From: High Country Engineering

Date: December 13, 2022

Subject: Purina Facility Entrance Retaining Wall Design Report

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Dr. Bero

Included in this document is the Final Report of High-Country Engineering's retaining wall and underground storage project within the Nestle Purina Facility in Flagstaff, Arizona.

For any further questions, please feel free to contact me, Tiffany McCremens, by email tdm284@nau.edu

Very Respectfully,
Tiffany May McCremens
Project Engineer
High Country Engineering

NESTLE PURINA RETAINING WALL

High Country Engineering

DECEMBER 1, 2022

TATTWANKSHI KANOJIYA, TIFFANY MCCREMENS, TYLER DERZAY
tsk57@nau.edu, tdm284@nau.edu, tld332@nau.edu

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This project would also not have been possible without the help of the Spring 2022 Capstone team Mesquite Engineering, and Civil Design and Engineering Inc. of Flagstaff, AZ for providing documents and information needed for location and retaining wall data.

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List of Abbreviations

ACI - American Concrete Institute

ADOT – Arizona Department of Transportation

BNSF - Burlington Northern Santa Fe Railway

CoF - City of Flagstaff

CD&E – Civil Design & Engineering, Inc.

EIT – Engineer in Training

HCE – High Country Engineering

IBC – International Building Code

RW – Retaining Wall

1.0 Project Introduction

High Country Engineering was tasked with designing a retaining wall for Flagstaff's Nestle Purina Pet Food Plant. Due to production increases at the facility, an increasing number of trucks require access to the plant. In Fall 2021, the Capstone team Mesquite Engineering designed a new facility access road for trucks to efficiently enter and exit the premises. The implementation of this road requires a reinforced retaining wall up to 21 feet to stabilize the road.

1.1 Project Background

The Nestle Purina Facility is in East Flagstaff, Arizona, off Country Club Dr. Specifically, the site is located at 4700 E Nestle Purina Ave, Flagstaff, AZ 86004, occupying APN 113-37-004B, 004D, and 113-28-004F. Figure 1.1 shows the project location relative to the City of Flagstaff, and shows the major highways that connect to the area, Interstate 17, and Interstate 40.

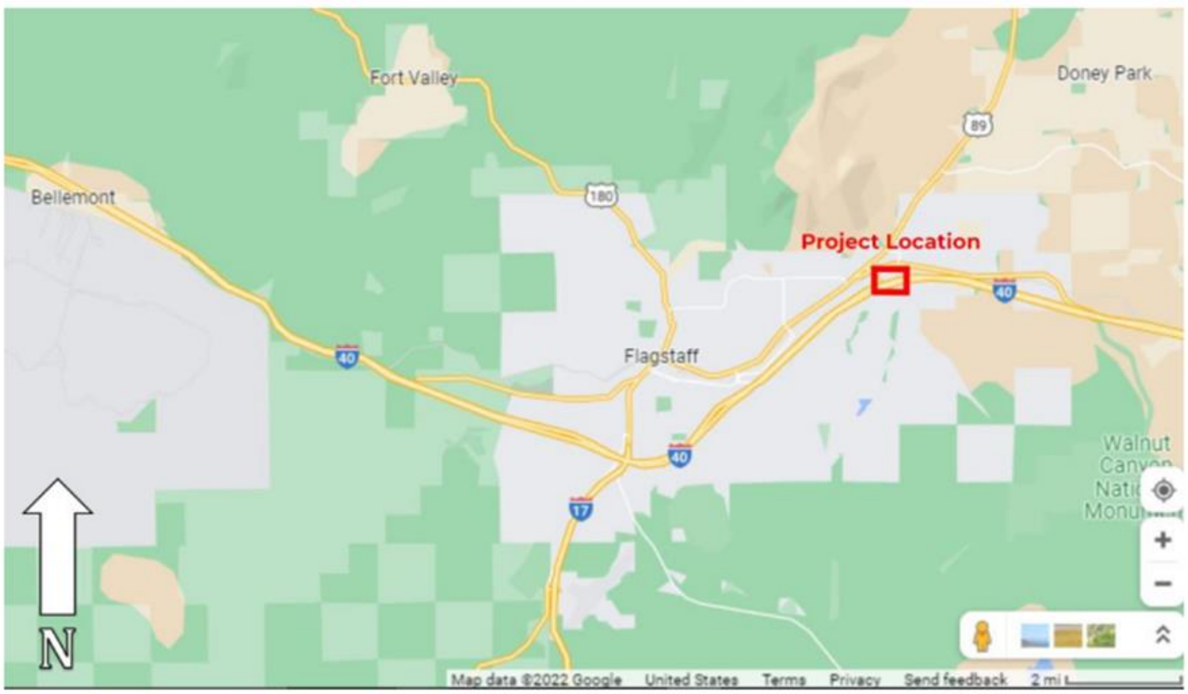

Figure 1.1: Vicinity of Project Location

Figure 1.2 describes the Nestle Purina facility, it is outlined in red.

Figure 1.2: Nestle Purina Facility

Figure 1.3 details the proposed new truck entrance from Industrial Drive, near the intersection of Industrial Drive and East Nestle Purina Avenue, the proposed retaining wall is highlighted in red.

Figure 1.3: Location of Proposed Retaining Wall [10]

Figure 1.4 shows a satellite/terrain image of the area where the proposed road/retaining wall will be built. In this image, the viewer is looking south from above the BNSF's railroad tracks to the north of the site. A ridge lining the parking lot and running parallel to the property boundary can clearly be seen in this figure.

Figure 1.4: Satellite/Terrain View of Proposed Site [10]

Nestle Purina is a secured site and High-Country Engineering was not given permission to conduct a site investigation. Thus, the topographic information was obtained from Civil Design & Engineering Inc. (CD&E Inc.). CD&E obtained this from City of Flagstaff 2-foot Contour GIS Data. High Country Engineering also used the City of Flagstaff's aerial LiDAR 2-foot contour lines from the Coconino County GIS Parcel Viewer to obtain topographic information of the project area [3,5]. Geotechnical Data was from Mesquite Engineering's soil classification obtained from the United States Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS) Web Soil Survey, and from conducting sieve analyses when granted access to the facility in the Fall of 2021.

2.0 Research and Data Collection

This section details information obtained at the outset of the project.

2.1 Codes and Standards

High Country Engineering investigated the codes and standards set by the Arizona Department of Transportation Manual (ADOT). Specifically, "Structural Details 7: Retaining Wall" included detailed information on the design, construction, and elevation parameters for the project [1]. ADOT Structural Detail 7 provided 4 different types of cases to design the retaining wall. Figure 2.1 below comes from the plan sheet that shows the typical cross section of a cantilever retaining wall. The four "cases" are described below.

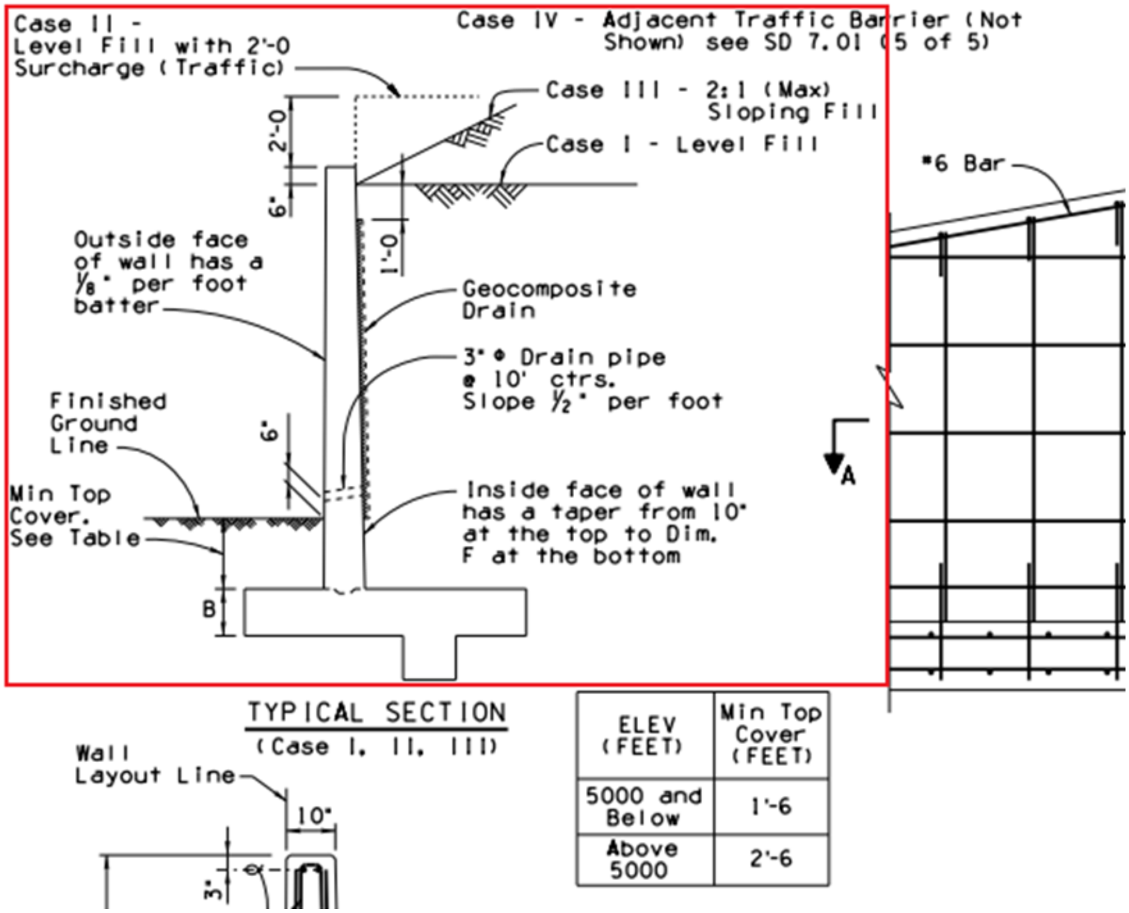

Figure 2.1: Typical RW Cross-Section (ADOT Structural 7 - Case I, II, II) [1]

Case I is termed "Level Fill" and is used only when backfill soil is brought level to the top of the retaining wall and there is no sloping backfill [1]. This case is appropriate for this project. Case II is termed "Level Fill with 2'-0" Surcharge (Traffic)" adds an additional 2-foot layer of surcharge above a level backfill, the surcharge being additional soil. This surcharge adds lateral earth pressure to the wall that can either be dead loads (gravity) or live loads (vehicles) [2]. Since the Purina retaining wall is designed to retain soils up to existing grade, and no traffic loads will be applied to the backfill soil, Case II does not apply. Case III is termed "2:1 (Max) Sloping Fill" and is used when the height of the wall is lower than existing grade and the backfill soil would create an angular pressure on the back of the wall [1]. Since the area behind the wall will be equal to the height of the wall, Case III does not apply.

Figure 2.2 below shows Case IV, termed "Adjacent Traffic Barrier" that adds an additional traffic barrier that is adjacent to the retaining wall. It focuses on guiding vehicles through the roadway and prevent collisions. This case does not apply to this project.

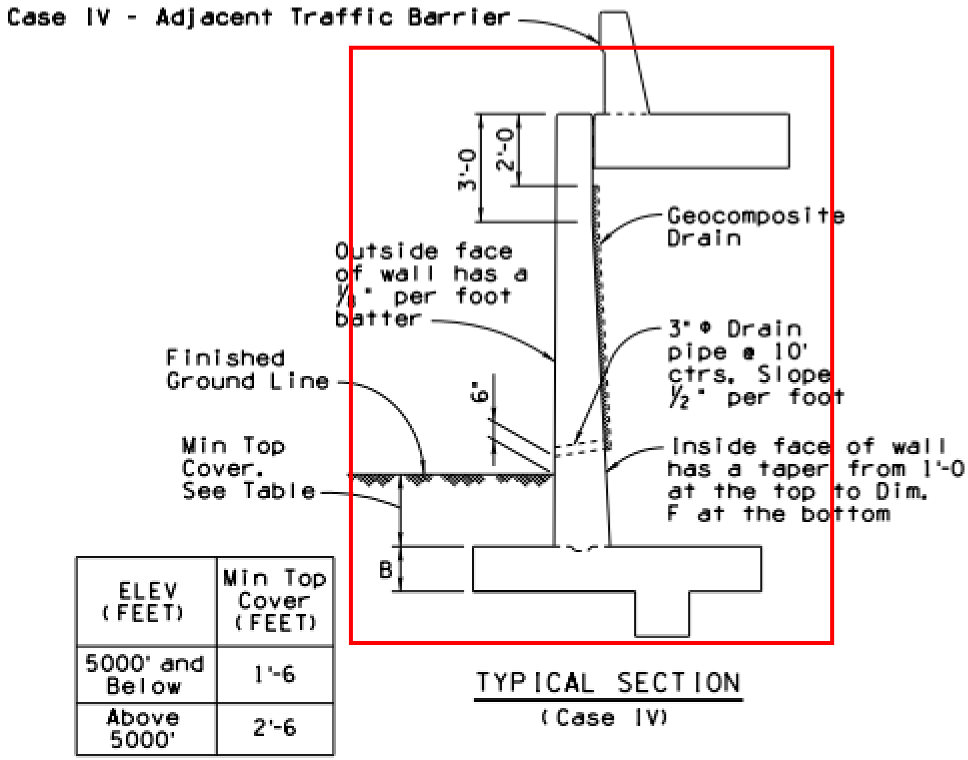

Figure 2.2: Typical RW Cross-Section ADOT Structural 7 (Case IV) [1]

The American Concrete Institute (ACI) provided information for retaining walls designed utilizing reinforced concrete. Chapter 11 of ACI-318 contained details on structural concrete materials, design, and detailing requirements that must be followed for the retaining wall (e.g., load distribution, design limits, required strength, and reinforcement details/limits) [6]. Chapter 13 detailed the concrete and reinforcement requirements for foundations. Section 13.3: Shallow Foundations was appropriate for the project as the maximum depth of excavation proposed to be approximately 21 feet. According to the ACI, the "[the] minimum base area of foundation shall be proportioned to not exceed the permissible bearing pressure when subjected to forces and moments applied to the foundation" [6]. The specific equations and codes are further addressed in the design and analysis of the preferred alternative selection (Section 5.0).

The International Building Code (IBC) provided similar design standards as the ACI but contained sections that specifically discussed concrete retaining/foundation walls. Section 18.07 contained structural and geotechnical design parameters for retaining walls: "[RW's] shall be designed to ensure stability against overturning, sliding, excessive foundation pressure and water uplift" [4]. As mentioned above, the specific equations and codes are further addressed in the design and analysis of the preferred alternative selection (Section 5.0).

The City of Flagstaff Building Code mandates retaining walls shall be used to stabilize earth more than four (4) feet in height [2]. City of Flagstaff also requires all retaining walls more than five (5) feet shall be terraced in increments of 5 feet vertical and 3 feet horizontal. Since the northern retaining wall location is close to a shared boundary with BNSF Railroad, this design would likely encroach into mandatory building setbacks from the property line or would simply cross the property line. Crossing into an adjacent property or building in the mandated setbacks is not permitted and therefore a terraced retaining wall design cannot be considered. Hence, the structural details provided by ADOT were the primary source for standards. Other ADOT Manuals such as the Pavement Design and Drainage may be considered for the project as a hydraulic structure shall be built to manage the excess runoff from the proposed roadway due to the retaining wall. Additional standards/information are addressed in the Post-Development Hydraulic and Hydrologic Analyses (Section 5.2).

2.2 Retaining Wall Design Research

Retaining wall design parameters were researched to inform future design decisions. Details included types of retaining walls and foundations, materials, costs, failure modes, reinforcement, computations of forces, safety factors, and hydraulic considerations in design. Due to the large scale and excavation depth of the retaining wall, the types of walls were limited to gravity, cantilever, piling, and anchored.

The three pertinent features of a retaining wall: stem (vertical member holding the backfilled dirt), toe (portion of the footing located at the front of the wall), and heel (footing located at the backfill side) [7]. These features are prevalent in all types of retaining walls. Ultimately, the stem is the actual wall, and the heel and toe are necessary to the ensure the equilibrium of the retaining wall by counterbalancing the rotation of the wall due to soil pressure at the back of the wall. The failure of these parts can result to the wall sliding across its base and overturning due to the unbalanced forces (lateral forces pushing against the wall). These failures will be discussed in the design and analysis portion (Section 5.0).

Three critical factors that must be analyzed for all types of retaining walls are overturning, sliding, and bearing capacity failure. A retaining wall may overturn about its toe, the forwardmost point of the retaining wall foundation. A factor of safety between 2 and 3 is generally acceptable to prevent overturning. A retaining wall may slide along its base due to lack of soil adhesion, and lack of self-weight. A factor of safety of at least 1.5 is required to prevent sliding. A retaining wall may also fail due to loss of bearing capacity of the supporting soil. A factor of safety of 3 or greater is generally required to prevent bearing capacity failures. It is also important that any water behind the wall be able to drain from the backfill soil to prevent excess water pressure behind the wall.

The most common type of retaining walls is gravity retaining walls (GRW), utilizing the gravitational force of their own weight to withstand the lateral earth pressure from the soil behind as well as avoid toppling/sliding [7]. Gravity walls have slanted sides and a larger base to increase stability of the greater lateral earth pressures at depth. The advantage of a gravity wall is its simple design and moderate/low costs. However, a major disadvantage is the gravity walls are generally only built to a height of up to 9-10 feet. Exceeding this optimal range can result in bearing capacity failure due to the increase in ground surface weight; therefore, can also reduce the structural and geotechnical integrity of the wall holding soil against it [7]. Figure 2.3 shows a gravity wall. Three forces usually act upon a gravity wall: earth pressure, gravity (weight of wall), and reactive responding to the first two forces. These forces can be found in equilibrium of one another; thus, the wall remains in place through its own weight.

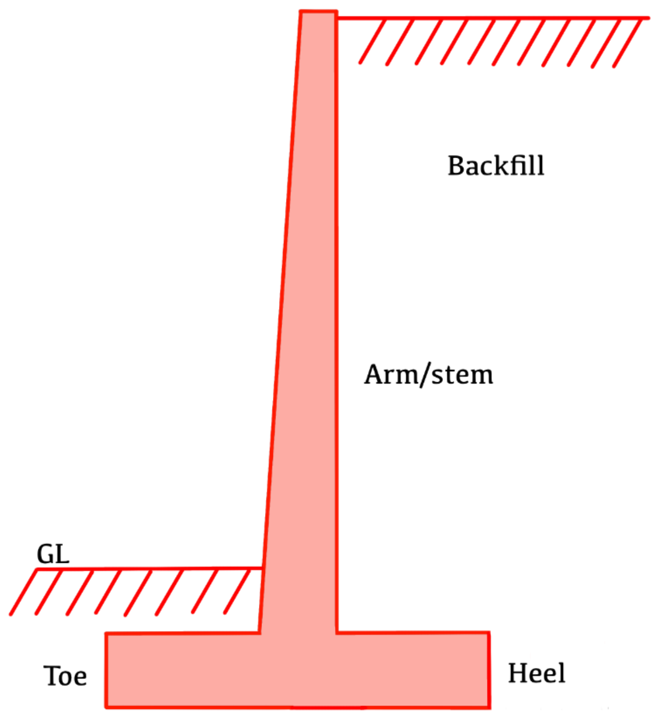

Figure 2.3: Simplified Sketch of Gravity Wall [11]

The second most common type of retaining walls are cantilever walls, which have an L-shaped (or inverted T-shaped) base as the wall foundation. Because of this foundation, overturning is dramatically reduced [7]. The weight of the earth (and resulting vertical tension) on the front of the T-shaped foundation, adds to its stability. When compared to other retaining wall styles, cantilever walls have the benefit of taking up less area once constructed and being appropriate for retained heights greater than 25 feet [7]. Figure 2.4 shows the forces acting on a cantilever wall. These forces are equalized by the extending arm(s) at the bottom of the wall. In this type of wall, a shear "key" can be attached to the bottom of the footing to prevent sliding.

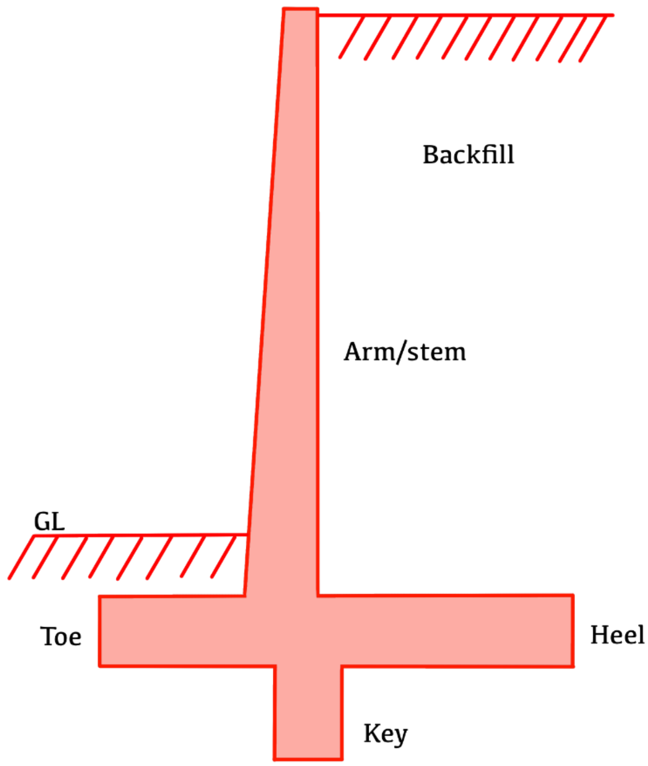

Figure 2.4: Simplified Sketch of Cantilever Wall [11]

Sheet pile walls operate as beam spans that span vertically between sources of support, resisting pressure from the earth and water as sheet piles allow for deep excavations to be produced, facilitating the building of additional permanent constructions below ground and at water level [7]. The sheet piles are often removed when work is finished and reused on new projects. Steel sheet piles have been used as long-term retaining walls for constructions such quay walls, bridge abutments, subterranean storage tanks, basements, and underground parking garages. Sheet pile walls usually extend X' (OR USE A 5%) below grade on the open wall side. The advantages of a sheet pile wall are that the construction process is quicker compared to reinforced walls, it is suitable for all soil types, and it is a sustainable product that minimizes waste [7]. However, the biggest disadvantage is that Flagstaff has a large presence of limestone/bedrock that creates complications when trying to drive piles into the ground [7]. Without access to the site, it cannot be determined if there is a presence of limestone/bedrock, thus the possibility of considering this type of retaining wall as an option is unlikely. Figure 2.5 shows that piling walls have the same forces as gravity and cantilever walls, however soil from both sides helps to resist the bending forces from high loads.

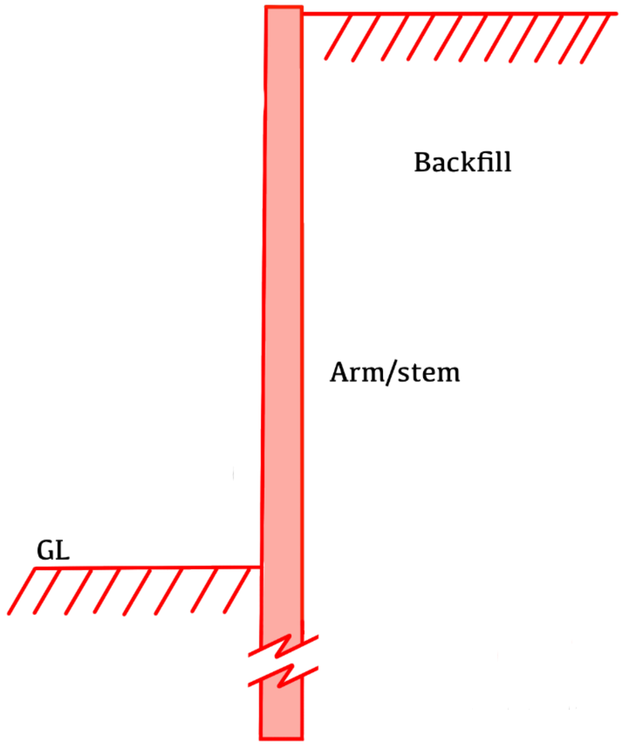

Figure 2.5: Simplified Sketch of Sheet Piled Wall [11]

Anchored Retaining Walls, also known as Mechanically Stabilized Earth (MSE) walls, are retaining walls that are fastened to the ground via geotextile fabrics and/or soil nails. These walls usually required building in layers, for multiple anchors or layers of geotextile fabric that enables a variety of "fronts" to be supported by these anchors or layers of geotextile fabrics [7]. Typically, pressurized concrete or mechanical techniques are used to extend the ends of these anchors after they have been forcibly pushed into the ground. Disadvantages of this retaining wall style include the need of specialty materials not commonly available, as well as the need for specialized contractors licensed to build MSE retaining walls. Lastly, these walls require a large amount of space behind the wall for the anchors and geotextile fabrics, which is a concern for the northern retaining wall, and the ridge at the property line [7]. Figure 2.6 shows the equilibrium forces acting on the wall, with the driven cables containing expanding anchors to structural support and stabilize the wall.

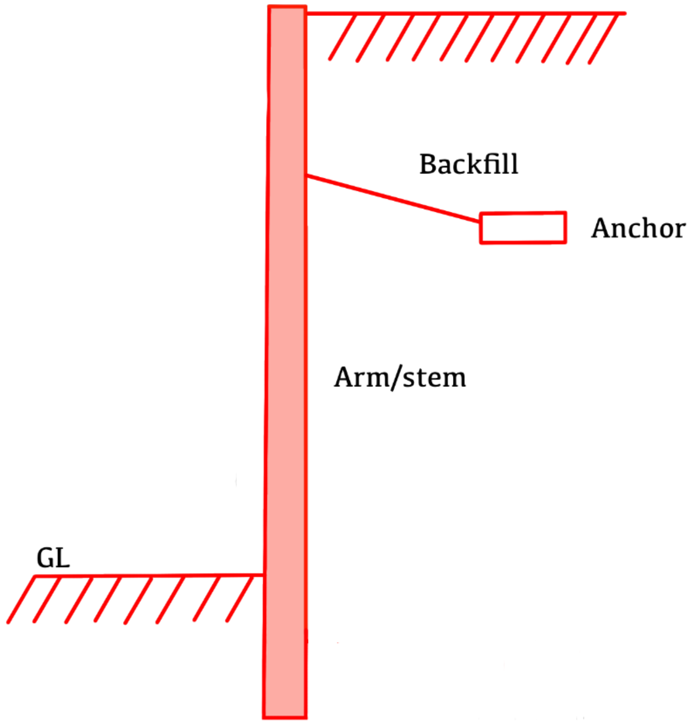

Figure 2.6: Simplified Sketch of Anchored Wall [11]

2.2.1 Retaining Wall Failures

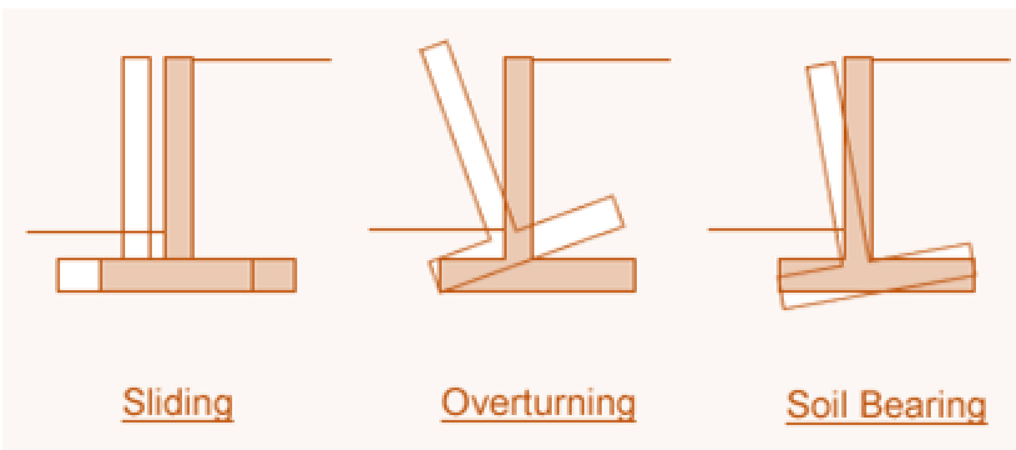

Figure 2.7: Retaining Wall Failures [16]

Figure 2.7 shows the common failures that can occur with retaining walls: sliding across the base, overturning about its toe, and loss of bearing capacity [16].

The backfill presses on the wall from the side. The passive pressure at the front of the wall and the friction between the footing and the subsurface soil both work to prevent this sliding force [16]. A shear key might be supplied if extra sliding resistance is needed. The minimal value for the safety factor against sliding, which is calculated as the resisting force divided by the driving force, should be greater than 1.5 [8. 16].

The vertical forces, which include the self-weight of the wall and the weight of the backfill over the heel, must provide an opposing moment to counteract the overturning moment caused by the applied forces [16]. The resisting moment divided by the overturning moment is known as the factor of safety against overturning, and a minimum value of 2 should be used [8. 16].

When a load is applied to the ground, such as from a building foundation, a crane, or a retaining wall, the ground must be able to hold it without experiencing severe settlement or failure [16]. Therefore, understanding the ground bearing pressure or bearing capacity of soil is crucial. Thus, a factor of safety value higher than 3 must be used [8, 16]

2.3 Obtained Data

Since HCE was not granted access to enter Nestle Purina's premises, geotechnical, and hydraulic data were provided by Mesquite Engineering [5]. Mesquite Engineering took two soil samples for the parking lot and the proposed roadway area and conducted a sieve analysis (ASTM C136) and determined liquid/plastic limits. They concluded that the hydrologic soil type was classified as a Group C soil, Sandy Clay Loam. This type of soil is well draining, minimally cohesive, and provides very good bearing capacity to support the proposed retaining wall [8]. Due to the well-draining nature of this soil, any groundwater will be able to pass through the soil without causing buoyancy and lifting problems such as heaving. For construction purposes, Type C soil requires a maximum sloping of 1H:1V (horizontal to vertical slope) [8]. This is to protect workers in the trench preventing cave-ins and allows for quick exit in emergencies per the Occupational Health and Safety Administration (OSHA).

Topographic information for the project was obtained from Civil Design & Engineering Inc. (CD&E Inc.). High Country Engineering also used the City of Flagstaff's aerial LiDAR 2-foot contour lines from the Coconino County GIS Parcel Viewer. CD&E also granted High Country Engineering permission to utilize their maps of underground utilities in the area.

