NESTLE PURINA RETAINING WALL DESIGN

HIGH COUNTRY ENGINEERING – CENE 486C – 12/09/22

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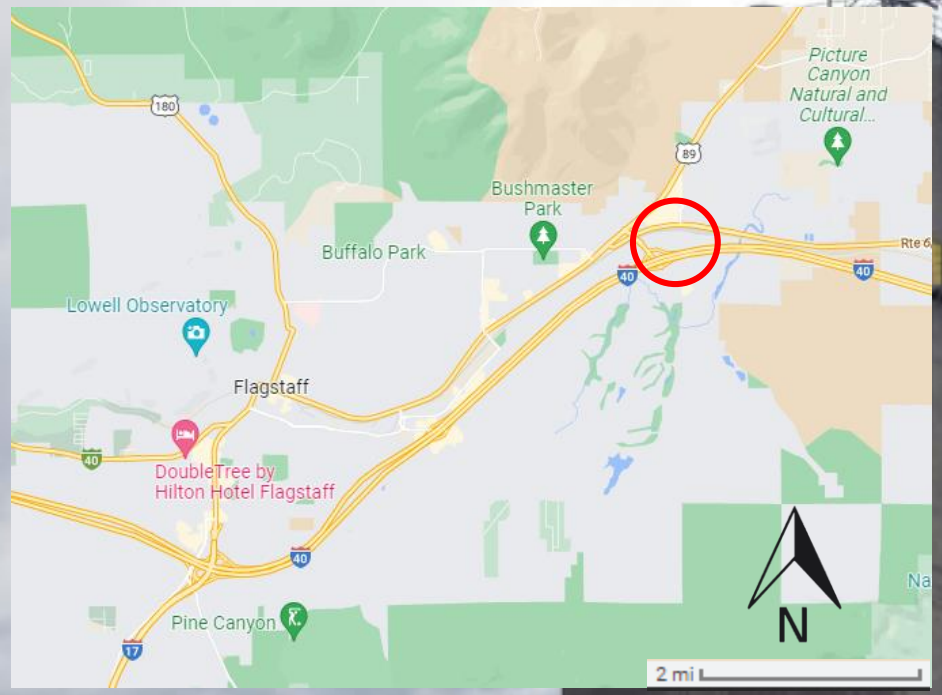


Figure 1: Vicinity Map [3]

Increase of production requires the need for more access to the plant

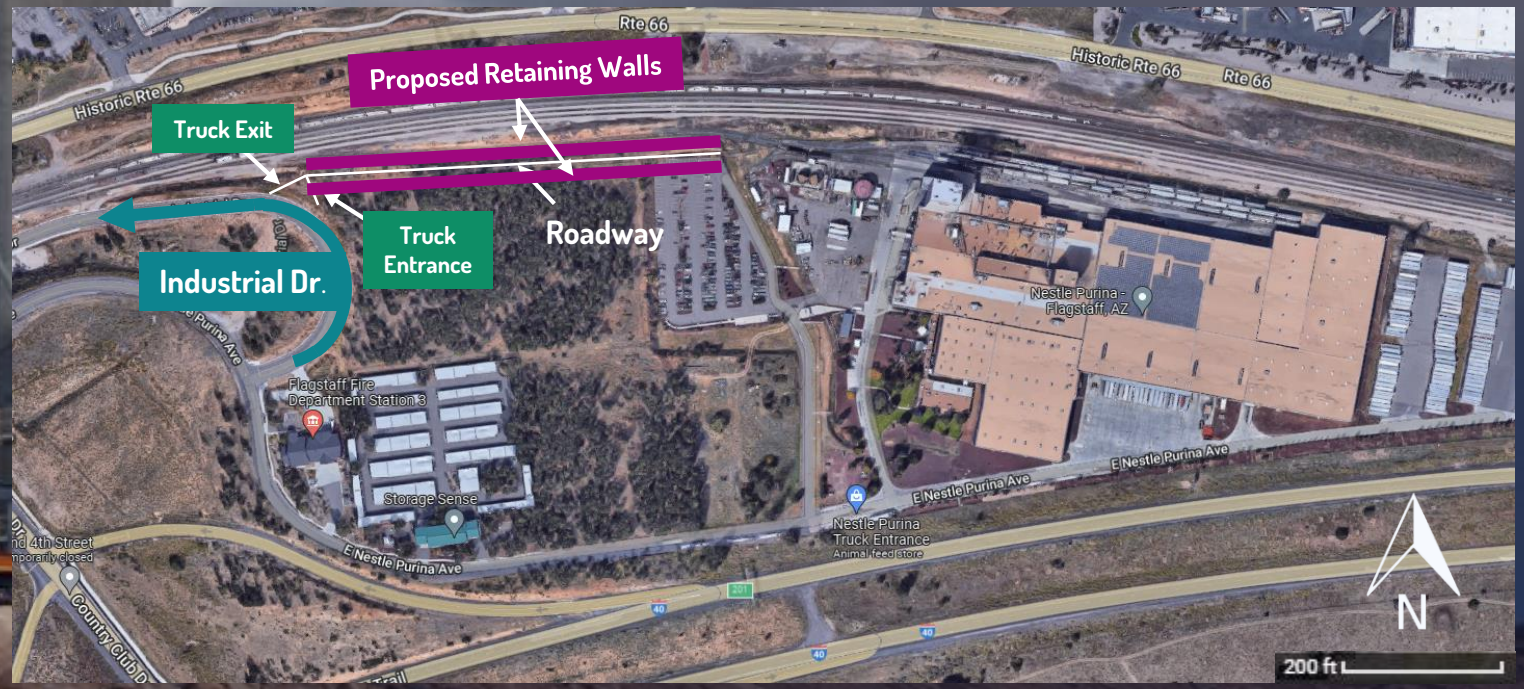


Figure 2: Location Map [3]

