Hamilton Co.– City of Madeira HAM-CR101-13.63
PID No. 111842

Analysis Summary

The drainage design was done in accordance with requirements specified within the Ohio Department of Transportation Location and Design Manual, Volume 2. The relevant sections are noted below and shown within the report.

- Storm Sewer Design Criteria - Section 1104.3
- Ditch Design Criteria – Section 1102.3
- Pavement Drainage Criteria - Section 1103.3.1,2,3
- Erosion Control & BMP Design Criteria – Section 1111.2

Storm Drainage Summary

The storm drainage system was designed to maintain the existing drainage pattern of the intersection. However, a small amount of stormwater was diverted to the south back to the intersection along the northern leg of Miami Rd. This was done due of the uncertainty of the outlet from the existing drainage structure just outside of the project limits on the eastern side of the northern leg. We felt that no additional stormwater should be added to the existing structure without know where the location and condition of the existing outlet.

BMP and Erosion Control

BMP Summary

The total project EDA for this project is 0.986 Acres. Per L&D V2, Section 1111.2, The Project EDA less than 1 acre eliminating the need for water quality treatment.

Erosion Control Summary

Swales were utilized in areas of the project to convey offsite drainage when needed. Erosion Control measures were taken to ensure the stability of the swales given the topography and stormwater runoff from the various watersheds. Item 836(Seeding and Erosion Control with Turf Reinforcing Mat), Type 1, are utilized to ensure the stability of the swales.

less than the capacity of the ditch and thereby control the catch basin spacing. Figure 1102-1 is used to check the capacity of a catch basin grate in a sump. To use Figure 1102-1, double the calculated discharge at the ditch checkpoint to compensate for possible partial clogging of the grate.

In cut sections, carry the accumulated ditch flow as far as the capacity, allowable depth, or shear of flow will permit. The first catch basin in the roadside or median ditch will determine the need for a storm sewer system required for the remainder of the cut. Extend shear control as far as inexpensive flexible ditch linings will permit.

When locating ditch catch basins, provide positive outlets for underdrains and access to longitudinal sewer systems.

1102.3.6 Arbitrary Maximum Catch Basin Spacing

Catch basins are required at the low point of all sags. Omit the earth dike shown on the standard construction drawings when used in a sag. The maximum distance between catch basins in depressed medians in fill sections is as follows:

Depressed Median Catch Basin Spacing (Fill Sections)		
Median Width (ft)	Desirable Spacing (ft)	Maximum Spacing (ft)
84	1250	1500
60	1000	1250
40	800	1000

Where underdrains are utilized, place catch basins at a maximum spacing of 1000 feet to provide a positive outlet for the underdrains.

1103 Pavement Drainage

1103.1 General

Refer to the LD1 for pavement cross-slope design criteria.

When curb or barrier is provided, determine the proper type of pavement inlet or catch basin to control the spread of water into the traveled lane. Maximize the allowable spread without exceeding the allowable depth of flow at the face of curb or

C1103.1

When paved shoulders are provided, the drainage cost can be decreased due to the large volume of flow that can be carried on the pavement shoulder.

Additional information concerning pavement drainage can be obtained from the FHWA Hydraulic Engineering Circular No. 22, Urban Drainage Design Manual.

barrier.

Reduce the need for bridge scuppers by intercepting the flow prior to the bridge.

1103.2 Design Frequency

C1103.2

Locate pavement inlets or catch basins to limit the spread of flow on the traveled lane to those shown in Table 1103-1. Base the design on the following frequencies:

Facility	Design (years)
Freeways	10
High Volume Highways (Over 6000 ADT)	5
All other Highways	2

For underpasses or other depressed roadways where ponded water can be removed only through the storm sewer system, check the spread for a 50-year storm on Freeways and other high volume highways as defined above. Use a 25-year storm on other multiple lane highways. Ponding is permitted to cover all but one through lane of a multiple lane roadway.

These criteria are intended for sag locations with no outlet except through the storm sewer system. Examples include sag locations with barrier wall, underpasses, or other depressed cut sections without an alternative outlet.

Typically, these criteria do not apply to 2-lane or other curbed roadway facilities where water can overtop the curb. Contact OHE if encountered.

The depth of flow or ponding at the curb cannot exceed 1 inch below the top of the curb for the design storm discharge regardless of the type of highway. A maximum depth of 6 inches is permitted where a barrier is provided.

Table 1103-1

Facility	Allowable Pavement Spread* (ft)
Freeways	0
High Volume Highways (Over 6000 ADT)	
≥ 45 mph	4
< 45 mph 2 lanes	6
4 lanes	8
All other Highways	
2 lanes	6
≥4 lanes	8

* Pavement spread applies only to the through lane and assumes a 12 ft. lane width.

The speeds listed in the manual are design speeds.

Where lanes are less than the standard 12 ft. lane width, reduce the allowable spread an equal amount. Therefore, 11 ft. lanes on All other Highways with 2 lanes will have an allowable spread of 5 ft. instead of 6 ft.

In some instances, using the legal speed instead of the design speed will result in a more practical pavement spread design. Contact OHE if encountered.

If design requirements cannot be met, contact OHE for guidance in a Performance Based Practical

PBPD focuses on performance improvements that benefit both project and system needs rather than

Design.

strict adherence to published standards. Standards are not abandoned but all factors are considered to produce a balanced decision that does not compromise safety.

1103.3 Estimating Design Discharge

Estimate runoff contributing to curbed pavements by the rational method, as explained in Sections 1101.2.1, 1101.2.2 and 1101.2.3.

The time of concentration $\mathbf{t_c}$ is the actual time of concentration calculated according to Section 1101.2.2 with an absolute minimum time of 10 minutes.

Contact OHE when the contributing drainage area is difficult to determine, and the calculations indicate the need for more basins than existing or the required spacing between basins is less than or equal to 100 feet.

C1103.3

The profile and cross section of the roadway may need to be modified in order to obtain a reasonable basin spacing by using a rolling gutter profile. If the geometrics cannot be revised, a contributing drainage area will need to be assumed. Use the entire contributing drainage area for the storm sewer design.

1103.4 Capacity of Pavement Gutters

Use the following equation to determine flow capacity for a standard curb and straight pavement slope:

$$Q = \frac{0.56ZS^{1/2}Y^{8/3}}{n}$$

Where:

Q = Discharge (cfs)

Z = $1/S_x$

n = Manning's Coefficient of Roughness (Table 1102-2)

S = Longitudinal pavement slope (ft/ft)

Y = Depth of flow in gutter section at curb (ft)

Use the following equations to determine flow capacity for a composite gutter section:

$$Q_1 = (0.56ZS_{x(1)}{}^{1/2}Y^{8/3})/n_{(1)}$$

$$Q_2 = (0.56ZS_{x(1)}{}^{1/2}Y_1{}^{8/3})/n_{(1)}$$

$$Q_3 = (0.56ZS_{x(2)}{}^{1/2}Y_1{}^{8/3})/n_{(2)}$$

C1103.4

The longitudinal slope can vary on the approach to the inlet or catch basin, especially in a sag. When flatter grades are located at a sump, using the flatter slope will underestimate the overall gutter capacity and result in overestimated spread values. Examine the approach lengths of the grades to determine an average slope. If one of the grades has a much longer approach length, use this most predominant slope.

On curbed facilities, design sag vertical curves to prevent inadequate drainage near the bottom. This can be achieved by providing a minimum longitudinal slope of 0.3 percent at the two points 50 ft. from the bottom. This yields a maximum value of K = 167 for the vertical curve, which is typically called the drainage maximum.

Composite Gutter Section: In most cases, the top width of the water surface in a pavement gutter far exceeds the height of the curb. The hydraulic radius does not accurately describe the gutter cross section in this situation, thereby requiring a modification to the Manning's equation to analyze the gutter flow.

INLET SPACING DESIGN

PID : 111842 **Date :** 11/28/2023 **Project :** HAM CR101 13.63 **Location :** Int. of E. Galbraith Rd. and Miami. Ave.

Description : Spread Calcs DR-5 **Designer :** CRS

Rainfall Area: C **Storm Frequency (yr.) :** 5 **Total Allow. Spread (ft.) :** 6.00 **Allowable Depth (ft.)** 0.41

STATION	C.B. Type	GUTTER LENGTH (ft.)	RUNOFF COEF	RUNOFF AREA (acres)	CONC. TIME (min.)	GUTTER TIME (min.)	TIME USED (min.)	LONG. SLOPE (ft./ft.)	GUTT. SLOPE (ft./ft.)	PAVT. SLOPE (ft./ft.)	GUTT. WIDTH (ft.)	LOCAL DEPRESS. (ft.)	RAIN FALL (in./hrs.)	INTERCPTD FLOW (cfs.)	BYPASS FLOW (cfs.)	TOTAL FLOW (cfs.)	DEPTH FLOW (ft.)	PAVT. SPREAD (ft.)	
4+10	Begin																		
3+07	CB-3	117.00	0.00	0.00	0.00	0.00	0.00	0.0100	0.0800	0.0200	2.00	0.1670	0.00	******	******	0.23	0.136	1.70	Sag
3+03	Begin																		
3+07	CB-3	15.00	0.00	0.00	0.00	0.00	0.00	0.0100	0.0800	0.0200	2.00	0.1670	0.00	******	******	0.06	0.082	1.03	End

SUMP DATA

Total Flow (cfs) : 0.29 **Ponded Depth (ft.) :** 0.012 **Spread on Pavement (ft.) :** 1.51

INLET SPACING DESIGN

PID : 111842 **Date :** 11/28/2023 **Project :** HAM CR101 13.63 **Location :** Int. of E. Galbraith Rd. and Miami. Ave.

Description : Spread Calcs DR-9, DR-6 **Designer :** CRS

Rainfall Area: C **Storm Frequency (yr.) :** 5 **Total Allow. Spread (ft.) :** 6.00 **Allowable Depth (ft.)** 0.41

STATION	C.B. Type	GUTTER LENGTH (ft.)	RUNOFF COEF	RUNOFF AREA (acres)	CONC. TIME (min.)	GUTTER TIME (min.)	TIME USED (min.)	LONG. SLOPE (ft./ft.)	GUTT. SLOPE (ft./ft.)	PAVT. SLOPE (ft./ft.)	GUTT. WIDTH (ft.)	LOCAL DEPRESS. (ft.)	RAIN FALL (in./hrs.)	INTERCPTD FLOW (cfs.)	BYPASS FLOW (cfs.)	TOTAL FLOW (cfs.)	DEPTH FLOW (ft.)	PAVT. SPREAD (ft.)	
4+10	Begin																		
3+00	CB-3A	107.00	0.00	0.00	0.00	0.00	0.00	0.0241	0.0800	0.0200	2.00	0.1670	0.00	0.29	0.00	0.29	0.126	1.58	
17+31	CB-3A	92.00	0.00	0.00	0.00	0.00	0.00	0.0139	0.0800	0.0200	2.00	0.1670	0.00	0.51	0.00	0.51	0.173	2.64	
17+75	CB-3A	44.00	0.00	0.00	0.00	0.00	0.00	0.0043	0.0800	0.0200	2.00	0.1670	0.00	******	******	0.42	0.198	3.90	End

No CB, flow discharge to ditch

INLET SPACING DESIGN

PID : 111842 **Date :** 11/28/2023 **Project :** HAM CR101 13.63 **Location :** Int. of E. Galbraith Rd. and Miami. Ave.