3.0 Topographic Map

Figure 3.1 shows the topographic map created by High Country Engineering, utilizing Civil 3D. From HCE's research and findings, the proposed retaining wall will have a total length of approximately 700 LF (linear feet), beginning at station 6+50 and ending at 13+50.

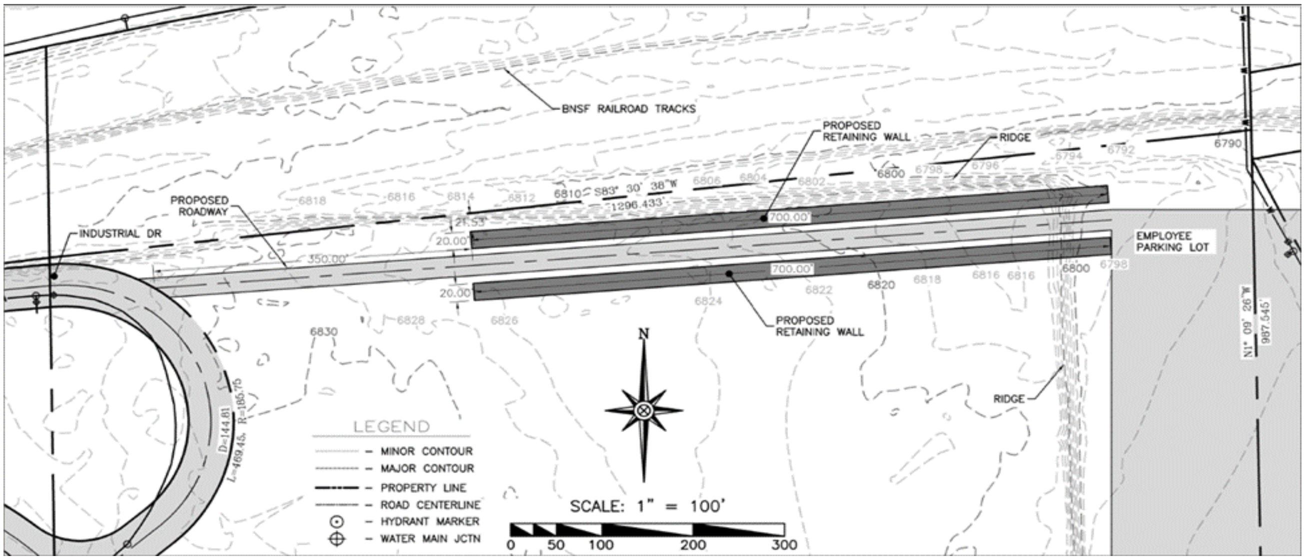

Figure 3.1: Topographic Map

Figure 3.2 shows the profile for the planned road. The maximum depth from the existing grade to the proposed grade of the roadway is estimated to be 16.6 feet. Adding an additional 2.5 feet for frost depth, the maximum wall height totals approximately 21 feet.

The topographic map and profile can also be seen in the plan set, located in the appendix.

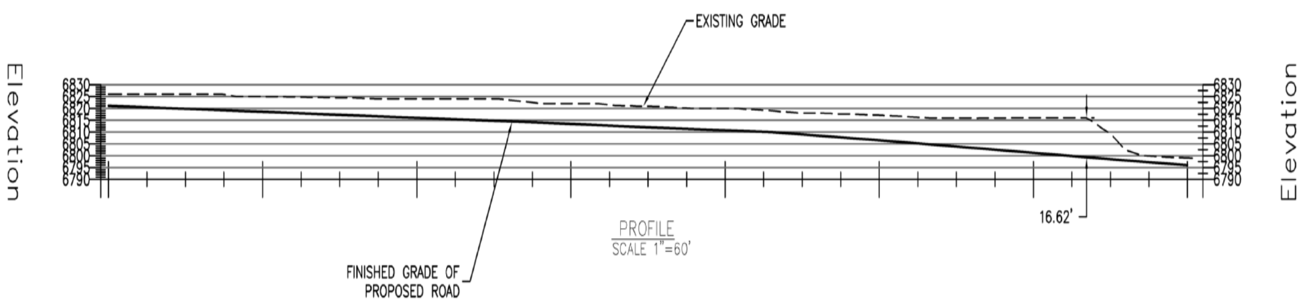

Figure 3.2: Existing and Proposed RW Grade Profile

4.0 Development of Alternatives and Selection of Preferred Alternative

This section details information regarding the process of selecting the preferred alternative for both the retaining wall and associated hydraulic/hydrologic design.

4.1 Alternative Designs Development – Retaining Walls

As addressed in Section 2.2, gravity walls are limited to a maximum height of 10' therefore were not further considered [7]. Anchored (MSE) walls were not considered because construction requires special contractors during construction, which would substantially increase the construction timeline, which would lead to increase in traffic delay. Piling walls were a potential wall type however they require more excavation and in turn, increased cost [7].

Thus, the cantilever wall type was chosen over the other designs due to practicality and structural/geotechnical capability. The formwork of the wall was also an advantage, with the key/toe on one side of the wall providing durability and preventing the wall from toppling from failure [7]. Additionally, the ADOT Structural Detail 7, which applies to this project, is a reinforced concrete cantilever.

Upon selection of the cantilever wall type, two alternatives were developed for further consideration and are discussed below.

4.1.1 Alternative Concrete Cantilever – Continuous Foundation

This retaining wall is one continuous 700-foot wall with no discontinuities. Since this design requires one solid continuous foundation, the entire wall would be approximately 21 feet tall. Because of the size/weight of this wall, this design requires a large foundation along its entire length. Resulting in large quantities of concrete and reinforcing steel. Figure 4.1 shows the details of a continuous footing.

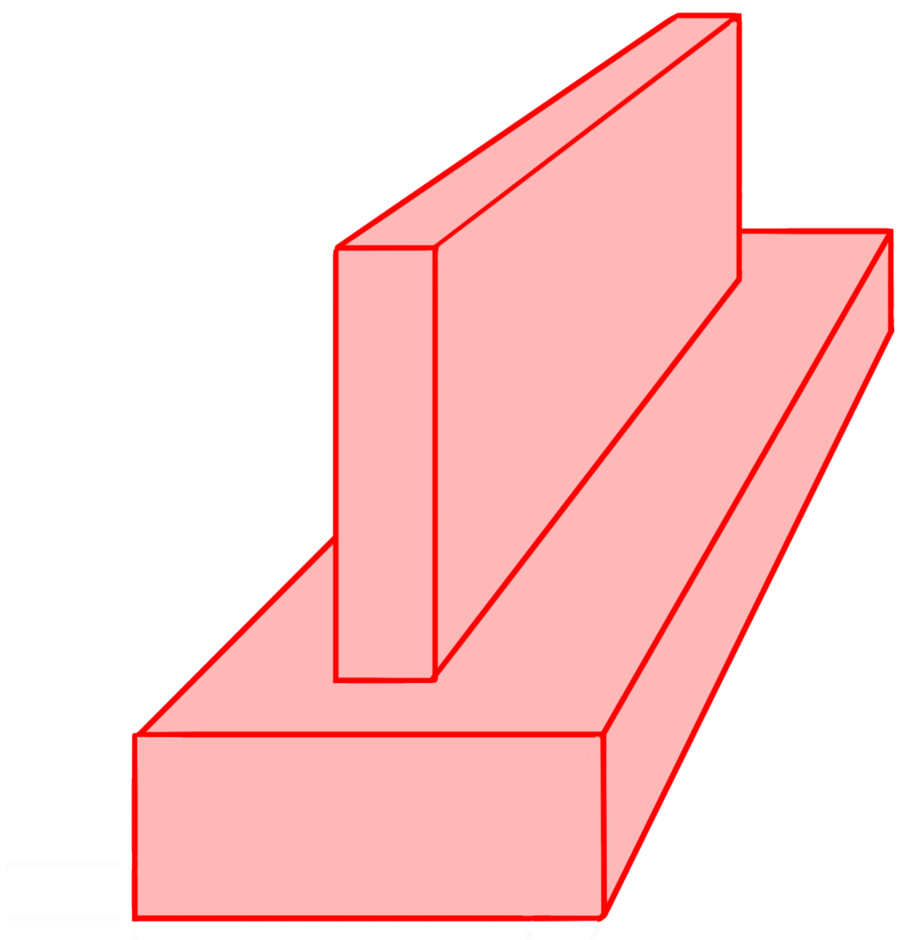

Figure 4.1: Continuous Footing

4.1.2 Alternative 2: Reinforced Concrete Cantilever – Stepped Foundation

A stepped foundation is a foundation made of a series of horizontal steps which follows the sloping of the ground level as shown in Figure 4.2. The advantages of this foundation design are that the walls can be built in sections and the minimum design criteria for that section's height requirement can be used. This design reduces construction material quantities, and construction time since the excavators don't have to dig as deep for the foundations.

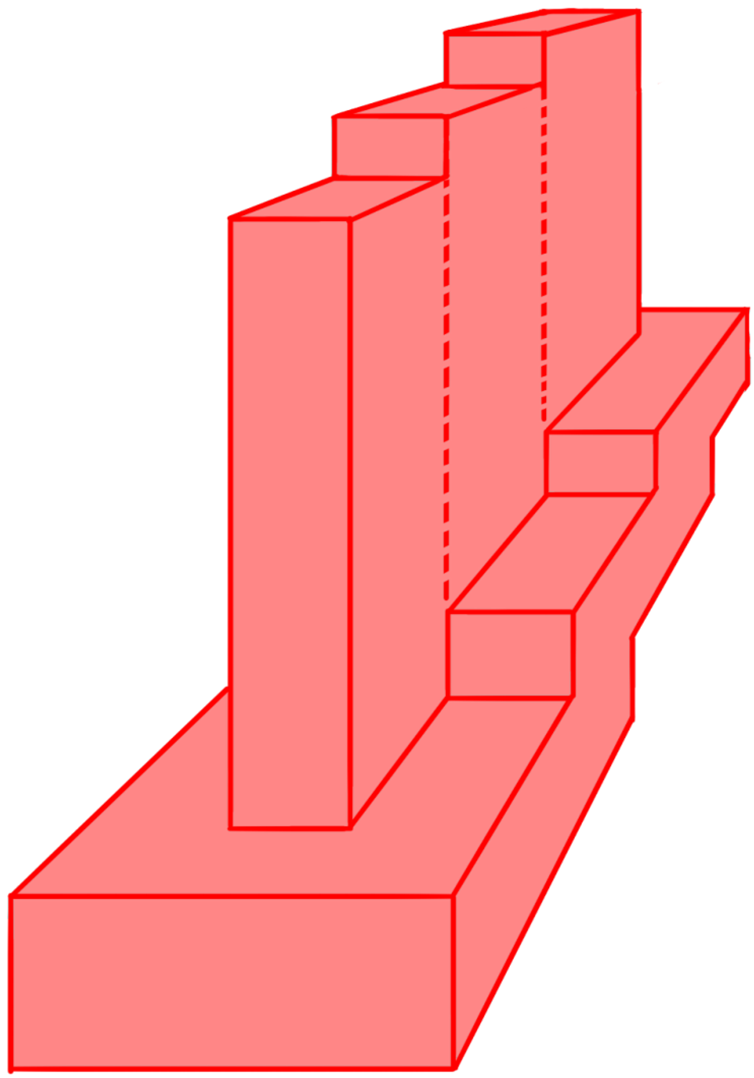

Figure 4.2: Stepped Footing

4.2 Alternative Designs Development – Hydraulic Design

All retaining walls require hydrologic management of runoff through/from the structure. Thus, HCE proposed the following alternatives: Detention Pond, Retention Pond, and Underground Storage. These alternatives are discussed in the sections below.

4.2.1 Alternative Hydraulic Design – Detention Pond

Detention ponds are inexpensive methods of attenuating flood volumes. Due to the City of Flagstaff's "First Flush" policy, the first inch of a storm's volume must be attenuated and cleaned by means of ground infiltration or other treatment methods. A detention pond allows for the volumes required for the "First Flush" to be captured and treated, while excess water can be redirected to other locations such as to the Rio de Flag. 4.3 shows a diagram of a detention pond.

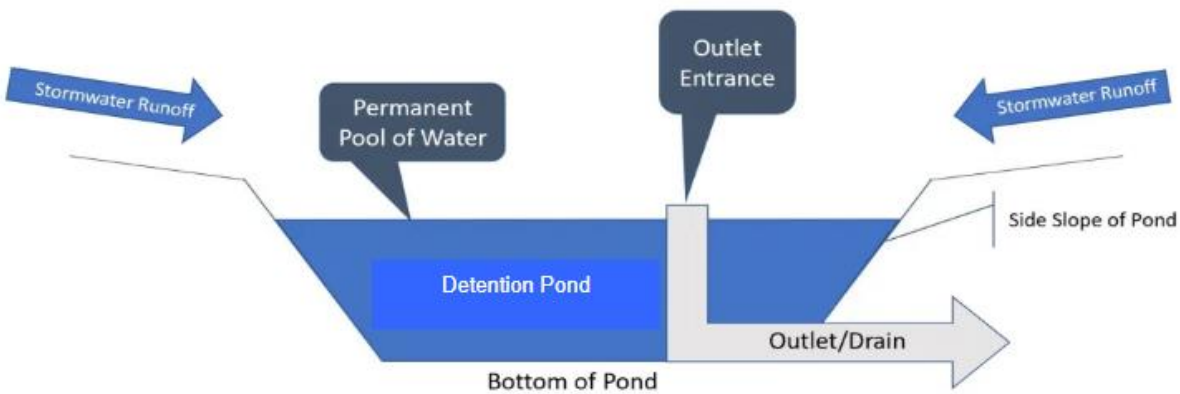

Figure 4.3: Detention Pond Main Features [14]

4.2.2 Alternative Hydraulic Design – Retention Pond

Retention ponds are similar to detention ponds in almost all aspects, however; retention ponds do not allow for water above the attenuation volumes to leave the pond. This pond is only designed to collect water and allow it to either evaporate or to infiltrate into the ground. Figure 4.4 shows a diagram of a retention pond and its main features.

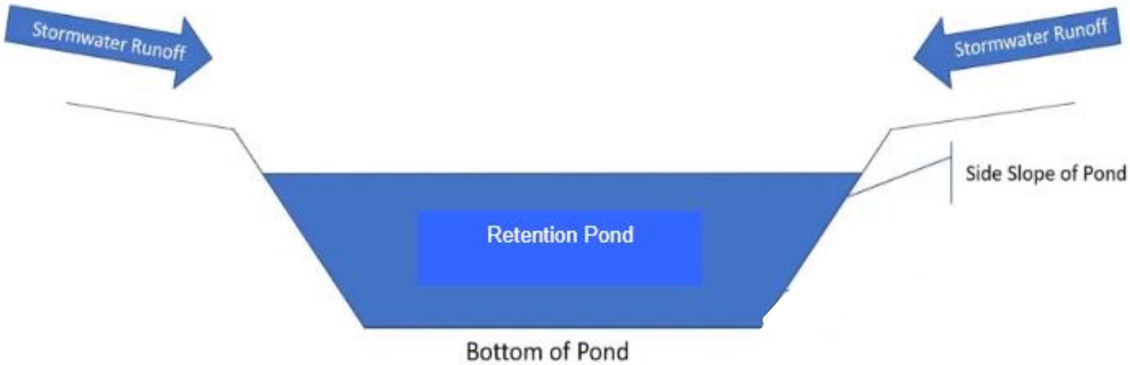

Figure 4.4: Retention Pond Main Features [14]

4.2.3 Alternative Hydraulic Design – Underground Storage

This method of hydraulic management captures the surface runoff, then stores the water in underground chambers. This method can be used for both retention and detention, thus satisfying the "First Flush" requirement. A significant design consideration for this method is that the underlying soil muse have appropriate percolation rates to allow for quick infiltration. Figure 4.5 shows the design of common underground storages and the one considered for design.

Figure 4.5: Underground Storage Main Features [14]

4.3 Evaluation of Alternatives and Selection of Final Designs

Two decision matrices were developed to select the preferred designs for both the retaining wall and hydraulic design. For each matrix, the criteria were considered of equal weight. The rating systems are ranked from a scale of 0-2. A score of 2 signified that the structural/hydraulic design exceeds the criteria. A score of 1 signified that the design fully meets the criteria, and a score of 0 signifies that the design meets the criteria but has drawbacks. The evaluation based on these criteria is qualitative, as detailed design calculations were not performed at this point in the analysis.

4.3.1 Retaining Wall Evaluation and Preferred Alternative Selection

Strength, and costs, were the two criteria for the RW.

Strength included the retaining wall's potential to resist the forces (lateral, surcharge, and axial loads) and its ability to prevent sliding/failure. From a geotechnical standpoint, the type of footing was judged on its strength as a foundation to keep the wall in place. Strength also relates to its safety from preventing the wall's failure from causing potential fatalities. The continuous foundation received a score of 2 in strength because it is a solid wall unlike the stepped, where there are multiple sections that must align. The stepped wall does meet the requirement and received a score of 1 because it does not have the structural integrity of the continuous wall.

Costs (found in Table 6.0) such as stabilization, and drainage include the cost of materials needed for excavation and construction of the RW, and time and ease of construction, as the latter is generally proportional to the former. The continuous foundation has severe drawbacks due to its being overdesigned for the location. This wall requires extensive excavation and reinforced concrete, and increased construction time as well. The stepped foundation wall is more suited to the site and requires less excavation and fewer materials, thus decreasing the time to construct and the complexity. Therefore, the continuous wall scored a 0 and the stepped wall scored a 2.

Table 4.1 shows the retaining wall decision matrix.

Table 4.1: Retaining Wall Decision Matrix and Criteria

Criteria	**Alternative 1: Reinforced Concrete Cantilever: Continuous Foundation**	**Alternative 2: Reinforced Concrete Cantilever: Stepped Foundation**
Strength	2	1
Cost	0	2
Total	**2**	**3**

The stepped foundation would require less materials and construction time, benefitting the Purina facility financially, and reducing the time that Industrial Rd would be closed during construction. This foundation causes the retaining walls to be built in sections, but will also allow for a nice, clean, stepped design following the natural elevation as well. Therefore, the stepped foundation wall was selected.

4.3.2 Hydraulic Design Evaluation and Preferred Alternative Selection

The criteria for the decision as to which type of hydraulic control is required included space required, materials and costs, construction time, and health concerns.

Space required is analyzed based on the computed acreage and is detailed in Section 5.2 below.

The Materials/cost found in Table 6.0 refers to the feasibility in obtaining the materials at a reasonable cost.

Health concerns included potential biological/ecological issues. The primary health issue is detention/retention ponds that may accumulate disease vectors such as flies and mosquitoes due to the large body of water.

4.3.2.1 Preliminary Hydraulic Design

The preliminary designs were created using the ADOT Hydrology Manual utilizing a 100-year storm event [16]. Preliminary calculations can be found in the appendix.

4.3.2.2 Hydraulic Design Decision Matrix

Based on the information in Table 4.2 below, all three alternatives met the requirements-based space required., yet retention pond was rated lower due its need for more space due to the permanent pool of water that would remain in the area. Underground storage scored a 2 because it takes less surface area than the other alternatives.

Regarding materials/cost underground storage costs are significantly higher than detention and retention ponds due to the excavation requirements and the purchase of tanks. Thus, underground storage was scored a 0 while the ponds each scored a 1.

Regarding construction time, the retention pond received the highest score as the design only requires a large excavation. The detention pond also requires this as well; however, the construction of the drainage/outlet would account for additional time in the construction process. Furthermore, the underground storage ranked lowest in this category as the design requires both a large excavation as well as constructing a complex system underground; thus, prolonging the installation timeline.

Regarding health concerns. the detention and retention ponds can cause significant health concerns to nearby facilities and habitats due to standing water and can lead to unsanitary conditions due to bacteria/algae growth and supporting nuisance vectors. Therefore, both ponds scored a 0 while the underground storage scored a 2.

Table 4.2 shows the decision matrix for the hydrologic/hydraulic design.

Table 4.2: Hydrologic and Hydraulic Decision Matrix and Criteria

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

The underground storage will prevent the breeding of mosquitoes, will not interfere with future expansion of the facility, and requires minimal maintenance, all while satisfying City of Flagstaff's "First Flush" stormwater cleaning policy. Additionally, the underground storage can also be used for other Low Impact Development needs/requirements such as irrigation and landscaping. Therefore, underground storage was the selected hydraulic structure design. It must be noted that subsurface conditions are unknown at this time, and the presence of bedrock instead of soil may dramatically increase costs such that it may not be a feasible alternative, and reconsideration of the ponds as the selected option would be required.

5.0 Final Design and Analysis

This section includes the design and analyses of the reinforced concrete cantilever wall with a stepped foundation for the retaining wall design (Section 5.1) and for the underground storage unit for the hydraulic design (Section 5.2).

5.1 Retaining Wall Design and Analysis

The reinforced concrete cantilever wall with a stepped foundation was chosen as the preferred design alternative The retaining wall design utilized was from the ADOT Structural Detail 7 (Appendix C) [1]. Figures 5.1 – 5.2 show a simplified plan, front, and profile view of the wall with the relevant dimensions. These figures can also be seen in the plan set in appendix D.

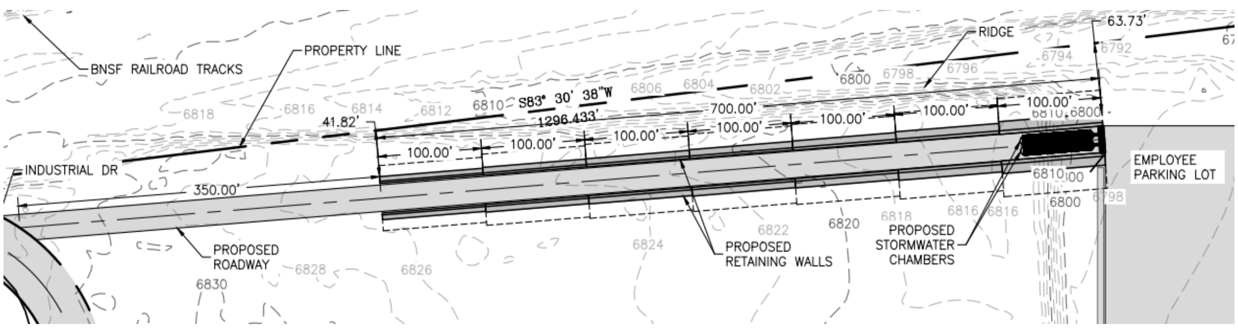

Figure 5.1: Plan View of the Sectioned Walls and Underground Storage

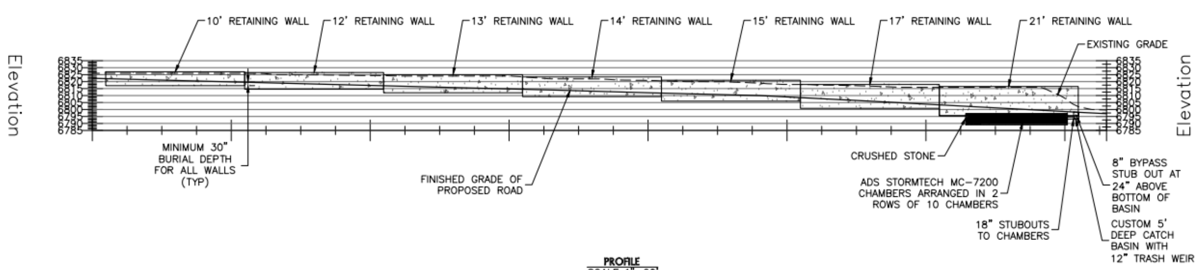

Figure 5.2: Profile of Retaining Wall Sections

Failure analyses were conducted to assure that the required factors of safety were met.

Since the retaining wall is a stepped footing foundation with seven steps seven individual retaining walls were each analyzed. As shown in Figure 5.2 above, these walls vary in height from 10’ to 21’.

Factors of Safety were also pertinent in determining the overturning, sliding, load bearing capacities of the retaining wall. The following the factors of safety were used: FS greater than 2 (overturning), FS greater than 1.5 (sliding), and FS greater than 3 (bearing capacity) [8, 16].

Overturning is the potential failure of a retaining wall where a moment of turning occurs at the bottom of the toe of the retaining wall. As seen in Table 5.0 below, the FS for overturning is greater than 3 and therefore the 21-ft design will be safe from this failure. Sliding of the wall is the potential pressure the backfill could cause on the wall causing it to move from its original location forward toward the road. Sliding also passes the FS requirement at 1.51 > 1.5. This lets the designed 21-ft to have no cause for concern of sliding. Load bearing capacity, like sliding, is a potential failure that may cause the wall to move forward due to the pressures of the backfill, however instead of the wall being ‘pushed’, it instead rotates on the base of the retaining wall. Based on the calculations done, load bearing capacity exceeds the FS requirement at 2.30.

Table 5.0: FS Values for Failures at Various Heights

	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**

Below is a figure with example calculations done for the FS Values for failure (also found in Appendix A: Retaining Wall Calculations). In this figure, the FS value for overturning for the 21-ft wall.

21' Retaining Wall Failure Calculations

Dimensions:

H (ft) =	21	W (ft) =	11.5	B (ft) =	1.58	C (ft) =	3.25
F (ft) =	1.75	E (ft) =	6.5	X (ft) =	3.17	D (ft) =	2.5

Earth Pressures:

γ (pcf) =	95	δ=	13	Kp =	0.37
c (psf) =	417	ca (psf) =	0	Ka =	0.39
ϕ (°) =	22	γc (pcf) =	150	α=	0

$$K_p = \tan^2\left(45 + \frac{\phi_2'}{2}\right).$$

$$K_a = \tan^2\left(45 - \frac{\phi_1'}{2}\right)$$

Pp (lb) =	2992.73	Ph (lb) =	7881.28	Pv (lb) =	0	Pa (lb) =	8143.36

$$P_p = \frac{1}{2}\gamma_2 D_1^2 K_p + 2c_2' D_1 \sqrt{K_p}$$

$$P_a \cos\alpha = P_h = P_a$$

$$P_v = P_a \sin\alpha$$

$$P_a = \tfrac{1}{2}\gamma_1 H'^2 K_a$$

Section	Area (ft^2)	Weight (lb)	Moment Arm (ft)	Moment (lb*ft)
1	136.5	12967.5	8.25	106981.88
2	0	0	0	0.00
3	17.50	2625	5	13125.00
4	1.79	267.75	3.25	870.19
5	18.20833333	2731.25	5.75	15704.69
6	3.75	562.5	7.58	4265.63
	ΣV (lb) =	19154	ΣMr (lb) =	140947.38

Slope Heel of Wall at 45° and Extend Key to H=2.5 ft

$$P_a = \frac{1}{2}\gamma_1 K_a (H' - D')^2 + \frac{A}{2}\gamma_1 K_a [H'^2 - (H' - D')^2]$$

Pa1 (lb) = 7881.276

Overturning:

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

ΣMo (lb*ft) = 61301.41

$$M_o = P_h\left(\frac{H'}{3}\right)$$

FS (overturning) = 2.30

Figure 5.3: 21-ft Calculations FS Value for Overturning

After FS Values were confirmed to be acceptable based on the given requirements, the design for the retaining wall could be conducted. Below in figure 5.2 is the design specifications done for the 21-ft design wall. The wall required an extension of the key from 15 inches to 30 inches and the heel to be cut at a 45-degree angle to ensure stability for load bearing.

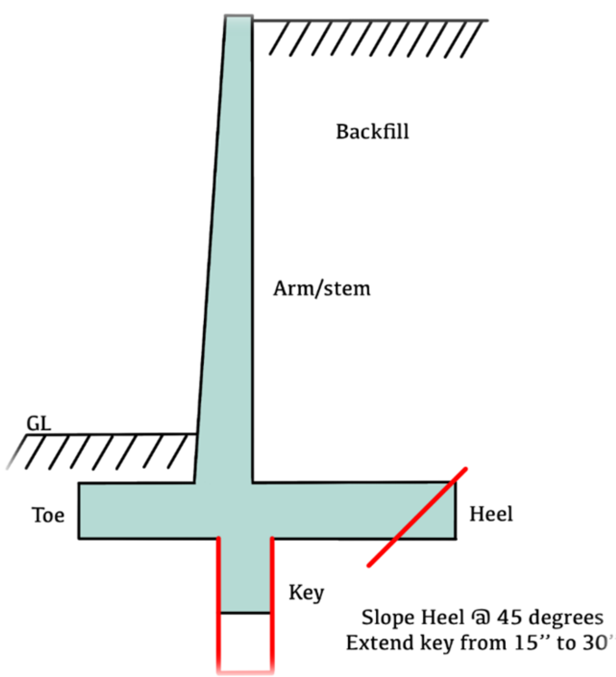

Figure 5.4: 21-ft Wall Specifications

5.2 Hydraulic Design and Analysis

The underground storage was designed utilizing the artificial watershed seen in Figure 5.5. The figure also shows where the proposed stormwater chambers will be located, almost spanning the 21' Retaining Wall. Figure 5.6 also shows the actual design of the underground chambers: 20 StormTech MC-7200 Chambers and 4 end caps with a 15-inch cut-stone base.