Design a Retaining Wall with a 22-foot cut and hydraulic system

View facing toward the South

Figure 3: Satellite/Terrain View of Site

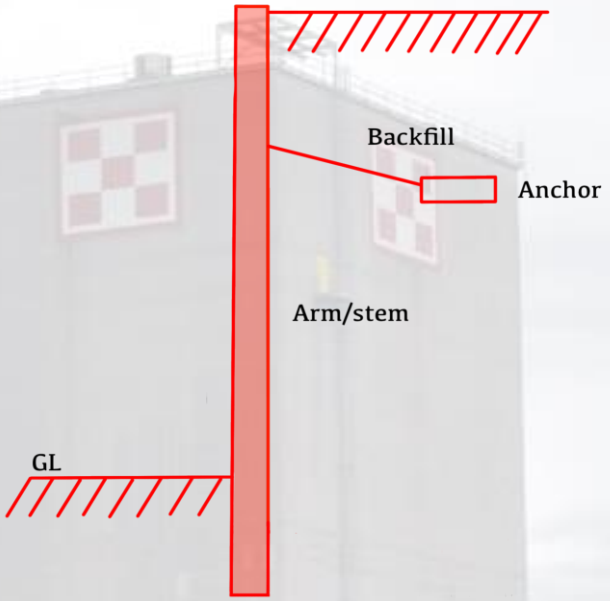
BASICS OF A RETAINING WALL

Figure 3: Satellite/Terrain View of Site

Piling

Pros
Very Strong, Minimal Space.

Cons
Requires Extensive Geotech, Highest Cost



Anchored

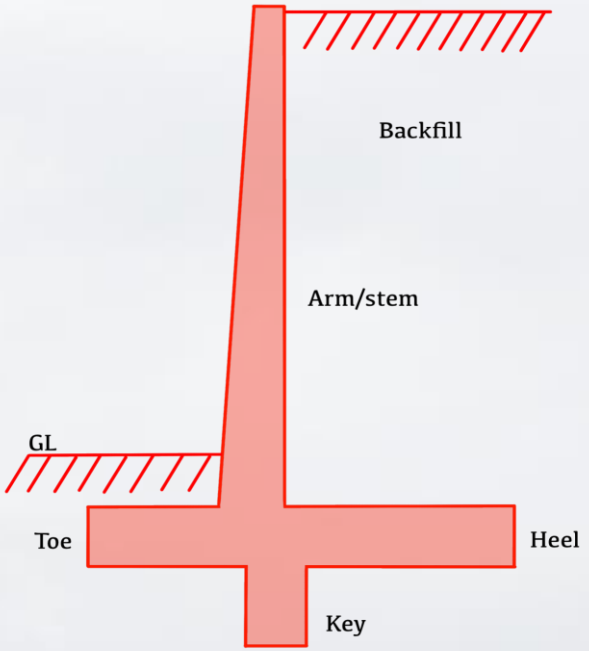
Pros
Lowest Quantity of Concrete

Cons
Requires Specially Licensed Contractors

Gravity

Pros
Simple Design

Cons
Unstable for heights greater than 15 ft.



Cantilever

Pros
Conventional Design, meets all Factors of Safety, can use ADOT Structural Details

Cons
Requires more excavation/materials

CODES AND STANDARDS FOR DESIGN

- Arizona Department of Transportation Manual (ADOT)
- International Building Code (IBC)
- City of Flagstaff Building Code
- ADOT Hydrology Manual

Results:

- ADOT Structural Details-7
  - Case I of retaining walls “Level Fill”
- Safety Factors
  - Overturning FS > 2
  - Sliding FS > 1.5
  - Bearing Capacity FS > 3

