APPENDIX A. Key Reference Documents and Select Literature Review Projects

A.1 Key Literature Review Documents

Primary Industry-Specific References

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Federal Highway Administration (FHWA). 2013. "Urban Drainage Design Manual." *Hydraulic Engineering Circular No. 22, Third Edition*. U.S. Department of Transportation, Federal Highway Administration, Washington, D.C.

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A.2 Select Airport Permeable Pavement Projects

A.2.1 San Diego International Airport Terminal 2 Short-Term Parking Lot Pavement

San Diego County's *Low-Impact Development (LID) Handbook* (2014) details a variety of LID stormwater management strategies, including permeable pavement, and presents a 2012 case study involving the use of permeable pavement and rock infiltration swales at the San Diego International Airport. The project featured permeable interlocking concrete paver (PICP) construction in the parking stalls and along the perimeter of the Terminal 2 Short-term Parking Lot (see figure A-1). The pavers were placed on 2 inches of bedding course (washed ASTM No. 8 stone), a 4-inch structural base (washed ASTM No. 57 stone), and a 24-inch reservoir layer (ASTM No. 2 stone). Compaction of the natural subgrade soil was minimized to facilitate stormwater infiltration.

For the project, detailed design steps were established, and designated maintenance activities for the permeable pavement were developed. Key implementation challenges included topographical constraints and drainage patterns (locations of available land for LID did not always coincide with areas to which runoff flows) and the sourcing and furnishing of specified materials (difficulty in finding a quarry or supplier that could provide washed ASTM No. 2 and No. 8 aggregates). Construction oversight and open communication with the contractor were found to be important components to the success of the project.

Figure A-1. Permeable interlocking paver installation at San Diego International Airport Terminal 2 Short-Term Parking Lot (San Diego County 2014).

A.2.2 Stewart International Airport Parking Lot Pavements

In 2007 and 2010, the Port Authority of New York and New Jersey (PANY/NJ) implemented permeable pavement systems on two separate parking lots at Stewart International Airport in Orange County, New York (Cremin 2010). The 2007 Parking Lot D pavement project utilized pervious asphalt pavement with 100 percent stormwater infiltration design covering a 3-acre area. The 2010 project involved a 6-acre expansion of Parking Lot A (in front of the airlines terminal) (Louie et al. 2011). The 2010 project consisted of a 3-inch porous asphalt surface, underlain by 2 inches of choker stone and an 18- to 36-inch stone base reservoir with large voids (see figure A-2). It also included an extensive system of infiltration trenches and sub-drains, and the use of rain tanks with filter fabric.

The porous asphalt mix used for the parking lot "A" project was adapted from the NJDOT, calling for 6 percent by weight of Performance Grade (PG) 76-22 modified asphalt binder with a cellulose fiber (Louie et al. 2011). The aggregate gradation consisted of a 3/8-inch maximum top size with primarily No. 4 and a minimum of fines (Louie et al. 2011). The PANY/NJ used the NJDOT mix design because of experience with the Parking Lot D performance. Although the Parking Lot D permeable pavement used the same design elements as that of Parking Lot A, it included a porous asphalt surface mix typically used by the PANY/NJ for airfield applications with infrequent tire contact surfaces (e.g., shoulders, erosion pavements). The mix contained larger aggregate sizes and lower asphalt binder content, which combined with possible shortcomings in paving practices, resulted in mat joint raveling and surface segregation after the first winter season (Louie et al. 2011).

In addition to the porous asphalt mix revision, stricter material quality controls and structured paving procedures were enforced, and a 12-in wide emulsified asphalt slurry was applied on the surface of all mat joints to help mitigate raveling. Although early indications of the effect of these actions were positive, the PANY/NJ is continuing to monitor the long-term performance of the pavement.

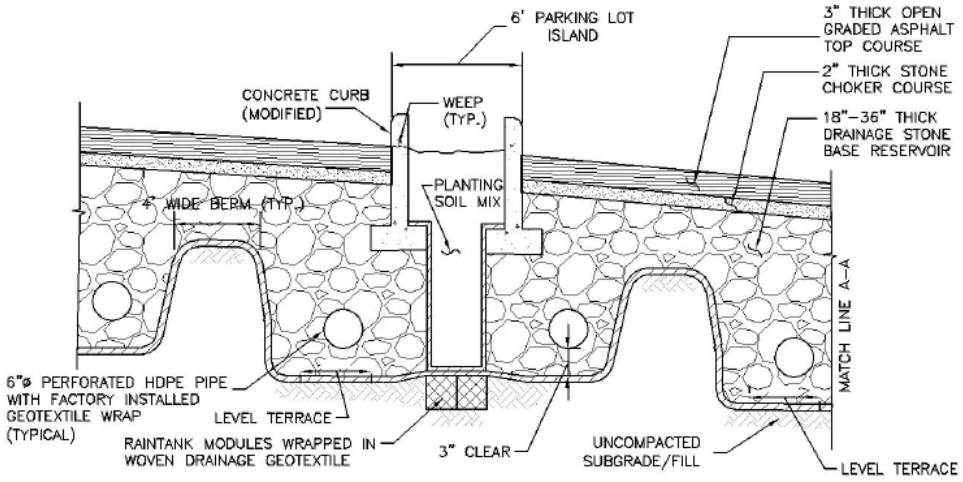

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Figure A-2. Stewart International Airport Parking Lot A section (Louie et al. 2011).

A.2.3 Burlington International Airport Heritage Flight Center Parking Lot Pavement

As part of a 2008 Vermont Agency of Transportation (AOT) study evaluating the strength and hydraulic characteristics of pervious concrete pavement, test pavements were constructed at two separate facilities—College Street in Burlington, Vermont and a parking lot at the Heritage Flight Center at the Burlington International Airport (Suozzo and Dewoolkar 2012). The Heritage parking lot pavement consisted of a 6-inch pervious concrete surface placed on a 34-inch gravel subbase. Initial infiltration rates following construction ranged between 2,000 and 4,000 in/hr. Monitoring of infiltration over a 1-year period (figure A-3 identifies the test locations) showed typical rate reductions between 10 and 30 percent. Parking stalls exhibited the lowest reduction rates, while entrances showed the highest rates due to compaction under delivery trucks and clogging caused by asphalt particles redistributed from nearby roads.

Figure A-4 shows the effects of surface cleaning of the Heritage parking lot facility using two different methods—a sweeper and a vacuum truck. Although both techniques generally resulted in increases to the infiltration rates, it was determined that the vacuum truck was more effective in removing clogging material and providing improved infiltration rates.

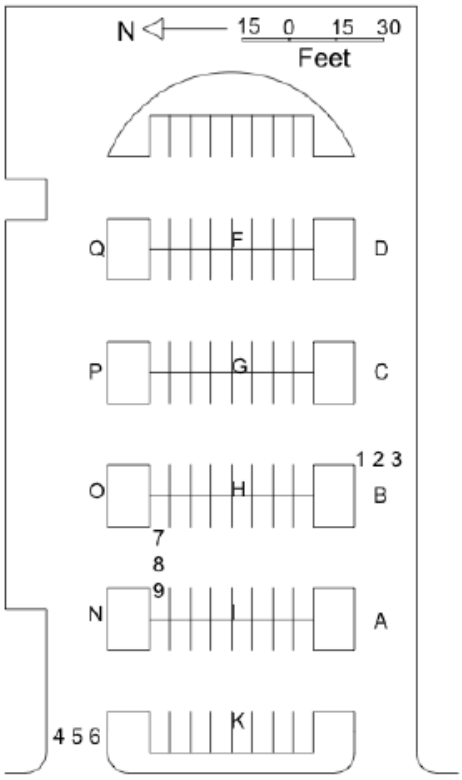

Figure A-3. Heritage Flight pervious concrete parking facility and testing layout (Suozzo and Dewoolkar 2012).

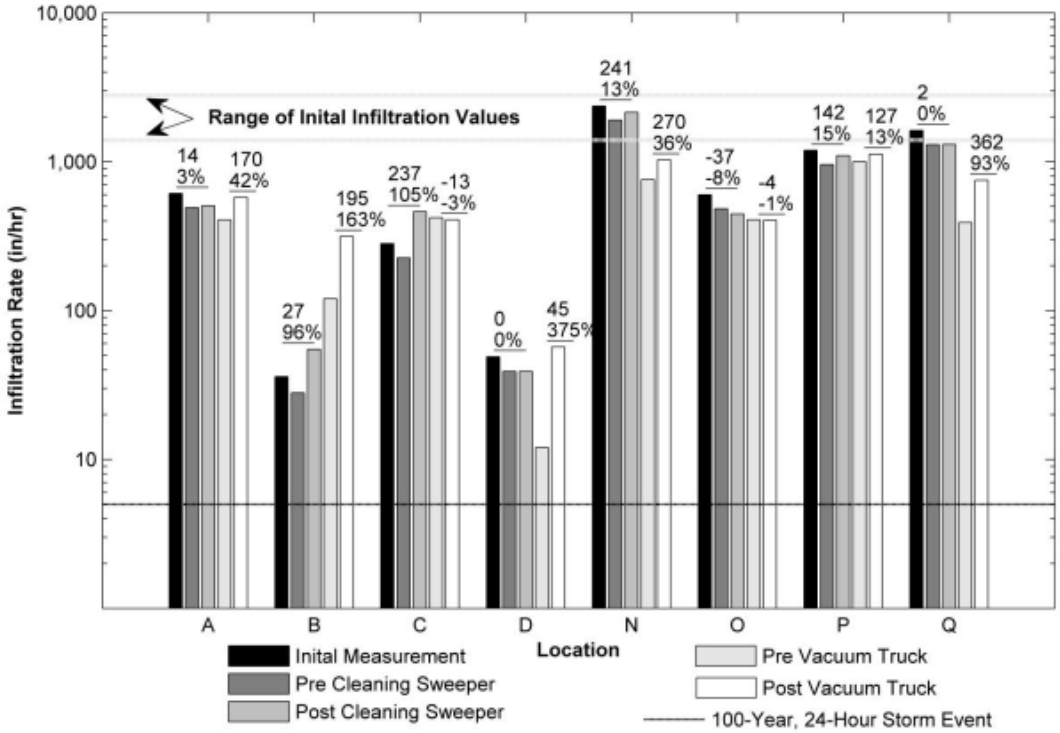

Figure A-4. Results of maintenance operations at the Heritage Flight parking lot (Suozzo and Dewoolkar 2012).

A.2.4 Wittman Regional Airport Taxiway Shoulder Pavement

This project at Wittman Field in Oshkosh, Wisconsin included the expansion of the existing airport facility to accommodate additional amenities, exhibit space, and 3 miles of new roads (Givens and Eggen n.d.). Stormwater conditions were challenging due to the proximity to the airport, high land value, and concerns for pedestrian safety with traditional stormwater systems. Potential considerations included a conventional stormwater pond, a pervious pavement system (twice the cost of a conventional pond), and a stormwater pond 0.5 miles from the site (ten times the cost of a conventional pond). The pervious pavement system was selected due to the lower traffic volumes, no winter issues, and various identified benefits—no loss of prime exhibit space, elimination of safety concerns, and maximizing of exhibitor space).

The project included the use of two types of permeable pavement systems—porous asphalt and Geoweb (a pavement surface comprised of gravel filled plastic grids). The porous asphalt system was implemented on a 50-foot wide taxiway extension and the 30-foot wide roadways, denoted as Inner X North and Inner X South. As shown in figure A-5, the pavement system consisted of an 18-inch thick clean stone reservoir (33 percent void space) underlying both the traveled taxiway (dense-graded asphalt surface on 0.75-inch aggregate base) and the adjacent shoulder (porous asphalt). A geosynthetic filter fabric was placed around the stone reservoir to separate it from subsoils, and lateral subdrain pipes were installed at the bottom of the reservoir. Because of longitudinal grade issues, lateral dense aggregate berms were constructed intermittently along the length of the facility.

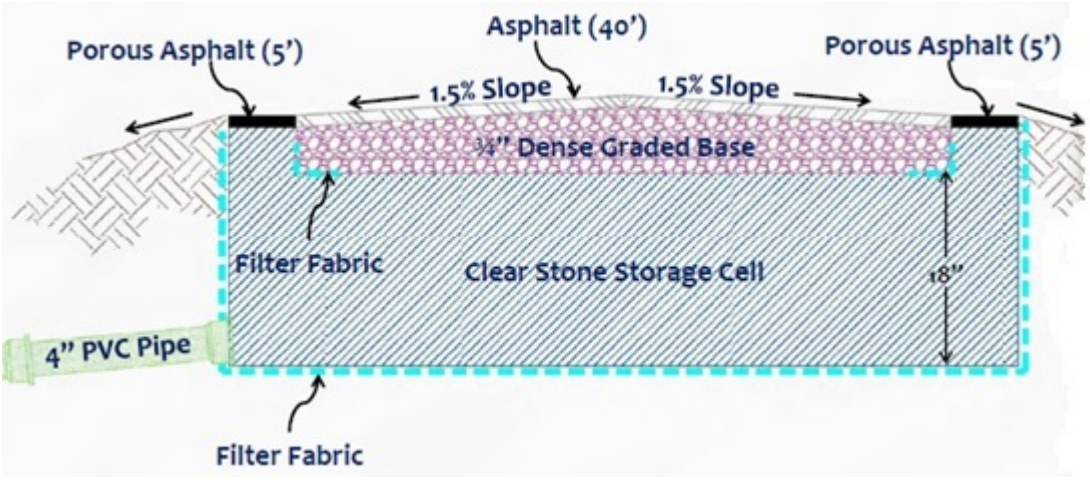

Figure A-5. Cross-section of porous asphalt taxiway shoulder pavement at Wittman Field (Givens and Eggen 2012).

The porous asphalt system was designed to handle a 100-year storm event and the application of light traffic only (no heavy vehicles). Intended maintenance for the system included vacuum sweeping twice daily during the annual AirVenture exhibit and winter maintenance in the form of plowing only (no sand application). It must be noted that the pavement only sees significant loading for the days of the summer airfest. Post-construction performance information for the pavement is unavailable.

A.2.5 General Mitchell International Airport Runway Shoulder Pavement

This pervious pavement demonstration project at General Mitchell International Airport in Milwaukee, Wisconsin was constructed in 2004 (Schwandt 2012). The project included placement of a 25-foot wide by 300-foot long porous asphalt pavement shoulder at the intersection of runways 1L-19R and 7R-25L. The existing shoulder slope ranged from 1.5 to 5.0 percent. As illustrated in figure 7, the porous asphalt layers were constructed using a PG 64-22 binder, 1/2-inch maximum aggregate size, 4.0 percent asphalt binder content, and 17 percent air voids. Since the existing subgrade consisted of very tight clays (e.g., no infiltration) a perforated underdrain pipe was added in the subbase layer for drainage. Shortly after construction the surface began to ravel, which is likely due to the relatively low asphalt binder content. By 2016 the shoulder pavement was replaced with conventional HMA pavement.

