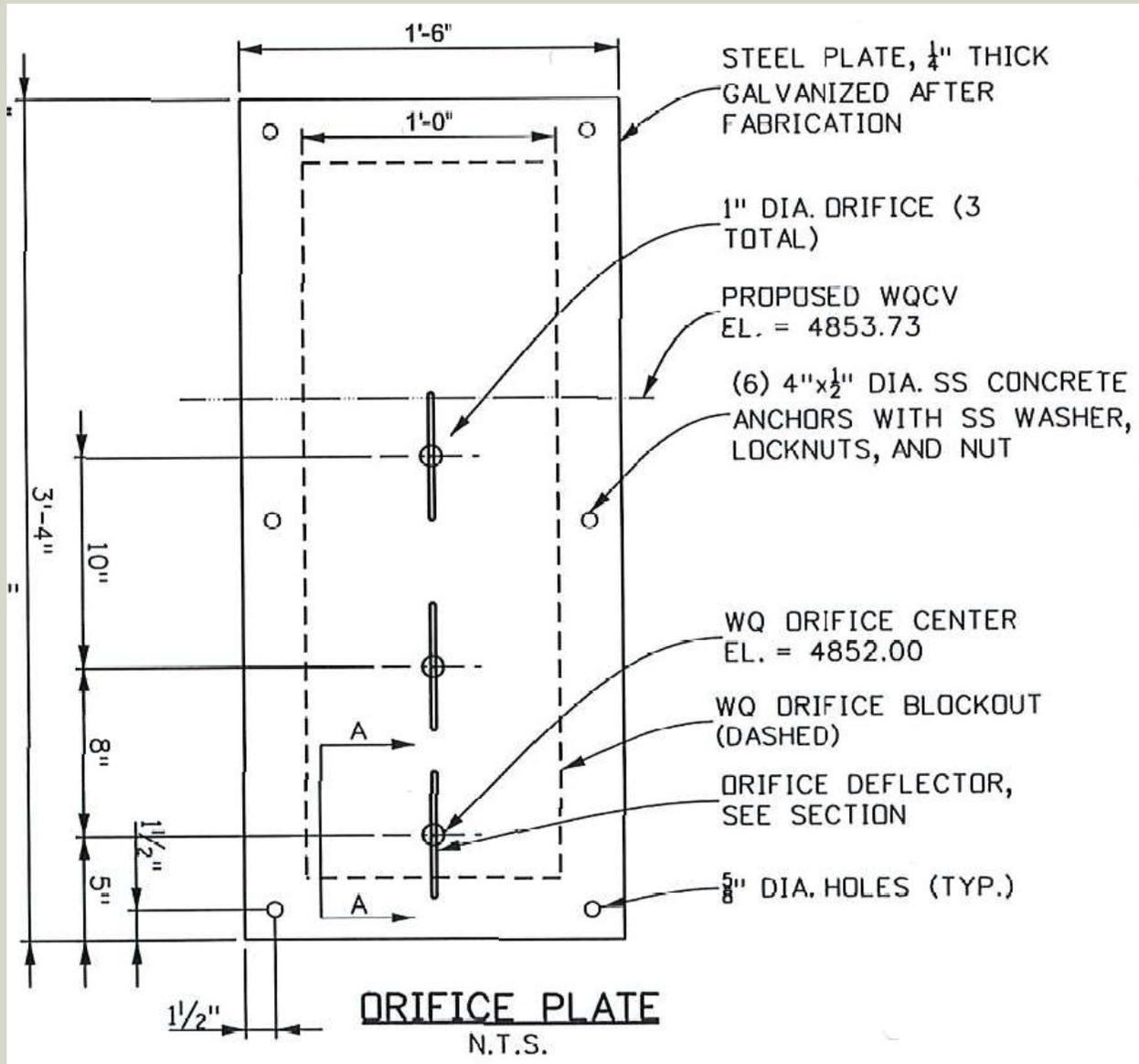
- / Familiarize yourself with UD-Detention; there are published videos.
- / Spreadsheet will give drain times for various orifice/weir combinations.
- / Requires a stage/storage curve to be entered to reflect proposed pond grading.
- / **If desired, check to ensure construction plans reflect UD-Detention values for:**
 - › Orifice elevation and size
 - › Weir elevation and length
 - › WQCV elevation (and EURV & 100-year elevations as applicable)
- / **Check to ensure as-built reflects construction plans.**