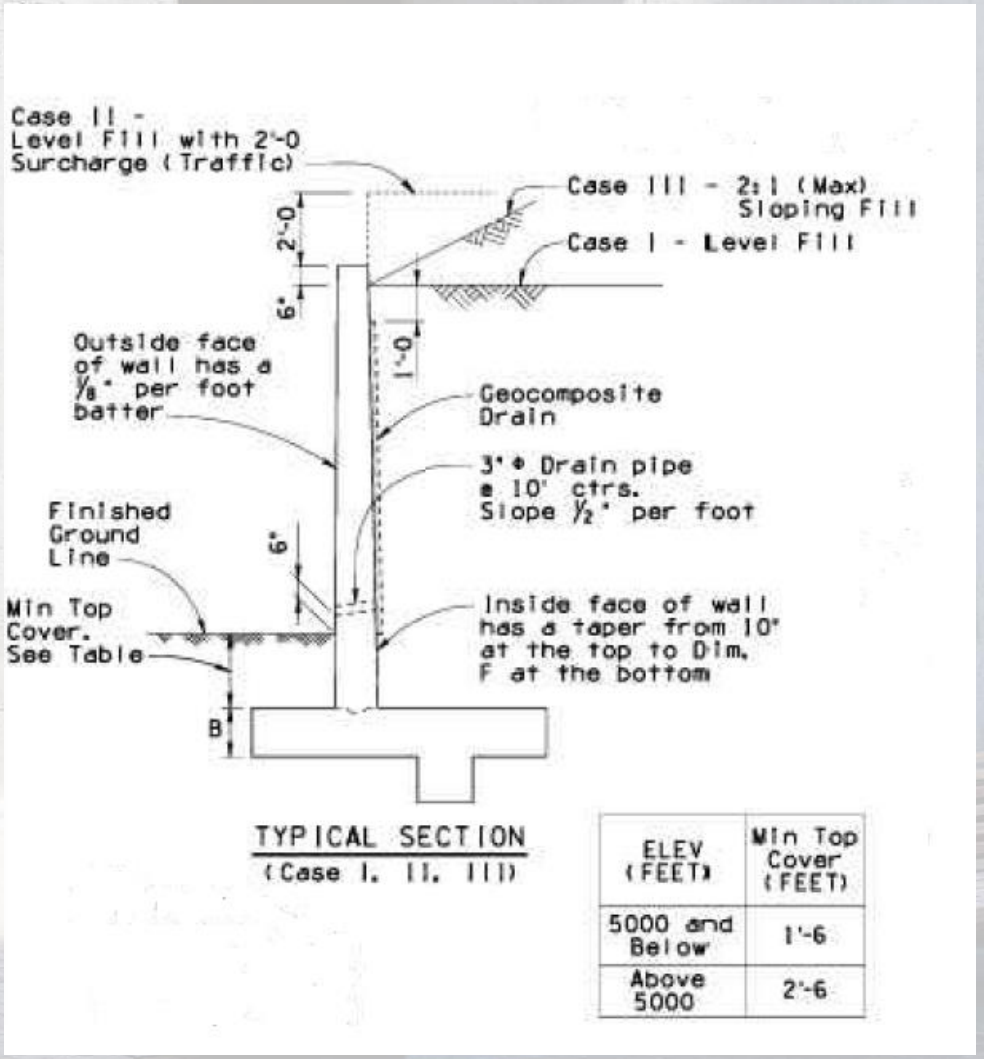


Figure 4: Example of ADOT Retaining Wall

DESIGN AND SELECTION OF PREFERRED ALTERNATIVE

- Retaining Wall Designs
  - Reinforced concrete cantilever - continuous foundation
  - Reinforced concrete cantilever - stepped foundation

Figure 5: Continuous Foundation Diagram

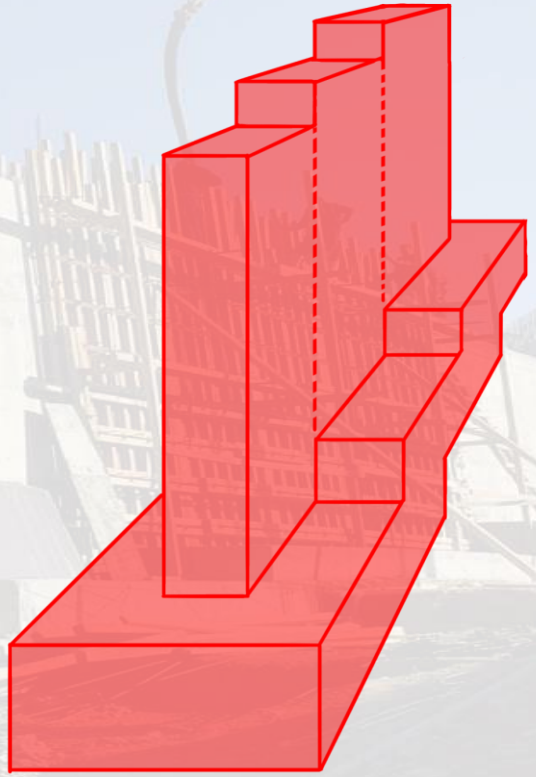


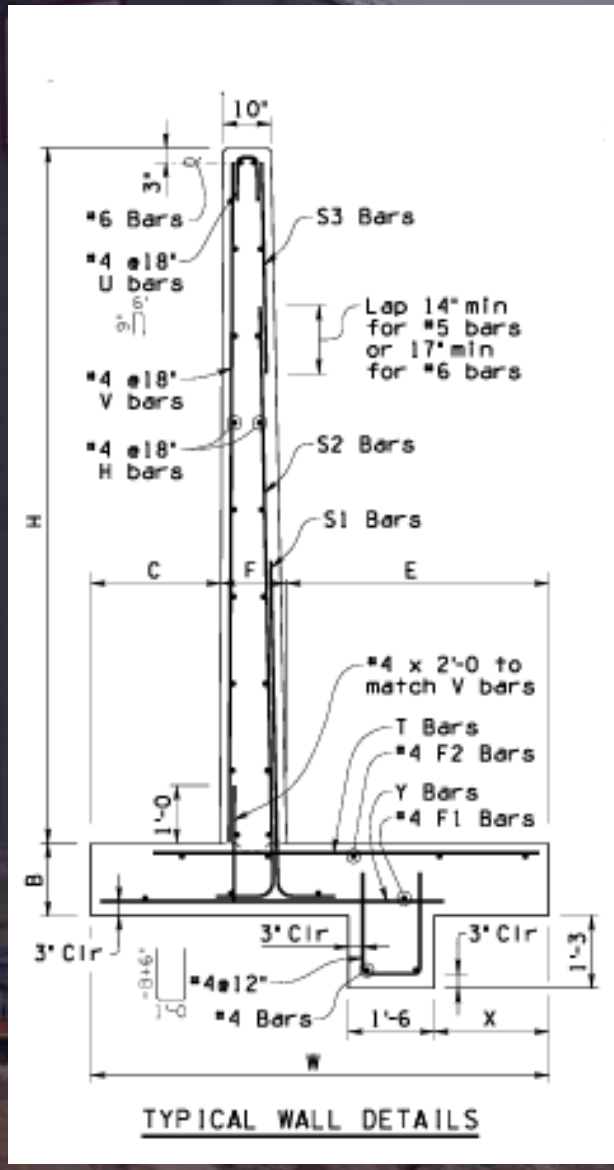
Figure 6: Stepped Foundation Diagram

RETAINING WALL DECISION MATRIX

Alternative 1: Reinforced Concrete Cantilever: Continuous Foundation	
Criteria	Ranking
Strength	2
Materials and Cost	0
Total	2

Alternative 2: Reinforced Concrete Cantilever: Stepped Foundation	
Criteria	Ranking
Strength	1
Materials and Cost	2
Total	3