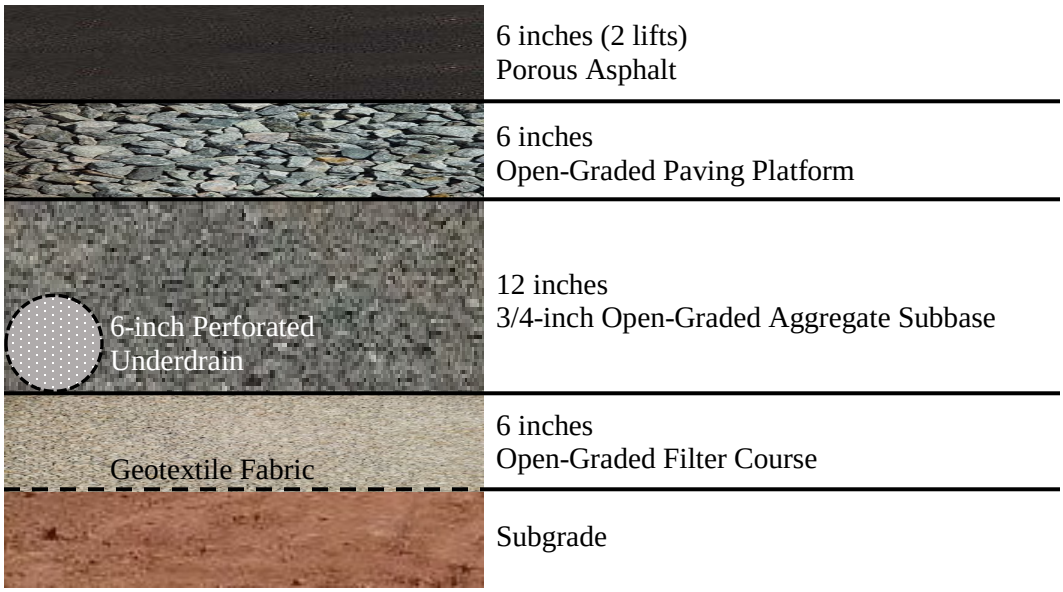

Figure A-6. Cross-section of porous asphalt runway shoulder pavement at General Mitchell Airport.

APPENDIX B. Case Studies

B.1 Culpeper Regional Airport Porous Asphalt Apron

CULPEPER REGIONAL AIRPORT

T-HANGAR AND EXECUTIVE HANGAR DEVELOPMENT

B.1.1 Project Overview

Culpeper Regional Airport (CJR) is a county-owned public-use airport located northeast of the central business district of Culpeper, Virginia. The airport opened in 1969 and has been owned by the County of Culpeper since 1989. It can handle corporate size jets and large twin engine aircraft. The airport has held an "Air Fest" every October since 1998, with performances such as aerobatics and vintage aircraft displays.

As part of CJR's planned growth, additional T-hangars and executive hangars are being added to the airfield (see figure B-1). The airport's expansion requires stormwater retention facilities to offset the development (impermeable area). However, the airport does not have available land to provide sufficient stormwater detention areas for the new apron paved areas: there is a roadway to the west and existing developments to the north, east, and south. Therefore, another method of reducing the stormwater time of concentration had to be provided. The design team (Campbell & Paris Engineers [C&P]) determined that a permeable pavement could be incorporated in the apron area to provide the required stormwater detention.

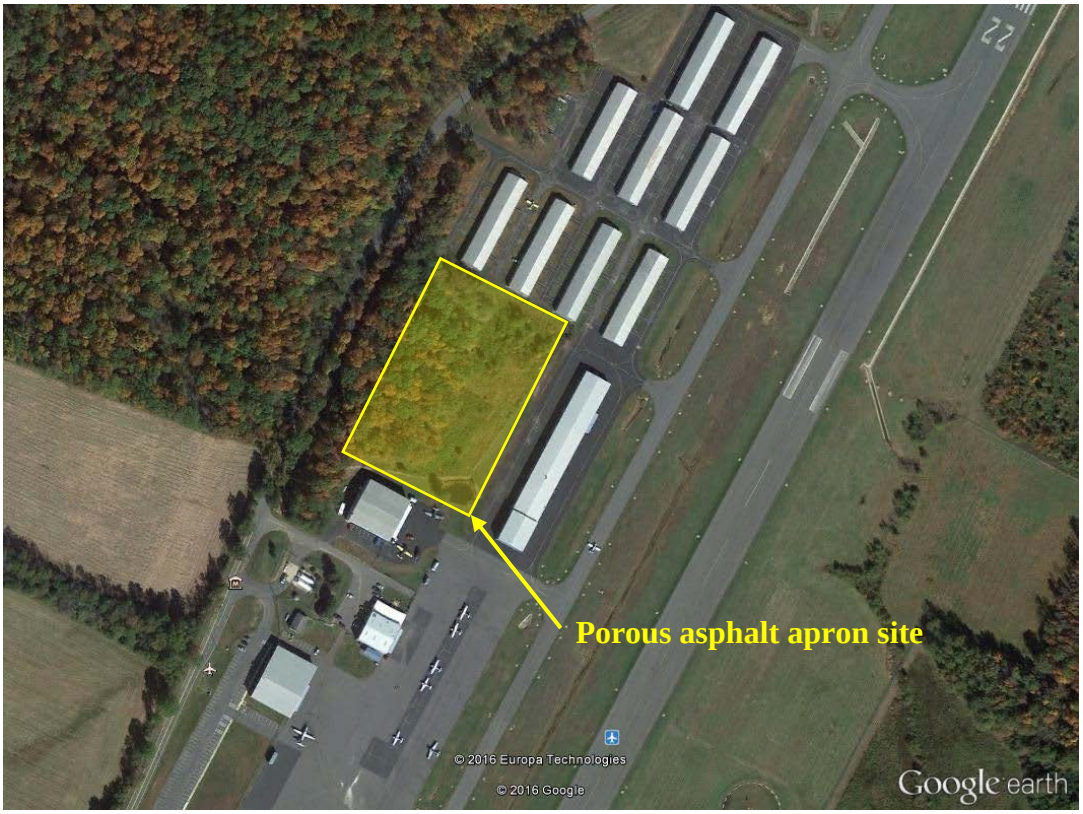

Figure B-1. Overview of Culpeper Regional Airport proposed apron site (map data ©2016 Google and Europa Technologies).

In addition to the experience of the design team, the project had a strong "champion." A County Administrator at the time (a former Naval Wing Commander) helped to get the project off the ground and was a big advocate for the project throughout the planning and design.

The original project design included both permeable and impermeable pavement areas. Dense-graded asphalt was initially planned for the taxilanes, and porous asphalt planned for the remainder of the apron area. However, at the Contractor's request the permeable pavement is being used for all pavement. The use of the permeable pavement in the taxilanes facilitated easier construction for the Contractor and would result in a more uniform product. After consideration with the airport, the design team allowed the use of permeable pavement because:

- "Locked wheel" turns are not anticipated.
- Aircraft loading is light (37,000 lbs and less).
- There is no parking on the apron (pavement is only used to travel to and from the hangars).

The cross section for the permeable pavement consists of the following:

- 1.5-inches FAA porous friction course (P-402).
- 2.5-inches Virginia Department of Transportation (VDOT) permeable asphalt mixture 19.0 (PAM-19.0).
- 6-inches VDOT cement stabilized open-graded material (S-OGM).
- 6-inches drainage layer (VDOT #1 surge stone).

The apron portion of the project is funded through a Virginia Department of Aviation (VDOA) grant, and the hangars are funded with Department of Agriculture funding. The project does not have FAA funding, so there were no modifications of standards.

The cost of the porous asphalt surface was slightly more than dense-graded asphalt. P-401 material was $155 per ton and P-402 material (used for the porous asphalt) was approximately $20 per ton higher. The permeable asphalt mixture (PAM-19.0), a VDOT material specification, was $110 per ton. The PAM-19.0 is a material similar to what the Contractor had used before (PAM-12.0), so the Contractor was relatively familiar with the material. VDOT surge stone versus FAA aggregate (P-209) was not much different in cost. Similarly, the cement-treated base (P-304) and cement S-OGM were the same unit cost ($20 per syd).

There were only two other bidders besides the winning Contractor, and their costs were much higher. This may be because those bidders were less familiar with permeable pavement materials and construction, and therefore had increased unit costs to account for the unknown.

Although a cost comparison was not performed for this project, the use of permeable pavement reduces the need for a lot of typical drainage items that would have been required for a more typical project. The use of a permeable pavement also mitigated the creation of a potential bird attractant with the use of detention ponds.

B.1.2 Design Considerations

The location of the project was fixed by available airport land and existing facility layout. That is, finding a site with suitable infiltration or other desired hydrological properties for design was not possible. The system had to be designed to the available site.

B.1.2.1 Hydrologic Design

Storage Capacity

The permeable pavement was designed to retain 100 percent of the 10-year design storm to reduce peak flow rates in the proposed conditions. The permeable pavement is designed to provide detention, rather than infiltration, due to the underlying low permeability soils.

The storage capacity goal was to meet the existing conditions for runoff. The additional detention and storage provided by the permeable pavement results in a reduction of peak flow rates from existing to proposed conditions.

Roof drains tie directly into the underdrain beneath the permeable pavement, which is surrounded by crushed stone aggregate. However, it is expected that a significant amount of stormwater from roof drains percolates into the surrounding crushed stone.

Infiltration Rates

Borings located in the area of the planned permeable pavement indicated the presence of low permeability silty clays. C&P assumed an infiltration rate of 0.00 to 0.05 inches per hour because of these poor draining soils. An underdrain was provided under the permeable pavement section to convey stormwater that does not infiltrate into the underlying soil strata. Surface infiltration rates were not established.

Water Quality Standards

Water quality treatment goals were not specifically established for the project. While the Virginia Department of Environmental Quality (DEQ) does have established guidelines, it did not require set water quality treatment goals for this project because of the use of permeable pavement. The airport as a whole has the required permits with DEQ. Although there were not specific treatment goals for the project, the permeable pavement was designed to retain one-half inch of stormwater from all impervious surfaces. Following project completion, water quality will be monitored at the airport's outfalls. It is anticipated the filtering process alone should improve existing water quality.

B.1.2.2 Pavement Design

The apron pavement is designed for general aviation aircraft weighing 37,000 lbs or less. The structural design was performed using FAARFIELD by using both default layers that are as close as possible to the materials being used and the "user defined" layers. The thickness design did not include the surge stone layer (figure B-2), and is therefore believed to be more conservative.

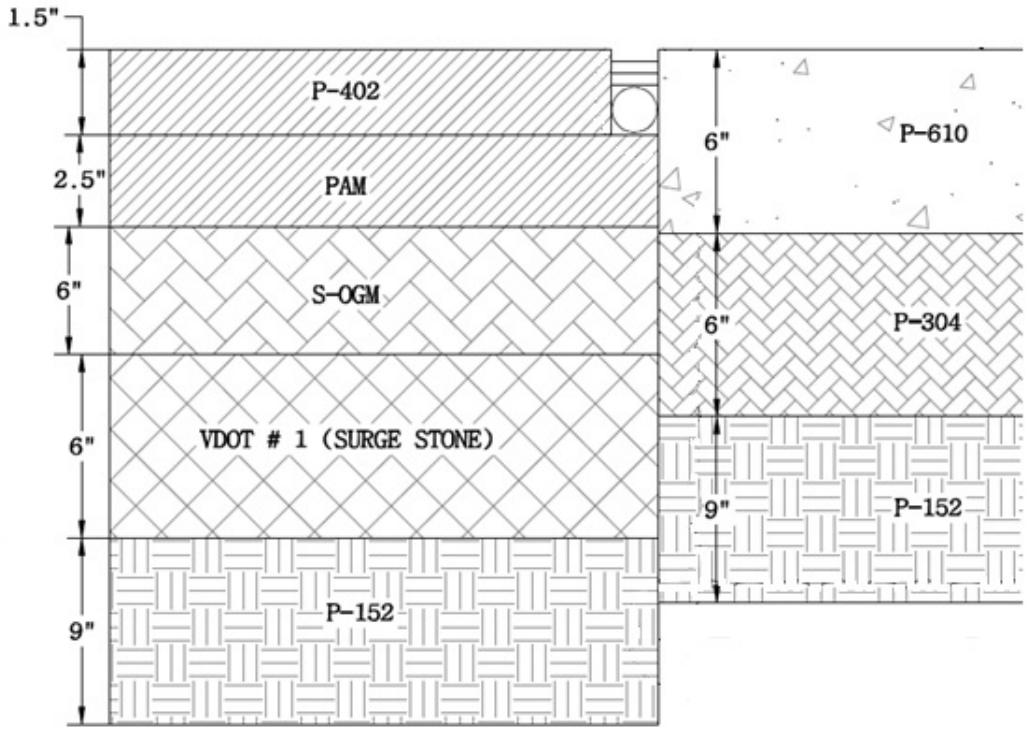

Figure B-2. Culpeper Regional airport porous asphalt cross section (C&P 2016).

The subgrade support value used for design is the soaked CBR to account for the subgrade being saturated after rain events.

B.1.3 Material Selection

B.1.3.1 Porous Asphalt

The porous asphalt surface course consists of 1.5 inches of P-402 porous friction course. The specified particle distribution for the aggregate used in the mixture is provided in table B-1. Other information regarding properties and testing required for the aggregate used in the asphalt mixture is available in Section 402-2.1 of the specification.

Table B-1. Aggregate gradation requirements for porous asphalt.

Sieve	3/4" maximum	Job-Mix (Production) Tolerances
3/4 in	100	---
1/2 in	70-90	+/- 5%
3/8 in	40-65	+/- 5%
No. 4	15-25	+/- 5%
No. 8	8-15	+/- 2%
No. 30	5-9	+/- 2%
No. 200	1-5	+/- 2%

According to the specifications, the bituminous content shall be within ±1 percent of the value obtained from the formula: $2K_c + 4.0$. Where, K_c is the surface area constant for that part of the total dry aggregate that will pass a ¾-in (19.0-mm) sieve and be retained on the No. 4 (4.75 mm) sieve.

The bituminous material is a viscosity-graded asphalt cement meeting the properties summarized in table 2 and ASTM D-3381, Table 2. A synthetic rubber additive is added to the binder in an amount not less than 2 percent by weight. The binder and additive is to be uniformly mixed to provide the requirements summarized in table B-2. Additional details are available in Section 402-2.3 of the specifications.

Table B-2. Porous asphalt test requirements.

Property	ASTM	Min.	Max.
Viscosity at 140 °F, Poises	D-2171	1600	2400
Viscosity at 275 °F, centistokes	D-2170	325	
Flash Point, °F	D-92	450	
Ductility at 77 °F (5 cm/min) cm	D-113	100	
Ductility at 39.2 °F (5 cm/min) cm	D-113	50	
Toughness, inch-pounds	D-5801	110	
Tenacity, inch-pounds	D5801	75	
Tests on Residue of Thin Film Oven Test			
Viscosity at 140 °F, Poises	D-2170	--	8000
Ductility at 77 °F, (5 cm/min) cm	D-113	100	
Ductility at 39.2 °F, (5 cm/min) cm	D-113	25	

It is also specified in the contract documents to apply bituminous tack coat in between stabilized layers at a rate of 0.2 gallons per syd, using the P-603 specification.