› OTHER OUTLET SIZING CALCULATIONS MAY BE USED BY ENGINEERS

- / Familiarize yourself with orifice and weir equations.
- / Ensure design matches construction plans and AB condition reflects plans



EXAMPLE 1 OUTLET CONFORMANCE



- This is the original as-built that was provided.
- ✓ Note there are no as-built elevations or dimensions.
- ✓ The WQCV elevation is noted as 4853.73 and the lower orifice centroid at 4852.00.
- ✓ Orifices are called as 1" diameter.
- ✓ A surveyed as-built was requested.

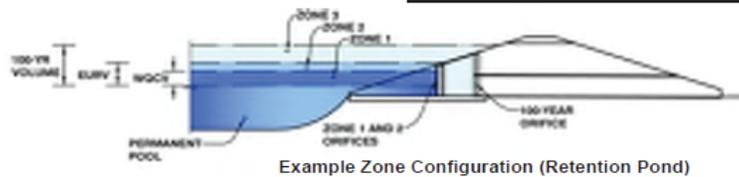
EXAMPLE 1 OUTLET CONFORMANCE

Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)

Project: _____

Basin ID: _____



Example Zone Configuration (Retention Pond)

	Stage (ft)	Zone Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	1.79	0.137	Orifice Plate
Zone 2			Weir&Pipe (Circular)
Zone 3			Not Utilized
		0.137	Total

User Input: Orifice at Underdrain Outlet (typically used to drain WQCV in a Filtration BMP)

Underdrain Orifice Invert Depth = ft (distance below the filtration media surface)
 Underdrain Orifice Diameter = inches

Calculated Parameters for Underdrain

Underdrain Orifice Area = ft²
 Underdrain Orifice Centroid = feet

User Input: Orifice Plate with one or more orifices or Elliptical Slot Weir (typically used to drain WQCV and/or EURV in a sedimentation BMP)

Invert of Lowest Orifice = ft (relative to basin bottom at Stage = 0 ft)
 Depth at top of Zone using Orifice Plate = ft (relative to basin bottom at Stage = 0 ft)
 Orifice Plate: Orifice Vertical Spacing = inches
 Orifice Plate: Orifice Area per Row = sq. inches (diameter = 1 inch)

Calculated Parameters for Plate

WQ Orifice Area per Row = ft²
 Elliptical Half-Width = feet
 Elliptical Slot Centroid = feet
 Elliptical Slot Area = ft²

User Input: Stage and Total Area of Each Orifice Row (numbered from lowest to highest)