Description : Spread Calcs DR-19, DR-18, DR-16, DR-2 **Designer :** CRS

Rainfall Area: C **Storm Frequency (yr.) :** 5 **Total Allow. Spread (ft.) :** 6.00 **Allowable Depth (ft.)** 0.41

STATION	C.B. Type	GUTTER LENGTH (ft.)	RUNOFF COEF	RUNOFF AREA (acres)	CONC. TIME (min.)	GUTTER TIME (min.)	TIME USED (min.)	LONG. SLOPE (ft./ft.)	GUTT. SLOPE (ft./ft.)	PAVT. SLOPE (ft./ft.)	GUTT. WIDTH (ft.)	LOCAL DEPRESS. (ft.)	RAIN FALL (in./hrs.)	INTERCPTD FLOW (cfs.)	BYPASS FLOW (cfs.)	TOTAL FLOW (cfs.)	DEPTH FLOW (ft.)	PAVT. SPREAD (ft.)	
14+46	Begin																		
15+22	CB-3A	77.00	0.00	0.00	0.00	0.00	0.00	0.0268	0.0800	0.0200	2.00	0.1670	0.00	0.11	0.00	0.11	0.086	1.07	
15+78	CB-3	55.00	0.00	0.00	0.00	0.00	0.00	0.0168	0.0800	0.0200	2.00	0.1670	0.00	0.10	0.00	0.10	0.091	1.13	
1+80	CB-3A	77.00	0.00	0.00	0.00	0.00	0.00	0.0630	0.0800	0.0200	2.00	0.1670	0.00	0.34	0.00	0.34	0.112	1.40	
0+86	CB-3A	93.00	0.00	0.00	0.00	0.00	0.00	0.0565	0.0800	0.0200	2.00	0.1670	0.00	******	******	0.62	0.143	1.79	End

INLET SPACING DESIGN

PID : 111842 **Date :** 11/28/2023 **Project :** Ham CR101 13.63 **Location :** Int. of E. Galbraith Rd. and Miami. Ave.

Description : Spread Calcs DR-12, DR-14 **Designer :** CRS

Rainfall Area: C **Storm Frequency (yr.) :** 5 **Total Allow. Spread (ft.) :** 6.00 **Allowable Depth (ft.)** 0.41

STATION	C.B. Type	GUTTER LENGTH (ft.)	RUNOFF COEF	RUNOFF AREA (acres)	CONC. TIME (min.)	GUTTER TIME (min.)	TIME USED (min.)	LONG. SLOPE (ft./ft.)	GUTT. SLOPE (ft./ft.)	PAVT. SLOPE (ft./ft.)	GUTT. WIDTH (ft.)	LOCAL DEPRESS. (ft.)	RAIN FALL (in./hrs.)	INTERCPTD FLOW (cfs.)	BYPASS FLOW (cfs.)	TOTAL FLOW (cfs.)	DEPTH FLOW (ft.)	PAVT. SPREAD (ft.)	
16+57	Begin																		
2+17	CB-3A	21.00	0.00	0.00	0.00	0.00	0.00	0.0189	0.0800	0.0200	2.00	0.1670	0.00	0.09	0.00	0.09	0.085	1.06	
0+86	CB-3A	128.00	0.00	0.00	0.00	0.00	0.00	0.0581	0.0800	0.0200	2.00	0.1670	0.00	******	******	0.24	0.100	1.25	End

INLET SPACING DESIGN

PID : 111842 **Date :** 11/28/2023 **Project :** HAM CR101 13.63 **Location :** Int. of E. Galbraith Rd. and Miami. Ave.

Description : Spread Calcs DR-11, DR-15 **Designer :** CRS

Rainfall Area: C **Storm Frequency (yr.) :** 5 **Total Allow. Spread (ft.) :** 6.00 **Allowable Depth (ft.)** 0.41

STATION	C.B. Type	GUTTER LENGTH (ft.)	RUNOFF COEF	RUNOFF AREA (acres)	CONC. TIME (min.)	GUTTER TIME (min.)	TIME USED (min.)	LONG. SLOPE (ft./ft.)	GUTT. SLOPE (ft./ft.)	PAVT. SLOPE (ft./ft.)	GUTT. WIDTH (ft.)	LOCAL DEPRESS. (ft.)	RAIN FALL (in./hrs.)	INTERCPTD FLOW (cfs.)	BYPASS FLOW (cfs.)	TOTAL FLOW (cfs.)	DEPTH FLOW (ft.)	PAVT. SPREAD (ft.)	
16+57	Begin																		
16+71	CB-3A	18.00	0.00	0.00	0.00	0.00	0.00	0.0127	0.0800	0.0200	2.00	0.1670	0.00	0.12	0.00	0.12	0.102	1.28	
17+31	CB-3A	61.00	0.00	0.00	0.00	0.00	0.00	0.0091	0.0800	0.0200	2.00	0.1670	0.00	0.14	0.00	0.14	0.115	1.44	
17+75	CB-3A	44.00	0.00	0.00	0.00	0.00	0.00	0.0050	0.0800	0.0200	2.00	0.1670	0.00	******	******	0.06	0.094	1.17	End

INLET SPACING DESIGN

PID : 111842 **Date :** 11/28/2023 **Project :** HAM CR101 13.63 **Location :** Int. of E. Galbraith Rd. and Miami. Ave.

Description : Spread Calcs DR-3 to DR-4 **Designer :** CRS

Rainfall Area: C **Storm Frequency (yr.) :** 5 **Total Allow. Spread (ft.) :** 6.00 **Allowable Depth (ft.)** 0.41

STATION	C.B. Type	GUTTER LENGTH (ft.)	RUNOFF COEF	RUNOFF AREA (acres)	CONC. TIME (min.)	GUTTER TIME (min.)	TIME USED (min.)	LONG. SLOPE (ft./ft.)	GUTT. SLOPE (ft./ft.)	PAVT. SLOPE (ft./ft.)	GUTT. WIDTH (ft.)	LOCAL DEPRESS. (ft.)	RAIN FALL (in./hrs.)	INTERCPTD FLOW (cfs.)	BYPASS FLOW (cfs.)	TOTAL FLOW (cfs.)	DEPTH FLOW (ft.)	PAVT. SPREAD (ft.)	
3+03	Begin																		
15+69	CB-3	16.00	0.00	0.00	0.00	0.00	0.00	0.0053	0.0800	0.0200	2.00	0.1670	0.00	******	******	0.06	0.093	1.16	Sag
14+46	Begin																		
15+35	CB-3A	92.00	0.00	0.00	0.00	0.00	0.00	0.0282	0.0800	0.0200	2.00	0.1670	0.00	0.38	0.00	0.38	0.136	1.69	
15+69	CB-3	36.00	0.00	0.00	0.00	0.00	0.00	0.0249	0.0800	0.0200	2.00	0.1670	0.00	******	******	0.12	0.090	1.13	End

CB-3 is actually a curb cut

SUMP DATA

Total Flow (cfs) : 0.18 **Ponded Depth (ft.) :** 0.000 **Spread on Pavement (ft.) :** 0.00

of the design to OHE for review and approval.

1104.2.2.2 Under Paved Shoulder

The above applies to paved shoulder areas, unless the cost of any other possible location is prohibitive.

1104.2.3 Access

For storm sewers under 36 inches in diameter located under or near the edge of pavement, provide access at intervals up to 300 feet maximum. For sewers sized 36 to 60 inches provide manholes spaced every 500 feet maximum and for larger sewers provide manholes spaced every 750 to 1000 feet maximum.

For manhole, inlet and catch basin details refer to the [Hydraulic SCDs.](Hydraulic SCDs)

C1104.2.3

Most standard inlets and catch basins provide satisfactory access to small diameter shallow sewers. They can also be used where changes in pipe size or minor horizontal/vertical changes in alignment occur. Larger changes may require manholes.

It may be necessary to locate longitudinal trunk sewers away from the curb to provide for a utility strip between the curb and the sidewalk and to avoid a conflict with the underdrains. This will require properly spaced manholes in the sewer line.

1104.2.4 Rock Excavation

If it is known that bedrock will be encountered in the excavation for storm sewer installation, relocate the storm sewer. If bedrock cannot be avoided, separate the quantities of the storm sewer in rock and include Item 611, As Per Plan, in the plans.

1104.3 Storm Sewer Design Criteria

1104.3.1 Design Frequency

Size all storm sewers using open channel, just full capacity design to flow just full for a 10-year frequency storm. The size is determined by working downstream from the first sewer run. It is acceptable to use a discharge of a more frequent occurrence if consistent with local criteria or to avoid extensive replacement of an existing downstream drainage system.

C1104.3.1

Just full is the depth of flow for maximum discharge. Just full capacity design assumes a free water surface at a depth of 93.8% of the pipe diameter for circular conduits. Maximum flow and velocity are considered to occur at this depth.

This design methodology provides a conservative margin of safety by providing additional headroom due to increased pipe diameters.

1104.3.2 Hydraulic Grade Line

Determine the elevation of the hydraulic grade line at the upper end of each sewer run using a 25-year frequency. Start at the storm sewer system outlet and work upstream. It is acceptable to use a hydraulic grade line of a more frequent occurrence if consistent with local criteria and / or to avoid extensive replacement of an existing downstream

C1104.3.2

Ordinarily, the hydraulic grade line is above the top of the pipe, causing the system to operate under pressure. If, however, any run in the system does not flow full, (pipe slope steeper than the friction slope) the hydraulic grade line will follow the friction slope until it reaches the normal depth of flow in the steep run. From that point, the hydraulic drainage system.

The starting elevation for the hydraulic grade line determination is the higher of either: the downstream tailwater channel water surface elevation or (dc+D)/2 at the system outlet as explained in Section 1105.6.1.

Use the same intensity **i** in the Rational Equation Q = CiA to determine the check discharge for all sewer runs as that calculated for the last, or downstream run, in a continuous sewer system.

grade line will coincide with the normal depth of flow until it reaches a run flatter than the friction slope for that run.

These criteria are not intended to lower existing high-water elevations.

The check discharge is the 25-year frequency.

The hydraulic grade line must not exceed the following:

A. 12 inches below the near edge of pavement for sections without curb.

B. The elevation of a curb opening inlet or grate elevation of a pavement catch basin, as shown on the SCD.

Hydraulic grade line requirement A is for ditch sections and B is for curbed sections.

Use a 50-year frequency check storm discharge to determine the elevation of the hydraulic grade line for freeways having depressed sags drained by storm sewers.

One directional lane of a multiple lane highway or one-half of a lane on a 2-lane highway must be passable when the sewer system is discharging the check storm.

The 50-year frequency is based on Code of Federal Regulation 23 CFR 650.115(a)(2) requirements.

These criteria are intended for sag locations with no outlet except through the storm sewer system. Examples include sag locations with barrier wall, underpasses, or other depressed cut sections without an alternative outlet.

Typically, these criteria do not apply to 2-lane or other curbed roadway facilities where water can overtop the curb. Contact OHE if encountered.