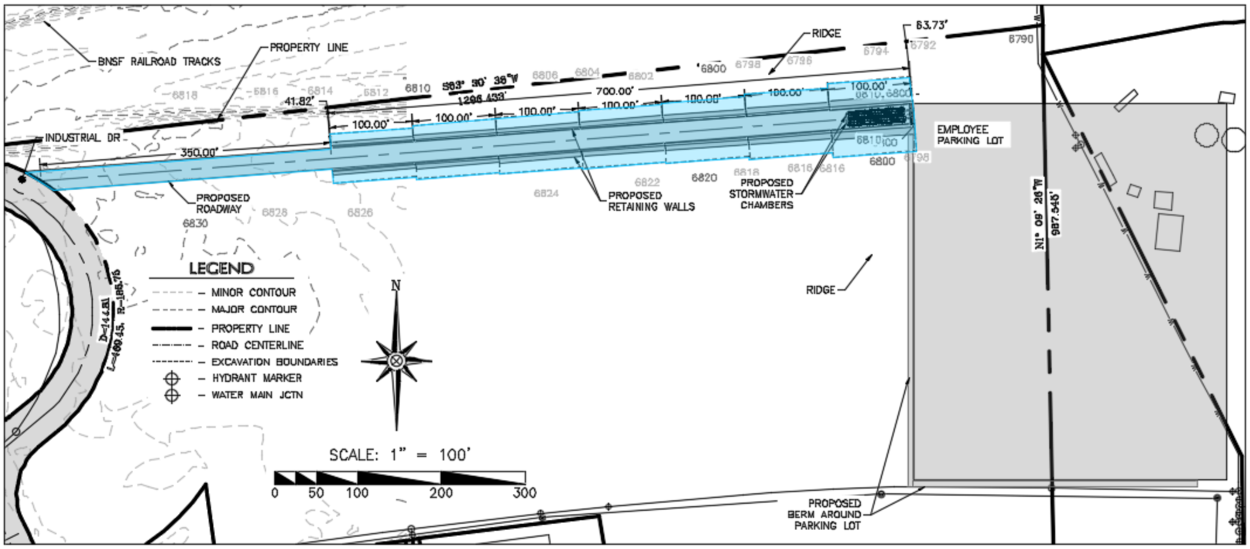

Figure 5.5: Artificial Watershed

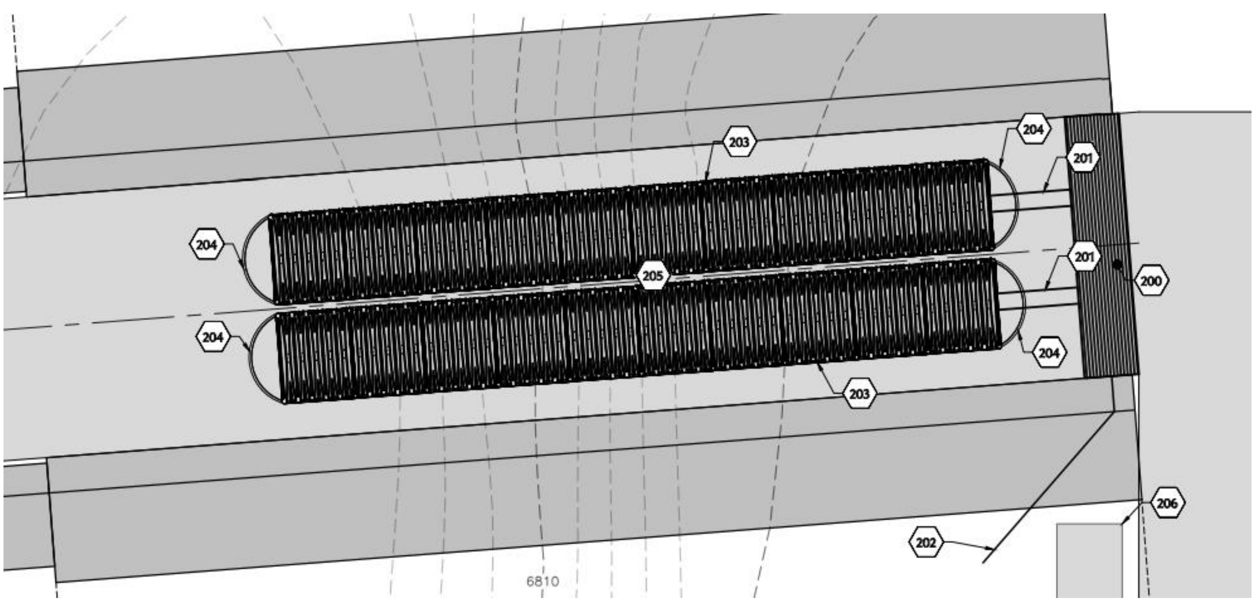

Figure 5.6: Stormwater Chambers

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

Figure 5.7: Design Calculations

Figure 5.7 shows the calculations of each unit. It was recommended to design the recommended volume to about 133% since there is a possibility of 2 500-year storm events occurring.

6.0: Construction Cost Estimate

Table 6.0 shows the construction cost estimate for the project, including road construction. These values also installed costs (includes labor costs) The following units are defined as such: LS (unitless), CY (cubic yard), SY (square foot yard), LF (linear foot), and EA (each). The unit prices were obtained from the David & Hutchenson Bids Document [17]. For Item 2 (Removal and Disposal of Trees), 100 trees were an approximate estimate. As stated, HCE was not allowed to conduct a site visit. Hence, HCE utilized Google Earth and attempted to count the number of trees within the area, estimating to about 100. Additionally, due to property restraints in the software, some angles were blurred, and it was possible that some trees were not accounted in the estimated quantities.

Some of the excavated dirt will be hauled and stored in an area within the project site that will be used for the additional backfill needed. However, the remainder will be hauled outside of the project site and disposed of at a municipal landfill site. For Item 7 (Retaining Wall), the cost also accounted for concrete and rebar. Additionally, Item 8 (Catch Basin) was also added to provide proper drainage and catch debris that will prevent clogging. The total cost for the entire construction process estimates to about $7.8 million.

Table 6.0: Construction Cost Estimate

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**

7.0 Plan Set

The Plan Set is provided in Appendix D: Plan Set.

7.0: Impacts Analysis

High Country Engineering is aware that this project demonstrates both positive and negative economic, environmental, and social impacts for Nestle Purina and the City of Flagstaff.

From an environmental standpoint, the retaining wall has a net-positive impact is it prevents soil erosion by supporting the surrounding soils and providing proper drainage for the deep cut the road requires. The underground storage prevents contaminated water from leaving the site and affecting the adjacent Rio de Flag. Additionally, effective drainage avoids pooling water, flash flooding, and other flows that can damage the surrounding landscape and facility. However, the retaining wall also has a negative environmental impact as the large amount of concrete needed for the retaining wall as the material omits potent, greenhouse gases (carbon dioxide) that can exacerbate soil erosion and flooding. Additionally, the short- and long-term effects from this project will evidently disrupt the native land; consequently, the entire landscape will drastically change throughout time due to the development of the project.

From an economic standpoint, this retaining wall was built to support the proposed roadway designed by Mesquite Engineering. This road will increase traffic flow efficiency to accommodate the large truck volume. Evidently, more efficient transportation can increase revenue for Nestle Purina. However, a negative impact includes the substantial capital cost to construct the project. The road may be closed during the construction timeline of the retaining wall that can cause truck detours that affect the delivery of certain items and decrease their revenue during that specific period.

From a socioeconomic standpoint, this project would create more jobs during the construction phase. Additionally, this will benefit the productivity and efficiency for Nestle Purina workers having access to enter the site without the disruption of trucks.

8.0 Summary of Engineering Work

High Country Engineering has completed all the deliverables by the due date addressed in the Gantt Chart (see Appendix D). No major schedule changes were made except for the deletion of Task 3.0 Hydrologic Analyses – Current Conditions. As the site chosen for the project is undeveloped and was unaffected by stormwater flows, only post-development analysis were performed.

9.0 Summary of Engineering Costs

The project was completed with slightly fewer (54 hours) hours than proposed. This was primarily due to lack of site access, resulting in no on-site work. Required site data were obtained from Mesquite Engineering, the City of Flagstaff parcel map, and Civil Design and Engineering Inc. Additionally, ADOT Structural Detail 7 provided all design parameters of the retaining wall, so HCE did not need to perform any structural designs or calculations, other than factor of safety calculations and sizing.

Additionally, project staff hours changed for each position as the Senior and EIT worked more hours than project, and the opposite for both the drafter and intern. This was due to requiring more clarification and examination from the higher position, both double-checking and assisting the entry-level position to ensure that the project information and data were accurate.

Total cost of all engineering services for this project was $65,503, with a discrepancy of $177, as compared to the projected $65,680. Table 9.0 below portrays a rundown of all the required services and their cost estimates.

Table 9.0: Engineering Cost Comparisons

Cost of Services						
Position	Hourly Rate	Project Hours	Project Costs	Actual Hours	Actual Costs	Discrepancies
Senior Engineer	$199	85	$16,902	103	$20,497	$3,595
Engineer in Training	$153	120	$18,317	143	$21,879	$3,562
Drafter	$93	200	$18,588	143	$13,299	-$5,289
Intern	$54	220	$11,873	182	$9,828	-$2,045
Total		625	$65,680	571	$65,503	-$177

10.0 Conclusion

For the proposed roadway at Nestle Purina, High Country Engineering has designed reinforced cantilever retaining wall with a stepped foundation and subterranean storage as a continuation of Mesquite Engineer's alternative roadway entrance project. The retaining wall spans 700 ft, with 7 sections of 100' varying in height. Additionally, the underground storage consists of 20 StormTech MC-7200 chambers with a required storage of 4500 CF. The total cost for construction is approximately $7.8 million.

11.0 References

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12.0 Appendices

Appendix A: Retaining Wall Design Calculations

10’ Retaining Wall Failure Calculations

10' Retaining Wall Failure Calculations

Dimensions:

H (ft) = 10	W (ft) = 6	B (ft) = 1.17	C (ft) = 1.75
F (ft) = 1	E (ft) = 3.25	X (ft) = 1.33	D (ft) = 2.5

Earth Pressures:

γ (pcf) = 95	δ= 13	Kp = 0.37
c (psf) = 417	ca (psf) = 0	Ka = 0.39
ϕ (°) = 22	γc (pcf) = 150	α= 0

$$K_p = \tan^2\left(45 + \frac{\phi_2'}{2}\right).$$

$$K_a = \tan^2\left(45 - \frac{\phi_1'}{2}\right)$$

Pp (lb) = 2161.35	Ph (lb) = 1846.567043	Pv (lb) = 0	Pa (lb) = 1846.57

$$P_p = \frac{1}{2}\gamma_2 D_1^2 K_p + 2c_2' D_1 \sqrt{K_p}$$

$$P_a \cos\alpha = P_h = P_a$$

$$P_v = P_a \sin\alpha$$

$$P_a = \tfrac{1}{2}\gamma_1 H'^2 K_a$$

Section	Area (ft^2)	Weight (lb)	Moment Arm (ft)	Moment (lb*ft)
1	32.5	3087.5	4.375	13507.8125
2	0	0	0	0
3	8.33	1250	2.33	2916.666667
4	0.85	127.5	2.31	293.8875
5	7	1050	3	3150
6	1.88	281.25	3.92	1101.65625

ΣV (lb) = 5796.25 ΣMr (lb*ft) = 20970.02

Overturning:

$$\mathrm{FS}_{(\text{overturning})} = \frac{\Sigma M_R}{\Sigma M_o}$$

ΣMo (lb*ft) = 6873.33

$$M_o = P_h\left(\frac{H'}{3}\right)$$

FS (overturning) = 3.05

Sliding Along Base:

$$\mathrm{FS}_{(\text{sliding})} = \frac{(\Sigma V)\tan\delta' + Bc_a' + P_p}{P_a\cos\alpha}$$

FS (sliding) = 2.62

Bearing Capacity Failure:

$$\overline{X} = \frac{\Sigma M_R - \Sigma M_o}{\Sigma V} \qquad e = \frac{B}{2} - \overline{X}$$

$$q_{\text{toe}} = \frac{\Sigma V}{B}\left(1 + \frac{6e}{B}\right)$$

X(bar) (ft) = 2.43	e (ft) = 0.57

$$q_{\text{heel}} = \frac{\Sigma V}{B}\left(1 - \frac{6e}{B}\right)$$

q max/toe (psf) = 1514.72	q min/heel (psf) = 417.37

Nc = 16.88	Fcd = 1.06	Fci = 1
Nq = 7.82	Fqd = 1.01	Fqi = 1
Nγ = 7.13	Fγd = 1	Fγi = 1

$$F_{cd} = F_{qd} - \frac{1 - F_{qd}}{N_c \tan\phi_2'}$$

$$F_{qd} = 1 + 2\tan\phi_2'(1 - \sin\phi_2')^2 \frac{D}{B'}$$

$$F_{\gamma d} = 1$$

qu (psf) = 10964.02

$$q_u = c_2' N_c F_{cd} F_{ci} + q N_q F_{qd} F_{qi} + \tfrac{1}{2}\gamma_2 B' N_\gamma F_{\gamma d} F_{\gamma i}$$

FS (BC Failure) = 7.24

$$\mathrm{FS}_{(\text{bearing capacity})} = \frac{q_u}{q_{\max}}$$

12’ Retaining Wall Failure Calculations

12' Retaining Wall Failure Calculations

Dimensions:

H (ft) = 12	W (ft) = 7	B (ft) = 1.25	C (ft) = 2
F (ft) = 1	E (ft) = 4	X (ft) = 1.67	D (ft) = 2.5

Earth Pressures:

γ (pcf) = 95	δ= 13	Kp = 0.37
c (psf) = 417	ca (psf) = 0	Ka = 0.39
ϕ (°) = 22	γc (pcf) = 150	α= 0

$K_p = \tan^2\left(45 + \frac{\phi_2'}{2}\right)$

$K_a = \tan^2\left(45 - \frac{\phi_1'}{2}\right)$

Pp (lb) = 2161.35	Ph (lb) = 2659.06	Pv (lb) = 0	Pa (lb) = 2659.06
$P_p = \frac{1}{2}\gamma_2 D_1^2 K_p + 2c_2' D_1 \sqrt{K_p}$	$P_a \cos\alpha = P_h = P_a$	$P_v = P_a \sin\alpha$	$P_a = \frac{1}{2}\gamma_1 H'^2 K_a$

Section	Area (ft^2)	Weight (lb)	Moment Arm (ft)	Moment (lb*ft)
1	48	4560	5	22800
2	0	0	0	0
3	10.00	1500	3	4500
4	1.02	153	2	306
5	8.75	1312.5	3.5	4593.75
6	1.88	281.25	4.58	1288.13
	ΣV (lb) =	7806.75	ΣMr (lb) =	33487.88

Overturning: $FS_{(overturning)} = \frac{\Sigma M_R}{\Sigma M_o}$ ΣMo (lb*ft) = 11744.1664 $M_o = P_h\left(\frac{H'}{3}\right)$

FS (overturning) = 2.85

Sliding Along Base: $FS_{(sliding)} = \frac{(\Sigma V)\tan\delta' + Bc_a' + P_p}{P_a \cos\alpha}$

FS (sliding) = 2.17

Bearing Capacity Failure: $\overline{X} = \frac{\Sigma M_R - \Sigma M_o}{\Sigma V}$ $e = \frac{B}{2} - \overline{X}$

$q_{toe} = \frac{\Sigma V}{B}\left(1 + \frac{6e}{B}\right)$

$q_{heel} = \frac{\Sigma V}{B}\left(1 - \frac{6e}{B}\right)$

X(bar) (ft) = 2.79	e (ft) = 0.71

q max/toe (psf) = 1798.51	q min/heel (psf) = 431.99

Nc = 16.88	Fcd = 1.05	Fci = 1
Nq = 7.82	Fqd = 1.01	Fqi = 1
Nγ = 7.13	Fγd = 1	Fγi = 1

$F_{cd} = F_{qd} - \frac{1 - F_{qd}}{N_c \tan\phi_2'}$

$F_{qd} = 1 + 2\tan\phi_2'(1 - \sin\phi_2')^2 \frac{D}{B'}$

$F_{\gamma d} = 1$

qu (psf) = 11143.20 $q_u = c_2' N_c F_{cd} F_{ci} + q N_q F_{qd} F_{qi} + \frac{1}{2}\gamma_2 B' N_\gamma F_{\gamma d} F_{\gamma i}$

FS (BC Failure) = 6.20 $FS_{(bearing\ capacity)} = \frac{q_u}{q_{max}}$

13’ Retaining Wall Failure Calculations

13' Retaining Wall Failure Calculations

Dimensions:

H (ft) = 13	W (ft) = 7.5	B (ft) = 1.25	C (ft) = 2.25
F (ft) = 1	E (ft) = 4.25	X (ft) = 1.83	D (ft) = 2.5

Earth Pressures:

γ (pcf) = 95	δ= 13	Kp = 0.37
c (psf) = 417	ca (psf) = 0	Ka = 0.39
ϕ (°) = 22	γc (pcf) = 150	α= 0

$$K_p = \tan^2\left(45 + \frac{\phi'_2}{2}\right)$$

$$K_a = \tan^2\left(45 - \frac{\phi'_1}{2}\right)$$

Pp (lb) = 2161.35	Ph (lb) = 3120.70	Pv (lb) = 0	Pa (lb) = 3120.70
$P_p = \frac{1}{2}\gamma_2 D_1^2 K_p + 2c'_2 D_1\sqrt{K_p}$	$P_a \cos\alpha = P_h = P_a$	$P_v = P_a \sin\alpha$	$P_a = \frac{1}{2}\gamma_1 H'^2 K_a$

Section	Area (ft^2)	Weight (lb)	Moment Arm (ft)	Moment (lb*ft)
1	55.25	5248.75	5.375	28212.03
2	0	0	0	0.00
3	10.83	1625	3.25	5281.25
4	1.11	165.75	2.25	372.94
5	9.375	1406.25	3.75	5273.44
6	1.88	281.25	4.92	1382.81
	ΣV (lb) =	8727	ΣMr (lb) =	40522.47

Overturning:

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

ΣMo (lb*ft) = 14823.32

$$M_o = P_h\left(\frac{H'}{3}\right)$$

FS (overturning) = 2.73

Sliding Along Base:

$$FS_{(sliding)} = \frac{(\Sigma V)\tan\delta' + Bc'_a + P_p}{P_a \cos\alpha}$$

FS (sliding) = 1.99

Bearing Capacity Failure:

$$\overline{X} = \frac{\Sigma M_R - \Sigma M_o}{\Sigma V} \qquad e = \frac{B}{2} - \overline{X}$$

$$q_{toe} = \frac{\Sigma V}{B}\left(1 + \frac{6e}{B}\right)$$

$$q_{heel} = \frac{\Sigma V}{B}\left(1 - \frac{6e}{B}\right)$$

X(bar) (ft) = 2.94	e (ft) = 0.81

q max/toe (psf) = 1913.16	q min/heel (psf) = 414.04

$$F_{cd} = F_{qd} - \frac{1 - F_{qd}}{N_c \tan\phi'_2}$$

Nc = 16.88	Fcd = 1.05	Fci = 1
Nq = 7.82	Fqd = 1.01	Fqi = 1
Nγ = 7.13	Fγd = 1	Fγi = 1

$$F_{qd} = 1 + 2\tan\phi'_2(1 - \sin\phi'_2)^2\frac{D}{B'}$$

$$F_{\gamma d} = 1$$

qu (psf) = 11227.24 $\quad q_u = c'_2 N_c F_{cd} F_{ci} + q N_q F_{qd} F_{qi} + \frac{1}{2}\gamma_2 B' N_\gamma F_{\gamma d} F_{\gamma i}$

FS (BC Failure) = 5.87

$$FS_{(bearing\ capacity)} = \frac{q_u}{q_{max}}$$

14’ Retaining Wall Failure Calculations

14' Retaining Wall Failure Calculations

Dimensions:

H (ft) = 14	W (ft) = 8	B (ft) = 1.25	C (ft) = 2.25
F (ft) = 1.17	E (ft) = 4.58	X (ft) = 2	D (ft) = 2.5

Earth Pressures:

γ (pcf) = 95	δ= 13	Kp = 0.37
c (psf) = 417	ca (psf) = 0	Ka = 0.39
ϕ (°) = 22	γc (pcf) = 150	α= 0

$$K_p = \tan^2\left(45 + \frac{\phi'_2}{2}\right).$$

$$K_a = \tan^2\left(45 - \frac{\phi'_1}{2}\right)$$

Pp (lb) = 2161.35	Ph (lb) = 3619.27	Pv (lb) = 0	Pa (lb) = 3619.271

$$P_p = \frac{1}{2}\gamma_2 D_1^2 K_p + 2c'_2 D_1 \sqrt{K_p}$$

$$P_a \cos\alpha = P_h = P_a$$

$$P_v = P_a \sin\alpha$$

$$P_a = \tfrac{1}{2}\gamma_1 H'^2 K_a$$

Section	Area (ft^2)	Weight (lb)	Moment Arm (ft)	Moment (lb*ft)
1	64.17	6095.83	5.71	34797.05
2	0	0	0	0.00
3	11.67	1750	3.42	5979.17
4	1.19	178.5	2.25	401.63
5	10	1500	4	6000.00
6	1.88	281.25	5.25	1476.56
	ΣV (lb) =	9805.58	ΣMr (lb) =	48654.40

Overturning:

$$FS_{(\text{overturning})} = \frac{\Sigma M_R}{\Sigma M_o}$$

ΣMo (lb*ft) = 18397.96

$$M_o = P_h\left(\frac{H'}{3}\right)$$

FS (overturning) = 2.64

Sliding Along Base:

$$FS_{(\text{sliding})} = \frac{(\Sigma V)\tan\delta' + Bc'_a + P_p}{P_a \cos\alpha}$$

FS (sliding) = 1.85

Bearing Capacity Failure:

$$\overline{X} = \frac{\Sigma M_R - \Sigma M_o}{\Sigma V} \qquad e = \frac{B}{2} - \overline{X}$$

$$q_{\text{toe}} = \frac{\Sigma V}{B}\left(1 + \frac{6e}{B}\right)$$

$$q_{\text{heel}} = \frac{\Sigma V}{B}\left(1 - \frac{6e}{B}\right)$$

X(bar) (ft) = 3.09	e (ft) = 0.91

q max/toe (psf) = 2066.25	q min/heel (psf) = 385.15

Nc = 16.88	Fcd = 1.04	Fci = 1
Nq = 7.82	Fqd = 1.01	Fqi = 1
Nγ = 7.13	Fγd = 1	Fγi = 1

$$F_{cd} = F_{qd} - \frac{1 - F_{qd}}{N_c \tan\phi'_2}$$

$$F_{qd} = 1 + 2\tan\phi'_2(1 - \sin\phi'_2)^2\frac{D}{B'}$$

$$F_{\gamma d} = 1$$

qu (psf) = 11301.61

$$q_u = c'_2 N_c F_{cd} F_{ci} + q N_q F_{qd} F_{qi} + \tfrac{1}{2}\gamma_2 B' N_\gamma F_{\gamma d} F_{\gamma i}$$

FS (BC Failure) = 5.47

$$FS_{(\text{bearing capacity})} = \frac{q_u}{q_{\max}}$$

15' Retaining Wall Failure Calculations

15' Retaining Wall Failure Calculations

Dimensions:

H (ft) = 15	W (ft) = 8.5	B (ft) = 1.25	C (ft) = 2.5
F (ft) = 1.25	E (ft) = 4.75	X (ft) = 1.17	D (ft) = 2.5

Earth Pressures:

γ (pcf) = 95	δ= 13	Kp = 0.37
c (psf) = 417	ca (psf) = 0	Ka = 0.389
ϕ (°) = 22	γc (pcf) = 150	α= 0

$$K_p = \tan^2\left(45 + \frac{\phi_2'}{2}\right).$$

$$K_a = \tan^2\left(45 - \frac{\phi_1'}{2}\right)$$

Pp (lb) = 2161.35	Ph (lb) = 4154.78	Pv (lb) = 0	Pa (lb) = 4154.78

$$P_p = \frac{1}{2}\gamma_2 D_1^2 K_p + 2c_2' D_1 \sqrt{K_p} \qquad P_a \cos\alpha = P_h = P_a \qquad P_v = P_a \sin\alpha \qquad P_a = \tfrac{1}{2}\gamma_1 H'^2 K_a$$

Section	Area (ft^2)	Weight (lb)	Moment Arm (ft)	Moment (lb*ft)
1	71.25	6768.75	6.13	41458.59
2	0	0	0	0.00
3	12.50	1875	3.75	7031.25
4	1.28	191.25	2.5	478.13
5	10.625	1593.75	4.25	6773.44
6	1.88	281.25	6.58	1851.56
	ΣV (lb) =	10710	ΣMr (lb) =	57592.97

Overturning:

$$\mathrm{FS}_{(\text{overturning})} = \frac{\Sigma M_R}{\Sigma M_o}$$

ΣMo (lb*ft) = 22505.04

$$M_o = P_h\left(\frac{H'}{3}\right)$$

FS (overturning) = 2.56

Sliding Along Base:

$$\mathrm{FS}_{(\text{sliding})} = \frac{(\Sigma V)\tan\delta' + Bc_a' + P_p}{P_a \cos\alpha}$$

FS (sliding) = 1.71

Bearing Capacity Failure:

$$\overline{X} = \frac{\Sigma M_R - \Sigma M_o}{\Sigma V} \qquad e = \frac{B}{2} - \overline{X}$$

$$q_{\text{toe}} = \frac{\Sigma V}{B}\left(1 + \frac{6e}{B}\right)$$

$$q_{\text{heel}} = \frac{\Sigma V}{B}\left(1 - \frac{6e}{B}\right)$$

X(bar) (ft) = 3.28	e (ft) = 0.97

q max/toe (psf) = 2126.12	q min/heel (psf) = 393.88

Nc = 16.88	Fcd = 1.04	Fci = 1
Nq = 7.82	Fqd = 1.01	Fqi = 1
Nγ = 7.13	Fγd = 1	Fγi = 1

$$F_{cd} = F_{qd} - \frac{1 - F_{qd}}{N_c \tan\phi_2'}$$

$$F_{qd} = 1 + 2\tan\phi_2'(1 - \sin\phi_2')^2\frac{D}{B'}$$

$$F_{\gamma d} = 1$$

qu (psf) = 11412.13

$$q_u = c_2' N_c F_{cd} F_{ci} + q N_q F_{qd} F_{qi} + \tfrac{1}{2}\gamma_2 B' N_\gamma F_{\gamma d} F_{\gamma i}$$

FS (BC Failure) = 5.37

$$\mathrm{FS}_{(\text{bearing capacity})} = \frac{q_u}{q_{\max}}$$

17' Retaining Wall Failure Calculations

17' Retaining Wall Failure Calculations

Dimensions:

H (ft) = 17	W (ft) = 10.17	B (ft) = 1.33	C (ft) = 2.75
F (ft) = 1.42	E (ft) = 6	X (ft) = 2.5	D (ft) = 2.5

Earth Pressures:

γ (pcf) = 95	δ= 13	Kp = 0.37
c (psf) = 417	ca (psf) = 0	Ka = 0.39
ϕ (°) = 22	γc (pcf) = 150	α= 0

$$K_p = \tan^2\left(45 + \frac{\phi_2'}{2}\right).$$

$$K_a = \tan^2\left(45 - \frac{\phi_1'}{2}\right)$$

Pp (lb) = 2161.35	Ph (lb) = 5336.58	Pv (lb) = 0	Pa (lb) = 5336.58

$$P_p = \frac{1}{2}\gamma_2 D_1^2 K_p + 2c_2' D_1 \sqrt{K_p}$$ $$P_a \cos\alpha = P_h = P_a$$ $$P_v = P_a \sin\alpha$$ $$P_a = \tfrac{1}{2}\gamma_1 H'^2 K_a$$

Section	Area (ft^2)	Weight (lb)	Moment Arm (ft)	Moment (lb*ft)
1	102	9690	6.835	66231.15
2	0	0	0	0
3	14.17	2125	4.17	8861.25
4	1.45	216.75	2.75	596.0625
5	13.521667	2028.25	4.75	9634.1875
6	1.88	281.25	6.25	1757.8125
	ΣV (lb) =	14341.25	ΣMr (lb) =	87080.46

Overturning: $$\text{FS}_{(\text{overturning})} = \frac{\Sigma M_R}{\Sigma M_o}$$ ΣMo (lb*ft) = 32606.50 $$M_o = P_h\left(\frac{H'}{3}\right)$$

FS (overturning) = 2.67

Sliding Along Base: $$\text{FS}_{(\text{sliding})} = \frac{(\Sigma V)\tan\delta' + Bc_a' + P_p}{P_a \cos\alpha}$$

FS (sliding) = 1.65

Bearing Capacity Failure: $$\overline{X} = \frac{\Sigma M_R - \Sigma M_o}{\Sigma V}$$ $$e = \frac{B}{2} - \overline{X}$$

$$q_{\text{toe}} = \frac{\Sigma V}{B}\left(1 + \frac{6e}{B}\right)$$

$$q_{\text{heel}} = \frac{\Sigma V}{B}\left(1 - \frac{6e}{B}\right)$$

X(bar) (ft) = 3.80	e (ft) = 1.28

q max/toe (psf) = 2480.30	q min/heel (psf) = 340.92

$$F_{cd} = F_{qd} - \frac{1 - F_{qd}}{N_c \tan\phi_2'}$$

Nc = 16.88	Fcd = 1.03	Fci = 1
Nq = 7.82	Fqd = 1.00	Fqi = 1
Nγ = 7.13	Fγd = 1	Fγi = 1

$$F_{qd} = 1 + 2\tan\phi_2'(1 - \sin\phi_2')^2 \frac{D}{B'}$$

$$F_{\gamma d} = 1$$

qu (psf) = 11717.21 $$q_u = c_2' N_c F_{cd} F_{ci} + q N_q F_{qd} F_{qi} + \tfrac{1}{2}\gamma_2 B' N_\gamma F_{\gamma d} F_{\gamma i}$$

FS (BC Failure) = 4.72 $$\text{FS}_{(\text{bearing capacity})} = \frac{q_u}{q_{\max}}$$

21' Retaining Wall Failure Calculations

21' Retaining Wall Failure Calculations

Dimensions:

H (ft) = 21	W (ft) = 11.5	B (ft) = 1.58	C (ft) = 3.25
F (ft) = 1.75	E (ft) = 6.5	X (ft) = 3.17	D (ft) = 2.5

Earth Pressures:

γ (pcf) = 95	δ= 13	Kp = 0.37
c (psf) = 417	ca (psf) = 0	Ka = 0.39
ϕ (°) = 22	γc (pcf) = 150	α= 0

$$K_p = \tan^2\left(45 + \frac{\phi'_2}{2}\right)$$

$$K_a = \tan^2\left(45 - \frac{\phi'_1}{2}\right)$$

Pp (lb) = 2992.73	Ph (lb) = 7881.28	Pv (lb) = 0	Pa (lb) = 8143.36

$$P_p = \frac{1}{2}\gamma_2 D_1^2 K_p + 2c'_2 D_1\sqrt{K_p} \qquad P_a\cos\alpha = P_h = P_a \qquad P_v = P_a\sin\alpha \qquad P_a = \tfrac{1}{2}\gamma_1 H'^2 K_a$$

Section	Area (ft^2)	Weight (lb)	Moment Arm (ft)	Moment (lb*ft)
1	136.5	12967.5	8.25	106981.88
2	0	0	0	0.00
3	17.50	2625	5	13125.00
4	1.79	267.75	3.25	870.19
5	18.208333	2731.25	5.75	15704.69
6	3.75	562.5	7.58	4265.63
	ΣV (lb) =	19154	ΣMr (lb) =	140947.38

Slope Heel of Wall at 45° and Extend Key to H=2.5 ft

$$P_a = \frac{1}{2}\gamma_1 K_a (H' - D')^2 + \frac{A}{2}\gamma_1 K_a[H'^2 - (H' - D')^2]$$