RETAINING WALL ANALYSIS



Dimensions						
H	W	B	C	F	E	X
4'	3'-0	1'-0	10"	10"	1'-4	8"
5'	3'-6	1'-0	1'-0	10"	1'-8	9"
6'	4'-0	1'-0	1'-2	10"	2'-0	10"
7'	4'-6	1'-0	1'-4	10"	2'-4	11"
8'	5'-0	1'-2	1'-6	10"	2'-8	1'-0
9'	5'-6	1'-2	1'-9	1'-0	2'-9	1'-2
10'	6'-0	1'-2	1'-9	1'-0	3'-3	1'-4
11'	6'-6	1'-2	2'-0	1'-0	3'-6	1'-6
12'	7'-0	1'-3	2'-0	1'-0	4'-0	1'-8
13'	7'-6	1'-3	2'-3	1'-0	4'-3	1'-10
14'	8'-0	1'-3	2'-3	1'-2	4'-7	2'-0
15'	8'-6	1'-3	2'-6	1'-3	4'-9	2'-2
16'	9'-0	1'-4	2'-6	1'-4	5'-2	2'-4
17'	9'-6	1'-4	2'-9	1'-5	5'-4	2'-6
18'	10'-0	1'-5	2'-9	1'-6	5'-9	2'-8
19'	10'-6	1'-6	3'-0	1'-7	5'-11	2'-10
20'	11'-0	1'-6	3'-0	1'-8	6'-4	3'-0
21'	11'-6	1'-7	3'-3	1'-9	6'-6	3'-2
22'	12'-0	1'-8	3'-3	1'-10	6'-11	3'-4
23'	12'-6	1'-9	3'-6	2'-0	7'-0	3'-6
24'	13'-0	1'-10	3'-6	2'-2	7'-4	3'-8
25'	13'-6	2'-0	3'-9	2'-4	7'-5	3'-10
26'	14'-0	2'-3	3'-9	2'-6	7'-9	4'-0
27'	14'-6	2'-6	4'-0	2'-8	7'-10	4'-2
28'	15'-0	2'-9	4'-0	2'-10	8'-2	4'-4
29'	15'-6	3'-0	4'-3	3'-0	8'-3	4'-6
30'	16'-0	3'-3	4'-3	3'-2	8'-7	4'-8

Figure 7: ADOT Typical Retaining Wall with Varying Dimensions [1]

RETAINING WALL ANALYSIS

- Safety Factors
  - Overturning FS > 2
  - Sliding FS > 1.5
  - Bearing Capacity FS > 3

$$FS_{overturning} = \frac{\Sigma M_R}{\Sigma M_o}$$

$$FS_{sliding} = \frac{\Sigma F_y + Bc'_s + P_p}{P_a}$$

$$FS_{Bearing\ Capacity} = \frac{q_u}{q_{max}}$$

	10-ft Walls	12-ft Walls	13-ft Walls	14-ft Walls	15-ft Walls	17-ft Walls	21-ft Walls
FS Overturning	**3.05**	**2.85**	**2.73**	**2.64**	**2.56**	**2.67**	**2.30**
FS Sliding	**2.62**	**2.17**	**1.99**	**1.85**	**1.71**	**1.65**	**1.51**
FS Bearing Capacity	**7.24**	**6.2**	**5.87**	**5.47**	**5.37**	**4.72**	**3.91**