1104.3.3 Runoff Coefficient

Determine the runoff coefficient per Section 1101.2.2.

1104.3.4 Time of Concentration

Determine the time of concentration as explained in Section 1101.2.1. Use a minimum time of concentration of 15 minutes to the first ditch catch basin and 10 minutes to the first pavement inlet. Use the actual calculated time of concentration when values greater than these minimums occur.

1104.3.5 Pipe Roughness Coefficient

Use a Manning's **n** of 0.015 for sewers 60 inches in diameter and under, and 0.013 for larger sewers. The typical **n** value for smooth pipe, concrete, vitrified clay, bituminous lined corrugated steel or

C1104.3.5

The increased **n** values are recommended to compensate for minor head losses incurred at catch basins, inlets and manholes located in a storm sewer system.

thermoplastic is 0.012.

1104.3.6 Minimum Pipe Size

Use a minimum pipe diameter of 15 inches for Freeways and Freeway ramps and 12 inches for other highways.

C1104.3.6

Where an existing storm sewer is to remain in service, it is not necessary to replace hydraulically adequate pipes to meet these criteria.

1104.3.7 Maximum Slope

The maximum slope is 4:1 H:V or the slope that produces a velocity exceeding 10 fps. Provide drop structures for energy dissipation when slopes or velocities exceed the allowable limits.

For storm sewers along embankment slopes that exceed 3:1 H:V, designate as Type F, Broken Back per Figure 1104-1.

1104.3.8 Outlet Velocity Protection

Provide outlet velocity protection for all Storm Sewers with an outlet velocity greater than 5 fps.

Provide rock channel protection for erosion control per Figure 1002-4.

Provide a filter with the RCP. Use a geotextile fabric filter when not under water. Use an aggregate filter when the RCP is under water. The cost of the filter is included in the unit bid price for Item 601, Rock Channel Protection with Filter.

C1104.3.8

A filter is provided with the RCP to prevent soil piping through the rock. Aggregate filter is specified for placement under water as the fabric filter is buoyant and may cause difficulty during installation. Use aggregate filter for RCP placed under the OHWM.

1104.4 Storm Sewer Hydraulic Design Procedure

Provide storm sewer computations. Tabulate the calculations for lateral connections to the longitudinal trunk sewer separately from the trunk sewer calculations.

Software is available at the OHE Hydraulic Software and Design Resources web page and can be used for these calculations. OpenRoads SUDA may also be used for these calculations. Other software packages may be utilized with approval from OHE.

C1104.4

With the layout suggested in Section 1104.3, start with the upper catch basin or inlet and determine the value of CA for the contributing flow (CA is the product of the weighted coefficient of runoff and the drainage area). Next, determine the time of concentration for the first area and the corresponding rainfall intensity **i** from the proper curve shown on Figure 1101-2. The design discharge **Q** to use to determine the required size of the first sewer from MH No. 1 to MH No. 2 is the product of CA x i. At manhole No. 2, determine the value of CA for the additional area contributing at that point and add to the CA for MH No. 1.

Compute the time of flow in the storm sewer from MH No.1 to MH No. 2 in minutes and add to the time of concentration at MH No. 1. Check the time of concentration for the area contributing to MH No. 2, and use the larger of the two as the duration for the new value of rainfall intensity for computing

Ham-CR101 13.63 Hydrology - Storm System Design Flows											
						Calculations By:	CRS		Date:	#########	
						Checked By:			Date:		
Rational Method											
Drainage Area		Input Summary				Q (cfs)					
Drainage Area ID	Station	Area Prop.	Tc (min)	Weighted C_{value}	Intensity Value (10 Yr)	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year
DR-1	14+40	5.956	21.3	0.40	3.74	6.56	7.89	8.90	10.22	11.13	11.97
DR-2	0+86	0.223	10.0	0.58	5.32	0.52	0.62	0.68	0.77	0.83	0.90
DR-3	15+35	0.111	10.0	0.70	5.32	0.32	0.38	0.41	0.47	0.51	0.55
DR-4A	15+72	0.028	10.0	0.90	5.32	0.10	0.12	0.13	0.15	0.16	0.18
DR-4B	15+72	0.013	10.0	0.90	5.32	0.05	0.06	0.06	0.07	0.08	0.08
DR-5	3+07	0.054	10.0	0.90	5.32	0.20	0.23	0.26	0.29	0.32	0.34
DR-6A	17+72	0.178	10.0	0.59	5.32	0.43	0.51	0.56	0.64	0.69	0.74
DR-6B	17+72	0.155	10.0	0.56	5.32	0.36	0.42	0.46	0.52	0.57	0.61
DR-7	4+11	0.625	10.0	0.65	5.32	1.66	1.96	2.16	2.44	2.64	2.86
DR-9	16+49	0.082	10.0	0.74	5.32	0.25	0.29	0.32	0.36	0.39	0.43
-	-	-	-	-	-	-	-	-	-	-	-
DR-11	16+71	0.028	10.0	0.90	5.32	0.10	0.12	0.13	0.15	0.16	0.18
DR-12	2+16	0.021	10.0	0.90	5.32	0.08	0.09	0.10	0.11	0.12	0.13
-	-	-	-	-	-	-	-	-	-	-	-
DR-14	0+87	0.057	10.0	0.86	5.32	0.20	0.24	0.26	0.29	0.32	0.34
DR-15A	17+73	0.032	10.0	0.90	5.32	0.12	0.14	0.15	0.17	0.19	0.20
DR-15B	17+73	0.014	10.0	0.90	5.32	0.05	0.06	0.07	0.08	0.08	0.09
DR-16	1+80	0.088	10.0	0.80	5.32	0.29	0.34	0.38	0.43	0.46	0.50
-	-	-	-	-	-	-	-	-	-	-	-
DR-18	15+78	0.027	10.0	0.74	5.32	0.08	0.10	0.11	0.12	0.13	0.14
DR-19	15+23	0.025	10.0	0.90	5.32	0.09	0.11	0.12	0.14	0.15	0.16
DR-20	14+45	0.231	10.0	0.67	5.32	0.63	0.74	0.82	0.93	1.00	1.08
DR-21	3+13	3.150	10.0	0.62	5.32	7.96	9.40	10.37	11.72	12.66	13.72
-	-	-	-	-	-	-	-	-	-	-	-
DR-23	15+72	0.032	10.0	0.90	5.32	0.12	0.14	0.15	0.17	0.19	0.20
DR-24	15+73	0.014	10.0	0.90	5.32	0.05	0.06	0.07	0.08	0.08	0.09
DR-25	15+21	0.037	10.0	0.50	5.32	0.08	0.09	0.10	0.11	0.12	0.13
-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-

Hamilton County - Zone C *i=a/(b+tc)^c* *Q=C*I*A*

Rainfall Intensity

Frequency	a	b	c	i(tc=5)	i(tc=15)	i(tc=30)	i(tc=60)
2	56.29900	10.00000	0.87600	5.25	3.36	2.22	1.36
5	67.93300	11.00000	0.86900	6.11	4.00	2.70	1.67
10	84.55000	13.00000	0.88200	6.61	4.47	3.06	1.92
25	95.73600	14.00000	0.87100	7.37	5.10	3.55	2.25
50	96.78300	14.00000	0.85000	7.92	5.53	3.88	2.49
100	80.43600	11.50000	0.79400	8.68	5.96	4.18	2.71

HAM-CR101 13.63 Hydrology - Storm System Design Flows																							
																	Calculations By:	CRS	DATE:	11/28/2023			
																	Checked By:		DATE:				
Time of Concentration Calculations																							
Drainage Area	Sheet Flow - $t_o = [1.8(1.1 - C)L^{1/2}]/s^{1/3}$					Shallow Concentrated Flow $V = 3.281ks^{0.5}$					Open Channel/Piped Flow											Time Of Conc.	Time Of Conc.
ID	Slope	Length	C		Time	Slope	k	V	L	Time	Elevation		Length	Slope	n	SS Lt	SS Rt	BW	Depth	V	Time	T_C (min)	T_C (min)
	%	ft			min	%		ft/s	ft	min	From	To	ft	ft/ft		z:1	z:1	ft.	ft.	ft/s	min	10/15	>= 10/15 min
DR-1	6.50	244	0.3		12.1	4.4000	0.152	1.05	558	8.9	804.53	800.72	97	0.0393	0.030	4.0	4.0	0.0	1.0	6.08	0.3	21.3	21.3
DR-2	8.50	45	0.9		1.2	6.4000	0.152	1.26	559	7.4	790.21	788.98	20	0.0615	0.012	8.0	1.0	0.0	1.0	18.74	0.0	8.6	10.0
DR-3	Tc=10 Minutes																					0.0	10.0
DR-4A	Tc=10 Minutes																					0.0	10.0
DR-4B	Tc=10 Minutes																					0.0	10.0
DR-5	Tc=10 Minutes																					0.0	10.0
DR-6A	6.20	125	0.4		7.7	4.8000	0.457	3.29	35	0.2	795.66	795.55	20	0.0055	0.040	8.0	1.0	0.0	0.2	0.58	0.6	8.5	10.0
DR-6B	4.40	138	0.4		9.0	4.8000	0.457	3.29	73	0.4	795.66	795.55	20	0.0055	0.040	8.0	1.0	0.0	0.2	0.58	0.6	10.0	10.0
DR-7	2.80	138	0.9		3.0	1.3000	0.457	1.71	65	0.6	828.00	802.50	703	0.0363	0.040	6.0	6.0	0.0	1.0	4.43	2.6	6.2	10.0
DR-9	Tc=10 Minutes																					0.0	10.0
-	-																					-	-
DR-11	Tc=10 Minutes																					0.0	10.0
DR-12	Tc=10 Minutes																					0.0	10.0
-	-																					0.0	10.0
DR-14	Tc=10 Minutes																					0.0	10.0
DR-15A	Tc=10 Minutes																					0.0	10.0
DR-15B	Tc=10 Minutes																					0.0	10.0
DR-16	Tc=10 Minutes																					0.0	10.0
-	-																					-	-
DR-18	Tc=10 Minutes																					0.0	10.0
DR-19	Tc=10 Minutes																					0.0	10.0
DS-20	2.40	43	0.7		3.5	2.2000	0.457	2.22	27	0.2	802.66	799.33	102	0.0327	0.040	3.0	3.0	0.0	0.5	2.58	0.7	4.4	10.0
DR-21	7.50	43	0.7		2.6	17.6871	0.457	6.31	147	0.4	823.71	795.16	676	0.0422	0.040	3.0	3.0	0.0	0.5	2.93	3.8	6.8	10.0
-	-																					-	-
DR-23	Tc=10 Minutes																					0.0	10.0
DR-24	Tc=10 Minutes																					0.0	10.0
DR-25	Tc=10 Minutes																					0.0	10.0
-	-																						
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

upper	lower	length	sheet slope	upper	lower	scf length	scf slope
830.760	827.520	43.000	0.075	827.520	823.710	147.000	0.026

s = Slope in ft/ft.
L = Length in feet.
C = Coefficient of Runnoff
k = Intercept Coefficient for Shallow Concentrated Flow Calculations
V is velocity in ft/s.
T_C is time of concentration in minutes.