Pa1 (lb) = 7881.276

Soil friction angle, ϕ'_1 (deg)	A
20	0.28
25	0.14
30	0.06
35	0.03
40	0.018

Overturning:

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

ΣMo (lb*ft) = 61301.41

$$M_o = P_h\left(\frac{H'}{3}\right)$$

FS (overturning) = 2.30

Sliding Along Base:

$$FS_{(sliding)} = \frac{(\Sigma V)\tan\delta' + Bc'_a + P_p}{P_a\cos\alpha}$$

FS (sliding) = 1.51

Bearing Capacity Failure:

$$\overline{X} = \frac{\Sigma M_R - \Sigma M_o}{\Sigma V} \qquad e = \frac{B}{2} - \overline{X}$$

$$q_{toe} = \frac{\Sigma V}{B}\left(1 + \frac{6e}{B}\right)$$

$$q_{heel} = \frac{\Sigma V}{B}\left(1 - \frac{6e}{B}\right)$$

X(bar) (ft) = 4.16	e (ft) = 1.59

q max/toe (psf) = 3048.83	q min/heel (psf) = 282.30

Nc = 16.88	Fcd = 1.03	Fci = 1
Nq = 7.82	Fqd = 1.00	Fqi = 1
Nγ = 7.13	Fγd = 1	Fγi = 1

$$F_{cd} = F_{qd} - \frac{1 - F_{qd}}{N_c\tan\phi'_2}$$

$$F_{qd} = 1 + 2\tan\phi'_2(1 - \sin\phi'_2)^2\frac{D}{B'}$$

$$F_{\gamma d} = 1$$

qu (psf) = 11932.13

$$q_u = c'_2 N_c F_{cd} F_{ci} + q N_q F_{qd} F_{qi} + \tfrac{1}{2}\gamma_2 B' N_\gamma F_{\gamma d} F_{\gamma i}$$

FS (BC Failure) = 3.91

$$FS_{(bearing\ capacity)} = \frac{q_u}{q_{max}}$$

Appendix B: Hydraulic Design Calculations

100-YR Storm Rational Method Data

100-YR Storm Rational Method Data

Time of Concentration (Tc)

$$T_c = 11.4L^{0.5}K_b{}^{0.52}S^{-0.31}i^{-0.38}$$

Units

L (ft) =	1160	L (mi) =	0.2197
ΔH (ft) =	36	(6834 ft - 6798 ft)	
S (ft/mi) =	163.8621		
Kb (paved) =	0.02		

	T(hr)	i (in/hr)	Tc (hr)	T-Tc =
60 min	1	2.44	0.102484	0.897516
30 min	0.5	3.94	0.0854232	0.414577
15 min	0.25	5.86	0.0734621	0.176538
10 min	0.167	7.09	0.0683311	0.098336
5 min	0.083	9.31	0.0616117	0.021722

Although 5 min Tc is closer to T, minimum Tc = 10 min
per ADOT Hydrology Manual 2.2.4

Runoff (Q) for Impervious Surfaces

Runoff (Q) for Impervious Surfaces

$$Q_{Paved} = CiA$$

Units		
i (in/hr) =	7.09	
Road Area:	2	lanes
W (ft) =	12	
L (ft) =	1160	
A (Road) (ft^2) =	27840	
Gutter Area:	2	gutters
W (ft) =	3	
L (ft) =	700	
A (Gutter) (ft^2) =	4200	
Top of Walls Area:	2	walls
W (ft) =	0.833	10" Wall Tops per ADOT Retaining Wall Structural Detail SD 7.01
L (ft) =	700	
A (Top of Walls) (ft^2) =	1167	
A (total) (acres)=	0.762	(ft^2) / (43560ft^2/acre)
C (Impervious)=	0.95	Per ADOT Hydrology Manual Figure 2-1
Q (Impervious) (cfs) =	**5.13461**	

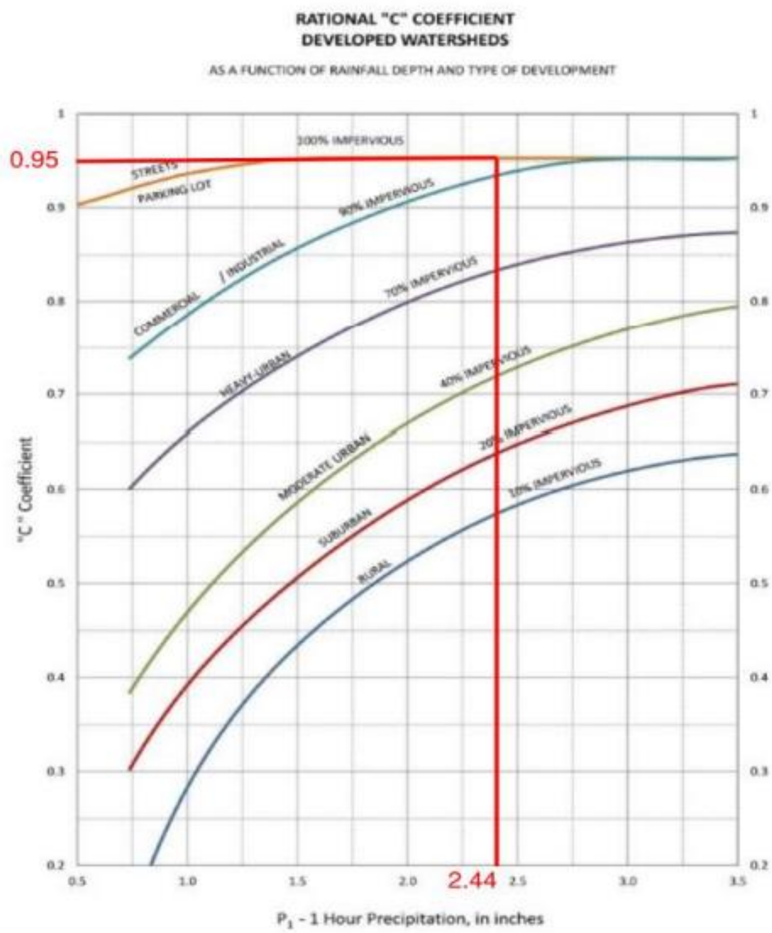


Figure 2-1 Rational "C" Coefficient – Developed Watersheds

Runoff (Q) for Pervious Surfaces

Runoff (Q) for Pervious Surfaces

$$Q_{Pervious} = CiA$$

Units			
i (in/hr) =	7.09		
Wall 1 Area:	2	Walls	
W (ft) =	13.25	(Width of Cantilever Heel + Height of Wall)	10+3.25
L (ft) =	100		
A (Road) (ft^2) =	2650		
Wall 2 Area:	2	Walls	
W (ft) =	16	(Width of Cantilever Heel + Height of Wall)	12+4
L (ft) =	100		
A (Road) (ft^2) =	3200		
Wall 3 Area:	2	Walls	
W (ft) =	17.25	(Width of Cantilever Heel + Height of Wall)	13+4.25
L (ft) =	100		
A (Road) (ft^2) =	3450		

Wall 4 Area:	2	Walls	
W (ft) =	18.5	(Width of Cantilever Heel + Height of Wall)	14+4.5
L (ft) =	100		
A (Road) (ft^2) =	3700		
Wall 5 Area:	2	Walls	
W (ft) =	19.75	(Width of Cantilever Heel + Height of Wall)	15+4.75
L (ft) =	100		
A (Road) (ft^2) =	3950		
Wall 6 Area:	2	Walls	
W (ft) =	22.333	(Width of Cantilever Heel + Height of Wall)	17+5.333
L (ft) =	100		
A (Road) (ft^2) =	4466.6		
Wall 7 Area:	2	Walls	
W (ft) =	27.5	(Width of Cantilever Heel + Height of Wall)	21+6.5
L (ft) =	100		
A (Road) (ft^2) =	5500		
A (Total) (acres) =	0.618	(ft^2) / (43560ft^2/acre)	
C (Impervious)=	0.54	Per ADOT Hydrology Manual Figure 2-4	
Q (Pervious) (cfs) =	**2.36577**		

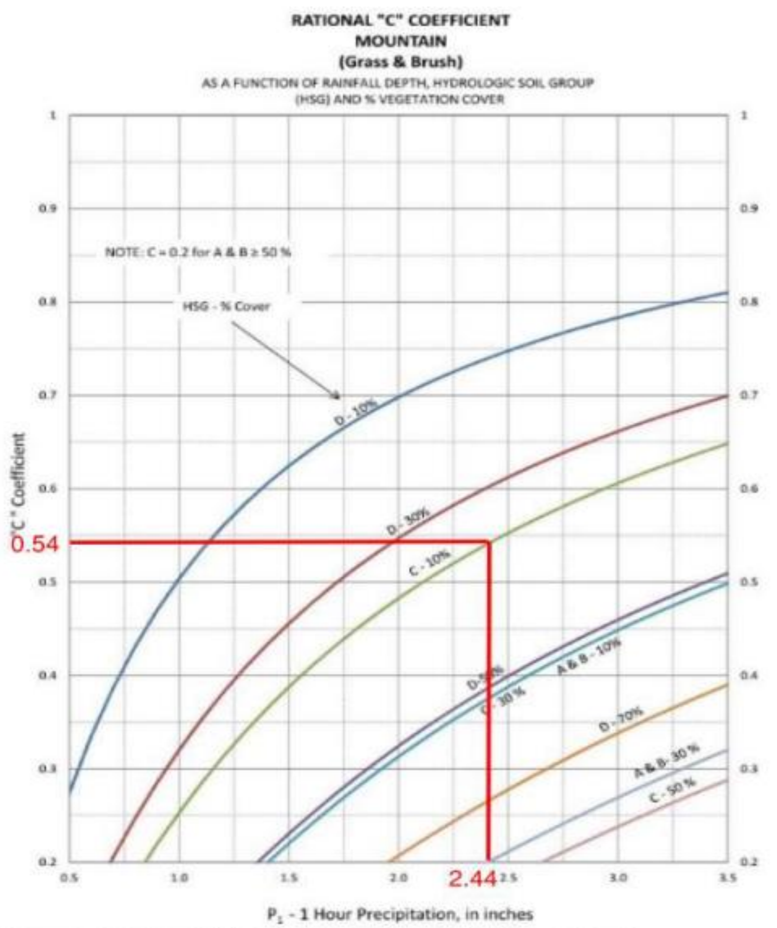


Figure 2-4 Rational "C" Coefficient – Mountain (Grass & Brush)

Total Water Storage Volume

Total Water Storage Volume:

Q (Impervious) (cfs) =	5.135
Q (Pervious) (cfs) =	2.366
Q (Total) (cfs) =	7.500
Tc (min) =	10
Tc (sec) =	600

Required Storage Volume (ft^3)= 4500
Recommended Volume (133%) Required Volume (ft^3) = 6000

Chamber Storage:

Stormtech Chamer Volume (with 9" Stone Foundation Depth) (ft^3) =	267.3
Stormtech Chamer Volume (with 12" Stone Foundation Depth) (ft^3) =	273.3
Stormtech Chamer Volume (with 15" Stone Foundation Depth) (ft^3) =	279.3
Stormtech Chamer Volume (with 18" Stone Foundation Depth) (ft^3) =	285.3
Stormtech End Cap Volume (with 9" Stone Foundation Depth) (ft^3) =	115.3
Stormtech End Cap Volume (with 12" Stone Foundation Depth) (ft^3) =	118.6
Stormtech End Cap Volume (with 15" Stone Foundation Depth) (ft^3) =	121.9
Stormtech End Cap Volume (with 18" Stone Foundation Depth) (ft^3) =	125.2

2 Trenches, 4 Caps @ 9" Depth =	21	Chambers	Divisible by 2?	No	NO GOOD
2 Trenches, 4 Caps @ 12" Depth =	21	Chambers	Divisible by 2?	No	NO GOOD
2 Trenches, 4 Caps @ 15" Depth =	20	Chambers	Divisible by 2?	Yes	OK
2 Trenches, 4 Caps @ 18" Depth =	20	Chambers	Divisible by 2?	Yes	OK
3 Trenches, 6 Caps @ 9" Depth =	20	Chambers	Divisible by 3?	No	NO GOOD
3 Trenches, 6 Caps @ 12" Depth =	20	Chambers	Divisible by 3?	No	NO GOOD
3 Trenches, 6 Caps @ 15" Depth =	19	Chambers	Divisible by 3?	No	NO GOOD
3 Trenches, 6 Caps @ 18" Depth =	19	Chambers	Divisible by 3?	No	NO GOOD

Use 2 Rows of 10 Chambers each

Nominal Chamber Specifications
(not to scale)

Size (L x W x H)
83" x 100" x 60"
2108 mm x 2540 mm x 1524 mm

Chamber Storage
175.9 ft³ (4.98 m³)

Min. Installed Storage*
267.3 ft³ (7.57 m³)

Weight
202 lbs (91.6 kg)

Nominal End Cap Specifications
(not to scale)

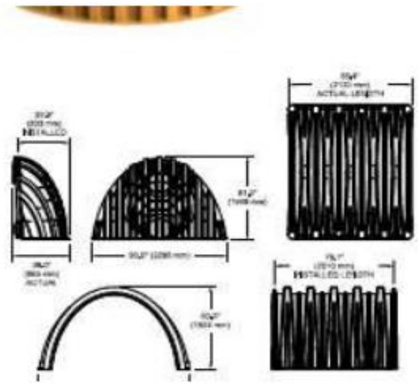
Size (L x W x H)
38" x 90" x 61"
965 mm x 2286 mm x 1549 mm

End Cap Storage
39.5 ft³ (1.12 m³)

Min. Installed Storage*
115.3 ft³ (3.26 m³)

Weight
Nominal 90.0 lbs (40.8 kg)

*Assumes a minimum of 12" (300 mm)



StormTech MC-7200 Specifications

Storage Volume Per Chamber

	Bare Chamber Storage ft³ (m³)	Chamber and Stone Foundation Depth in. (mm)			
		9 in (230 mm)	12 in (300 mm)	15 in (375 mm)	18 in (450 mm)
Chamber	175.9 (4.98)	267.3 (7.57)	273.3 (7.74)	279.3 (7.91)	285.3 (8.08)
End Cap	39.5 (1.12)	115.3 (3.26)	118.6 (3.36)	121.9 (3.45)	125.2 (3.54)

Note: Assumes 9" (230 mm) row spacing, 40% stone porosity, 12" (300 mm) stone above and includes the bare chamber/end cap volume. End cap volume assumes 12" (300 mm) stone perimeter in front of end cap.

Amount of Stone Per Chamber

English Tons (yds³)	Stone Foundation Depth			
	9 in	12 in	15 in	18 in
Chamber	12.1 (8.5)	12.9 (9.0)	13.6 (9.6)	14.3 (10.1)
End Cap	9.8 (7.0)	10.2 (7.3)	10.6 (7.6)	11.1 (7.9)
Metric Kilograms (m³)	230 mm	300 mm	375 mm	450 mm
Chamber	10977 (6.5)	11703 (6.9)	12338 (7.3)	12973 (7.7)
End Cap	8890 (5.3)	9253 (5.5)	9616 (5.8)	10069 (6.0)

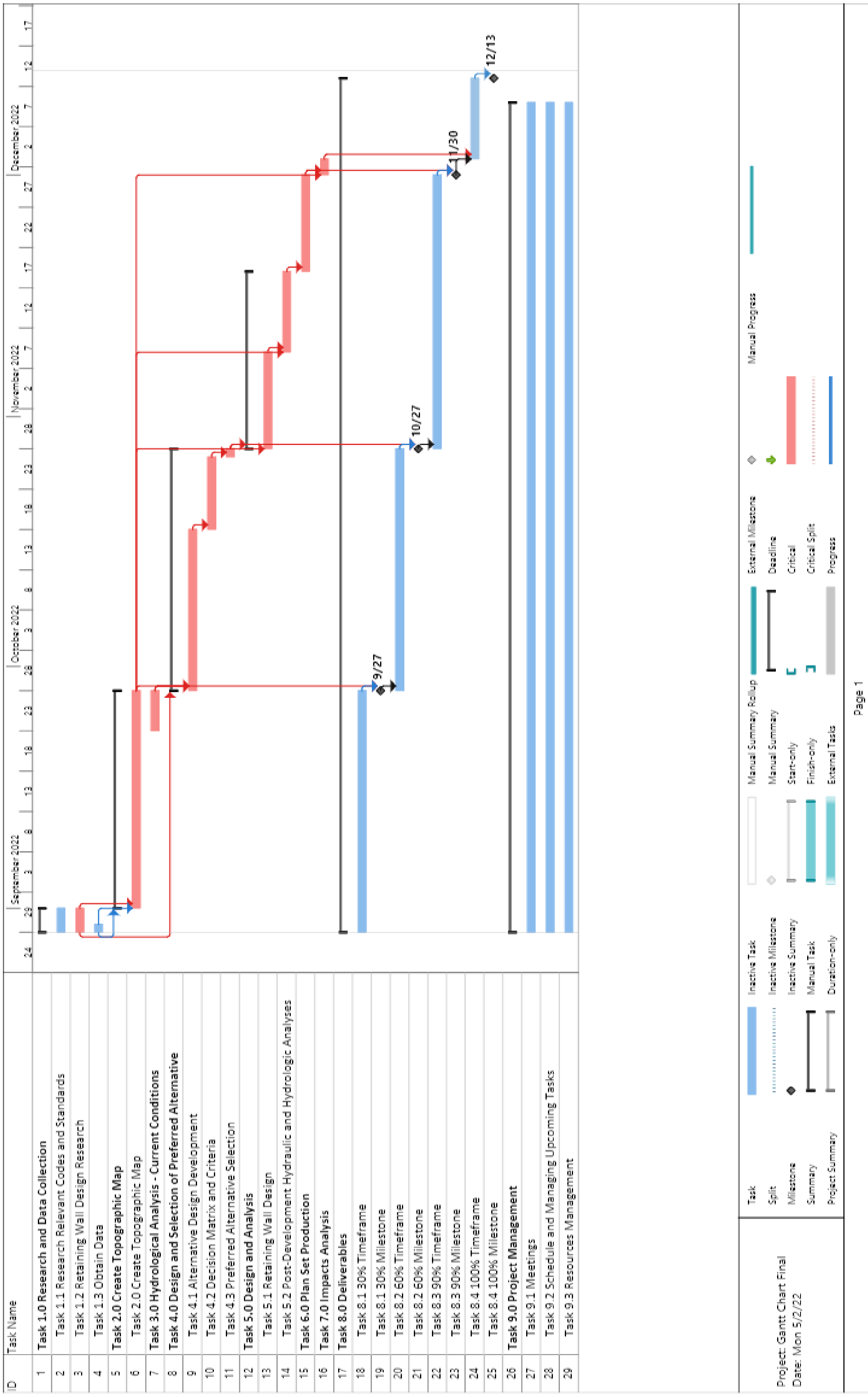
Note: Assumes 12" (300 mm) of stone above and 9" (230 mm) row spacing and 12" (300 mm) of perimeter stone in front of end caps. 1 yd³ = 1.42 english tons.

Volume Excavation Per Chamber yd³ (m³)

	Stone Foundation Depth			
	9 in (230 mm)	12 in (300 mm)	15 in (375mm)	18 in (450 mm)
Chamber	17.2 (13.2)	17.7 (13.5)	18.3 (14.0)	18.8 (14.4)
End Cap	9.7 (7.4)	10.0 (7.6)	10.3 (7.9)	10.6 (8.1)

Note: Assumes 9" (230 mm) of separation between chamber rows, 12" (300 mm) of perimeter in front of the end caps, and 24" (600 mm) of cover. The volume of excavation will vary as depth of cover increases.

Appendix C: Gantt Chart



Appendix D: Plan Set

Plan Set is attached below.

BUILDING, DRAINAGE, AND WATER/SEWER PLANS
PURINA FACILITY NEW ENTRANCE
APN: 113-28-004F
FLAGSTAFF, AZ, 86004

CITY OF FLAGSTAFF GENERAL NOTES

1. APPROVAL OF THESE PLANS BY THE CITY ENGINEER IS FOR A ONE (1) YEAR PERIOD, SUBSEQUENT TO THE DATE OF APPROVAL. IF CONSTRUCTION WORK IS NOT STARTED WITHIN THE ONE (1) YEAR PERIOD, OR HAS BEEN DISCONTINUED FOR ANY REASON FOR LONGER THAN ONE (1) YEAR, THE PLANS SHALL BE RESUBMITTED FOR REVIEW AND RE-APPROVAL.

2. PLAN REVIEW BY THE CITY DOES NOT EXTEND TO MATERIAL QUANTITIES SHOWN ON THE PLANS.

3. A PUBLIC WORKS PERMIT, ISSUED BY THE CITY, IS REQUIRED FOR ALL WORK IN CITY RIGHTS-OF-WAY OR EASEMENTS AND FOR CONSTRUCTION OF ANY IMPROVEMENTS INTENDED TO BECOME PUBLIC PROPERTY.

4. THE CITY SHALL BE NOTIFIED TWENTY-FOUR (24) HOURS PRIOR TO BEGINNING DIFFERENT PHASES OF CONSTRUCTION SO THAT CITY INSPECTORS MAY BE SCHEDULED.

5. ALL MATERIALS AND WORKMANSHIP SHALL COMPLY WITH TITLE 13, ENGINEERING DESIGN STANDARDS AND SPECIFICATIONS FOR NEW INFRASTRUCTURE, CURRENT "MAG UNIFORM STANDARD SPECIFICATIONS AND DETAILS FOR PUBLIC WORKS CONSTRUCTION," THE CITY OF FLAGSTAFF STORMWATER DESIGN MANUAL, AND WITH GENERALLY ACCEPTED ENGINEERING DESIGN AND CONSTRUCTION PRACTICE. ALL WORK AND MATERIALS, WHICH DO NOT CONFORM TO THE STANDARDS AND SPECIFICATIONS, ARE SUBJECT TO REMOVAL AND REPLACEMENT AT THE CONTRACTOR'S EXPENSE. THE CONTRACTOR IS RESPONSIBLE FOR REVIEWING CHAPTER 13-21, WHICH MAKES MINOR MODIFICATIONS TO CERTAIN MAG SPECIFICATIONS AND DETAILS.

6. ANY WORK PERFORMED WITHOUT THE KNOWLEDGE AND APPROVAL OF THE CITY ENGINEER OR HIS AUTHORIZED REPRESENTATIVE IS SUBJECT TO REMOVAL AND REPLACEMENT AT THE CONTRACTOR'S EXPENSE.

7. THE CITY ENGINEER OR HIS AUTHORIZED REPRESENTATIVE MAY SUSPEND THE WORK BY WRITTEN NOTICE WHEN, IN HIS JUDGMENT, PROGRESS IS UNSATISFACTORY, WORK BEING DONE IS UNAUTHORIZED OR DEFECTIVE, WEATHER CONDITIONS ARE UNSUITABLE, OR THERE IS DANGER TO THE PUBLIC HEALTH OR SAFETY.

8. THE CITY ENGINEER MAY ORDER ANY OR ALL MATERIALS USED IN THE WORK TO BE TESTED ACCORDING TO THE AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO) AND THE AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM) STANDARDS. THE CONTRACTOR SHALL, AT HIS EXPENSE, SUPPLY ALL SAMPLES REQUIRED FOR TESTING.

9. ACCESS THAT MEETS SECTION 13-13-004-0001, FIRE ACCESS, SHALL BE IN PLACE AND APPROVED BEFORE AND AT ALL TIMES DURING ON-SITE COMBUSTIBLE CONSTRUCTION AND/OR PRIOR TO ISSUANCE OF BUILDING PERMITS IN NEW SUBDIVISIONS. FIRE DEPARTMENT AND ENGINEERING SECTION APPROVAL IS REQUIRED FOR OBSTRUCTION OF ACCESS OR WATER SYSTEM SHUTDOWN.

10. THE CONTRACTOR SHALL BE RESPONSIBLE FOR MAINTENANCE OF THE STREETS AND OF PARTIALLY COMPLETED PORTIONS OF THE WORK UNTIL FINAL ACCEPTANCE OF THE WORK. THE CONTRACTOR SHALL SUBMIT TO THE CITY ENGINEER FOR APPROVAL A CONSTRUCTION SCHEDULE FOR ANY STREETS REQUIRED TO BE CLOSED OR PARTIALLY CLOSED FOR THE CONSTRUCTION ACTIVITY. THE CONTRACTOR SHALL REOPEN THE STREETS NO LATER THAN THE OPENING DATE SHOWN ON THE CONSTRUCTION SCHEDULE OR UPON ORDER OF THE CITY ENGINEER. THE REGULATION AND CONTROL OF CONSTRUCTION TRAFFIC SHALL BE AS DIRECTED BY THE CITY ENGINEER OR HIS AUTHORIZED REPRESENTATIVE.

11. APPROVAL OF A PORTION OF THE WORK IN PROGRESS DOES NOT GUARANTEE ITS FINAL ACCEPTANCE. TESTING AND EVALUATION MAY CONTINUE UNTIL WRITTEN FINAL ACCEPTANCE OF A COMPLETE WORKABLE UNIT. ANY DEFECTS WHICH APPEAR IN THE WORK WITHIN ONE (1) YEAR FROM THE DATE OF ACCEPTANCE AND WHICH ARE DUE TO IMPROPER WORKMANSHIP OR INFERIOR MATERIALS SUPPLIED SHALL BE CORRECTED BY OR AT THE EXPENSE OF THE OWNER/DEVELOPER OR THE CONTRACTOR.

12. ACCEPTANCE OF COMPLETED PUBLIC IMPROVEMENTS WILL NOT BE GIVEN UNTIL DEFECTIVE OR UNAUTHORIZED WORK IS REMOVED, AND FINAL CLEAN-UP IS COMPLETE.

13. LOCATION OF UNDERGROUND UTILITIES BEFORE WORK IS BEGUN IS TO BE ACCOMPLISHED IN ACCORDANCE WITH A.R.S. SECTION 40-360.22.

14. IF WORK IS DONE ON PRIVATE PROPERTY IN RELATION TO A PROJECT CONSTRUCTED UNDER THESE STANDARDS, THE CONTRACTOR WILL PROVIDE THE CITY WITH WRITTEN AUTHORIZATION FROM THE PROPERTY OWNER TO DO SO.

15. THE ESTABLISHMENT AND USE OF TEMPORARY CONSTRUCTION YARDS SHALL CONFORM TO THE CURRENT CITY ZONING CODE STANDARDS FOR TEMPORARY USES.

16. ALL EXCAVATED MATERIAL SHALL BE DISPOSED OF IN ACCORDANCE WITH APPLICABLE CITY CODES AND REGULATIONS. THE CONTRACTOR SHALL OBTAIN ALL REQUIRED CITY APPROVALS AND PERMITS AS DEEMED NECESSARY BY THE CITY TO DISPOSE OF EXCAVATED MATERIAL.

17. ALL CONSTRUCTION STAKING SHALL BE THE RESPONSIBILITY OF THE CONTRACTOR/DEVELOPER AND PERFORMED UNDER THE DIRECT SUPERVISION OF A REGISTERED LAND SURVEYOR OR CIVIL ENGINEER.

18. ALL TRAFFIC SIGN SHEETING SHALL BE TYPE VIII AS DESIGNED BY ASTM D4956-07E1 STANDARD SPECIFICATIONS FOR RETROREFLECTIVE SHEETING FOR TRAFFIC CONTROL, UNLESS SPECIFIED OTHERWISE ON THE CONSTRUCTION PLANS.

19. WHEN THE CONSTRUCTION PLANS SPECIFY GRAFFITI CONTROL ON BRIDGES OR OTHER STRUCTURES, THE CONTRACTOR SHALL SEAL THE STRUCTURE FIRST USING MONOCHEM AQUASEAL ME 12 AND THEN APPLY MONOCHEM PERMASHIELD, SACRIFICIAL GRAFFITI CONTROL SYSTEM (OR APPROVED EQUAL).

20. ALL AREAS DISTURBED DURING CONSTRUCTION SHALL BE STABILIZED AND RESEEDED IN ACCORDANCE WITH CHAPTER 13-17. IN THE EVENT THAT THE CONSTRUCTION ACTIVITY DISTURBS MORE THAN ONE (1) ACRE, A STORMWATER POLLUTION PREVENTION PLAN (SWPPP) SHALL BE PREPARED IN ORDER TO OBTAIN A CONSTRUCTION GENERAL PERMIT FROM ADEQ. (ORD. 2017-22, REP&REEN, 07/05/2017)

21. ALL SURVEY MONUMENTS WITHIN OR AROUND THE CONSTRUCTION AREA SHALL BE PROTECTED IN PLACE. ANY MONUMENTS THAT ARE DISTURBED OR DISPLACED BY CONSTRUCTION SHALL BE RESET BY THE RLS AT THE CONTRACTOR'S EXPENSE IN ACCORDANCE WITH CITY OF FLAGSTAFF ENGINEERING STANDARDS SECTION 13-03-005-0004 AND A.R.S. 33-103.

CITY OF FLAGSTAFF WATER AND SEWER NOTES

ALL DESIGN, CONSTRUCTION, TESTING AND INSPECTION SHALL CONFORM TO THE ADEQ REQUIREMENTS: WATER DISTRIBUTION IN ACCORDANCE WITH BULLETINS 10 AND 8, AND SEWER COLLECTION IN ACCORDANCE WITH AAC TITLE 18. IN THE EVENT THE ADEQ REQUIREMENTS CONFLICT WITH THESE STANDARDS, THE MORE RESTRICTIVE SHALL APPLY.

A. ROUGH GRADING SHALL BE COMPLETED WITHIN ONE-TENTH (1/10) OF A FOOT OF PLAN GRADE AND APPROVED BY THE CITY ENGINEER'S AUTHORIZED REPRESENTATIVES PRIOR TO INSTALLATION OF UNDERGROUND UTILITIES.

B. NO TRENCH SHALL BE FILLED WITH BEDDING MATERIAL OR BACKFILL UNTIL THE EXCAVATION AND PIPE LAYING, RESPECTIVELY, HAVE BEEN APPROVED BY THE CITY ENGINEER'S AUTHORIZED REPRESENTATIVE.

C. A WATER PRESSURE TEST IS REQUIRED OF ALL WATER LINES AND A HYDROSTATIC OR AIR TEST IS REQUIRED OF ALL SEWER LINES AND MANHOLES. TESTS ARE TO BE CONDUCTED AFTER BACKFILLING IS COMPLETE AND COMPACTED ON ALL PUBLIC AND/OR PRIVATE UNDERGROUND UTILITIES.