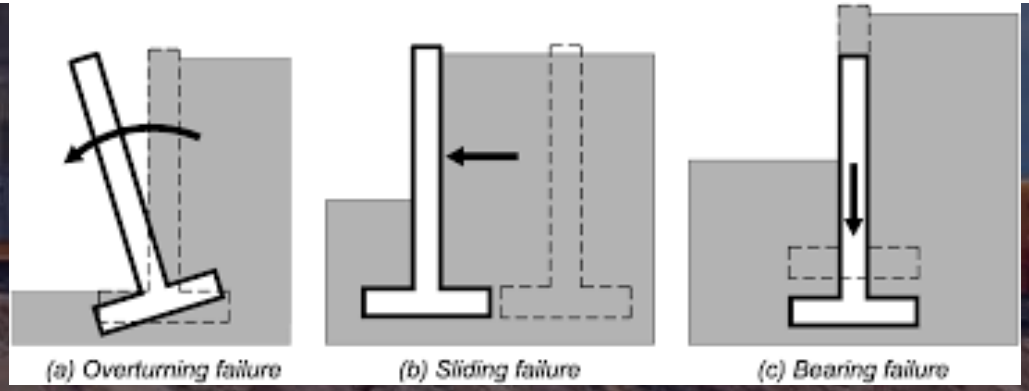


Figure 8: RW Failure Calculations

RETAINING WALL ANALYSIS

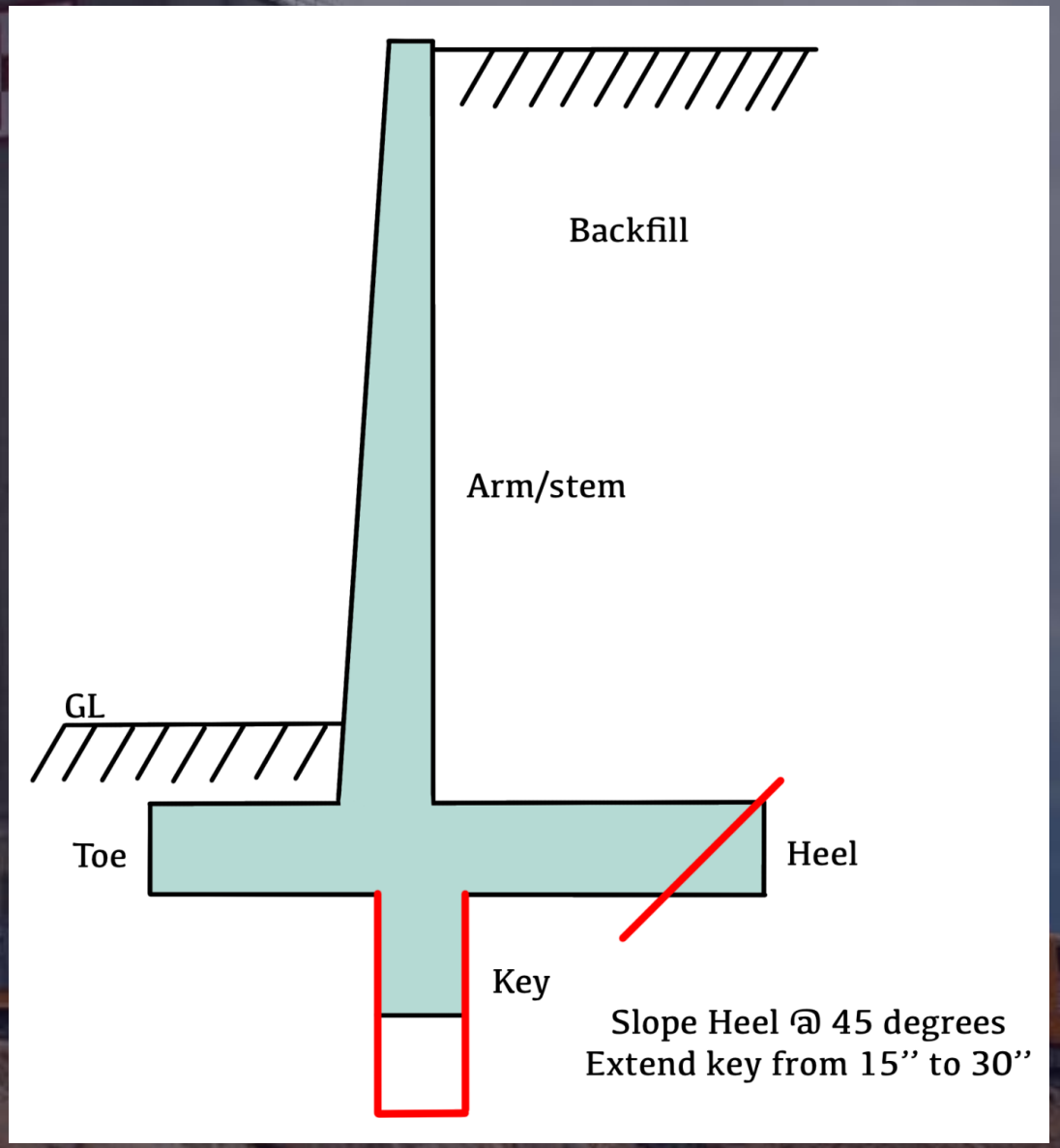


Figure 9: RW Failure Calculations

HYDROLOGIC/HYDRAULICS

Figure 10: Underground Water Storage

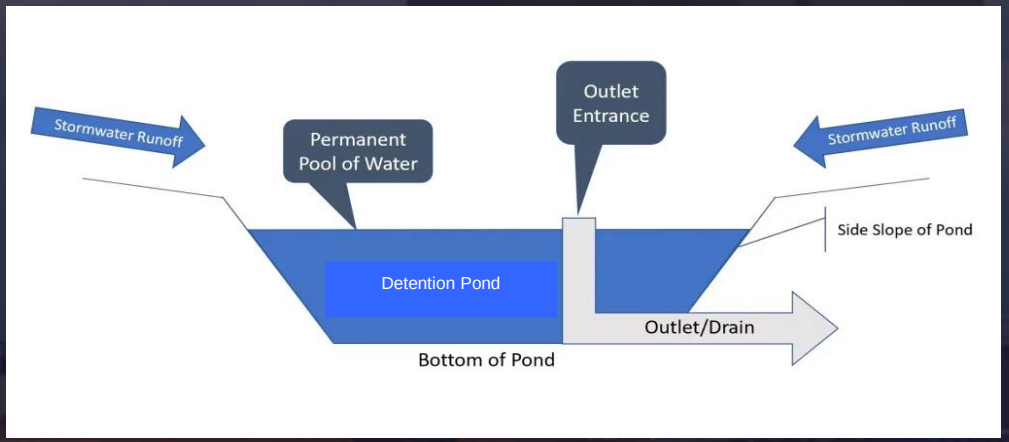


Figure 11: Detention Pond

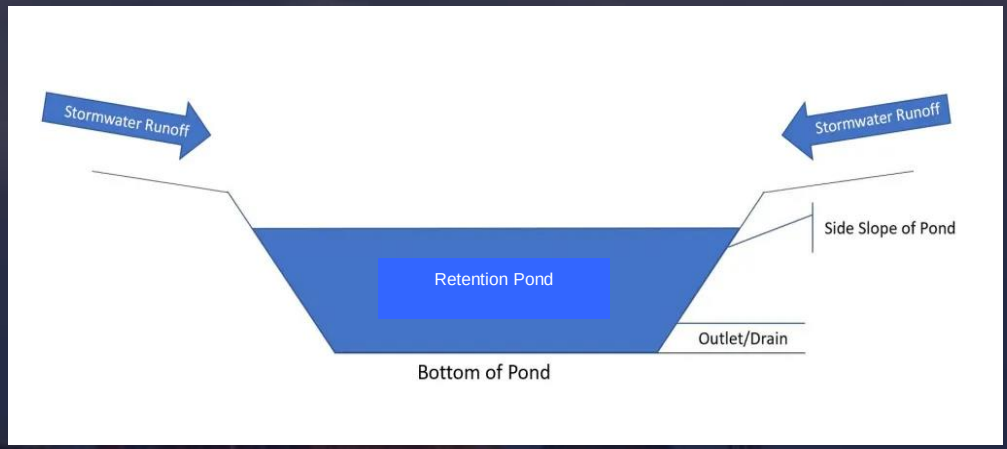


Figure 12: Retention Pond

HYDROLOGIC/HYDRAULICS DECISION MATRIX

Alternative 1: Detention Pond		Alternative 2: Retention Pond		Alternative 3: Underground Storage	
Criteria	Ranking	Criteria	Ranking	Criteria	Ranking
Space Required	1	Space Required	0	Space Required	2
Materials and Cost	1	Materials and Cost	1	Materials and Cost	0
Construction Timeline	1	Construction Timeline	2	Construction Timeline	0
Health Concerns	0	Health Concerns	0	Health Concerns	2
Total	3	Total	3	Total	4