HAM-CR101-13.63 Hydrology - Storm System Design Flows
Weighted C Value Calculations

Calculations By: CRS Date: 11/28/2023
Checked By: Date:

Runoff Factors	Pavements & Roofs	Grass Shoulders	Cultivated Fields			Suburban, Normal Residential		Lawns		Ponds	Gravel Pavement	Meadows & Pasture Land		Total Drainage Area (ACRES)	Composite C Values
		Berms and Slopes 4:1 or Flatter	Residue > 20%	Rolling 2%-10%	Hilly Over 10%	Flat 0% - 2%	Rolling 2% - 10%	Flat 0% - 2%	Rolling 2% - 10%		Flat 0% - 2%	Flat 0% - 2%	Rolling 2% - 10%		
	0.90	0.50	0.30	0.20	0.30	0.40	0.50	0.40	0.30	0.20	0.50	0.25	0.30		
Area/Node	Area (ACRES)	Area (ACRES)	Area (ACRES)	Area (ACRES)	Area (ACRES)	Area (ACRES)	Area (ACRES)	Area (ACRES)	Area (ACRES)	Area (ACRES)	Area (ACRES)	Area (ACRES)	Area (ACRES)		
DR-1	0.987								4.969					5.96	0.40
DR-2	0.042						0.181							0.223	0.58
DR-3	0.056						0.055							0.11	0.70
DR-4A	0.028													0.028	0.90
DR-4B	0.013													0.013	0.90
DR-5	0.054													0.054	0.90
DR-6A	0.042						0.136							0.178	0.59
DR-6B	0.024						0.131							0.155	0.56
DR-7	0.235						0.390							0.625	0.65
DR-9	0.049						0.033							0.082	0.74
-		0.001												0.001	0.50
DR-11	0.028													0.028	0.90
DR-12	0.021													0.021	0.90
-	0.090	0.074												0.164	0.72
DR-14	0.051						0.006							0.057	0.86
DR-15A	0.032													0.032	0.90
DR-15B	0.014													0.014	0.90
DR-16	0.067						0.021							0.088	0.80
-		0.001												0.001	0.50
DR-18	0.016						0.011							0.027	0.74
DR-19	0.025													0.025	0.90
DR-20	0.096						0.135							0.231	0.67
DR-21	0.936						2.214							3.150	0.62
-		0.001												0.001	0.50
DR-23	0.032													0.032	0.90
DR-24	0.014													0.014	0.90
DR-25							0.037							0.037	0.50
-	0.100													0.100	0.90
-	0.104													0.104	0.90

Mead Hunt, Inc.
4700 Lakehurst Court, Suite 110
Columbus, OH 43016

STORM SEWER SYSTEM

PID : 111842 **Date :** 03/28/2022 **Project :** Ham CR 101 13.63 **Location :** Hamilton County, Int of E Galbraith and Miami Ave.

Description : Storm Sewer Analysis DR-1,DR-7, DR-21 to Ex CB 22(Outlet) **Designer :** CRS

Rainfall Area: C **Just Full Capacity Frequency (yrs.) :** 10 **Hydraulic Gradient Frequency (yrs.) :** 25

Minimum Pipe Size : 12.00 **Tailwater Elevation (ft.):** 0.00

JUNCTION From	To	STATION From / To	ΔAREA / ΣAREA (acres)	ΔCA / ΣCA	BEGIN TIME (min.)	RAINFALL INTENSITY (10 yrs.)	(25 yrs.)	DISCHARGE (cfs.) (10 yrs.)	(25 yrs.)	PIPE DIAM. (in.)	PIPE LENGTH (ft.)	PIPE SLOPE (ft./ft.)	F/L PIPE IN / OUT (ft.)	MEAN VEL (fps.)	JUST FULL CAPACITY (cfs.)	FRICT SLOPE (ft./ft.)	HYGR EL. IN / OUT (ft.)	COVER IN / OUT (ft.)	COVER MINUS HY GR	COVER MINUS CROWN	INLET TYPE MANNING'S 'n'
DR1	DR3	14+40	5.98	2.39	21.30	3.69	4.39	8.8	10.5	18	96.3	0.0238	796.54	8.40	15.10	0.0133	797.51	799.25	1.74	1.21	CB 8
begin		15+35	5.98	2.39									794.25				795.62	798.34			0.015
DR3	DR4	15+35	0.11	0.08	21.49	3.67	4.38	9.1	10.8	18	42.8	0.0152	794.25	7.07	12.07	0.0141	795.58	798.34	2.76	2.59	CB 3A
		15+75	6.09	2.47									793.60				794.98	798.10			0.015
DR21	DR4	3+13	3.19	1.98	10.00	5.30	4.37	10.5	8.6	18	15.7	0.0172	792.44	7.62	12.84	0.0090	793.64	795.15	1.51	1.21	CB 5
begin		15+75	9.28	4.45									792.17				793.50	798.10			0.015
DR5	DR4	3+07	0.05	0.05	10.00	5.30	4.37	0.3	0.2	18	15.4	0.0331	792.17	3.47	17.82	0.0000	793.50	797.36	3.86	3.69	CB 3A
begin		15+71	9.33	4.49									791.66				793.50	798.10			0.015
DR4	DR18	15+75	0.00	0.00	21.59	3.66	4.37	16.5	19.6	24	51.9	0.0150	791.94	8.24	25.86	0.0100	793.50	798.10	4.60	4.16	MH 3
		15+78	9.33	4.49									791.16				792.98	797.72			0.015
DR18	DR26	15+78	0.03	0.02	21.70	3.65	4.37	17.4	20.7	24	5.6	0.0107	791.16	7.26	21.83	0.0112	792.98	797.22	4.24	4.06	CB 3
		15+78	9.36	4.51									791.10				792.92	797.90			0.015
DR20	DR23	14+45	0.23	0.15	10.00	5.30	6.45	0.8	1.0	12	30.1	0.0136	797.34	3.70	3.88	0.0010	797.70	799.53	1.83	1.19	CB 2-2B
begin		14+74	9.59	4.67									796.93				797.64	799.60			0.015
DR23	DR24	14+74	0.03	0.03	10.14	5.27	6.43	1.0	1.2	12	22.2	0.0279	796.93	5.02	5.55	0.0015	797.26	799.60	2.34	1.67	CB 2-2B
		14+96	9.62	4.70									796.31				797.04	799.48			0.015

STORM SEWER SYSTEM

JUNCTION From To	STATION From To	ΔAREA Σ AREA (acres)	ΔCA ΣCA	BEGIN TIME (min.)	RAINFALL INTENSITY (10 yrs.)	 (25 yrs.)	DISCHARGE (cfs.) (10 yrs.)	 (25 yrs.)	PIPE DIAM. (in.)	 LENGTH (ft.)	 SLOPE (ft./ft.)	F/L PIPE IN / OUT (ft.)	MEAN VEL (fps.)	JUST FULL CAPACITY (cfs.)	FRICT SLOPE (ft./ft.)	HYGR EL. IN / OUT (ft.)	COVER IN / OUT (ft.)	COVER MINUS HY GR	COVER MINUS CROWN	INLET TYPE MANNING'S 'n'
DR24 DR19	14+96 15+22	0.01 9.63	0.01 4.71	10.21	5.25	6.41	1.0	1.3	12	24.1	0.0237	796.31 795.74	4.81	5.11	0.0017	796.66 796.48	799.48 798.78	2.82	2.17	CB 2-2B 0.015
DR19 DR18	15+22 15+78	0.03 9.66	0.02 4.73	10.29	5.24	6.36	1.2	1.5	12	50.9	0.0244	795.74 794.50	5.14	5.18	0.0024	796.12 795.26	798.78 797.22	2.66	2.04	CB 3A 0.015
DR25 DR19 begin	15+21 15+22	0.04 9.70	0.02 4.75	10.00	5.30	6.48	0.1	0.1	12	8.0	0.0175	795.88 795.74	2.19	4.39	0.0000	796.31 796.31	798.55 798.78	2.24	1.67	CB 2-2B 0.015
DR26 DR27	15+77 1+79	0.00 9.70	0.00 4.75	21.71	3.65	4.35	17.4	20.7	24	68.0	0.0250	791.10 789.40	10.15	33.35	0.0111	792.29 791.21	797.90 795.41	5.61	4.80	MH 3 0.015
DR16 DR27 begin	1+80 1+79	0.09 9.78	0.07 4.82	10.00	5.30	6.49	0.4	0.5	12	6.1	0.0656	790.80 790.40	5.17	8.51	0.0002	791.04 791.04	794.71 795.41	3.67	2.91	CB 3A 0.015
DR27 DR28	1+79 0+87	0.00 9.78	0.00 4.82	21.82	3.64	4.34	17.6	20.9	24	93.0	0.0376	789.40 785.90	11.87	40.91	0.0114	790.46 787.72	795.41 789.70	4.95	4.01	MH 3 0.015
DR2 DR28 begin	0+87 0+87	0.22 10.01	0.13 4.95	10.00	5.30	4.33	0.7	0.6	12	6.0	0.0333	786.10 785.90	4.86	6.06	0.0003	787.02 787.01	788.98 789.70	1.96	1.88	CB 3A 0.015
DR28 EX29 final	0+87 0+08	0.00 10.01	0.00 4.95	21.95	3.63	4.33	18.0	21.4	24	79.0	0.0334	785.90 783.26	11.43	38.55	0.0119	787.01 785.09	789.70 786.26	2.69	1.80	MH 3 0.015

STORM SEWER SYSTEM

PID : 111842 **Date :** 03/28/2022 **Project :** Ham CR 101 13.63 **Location :** Hamilton County, Int of E Galbraith and Miami Ave.