D. WATER AND SEWER SERVICE LINES ARE TO BE MARKED AS SHOWN ON THE STANDARD SERVICE DETAILS.

E. WATER LINE DISINFECTION IS TO BE ACCOMPLISHED AS OUTLINED IN ARIZONA DEPARTMENT OF ENVIRONMENTAL QUALITY (ADEQ) "BULLETIN NO. 8."

F. WATER PIPE CLASSIFICATION SHALL BE CLASS 305 FOR A.W.W.A. C-900 PVC AND CLASS 350 FOR DUCTILE IRON UNLESS OTHERWISE APPROVED BY THE CITY ENGINEER. C-900 SHALL CONFORM TO CAST-IRON-EQUIVALENT OUTSIDE DIAMETER AND HAVE ELASTROMERIC GASKETS AND COUPLINGS. ALL DUCTILE IRON PIPE SHALL BE POLYETHYLENE ENCASED IN ACCORDANCE WITH MAG SPECIFICATIONS.

G. ALL MATERIALS THAT COME INTO CONTACT WITH DRINKING WATER SHALL CONFORM TO NSF STANDARD 61 INCLUDING, BUT NOT LIMITED TO, GASKETS, LUBRICANTS, PIPE FITTINGS, AND VALVES (NSF-PW SEAL) (R18-4-119B).

H. ALL PUBLIC SANITARY SEWER LINES AND PRIVATE SEWER SERVICE LINES WITHIN A PUBLIC UTILITY EASEMENT OR RIGHT-OF-WAY WILL BE INSPECTED PRIOR TO ACCEPTANCE BY THE CITY.

I. WATER AND SEWER MAINS SHALL BE SEPARATED IN ORDER TO PROTECT PUBLIC WATER SYSTEMS FROM POSSIBLE CONTAMINATION. ALL DISTANCES ARE MEASURED PERPENDICULARLY FROM THE OUTSIDE OF THE SEWER MAIN TO THE OUTSIDE OF THE WATER MAIN. SEPARATION REQUIREMENTS ARE AS FOLLOWS:

1. A WATER MAIN SHALL NOT BE PLACED:

   a. WITHIN SIX (6) FEET, HORIZONTAL DISTANCE, AND LESS THAN TWO (2) FEET, VERTICAL DISTANCE, ABOVE THE TOP OF A SEWER MAIN UNLESS EXTRA PROTECTION IS PROVIDED. EXTRA PROTECTION SHALL CONSIST OF CONSTRUCTING THE SEWER MAIN WITH MECHANICAL JOINT DUCTILE IRON PIPE OR WITH SLIP-JOINT DUCTILE IRON PIPE IF JOINT RESTRAINT IS PROVIDED. ALTERNATE EXTRA PROTECTION SHALL CONSIST OF ENCASING BOTH THE WATER AND SEWER MAINS IN AT LEAST SIX (6) INCHES OF CONCRETE FOR AT LEAST TEN (10) FEET BEYOND THE AREA COVERED BY THIS SUBSECTION.

   b. WITHIN TWO (2) FEET HORIZONTALLY AND TWO (2) FEET BELOW THE SEWER MAIN. WHEN A WATER MAIN IS PLACED BELOW A SEWER MAIN, EXTRA PROTECTION IS ALWAYS REQUIRED REGARDLESS OF THE VERTICAL SEPARATION.

2. NO WATER PIPE SHALL PASS THROUGH OR COME INTO CONTACT WITH ANY PART OF A SEWER MANHOLE. THE MINIMUM HORIZONTAL SEPARATION BETWEEN WATER MAINS AND MANHOLES SHALL BE SIX (6) FEET, MEASURED FROM THE CENTER OF THE MANHOLE.
3. THE MINIMUM SEPARATION BETWEEN FORCE MAINS OR PRESSURE SEWERS AND WATER MAINS SHALL BE TWO (2) FEET VERTICALLY AND SIX (6) FEET HORIZONTALLY UNDER ALL CONDITIONS. WHERE A SEWER FORCE MAIN CROSSES ABOVE OR LESS THAN SIX (6) FEET BELOW A WATER LINE, THE SEWER MAINS SHALL BE ENCASED IN AT LEAST SIX (6) INCHES OF CONCRETE OR CONSTRUCTED USING MECHANICAL JOINT DUCTILE IRON PIPE FOR TEN (10) FEET ON EITHER SIDE OF THE WATER MAIN.
4. EVEN WHEN EXTRA PROTECTION IS UTILIZED, THE MINIMUM CLEARANCE BETWEEN WATER AND SEWER SHALL BE ONE (1) FOOT.
5. THE SEPARATION REQUIREMENTS DO NOT APPLY TO BUILDING, PLUMBING, OR INDIVIDUAL HOUSE SERVICE CONNECTIONS.

J. WHEN HYDROSTATIC TESTING IS PERFORMED, SEWER LINES SHALL BE TESTED FOR INFILTRATION/EXFILTRATION IN ACCORDANCE WITH ADEQ ENGINEERING BULLETIN NO. 11. MANHOLES SHALL BE TESTED BY FILLING THE MANHOLE WITH WATER. THE APPLICANT SHALL ENSURE THAT THE DROP IN WATER LEVEL DOES NOT EXCEED ONE-THOUSANDTH (0.001) OF THE TOTAL MANHOLE VOLUME IN ONE (1) HOUR.

WHEN AIR TESTING IS PERFORMED, SEWER LINES SHALL BE TESTED IN ACCORDANCE WITH ASTM F1417-92. MANHOLES SHALL BE TESTED IN ACCORDANCE WITH ASTM C1244.

K. SEWER PIPE SHALL BE SDR 35, ASTM D3034 FOR PVC PIPE, OR CLASS 150 DIP LINED WITH PROTECTO 401 CERAMIC EPOXY OR HDPE ASTM F894. ALL DUCTILE IRON PIPELINES SHALL BE POLYETHYLENE ENCASED IN ACCORDANCE WITH MAG SPECIFICATIONS. SPECIAL DESIGN CONSIDERATIONS MAY REQUIRE A HIGHER CLASS RATING OF DIP.

L. NO WATER SETTLING OF TRENCH FILL MATERIAL IS ALLOWED.

M. ALL WATER AND SEWER DESIGN AND CONSTRUCTION SHALL CONFORM TO THE CURRENT ARIZONA DEPARTMENT OF ENVIRONMENTAL QUALITY (ADEQ) REQUIREMENTS. WHEN ADEQ REQUIREMENTS ARE IN CONFLICT WITH THESE STANDARDS, THE MORE RESTRICTIVE SHALL APPLY.

N. TRACER WIRES AND TAPES SHALL BE INSTALLED PRIOR TO TESTING THE WATER OR SEWER MAIN AS REQUIRED BY SECTION 13-09-001-0002. (STRIP WIRE TWO (2) INCHES AT TERMINATION OF THE SERVICE.)

O. WATER VALVES SHALL BE ADJUSTED IN ACCORDANCE WITH CITY OF FLAGSTAFF ENGINEERING DETAIL NO. 9-03-060 AND MANHOLES SHALL BE ADJUSTED IN ACCORDANCE WITH CITY OF FLAGSTAFF ENGINEERING DETAIL NO. 9-03-062.

P. ONE HUNDRED PERCENT (100%) OF THE SEWER LINE SHALL BE TESTED FOR UNIFORM SLOPE BY REMOTE CAMERA AND TESTED FOR SHORT-TERM DEFLECTION.

   1. WHEN A SEWER SERVICE IS REQUIRED TO BE ABANDONED, IT SHALL BE ABANDONED AT THE PROPERTY LINE AND CAPPED USING THE APPROPRIATE MATERIALS (PVC, CLAY, OR CONCRETE).
   2. WHEN AN EXISTING WATER SERVICE IS REQUIRED TO BE ABANDONED, IT SHALL BE ABANDONED AT THE MAIN. THE SADDLE AND CORP. STOP SHALL BE REMOVED AND THE MAIN CLAMPED WITH AN APPROVED FULL CIRCLE REPAIR CLAMP.

Q. THE LOCATION OF WATER SERVICES SHALL BE IDENTIFIED BY BRANDING A "W" ON THE TOP OR FACE OF CURB.

R. SEWER SERVICE LOCATIONS SHALL BE IDENTIFIED BY BRANDING AN "S" ON THE TOP OR FACE OF THE CURB. (ORD. 2017-22, REP&REEN, 07/05/2017)

CITY OF FLAGSTAFF PAVING NOTES

A. EXACT POINT OF MATCHING TERMINATION AND OVERLAY, IF NECESSARY, SHALL BE DETERMINED IN THE FIELD BY THE CITY ENGINEER OR HIS AUTHORIZED REPRESENTATIVE. WHEN A LONGITUDINAL JOINT ASSOCIATED WITH A TRENCH PATH, PAVEMENT MATCHUP OR OTHER OCCURS ON A STREET THAT INCLUDES A BIKE LANE, THE JOINT SHALL BE LOCATED OUTSIDE THE BIKE LANE.

B. NO JOB WILL BE CONSIDERED COMPLETE UNTIL:
1. ALL CURBS, PAVEMENTS, SIDEWALKS, CATCH BASINS, STORM DRAINS, AND MANHOLES HAVE BEEN CLEANED OF ALL DIRT AND DEBRIS;
2. SURVEY MONUMENTS ARE INSTALLED AND STAMPED; AND
3. ALL FRAMES, COVERS, AND VALVE BOXES ARE ADJUSTED TO GRADE.

C. NO PAVING CONSTRUCTION SHALL BE STARTED UNTIL ALL UTILITY LINES ARE COMPLETED AND APPROVED UNDER PROPOSED PAVED AREAS.

D. BASE COURSE WILL NOT BE PLACED UNTIL SUBGRADE HAS BEEN APPROVED BY THE CITY ENGINEER OR HIS AUTHORIZED REPRESENTATIVE.

E. THE LOCATION OF ALL WATER VALVES, FIRE HYDRANTS, AND MANHOLES MUST AT ALL TIMES DURING CONSTRUCTION BE REFERENCED AND MADE ACCESSIBLE TO THE CITY.

F. UTILITY FACILITIES IN CONFLICT WITH THIS WORK WILL BE RELOCATED BY THE PERMITTEE OR THE UTILITY OWNER. THIS ACTIVITY SHALL BE COORDINATED WITH THE OWNER OF THE UTILITY TO PREVENT ANY UNNECESSARY INTERRUPTION OF SERVICE TO EXISTING CUSTOMERS.

G. EXISTING STREET NAME SIGNS, TRAFFIC SIGNS AND DEVICES ASSOCIATED WITH THE PROJECT SHALL BE MAINTAINED DURING CONSTRUCTION AND RELOCATED BY THE CONTRACTOR AS SHOWN ON THE APPROVED PLANS.

H. ANY CHANGES OR ADDITIONS TO PAVEMENT MARKINGS CAUSED BY PAVEMENT OVERLAY, CHIP SEAL, OR INSTALLATION OF UNDERGROUND FACILITIES SHALL BE SHOWN ON THE APPROVED PLANS.

I. ON PROJECTS WHERE THE CONTRACTOR CAUSES EXCESSIVE DAMAGE TO AN EXISTING PAVED STREET OR THERE ARE MULTIPLE STREET CUTS (MAXIMUM OF FOUR (4) IN FIVE HUNDRED (500) FEET) AN ASPHALT OVERLAY SHALL BE REQUIRED.

J. A PRIME COAT IS NOT REQUIRED UNLESS SO SPECIFIED IN THE SOILS AND PAVEMENT REPORT AND/OR SHOWN ON THE PLANS.

K. ALL CURB AND GUTTER, SIDEWALK, DRIVEWAYS, AND SIDEWALK RAMPS SHALL BE CONSTRUCTED ON A MINIMUM THREE (3) INCHES OF AGGREGATE BASE COURSE (ABC). THE ABC SHALL BE CONSTRUCTED IN ACCORDANCE WITH MAG SECTION 310, AND SHALL BE COMPACTED TO NINETY-FIVE PERCENT (95%) RELATIVE DENSITY. ALL PRECAST STRUCTURES SUCH AS MANHOLE BASES, CATCH BASINS, AND BOX CULVERTS SHALL BE CONSTRUCTED ON A MINIMUM OF THREE (3) INCHES OF ABC.

L. PERMANENT PAVEMENT MARKINGS.
1. LONGITUDINAL PAVEMENT MARKINGS SHALL BE INSTALLED IN ACCORDANCE WITH SECTION 13-16-006-0001.
2. TRANSVERSE PAVEMENT MARKINGS SUCH AS STOP BARS, CROSSWALKS, ARROWS, AND LEGENDS SHALL BE INSTALLED IN ACCORDANCE WITH SECTION 13-16-006-0002.

M. TEMPORARY PAVEMENT MARKINGS.
1. TEMPORARY PAVEMENT MARKINGS, WHEN APPROVED, SHALL BE INSTALLED IN ACCORDANCE WITH SECTIONS 13-16-006-0001 AND 13-16-006-0002.
   NOTES:
   1. THE USE OF TEMPORARY MARKINGS IS STRONGLY DISCOURAGED AND MAY ONLY BE USED WITH PRIOR APPROVAL.WHEN IT IS USED, THE CONTRACTOR MUST BE AVAILABLE TO RESTRIPE AS NEEDED UNTIL THE PERMANENT MARKINGS CAN BE INSTALLED.
2. WHEN IT IS IMPRACTICABLE FOR THE CONTRACTOR TO PROVIDE PERMANENT MARKINGS, THE CITY PUBLIC WORKS DEPARTMENT MAY INSTALL THE MARKINGS ON BEHALF OF THE CONTRACT PROVIDED THE FEE FOR THE WORK IS AGREED UPON AND PAID FOR IN ADVANCE.

N. THE MAXIMUM THICKNESS OF A SINGLE LIFT OF PAVEMENT SHALL BE FOUR (4) INCHES. (ORD. 2017-22, REP&REEN, 07/05/2017)

GENERAL NOTES

WORK SHALL BE DONE IN ACCORDANCE WITH THE MOST CURRENT EDITION(S) OF THE FOLLOWING SPECIFICATIONS AND THESE PLANS. MAG UNIFORM STANDARD SPECIFICATIONS FOR PUBLIC WORKS CONSTRUCTION, MAG UNIFORM STANDARD DETAILS FOR PUBLIC WORKS CONSTRUCTION, CITY OF FLAGSTAFF ENGINEERING DESIGN AND CONSTRUCTION STANDARDS WITH MAG ADDENDUM AS APPROPRIATE, ADEQ ENGINEERING BULLETINS NO. 8 , 10, 11 AND 12. AW.W.A. STANDARDS MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES (M.U.T.C.D.), A.D.O.T. STANDARD SPECIFICATIONS AND DRAWINGS.

IT SHALL BE THE CONTRACTOR'S RESPONSIBILITY TO OBTAIN COPIES OF THE ABOVE STANDARDS, SPECIFICATIONS AND DETAILS, AS WELL AS ALL OTHER STANDARDS AND SPECIFICATIONS WHICH MAY BE NECESSARY TO COMPLETELY AND ACCURATELY INTERPRET THESE PLANS.

ALL QUANTITIES SHOWN ARE APPROXIMATE AND ARE FURNISHED SOLELY FOR THE CONTRACTOR'S CONVENIENCE. THEY DO NOT NECESSARILY CORRESPOND TO BID SCHEDULE ITEMS. PAYMENT WILL BE BASED ON BID SCHEDULE ITEMS THE CONTRACTOR SHALL NOT BE RELIEVED OF RESPONSIBILITY FOR INDEPENDENTLY ESTIMATED QUANTITIES PRIOR TO BIDDING.

THE LOCATION OF EXISTING FEATURES INDICATED ON THE PLANS ARE APPROXIMATE ONLY. THE CONTRACTOR SHALL NOT BE RELIEVED OF RESPONSIBILITY FOR MAKING COMPLETE AND ACCURATE ON-SITE DETERMINATIONS OF THE LOCATIONS OF ALL UTILITIES, STRUCTURES AND FIELD CONDITIONS, WHICH MAY AFFECT THE PROGRESS OF THE WORK.

THE CONTRACTOR IS RESPONSIBLE FOR DETERMINING WHAT PERMITS WILL BE REQUIRED FOR THE WORK AND OBTAINING AT HIS OWN EXPENSE ALL PERMITS REQUIRED UNLESS STATED OTHERWISE IN THE CONTRACT.

DEVELOPEMENT NAME:	PURINA FACILITY NEW ENTRANCE
SITE ADDRESS:	111
ASSESSOR'S PARCEL NUMBER:	APN: 113-28-004F
PROPERTY OWNER:	801 CHECKERBOARD SQUARE TAX DEPT 4C SAINT LOUIS, MO 63164
APPLICANT:	NESTLE PURINA INC.
PREPARER:	HIGH COUNTRY ENGINEERING, INC. TYLER DERZAY 2112 S HUFFER LN. FLAGSTAFF, AZ 86001 (928) 123-4567

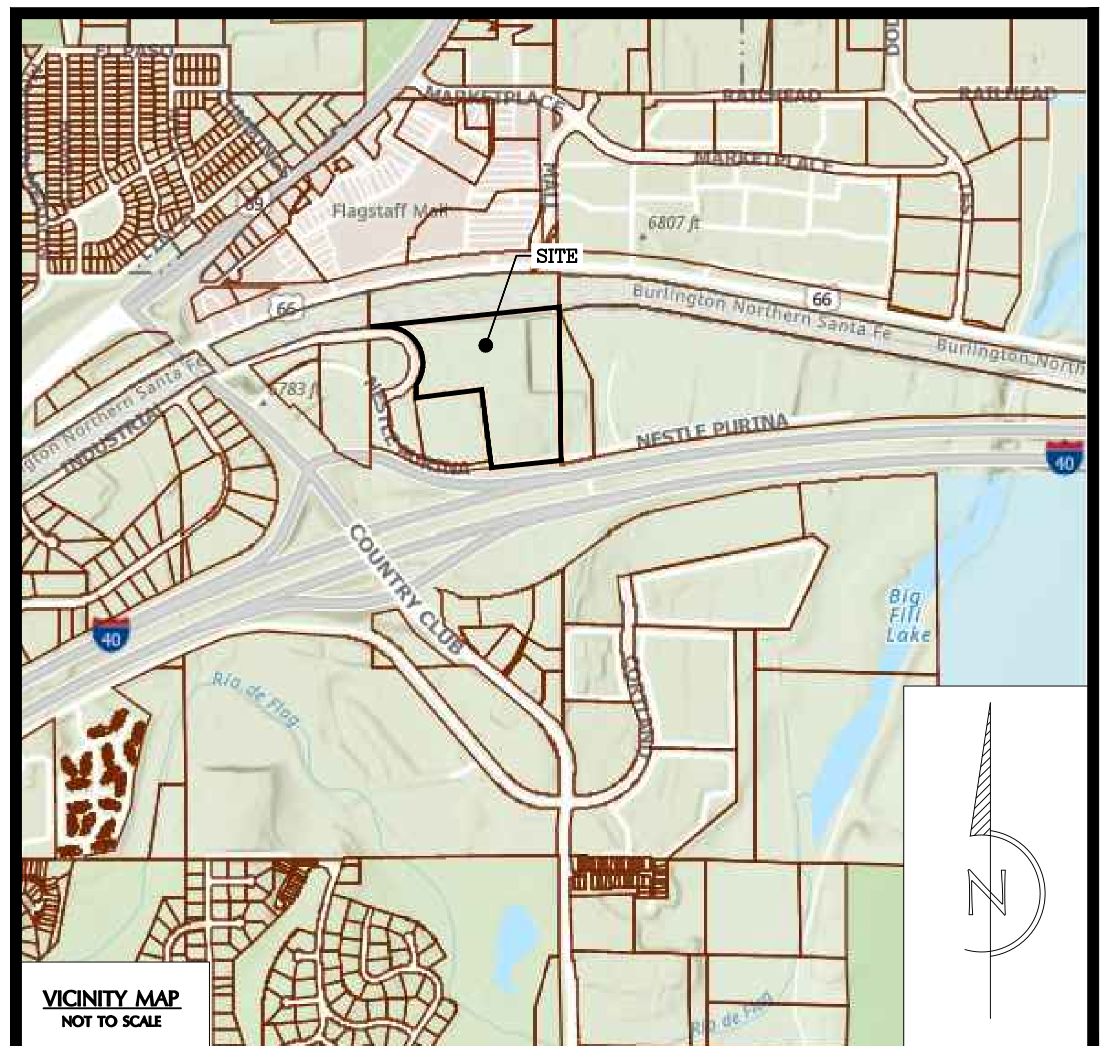
FEMA INFORMATION

THIS PARCEL HAS A ZONE 'X' CLASSIFICATION (AREA OF MINIMAL FLOOD HAZARD) PER FEMA FIRM PANEL 6827.

LID CALCULATIONS

TOTAL ADDED IMPERVIOUS AREA = 33,207 SF

TOTAL VOLUME = 6,000 CU.FT.



VICINITY MAP
NOT TO SCALE

SHEET INDEX

CITY APPROVAL

CONCEPT APPROVAL

THE CITY APPROVES THESE PLANS FOR CONCEPT ONLY. THE CITY SHALL NOT BE LIABLE FOR ERRORS OR OMISSIONS OF THE DESIGN ENGINEER

CONSTRUCTION AUTHORIZATION

APPROVAL BY THE CITY OF FLAGSTAFF IS REQUIRED PRIOR TO BEGINNING OF CONSTRUCTION. WITHOUT C.O.F. APPROVAL THESE PLANS HAVE NOT BEEN COMPLETED WITH RESPECT TO AGENCY REVIEW. ADDITIONALLY, IT IS THE OWNER/CONTRACTORS RESPONSIBILITY TO OBTAIN THE NECESSARY PERMITS PRIOR TO COMMENCEMENT OF CONSTRUCTION ACTIVITIES ON THIS PROJECT.

CITY ENGINEER DATE

PUBLIC WORKS DIRECTOR DATE

WATER SERVICES DIRECTOR DATE

LANDSCAPE DESIGNER DATE

BY SIGNING THESE PLANS THE DESIGNER OF THE LANDSCAPING PLANS CONFIRMS THAT THESE GRADING PLANS HAVE BEEN REVIEWED, IS AWARE OF THE SCOPE OF THE PROJECT, AND HAS IDENTIFIED AND ADDRESSED ANY POTENTIAL CONFLICT BETWEEN THE LANDSCAPING AND GRADING PLAN.

HIGH COUNTRY ENGINEERING, INC
2112 S HUFFER LN
FLAGSTAFF, ARIZONA 86001
PHONE (928) 123-4567

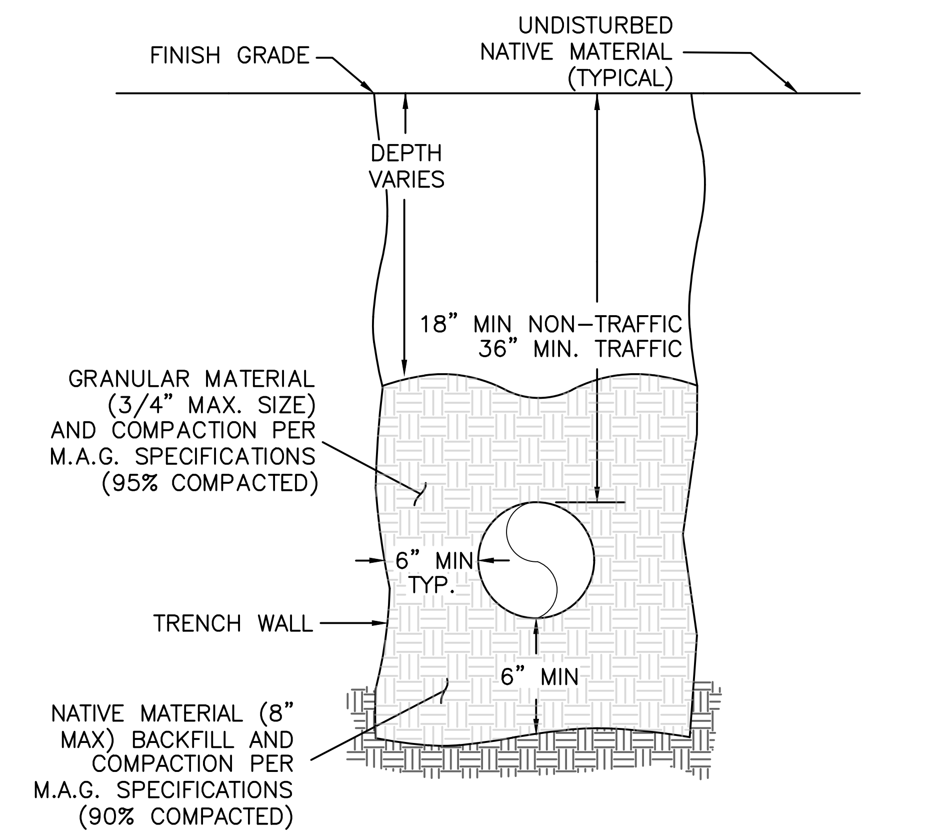
COVER SHEET AND NOTES
PURINA FACILITY NEW ENTRANCE
APN: 113-28-004F
4700 E NESTLE PURINA AVE
FLAGSTAFF, AZ, 86004

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

CALL TWO WORKING DAYS BEFORE YOU DIG
DIAL 811
BLUE STAKE CENTER

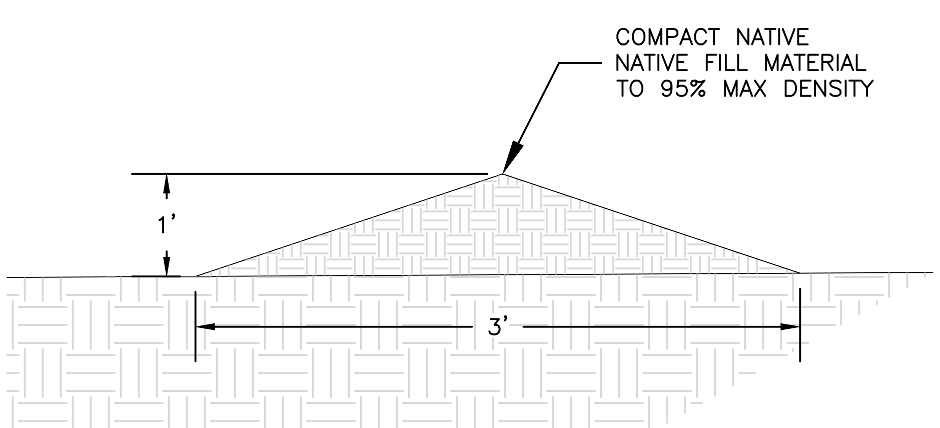
project: PURINA ENTRANCE	
proj. #: 22-486C	
drawing name:	
COVER SHEET AND NOTES	
drawn by: TLD	
reviewed by: TLD	
date: 12/01/2022	

revisions:	
date:	
date:	
date:	



A TRENCH DETAIL

NOT TO SCALE



B BERM DETAIL

NOT TO SCALE

UTILITIES

UNDERGROUND UTILITY LOCATIONS SHOWN ON THESE PLANS WERE DETERMINED FROM FIELD MEASUREMENTS, CONSTRUCTION PLANS, RECORD PLANS, OR UTILITY MAPS FURNISHED BY OTHERS. LOCATIONS OF UNDERGROUND UTILITIES ARE TO BE REGARDED AS APPROXIMATE ONLY.

IT IS THE CONTRACTOR'S RESPONSIBILITY TO ESTABLISH IN THE FIELD THE ACTUAL LOCATIONS OF ALL UNDERGROUND LINES WHICH MAY IN ANY WAY AFFECT THE WORK.

IT IS NOT WITHIN THE SCOPE OF THE PLANS FOR THE ENGINEER TO LOCATE, IDENTIFY OR FORESEE EVERY UTILITY CONFLICT WHICH MAY ARISE DURING THE CONSTRUCTION PHASE OF THE PROJECT. BUT IT IS THE INTENT OF THE OWNER TO REASONABLY COMPENSATE THE CONTRACTOR FOR WORK REQUIRED TO RELOCATE OR ADJUST UTILITIES CONFLICTING WITH THE CONSTRUCTION OF THE PROJECT. TO THAT END, UTILITIES (AS DEFINED IN MAG 101.2) WHICH ARE ENCOUNTERED WILL BE ADDRESSED AS FOLLOWS:

1. UTILITY RELOCATIONS OR ADJUSTMENTS NOTED ON THE PLANS SHALL BE PAID FOR PER THE BID SCHEDULE.

2. UTILITY RELOCATIONS OR ADJUSTMENTS NOT NOTED ON THE PLANS SHALL BE ADDRESSED ON A CASE BY CASE BASIS. THE ENGINEER SHALL DETERMINE WHAT WORK IS REQUIRED TO PRODUCE THE DESIRED FINAL PRODUCT. IF A UNIT BID PRICE DOES NOT EXIST THEN COMPENSATION MUTUALLY ACCEPTABLE TO THE OWNER, CONTRACTOR, AND ENGINEER SHALL BE MADE.

IN EITHER SITUATION, WORK ON THE SPECIFIC CASE SHALL NOT PROCEED UNTIL THE AMOUNT OF COMPENSATION IS AGREED UPON.

COMPENSATION FOR UTILITY RELOCATIONS AND ADJUSTMENTS SHALL NOT INCLUDE COSTS FOR REPAIR TO THE UTILITY DAMAGED BY THE CONTRACTOR OR HIS SUBCONTRACTOR(S). THE CONTRACTOR IS NOT RELIEVED OF THE RESPONSIBILITY FOR DETERMINING THE LOCATION OF ALL UTILITIES AFFECTING THE WORK.

THE APPROPRIATE UTILITY COMPANIES SHALL BE NOTIFIED BY THE CONTRACTOR PRIOR TO ANY CONSTRUCTION. "BLUE STAKE" NUMBER IS 1-800-STAKEIT. THE CONTRACTOR SHALL ALLOW TWO WORKING DAYS AFTER "BLUE STAKE" IS NOTIFIED, BEFORE COMMENCING ANY EXCAVATION WORK IN THE PROXIMITY OF BURIED UTILITES.

AT LEAST 48 HOURS PRIOR NOTICE IS REQUIRED BEFORE DISRUPTING EXISTING UTILITY SERVICE TO MAKE CONNECTIONS OR DISCONNECTIONS. THE NOTICE MUST INCLUDE THE EXACT TIME OF THE DISRUPTION OF SERVICE AND THE EXPECTED DURATION OF THE LOSS OF SERVICE.