B.1.3.2 Porous Asphalt Mixture

The base layer consist of 2.5 inches of VDOT's PAM-19.0. PAM-19 is a "medium" (3/4 inch [19.0 mm] aggregate size) mix identified for use as an intermediate layer. PAM-19.0 is an open-graded asphalt mix applied atop a stone reservoir in a porous pavement structure (VDOT 2016).

B.1.3.3 Stabilized Open-Graded Mix

Underneath 2.5-inch of PAM-19, the subbase layer consists of a 6-inch stabilized, open-graded mix (S-OGM). This material is used as a porous base layer/drainage layer under the porous friction course. C&P developed the specification based on the Unified Facilities Guideline Specifications. The aggregates for the S-OGM layer are well graded within the limits specified in table B-3 for VDOT #57.

According to the project specifications, Section S-OGM-2.4, the S-OGM layer will contain a minimum of 300 lbs per cyd of portland cement. An increase of up to 375 lbs per cyd in portland cement is allowed to ensure this layer will not rut or be disturbed by the contractor's paving equipment.

Table B-3. Gradation of drainage layer material (VDOT #57).

Percentage of Weight Passing Square-Mesh Sieve	
Sieve Nominal Size Square Openings	**% passing**
1 1/2 in	100
1 in	95 - 100
3/4 in	---
1/2 in	25 – 60
3/8 in	---
No. 4	0 – 10
No. 8	0 – 5
No 16	---

B.1.3.4 Drainage Layer/Surge Stone

The S-OGM layer is placed on a 6-inch drainage/separation layer. This layer uses VDOT #1 surge stone. The specification for the particle distribution for VDOT #1 surge stone is provided in table B-4.

Table B-4. Gradation of drainage layer material (VDOT #1).

Percentage of Weight Passing Square-Mesh Sieve	
Sieve Nominal Size Square Openings	**% passing**
4 inch	100
3 1/2 inch	90 – 100
2 1/2 inch	26 – 60
1 1/2 inch	0 – 15
3/4 inch	0 – 5

B.1.3.5 Fabric

A geotextile filter fabric is used to line the outfall trenches. According to Section DL-2.2 of the specifications, the fabric is nonwoven 100 percent polyester material with a minimum thickness of 75 mils. Other properties for the fabric will conform to those outlined in table B-5.

Table B-5. Summary of fabric property requirements.

Fabric property	**Unit**	**ASTM**	**Value**
Grab Tensile	pounds	D 4632	180
Elongation	%	D 4632	50
Puncture	pounds	D 4833	80
Burst	PS	D 3786	290
Trapezoid Tear	pounds	D 4533	50
UV Resistance	%	D 4355	70
Water Flow Rate	GPM / SF	D 4491	130
Permeability	cm / sec	D 4491	33
AOS	sieve size	D 4751	70
	mm		210

B.1.3.6 Subgrade

Subgrade excavation and embankment fall under the FAA P-152 specification, including compaction requirements. Therefore, subgrade compaction requirements typical of FAA-sponsored projects are being followed.

B.1.4 Construction Considerations

Design of the surrounding grading and landscaping was done in such a manner as to minimize the amount of run-on that may occur. Temporary stormwater control measures focus on keeping water from running into the project site. There was also significant discussion with the contractor in the pre-construction meeting to keep equipment off of the pavement area as much as possible to avoid dragging materials onto the pavement that could clog the system.

The contractor has previous experience with permeable pavement, having constructed permeable pavement projects for VDOT. The material supplier also has experience producing the specified materials. This experience is a more significant factor without there being full-time construction inspection.

Quality assurance activities (control and acceptance) are provided in the project specifications and were not changed for this project. One drawback to being a State-funded project is that full-time construction inspection by the engineer is not included in the funding.

The project is under construction at the time of this report. Several photos of construction activities were provided.

B.1.5 Performance and Maintenance Activities

The design documents recommend high-volume vacuum sweeper cleaning of the constructed surface at least twice a year. It further indicates that if infiltration cannot be restored with vacuuming, power washing may be required.

Winter maintenance recommendations state that abrasive deicing materials (such as sand) are not to be used. It was also discussed that plow blades should be kept approximately an inch above the surface of the pavement.

For small repairs of the surface, patching with conventional asphalt is recommended in the documents.

B.1.6 Lessons Learned/Barriers

C&P expressed the need to require that the contractor is experienced with permeable pavement materials and construction. The experience not only helps ensure a better quality end product but can reduce bid prices by not having “unknown” components as part of the bid and the work.

Another cost control measure discussed is to convince the contractors to compare permeable materials to a known similar material, such as the cement-stabilized, open-graded aggregate and P-304. The use of local state mixes can also reduce costs because they are likely to be a commonly produced material.

It was stated during the interview that if you do something out of the ordinary [such as a permeable pavement], design it with the materials contractors are used to and the prices will be more manageable.

B.1.7 Sources of Information

The project team would like to acknowledge the valuable input and assistance provided by the following individuals:

- H. D. Campbell, Jr., P.E., Principal, Campbell & Paris Engineers
- Kerr Chase, P.E., Campbell & Paris Engineers

The following documents also provided valuable information used in this summary:

- Construction specifications and project drawings provided by C&P.
- Construction photos, 2016.

B.1.8 Culpeper Regional Airport Porous Asphalt Apron Specifications

CULPEPER REGIONAL AIRPORT

CULPEPER, VIRGINIA

CONTRACT DOCUMENTS AND TECHNICAL SPECIFICATIONS

T-HANGAR AND EXECUTIVE HANGAR DEVELOPMENT

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Item P-152 Excavation and Embankment

DESCRIPTION

152-1.1 This item covers excavation, disposal, placement, and compaction of all materials within the limits of the work required to construct safety areas, runways, taxiways, aprons, and intermediate as well as other areas for drainage, building construction, parking, or other purposes in accordance with these specifications and in conformity to the dimensions and typical sections shown on the plans.

152-1.2 Classification. All material excavated shall be classified as defined below:

a. Unclassified Excavation. Unclassified excavation shall consist of the excavation and disposal of all material, regardless of its nature, which is not otherwise classified and paid for under the following items.

b. Rock Excavation. Rock excavation shall include all solid rock in ledges, in bedded deposits, in unstratified masses, and conglomerate deposits which are so firmly cemented they cannot be removed without blasting or using rippers. All boulders containing a volume of more than $^1/_2$ cubic yard (0.4 cubic meter) will be classified as "rock excavation." Rock excavation will not be measured or paid for separately; any rock excavation the contractor encounters on site will be incidental to "unclassified excavation."

c. Drainage Excavation. Drainage excavation shall consist of all excavation made for the primary purpose of drainage and includes drainage ditches, such as intercepting, inlet or outlet; temporary levee construction; or any other type as shown on the plans. Drainage excavation shall not be separately measured or paid for. Drainage excavation will be incidental to the drainage pipe, drainage structure, or other utility installed.

152-1.3 Unsuitable Excavation. Any material containing vegetable or organic matter, such as mulch, peat, organic silt, or sod, and soil classified as E-9 (Unified Soil Classification types OL, OH, PT) shall be considered unsuitable for use in embankment construction. If there is a question as to the suitability of a soil, the Engineer shall direct the Contractor to obtain a sample of the soil. Based on the sample obtained, the Engineer will determine the suitability of the excavation/embankment material. Material, when approved by the Engineer as suitable to support vegetation, may be used on the embankment slope.

CONSTRUCTION METHODS

152-2.1 General. Before beginning excavation, grading, and embankment operations in any area, the area shall be completely cleared and grubbed in accordance with Item P-151.

The suitability of material to be placed in embankments shall be subject to approval by the Engineer. All unsuitable material shall be disposed of in waste areas shown on the plans. All waste areas shall be graded to allow positive drainage of the area and of adjacent areas. The surface elevation of waste areas shall not extend above the surface elevation of adjacent usable areas of the airport, unless specified on the plans or approved by the Engineer.

When the Contractor's excavating operations encounter artifacts of historical or archaeological significance, the operations shall be temporarily discontinued. At the direction of the Engineer, the Contractor shall excavate the site in such a manner as to preserve the artifacts encountered and allow for their removal. Such excavation will be paid for as extra work.

Those areas outside of the pavement areas in which the top layer of soil material has become compacted, by hauling or other activities of the Contractor shall be scarified and disked to a depth of 4 in (100 mm), in order to loosen and pulverize the soil.

If it is necessary to interrupt existing surface drainage, sewers or under-drainage, conduits, utilities, or similar underground structures, the Contractor shall be responsible for and shall take all necessary precautions to preserve them or provide temporary services. When such facilities are encountered, the Contractor shall notify the Engineer, who shall arrange for their removal if necessary. The Contractor shall, at his/her own expense, satisfactorily repair or pay the cost of all damage to such facilities or structures that may result from any of the Contractor's operations during the period of the contract.

152-2.2 EXCAVATION. No excavation shall be started until the work has been staked out by the Contractor and the Engineer has obtained elevations and measurements of the ground surface. All suitable excavated material shall be used in the formation of embankment, subgrade, or for other purposes shown on the plans. All unsuitable material shall be disposed of as shown on the plans.

When the volume of the excavation exceeds that required to construct the embankments to the grades indicated, the excess shall be used to grade the areas of ultimate development or disposed of as directed. When the volume of excavation is not sufficient for constructing the fill to the grades indicated, the deficiency shall be obtained from borrow areas.

The grade shall be maintained so that the surface is well drained at all times. When necessary, temporary drains and drainage ditches shall be installed to intercept or divert surface water that may affect the work.

a. Undercutting. Rock, shale, hardpan, loose rock, boulders, or other material unsatisfactory for runway and taxiway safety areas, subgrades, roads, shoulders, or any areas intended for turfing shall be excavated to a depth specified by the Engineer , below the subgrade. Muck, peak, matted roots, or other material, unsatisfactory for subgrade foundation, shall be removed to the depth specified.

Materials classified as unsuitable shall be disposed of at locations shown on the plans or as directed by the Engineer. This excavated material shall be paid for at the contract unit price per cubic yard for unclassified excavation. The excavated area shall be refilled with suitable material, obtained from the grading operations or borrow areas and thoroughly compacted by rolling. The necessary refilling will constitute a part of the embankment. Backfill of unsuitable material excavations will be made from the excess excavation volume that meets the requirements of suitable material at acceptable moisture contents to allow for proper compaction.

The Contractor may, at his/her option, and to facilitate schedule requirements, backfill any areas of unsuitable material removal with material meeting the requirements of #57 aggregate. If material meeting the requirements of #57 aggregate are utilized there will be no requirements for compaction of the backfill. Should the Contractor elect to use the #57 aggregate backfill the cost for such backfill and all associated work shall be the same as for unclassified excavation.

Where rock cuts are made and refilled with selected material, any pockets created in the rock surface shall be drained in accordance with the details shown on the plans.

A material that is high in moisture content and which yields under proofrolling does not classify as unsuitable material unless so classified in accordance with Section 152.1.3. Undercutting of subgrade or excavation material classified as containing moisture above its optimum moisture content, does not constitute the excavated material as unsuitable. The Contractor is expected and required to manipulate and dry the material unless the material is classified as unsuitable in accordance with

Section 152.1.3. If the material is classified as unsuitable material then the contractor shall remove the material to the depth directed by the Engineer. The removal of unsuitable material shall be paid for at the same unit price as unclassified excavation.

The backfill of such areas shall not begin until the volume of the excavation is determined by cross sections or other means acceptable by the Engineer . The backfill of the excavation to remove the unsuitable material shall be accomplished in the same manner as other embankment called out in this section with regard to the thickness and compaction requirements. The payment for the backfill of excavations to remove unsuitable material shall be in accordance with a specific pay item, designated for use as a backfill material and acceptable for use by the Engineer. The backfill material may consist of suitable embankment, or #57 aggregate.

b. Overbreak. Overbreak, including slides, is that portion of any material displaced or loosened beyond the finished work as planned or authorized by the Engineer. The Engineer shall determine if the displacement of such material was unavoidable and his/her decision shall be final. All overbreak shall be graded or removed by the Contractor and disposed of as directed; however, payment will not be made for the removal and disposal of overbreak that the Engineer determines as avoidable. Unavoidable overbreak will be classified as "Unclassified Excavation."

c. Removal of Utilities. The removal of existing structures and utilities required to permit the orderly progress of work will be accomplished by someone other than the Contractor, for example, the utility unless otherwise shown on the plans. All existing foundations shall be excavated for at least 2 feet (60 cm) below the top of subgrade or as indicated on the plans, and the material disposed of as directed. All foundations thus excavated shall be backfilled with suitable material and compacted as specified herein.

d. Compaction Requirements. The subgrade under areas to be paved shall be compacted to the depth shown on the plans and to a density of not less than 95% for the cohesive soils and 100% for non-cohesive soils of the maximum density as determined by ASTM D 1557.

If nuclear density machines are to be used for density determination, the machines shall be calibrated in accordance with ASTM D 2922. The nuclear equipment shall be calibrated using blocks of materials with densities that extend through a range representative of the density of the proposed embankment material. (See Section 120 of the General Provisions for additional guidance with nuclear density testing)

The in-place field density shall be determined in accordance with ASTM D 1556 or ASTM D 2167. Stones or rock fragments larger than 4 in (100 mm) in their greatest dimension will not be permitted in the top 6 in (150 mm) of the subgrade. The finished grading operations, conforming to the typical cross section, shall be completed and maintained at least 1,000 feet (300 m) ahead of the paving operations or as directed by the Engineer.

In cuts, all loose or protruding rocks on the back slopes shall be barred loose or otherwise removed to line of finished grade of slope. All cut-and-fill slopes shall be uniformly dressed to the slope, cross section, and alignment shown on the plans or as directed by the Engineer.

Blasting is not approved for this contract.

152-2.3 BORROW EXCAVATION. Borrow areas within the airport property are indicated on the plans. Borrow excavation shall be made only at these designated locations and within the horizontal and vertical limits as staked or as directed.

When borrow sources are outside the boundaries of the airport property, it shall be the Contractor's responsibility to locate and obtain the supply, subject to the approval of the Engineer. The Contractor shall notify the Engineer, at least 15 days prior to beginning the excavation, so necessary measurements and tests can be made. All unsuitable material shall be disposed of by the Contractor. All borrow pits shall be opened up to expose the vertical face of various strata of acceptable material to enable obtaining a uniform product. Borrow pits shall be excavated to regular lines to permit accurate measurements, and they shall be drained and left in a neat, presentable condition with all slopes dressed uniformly.