Description : Storm Sewer Analysis DR-1,DR-7, DR-21 to Ex CB 22(Outlet) **Designer :** CRS

Rainfall Area: C **Just Full Capacity Frequency (yrs.) :** 10 **Hydraulic Gradient Frequency (yrs.) :** 25

Minimum Pipe Size : 12.00 **Tailwater Elevation (ft.):** 0.00

JUNCTION From To	STATION From To	ΔAREA ΣAREA (acres)	ΔCA ΣCA	BEGIN TIME (min.)	RAINFALL INTENSITY (10 yrs.)	RAINFALL INTENSITY (25 yrs.)	DISCHARGE (cfs.) (10 yrs.)	DISCHARGE (cfs.) (25 yrs.)	PIPE DIAM. (in.)	PIPE LENGTH (ft.)	PIPE SLOPE (ft./ft.)	F/L PIPE IN / OUT (ft.)	MEAN VEL (fps.)	JUST FULL CAPACITY (cfs.)	FRICT SLOPE (ft./ft.)	HYGR EL. IN / OUT (ft.)	COVER IN / OUT (ft.)	COVER MINUS HY GR	COVER MINUS CROWN	INLET TYPE MANNING'S 'n'
DR7 DR9 begin	4+11 3+00	0.63 0.63	0.41 0.41	10.00	5.30	6.43	2.2	2.6	15	105.8	0.0576	799.74 793.65	8.01	14.45	0.0022	800.11 794.60	802.18 797.09	2.07	1.19	CB 2-2B 0.015
DR9 DR8	3+00 16+69	0.08 0.71	0.06 0.47	10.22	5.25	6.40	2.5	3.0	15	27.7	0.0152	793.65 793.23	5.15	7.42	0.0028	794.28 794.20	797.09 799.00	2.81	2.19	CB 3A 0.015
DR8 DR11	16+69 16+70	0.03 0.73	0.02 0.49	10.31	5.23	6.28	2.6	3.1	15	47.4	0.0481	793.23 790.95	7.91	13.21	0.0030	793.66 791.97	799.00 796.39	5.34	4.52	CB 3A 0.015
DR6 DR15 begin	17+73 17+73	0.33 1.07	0.20 0.69	10.00	5.30	6.45	1.1	1.3	12	27.6	0.0080	792.20 791.98	3.29	2.97	0.0018	792.77 792.72	795.62 795.60	2.85	2.42	CB 3A 0.015
DR15 DR11	17+73 16+70	0.05 1.11	0.04 0.73	10.14	5.27	6.28	1.3	1.5	12	102.5	0.0076	791.98 791.20	3.39	2.90	0.0025	792.52 791.97	795.60 796.39	3.08	2.62	CB 3A 0.015
DR11 DR12	16+70 16+43	0.03 1.14	0.03 0.76	10.64	5.17	6.28	3.9	4.8	15	37.3	0.0086	790.95 790.63	4.64	5.58	0.0072	791.97 791.70	796.39 796.32	4.42	4.19	CB 3A 0.015
DR12 DR14	16+43 0+86	0.02 1.16	0.02 0.78	10.78	5.14	6.21	4.0	4.8	15	130.7	0.0451	790.63 784.74	8.73	12.79	0.0074	791.18 785.81	796.32 788.93	5.14	4.44	CB 3A 0.015
DR14 ECB2 final	0+87 0+09	0.06 1.22	0.05 0.83	11.03	5.09	6.16	4.2	5.1	15	78.0	0.0213	784.74 783.08	6.71	8.79	0.0082	785.45 784.16	788.93 785.24	3.48	2.94	CB 3A 0.015

1102.2.5 Channel Linings and Bank Stabilization

Use soil bioengineering to stabilize banks for channel relocations or ditch stream captures.

Specify native plant species.

C1102.2.5

Bank stabilization using bioengineering is covered in the previously referenced USDA publication as well as the AASHTO Model Drainage Manual and the USDA, Natural Resources Conservation Service publication, Engineering Field Handbook, Chapter 16, Streambank and Shoreline Protection, part 650. The design procedures and methods for determining the effectiveness of the traditional channel linings are covered in the FHWA publication, Design of Roadside Channels with Flexible Linings (Hydraulic Engineering Circular No. 15).

1102.3 Ditch Design Criteria

1102.3.1 Design Frequency

Determine the depth of flow and the shear stress based on the following frequencies:

ADT	Depth of Flow Design (years)	Shear Stress Design (years)
≤3000	5	2
>3000	10	5

Where a flexible ditch lining is required for calculated stresses exceeding the allowable for seed, the minimum width of the lining is 7.5 feet. Additional required width is in increments of 3.5 feet. The installed width of all ditch linings is centered on the flow line of the ditch.

The depth of flow is limited to an elevation 1 foot below the edge of pavement for the design discharge. The depth of flow in toe of slope ditches is further limited such that the design year discharge does not overtop the ditch bank.

C1102.3.1

7.5 feet is the common commercially available width for flexible ditch lining.

1102.3.2 Ditch Protection

The shear stress for the five-year frequency storm must not exceed the values shown in Table 1102-1 for the various flexible linings.

Table 1102-1

Permanent Protection	
Protective Lining	**Allowable Shear Stress (lbs./ft²)**
Seed (659)	0.40
Sodding, Ditch Protection (660)	1.0
Temporary Protection	
Item 670 Ditch Erosion Protection Mat Type __	
B	1.50
C	2.0
E	2.25
G	1.75

The temporary linings will reach a value of 1.0 lbs./ft^2 upon vegetation establishment. Use the temporary lining shear stress values in Table 1102-1 on a temporary basis of 6 months or less.

Calculate the actual shear stress by the following equation:

$$\tau_{ac} = 62.4DS$$

Where:

D = Water surface depth (ft)

S = Channel slope (ft/ft)

τ_{ac} = Actual shear stress (lbs./ft^2)

If the calculated shear stress exceeds that shown in table 1102-1 then use the following permanent shear stress values within the stated limitations:

A. Seeding and Erosion Control with Turf Reinforcing Mat, SS836, where the ditch slope is 10% or less. Allowable shear stress for each type is as follows:

Turf Reinforcing Mat Shear Stress	
Type	**Allowable Shear Stress (lbs./ft²)**
1	3
2	4
3	5
4	6

B. Type B, C or D Rock Channel Protection may be used to line the ditch if the nearest point of the lining is outside the design clear zone or located behind guardrail or barrier. The actual shear stress is based upon the parameters of the channel slope and depth of flow for the 5-year discharge. The shear equation is valid for discharges less than 50 cfs with slopes less than 10%. Allowable shear stress for each type is as follows:

Rock Channel Protection Shear Stress	
Type	**Allowable Shear Stress (lbs./ft^2)**
B	6
C	4
D	2

C. Type B or C RCP may be utilized for lining ditches on profile grades from 10%- 25% that carry flow from the end of a cut section down to the valley floor. Use HEC-15 procedures with a safety factor of 1.5 for steep gradient channels. Contact OHE for further guidance of RCP usage for 5-year discharges greater than or equal to 50 cfs.

D. Tied concrete block mat protection, Item 601, may be used for slopes and channels. Provide for slopes that are 2:1 or flatter. Provide for channels when side slopes are 2:1 or flatter and profile grades are 25% or less. The matting may be used within the clear zone when the top of the blocks are flush with the finished grade. Install per the manufacturer recommendations. The allowable shear stress for each type is 12 lbs/ft^2. Specify Type 1 underlayment as the standard option. Provide Type 2 Underlayment in areas where establishing vegetation is difficult, such as, areas with poor soils, flumes on steep slopes, or areas subjected to constant flow.

E. Articulating concrete block revetment system, Item 601, may be used for slopes and channels with 2:1 or flatter side slopes. The revetment may be used within the clear zone when the top of the blocks are flush with the finished grade. Install per the manufacturer recommendations. The allowable shear stress for each type is as follows:

Articulating Concrete Block Revetment System Shear Stress	
Type	**Allowable Shear Stress (lbs./ft²)**
1	17
2	20
3	23

F. Consider a concrete lining only as a last resort. Contact OHE, before using a concrete lining.

1102.3.3 Roughness

Suggested values for Manning's Roughness Coefficient **n** for the hydraulic analysis of various types of open water carrier linings are listed in Table 1102-2.

Table 1102-2

Manning's Roughness Coefficient	
Type of Lining	**n**
Bare Earth	0.02
Seeded	0.03
Sod	0.04
Item 670	0.04
Concrete	0.015
Bituminous	0.015
Grouted Riprap	0.02
Tied Concrete Block	0.03
Rock Channel Protection	0.06 for ditches 0.04 for large channels

1102.3.4 Catch Basin Types

CB-4, CB-5 and CB-8 basins are suitable for the standard roadside designs covered in LD1. The bases can be expanded to accommodate larger diameter conduits by specifying SCD CB-4A , 5A, 8A.

The bar spacing can be decreased for safety reasons, by specifying Grate **E** for CB-4 and Grate **B** for CB-5. Provide 150 feet of Item 670, Ditch Erosion Protection, upstream of all CB-4, CB-5 and CB-8 basins, regardless of velocity.

The following catch basin types are generally recommended based on the size and shape of the ditch.

A. CB-4 for depressed medians wider than 40

C1102.3.4

The tilt built into the basin top provides a self-cleaning feature when the basins are used on continuous grades and the wide bar spacing minimizes clogging possibilities, thereby resulting in an efficient design.

feet.

B. CB-5 for 40-foot radius roadside or median ditches. Use Grate **B** where pedestrian traffic may be expected.

C. CB-8 for 20-foot radius roadside or depressed medians 40 feet or less in width.

D. CB-2-2-A in trapezoidal ditches where the basin is in a rural area. Locate the basin outside of the design clear zone or behind guardrail. The capacity of the side inlet window, for unsubmerged conditions, may be determined by the standard weir equation:

$$Q = CLH^{3/2}$$

Where **C** is a weir coefficient, generally 3.0, L is the length of opening in feet, **H** is the distance from the bottom of the window to the surface of the design flow in feet. The catch basin grate is considered as an access point for the storm sewer and its capacity to admit flow is ignored for continuous grades.

E. Use a CB-2-2-B basin where minor, non-clogging flows are involved such as yard sections and the small triangular area created by the guardrail treatment for a depressed median at bridge terminals. Provide CB-2-3 through CB-2-6 basins where a larger base is required to accommodate conduits greater than 21 inches in span or sewer junctions, or where a CB-2-2-B will not provide adequate access to the sewer.

F. In urban areas use Standard Side Ditch Inlets to drain small areas of trapped water behind curbs and/or between driveways.

For lower ADT highways consider using CB-5, CB-2-2-A, within the safety limitations as discussed in Section D above, and CB-2-2-B. Where additional capacity is required use CB-4.

For catch basin details refer to the Hydraulic SCDs.

1102.3.5 Calculated Catch Basin Spacing

Provide catch basins to intercept flow from open water carriers when the depth of flow or shear exceeds the maximum allowable for the design storm for all highway classifications.

When the calculated depth of flow or shear exceeds the maximum allowable at the checkpoint in the ditch, a catch basin or ditch lining will be required. However, the capacity of the catch basin may be

C1102.3.5

CB-4, CB-5 and CB-8, include an earth dike. The dike is approximately 12 inches above the flowline of the grate, immediately downstream from the catch basin and serves to block the flow on continuous grades and create a sump condition.