TOPOGRAPHIC MAP/SITE PLAN

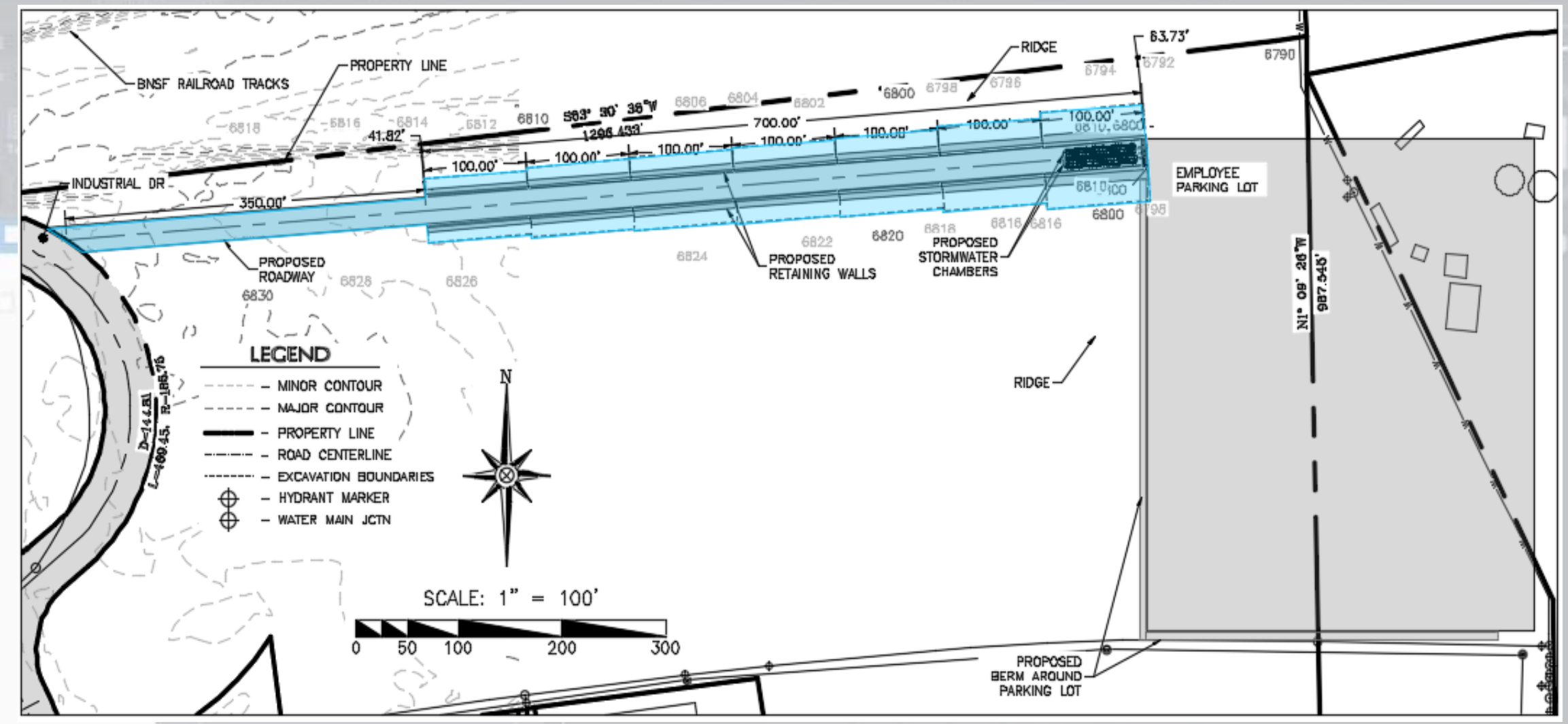


Figure 13: Topographic Map/Site Plan

HYDROLOGIC/HYDRAULIC ANALYSIS

100-YR Storm Rational Method Data

Tc = 10 minutes

	C	i (in/hr)	A (acres)	Q (cfs)
Impervious	0.95	7.09	0.762	**5.13**
Pervious	0.54	7.09	0.618	**2.37**

Required Storage = 4500 CF

Recommended Volume (133%) Required Volume = **6000 CF**

Component	Volume (CF)
Chamber with 15" Crushed Stone Base	279.3
End Cap with 15" Crushed Stone Base	121.9

Using **20** Stormtech MC-7200 Chambers and **4** End Caps, with 15" crushed stone base Satisfies the Recommended Volume