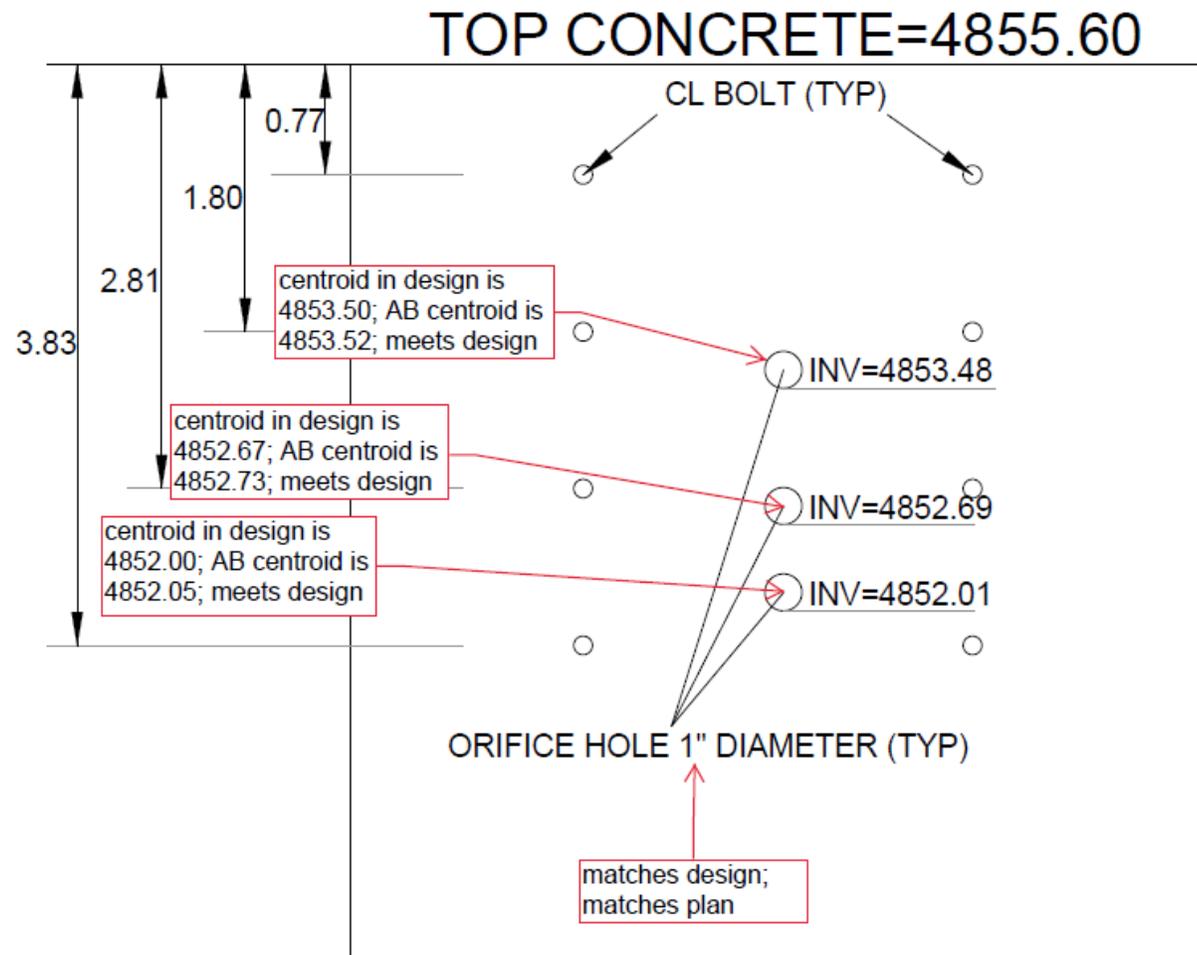
	Row 1 (required)	Row 2 (optional)	Row 3 (optional)	Row 4 (optional)	Row 5 (optional)	Row 6 (optional)	Row 7 (optional)	Row 8 (optional)
Stage of Orifice Centroid (ft)	0.00	0.67	1.50					
Orifice Area (sq. inches)	0.79	0.79	0.79					
	Row 9 (optional)	Row 10 (optional)	Row 11 (optional)	Row 12 (optional)	Row 13 (optional)	Row 14 (optional)	Row 15 (optional)	Row 16 (optional)
Stage of Orifice Centroid (ft)								
Orifice Area (sq. inches)								

3 rows of 1" matches plan & elevations match plan

- Meanwhile, UD-Detention was checked to confirm plans matched design.
- / WQCV stage is 1.79, not 1.73; consider this close enough.
- / 2nd row is 8" above first row and 3rd row is 18" above first row, matching plans.



EXAMPLE 1 OUTLET CONFORMANCE



- Requested figure and associated evaluation is at the left.
- / The lower orifice centroid at 4852.05, not 4852.00. Other orifices are off by similar margins. This is a very good installation.
- / Orifices are called as 1" diameter per plan and UD-Detention.
- / Top of concrete (overflow weir) is at 4855.60 per plan value of 4855.6

CERTIFICATION (OR NOT)

- › **CERTIFICATION IS AT THE DISCRETION OF THE PROFESSIONAL ENGINEER**
 - / There is a reason a specific tolerance is not specified in pond volume certification statements.
 - / I gravitate toward a 5% threshold, but I am also likely to approve 7%.
 - / Pond volume calculation method may be revised to acquire more volume.
 - / Remember that the Contractor was paid to build the pond to plan.
 - / The way water leaves the pond should be generally consistent with the design.
 - » An inch here or there is not typically critical, but more than that may be problematic. However, an inch difference can mean the difference between 4% and 12%
- › **REFUSAL TO CERTIFY MAY RESULT IN A REQUEST FOR JUSTIFICATION**
 - / Be prepared to review your work.
 - / Section cuts in CADD can help others see the problem areas.
 - / Be open to receiving additional information from design team and/or Contractor.



QUESTIONS?