DITCH ANALYSIS

PID : 111842 **Date :** 06/10/2022 **Project :** Ham CR101 13.63 **Location :** Sta 13+90-Sta 14+40RT

Description : Swale to DR-1 on Miami Dr. **Designer :** CRS

Rainfall Area : C

Allowable Shears

	Seed:	0.40	**Jute Mat:**	0.45	**Temporary Mat:**	1.00
Permanent Mat	**Type 1:**	2.00	**Type 2:**	3.00	**Type 3:**	5.00
RCP	**Type B:**	6.00				

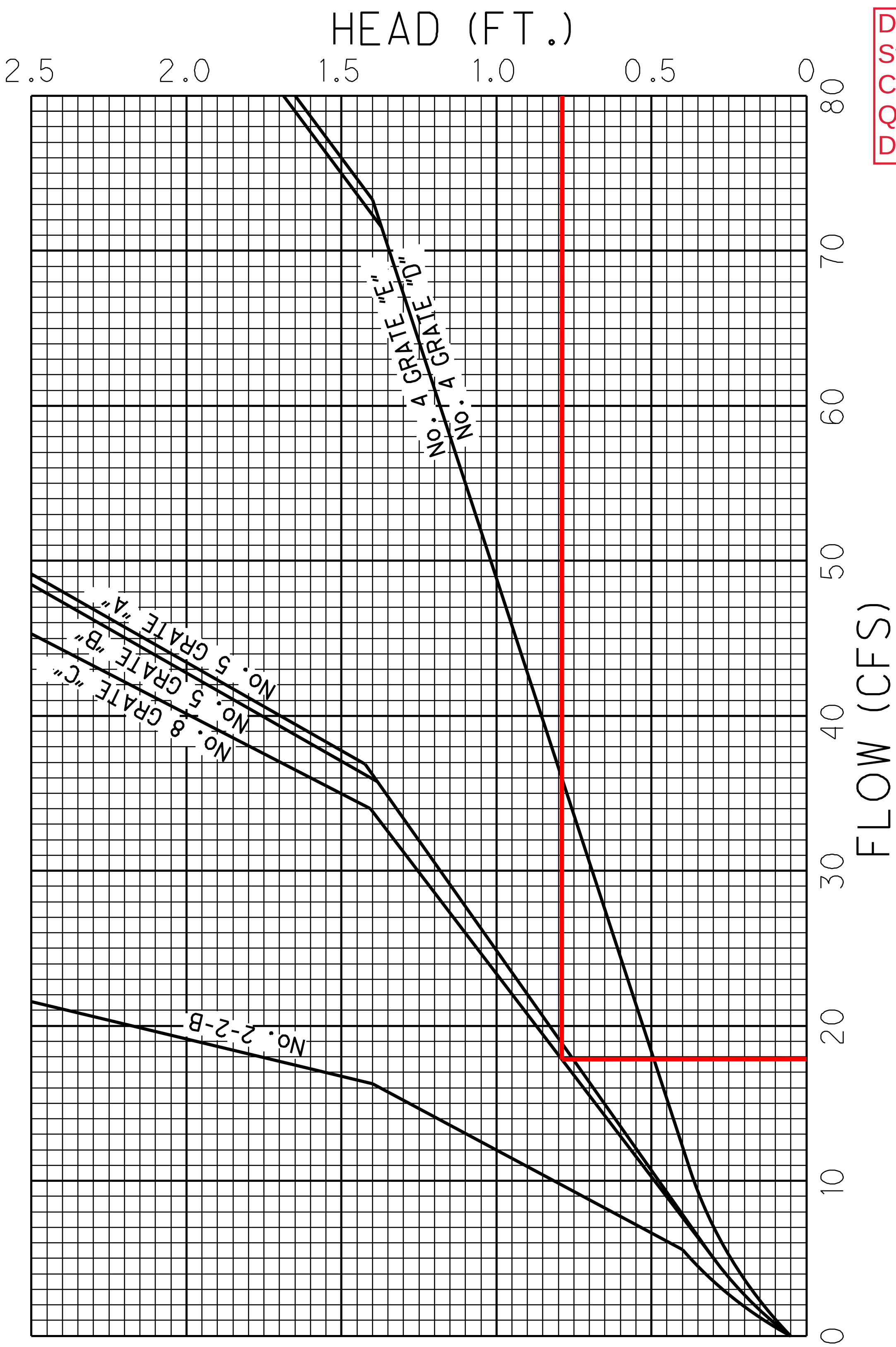
(*) Warning: Grade is steeper than allowable. If value is parantheses, design parameters have been exceeded. - See user manual.

STATION BEGIN	STATION END	SIDE	LENGTH (ft.)	RADIUS WIDTH (ft.)	IN SLOPE (ft./ft.)	BACK SLOPE (ft./ft.)	GRADE (ft./ft.)	AREA (acres)	AREA SUM (acres)	RUNOFF COEFF.	CA (Sum)	PROTECT TYPE	RAIN INT. (in./hr.)	STORM FREQ. (yrs.)	MANN. COEFF.	TIME FLOW (min.)	VEL. FLOW (fps.)	SHEAR (lbs./ sq.ft.)	DESIGN FLOW (cfs.)	DEPTH FLOW (ft.)	WIDTH FLOW (ft.)
13+90	14+40	R	50.00	0.00	4.00	4.00	0.0250	6.00	6.00	0.40	2.40	Seed	3.32	5	0.030	21.21	3.88	1.12	7.98	0.72	5.74
												Jute Mat	3.32	5	0.040	21.27	3.12	1.25	7.97	0.80	6.39
												Temp. Mat	3.32	5	0.040	21.27	3.12	1.25	7.97	0.80	6.39
												Perm, Type 1	3.32	5	0.040	21.27	3.12	1.25	7.97	0.80	6.39
												Perm, Type 1	3.74	10	0.040	21.26	3.22	1.30	8.99	0.84	6.69

CAPACITY OF A GRATE CATCH BASIN IN A SUMP

1102-1
REFERENCE SECTION 1102.3.5

DR-1, Miami Ave.
Sta 14+40 RT
CB-8
Q10(x2)=17.9 CFS
Depth=0.78'

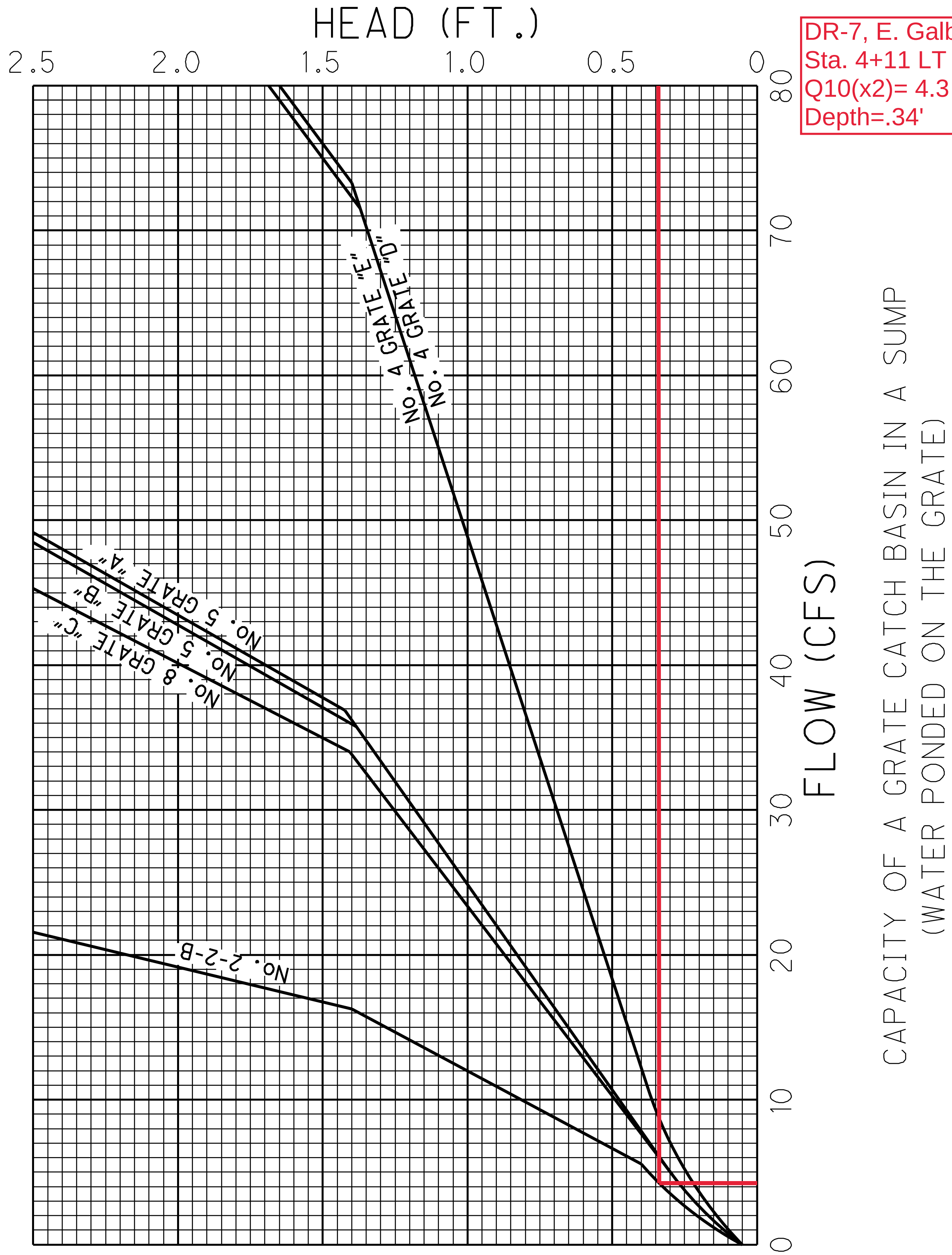


CAPACITY OF A GRATE CATCH BASIN IN A SUMP
(WATER PONDED ON THE GRATE)

CAPACITY OF A GRATE CATCH BASIN IN A SUMP

1102-1
REFERENCE SECTION 1102.3.5

DR-7, E. Galbraith Rd.
Sta. 4+11 LT
Q10(x2)= 4.3 cfs
Depth=.34'