152-2.4 EXCESS EXCAVATION. Excess excavation not incorporated in to embankment sections shall be placed at the location shown on the drawings. The excess embankment shall be completed to 90% maximum density in accordance with ASTM D1557 and graded to drain in all directions. At the completion of the project, the area shall be seeded and mulched in accordance with Item T-901 and T-908.

152-2.5 DRAINAGE EXCAVATION. Drainage excavation shall consist of excavating for drainage ditches such as intercepting; inlet or outlet, for temporary levee construction; or for any other type as designed or as shown on the plans. The work shall be performed in the proper sequence with the other construction. All satisfactory material shall be placed in fills; unsuitable material shall be placed in waste areas or as directed. Intercepting ditches shall be constructed prior to starting adjacent excavation operations. All necessary work shall be performed to secure a finish true to line, elevation, and cross section.

The Contractor shall maintain ditches constructed on the project to the required cross section and shall keep them free of debris or obstructions until the project is accepted. Drainage excavation shall not be separately measured or paid for. Drainage excavation will be incidental to the drainage pipe, drainage structure, or other utility installed.

152-2.6 PREPARATION OF EMBANKMENT AREA. Where an embankment is to be constructed to a height of 4 feet (120 cm) or less, all sod and vegetable matter shall be removed from the surface upon which the embankment is to be placed, and the cleared surface shall be completely broken up by plowing or scarifying to a minimum depth of 6 in (150 mm). This area shall then be compacted as indicated in paragraph 2.6. When the height of fill is greater than 4 feet (120 cm), sod not required to be removed shall be thoroughly disked and recompacted to the density of the surrounding ground before construction of embankment.

Where embankments are to be placed on natural slopes steeper than 3 to 1, horizontal benches shall be constructed as shown on the plans.

No direct payment shall be made for the work performed under this section. The necessary clearing and grubbing and the quantity of excavation removed will be paid for under the respective items of work.

152-2.7 FORMATION OF EMBANKMENTS. Embankments shall be formed in successive horizontal layers of not more than 8 in (200 mm) in loose depth for the full width of the cross section, unless otherwise approved by the Engineer.

The grading operations shall be conducted, and the various soil strata shall be placed, to produce a soil structure as shown on the typical cross section or as directed. Materials such as brush, hedge, roots, stumps, grass and other organic matter, shall not be incorporated or buried in the embankment.

Operations on earthwork shall be suspended at any time when satisfactory results cannot be obtained because of rain, freezing, or other unsatisfactory conditions of the field. The Contractor shall drag, blade, or slope the embankment to provide proper surface drainage.

The material in the layer shall be within +/-2 percent of optimum moisture content before rolling to obtain the prescribed compaction. In order to achieve a uniform moisture content throughout the layer, wetting or drying of the material and manipulation shall be required when necessary. Should the material be too wet to permit proper compaction or rolling, all work on all of the affected portions of the embankment shall be delayed until the material has dried to the required moisture content. Sprinkling of dry material to obtain the proper moisture content shall be done with approved equipment that will sufficiently distribute the water. Sufficient equipment to furnish the required water shall be available at all times. Samples of all embankment materials for testing, both before and after placement and compaction, will be taken for each 4,500 square yards and per 8-inch lift. Based on these tests, the Contractor shall make the necessary corrections and adjustments in methods, materials or moisture content in order to achieve the correct embankment density.

Rolling operations shall be continued until the embankment is compacted to not less than 95 percent of maximum density for noncohesive soils, and 90 percent of maximum density for cohesive soils as determined by ASTM D 1557. Under all areas to be paved, including paved drainage ditches, the embankments shall be compacted to a depth indicated on the drawings and to a density of not less than 95 percent for cohesive soils and 100 percent for non-cohesive soils of the maximum density as determined by ASTM D 1557

On all areas outside of the pavement areas, no compaction will be required on the top 4 in (100 mm).

The in-place field density shall be determined in accordance with ASTM D 1556 or ASTM D 2167.

Compaction areas shall be kept separate, and no layer shall be covered by another until the proper density is obtained.

During construction of the embankment, the Contractor shall route his/her equipment at all times, both when loaded and when empty, over the layers as they are placed and shall distribute the travel evenly over the entire width of the embankment. The equipment shall be operated in such a manner that hardpan, cemented gravel, clay, or other chunky soil material will be broken up into small particles and become incorporated with the other material in the layer.

In the construction of embankments, layer placement shall begin in the deepest portion of the fill; as placement progresses, layers shall be constructed approximately parallel to the finished pavement grade line.

When rock and other embankment material are excavated at approximately the same time, the rock shall be incorporated into the outer portion of the embankment and the other material shall be incorporated under the future paved areas. Stones or fragmentary rock larger than 4 in (100 mm) in their greatest dimensions will not be allowed in the top 6 in (150 mm) of the subgrade. Rockfill shall be brought up in layers as specified or as directed and every effort shall be exerted to fill the voids with the finer material forming a dense, compact mass. Rock or boulders shall not be disposed of outside the excavation or embankment areas, except at places and in the manner designated by the Engineer.

When the excavated material consists predominantly of rock fragments of such size that the material cannot be placed in layers of the prescribed thickness without crushing, pulverizing or further breaking down the pieces, such material may be placed in the embankment as directed in layers not exceeding 2

feet (60 cm) in thickness. Each layer shall be leveled and smoothed with suitable leveling equipment and by distribution of spalls and finer fragments of rock. These type lifts shall not be constructed above an elevation 4 feet (120 cm) below the finished subgrade. Density requirements will not apply to portions of embankments constructed of materials which cannot be tested in accordance with specified methods.

Frozen material shall not be placed in the embankment nor shall embankment be placed upon frozen material.

There will be no separate measurement of payment for compacted embankment, and all costs incidental to placing in layers, compacting, disking, watering, mixing, sloping, and other necessary operations for construction of embankments will be included in the contract price for excavation, borrow, or other items.

152-2.8 FINISHING AND PROTECTION OF SUBGRADE. After the subgrade has been substantially completed the full width shall be conditioned by removing any soft or other unstable material that will not compact properly. The resulting areas and all other low areas, holes or depressions shall be brought to grade with suitable select material. Scarifying, blading, rolling and other methods shall be performed to provide a thoroughly compacted subgrade shaped to the lines and grades shown on the plans.

Grading of the subgrade shall be performed so that it will drain readily. The Contractor shall take all precautions necessary to protect the subgrade from damage. He/she shall limit hauling over the finished subgrade to that which is essential for construction purposes.

All ruts or rough places that develop in a completed subgrade shall be smoothed and recompacted.

No subbase, base, or surface course shall be placed on the subgrade until the subgrade has been approved by the Engineer.

152-2.9 HAUL. All hauling will be considered a necessary and incidental part of the work. Its cost shall be considered by the Contractor and included in the contract unit price for the pay of items of work involved. No payment will be made separately or directly for hauling on any part of the work or for transport of the excess excavation to the stockpiling site shown on the drawings.

152-2.10 TOLERANCES. In those areas upon which a subbase or base course is to be placed, the top of the subgrade shall be of such smoothness that, when tested with a 16 ft (4.8 m) straightedge applied parallel and at right angles to the centerline, it shall not show any deviation in excess of 1/2 in (12 mm), or shall not be more than 0.05 ft (0.015 m) from true grade as established by grade hubs or pins. Any deviation in excess of these amounts shall be corrected by loosening, adding, or removing materials; reshaping; and recompacting by sprinkling and rolling.

On safety areas, intermediate and other designated areas, the surface shall be of such smoothness that it will not vary more than 0.10 ft (0.03 m) from true grade as established by grade hubs. Any deviation in excess of this amount shall be corrected by loosening, adding or removing materials, and reshaping.

152-2.10 PROOFROLLING/SUBGRADE PREPARATION. The subgrade shall be proofrolled with a standard motor grader. The Engineer will monitor the proofrolling and determine areas for removal of yielding subgrade. Any material the Engineer orders to be removed shall be tested by the Contractor for suitability in accordance with Section 152-1.3. There is no direct payment for additional testing by the Contractor to determine suitability. If the yielding areas are composed of suitable material with an excess of moisture, the Contractor shall provide for drying the subgrade to within the optimum moisture content tolerances and recompacting the subgrade at no additional costs. The Contractor, to facilitate his schedule, may elect to remove suitable yielding subgrade material with the moisture content above the

optimum and backfill the area with material meeting the requirements of Item P-209 for #57 aggregate. Should the Contractor elect to use this option there will be no compaction requirements for the #57 aggregate backfill nor will there any additional payment for the removal and replacement operation.

152-2.11 TOPSOIL. No direct payment will be made for topsoil as such under Item P-152. The quantity removed and placed directly or stockpiled shall be paid for at the contract unit price per cubic yard for ``Unclassified Excavation." No additional payment will be made for rehandling the topsoil.

METHOD OF MEASUREMENT

152-3.1 The yardage paid for as unclassified excavation shall be the number of cubic yards of embankment removed from the original ground position shown on the plans (exclusive of stripping) shown to the neat lines shown on the drawings. Pay quantities shall be computed to the neat lines shown on the drawings by method of average end areas of materials acceptably excavated or placed as specified. No separate measurement shall be made for ditch excavation. The contractor shall provide field run cross-sections at fifty foot intervals for the computation of all "embankment in place." This work shall include plotting existing ground after clearing or pavement demolition operations but before any other work begins and plotting finished ground after excavations are complete to establish the "average-end" volume of materials placed. The Engineer may verify the survey results with his own independent survey. All cross-sections provided by the contractor shall be plotted on standard 24"x36" (10x10) grid vellum sheets at the same scale as the cross-sections shown on the plans. All survey work including the resulting plots shall be certified by a professional land surveyor registered in the State of Virginia. The contractor may perform his own computation of the "average-end" volumes; however, the Engineer will perform an independent computation before establishing the final pay quantities. This work shall be paid for under item "Original and Final Quantity Survey."

Unclassified excavation will either be stockpiled onsite or removed offsite. Based on bid results and the best interest of the owner, the project will be awarded with *either* the “unclassified excavation – stockpile onsite” or “unclassified excavation – remove offsite” pay item.

Measurement shall not include the yardage of material placed without authorization beyond normal slope lines, or the yardage of material used for purposes other than those directed. All such work shall be incidental to the unit cost for embankment in place.

Rock excavation will not be measured separately for payment. Any costs shall be incidental to “unclassified excavation.”

Proofrolling / subgrade preparation shall be measured per square yard. This item shall include fine grading, compaction, and any preparation or work required to finish the subgrade to the requirements of this specification.

Measurement of backfill of unsuitable material excavation shall be made by the average end area method described above. The Engineer will direct the surface areas and the depth of excavation to be removed. Following excavation operations, the area will be cross sectioned as described above and the volume of material removed will represent the volume of backfill paid for under this item.

BASIS OF PAYMENT

152-4.1 Payment shall be made at the contract unit price per cubic yard for "unclassified excavation – stockpile onsite". This price shall be full compensation for furnishing all materials, labor, equipment,

tools, quality control testing and incidentals necessary to complete the item. This item will include stockpiling the excess material on airport property in accordance with the plans and specifications.

152-4.2 Payment shall be made at the contract unit price per cubic yard for "unclassified excavation – remove offsite". This price shall be full compensation for furnishing all materials, labor, equipment, tools, quality control testing and incidentals necessary to complete the item. This item will include removing the excess material from airport property.

152-4.3 Payment shall be made at the contract unit price per cubic yard for "backfill unsuitable excavation". This price shall be full compensation for furnishing all materials, labor, equipment, tools, quality control testing and incidentals necessary to complete the item.

152-4.4 Payment shall be made at the contract unit price per square yard for “Proofrolling/Subgrade Preparation. This price shall be full compensation for furnishing all materials, labor, equipment, tools, quality control testing and incidentals necessary to complete the item.

152-4.5 Payment for the original and final surveys shall be full compensation for providing the information as detailed in Section 152-3.1.

Payment will be made under:

P-152-**4.1**	**Unclassified excavation – stockpile onsite**	**- per cubic yard**
P-152-4.2	Unclassified excavation – remove offsite	- per cubic yard
P-152-4.3	Backfill unsuitable excavation	- per cubic yard
P-152-4.4	Proofrolling / subgrade preparation	- per square yard
P-152-4.5	Original and final surveys	- per lump sum

TESTING REQUIREMENTS

ASTM D 698	Test for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures, Using 5.5-pound (2.49 kg) Rammer and 12 in (305 mm) Drop
ASTM D 1556	Test for Density of Soil In Place by the Sand-Cone Method
ASTM D 1557	Test for Laboratory Compaction Characteristics of Soil Using Modified Effort
ASTM D 2167	Test for Density and Unit Weight of Soil In Place by the Rubber Balloon Method.
ASTM D 6938	In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods

END OF ITEM P-152

Section S-OGM Stabilized Open-Graded Mix

S-OGM-1 GENERAL. This item shall provide for the installation of a porous base course and / or drainage layer underlying a porous friction course surface course associated with the completion of an apron pavement.

S-OGM-1.1 REFERENCES. The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 29	Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
ASTM C 88	Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C 117	Standard Test Method for Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C 131	Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C 136	ASTM C136-06 Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C 150	Standard Specification for Portland Cement
ASTM D 2487	Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D 4791	Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
ASTM D 6938	Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

S-OGM-1.2. UNIT PRICES. Payment shall be made by the square yard for material accepted in place, and by the ton for cement utilized in the S-OGM mix. Payment for cement will not exceed the maximum amount for any lots (375 lb / yd^3 per paragraph S-OGM-2.4).

S-OGM-1.2-11	Stabilized open-graded mix (S-OGM, 10”)	- per square yard
S-OGM-1.2-2	Portland cement for S-OGM	- per ton

S-OGM-1.2.1 Waybills and Delivery Tickets. Copies of waybills and delivery tickets shall be submitted during the progress of the work. Before the final payment is allowed, the contractor shall file certified waybills and certified delivery tickets for all aggregates and cementitious materials authorized for use based on the theoretical mix design percentage of cement.

S-OGM-1.2.2 Measurement. Deductions will be made for any material wasted, unused, rejected, or used for the convenience of the contractor.

S-OGM-1.2.3 Cement-Stabilized Drainage Layer. The quantity of cement-stabilized drainage layer material completed and accepted shall be measured in square yards.

S-OGM-1.2.4 Cementitious Material. The quantity of Portland cement used in the accepted cement-stabilized mix shall be paid for by the ton.

S-OGM-1.2.5 Payment. The quantities of drainage layer aggregates and stabilizing materials as specified above will be paid for at the contract unit prices, which will constitute full compensation for the construction and completion of the drainage open-graded drainage layer, including the test section, and the furnishing of all other necessary labor and incidentals.

S-OGM-1.3 SYSTEM DESCRIPTION. The contractor shall build a drainage layer under the pavements as indicated and in accordance with the following subparagraphs.

S-OGM-1.3.1 Cement Stabilized Drainage Layer. A drainage layer consisting of open graded material stabilized with Portland cement.