CERTAIN UTILITIES ARE TO REMAIN IN SERVICE DURING THE CONSTRUCTION OF THE FILL AND UPON COMPLETION OF THIS CONTRACT. THESE UTILITIES SHALL BE PROTECTED DURING THE CONSTRUCTION AND CUT OR FILL PLACEMENT SHALL NOT PROHIBIT MAINTENANCE ACCESS TO THESE UTILITIES.

MISCELLANEOUS REMOVALS AND OTHER WORK

REMOVALS NECESSITATED BY THE WORK AS IT PROGRESSES AND NOT SPECIFICALLY CALLED OUT ON THE PLANS WILL BE CONSIDERED INCIDENTAL WORK.

CLEANUP AND DUST CONTROL

THROUGHOUT ALL PHASES OF THE CONSTRUCTION THE CONTRACTOR SHALL KEEP THE WORK AREA, ADJACENT PROPERTIES AND STREETS CLEAN AND FREE FROM RUBBISH, EXCESS MATERIALS, DUST AND DEBRIS GENERATED BY THE CONSTRUCTION ACTIVITY

WATER SUPPLY

THE CONTRACTOR SHALL MAKE ARRANGEMENTS FOR AND PROVIDE ALL NECESSARY WATER FOR HIS CONSTRUCTION OPERATION AT HIS OWN EXPENSE.

DRAINAGE MAINTENANCE DURING CONSTRUCTION

ADEQUATE DRAINAGE OF THE CONSTRUCTION AREA SHALL BE PROVIDED AT ALL TIMES. CONSTRUCTION DRAINS SHALL BE PROVIDED AS NEEDED TO ENABLE WATER TO DRAIN FROM THE CONSTRUCTION AREA RAPIDLY AND WITHOUT DAMAGING OF THE WORK IN PROGRESS. TO FURTHER PROMOTE GOOD DRAINAGE OF THE SITE, DRAINAGE CHANNELS, CULVERTS, AND STRUCTURES SHALL BE CONSTRUCTION FROM DOWN STREAM TO UPSTREAM IS SUCH A WAY THAT DURING CONSTRUCTION THEY DO NOT IMPEDE THE FLOW OF WATER FROM THE CONSTRUCTION AREA.

DAMAGE TO ADJACENT PROPERTIES OR TO ANY PORTION OF THE WORK CAUSED BY THE CONTRACTORS FAILURE TO PROVIDE ADEQUATE DRAINAGE OF THE CONSTRUCTION AREA OR TO ORDER THE WORK SO AS TO MINIMIZE THE POSSIBLE EXTENT OF SUCH DAMAGE SHALL BE REPAIRED AT THE CONTRACTOR'S EXPENSE. NO EXTENSION OF TIME SHALL BE GRANTED ON ACCOUNT OF THE TIME REQUIRED TO MAKE SUCH REPAIRS.

ADOT IMPROVEMENTS

NO IMPROVEMENTS WILL BE PERFORMED IN ADOT R.O.W.

GENERAL STRIPING NOTES

ALL PAVEMENT STRIPING SHALL CONFORM TO THE APPLICABLE ADOT SPECIFICATIONS FOR PAINT. ALL PARKING STALL STRIPING SHALL BE 4" WIDE, WHITE PAINT, TREATED FOR REFLECTIVITY. ALL STRIPING SHALL BE IN CONFORMANCE WITH THE "MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES", LATEST EDITION.

GRADING AND DRAINAGE STATEMENT

ADEQUATE DRAINAGE, EROSION AND SEDIMENT CONTROL MEASURES, BEST MANAGEMENT PRACTICES, AND/OR OTHER STORMWATER MANAGEMENT FACILITIES SHALL BE PROVIDED AND MAINTAINED AT ALL TIMES DURING CONSTRUCTION. DAMAGES TO ADJACENT PROPERTY AND/OR THE CONSTRUCTION SITE CAUSED BY THE CONTRACTOR'S OR PROPERTY OWNER'S FAILURE TO PROVIDE AND MAINTAIN ADEQUATE DRAINAGE AND EROSION/SEDIMENT CONTROL FROM THE CONSTRUCTION AREA SHALL BE THE RESPONSIBILITY OF THE CONTRACTOR AND/OR PROPERTY OWNER.

RIGHT-OF-WAY AND TRAFFIC CONTROL

THE CONTRACTOR SHALL PROVIDE ANY NECESSARY TRAFFIC CONTROL DEVICES REQUIRED FOR THE CONTROL OF VEHICLE AND PEDESTRIAN TRAFFIC AFFECTED BY THE CONSTRUCTION. ALL TRAFFIC CONTROL PLANS MUST BE APPROVED BY THE OWNER OR HIS REPRESENTATIVE PRIOR TO IMPLEMENTATION.

CONSTRUCTION STAKES, LINES AND GRADES

THE CONTRACTOR SHALL BE RESPONSIBLE FOR RETAINING A REGISTERED LAND SURVEYOR, LICENSED TO PRACTICE IN ARIZONA, WHO SHALL BE RESPONSIBLE FOR PROVIDING ALL STAKES NECESSARY TO ESTABLISH CONSTRUCTION LINES AND GRADES. STAKES PROVIDED SHALL BE OF SUFFICIENT NUMBERS TO SATISFY THE ENGINEER THAT THE WORK MAY BE CONSTRUCTED IN ACCORDANCE WITH THE PLANS.

ALL COSTS ASSOCIATED WITH STAKING ARE TO BORNE BY THE CONTRACTOR. NO ADDITIONAL PAYMENT TO THE CONTRACTOR FOR EXTRA STAKES OR FOR RESTAKING WILL BE ALLOWED.

COF EROSION CONTROL NOTES

EROSION CONTROL SHOULD BE PROVIDED PER CHAPTER 13-17 OF THE CITY OF FLAGSTAFF CITY CODE.

FROM CITY OF FLAGSTAFF CODE DIVISION 13-17-001:

EROSION CONTROL APPLIES TO IMPROVEMENTS WITHIN THE CITY AND AS PART OF THE EROSION CONTROL SECTION OF A STORMWATER POLLUTION PREVENTION PLAN (SWPPP). MATERIALS, MEANS AND METHODS FOR EROSION CONTROL AND STABILIZATION, BEST MANAGEMENT PRACTICES (BMPS), EROSION CONTROL PLANS (ECPS), AND SWPPPS ARE DESCRIBED IN THE CITY OF FLAGSTAFF STORMWATER DESIGN MANUAL.

THE OWNER, DEVELOPER AND/OR CONTRACTOR IS RESPONSIBLE FOR COMPLYING WITH THE REQUIREMENTS OF THE NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) PERMIT PROGRAM. THIS GENERALLY INCLUDES SUBMITTAL OF A NOTICE OF INTENT TO THE ARIZONA DEPARTMENT OF ENVIRONMENTAL QUALITY (ADEQ) AND NOTICE OF TERMINATION TO ADEQ FOR THE PROJECT. PREPARATION AND IMPLEMENTATION OF A STORMWATER POLLUTION PREVENTION PLAN (SWPPP) FOR THE SITE IS REQUIRED IN ACCORDANCE WITH ADEQ AND CITY OF FLAGSTAFF ENGINEERING STANDARDS.

ALL DISTURBED AREAS WITHIN THE PROJECT SITE AND AS SHOWN ON THE PLANS SHALL BE STABILIZED. WORK SHALL BE PERFORMED ACCORDING TO THE PROVISIONS OF THIS SECTION AND SHALL INCLUDE BUT NOT BE LIMITED TO THE FURNISHING, HAULING, PLACEMENT AND APPLICATION OF EROSION CONTROL MATERIALS.

IT IS RECOMMENDED THAT CONTRACTORS SEE THE ADEQ SMART NOI (NOTICE OF INTENT) PROGRAM WEBSITE FOR INFORMATION AND PROCESSES. (HTTP://AZ.GOV/WEBAPP/NOI/MAIN.DO) (ORD. 2017-22, REP&REEN, 07/05/2017)

HIGH COUNTRY ENGINEERING, INC
2112 S HUFFER LN
FLAGSTAFF, ARIZONA 86001
PHONE (928) 123-4567

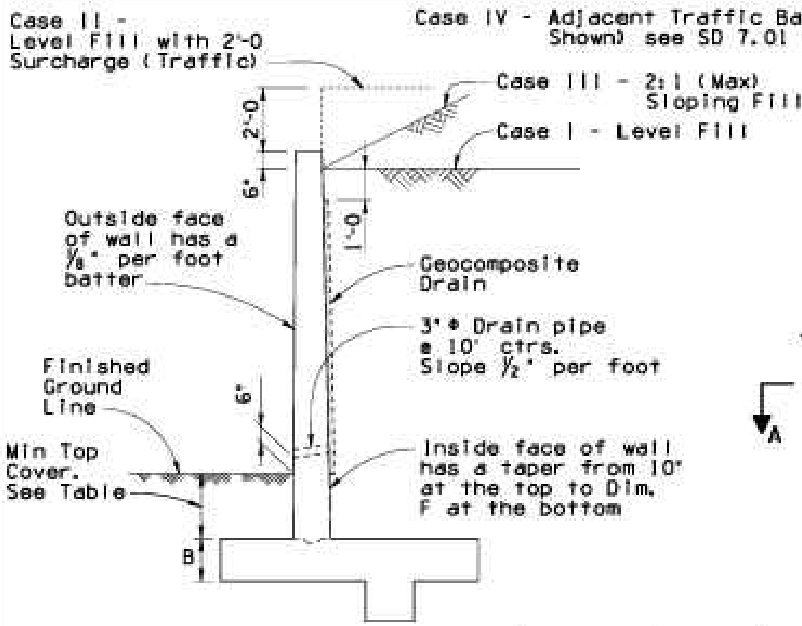
GENERAL NOTES (CONT.) AND DETAILS
PURINA FACILITY NEW ENTRANCE
APN: 113-28-004F
4700 E NESTLE PURINA AVE
FLAGSTAFF, AZ, 86004

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

CALL TWO WORKING DAYS BEFORE YOU DIG
DIAL 811
BLUE STAKE CENTER

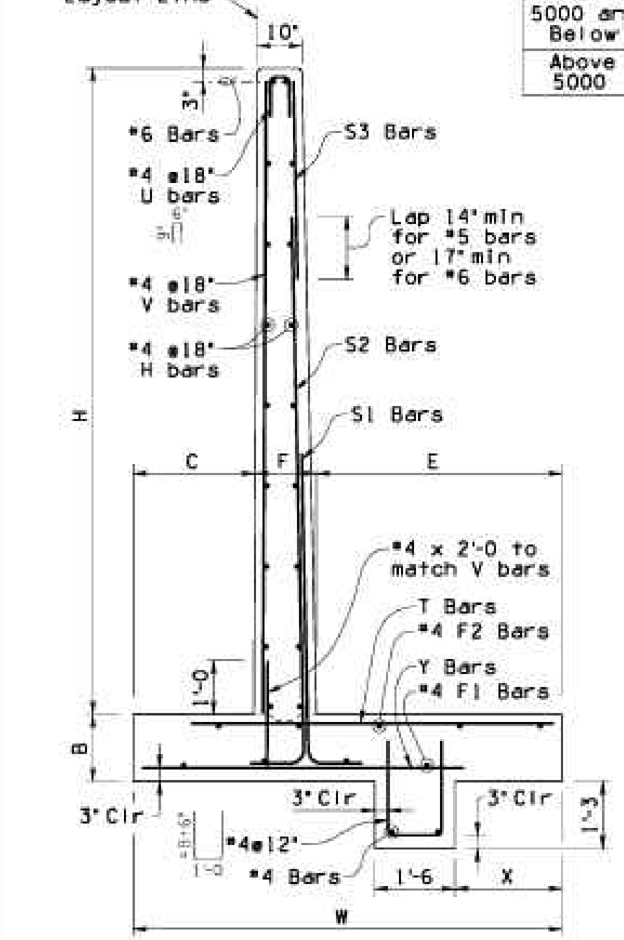
project: PURINA ENTRANCE	
proj. #: 22-486C	
drawing name:	
GENERAL NOTES (CONT.)	
drawn by: TLD	
reviewed by: TLD	
date: 12/01/2022	

revisions:	
date:	
date:	
date:	

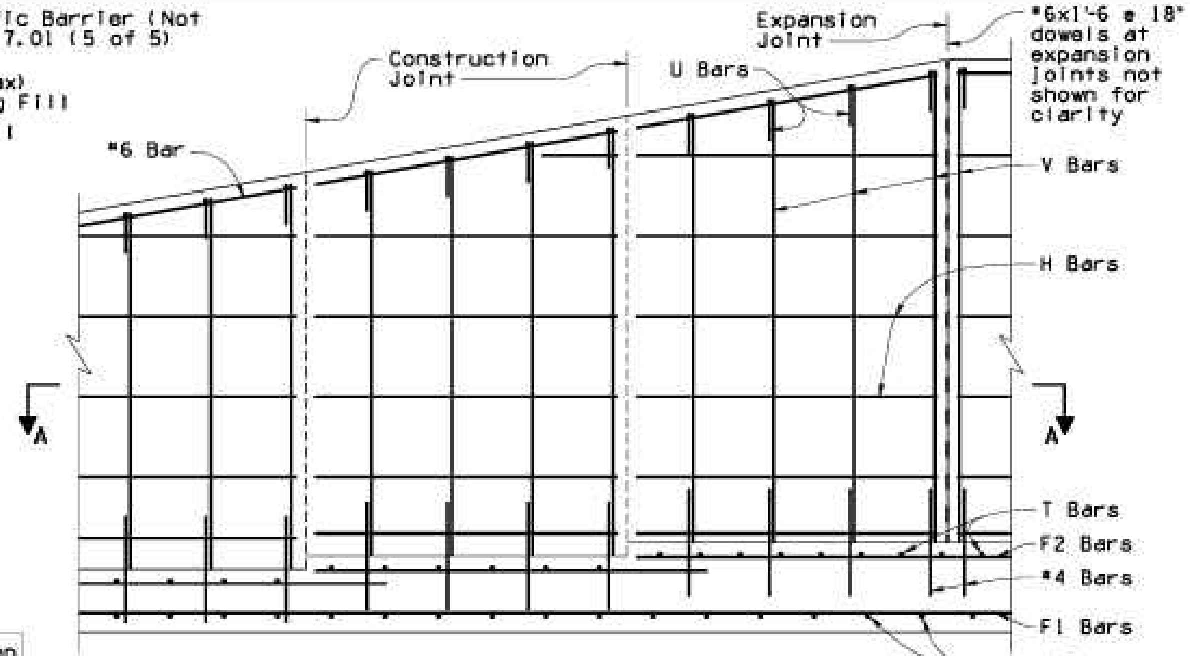


TYPICAL SECTION
(Case I, II, III)

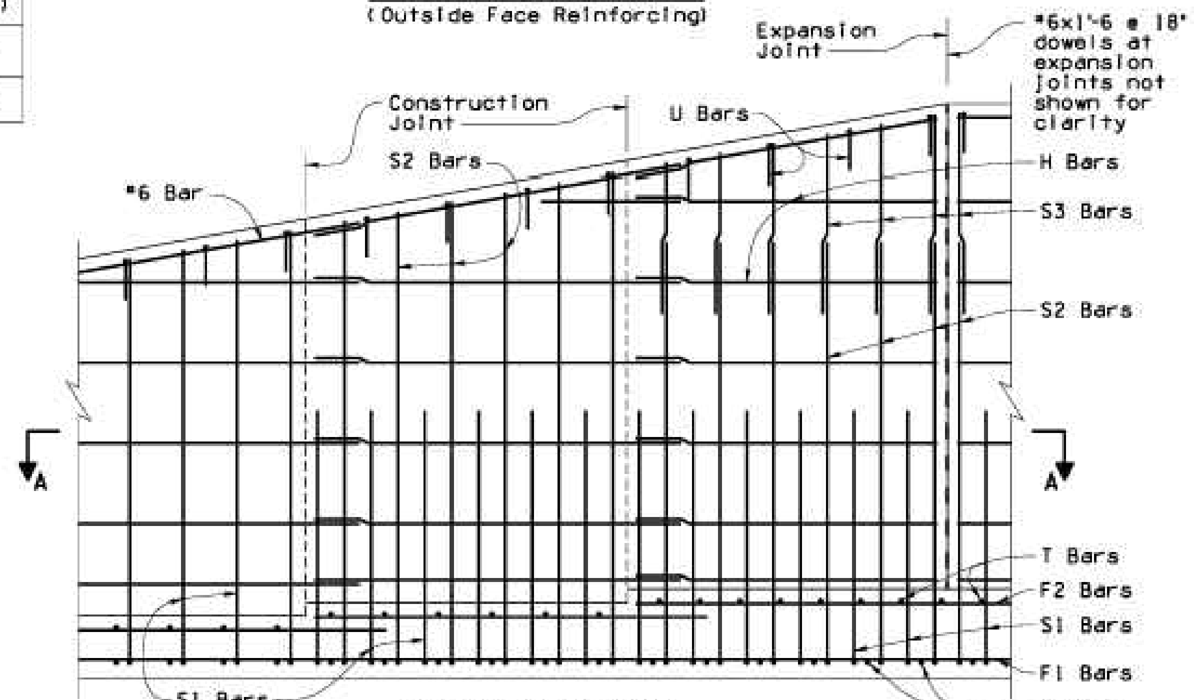
ELEV (FEET)	Min Top Cover (FEET)
5000 and Below	1'-6
Above 5000	2'-6



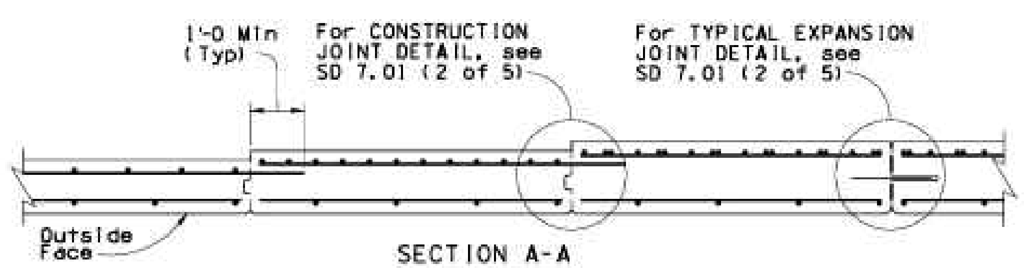
TYPICAL WALL DETAILS



TYPICAL ELEVATION
(Outside Face Reinforcing)



TYPICAL ELEVATION
(Inside Face Reinforcing)



SECTION A-A

GENERAL NOTES:

Construction Specification - Arizona Department of Transportation Standard Specifications for Road and Bridge Construction, latest Edition.

Design Specifications - AASHTO LRFD Bridge Design Specifications, 8th Edition, 2017.

Design:

Soil weight = 120 p.c.f.
Backfill angle of internal friction = 33°
Existing ground angle of internal friction = 31°

All Concrete shall be Class "S" (f'c = 3000 psi).

Reinforcing steel shall conform to ASTM Specification A615. All reinforcing shall be furnished as Grade 60.

All bends and hooks shall meet the requirements of AASHTO LRFD Article 5.10. All bend dimensions for reinforcing steel shall be out-to-out of bars.

All placement dimensions for reinforcing steel shall be to center of bars unless noted otherwise.

All reinforcing steel shall have 2 inch clear cover unless noted otherwise.

Chamfer all exposed corners ¾" unless noted otherwise.

Compact structure backfill for footing and wall base minimum 100 percent of ASTM D698 maximum dry density.

See Project Plans for wall layout, top of footing and finished grade elevations, footing step and wall joint locations. Construction joints shall match the locations of contraction joints.

See Project Plans for wall surface treatment. Increase the wall thickness at the face for the depth of surface treatment.

Dimensions shall not be scaled from drawings.

Pay item measure of square foot of wall constructed will be measured along the front face of the wall from top of footing to top of wall cap.

Item	RETAINING WALL (REINFORCED CONCRETE CANTILEVER)
Item No.	9140178
Measure	Square Foot

NOTES:

For Retaining wall dimensions, quantities and additional details, see SD 7.01 sheets 2 thru 5.

For Structural Excavation and Structure Backfill Limits, see SD 7.01 (4 of 5).

Note to Designer: The information presented in this Standard Drawing has been prepared in accordance with recognized engineering principles and is for general use. It should not be used for specific application without competent professional examination and verification of its suitability by a licensed professional engineer. Contents within the inner border line shall not be altered.

PRIOR DISTRIBUTION DATE 01/15

STANDARDS ENGINEER: A. ALZUBI
RECOMMENDED FOR APPROVAL GROUP MANAGER: D. EBERHART
APPROVED: STANDARDS COMMITTEE APPROVED FOR DISTRIBUTION 12/21 DATE

ARIZONA DEPARTMENT OF TRANSPORTATION
INFRASTRUCTURE DELIVERY AND OPERATIONS DIVISION
BRIDGE GROUP STANDARD DRAWING

RETAINING WALL
REINFORCED CONCRETE CANTILEVER

DRAWING NO. SD 7.01 (1 of 5)

HIGH COUNTRY ENGINEERING, INC
2112 S HUFFER LN
FLAGSTAFF, ARIZONA 86001
PHONE (928) 123-4567

RETAINING WALL STRUCTURAL DETAILS AND NOTES
PURINA FACILITY NEW ENTRANCE
APN: 113-28-004F
4700 E NESTLE PURINA AVE
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PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

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project: PURINA ENTRANCE
proj. #: 22-486C
drawing name: RET WALL DETAILS & NOTES
drawn by: TLD
reviewed by: TLD
date: 12/01/2022

revisions:
date:
date:
date:

CASE I - LEVEL FILL

H	W	B	C	F	E	X	S1 Bar Size	S1 Spacing	S1 Length	S2 Bar Size	S2 Spacing	S2 Length	S3 Bar Size	S3 Spacing	S3 Length	H Number +*	V Length	Y Bar Size	Y Spacing	Y Length	F1 Number +	T Bar Size	T Spacing	T Length	F2 Number +	qtveu-SERV Lbs./Sq.Ft.	qnveu-SERV Lbs./Sq.Ft.	B'SERV Ft.	qtveu-STR Lbs./Sq.Ft.	qnveu-STR Lbs./Sq.Ft.	B'STR Ft.
4'	3'-0	1'-0	10"	10"	1'-4	8"	5	12"	5'-6							4	3'-9	5	12"	2'-3	2	5	12"	2'-3	3	840	480	2.46	1130	650	2.36
5'	3'-6	1'-0	1'-0	10"	1'-8	9"	5	12"	6'-6							6	4'-9	5	12"	2'-9	2	5	12"	2'-9	3	920	560	2.91	1240	760	2.79
6'	4'-0	1'-0	1'-2	10"	2'-0	10"	5	12"	7'-6							6	5'-9	5	12"	3'-3	2	5	12"	3'-3	3	1010	650	3.31	1380	900	3.16
7'	4'-6	1'-0	1'-4	10"	2'-4	11"	5	12"	8'-6							8	6'-9	5	12"	3'-9	3	5	12"	3'-6	3	1110	750	3.70	1530	1040	3.52
8'	5'-0	1'-2	1'-6	10"	2'-8	1'-0	5	12"	9'-9							10	7'-9	5	12"	4'-3	3	5	12"	4'-0	3	1270	890	4.01	1750	1240	3.79
9'	5'-6	1'-2	1'-9	1'-0	2'-9	1'-2	5	12"	10'-9							10	8'-9	5	12"	4'-6	3	5	12"	4'-0	3	1350	970	4.40	1880	1370	4.14
10'	6'-0	1'-2	1'-9	1'-0	3'-3	1'-4	6	12"	11'-9							12	9'-9	5	12"	4'-9	3	5	12"	4'-6	4	1510	1130	4.73	2100	1590	4.45
11'	6'-6	1'-2	2'-0	1'-0	3'-6	1'-6	5	12"	4'-3	5	12"	12'-9				14	10'-9	5	12"	5'-3	4	5	12"	4'-9	4	1590	1210	5.12	2230	1710	4.81
12'	7'-0	1'-3	2'-0	1'-0	4'-0	1'-8	6	12"	5'-3	5	12"	13'-9				14	11'-9	5	12"	5'-6	4	6	12"	5'-6	5	1770	1380	5.42	2490	1960	5.08
13'	7'-6	1'-3	2'-3	1'-0	4'-3	1'-10	7	12"	6'-6	5	12"	14'-9				16	12'-9	5	12"	5'-9	4	6	9"	5'-9	5	1860	1470	5.81	2620	2090	5.43
14'	8'-0	1'-3	2'-3	1'-2	4'-7	2'-0	7	12"	7'-0	5	12"	15'-9				18	13'-9	5	12"	6'-3	4	7	12"	6'-9	5	2020	1630	6.14	2850	2320	5.74
15'	8'-6	1'-3	2'-6	1'-3	4'-9	2'-2	7	12"	8'-0	5	12"	16'-9				18	14'-9	6	12"	6'-6	5	7	12"	7'-0	5	2100	1710	6.53	2970	2450	6.10
16'	9'-0	1'-4	2'-6	1'-4	5'-2	2'-4	7	12"	7'-3	6	12"	8'-9	5	12"	10'-9	20	15'-9	6	12"	6'-9	5	8	12"	8'-3	6	2300	1900	6.82	3250	2710	6.36
17'	9'-6	1'-4	2'-9	1'-5	5'-4	2'-6	7	12"	6'-0	7	12"	9'-9	5	12"	10'-9	22	16'-9	6	9"	7'-3	5	8	12"	8'-6	6	2380	1980	7.21	3380	2840	6.72
18'	10'-0	1'-5	2'-9	1'-6	5'-9	2'-8	7	12"	7'-0	7	12"	10'-6	5	12"	11'-0	22	17'-9	6	9"	7'-6	5	7	8"	8'-6	6	2580	2170	7.50	3660	3110	6.99
19'	10'-6	1'-6	3'-0	1'-7	5'-11	2'-10	8	12"	8'-0	7	12"	10'-3	6	12"	12'-9	24	18'-9	6	9"	8'-0	6	8	9"	9'-3	7	2690	2270	7.86	3830	3260	7.30
20'	11'-0	1'-6	3'-0	1'-8	6'-4	3'-0	8	12"	7'-6	8	12"	11'-6	6	12"	12'-9	26	19'-9	6	8"	8'-3	6	8	8"	9'-6	7	2860	2440	8.19	4070	3500	7.61
21'	11'-6	1'-7	3'-3	1'-9	6'-6	3'-2	8	12"	8'-3	8	12"	12'-6	6	12"	12'-9	26	20'-9	7	12"	8'-9	6	9	9"	10'-6	7	2970	2540	8.54	4240	3660	7.92
22'	12'-0	1'-8	3'-3	1'-10	6'-11	3'-4	9	12"	9'-6	8	12"	13'-6	6	12"	13'-0	28	21'-9	7	12"	9'-0	6	9	9"	11'-0	7	3180	2740	8.83	4530	3940	8.18
23'	12'-6	1'-9	3'-6	2'-0	7'-0	3'-6	10	12"	12'-3	7	12"	14'-0	6	12"	13'-3	30	22'-9	8	12"	9'-3	6	8	6"	10'-3	7	3290	2840	9.18	4700	4100	8.49
24'	13'-0	1'-10	3'-6	2'-2	7'-4	3'-8	9	12"	9'-3	9	12"	15'-6	6	12"	13'-3	30	23'-9	8	12"	9'-6	7	8	6"	10'-6	8	3500	3040	9.47	5000	4380	8.76
25'	13'-6	2'-0	3'-9	2'-4	7'-5	3'-10	9	12"	10'-3	9	12"	16'-6	6	12"	13'-6	32	24'-9	8	12"	10'-0	7	8	6"	10'-9	8	3650	3170	9.78	5220	4580	9.02
26'	14'-0	2'-3	3'-9	2'-6	7'-9	4'-0	10	12"	13'-0	8	12"	17'-6	6	12"	13'-9	34	25'-9	8	12"	10'-3	7	8	6"	11'-0	8	3920	3410	9.99	5630	4940	9.19
27'	14'-6	2'-6	4'-0	2'-8	7'-10	4'-2	10	12"	12'-3	9	12"	18'-6	6	12"	14'-3	34	26'-9	8	12"	10'-6	7	8	6"	11'-0	8	4110	3570	10.26	5910	5180	9.41
28'	15'-0	2'-9	4'-0	2'-10	8'-2	4'-4	10	12"	13'-3	9	12"	19'-9	6	12"	14'-3	36	27'-9	8	12"	11'-0	7	8	6"	11'-6	8	4390	3820	10.47	6330	5550	9.58
29'	15'-6	3'-0	4'-3	3'-0	8'-3	4'-6	10	12"	12'-0	10	12"	21'-0	6	12"	14'-3	38	28'-9	8	12"	11'-3	7	8	6"	11'-9	9	4580	3980	10.73	6610	5800	9.79
30'	16'-0	3'-3	4'-3	3'-2	8'-7	4'-8	10	12"	13'-0	10	12"	22'-3	6	12"	14'-3	38	29'-9	8	12"	11'-6	8	8	6"	11'-9	9	4860	4230	10.94	7040	6180	9.97

+ Total number of bars in cross section.

* Total number includes the sum of both faces.

QUANTITIES

H	Concrete C.Y./Ln.Ft.	Steel Lbs./Ln.Ft.	Steel (Horiz. Lap) Lbs./Splice
4'	.30	27	10
5'	.35	31	12
6'	.40	33	12
7'	.45	38	14
8'	.53	42	15
9'	.61	44	15
10'	.67	53	17
11'	.72	57	19
12'	.80	66	20
13'	.86	78	21
14'	.96	84	22
15'	1.04	92	23
16'	1.16	108	25
17'	1.25	119	26
18'	1.37	128	26
19'	1.50	153	29
20'	1.61	171	30
21'	1.75	185	30
22'	1.90	203	32
23'	2.09	229	33
24'	2.29	236	34
25'	2.54	248	36
26'	2.84	264	37
27'	3.16	279	37
28'	3.50	294	38
29'	3.85	317	40
30'	4.22	328	41

LIMIT STATE NOTES:

qtveu-SERV = Total equivalent uniform vertical bearing stress to be used only for the evaluation of settlement based on the Service I Limit State as per ADOT SF-1.

qnveu-SERV = Net equivalent uniform vertical bearing stress to be used only for the evaluation of settlement based on the Service I Limit State as per ADOT SF-1.

B' SERV = Effective footing width to be used only for the evaluation of settlement based on the Service I Limit State as per ADOT SF-1.

qtveu-STR = Total equivalent uniform vertical bearing stress to be used only for the evaluation of bearing resistance based on the Strength I Limit State as per ADOT SF-1.

qnveu-STR = Net equivalent uniform vertical bearing stress to be used only for the evaluation of bearing resistance based on the Strength I Limit State as per ADOT SF-1.