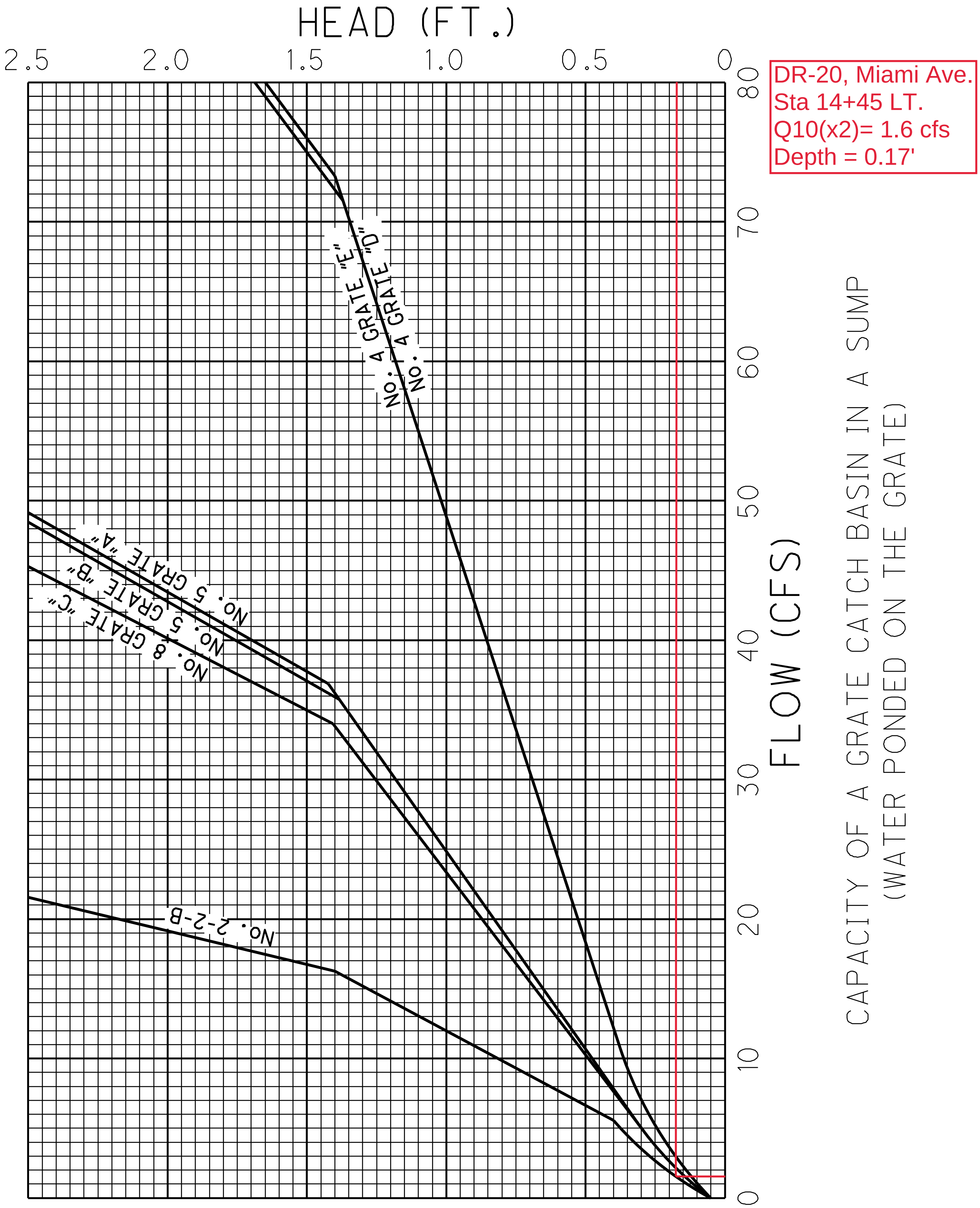


CAPACITY OF A GRATE CATCH BASIN IN A SUMP

1102-1

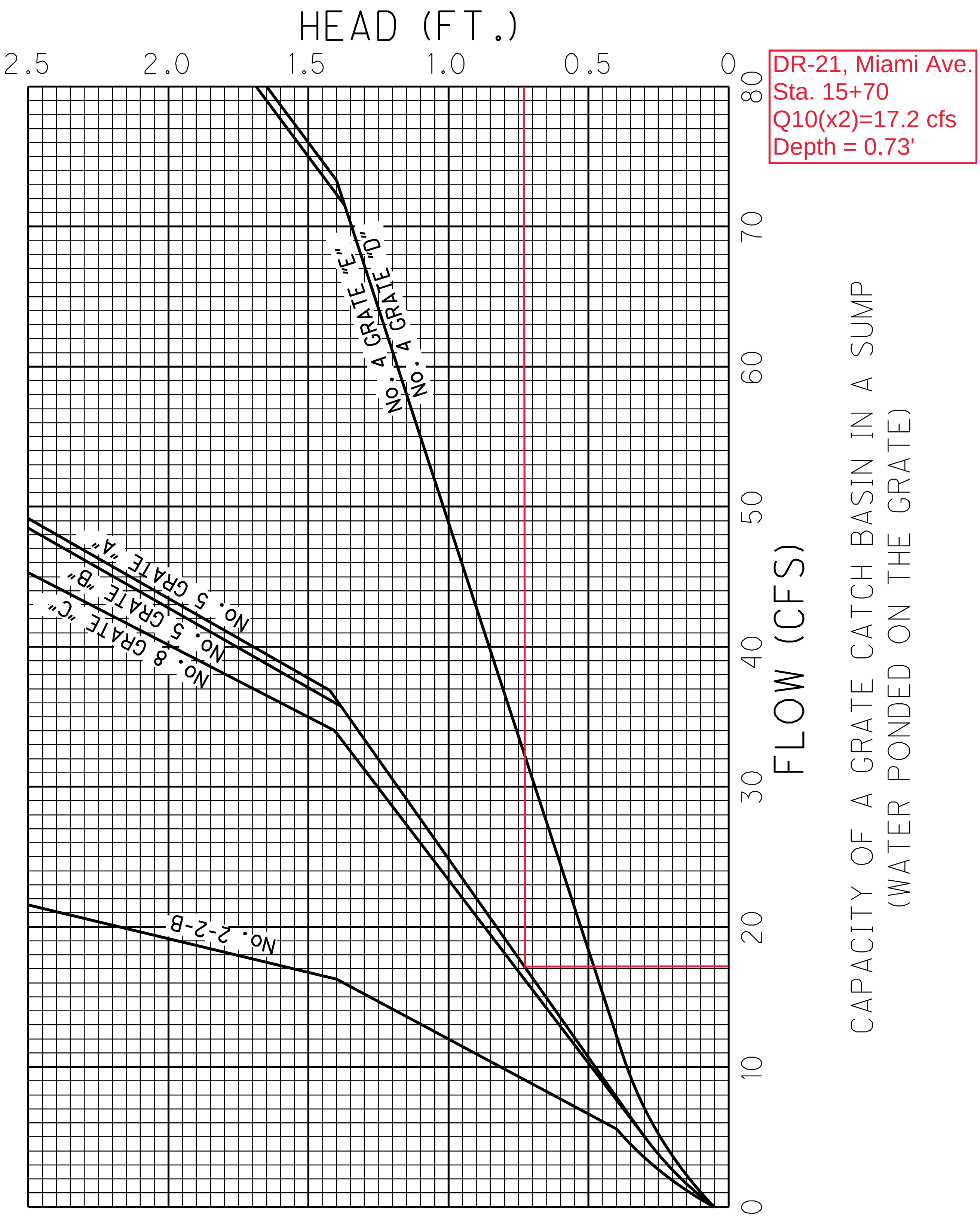
REFERENCE SECTION

1102.3.5



CAPACITY OF A GRATE CATCH BASIN IN A SUMP

1102-1
REFERENCE SECTION 1102.3.5



CAPACITY OF A GRATE CATCH BASIN IN A SUMP
(WATER PONDED ON THE GRATE)

For projects in the watersheds listed in Table 1109-1 and Table 1109-2, provide groundwater recharge calculations, riparian setback mitigation calculations, and temporary sediment basin sizing calculations and locations to OHE with the BMP submittals as outlined in Section 1112.2. Groundwater recharge calculations and riparian setback calculations are based on impacts outside the existing ODOT right-of-way. Determine the riparian setback limits according to Ohio EPA's construction general permit and identify the riparian setback limits on the Project Site Plan.

Determine mitigation for groundwater recharge and riparian setback through coordination between the District and OHE prior to the BMP submittal outlined in Section 1112.2. The District and OHE must coordinate with Ohio EPA as to any mitigation proposals prior to submittal of the NOI application.

Determine soil types required for groundwater recharge calculations using the NRCS Web Soil Survey website.

While sediment basin locations are typically provided by the Contractor, designers of projects being developed in the watersheds listed in Table 1109-1 and Table 1109-2 must identify locations of sediment basins with capacities required for these watersheds. Show the locations and calculations for sediment basins on the Project Site Plan. Additional temporary erosion and sediment control features will be added to the Storm Water Pollution Prevention Plan by the Contractor.

Submit the NOI, Project Site Plan, proposed mitigation and supplemental calculations to the Ohio EPA at least two months prior to plan package submittal to ensure that there are no delays.

1110 Temporary Sediment and Erosion Control

1110.1 General

Provide temporary sediment and erosion control on all projects that have Earth Disturbing Activities. As outlined in SS832, projects fall into four different scenarios associated with temporary sediment and erosion controls.

Scenario A: No EDA, No NOI

Scenario B: EDA > 0, No NOI

Scenario D: NOI required due to contractor

C1110.1

SWPPP requirements are outlined in SS832.

activities

Scenario F: EDA > 0, NOI required

Include SS832 on all projects.

Provide Item 832, Erosion Control, on all projects with EDA (Scenarios B, D, and F).

Provide Item 832, Storm Water Pollution Prevention Plan, Item 832, Storm Water Pollution Prevention Inspections, and Item 832, Storm Water Pollution Prevention Inspection Software, on projects with Project EDA > 0 that require an NOI, Scenario F.

Projects that have potential environmental impacts to habitat, species or with specific local requirements may also be required to submit an NOI and prepare a SWPPP as determined by the District Environmental Coordinator.

1110.2 Cost Estimate for Temporary Sediment and Erosion Control

For all projects that require Item 832, Erosion Control, furnish a dollar amount to be encumbered in the final plan package. Use the Item 832 Erosion Control Estimator spreadsheet to estimate this amount. The dollar amount for Item 832, Erosion Control, is used for both the **quantity** and the **total** fields.

The units for Item 832, Storm Water Pollution Prevention Plan, Item 832, Storm Water Pollution Prevention Inspections, and Item 832, Storm Water Pollution Prevention Inspection Software, are each lump sum.

1111 Post-Construction Storm Water Structural Best Management Practices

1111.1 General

For ODOT projects, submit any proposed alternative post-construction BMP designs that are not found in Section 1113 to OHE. A review and approval of the alternative BMP by OHE and Ohio EPA is required. Local-Let Local Public Agency projects may use an alternative post-construction BMP criterion with Ohio EPA approval.

Locate BMPs so that they are protected in accordance with the LD1.

C1111.1

Post-Construction Storm Water Best Management Practices (BMPs) are provided for long term management of storm water runoff quality and quantity so that a receiving stream’s physical, chemical and biological characteristics are protected, and stream functions are maintained.

Ohio EPA’s construction general permit includes requirements for post-construction BMPs on most projects that meet the disturbance threshold for an NOI. The construction general permit allows roadway projects administered by public entities, such as ODOT, to follow the criteria in this manual as an alternative to the specific post-construction BMP requirements in the permit. Many of the post-construction BMP design criteria in this manual are consistent with Ohio EPA's permit, but some criteria have been tailored to fit linear roadway construction as opposed to standard site development.

Local entities with local post-construction guidance may have more restrictive language regarding selection and use of BMPs as compared to the Department. Storm water discharge from ODOT right-of-way is not subject to local storm water requirements. While the local entity cannot force the Department to use their standards, it may be possible for the Department to incorporate the needs of the local entity subject to review and approval of OHE.

1111.2 Project Thresholds for Post-Construction BMP

Projects that do not require an NOI per Section 1109 do not require post-construction BMPs. Since Routine Maintenance Projects do not require an NOI, they do not require post-construction BMPs. For projects that do require an NOI, the requirement for post-construction BMPs is based on the Project EDA. While the requirement for an NOI is based on Total EDA, the requirement for post-construction BMP treatment is only based on Project EDA (Total EDA – Contractor EDA). Contractor EDA is stabilized after construction to match existing conditions.

The following types of projects do not require post-construction BMPs.

- Project EDA < 1 acre
- Routine Maintenance Projects as defined in Section 1109.2
- Projects including only earth disturbance from utility line, fence, guardrail, or noise wall installation

Provide post-construction BMPs for all projects with Project EDA ≥ 1 acre except those listed above.

For projects requiring post-construction BMPs, evaluate the following items:

- Need for Water Quantity and Quality Treatment vs. only Water Quality Treatment

C1111.2

As described in Section 1109, EDA is defined as any activity that exposes bare ground or an erodible material to storm water as well as anywhere that Item 659, Seeding, or Item 660, Sodding, is being provided. Contractor EDA is generally outside of the ODOT right-of-way and therefore is unable to be addressed by post-construction BMPs.

Projects may have a Total EDA ≥ 1 acre but a Project EDA < 1 acre. For these types of projects, an NOI is required because the Total EDA threshold is met, but a post-construction BMP is not required because the Project EDA threshold is not met.