S-OGM-1.4 SUBMITTALS. The following shall be submitted in accordance with the general provisions.

Reports:

- Sampling and testing
- Copies of field test results within 24 hours of completion of tests.
- Approval of materials
- Material sources and material test results prior to field use.
- Evaluation
- Test section construction report.

Records:

- Waybills and delivery tickets.
- Certified waybills and delivery tickets for all aggregates and cementitious materials actually used.

S-OGM-1.5 FIELD COMPACTION. Field compaction requirements shall be based on the results of a test section constructed by the contractor, using the materials, methods, and equipment proposed for use in the work. The test section shall meet the requirements of paragraph TEST SECTION.

S-OGM-1.6 EQUIPMENT.

S-OGM-1.6.1 General Requirements. All plant, equipment, and tools used in the performance of the work will be subject to approval before the work is started and shall be maintained in satisfactory working condition at all times.

S-OGM-1.6.2 Placement Equipment. An asphalt paving machine which incorporates a special tamping screed capable of providing 90% compaction of the non-stabilized separation layer and cement-stabilized drainage layer shall be used to place drainage layer material. Alternate methods may be used for the separation layer if it can be demonstrated in the test section that these methods obtain the specified results. No alternative method is allowed for the cement-stabilized layer.

S-OGM-1.6.3 Compaction Equipment. A dual or single smooth drum vibratory roller which provides a maximum compactive effort without crushing the drainage layer aggregate shall be used to compact drainage layer material.

S-OGM-1.6.4 Cementitious Mixing Plant. The cementitious mixing plant shall be an automatic or semiautomatic controlled, commercially manufactured unit capable of producing a cement-stabilized aggregate mixture consistent with the job mix formula determined by the contractor and approved by the engineer. Aggregate and cement shall be dry mixed sufficiently to prevent cement balls from forming when water is added.

S-OGM-1.7 WEATHER LIMITATION. Drainage layer material shall be placed when the atmospheric temperature is above 35° F (2° C). Areas of completed drainage layer or underlying courses that are damaged by freezing, rainfall, or other weather conditions or by contamination from sediments, dust, dirt, or foreign material shall be corrected by the contractor to meet specified requirements.

S-OGM-1.8 SAMPLING AND TESTING.

S-OGM-1.8.1 General Requirements. Sampling and testing shall be the responsibility of the contractor. Sampling and testing shall be performed by an approved commercial testing laboratory, subject to approval. If the contractor elects to establish testing facilities on his own, approval of such facilities shall be based on compliance with ASTM E 548, and no work requiring testing will be permitted until the contractor's facilities have been inspected and approved.

S-OGM-1.8.2 Sampling. Aggregate samples shall be taken in accordance with ASTM D 75. Cement-stabilized mixture samples shall be taken using methods approved by the engineer.

S-OGM-1.8.3 Test Methods.

S-OGM-1.8.3.1 Sieve Analyses. Sieve analyses shall be made in accordance with ASTM C 117 and ASTM C 136.

S-OGM-1.8.3.2 Density Tests. Field density tests shall be made in accordance with ASTM D 6938.

S-OGM-1.8.3.3 Soundness Test. Soundness tests shall be made in accordance with ASTM C 88.

S-OGM-1.8.3.4 Los Angeles Abrasion Test. Los Angeles abrasion tests shall be made in accordance with ASTM C 131.

S-OGM-1.8.3.5 Flat or Elongated Particles Tests. Flat and / or elongated particles tests shall be made in accordance with ASTM D 4791.

S-OGM-1.8.3.6 Fractured Faces Tests. When aggregates are supplies from crushed gravel, approved test methods shall be used to assure the aggregate meets the requirements for fractured faces in paragraph AGGREGATES.

S-OGM-1.8.4 Testing Frequency.

S-OGM-1.8.4.1 Cement Stabilized Drainage Layer. Sieve analyses shall be performed on aggregates prior to addition of Portland cement, at a rate of at least one test for every 1,000 yd^2 of production and not less than one test for each day's production. Cement titration tests on Portland cement stabilized material shall be made at the same frequency. Soundness tests, Los Angeles abrasion tests, fractured faces tests, and flat and / or elongated particles tests shall be performed at the rate of one test for every 10 sieve analyses tests if sources have changed from the original mix design. Field density tests shall be performed at a rate of at least two tests for every 1000 yd^2 of completed area and not less than two tests for each day's production.

S-OGM-1.8.5 Approval of Materials.

S-OGM-1.8.5.1 Aggregate. The aggregate source shall be selected at least 30 days prior to field use in the test section. Tentative approval of the source will be based on certified test results to verify that materials proposed for use meet the contract requirements. Final approval of both the source and the material will be based on test section performance and tests for gradation, soundness, Los Angeles abrasion, flat and / or elongated particles tests and fractured faces tests. For cement-stabilized drainage layer material, these tests shall be performed on aggregate samples taken prior to addition of cementitious material and subsequent placement in the test section.

S-OGM-1.8.5.2 Cementitious Materials. Cementitious sources and certified material test results shall be submitted for approval not less than 30 days prior to field use in the test section.

S-OGM-2.0 PRODUCTS.

S-OGM-2.1 GENERAL. Cement stabilized material will require engineer notification and delivery of approved materials in accordance with paragraph CEMENT STABILIZED JOB-MIX FORMULA.

S-OGM-2.2 AGGREGATES. Aggregates shall consist of clean, sound, hard, durable, angular particles of crushed stone or crushed gravel which meet the specification requirements. Aggregates shall be free of silt and clay as defined by ASTM D 2487, vegetable matter, and other objectionable materials or coatings.

S-OGM-2.2.1 Aggregate Quality. The aggregate shall have a soundness loss not greater than 18 percent weighted averaged at five cycles when tested in magnesium sulfate in accordance with ASTM C 88. The aggregate shall have a percentage of loss on abrasion not to exceed 40 after 500 revolutions as determined by ASTM C 131. The percentage of flat and / or elongated particles as determined by ASTM D 4791 shall not exceed 20 in the fraction retained on the ½ inch sieve, in the fraction passing the ½ inch sieve but retained on the no. 4 sieve, and in the percent passing the no. 4 sieve but retained on the no. 16 sieve. A flat particle is one having a ratio of width to thickness greater than 3; an elongated particle is one having a ratio of length to width greater than 3. When the aggregate is supplied from more than one source, aggregate from each source shall meet the requirements set forth herein. When the aggregate is supplied from crushed gravel it shall be manufactured from gravel particles 90 percent of which by weight are retained on the maximum-size sieve listed in TABLE 1. In the portion retained on each sieve specified, the crushed gravel shall contain at least 90 percent by weight of crushed pieces having two or more freshly fractured faces with the area of each face being at least equal to 75 percent of

the smallest midsectional area of the face. When two fractures are contiguous, the angle between planes of the fractures must be at least 30 degrees in order to count as two fractures faces.

S-OGM-2.2.2 Gradation Requirements. Drainage layer aggregates for the Portland cement layer shall be well graded within the limits specified in TABLE 1 (VDOT # 57 gradation).

TABLE 1. GRADATION OF DRAINAGE LAYER MATERIAL	
Percentage of Weight Passing Square-Mesh Sieve	
Sieve Nominal Size Square Openings	Percent Passing
1 ½"	100
1"	95 - 100
¾"	---
1/2"	25 – 60
3/8"	---
No. 4	0 – 10
No. 8	0 – 5
No 16	---
NOTE 1: Particles having diameters less than 0.02 mm shall not be in excess of 1.5% by weight of the total sample tested.	
NOTE 2: The values are based on aggregates of uniform specific gravity, and the percentages passing the various sieves may require appropriate correction by the engineer when aggregates of varying specific gravities are used.	
NOTE 3: Portland cement will be required to stabilize the OGM.	

S-OGM-2.3 CEMENTITIOUS MATERIALS. Portland cement to be mixed with aggregates shall be conform to ASTM C 150, type I or type II.

S-OGM-2.4 CEMENT-STABILIZED JOB-MIX FORMULA. The cement-stabilized mix shall consist of OGM and a minimum of 300 pounds of Portland cement per cubic yard with a water / cement ratio of 0.37. Based on the test section performance, the contractor shall be responsible for adjustments (increases) in Portland cement quantities up to 375 pounds per yd^3 to ensure the stabilized drainage layer will not rut or be disturbed by the contractor's proposed paving method. The contractor shall submit a job-mix formula (JMF) with the test section report for engineer approval. As a part of the JMF the laboratory shall prepare a set of four laboratory-prepared and cured specimens of the mix in accordance with ASTM D 560 and tested in accordance with ASMT D 1633. The samples shall be tested for compression strength and reported along with other information in the JMF.

S-OGM-3.0 EXECUTION.

S-OGM-3.1 STOCKPILING AGGREGATES. Aggregates shall be stockpiled at location designated by the engineer. Stockpile areas shall be cleared and leveled prior to stockpiling aggregates. All aggregates shall be stockpiled so as to prevent segregation and contamination. Aggregates obtained from different sources shall be stockpiled separately.

S-OGM-3.2 TEST SECTION.

S-OGM-3.2.1 General. A test section shall be constructed to evaluate the ability to carry traffic and the constructability of the drainage layer including required mixing, placement, and compaction procedures. Test section data will be used by the contractor and engineer to determine the required number of passes and the field dry density requirements for full scale production.

S-OGM-3.2.2 Scheduling. The test section shall be constructed a minimum of 10 days prior to the start of full-scale production to provide sufficient time for an evaluation of the proposed materials, equipment, and procedures including engineer QA testing.

S-OGM-3.2.3 Location and Size. The test section shall be placed within the production paving limits. The underlying courses and subgrade preparation, required for the pavement section, shall be completed, inspected, and approved in the test section prior to constructing the drainage layer. The test section shall be a minimum of 100 feet long and one full paving lane wide. Unacceptable material will be removed and replaced at the contractor's expense.

S-OGM-3.2.4 Initial Testing. Certified test results, to verify that the materials proposed for use in the test section meet the contract requirements, shall be provided by the contractor and approved by the engineer prior to the start of the test section.

S-OGM-3.2.5 Mixing, Placement, and Compaction. Mixing, placement, and compaction shall be accomplished using equipment meeting the requirements of paragraph EQUIPMENT. Compaction equipment speed shall be no greater than 1.5 miles per hour.

S-OGM-3.2.6 Procedure.

S-OGM-3.2.6.1 Cement Stabilized Drainage Layer. Density tests shall be conducted at the surface and at intervals of 2 inches of depth for the total layer thickness in accordance with ASTM D 6938. A composite sample representing the total layer thickness shall be taken adjacent to each density test location. Visual examination of each composite sample shall be made to determine if and when crushing of aggregate occurs. One density test and composite sample shall be taken before compaction and after each subsequent compaction pass at three separate locations as directed by the engineer. Compaction passes and density readings shall continue until the difference between the average total densities of any two consecutive passes is less than or equal to 0.5 pounds per ft^3.

S-OGM-3.2.7 Evaluation Procedures. The engineer will evaluate the data from the test section. For cement-stabilized drainage layer material, in-place density shall be plotted against cumulative passes and degradation will be based on visual observations in lieu of sieve analyses. With these results, the engineer will consult with the contractor quality control group who will maximize dry density while minimizing aggregated degradation. Generally, after 3 to 6 passes, only slight increases in dry density will be achieved. At this point the measured field density is at or near the optimum density obtainable for this material, for the given field conditions. The required field dry density shall then be set 2% lower than this optimum field dry density. Therefore the field dry density is to be set at 98% of the optimum density obtained in the test section. Within 10 days of completion of the test section, the contactor shall submit to the engineer a test section construction report complete with all required test data and correlations. The engineer will evaluate the data and provide to the contractor the required number of passes of the roller, the dry

density for field density control during construction, the depth at which to check the density, and the need for a final static pass of the roller.

S-OGM-3.3 PREPARATION OF UNDERLYING COURSE. Prior to constructing the drainage layer, the underlying course shall be cleaned of all foreign materials. During construction, the underlying course shall contain no frozen material. The underlying course shall conform to item P-152. Ruts or soft yielding spots in the underlying courses having inadequate compaction and deviations of the surface from the requirements set forth herein shall be corrected by loosening and removing soft or unsatisfactory material and by adding approved material, reshaping to line and grade, and recompacting to specified density. The finished underlying course shall not be disturbed by traffic or other operations and shall be maintained by the contractor in satisfactory condition until the drainage layer is placed.

S-OGM-3.4 TRANSPORTING MATERIAL

S-OGM-3.4.1 Cement Stabilized Material. Cement-stabilized material shall be transported from the mixing plant to the site in trucks equipped with protective covers. Loads that have crusts of unworkable material or have become excessively wet will be rejected. Hauling over freshly placed material will not be permitted.

S-OGM-3.5 PLACING

S-OGM-3.5.1 General. Drainage layer material shall be placed on the underlying course in lifts of uniform thickness using equipment meeting the requirements of paragraph EQUIPMENT. When a compacted layer 8 inches or less in thickness is required, the material shall be placed in a single lift. When a compacted layer in excess of 8 inches is required, the material shall be placed in lifts of equal thickness. No lift shall exceed 8 inches or be less than 3 inches when compacted. The lifts shall be so placed that when compacted they will be true to the grades or levels required with the least possible surface disturbance. Where the drainage layer is placed in more than one lift, the previously constructed lift shall be cleaned of loose and foreign material. Such adjustments in placing procedures or equipment shall be made to obtain true grades and minimize segregation and degradation of the drainage layer material.

S-OGM-3.5.2 Hand Spreading. In areas where machine spreading is impractical, drainage layer material shall be spread by hand. The material shall be spread uniformly in a loose layer so as to prevent segregation along with conforming to the required grade and thickness after compaction.

S-OGM-3.6 COMPACTION REQUIREMENTS. Compaction shall be accomplished using rollers meeting the requirements of paragraph EQUIPMENT and operating at a rolling speed of no greater than 1.5 miles per hour. Each lift of drainage material, including shoulders when specified under the shoulders, shall be compacted with the number of passes of the roller as specified by the engineer. In addition, a minimum field dry density, as specified by the engineer, shall be maintained. If the required field dry density is not obtained, the number of roller passes shall be adjusted in accordance with paragraph DEFICIENCIES. Excessive rolling resulting in crushing of aggregate particles shall be avoided. Not more than 30 minutes shall elapse between the start of moist mixing of cement-stabilized material and the start of field compaction. Field compaction shall be completed within 60 minutes. In all places not accessible to the rollers, the drainage layer material shall be compacted with mechanical hand operated tampers.

S-OGM-3.7 CURINNG OF CEMENT-STABILIZED MATERIAL. The completed cement-stabilized drainage layer shall be sheet cured for a period of five days following completion of

compaction. Curing sheets shall be polyethylene type, meeting the requirements of ASTM C-171. Curing operations shall commence immediately after compaction. The edges of the plastic sheets shall overlap and be fastened with waterproof tape and then weighted down to prevent the wind from getting under the plastic.