B' STR = Effective footing width to be used only for the evaluation of bearing resistance based on the Strength I Limit State as per ADOT SF-1.

For other applicable limit states, perform project specific-analysis using the procedures in ADOT SF-1 (Spread Footing: Bearing Resistance and Settlement).

ADOT SF-1 memorandum is found on the Bridge Group website (Geotech Services LRFD Design Memorandums).

QUANTITIES NOTE:

Quantities are shown for information purposes only. The pay item is measured per square foot of wall.

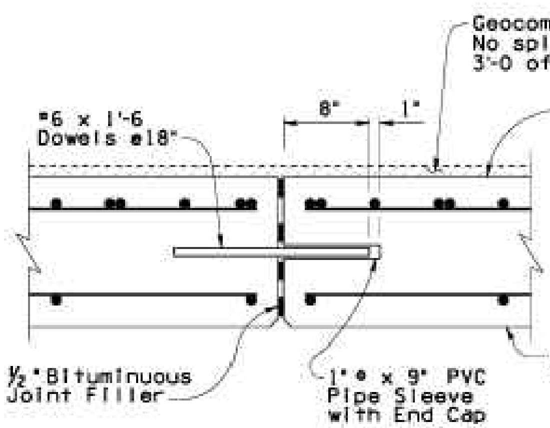
Quantities are for one L.F. of wall except for horizontal steel lap splices and footing steps.

Steel quantities for horizontal lap splices shall be added for wall segments greater than 30 feet, and add a splice for each additional wall segment greater than 30 feet. Horizontal 1'-0 lap splices occur at construction or contraction joints.

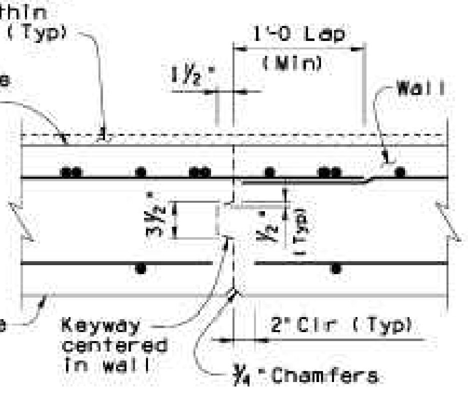
Steel and concrete quantities for footing steps shall be added to those shown in the table.

DOWEL NOTE:

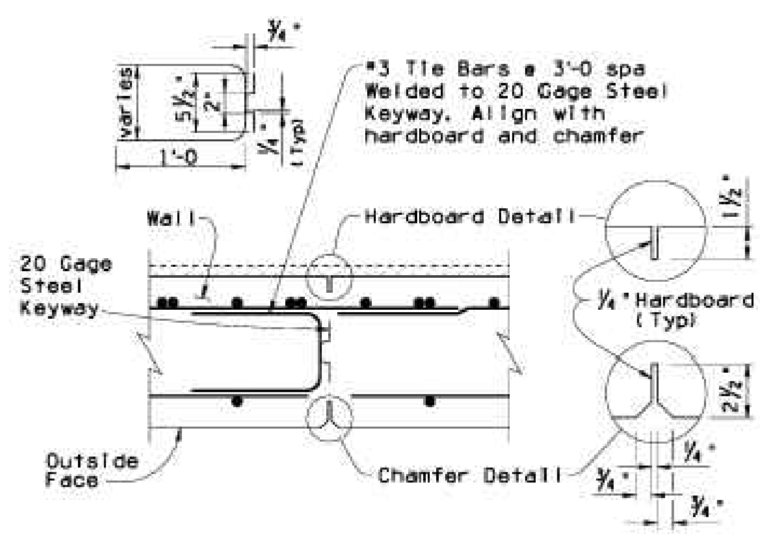
Dowel placement includes furnishing and placing PVC pipe sleeves in the concrete forms, and placing metal dowels in the PVC pipe sleeves.



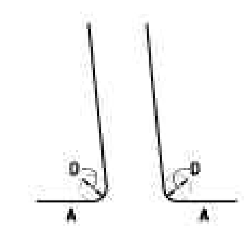
TYPICAL EXPANSION JOINT DETAIL



CONSTRUCTION JOINT DETAIL



CONTRACTION JOINT DETAIL



S2 BAR S1 BAR

Bar Size	Dimension A	Dimension D
5	1'-0	3 3/4"
6	1'-0	4 1/2"
7	1'-2	5 1/4"
8	1'-4	6"
9	1'-8	9"
10	1'-10	10"
11	2'-0	11"

JOINT NOTES:

All retaining walls shall have construction joints or contraction joints spaced at not more than 30'-0 apart or as shown. Contraction joints may be substituted for construction joints for wall pours longer than 30'-0.

Expansion joints shall be provided at intervals not exceeding 90'-0.

Footings may be continuous with no joints (except at footing step locations).

NOTES:

For General Notes, Typical Elevations, Sections and Details see SD 7.01 (1, 3, and 4).

For Structural Excavation Limits and Structure Backfill Limits, see SD 7.01 (4 of 5).

Note to Designers: The information presented in this Standard Drawing has been prepared in accordance with recognized engineering principles and is for general use. It should not be used for specific application without competent professional examination and verification of its suitability and applicability by a licensed professional engineer. Contents within the inner border line shall not be altered.

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STANDARDS ENGINEER A. ALZUBI
RECOMMENDED FOR APPROVAL
GROUP MANAGER D. EBERHART
APPROVED
STANDARDS COMMITTEE APPROVED FOR DISTRIBUTION 12/21 DATE

ARIZONA DEPARTMENT OF TRANSPORTATION
INFRASTRUCTURE DELIVERY AND OPERATIONS DIVISION
BRIDGE GROUP STANDARD DRAWING

RETAINING WALL
REINFORCED CONCRETE CANTILEVER

DRAWING NO. SD 7.01 (2 of 5)

HIGH COUNTRY ENGINEERING, INC
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PHONE (928) 123-4567

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reviewed by: TLD
date: 12/01/2022

revisions:
date:
date:
date:

ADS Advanced Drainage Systems, Inc.

SiteASSIST® FOR STORMTECH INSTRUCTIONS, DOWNLOAD THE INSTALLATION APP

MC-7200 STORMTECH CHAMBER SPECIFICATIONS

1. CHAMBERS SHALL BE STORMTECH MC-7200.
2. CHAMBERS SHALL BE ARCH-SHAPED AND SHALL BE MANUFACTURED FROM VIRGIN, IMPACT-MODIFIED POLYPROPYLENE COPOLYMERS.
3. CHAMBERS SHALL MEET THE REQUIREMENTS OF ASTM F2418-16a, "STANDARD SPECIFICATION FOR POLYPROPYLENE (PP) CORRUGATED WALL STORMWATER COLLECTION CHAMBERS" CHAMBER CLASSIFICATION 60x101.
4. CHAMBER ROWS SHALL PROVIDE CONTINUOUS, UNOBSTRUCTED INTERNAL SPACE WITH NO INTERNAL SUPPORTS THAT WOULD IMPEDE FLOW OR LIMIT ACCESS FOR INSPECTION.
5. THE STRUCTURAL DESIGN OF THE CHAMBERS, THE STRUCTURAL BACKFILL, AND THE INSTALLATION REQUIREMENTS SHALL ENSURE THAT THE LOAD FACTORS SPECIFIED IN THE AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS, SECTION 12.12, ARE MET FOR: 1) LONG-DURATION DEAD LOADS AND 2) SHORT-DURATION LIVE LOADS, BASED ON THE AASHTO DESIGN TRUCK WITH CONSIDERATION FOR IMPACT AND MULTIPLE VEHICLE PRESENCES.
6. CHAMBERS SHALL BE DESIGNED, TESTED AND ALLOWABLE LOAD CONFIGURATIONS DETERMINED IN ACCORDANCE WITH ASTM F2787, "STANDARD PRACTICE FOR STRUCTURAL DESIGN OF THERMOPLASTIC CORRUGATED WALL STORMWATER COLLECTION CHAMBERS". LOAD CONFIGURATIONS SHALL INCLUDE: 1) INSTANTANEOUS (<1 MIN) AASHTO DESIGN TRUCK LIVE LOAD ON MINIMUM COVER 2) MAXIMUM PERMANENT (75-YR) COVER LOAD AND 3) ALLOWABLE COVER WITH PARKED (1-WEEK) AASHTO DESIGN TRUCK.
7. REQUIREMENTS FOR HANDLING AND INSTALLATION:
   - TO MAINTAIN THE WIDTH OF CHAMBERS DURING SHIPPING AND HANDLING, CHAMBERS SHALL HAVE INTEGRAL, INTERLOCKING STACKING LUGS.
   - TO ENSURE A SECURE JOINT DURING INSTALLATION AND BACKFILL, THE HEIGHT OF THE CHAMBER JOINT SHALL NOT BE LESS THAN 3".
   - TO ENSURE THE INTEGRITY OF THE ARCH SHAPE DURING INSTALLATION, a) THE ARCH STIFFNESS CONSTANT SHALL BE GREATER THAN OR EQUAL TO 450 LBS/IN/IN. THE ASC IS DEFINED IN SECTION 6.2.8 OF ASTM F2418 AND b) TO RESIST CHAMBER DEFORMATION DURING INSTALLATION AT ELEVATED TEMPERATURES (ABOVE 73° F / 23° C), CHAMBERS SHALL BE PRODUCED FROM REFLECTIVE GOLD OR YELLOW COLORS.
8. ONLY CHAMBERS THAT ARE APPROVED BY THE SITE DESIGN ENGINEER WILL BE ALLOWED. UPON REQUEST BY THE SITE DESIGN ENGINEER OR OWNER, THE CHAMBER MANUFACTURER SHALL SUBMIT A STRUCTURAL EVALUATION FOR APPROVAL BEFORE DELIVERING CHAMBERS TO THE PROJECT SITE AS FOLLOWS:
   - THE STRUCTURAL EVALUATION SHALL BE SEALED BY A REGISTERED PROFESSIONAL ENGINEER.
   - THE STRUCTURAL EVALUATION SHALL DEMONSTRATE THAT THE SAFETY FACTORS ARE GREATER THAN OR EQUAL TO 1.95 FOR DEAD LOAD AND 1.75 FOR LIVE LOAD, THE MINIMUM REQUIRED BY ASTM F2787 AND BY SECTIONS 3 AND 12.12 OF THE AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS FOR THERMOPLASTIC PIPE.
   - THE TEST DERIVED CREEP MODULUS AS SPECIFIED IN ASTM F2418 SHALL BE USED FOR PERMANENT DEAD LOAD DESIGN EXCEPT THAT IT SHALL BE THE 75-YEAR MODULUS USED FOR DESIGN.
9. CHAMBERS AND END CAPS SHALL BE PRODUCED AT AN ISO 9001 CERTIFIED MANUFACTURING FACILITY.

IMPORTANT - NOTES FOR THE BIDDING AND INSTALLATION OF MC-7200 CHAMBER SYSTEM

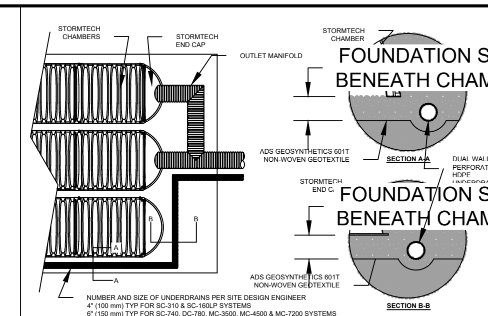
1. STORMTECH MC-7200 CHAMBERS SHALL NOT BE INSTALLED UNTIL THE MANUFACTURER'S REPRESENTATIVE HAS COMPLETED A PRE-CONSTRUCTION MEETING WITH THE INSTALLERS.
2. STORMTECH MC-7200 CHAMBERS SHALL BE INSTALLED IN ACCORDANCE WITH THE "STORMTECH MC-7200 CONSTRUCTION GUIDE".
3. CHAMBERS ARE NOT TO BE BACKFILLED WITH A DOZER OR EXCAVATOR SITUATED OVER THE CHAMBERS. STORMTECH RECOMMENDS 3 BACKFILL METHODS:
   - STONESHOOTER LOCATED OFF THE CHAMBER BED.
   - BACKFILL AS ROWS ARE BUILT USING AN EXCAVATOR ON THE FOUNDATION STONE OR SUBGRADE.
   - BACKFILL FROM OUTSIDE THE EXCAVATION USING A LONG BOOM HOE OR EXCAVATOR.
4. THE FOUNDATION STONE SHALL BE LEVELED AND COMPACTED PRIOR TO PLACING CHAMBERS.
5. JOINTS BETWEEN CHAMBERS SHALL BE PROPERLY SEATED PRIOR TO PLACING STONE.
6. MAINTAIN MINIMUM - 9" (230 mm) SPACING BETWEEN THE CHAMBER ROWS.
7. INLET AND OUTLET MANIFOLDS MUST BE INSERTED A MINIMUM OF 12" (300 mm) INTO CHAMBER END CAPS.
8. EMBEDMENT STONE SURROUNDING CHAMBERS MUST BE A CLEAN, CRUSHED, ANGULAR STONE MEETING THE AASHTO M43 DESIGNATION OF #3 OR #4.
9. STONE SHALL BE BROUGHT UP EVENLY AROUND CHAMBERS SO AS NOT TO DISTORT THE CHAMBER SHAPE. STONE DEPTHS SHOULD NEVER DIFFER BY MORE THAN 12" (300 mm) BETWEEN ADJACENT CHAMBER ROWS.
10. STONE MUST BE PLACED ON THE TOP CENTER OF THE CHAMBER TO ANCHOR THE CHAMBERS IN PLACE AND PRESERVE ROW SPACING.
11. THE CONTRACTOR MUST REPORT ANY DISCREPANCIES WITH CHAMBER FOUNDATION MATERIAL BEARING CAPACITIES TO THE SITE DESIGN ENGINEER.
12. ADS RECOMMENDS THE USE OF "FLEXSTORM CATCH IT" INSERTS DURING CONSTRUCTION FOR ALL INLETS TO PROTECT THE SUBSURFACE STORMWATER MANAGEMENT SYSTEM FROM CONSTRUCTION SITE RUNOFF.

NOTES FOR CONSTRUCTION EQUIPMENT

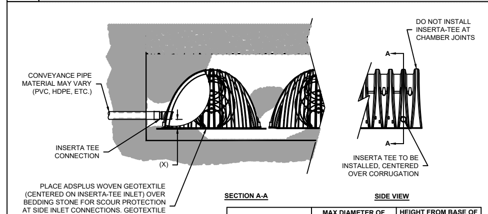
1. STORMTECH MC-7200 CHAMBERS SHALL BE INSTALLED IN ACCORDANCE WITH THE "STORMTECH MC-7200 CONSTRUCTION GUIDE".
2. THE USE OF EQUIPMENT OVER MC-7200 CHAMBERS IS LIMITED:
   - NO EQUIPMENT IS ALLOWED ON BARE CHAMBERS.
   - NO RUBBER TIRED LOADER, DUMP TRUCK, OR EXCAVATORS ARE ALLOWED UNTIL PROPER FILL DEPTHS ARE REACHED IN ACCORDANCE WITH THE "STORMTECH MC-7200 CONSTRUCTION GUIDE".
   - WEIGHT LIMITS FOR CONSTRUCTION EQUIPMENT CAN BE FOUND IN THE "STORMTECH MC-7200 CONSTRUCTION GUIDE".
3. FULL 36" (900 mm) OF STABILIZED COVER MATERIALS OVER THE CHAMBERS IS REQUIRED FOR DUMP TRUCK TRAVEL OR DUMPING.

USE OF A DOZER TO PUSH EMBEDMENT STONE BETWEEN THE ROWS OF CHAMBERS MAY CAUSE DAMAGE TO CHAMBERS AND IS NOT AN ACCEPTABLE BACKFILL METHOD. ANY CHAMBERS DAMAGED BY USING THE "DUMP AND PUSH" METHOD ARE NOT COVERED UNDER THE STORMTECH STANDARD WARRANTY.

CONTACT STORMTECH AT 1-888-892-2694 WITH ANY QUESTIONS ON INSTALLATION REQUIREMENTS OR WEIGHT LIMITS FOR CONSTRUCTION EQUIPMENT.



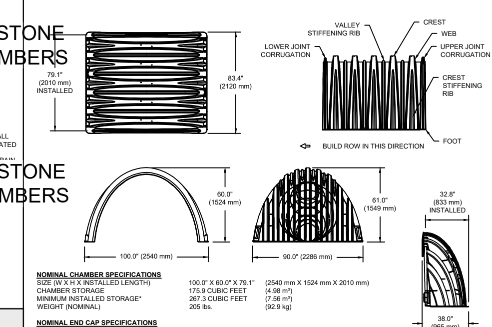
NUM — UNDERDRAIN DETAIL



CHAMBER	MAX DIAMETER OF INSERTA TEE	HEIGHT FROM BASE OF CHAMBER (X)
SC-310	6" (150 mm)	4" (100 mm)
SC-740	10" (250 mm)	4" (100 mm)
DC-780	10" (250 mm)	4" (100 mm)
MC-3500	12" (300 mm)	6" (150 mm)
MC-4500	12" (300 mm)	8" (200 mm)
MC-7200	12" (300 mm)	8" (200 mm)
INSERTA TEE FITTINGS AVAILABLE FOR SDR 26, SDR 35, SCH 40 IPS GASKETED & SOLVENT WELD, N-12, HP STORM, C-900 OR DUCTILE IRON		

NOTE:
PART NUMBERS WILL VARY BASED ON INLET PIPE MATERIALS. CONTACT STORMTECH FOR MORE INFORMATION.

6 — INSERTA-TEE SIDE INLET DETAIL



NOMINAL CHAMBER SPECIFICATIONS
SIZE (W X H X INSTALLED LENGTH) 100.0" X 60.0" X 79.1" (2540 mm X 1524 mm X 2010 mm)
CHAMBER STORAGE 175.9 CUBIC FEET ($4.98 m^3$)
MINIMUM INSTALLED STORAGE* 267.3 CUBIC FEET ($7.56 m^3$)
WEIGHT (NOMINAL) 205 lbs. (92.9 kg)

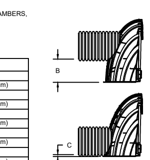
NOMINAL END CAP SPECIFICATIONS
SIZE (W X H X INSTALLED LENGTH) 90.0" X 61.0" X 32.8" (2286 mm X 1549 mm X 833 mm)
END CAP STORAGE 39.5 CUBIC FEET ($1.12 m^3$)
MINIMUM INSTALLED STORAGE* 115.3 CUBIC FEET ($3.26 m^3$)
WEIGHT (NOMINAL) 90 lbs. (40.8 kg)

*ASSUMES 12" (305 mm) STONE ABOVE, 9" (229 mm) STONE FOUNDATION AND BETWEEN CHAMBERS, 12" (305 mm) STONE PERIMETER IN FRONT OF END CAPS AND 40% STONE POROSITY.

PARTIAL CUT HOLES AT BOTTOM OF END CAP FOR PART NUMBERS ENDING WITH "B"
PARTIAL CUT HOLES AT TOP OF END CAP FOR PART NUMBERS ENDING WITH "T"
END CAPS WITH A PREFABRICATED WELDED STUB END WITH "W"

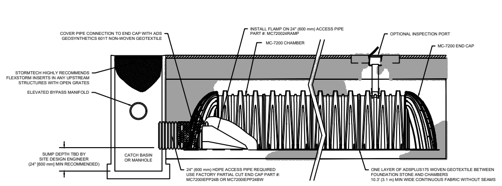
PART #	STUB	B	C
MC7200IEPP06T	6" (150 mm)	42.54" (1081 mm)	---
MC7200IEPP06B		---	0.86" (22 mm)
MC7200IEPP08T	8" (200 mm)	40.50" (1029 mm)	---
MC7200IEPP08B		---	1.01" (26 mm)
MC7200IEPP10T	10" (250 mm)	38.37" (975 mm)	---
MC7200IEPP10B		---	1.33" (34 mm)
MC7200IEPP12T	12" (300 mm)	35.69" (907 mm)	---
MC7200IEPP12B		---	1.55" (39 mm)
MC7200IEPP15T	15" (375 mm)	32.72" (831 mm)	---
MC7200IEPP15B		---	1.70" (43 mm)
MC7200IEPP18T	18" (450 mm)	29.36" (746 mm)	---
MC7200IEPP18TW			
MC7200IEPP18B		---	1.97" (50 mm)
MC7200IEPP18BW			
MC7200IEPP24T	24" (600 mm)	23.05" (585 mm)	---
MC7200IEPP24TW			
MC7200IEPP24B		---	2.26" (57 mm)
MC7200IEPP24BW			
MC7200IEPP30BW	30" (750 mm)	---	2.95" (75 mm)
MC7200IEPP36BW	36" (900 mm)	---	3.25" (83 mm)
MC7200IEPP42BW	42" (1050 mm)	---	3.55" (90 mm)

NOTE: ALL DIMENSIONS ARE NOMINAL



CUSTOM PREFABRICATED INVERTS ARE AVAILABLE UPON REQUEST. INVENTORIED MANIFOLDS INCLUDE 12-24" (300-600 mm) SIZE ON SIZE AND 15-48" (375-1200 mm) ECCENTRIC MANIFOLDS. CUSTOM INVERT LOCATIONS ON THE MC-7200 END CAP CUT IN THE FIELD ARE NOT RECOMMENDED FOR PIPE SIZES GREATER THAN 10" (250 mm). THE INVERT LOCATION IN COLUMN 'B' ARE THE HIGHEST POSSIBLE FOR THE PIPE SIZE.

2 — MC-7200 TECHNICAL SPECIFICATIONS



INSPECTION & MAINTENANCE

STEP 1) INSPECT ISOLATOR ROW PLUS FOR SEDIMENT
- A. INSPECTION PORTS (IF PRESENT)
  - A.1. REMOVE/OPEN LID ON NYLOPLAST INLINE DRAIN
  - A.2. REMOVE AND CLEAN FLEXSTORM FILTER IF INSTALLED
  - A.3. USING A FLASHLIGHT AND STADIA ROD, MEASURE DEPTH OF SEDIMENT AND RECORD ON MAINTENANCE LOG
  - A.4. LOWER A CAMERA INTO ISOLATOR ROW PLUS FOR VISUAL INSPECTION OF SEDIMENT LEVELS (OPTIONAL)
  - A.5. IF SEDIMENT IS AT, OR ABOVE, 3" (80 mm) PROCEED TO STEP 2. IF NOT, PROCEED TO STEP 3.
- B. ALL ISOLATOR PLUS ROWS
  - B.1. REMOVE COVER FROM STRUCTURE AT UPSTREAM END OF ISOLATOR ROW PLUS
  - B.2. USING A FLASHLIGHT, INSPECT DOWN THE ISOLATOR ROW PLUS THROUGH OUTLET PIPE
    - i) MIRRORS ON POLES OR CAMERAS MAY BE USED TO AVOID A CONFINED SPACE ENTRY
    - ii) FOLLOW OSHA REGULATIONS FOR CONFINED SPACE ENTRY IF ENTERING MANHOLE
  - B.3. IF SEDIMENT IS AT, OR ABOVE, 3" (80 mm) PROCEED TO STEP 2. IF NOT, PROCEED TO STEP 3.

STEP 2) CLEAN OUT ISOLATOR ROW PLUS USING THE JETVAC PROCESS
- A. A FIXED CULVERT CLEANING NOZZLE WITH REAR FACING SPREAD OF 45" (1.1 m) OR MORE IS PREFERRED
- B. APPLY MULTIPLE PASSES OF JETVAC UNTIL BACKFLUSH WATER IS CLEAN
- C. VACUUM STRUCTURE SUMP AS REQUIRED

STEP 3) REPLACE ALL COVERS, GRATES, FILTERS, AND LIDS; RECORD OBSERVATIONS AND ACTIONS.

STEP 4) INSPECT AND CLEAN BASINS AND MANHOLES UPSTREAM OF THE STORMTECH SYSTEM.

NOTES

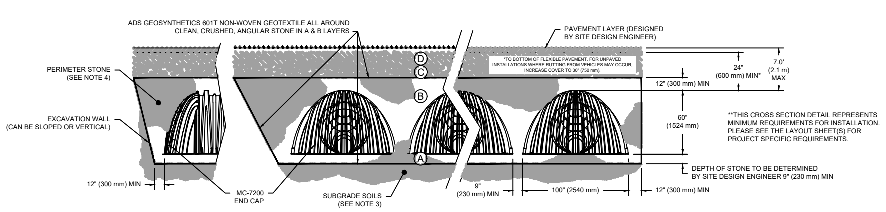
1. INSPECT EVERY 6 MONTHS DURING THE FIRST YEAR OF OPERATION. ADJUST THE INSPECTION INTERVAL BASED ON PREVIOUS OBSERVATIONS OF SEDIMENT ACCUMULATION AND HIGH WATER ELEVATIONS.
2. CONDUCT JETTING AND VACTORING ANNUALLY OR WHEN INSPECTION SHOWS THAT MAINTENANCE IS NECESSARY.

3 — MC-7200 ISOLATOR ROW PLUS DETAIL

ACCEPTABLE FILL MATERIALS: STORMTECH MC-7200 CHAMBER SYSTEMS

MATERIAL LOCATION		DESCRIPTION	AASHTO MATERIAL CLASSIFICATIONS	COMPACTION / DENSITY REQUIREMENT
D	**FINAL FILL:** FILL MATERIAL FOR LAYER 'D' STARTS FROM THE TOP OF THE 'C' LAYER TO THE BOTTOM OF FLEXIBLE PAVEMENT OR UNPAVED FINISHED GRADE ABOVE. NOTE THAT PAVEMENT SUBBASE MAY BE PART OF THE 'D' LAYER	ANY SOIL/ROCK MATERIALS, NATIVE SOILS, OR PER ENGINEER'S PLANS. CHECK PLANS FOR PAVEMENT SUBGRADE REQUIREMENTS.	N/A	PREPARE PER SITE DESIGN ENGINEER'S PLANS. PAVED INSTALLATIONS MAY HAVE STRINGENT MATERIAL AND PREPARATION REQUIREMENTS.
C	**INITIAL FILL:** FILL MATERIAL FOR LAYER 'C' STARTS FROM THE TOP OF THE EMBEDMENT STONE ('B' LAYER) TO 24" (600 mm) ABOVE THE TOP OF THE CHAMBER. NOTE THAT PAVEMENT SUBBASE MAY BE A PART OF THE 'C' LAYER.	GRANULAR WELL-GRADED SOIL/AGGREGATE MIXTURES, <35% FINES OR PROCESSED AGGREGATE. MOST PAVEMENT SUBBASE MATERIALS CAN BE USED IN LIEU OF THIS LAYER.	AASHTO M145[1] A-1, A-2-4, A-3 OR AASHTO M43[1] 3, 357, 4, 467, 5, 56, 57, 6, 67, 68, 7, 78, 8, 89, 9, 10	BEGIN COMPACTIONS AFTER 24" (600 mm) OF MATERIAL OVER THE CHAMBERS IS REACHED. COMPACT ADDITIONAL LAYERS IN 12" (300 mm) MAX LIFTS TO A MIN. 95% PROCTOR DENSITY FOR WELL GRADED MATERIAL AND 95% RELATIVE DENSITY FOR PROCESSED AGGREGATE MATERIALS.
B	**EMBEDMENT STONE:** FILL SURROUNDING THE CHAMBERS FROM THE FOUNDATION STONE ('A' LAYER) TO THE 'C' LAYER ABOVE.	CLEAN, CRUSHED, ANGULAR STONE	AASHTO M43[1] 3, 4	NO COMPACTION REQUIRED.
A	**FOUNDATION STONE:** FILL BELOW CHAMBERS FROM THE SUBGRADE UP TO THE FOOT (BOTTOM) OF THE CHAMBER.	CLEAN, CRUSHED, ANGULAR STONE	AASHTO M43[1] 3, 4	PLATE COMPACT OR ROLL TO ACHIEVE A FLAT SURFACE.[2,3]

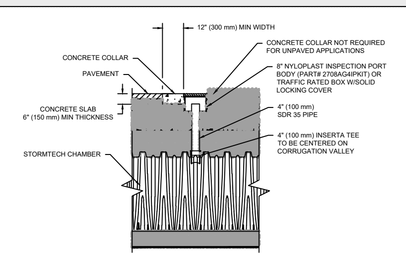
PLEASE NOTE:
1. THE LISTED AASHTO DESIGNATIONS ARE FOR GRADATIONS ONLY. THE STONE MUST ALSO BE CLEAN, CRUSHED, ANGULAR. FOR EXAMPLE, A SPECIFICATION FOR #4 STONE WOULD STATE: "CLEAN, CRUSHED, ANGULAR NO. 4 (AASHTO M43) STONE".
2. STORMTECH COMPACTION REQUIREMENTS ARE MET FOR 'A' LOCATION MATERIALS WHEN PLACED AND COMPACTED IN 9" (230 mm) (MAX) LIFTS USING TWO FULL COVERAGES WITH A VIBRATORY COMPACTOR.
3. WHERE INFILTRATION SURFACES MAY BE COMPROMISED BY COMPACTION, FOR STANDARD DESIGN LOAD CONDITIONS, A FLAT SURFACE MAY BE ACHIEVED BY RAKING OR DRAGGING WITHOUT COMPACTION EQUIPMENT. FOR SPECIAL LOAD DESIGNS, CONTACT STORMTECH FOR COMPACTION REQUIREMENTS.
4. ONCE LAYER 'C' IS PLACED, ANY SOIL/MATERIAL CAN BE PLACED IN LAYER 'D' UP TO THE FINISHED GRADE. MOST PAVEMENT SUBBASE SOILS CAN BE USED TO REPLACE THE MATERIAL REQUIREMENTS OF LAYER 'C' OR 'D' AT THE SITE DESIGN ENGINEER'S DISCRETION.