Projects that include construction activities only associated with utility line, fence, guardrail, or noise wall installation do not require post construction BMPs. These types of projects may require an NOI if the Total EDA threshold is met, but not a post-construction BMP.

(Section 1111.3)

- Project Type – Redevelopment or New Construction (Section 1111.6)
- If New Construction, calculate the Treatment Percent (Section 1111.7)
- Applicable BMP to be implemented (Section 1113)

All projects, including Local Public Agency projects, ODOT-let and Local-Let, are required to provide post-construction BMPs as indicated in this section. Coordinate with the LPA when a project requires post-construction BMPs outside ODOT right-of-way. Inform the LPA of maintenance responsibilities associated with post-construction BMPs.

1111.3 Water Quality and Water Quantity Treatment

Post-construction storm water treatment is divided into two categories: water quality treatment and water quantity treatment. Projects exceeding the minimum thresholds in Section 1111.2 must address water quality and potentially water quantity treatment in the post-construction BMP.

BMPs to address water quantity are not required for projects that meet any of the following criteria:

- Redevelopment projects as defined in Section 1111.6.1.
- New Construction Projects as defined in Section 1111.6.2 where less than 1 acre of new impervious area is created in new permanent right-of-way area being acquired for the project.
- Portions of New Construction Projects, as defined in Section 1111.6.2, which discharge from ODOT right-of-way, directly to a large river or to a lake and where the development area is less than 5 percent of the watershed area upstream of the development site, unless known water quality problems exist in the receiving waters. Only the project areas that drain from ODOT right-of-way to a large river or lake will be excluded from the requirement to provide quantity treatment. If portions of a project discharge to smaller waterbodies, quantity treatment may still be required for those portions.

C1111.3

Water quality treatment is providing for reduction of pollutants from storm water runoff before leaving the site. Water quantity treatment is reducing the volume or peak flow rate of storm water runoff in order to protect the receiving stream's physical characteristics.

If there is a question regarding the stream classification, contact OHE. A map of stream classifications can be found at ODOT's TIMS website. Click the **HUC – Stream Order** tab to view stream layers.

A large river has a drainage area >100 square miles or is fourth order or greater.

ODOT's BMPs are divided into two categories of treatment because Ohio EPA's General Construction Permit (OHC000005) states "Discharge rate is considered to have a negligible impact if the permittee can demonstrate that one of the following three conditions exist:

Ohio Department of Transportation - Office of Hydraulic Engineering

Post-Construction BMP Calculation Spreadsheet

Post Construction - Project Summary

Project Data

		Units
Project EDA	0.986	acres
Is the Project Routine Maintenance per L&D Vol. 2, Sec. 1112.2	No	
BMPs Required?	**BMPs not required**	NA
Ain (New Impervious Area in New Permanent R/W	0	acres
Does Entire Site Drain to Large River (>100 sq. miles)?	No	
Water Quality Treatment Required	**No**	
Water Quantity Treatment Required	**No**	

Treatment Percent and Treatment Requirement

Aix (Project EDA that is inside the existing right-of-way)	0	acres
Ain (New Impervious Area in New Permanent R/W)	0	acres
T% (Treatment Percent)	**#DIV/0!**	**%**
Treatment Requirement	**#DIV/0!**	**acres**

BMPs Provided

BMP Name	BMP Type	Contributing Drainage Area (acres)	Contributing Drainage Area in ODOT R/W (acres)

Treatment Provided

Total Area with ODOT R/W Treated (acres)	**0.00**
Treatment Requirements (acres)	**#DIV/0!**
Treatment Check	**#DIV/0!**

BMP Submittal Requirements (Per L&D, Vol. 2, Sec. 1116.2)

1. Estimated Project Earth Disturbed Area	Yes	**Good**
2. Treatment Percent Calculation	Yes	**Good**
3. BMP Selected for use	Yes	**Good**
4. Drainage area mapping for post-construction BMPs that show the total contributing drainage area and the amount of contributing area within ODOT right-of-way	Yes	**Good**
5. Plan sheets showing locations of post-construction BMP	Yes	**Good**
6. Calculations for each BMP	Yes	**Good**
7. Explanation for any area that is not treated	Yes	**Good**

NOTICE OF INTENT (NOI) ACREAGE CALCULATION FORM	1109-1 Reference Section 1109

		Area (acres)
Project Earth Disturbing Activities		0.99
If the project is a Maintenance Project, an NOI is not required. (See Section 1109)		
Contractor Earth Disturbing Activities		
Field Office per CMS Item 619:		
Enter 0.125 for Type A; 0.25 for Type B; or 1.00 for Type C		0.25
Batch Plant: Yes = 2.0; No = 0		0.00
Off-Project Waste / Borrow Pit:		
Add 1.0 acre per 15,000 CY of waste or borrow		0.05
Miscellaneous Other Off-Project Areas:		
Off-Project staging areas, stock yards, etc.		0.30
Contractor Earth Disturbing Activities	**Subtotal**	**0.60**
Total Earth Disturbing Activities (add Project EDA and Contractor EDA)	**TOTAL**	**1.59**
NOI Earth Disturbing Activities (see below to determine value)	**TOTAL**	**1.59**

Project Earth Disturbing Activities - Enter the area of earth disturbing activities directly related to project activities. Earth disturbing activity is defined as any activity that exposes bare ground or an erodible material to storm water as well as anywhere Item 659 Seeding, or Item 660 Sodding is being furnished.

Contractor Earth Disturbing Activities:

Field Office - These sizes were determined with regard to size of the trailer, parking, and some stock area for equipment and materials based on Item 619 Field Office.

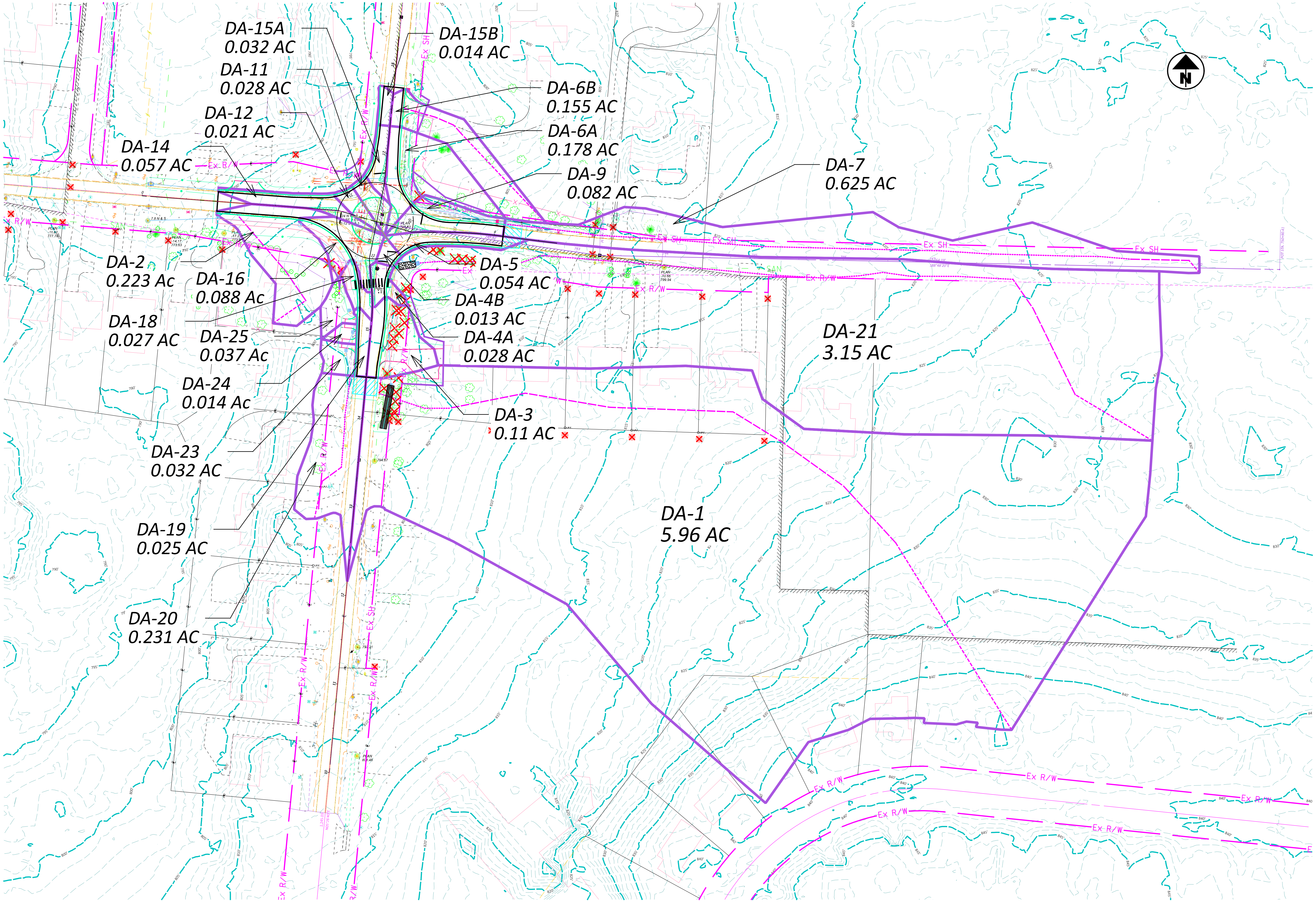
Batch Plant - It is assumed that a typical batch plant would occupy 2 acres of ground. The designer should investigate the location of the project relative to existing plants, facilities, etc. to estimate whether a batch plant might be used by the Contractor. This is not needed for existing plants, it is only for plants set up for the specific project.

Off-Project Waste / Borrow - The specified estimation is based on approximately 10 feet of depth or fill over 1 acre. The designer may choose a different value based on knowledge of the project area, bedrock elevations, previous projects, etc. Consideration should be given for grindings, as well. (10ft. x 43560 s.f. / 27 = 16,133 c.y. ~ 15,000 c.y.)

NOI Earth Disturbing Activities - This is the combined Project and Contractor Earth Disturbed Area. Based on project conditions and activities, some flexibility in the area calculation should be provided to avoid the possibility of the estimated work being less than the actual work. This scenario would require submittal of an NOI for projects originally calculated to be less than one acre during construction.

For projects with EDA less than one acre: No NOI is required.

A Routine Maintenance Project consists of activities that do not change the line, grade, or hydraulic capacity of the existing condition and has less than 5 acres of earth disturbing activities (see section 1109.2).



DRAINAGE AREA MAP

CTY-RTE-SECTION

MODEL: Unnamed Plan - Drainage Area Map [Sheet] PAPERSIZE: 17x11 (in.) DATE: 11/28/2023 TIME: 4:24:03 PM USER: 02676
X:\4012500\200066.01\110947_VAR-STW Safety Design 2020-4\111842_HAM CR101 13.63\400-Engineering\Drainage\Sheets\111842_DP100.dgn

DESIGN AGENCY
Mead & Hunt
CLIENT
THE CITY OF Madeira OHIO

DESIGNER	CRS
REVIEWER	SJS 12-01-23
PROJECT ID	
SUBSET 0	TOTAL 0
SHEET P.0	TOTAL 0