No construction traffic shall be permitted on the cement-stabilized material until the curing period is complete (5 days after placement).

S-OGM-3.8 FINISHING. The top surface of the drainage layer shall be finished after final compaction as determined from the test section. Adjustments in rolling and finishing procedures shall be made to obtain grades and minimize segregation and degradation of the drainage layer material.

S-OGM-3.9 EDGES OF DRAINAGE LAYER AND PIPE SYSTEM. The lateral drainage system material shall be placed along the edges of the drainage layer course concurrently with the layer being constructed. When the drainage layer is being constructed in two or more lifts, the lift thickness at the edge shall be thickened to allow placement of drainage pipe in the bottom lift.

S-OGM-3.10 SMOOTHNESS TEST. The surface of the top lift shall not deviate more than $^3/_8$ inch when tested with a 12 foot straightedge applied parallel with and at right angles to the centerline of the area to be paved. Deviations exceeding $^3/_8$ inch shall be corrected in accordance with paragraph DEFICIENCIES.

S-OGM-3.11 THICKNESS CONTROL. The completed thickness of the drainage layer shall be within ½ inch of the thickness indicated. Thickness shall be measured at intervals providing at least one measurement for each 500 yd^2 of the drainage layer. Measurements shall be made in test holes at least 3 inches in diameter. Where the measured thickness is more than ½ inch deficient, such areas shall be corrected in accordance with paragraph DEFICIENCIES. Where the measured thickness is ½ inch more than indicated, it will be considered as conforming with the requirements plus ½ inch, provided the surface of the drainage layer is within ½ inch of established grade. The average job thickness shall be the average of all job measurements as specified above but within ¼ inch of the thickness shown on the drawings.

S-OGM-3.12 DEFICIENCIES.

S-OGM-3.12.1 Grade and Thickness. Deficiencies in grade and thickness shall be corrected such that both grade and thickness tolerances are met. In no case will thin layers of material be added to the top surface of the drainage layer to meet grade or increase thickness. If the elevation of the top of the drainage layer is more than ½ above the plan grade it shall be trimmed to grade and finished in accordance with paragraph FINISHING. If the elevation of the top surface of the drainage layer is ½ inch or more below the required grade, the surface of the drainage layer shall be scarified to a depth of at least 3 inches, new material shall be added, and the layer shall be blended and recompacted to bring it to grade. Where the measured thickness of the drainage layer is more than ½ inch deficient, such areas shall be corrected by excavating to the required depth and replaced with new material to obtain a compacted lift thickness of at least 3 inches. The depth of required excavation shall be controlled to keep the final surface elevation within grade requirements and to preserve layer thickness of materials below the drainage layer.

S-OGM-3.12.2 Density. Density shall be considered deficient if the field dry density test results as determined by D 6938 are below the dry density specified by the engineer. If the densities are deficient, the layer shall be rolled with 2 additional passes of the specified roller. If the dry density is still deficient, work will be stopped until the cause of the low dry densities can be

determined by the contractor. The contractor will furnish a plan to the engineer to remediate the problem prior to continuing.

S-OGM-3.12.3 Smoothness. Deficiencies in smoothness shall be corrected as if they are deficiencies in grade or thickness. All tolerances for grade and thickness shall be maintained while correcting smoothness deficiencies.

END OF SECTION S-OGM

Section DL Drainage Layer

DL-1 GENERAL. This item shall provide for the installation of a porous base course and / or drainage layer underlying a porous friction course surface surface course associated with the completion of an apron pavement.

DL-1.1 REFERENCES. The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 29	Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
ASTM C 88	Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C 117	Standard Test Method for Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C 131	Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C 136	ASTM C136-06 Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C 150	Standard Specification for Portland Cement
ASTM D 2487	Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D 4791	Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
ASTM D 6938	Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

DL-1.2. UNIT PRICES. Payment shall be made by the square yard for material accepted in place.

DL-1.2	VDOT # 1 Aggregate (6”)	- per square yard

DL-1.2.1 Waybills and Delivery Tickets. Copies of waybills and delivery tickets shall be submitted during the progress of the work. Before the final payment is allowed, the contractor shall file certified waybills and certified delivery tickets for all aggregates authorized for use.

DL-1.2.2 Measurement. Deductions will be made for any material wasted, unused, rejected, or used for the convenience of the contractor.

DL-1.2.3 Drainage Separation Layer. The quantity of aggregate drainage layer material completed and accepted shall be measured in square yards. The thickness of aggregate drainage layer material in place and accepted shall be determined by the average job thickness obtained in accordance with paragraph THICKNESS CONTROL and the dimensions indicated.

DL-1.2.5 Payment. The quantities of drainage layer aggregates and stabilizing materials as specified above will be paid for at the contract unit prices, which will constitute full compensation for the construction and completion of the drainage open-graded drainage layer, including the test section, and the furnishing of all other necessary labor and incidentals.

DL-1.3 SYSTEM DESCRIPTION. The contractor shall build a drainage layer under the pavements as indicated and in accordance with the following subparagraphs.

DL-1.3.1 Aggregate Drainage Layer. A drainage layer consisting of a combination of open graded materials meeting the gradations of table 1.

DL-1.4 SUBMITTALS. The following shall be submitted in accordance with the general provisions.

Reports:

- Sampling and testing
- Copies of field test results within 24 hours of completion of tests.
- Approval of materials
- Material sources and material test results prior to field use.
- Evaluation
- Test section construction report.

Records:

- Waybills and delivery tickets.
- Certified waybills and delivery tickets for all aggregates and cementitious materials actually used.

DL-1.5 FIELD COMPACTION. Field compaction requirements shall be based on the results of a test section constructed by the contractor, using the materials, methods, and equipment proposed for use in the work. The test section shall meet the requirements of paragraph TEST SECTION.

DL-1.6 EQUIPMENT.

DL-1.6.1 General Requirements. All plant, equipment, and tools used in the performance of the work will be subject to approval before the work is started and shall be maintained in satisfactory working condition at all times.

DL-1.6.2 Placement Equipment. An asphalt paving machine which incorporates a special tamping screed capable of providing 90% compaction of the non-stabilized separation layer shall be used to place drainage layer material. Alternate methods may be used for the separation layer if it can be demonstrated in the test section that these methods obtain the specified results.

DL-1.6.3 Compaction Equipment. A dual or single smooth drum vibratory roller which provides a maximum compactive effort without crushing the drainage layer aggregate shall be used to compact drainage layer material.

DL-1.7 WEATHER LIMITATION. Drainage layer material shall be placed when the atmospheric temperature is above 35° F (2° C). Areas of completed drainage layer or underlying courses that are damaged by freezing, rainfall, or other weather conditions or by contamination from sediments, dust, dirt, or foreign material shall be corrected by the contractor to meet specified requirements.

DL-1.8 SAMPLING AND TESTING.

DL-1.8.1 General Requirements. Sampling and testing shall be the responsibility of the contractor. Sampling and testing shall be performed by an approved commercial testing laboratory, subject to approval. If the contractor elects to establish testing facilities on his own, approval of such facilities shall be based on compliance with ASTM E 548, and no work requiring testing will be permitted until the contractor's facilities have been inspected and approved.

DL-1.8.2 Sampling. Aggregate samples shall be taken in accordance with ASTM D 75.

DL-1.8.3 Test Methods.

DL-1.8.3.1 Sieve Analyses. Sieve analyses shall be made in accordance with ASTM C 117 and ASTM C 136.

DL-1.8.3.2 Density Tests. Field density tests shall be made in accordance with ASTM D 6938.

DL-1.8.3.3 Soundness Test. Soundness tests shall be made in accordance with ASTM C 88.

DL-1.8.3.4 Los Angeles Abrasion Test. Los Angeles abrasion tests shall be made in accordance with ASTM C 131.

DL-1.8.3.5 Flat or Elongated Particles Tests. Flat and / or elongated particles tests shall be made in accordance with ASTM D 4791.

DL-1.8.3.6 Fractured Faces Tests. When aggregates are supplies from crushed gravel, approved test methods shall be used to assure the aggregate meets the requirements for fractured faces in paragraph AGGREGATES.

DL-1.8.4 Testing Frequency.

DL-1.8.4.1 Aggregate Drainage Separation Layer. Sieve analyses, field density, and moisture content tests shall be performed at a rate of at least one test for every 1,000 yd^2 of completed area and not less than one test for each day's production. Soundness tests, Los Angeles abrasion tests, fractured faces tests, and flat and/or elongated particles tests shall be performed at the time of the design mix and whenever the source of materials change.

DL-1.8.5 Approval of Materials.

DL-1.8.5.1 Aggregate. The aggregate source shall be selected at least 30 days prior to field use in the test section. Tentative approval of the source will be based on certified test results to verify that materials proposed for use meet the contract requirements. Final approval of both the source and the material will be based on test section performance and tests for gradation, soundness, Los Angeles abrasion, flat and / or elongated particles tests and fractured faces tests. For cement-stabilized drainage layer material, these tests shall be performed on aggregate samples taken prior to addition of cementitious material and subsequent placement in the test section.

DL-2.0 PRODUCTS.

DL-2.1 AGGREGATES. Aggregates shall consist of clean, sound, hard, durable, angular particles of crushed stone or crushed gravel which meet the specification requirements. Aggregates shall be free of silt and clay as defined by ASTM D 2487, vegetable matter, and other objectionable materials or coatings. Aggregates shall be supplied from a VDOT-approved source.

DL-2.1.1 Aggregate Quality. The aggregate shall have a soundness loss not greater than 18 percent weighted averaged at five cycles when tested in magnesium sulfate in accordance with ASTM C 88. The aggregate shall have a percentage of loss on abrasion not to exceed 40 after 500 revolutions as determined by ASTM C 131. The percentage of flat and / or elongated particles as determined by ASTM D 4791 shall not exceed 20 in the fraction retained on the ½ inch sieve, in the fraction passing the ½ inch sieve but retained on the no. 4 sieve, and in the percent passing the no. 4 sieve but retained on the no. 16 sieve. A flat particle is one having a ratio of width to thickness greater than 3; an elongated particle is one having a ratio of length to width greater than 3. When the aggregate is supplied from more than one source, aggregate from each source shall meet the requirements set forth herein. When the aggregate is supplied from crushed gravel it shall be manufactured from gravel particles 90 percent of which by weight are retained on the maximum-size sieve listed in TABLE 1. In the portion retained on each sieve specified, the crushed gravel shall contain at least 90 percent by weight of crushed pieces having two or more freshly fractured faces with the area of each face being at least equal to 75 percent of the smallest midsectional area of the face. When two fractures are contiguous, the angle between planes of the fractures must be at least 30 degrees in order to count as two fractures faces.

DL-2.1.2 Gradation Requirements. Drainage layer aggregates for the Portland cement layer shall be well graded within the limits specified in TABLE 1 (VDOT #1 gradation).

TABLE 1. GRADATION OF DRAINAGE LAYER MATERIAL	
Percentage of Weight Passing Square-Mesh Sieve	
Sieve Nominal Size Square Openings	Percent Passing
4 in	100
3 ½ in	90 - 100
2 ½ in	26 - 60
1 ½ in	0 - 15
¾ in	0 - 5
NOTE 1: Particles having diameters less than 0.02 mm shall not be in excess of 1.5 percent by weight of the total sample tested.	
NOTE 2: The values are based on aggregates of uniform specific gravity, and the percentages passing the various sieves may require appropriate correction by the engineer when aggregates of varying specific gravities are used.	

DL-2.2 GEOTEXTILE FILTER FABRIC. The filter fabric used to line the outfall trench shall be a nonwoven 100% polyester material with a minimum thickness of 75 mils. Other properties shall be as follows:

Fabric Property	Units	ASTM Requirement	Value
Grab Tensile	lb	D 4632	180
Elongation	%	D 4632	50
Puncture	lb	D 4833	80
Burst	PS	D 3786	290
Trapezoid Tear	lb	D 4533	50
UV Resistance	%	D 4355	70
Water Flow Rate	GPM / SF	D 4491	130
Permeability	cm / sec	D 4491	33
AOS	sieve size	D 4751	70
	mm		210

DL-3.0 EXECUTION.

DL-3.1 STOCKPILING AGGREGATES. Aggregates shall be stockpiled at location designated by the engineer. Stockpile areas shall be cleared and leveled prior to stockpiling aggregates. All aggregates shall be stockpiled so as to prevent segregation and contamination. Aggregates obtained from different sources shall be stockpiled separately.

DL-3.2 TEST SECTION.

DL-3.2.1 General. A test section shall be constructed to evaluate the ability to carry traffic and the constructability of the drainage layer including required mixing, placement, and compaction procedures. Test section data will be used by the contractor and engineer to determine the required number of passes and the field dry density requirements for full scale production.

DL-3.2.2 Scheduling. The test section shall be constructed a minimum of 10 days prior to the start of full-scale production to provide sufficient time for an evaluation of the proposed materials, equipment, and procedures including engineer QA testing.

DL-3.2.3 Location and Size. The test section shall be placed within the production paving limits. The underlying courses and subgrade preparation, required for the pavement section, shall be completed, inspected, and approved in the test section prior to constructing the drainage layer. The test section shall be a minimum of 100 feet long and one full paving lane wide. Unacceptable material will be removed and replaced at the contractor's expense.

DL-3.2.4 Initial Testing. Certified test results, to verify that the materials proposed for use in the test section meet the contract requirements, shall be provided by the contractor and approved by the engineer prior to the start of the test section.

DL-3.2.5 Mixing, Placement, and Compaction. Mixing, placement, and compaction shall be accomplished using equipment meeting the requirements of paragraph EQUIPMENT. Compaction equipment speed shall be no greater than 1.5 miles per hour.

DL-3.2.6 Procedure.

DL-3.2.6.1 Aggregate Drainage Separation Layer. The test section shall be constructed with aggregate in a moist state so as to establish a correlation between number of roller passes and dry density achievable during field production. Density and moisture content tests shall be conducted at the surface and at intervals of 2 inches of depth down for the total layer

thickness, in accordance with ASTM D6938. Sieve analysis tests shall be conducted on composite samples, taken adjacent to the density test locations, which represent the total layer thickness. One set of tests, (i.e. density, moisture, and sieve analysis) shall be taken before compaction and after each subsequent compaction pass at three separate locations as directed by the engineer. Compaction passes and density readings shall continue until the difference between the average dry densities of any two consecutive passes is less than or equal to 0.5 lb / ft^3.