Figure 14: Hydrologic/Hydraulic Calculations

RETAINING WALL CONSTRUCTION PLAN

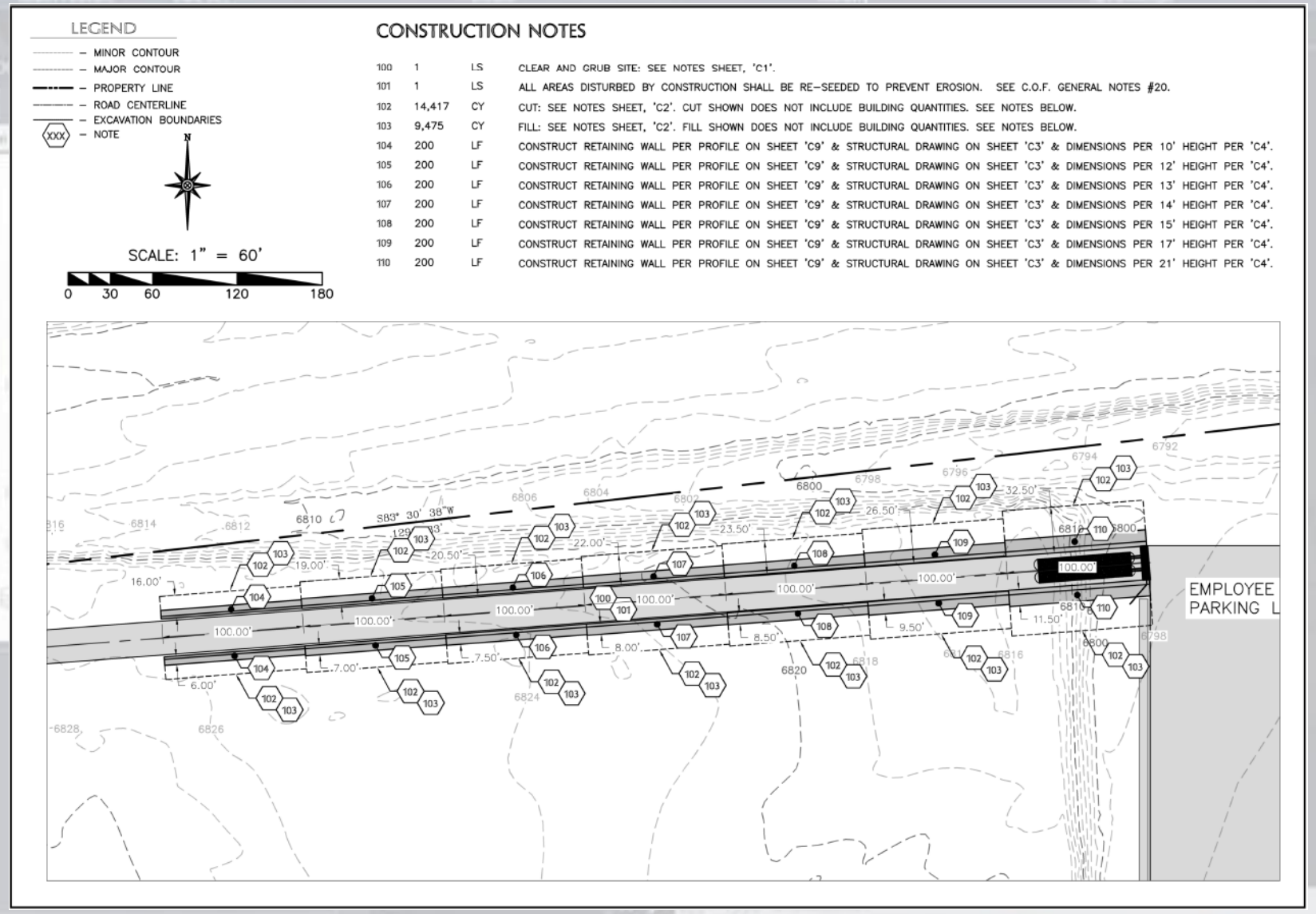


Figure 15: Retaining Wall Construction Plan

HYDRAULIC CONSTRUCTION PLAN

LEGEND

- MINOR CONTOUR
- MAJOR CONTOUR
- PROPERTY LINE
- ROAD CENTERLINE
- EXCAVATION BOUNDARIES
- NOTE

SCALE: 1" = 10'

0 5 10 20 30

CONSTRUCTION NOTES

200	1	EA	24' WIDE X 3' LONG X 5' DEEP CUSTOM CATCH BASIN
	1	EA	12" TRASH WEIR TO PREVENT DEBRIS FROM ENTERING DISPOSAL. OWNER MUST CONTRACT WITH A CERTIFIED TRASH PUMPER FOR TRASH REMOVAL AS NEEDED.
201	2	EA	18" STUB PIPES TO DISPOSAL
202	1	EA	8" BYPASS PIPE 24" ABOVE BOTTOM OF CATCH BASIN
203	20	EA	ADS STORMTECH MC-7200 UNDERGROUND STORMWATER CHAMBERS
	1	LS	CONSTRUCT CHAMBERS PER PROFILE ON SHEET 'C9' & DETAIL DRAWINGS ON SHEET 'C5' & 'C6'.
204	4	EA	ADS STORMTECH MC-7200 UNDERGROUND STORMWATER END CAPS
205	383	CY	CLEAN CRUSHED STONE SUCH AS PAVEMENT SUBBASE UNDER, SURROUNDING AND ABOVE CHAMBERS. SEE DETAILS ON SHEET 'C5'.
206	762	LF	CONSTRUCT BERM PER DETAIL 'B' ON SHEET 'C2'.