NOTES:

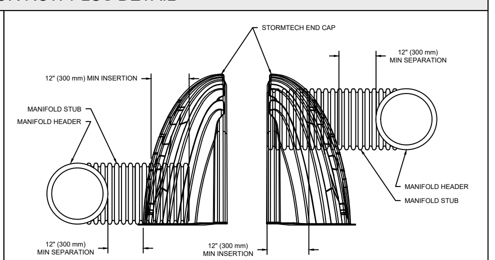
1. CHAMBERS SHALL MEET THE REQUIREMENTS OF ASTM F2418, "STANDARD SPECIFICATION FOR POLYPROPYLENE (PP) CORRUGATED WALL STORMWATER COLLECTION CHAMBERS" CHAMBER CLASSIFICATION 60x101
2. MC-7200 CHAMBERS SHALL BE DESIGNED IN ACCORDANCE WITH ASTM F2787 "STANDARD PRACTICE FOR STRUCTURAL DESIGN OF THERMOPLASTIC CORRUGATED WALL STORMWATER COLLECTION CHAMBERS".
3. THE SITE DESIGN ENGINEER IS RESPONSIBLE FOR ASSESSING THE BEARING RESISTANCE (ALLOWABLE BEARING CAPACITY) OF THE SUBGRADE SOILS AND THE DEPTH OF FOUNDATION STONE WITH CONSIDERATION FOR THE RANGE OF EXPECTED SOIL MOISTURE CONDITIONS.
4. PERIMETER STONE MUST BE EXTENDED HORIZONTALLY TO THE EXCAVATION WALL FOR BOTH VERTICAL AND SLOPED EXCAVATION WALLS.
5. REQUIREMENTS FOR HANDLING AND INSTALLATION:
   - TO MAINTAIN THE WIDTH OF CHAMBERS DURING SHIPPING AND HANDLING, CHAMBERS SHALL HAVE INTEGRAL, INTERLOCKING STACKING LUGS.
   - TO ENSURE A SECURE JOINT DURING INSTALLATION AND BACKFILL, THE HEIGHT OF THE CHAMBER JOINT SHALL NOT BE LESS THAN 3".
   - TO ENSURE THE INTEGRITY OF THE ARCH SHAPE DURING INSTALLATION, a) THE ARCH STIFFNESS CONSTANT AS DEFINED IN SECTION 6.2.8 OF ASTM F2418 SHALL BE GREATER THAN OR EQUAL TO 500 LBS/FT/%. AND b) TO RESIST CHAMBER DEFORMATION DURING INSTALLATION AT ELEVATED TEMPERATURES (ABOVE 73° F / 23° C), CHAMBERS SHALL BE PRODUCED FROM REFLECTIVE GOLD OR YELLOW COLORS.

1 — MC-7200 CROSS SECTION DETAIL



NOTE:
INSPECTION PORTS MAY BE CONNECTED THROUGH ANY CHAMBER CORRUGATION VALLEY.

4 — 4" PVC INSPECTION PORT DETAIL (MC SERIES CHAMBER)



NOTE: MANIFOLD STUB MUST BE LAID HORIZONTAL FOR A PROPER FIT IN END CAP OPENING.

7 — MC-SERIES END CAP INSERTION DETAIL

DRAWN: | DATE:
REVIEWED: | PROJECT NO:
REV: | NOT TO SCALE

MC-7200 STANDARD DETAILS

StormTech® Chamber System
888-892-2694 | WWW.STORMTECH.COM

ADS Advanced Drainage Systems, Inc.
4640 TRUEMAN BLVD
HILLIARD, OH 43026

SHEET

HIGH COUNTRY ENGINEERING, INC
2112 S HUFFER LN
FLAGSTAFF, ARIZONA 86001
PHONE (928) 123-4567

ADS STORMTECH CHAMBER DETAILS AND NOTES
PURINA FACILITY NEW ENTRANCE
APN: 113-28-004F
4700 E NESTLE PURINA AVE
FLAGSTAFF, AZ, 86004

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

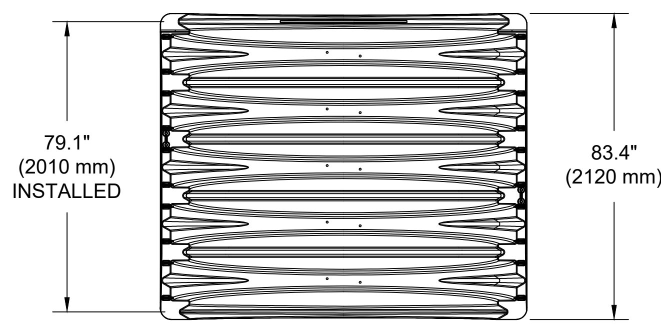
CALL TWO WORKING DAYS BEFORE YOU DIG
DIAL 811
BLUE STAKE CENTER

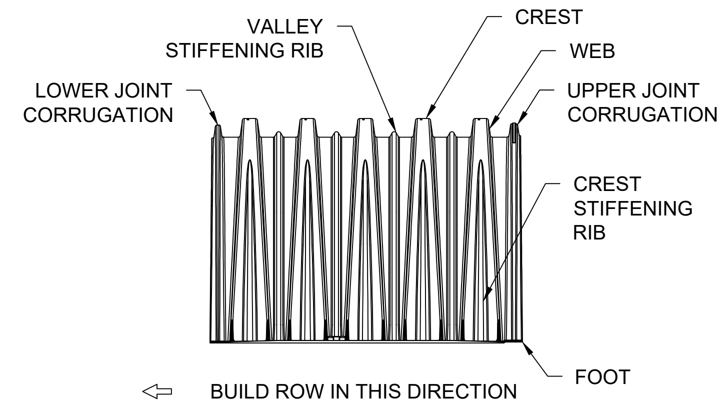
project: PURINA ENTRANCE
proj. #: 22-486C
drawing name:
CHAMBER DETAILS & NOTES
drawn by: TLD
reviewed by: TLD
date: 12/01/2022

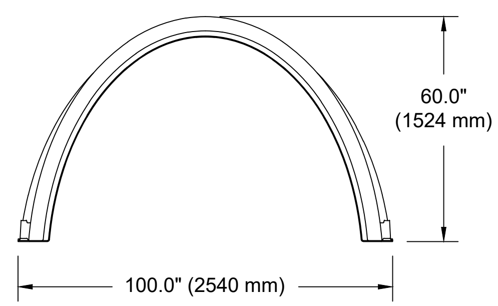
revisions:
date:
date:
date:

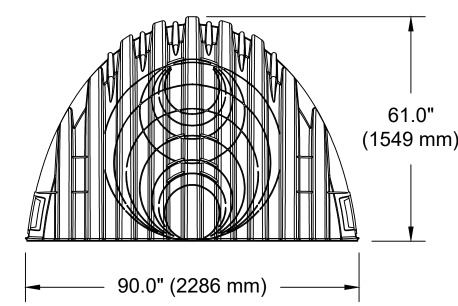
MC-7200 TECHNICAL SPECIFICATION

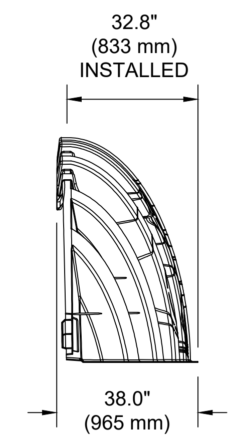
NTS











NOMINAL CHAMBER SPECIFICATIONS

SIZE (W X H X INSTALLED LENGTH)	100.0" X 60.0" X 79.1"	(2540 mm X 1524 mm X 2010 mm)
CHAMBER STORAGE	175.9 CUBIC FEET	(4.98 m³)
MINIMUM INSTALLED STORAGE*	267.3 CUBIC FEET	(7.56 m³)
WEIGHT (NOMINAL)	205 lbs.	(92.9 kg)

NOMINAL END CAP SPECIFICATIONS

SIZE (W X H X INSTALLED LENGTH)	90.0" X 61.0" X 32.8"	(2286 mm X 1549 mm X 833 mm)
END CAP STORAGE	39.5 CUBIC FEET	(1.12 m³)
MINIMUM INSTALLED STORAGE*	115.3 CUBIC FEET	(3.26 m³)
WEIGHT (NOMINAL)	90 lbs.	(40.8 kg)

*ASSUMES 12" (305 mm) STONE ABOVE, 9" (229 mm) STONE FOUNDATION AND BETWEEN CHAMBERS, 12" (305 mm) STONE PERIMETER IN FRONT OF END CAPS AND 40% STONE POROSITY.

PARTIAL CUT HOLES AT BOTTOM OF END CAP FOR PART NUMBERS ENDING WITH "B"
PARTIAL CUT HOLES AT TOP OF END CAP FOR PART NUMBERS ENDING WITH "T"
END CAPS WITH A PREFABRICATED WELDED STUB END WITH "W"

PART #	STUB	B	C
MC7200IEPP06T	6" (150 mm)	42.54" (1081 mm)	---
MC7200IEPP06B		---	0.86" (22 mm)
MC7200IEPP08T	8" (200 mm)	40.50" (1029 mm)	---
MC7200IEPP08B		---	1.01" (26 mm)
MC7200IEPP10T	10" (250 mm)	38.37" (975 mm)	---
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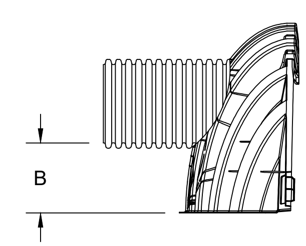
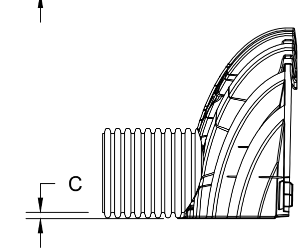
MC7200IEPP24BW			
MC7200IEPP30BW	30" (750 mm)	---	2.95" (75 mm)
MC7200IEPP36BW	36" (900 mm)	---	3.25" (83 mm)
MC7200IEPP42BW	42" (1050 mm)	---	3.55" (90 mm)

NOTE: ALL DIMENSIONS ARE NOMINAL





CUSTOM PREFABRICATED INVERTS ARE AVAILABLE UPON REQUEST. INVENTORIED MANIFOLDS INCLUDE 12-24" (300-600 mm) SIZE ON SIZE AND 15-48" (375-1200 mm) ECCENTRIC MANIFOLDS. CUSTOM INVERT LOCATIONS ON THE MC-7200 END CAP CUT IN THE FIELD ARE NOT RECOMMENDED FOR PIPE SIZES GREATER THAN 10" (250 mm). THE INVERT LOCATION IN COLUMN 'B' ARE THE HIGHEST POSSIBLE FOR THE PIPE SIZE.

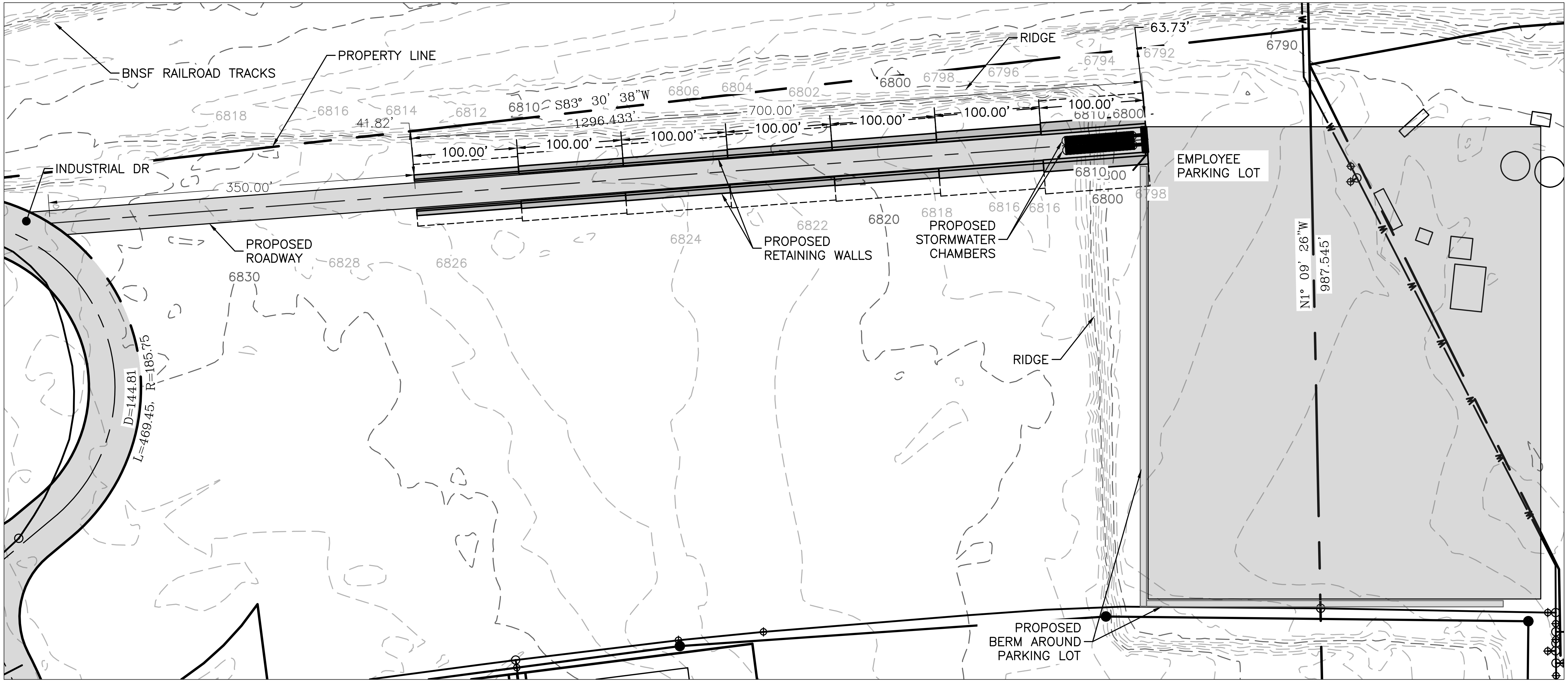
HIGH COUNTRY ENGINEERING, INC
2112 S HUFFER LN
FLAGSTAFF, ARIZONA 86001
PHONE (928) 123-4567

ADS STORMTECH CHAMBER DETAILS AND NOTES (CONT)
PURINA FACILITY NEW ENTRANCE
APN: 113-28-004F
4700 E NESTLE PURINA AVE
FLAGSTAFF, AZ, 86004

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

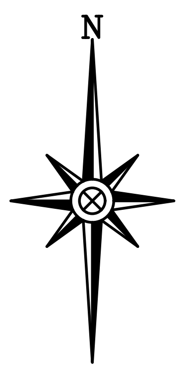
project: PURINA ENTRANCE
proj. #: 22-486C
drawing name:
CHAMBER DETAILS & NOTES
drawn by: TLD
reviewed by: TLD
date: 12/01/2022

revisions:
date:
date:
date:

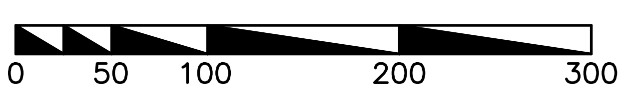


LEGEND

- MINOR CONTOUR
- MAJOR CONTOUR
- PROPERTY LINE
- ROAD CENTERLINE
- EXCAVATION BOUNDARIES
- HYDRANT MARKER
- WATER MAIN JCTN



SCALE: 1" = 100'



NOTES:

1. TOPOGRAPHIC INFORMATION PROVIDED BY CITY OF FLAGSTAFF AERIAL LiDAR. PARCEL BOUNDARIES ARE RECORD.
2. THE SUBJECT PARCEL BELONGS TO NESTLE PURINA PETCARE COMPANY.
3. ALL QUANTITIES ARE APPROXIMATE. THE CONTRACTOR IS RESPONSIBLE FOR ESTIMATING QUANTITIES TO ENSURE COMPLETION OF THE PROJECT AS DESIGNED.
4. EXISTING UNDERGROUND UTILITY LOCATIONS WERE DETERMINED FROM FIELD MEASUREMENTS, CONSTRUCTION PLANS, RECORD PLANS, OR UTILITY MAPS FURNISHED BY OTHERS. THEY ARE TO BE REGARDED AS APPROXIMATE ONLY. IT IS THE CONTRACTOR'S RESPONSIBILITY TO ESTABLISH THE ACTUAL LOCATIONS IN THE FIELD.
5. ALL EFFORTS WERE MADE BY THE DESIGNER TO LOCATE AND VERIFY ALL RIGHT-OF-WAYS AND EASEMENTS.
6. NO SETBACKS EXIST WITHIN 200' OF THE STRUCTURE THAT WILL EFFECT ITS INSTALLATION OR OPERATION.
7. ALL MATERIALS AND CONSTRUCTION SHALL BE IN COMPLIANCE WITH THE ARIZONA DEPARTMENT OF TRANSPORTATION STANDARDS, 2018 INTERNATIONAL BUILDING CODE STANDARDS, AND INTERNATIONAL CONCRETE DESIGN MANUAL STANDARDS.

HIGH COUNTRY ENGINEERING, INC
2112 S HUFFER LN
FLAGSTAFF, ARIZONA 86001
PHONE: (928) 123-4567

GENERAL SITE PLAN AND NOTES
PURINA FACILITY NEW ENTRANCE
APN: 113-28-004F
4700 E NESTLE PURINA AVE
FLAGSTAFF, AZ, 86004

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

CALL TWO WORKING DAYS BEFORE YOU DIG
DIAL 811
BLUE STAKE CENTER

project: PURINA ENTRANCE	
proj. #: 22-486C	
drawing name:	
SITE PLAN	
drawn by: TLD	
reviewed by: TLD	
date: 12/01/2022	

revisions:	
date:	
date:	
date:	

LEGEND

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

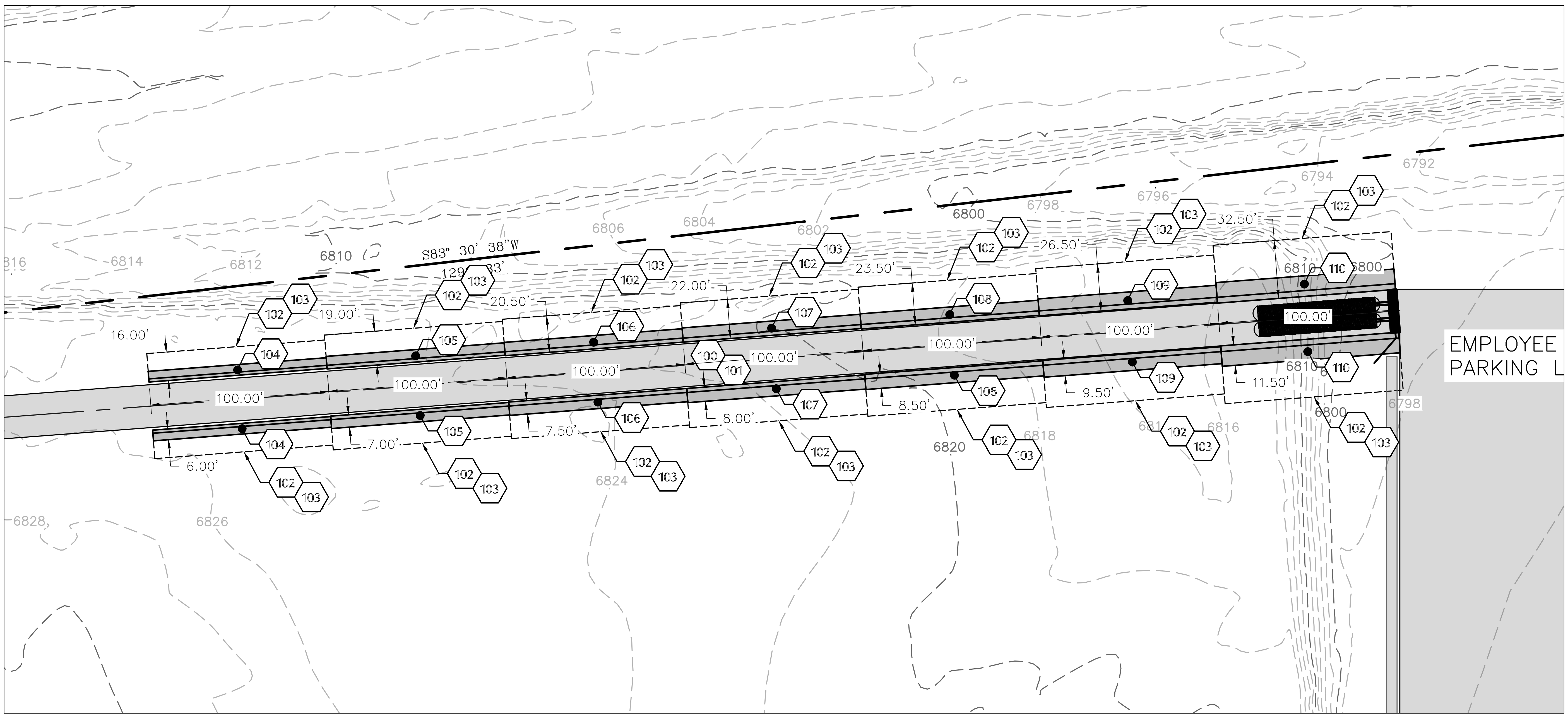
N

SCALE: 1" = 60'

0 30 60 120 180

CONSTRUCTION NOTES

100	1	LS	CLEAR AND GRUB SITE: SEE NOTES SHEET, 'C1'.
101	1	LS	ALL AREAS DISTURBED BY CONSTRUCTION SHALL BE RE-SEEDED TO PREVENT EROSION. SEE C.O.F. GENERAL NOTES #20.
102	14,417	CY	CUT: SEE NOTES SHEET, 'C2'. CUT SHOWN DOES NOT INCLUDE BUILDING QUANTITIES. SEE NOTES BELOW.
103	9,475	CY	FILL: SEE NOTES SHEET, 'C2'. FILL SHOWN DOES NOT INCLUDE BUILDING QUANTITIES. SEE NOTES BELOW.
104	200	LF	CONSTRUCT RETAINING WALL PER PROFILE ON SHEET 'C9' & STRUCTURAL DRAWING ON SHEET 'C3' & DIMENSIONS PER 10' HEIGHT PER 'C4'.
105	200	LF	CONSTRUCT RETAINING WALL PER PROFILE ON SHEET 'C9' & STRUCTURAL DRAWING ON SHEET 'C3' & DIMENSIONS PER 12' HEIGHT PER 'C4'.
106	200	LF	CONSTRUCT RETAINING WALL PER PROFILE ON SHEET 'C9' & STRUCTURAL DRAWING ON SHEET 'C3' & DIMENSIONS PER 13' HEIGHT PER 'C4'.
107	200	LF	CONSTRUCT RETAINING WALL PER PROFILE ON SHEET 'C9' & STRUCTURAL DRAWING ON SHEET 'C3' & DIMENSIONS PER 14' HEIGHT PER 'C4'.
108	200	LF	CONSTRUCT RETAINING WALL PER PROFILE ON SHEET 'C9' & STRUCTURAL DRAWING ON SHEET 'C3' & DIMENSIONS PER 15' HEIGHT PER 'C4'.
109	200	LF	CONSTRUCT RETAINING WALL PER PROFILE ON SHEET 'C9' & STRUCTURAL DRAWING ON SHEET 'C3' & DIMENSIONS PER 17' HEIGHT PER 'C4'.
110	200	LF	CONSTRUCT RETAINING WALL PER PROFILE ON SHEET 'C9' & STRUCTURAL DRAWING ON SHEET 'C3' & DIMENSIONS PER 21' HEIGHT PER 'C4'.



HIGH COUNTRY ENGINEERING, INC
2112 S HUFFER LN
FLAGSTAFF, ARIZONA 86001
PHONE (928) 123-4567

RETAINING WALL CONSTRUCTION PLAN
PURINA FACILITY NEW ENTRANCE
APN: 113-28-004F
4700 E NESTLE PURINA AVE
FLAGSTAFF, AZ, 86004

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

CALL TWO WORKING DAYS BEFORE YOU DIG
DIAL 811
BLUE STAKE CENTER

project: PURINA ENTRANCE
proj. #: 22-486C
drawing name:
RET. WALL CONST. PLAN
drawn by: TLD
reviewed by: TLD
date: 12/01/2022

revisions:
date:
date:
date:

LEGEND

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

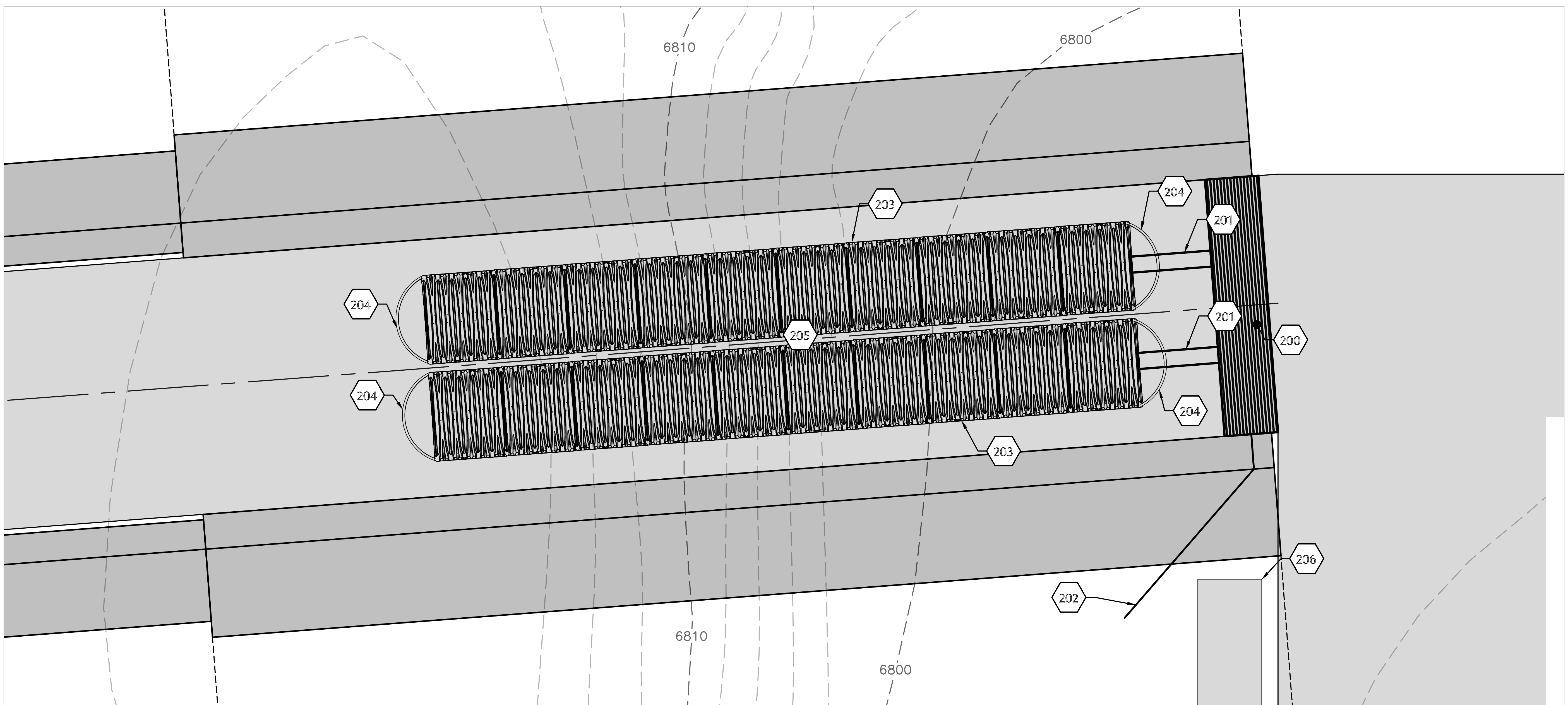
N

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'.



HIGH COUNTRY ENGINEERING, INC
2112 S HUFFER LN
FLAGSTAFF, ARIZONA 86001
PHONE (928) 123-4567

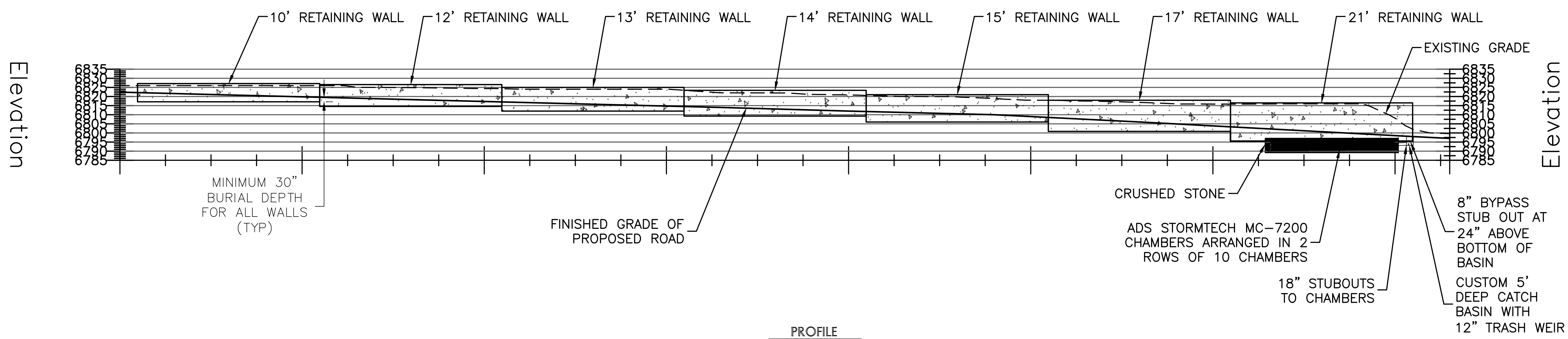
CHAMBER STORAGE CONSTRUCTION PLAN
PURINA FACILITY NEW ENTRANCE
APN: 113-28-004F
4700 E NESTLE PURINA AVE
FLAGSTAFF, AZ, 860004

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

CALL TWO WORKING DAYS BEFORE YOU DIG
DIAL 811
BLUE STAKE CENTER

project: PURINA ENTRANCE
proj. #: 22-486C
drawing name:
CHAMBER CONST. PLAN
drawn by: TLD
reviewed by: TLD
date: 12/01/2022

revisions:
date:
date:
date:



PROFILE
SCALE 1"=60'

HIGH COUNTRY ENGINEERING, INC
2112 S HUFFER LN
FLAGSTAFF, ARIZONA 86001
PHONE (928) 123-4567

ROAD PROFILE
PURINA FACILITY NEW ENTRANCE
APN: 113-28-004F
4700 E NESTLE PURINA AVE
FLAGSTAFF, AZ, 86004

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

CALL TWO WORKING DAYS BEFORE YOU DIG
DIAL 811
BLUE STAKE CENTER

project:	PURINA ENTRANCE
proj. #:	22-486C
drawing name:	
ROAD PROFILE	
drawn by:	TLD
reviewed by:	TLD
date:	12/01/2022

revisions:	
date:	
date:	
date:	