DL-3.2.7 Evaluation Procedures. The engineer will evaluate the data from the test section. For the aggregate drainage separation layer material the in-place density and percent passing the no. 4 and no 16 sieves sizes shall be plotted against cumulative passes. With these results, the engineer will consult with the contractor quality control group who will maximize dry density while minimizing aggregated degradation. Generally, after 3 to 6 passes, only slight increases in dry density will be achieved. At this point the measured field density is at or near the optimum density obtainable for this material, for the given field conditions. The required field dry density shall then be set 2% lower than this optimum field dry density. Therefore the field dry density is to be set at 98% of the optimum density obtained in the test section. For aggregate drainage separation layer material only, the data on the percent passing will be examined closely to determine if degradation of the aggregate is occurring. If the percent passing the given sieve sizes is increasing, then the aggregate is being broken down by the compaction effort and all compactive effort will be terminated. The field density selected will be balanced between aggregate degradation, dry density, and stability of the drainage layer surface. Stability of the layer surface will take precedence. Within 10 days of completion of the test section, the contactor shall submit to the engineer a test section construction report complete with all required test data and correlations. The engineer will evaluate the data and provide to the contractor the required number of passes of the roller, the dry density for field density control during construction, the depth at which to check the density, and the need for a final static pass of the roller.

DL-3.3 PREPARATION OF UNDERLYING COURSE. Prior to constructing the drainage layer, the underlying course shall be cleaned of all foreign materials. During construction, the underlying course shall contain no frozen material. The underlying course shall conform to item P-152. Ruts or soft yielding spots in the underlying courses having inadequate compaction and deviations of the surface from the requirements set forth herein shall be corrected by loosening and removing soft or unsatisfactory material and by adding approved material, reshaping to line and grade, and recompacting to specified density. The finished underlying course shall not be disturbed by traffic or other operations and shall be maintained by the contractor in satisfactory condition until the drainage layer is placed.

DL-3.4 TRANSPORTING MATERIAL

DL-3.4.1 Aggregate Drainage Separation Layer Material. Aggregate drainage layer material shall be transported to the site in a manner which prevents segregation and contamination of materials.

DL-3.5 PLACING

DL-3.5.1 General. Drainage layer material shall be placed on the underlying course in lifts of uniform thickness using equipment meeting the requirements of paragraph EQUIPMENT. When a compacted layer 8 inches or less in thickness is required, the material shall be placed in a single lift. When a compacted layer in excess of 8 inches is required, the material shall be placed in lifts of equal thickness. No lift shall exceed 8 inches or be less than 3 inches when compacted. The

lifts shall be so placed that when compacted they will be true to the grades or levels required with the least possible surface disturbance. Where the drainage layer is placed in more than one lift, the previously constructed lift shall be cleaned of loose and foreign material. Such adjustments in placing procedures or equipment shall be made to obtain true grades and minimize segregation and degradation of the drainage layer material.

DL-3.5.2 Hand Spreading. In areas where machine spreading is impractical, drainage layer material shall be spread by hand. The material shall be spread uniformly in a loose layer so as to prevent segregation along with conforming to the required grade and thickness after compaction.

DL-3.6 COMPACTION REQUIREMENTS. Compaction shall be accomplished using rollers meeting the requirements of paragraph EQUIPMENT and operating at a rolling speed of no greater than 1.5 miles per hour. Each lift of drainage material, including shoulders when specified under the shoulders, shall be compacted with the number of passes of the roller as specified by the engineer. In addition, a minimum field dry density, as specified by the engineer, shall be maintained. If the required field dry density is not obtained, the number of roller passes shall be adjusted in accordance with paragraph DEFICIENCIES. Excessive rolling resulting in crushing of aggregate particles shall be avoided. In all places not accessible to the rollers, the drainage layer material shall be compacted with mechanical hand operated tampers.

DL-3.7 FINISHING. The top surface of the drainage layer shall be finished after final compaction as determined from the test section. Adjustments in rolling and finishing procedures shall be made to obtain grades and minimize segregation and degradation of the drainage layer material.

DL-3.8 EDGES OF DRAINAGE LAYER AND PIPE SYSTEM. The lateral drainage system material shall be placed along the edges of the drainage layer course concurrently with the layer being constructed. When the drainage layer is being constructed in two or more lifts, the lift thickness at the edge shall be thickened to allow placement of drainage pipe in the bottom lift.

DL-3.9 SMOOTHNESS TEST. The surface of the top lift shall not deviate more than $^{3}/_{8}$ inch when tested with a 12 foot straightedge applied parallel with and at right angles to the centerline of the area to be paved. Deviations exceeding $^{3}/_{8}$ inch shall be corrected in accordance with paragraph DEFICIENCIES.

DL-3.10 THICKNESS CONTROL. The completed thickness of the drainage layer shall be within ½ inch of the thickness indicated. Thickness shall be measured at intervals providing at least one measurement for each 500 yd^2 of the drainage layer. Measurements shall be made in test holes at least 3 inches in diameter. Where the measured thickness is more than ½ inch deficient, such areas shall be corrected in accordance with paragraph DEFICIENCIES. Where the measured thickness is ½ inch more than indicated, it will be considered as conforming with the requirements plus ½ inch, provided the surface of the drainage layer is within ½ inch of established grade. The average job thickness shall be the average of all job measurements as specified above but within ¼ inch of the thickness shown on the drawings.

DL-3.11 DEFICIENCIES.

DL-3.11.1 Grade and Thickness. Deficiencies in grade and thickness shall be corrected such that both grade and thickness tolerances are met. In no case will thin layers of material be added to the top surface of the drainage layer to meet grade or increase thickness. If the elevation of the top of the drainage layer is more than ½ above the plan grade it shall be trimmed to grade and finished in accordance with paragraph FINISHING. If the elevation of the top surface of the

drainage layer is ½ inch or more below the required grade, the surface of the drainage layer shall be scarified to a depth of at least 3 inches, new material shall be added, and the layer shall be blended and recompacted to bring it to grade. Where the measured thickness of the drainage layer is more than ½ inch deficient, such areas shall be corrected by excavating to the required depth and replaced with new material to obtain a compacted lift thickness of at least 3 inches. The depth of required excavation shall be controlled to keep the final surface elevation within grade requirements and to preserve layer thickness of materials below the drainage layer.

DL-3.11.2 Density. Density shall be considered deficient if the field dry density test results are below the dry density specified by the engineer. If the densities are deficient, the layer shall be rolled with 2 additional passes of the specified roller. If the dry density is still deficient, work will be stopped until the cause of the low dry densities can be determined by the contractor. The contractor will furnish a plan to the engineer to remediate the problem prior to continuing.

DL-3.11.3 Smoothness. Deficiencies in smoothness shall be corrected as if they are deficiencies in grade or thickness. All tolerances for grade and thickness shall be maintained while correcting smoothness deficiencies.

END OF SECTION DL

Item P-402 Porous Friction Course (Central Plant Hot Mix)

DESCRIPTION

402-1.1 This item shall consist of a plant mixed, open-graded porous friction course, composed of mineral aggregate and bituminous material, mixed in a central mixing plant, and placed on a prepared surface in accordance with these specifications and shall conform to the dimensions and typical cross section as shown on the plans.

MATERIALS

402-2.1 AGGREGATE. The aggregate shall consist of crushed stone, crushed gravel, or crushed slag with or without other inert finely divided mineral aggregate. The aggregate shall be composed of clean, sound, tough, durable particles, free from clay balls, organic matter, and other deleterious substances. The portion of the material retained on the No. 8 sieve shall be known as coarse aggregate, the portion passing the No. 4 sieve and retained on the No. 200 sieve as fine aggregate, and the portion passing the No. 200 sieve as mineral filler.

a. Coarse Aggregate. Coarse aggregate shall contain at least 75 percent by weight crushed pieces having two or more fractured faces and 100 percent by weight particles with one or more fractured faces. The area of each face shall be equal to at least 75 percent of the smallest mid-sectional area of the piece. When two fractures are contiguous, the angle between the planes of fractures shall be at least 30 °to count as two fractured faces. Fractured faces shall be obtained by crushing. The coarse aggregate shall not contain more than 8 percent, by weight of flat or elongated pieces as defined in ASTM D 693. The percentage of wear shall not be greater than 30 percent when tested in accordance with ASTM C 131. The sodium sulfate soundness loss shall not exceed 12 percent after five cycles, when tested in accordance with ASTM C 88.

b. Fine Aggregate. Fine aggregate shall have a plasticity index of not more than 6.0 and a liquid limit of not more than 25 when tested in accordance with ASTM D 4318. The percentage of wear shall not be greater than 30 percent when tested in accordance with ASTM C 131. The sodium sulfate soundness loss shall not exceed 12 percent after five cycles, when tested in accordance with ASTM C 88.

If necessary, natural sand may be used to obtain the gradation of aggregate blend or workability. The amount of sand to be added will be adjusted to produce mixtures conforming to requirements of this specification.

402-2.2 FILLER. If filler, in addition to that naturally present in the aggregate, is necessary, it shall meet the requirements of ASTM D 242. When mineral filler is required to be batched separately, hydrated lime in the amount of 1.5 percent maximum by weight of the total aggregate shall be batched as part of the added mineral filler. No additional compensation will be allowed the Contractor for furnishing and using hydrated lime or other approved mineral filler that may be required by this specification.

402-2.3 BITUMINOUS MATERIAL. The bituminous material shall be viscosity graded asphalt cement meeting Table 1 of this section and ASTM D-3381, Table 2. A synthetic rubber additive shall be added to the bitumen in an amount not less than 2 percent by weight (% by weight of synthetic rubber solids). The bitumen and additive shall be uniformly mixed to provide a mixture meeting the following requirements:

Table 1

Property	ASTM	Min.	Max.
Viscosity at 140 °F, Poises	D-2171	1600	2400
Viscosity at 275 °F, centiStokes	D-2170	325	
Flash Point, °F	D-92	450	
Ductility at 77 °F (5 cm/min) cm	D-113	100	
Ductility at 39.2 °F (5 cm/min) cm	D-113	50	
Toughness, inch-pounds	D-5801	110	
Tenacity, inch-pounds	D-5801	75	
Thin Film Oven Test			
Tests on Residue			
Viscosity at 140 °F, Poises	D-2170	--	8000
Ductility at 77 °F, (5 cm/min) cm	D-113	100	
Ductility at 39.2 °F, (5 cm/min) cm	D-113	25	

Certified test results plus a sample of the bitumen-synthetic rubber mixture shall be provided for each tank load shipped to the project or for each mixed batch, whichever is smaller. Samples being tested shall contain the anti-stripping additive. No material shall be used before the test results are delivered to the Engineer. The Engineer will conduct independent acceptance tests on random samples. Material placed which does not meet specification requirements shall be removed and replaced at no additional cost to the owner. A temperature-viscosity curve for the material shall be provided to the Engineer.

402-2.4 ANTI-STRIPPING AGENT. Any anti-stripping agent or additive if required shall be heat stable, shall not change the asphalt cement viscosity beyond specifications, shall contain no harmful ingredients, shall be added in recommended proportion by approved method, and shall be a material approved by the Virginia Department of Transportation.

COMPOSITION

402-3.1 COMPOSITION OF MIXTURE. The porous friction course shall be composed of aggregate, filler, bituminous material-synthetic rubber mixture, and anti-stripping agent. The several aggregate fractions shall be sized, graded, and combined in the proportions that meet the requirements of the job mix formula.

402-3.2 JOB MIX FORMULA. No bituminous mixture shall be produced for payment until the Engineer has given written approval of the job mix formula. The job mix shall be prepared by a certified laboratory at the Contractor's expense and shall remain in effect for the duration of the project. The job mix formula shall establish a single percentage of aggregate passing each required sieve size, a single percentage of bituminous material to be added to the aggregate, the amount of anti strip agent to be added (minimum of one half of one percent by weight), and a single temperature for the mixture as it is discharged into the hauling units. Silicone may be added to the mixture at a maximum rate of 1 ounce per 5,000 gallons of asphalt to facilitate laydown and rolling. Proper asphalt content shall be determined by mixing trial batches in the laboratory.

The job mix formula shall be submitted to the Engineer at least 30 days prior to the start of paving and shall include:

a. Percent passing each sieve size and gradation requirements.

b. Percent of asphalt cement.

c. Asphalt viscosity.

d. Mixing temperature range.

e. Temperature of mix when discharged from the mixer.

f. Temperature viscosity relationship of the asphalt cement.

g. Percent of wear (LA abrasion).

h. Plasticity Index and Liquid Limit of fine aggregate.

i. Percent fractured faces.

j. Percent elongated particles.

k. Anti-strip agent.

The Contractor shall submit samples to the Engineer, upon request, for job mix formula verification testing.

The combined aggregate shall be of such size that the percentage composition by weight, as determined by laboratory sieves, will conform to the gradation shown in Table 2 when tested in accordance with ASTM C 136.

The gradations in Table 2 represent the limits, which determine the suitability of the aggregate for use from the source of supply. The aggregate, as finally selected, shall have a gradation within the limits designated in Table 2 and shall not vary from the low limit on one sieve to the high limit on the adjacent sieve, or vice versa, but shall be uniformly graded from coarse to fine.

Table 2. Aggregate-Porous Friction Course
Percentage By Weight Passing Sieves

Sieve	**3/4" maximum**	**Job-Mix (Production) Tolerances ****
3/4"	100	---
1/2"	70-90	+/- 5%
3/8"	40-65	+/- 5%
#4	15-25	+/- 5%
#8	8-15	+/- 2%
#30	5-9	+/- 2%
#200	1-5	+/- 2%
Bitumen		+/- 0.2%
Temperature of Mix		+/- 20 °F.
** The gradation job mix tolerance limits will apply if they fall outside the master grading band in Table 2 except for the top two sieve sizes starting at the 100% passing band. These two sieve size bands shall also be additional limits for production.		

The gradations shown are based on aggregates of uniform specific gravity. The percentages passing the various sieves will be subject to appropriate adjustments by the Engineer when aggregates of varying specific gravities are used. The adjustments to the job mix gradation curve should result in a curve of the same general shape as the median curve of the gradation band in Table 2 and fall within the gradation band.

The Asphalt Institutes Manual Series No. 2 (MS-2) contains a convenient procedure for "adjusting" the job mix gradation when aggregates of non uniform specific gravity are proposed for use.

The bituminous content of porous friction courses shall be expressed as a percentage of the total mix by weight and shall be approved by the Engineer on the basis of laboratory tests. The materials used in the mix design shall be the same as those used on the project.

The bituminous content shall be within plus or minus 1 percent of the value obtained from the formula:

$2K_c + 4.0$

where K_c is the surface area constant for that part of the total dry aggregate that will pass a ¾ in (19.0 mm) sieve and be retained on the No. 4 (4.75 mm) sieve. Procedures for determining K_c are contained in the Asphalt Institute's Manual Series No. 2 (MS-2). The bituminous content so estimated is the percentage by weight of the total dry aggregates and must be converted to the percent by weight of the total mix in the approved job-mix formula.

The contractor's laboratory used to develop the job mix formula shall meet the requirements of ASTM D 3666. The laboratory accreditation must be current and listed on the accrediting authority's website. All test methods required for developing the JMF must be listed on the lab accreditation. A copy of the laboratory's current accreditation and accredited test methods shall be submitted to the Engineer prior to start of construction.