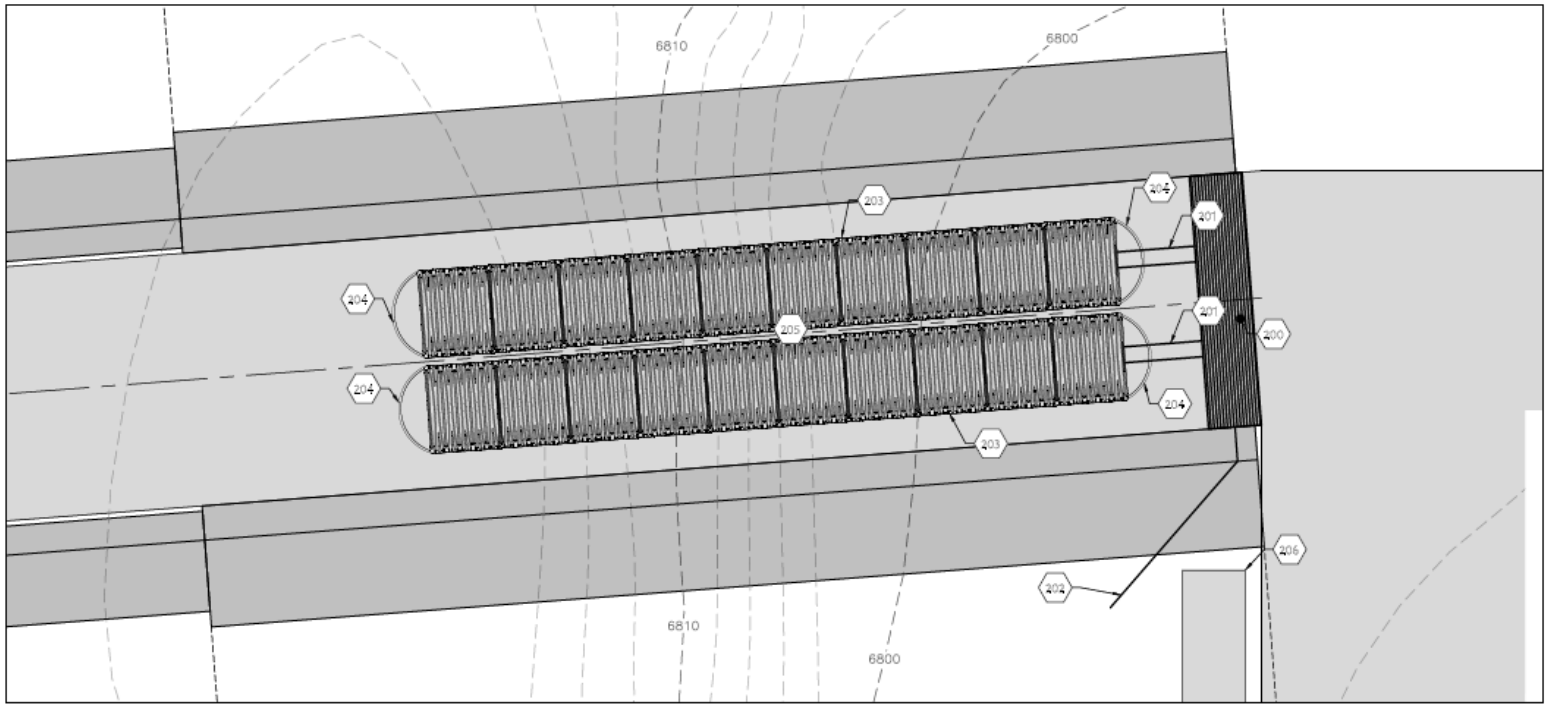


Figure 16: Hydraulic Construction Plan

PROFILE VIEW

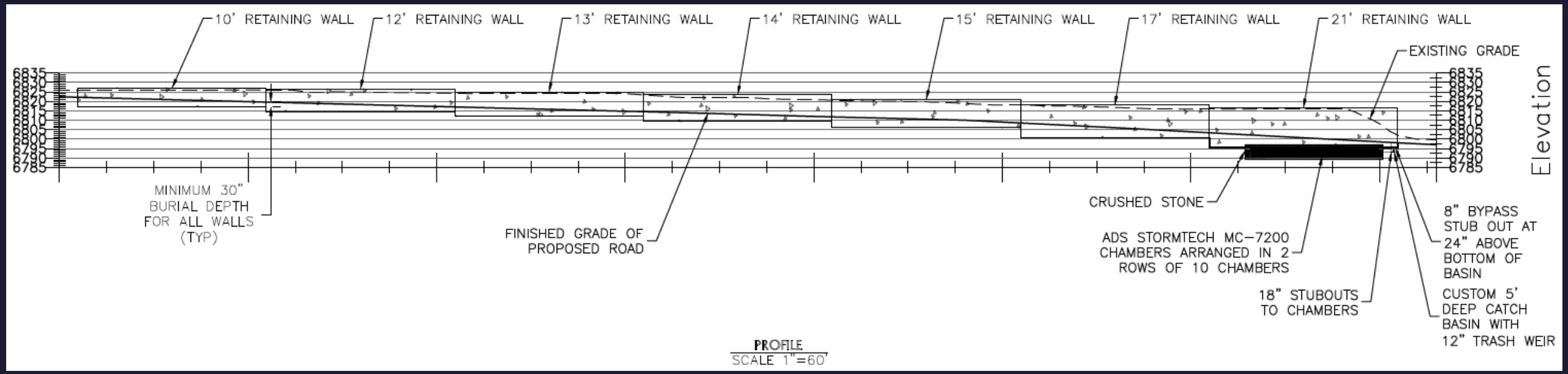


Figure 17: Profile View

COST TO CONSTRUCT

Retaining Wall					
Item Number	Item Description	Unit	Estimated Quantities	Unit Price ($)	Total ($)
1	Mobilization & Administration	LS	1	66,410	66,410
2	Remove and Dispose of Tree > 12” Diameter	Tree	100	500	50,000
3	Excavation	CY	14,417	165	2,378,805
4	Subgrade Stabilization	SY	4,900	20	98,000
5	Curb and Gutter	LF	1,400	20	28,000
6	Asphalt Pavement	SY	3,600	40	144,000
7	Retaining Wall	CY	3,450	1000	3,450,000
8	Catch Basin	LS	1	10,000	10,000
9	Storm Drainpipe	LF	20	150	3,000
10	StormTech MC-7200 Chambers	EA	20	915	18,300
11	StormTech MC-7200 End Caps	EA	4	180	720
12	Stone Fill around Chambers	CY	383	150	57,450
13	Retaining Wall Backfill	CY	9,475	165	1,563,375
Total					7,868,060

Figure 18: Construction Cost Analysis

IMPACTS

Economic

Positive – increase traffic efficiency
Positive – increase Nestle Purina revenue
Negative – Substantial capital cost with construction (underground storage)

Environmental

Positive – prevents soil erosion by supporting the surrounding soils
Positive – proper drainage for the deep cut the road requires
Positive – prevents contaminated water seepage and pooling water/flash flooding
Negative – large amount of concrete
Negative – disrupting native land

Social

Positive – create more jobs during construction
Positive – employees have easier access to workplace, less time wasted in traffic at plant
Negative – traffic delays during construction

REFERENCES

[1] Arizona Department of Transportation, "Infrastructure Delivery and Operations Division - Bridge Group Standard Drawing - "Retaining Wall Reinforced Concrete Cantilever, Drawing No. SD 7.01" Structural Details-7 Retaining Walls, Dec. 2021. [Online] [Accessed: 10-Aug.-2022].

[2] FLAGSTAFF CITY CODE, TITLE 4, BUILDING REGULATIONS

[3] Google Maps - Nestle Purina Location

[4] International Building Code (IBC)

[5] Mesquite Engineering, Final Proposal

[6] Fbn, "Why employees love working for Nestlé Purina," Flagstaff Business News, 03-Jan-2018. [Online]. Available: https://www.flagstaffbusinessnews.com/employees-love-working-nestle-purina/. [Accessed: 22-Feb-2022]. (Background Title Image)

[7] Wikipedia - Retaining Wall (Typical Retaining Walls Image)

[8] HMH Group, "Concrete Retaining Wall", 2015, https://hmhgroup.co/portfolio/concrete-retaining-wall/

[9] Streams and Urbanization - Scientific Figure on ResearchGate. Available from: https://www.researchgate.net/figure/a-A-detention-pond-designed-to-capture-and-temporarily-store-runoff-from-the-adjacent_fig7_226149021 [accessed 25 Oct, 2022]

THANK YOU!
ANY QUESTIONS?