402-3.3 TEST SECTION. At least one full day prior to full production, the Contractor shall prepare a quantity of bituminous mixture according to the approved job mix formula. The amount of mixture should be sufficient to construct a test section at least 50 feet long and 20 feet wide, placed in two sections and of the same depth specified on the plans. The test area will be designated by the Engineer. The underlying pavement on which the test section is to be constructed shall be the same as the remainder of the course represented by the test section. The equipment to be used in construction of the test section shall be the same type and weight to be used on the remainder of the course represented by the test section. No bituminous mixture shall be produced for payment prior to successful placement of and acceptance of a test strip by the Engineer.

If the test section should prove to be unsatisfactory, the necessary adjustments to plant operation, and/or placement procedures shall be made. Additional test sections, as required, shall be constructed and evaluated for conformance to the specifications. When the test section does not conform to specification requirements the test section shall be removed and replaced at the Contractors expense. Full production shall not begin without approval of the Engineer. Test sections, which conform to specification requirements, shall be measured and paid in accordance with Paragraphs 402-5.1 and 402-6.1. The asphalt content may be adjusted by the engineer during the test section and will be used as the target asphalt content.

CONSTRUCTION METHODS

402-4.1 WEATHER AND SEASONAL LIMITATIONS. The porous friction course shall be constructed only on a dry surface when the atmospheric temperature is 50 °F (10 °C) and rising (at calm wind conditions) and when the weather is not foggy or rainy.

402-4.2 BITUMINOUS MIXING PLANT. Plants used for the preparation of bituminous mixtures shall conform to the requirements of ASTM D 995 with the following changes:

Requirements for all plants include:

(1) Truck Scales. The bituminous mixture shall be weighed on approved scales furnished by the Contractor, or on public scales at the Contractor's expense. Such scales shall be inspected and sealed as often as the Engineer deems necessary to assure their accuracy. Scales shall conform to the requirements of Section 90.

(2) Testing Laboratory. The Contractor or producer shall provide laboratory facilities for control and acceptance testing functions during periods of mix production, sampling, and testing and whenever materials subject to the provisions of these specifications are being supplied or tested. The laboratory shall provide adequate equipment, space, and utilities as required for the performance of the specified tests.

(3) Inspection of Plant. The Engineer, or Engineer's authorized representative, shall have access, at all times, to all parts of the plant for checking adequacy of equipment; inspecting operation of the plant; verifying weights, proportions, and materials properties; and checking the temperatures maintained in the preparation of the mixtures.

(4) Storage Bins and Surge Bins. Paragraph 3.9 of ASTM D 995 is deleted.

402-4.3 HAULING EQUIPMENT. Trucks used for hauling bituminous mixtures shall have tight, clean, smooth metal beds. Petroleum products shall not be used for coating truck beds. To prevent the mixture from adhering to them, the beds shall be lightly coated with an approved asphalt release agent. The truck beds shall be raised to drain any excess solution before loading the mixture in the trucks. Each truck shall have a suitable cover to protect the mixture from adverse weather. If conditions warrant, truck beds shall be insulated and covers shall be securely fastened so that the mixture will be delivered to the site at the specified temperature.

402-4.4 BITUMINOUS PAVERS. Bituminous pavers shall be self-contained, power-propelled units with an activated screed or strike-off assembly, heated if necessary, and shall be capable of spreading and finishing courses of bituminous plant-mix material which will meet the specified thickness, smoothness, and grade.

The paver shall have a receiving hopper of sufficient capacity to permit a uniform spreading operation. The hopper shall be equipped with a distribution system to place the mixture uniformly in front of the screed. The screed or strike-off assembly shall effectively produce a finished surface of the required smoothness and texture without tearing, shoving, or gouging the mixture.

The paver shall be capable of operating at forward speeds consistent with satisfactory laying of the mixture.

Pavers shall be equipped with an automatic grade control system capable of maintaining the screed elevation as specified herein. The control system shall be automatically activated from either a reference line or surface through a system of mechanical sensors or sensor-directed mechanisms or devices that will maintain the paver screed at a predetermined transverse slope and at the proper elevation to obtain the required surface.

The controls shall be capable of working in conjunction with any of the following attachments:

a. Ski-Type device of not less than 30 feet in length or as directed by the Engineer.

b. Taut stringline (wire) set to grade.

c. Short ski or shoe.

d. Laser controls.

The controls shall be so arranged that independent longitudinal grade controls can be operated simultaneously on both sides of the machine or independently on either side. The electronic controls shall be arranged so that the machine can be controlled automatically, semi-automatically, or manually.

The automatic equipment shall be capable of controlling the grade to within plus or minus 1/8 in and the transverse slope to within plus or minus one tenth of one percent from the controlling grade.

The machine shall be equipped with a spirit level or other type of slope indicator that will continuously indicate the average transverse slope of the screen. Curvature of spirit level tubes shall be as required to produce a bubble movement of not less than $^{1}/_{8}$ in for each $^{1}/_{10}^{th}$ of 1% change in the transverse slope.

The paving machine shall be capable of being equipped with an infrared joint heater if directed by the Engineer. The output of infrared energy shall be in the one to six micron range. Converters shall be arranged end to end directly over the joint to be heated in sufficient numbers to continuously produce, when in operation, a minimum of 240,000 BTU per hour. The joint heater shall be positioned not more than 1 in above the pavement to be heated and in front of the paver screed and shall be fully adjustable. Heaters will be required to be in operation at all times.

402-4.5 ROLLERS. Rollers shall be steel wheel. Split drum rollers are not acceptable. They shall be in good condition, capable of reversing without backlash, and operating at slow speeds to avoid displacement of the bituminous mixture. The wheels shall be equipped with adjustable scrapers and sprinkling apparatuses using a water soluble asphalt release agent, approved by the engineer, to prevent the bituminous mixture from sticking to the wheels. The number, type, and weight of rollers shall be sufficient to compact the mixture without detrimentally affecting the material.

402-4.6 PREPARATION OF MINERAL AGGREGATE. The aggregate for the mixture shall be dried and heated at the central mixing plant before entering the mixer. When introduced into the mixer, the combined aggregate moisture content (weighted according to the composition of the blend) shall be less than 0.25 percent for aggregate blends with water absorption of 2.5 percent or less and less than 0.50 percent for aggregate blends with water absorption greater than 2.5 percent. Water absorption of aggregates shall be determined by ASTM C 127 and C 128. The water absorption for the aggregate blend shall be the weighted average of the absorption values for the coarse aggregate retained on the No. 4 sieve (4.75 mm) and the fine aggregate passing the No. 4 sieve (4.75 mm). The water content test will be conducted in accordance with ASTM C 566. In no case shall the moisture content be such that foaming of the mixture occurs prior to placement. At the time of mixing, the temperature of the aggregate shall be within the range specified in the job mix formula. The maximum temperature and rate of heating shall be such that no damage occurs to the aggregates. Particular care shall be taken so that aggregates high in calcium or magnesium content are not damaged by overheating. The aggregate shall be screened to specified sizes and conveyed in separate bins ready for mixing with bituminous material.

402-4.7 PREPARATION OF BITUMINOUS MIXTURE. The bituminous mixture shall be prepared in a central mixing plant. The mixture shall be prepared at the temperature designated by the mix design.

The dry aggregate shall be combined in the plant using the proportionate amounts of each aggregate size required to meet the specified gradation. The quantity of aggregate for each batch shall be determined, measured, and conveyed into the mixer.

The quantity of bituminous material for each batch or the calibrated amount for continuous mixers shall be determined by the certified laboratory that prepared the mix design. It shall be measured by weight and introduced into the mixer within the temperature range specified in the job mix formula. For batch mixers, all aggregates shall be in the mixer before the bitumen material is added. In no case shall the temperature of the aggregate be more than 25° F above the temperature of the bituminous material. Mixing shall continue until all particles are coated uniformly. In no case shall the bituminous mixture be stored in storage silos or surge bins.

402-4.8 TRANSPORTATION AND DELIVERY OF THE MIXTURE. The mixture shall be placed at a temperature between 250 °F and 300 °F. Loads shall be sent from the plant so that all spreading and compacting of the mixture may be accomplished during daylight hours. Excessive waiting or delay of haul trucks at the job site shall not be allowed and mix supplied at temperatures outside the specified range will not be accepted. Bleeding and rich spots resulting from segregation during transportation shall not be accepted.

402-4.9 SPREADING AND LAYING. Immediately before placing the porous friction course, the underlying course shall be cleared of all loose or deleterious material with power blowers, power brooms, or hand brooms as directed. A tack coat conforming to Item P-603 Bituminous Tack Coat shall be placed on all existing surfaces for bonding the PFC to the existing surface. Placement of the PFC must be delayed until the tack coat has properly cured.

The mixture shall be deposited from haul units directly into the laydown machine hopper and placed in a continuous operation.

Hauling over material already placed shall not be permitted until the material has been thoroughly compacted and allowed to cure for a period of at least 12 hours.

402-4.10 COMPACTION OF MIXTURE. After spreading, rolling shall be done immediately. Two or four passes, at the discretion of the Engineer, with a steel wheel roller weighing no more than 10 tons, shall be made for compaction. Care should be taken to avoid over rolling or rolling when material is too cool. To prevent adhesion of the mixture to the roller, the wheels shall be kept properly moistened using a water soluble asphalt release agent approved by the engineer. Rolling operations shall be conducted in such a manner that shoving or distortion will not develop. The amount of rolling shall be limited to only that necessary for compacting the porous friction course and bonding it to the underlying surface course. Any mixture, which becomes loose, broken, mixed with dirt, or in any way defective, shall be removed and replaced with fresh mixture and immediately compacted to conform to the surrounding area. Such rework shall be done at the Contractor’s expense. Spreading of the mixture shall be done carefully with particular attention given to making the operation as continuous as possible. Hand working shall be kept to an absolute minimum.

Contractor quality control shall use a nuclear gauge to monitor compaction efforts.

402-4.11 JOINTS. The formation of all joints shall be made in such a manner as to ensure a continuous bond between old and new sections of the course. All joints shall present the same texture, density, and smoothness as other sections of the course.

The roller shall not pass over the unprotected end of the freshly laid mixture except when necessary to form a transverse joint. When necessary to form a transverse joint, it shall be made by means of placing a bulkhead or by tapering the course, in which case the edge shall be cut back to its full depth and width on

a straight line to expose vertical face. In both methods all contact surfaces shall be given a tack coat of bituminous material before placing any fresh mixture against the joint.

Longitudinal joints which are irregular, damaged, or otherwise defective shall be cut back to expose a clean, sound surface for the full depth of the course. All contact surfaces shall be given a tack coat of bituminous material prior to placing any fresh mixture against the joint. The longitudinal joint shall offset that in the existing course by at least 1 ft (30 cm).

402-4.12 SHAPING EDGES. While the surface is being compacted and finished, the Contractor shall carefully shape the longitudinal outside edges of the PFC to a vertical face at the established edge. When transitioning from PFC to existing pavement, transverse edges shall be constructed with a finer graded bituminous mixture.

402-4.13 SURFACE TESTS. The Contractor is responsible for supplying an acceptable metal 12 ft straight edge. After completion of final rolling, the finished surface shall be tested with the 12 ft straightedge and shall not vary more than 1/4 in. The 12 ft straight edge shall be applied parallel with and at right angles to the runway centerline in a pattern that includes longitudinal and transverse joints. The 12 ft straightedge shall be advanced approximately 1/2 its length in the line of measurement. Areas of the porous friction course exceeding the specified tolerances shall be removed, as directed by the Engineer, and replaced with new material at the Contractor's expense. The Engineer shall immediately notify the Contractor of such unsatisfactory visual defects such as non-uniform texture, roller marks, bleeding of bituminous material, cracking and shoving of the mixture during rolling operations. Areas of the porous friction course, which possess such defects, shall be removed, as directed by the Engineer, and replaced with new material at the Contractors expense. Skin patching or hand working shall not be permitted.

402-4.14 ACCEPTANCE SAMPLING AND TESTING OF BITUMINOUS MATERIAL AND AGGREGATE. The Contractor shall perform all acceptance sampling and testing, and the costs of these tests shall be incidental to the cost of the material. Certified test results will be submitted to the Engineer for review and approval. The Engineer will have the option to be present when samples are taken or tests conducted. The testing laboratory performing the testing shall meet the requirements of ASTM D 3666. Samples of the PFC mixture shall be taken at the point of discharge in hauling units and tested to control uniformity in bituminous content and gradation. Samples shall be taken in accordance with ASTM D 979 and prepared in accordance with ASTM D 2172 or ASTM D 6307. One sample shall be taken from each lot on a random basis in accordance with procedures contained in ASTM D 3665. A lot shall consist of 1,000 tons or 1/2 day's production, whichever is less. Should the average bituminous content for any two consecutive lots not fall within job mix tolerances under 402-3.1, the Contractor shall cease production until such out-of-tolerance conditions have been remedied. Any material, placed after the contractor has been informed of two consecutive failing tests, shall be rejected and removed at the Contractor's expense.

Aggregate from each hot bin or aggregate feed shall be sampled on a random basis and tested for gradation analysis in accordance with ASTM C 136. One sample shall be taken on a random basis in accordance with ASTM D 3665 for each lot. A lot shall consist of 500 tons or 1/4 day's production, whichever is less. If any two consecutive samples fail to meet the tolerances of the job mix formula gradation, the Contractor shall cease plant production until such out-of tolerance conditions have been remedied. Any material, placed after the contractor has been informed of two consecutive failing tests, shall be rejected and removed at the Contractor's expense.

The Engineer will notify the Contractor of unsatisfactory visual defects in the completed bituminous friction course such as non-uniform texture, roller marks, bleeding of bituminous material, cracking and shoving of the mixture during the roller operations, or nonconformance to the surface smoothness criteria

specified. Unsatisfactory bituminous friction course shall be removed and replaced at the Contractor's expense as directed by the Engineer.

402-4.15 BITUMINOUS AND AGGREGATE MATERIAL (CONTRACTOR'S RESPONSIBILITY). Samples of the bituminous and aggregate materials that the Contractor proposes to use, together with a statement of their source and character, shall be submitted for approval prior to use. The Contractor shall require the manufacturer or producer of the bituminous and aggregate materials to furnish material subject to this and all other pertinent requirements of the contract. Only those materials that have been tested and approved for the intended use shall be acceptable.

The Contractor shall furnish the vendor's certified test reports for each carload or equivalent of bituminous material shipped to the project. The report shall be delivered to the Engineer before permission is granted to use the material. The vendor's certified test report for the bituminous material shall not be interpreted as a basis for final acceptance. All test reports shall be subject to verification by testing sample materials received for use on the project.

402-4.16 PROTECTION OF PAVEMENT. After final rolling, no vehicular traffic of any kind shall be permitted on the pavement until it has cured at least 12 hours or unless otherwise authorized by the Engineer. Newly constructed pavement areas shall not be opened to aircraft traffic until 24 hours after completion or unless otherwise authorized by the Engineer.

402-4.17 MAINTENANCE. Care will be taken after installation of the porous friction course to protect it from fine aggregate, salt, silt, or other matter that could cause the voids in the material to close. No deicing materials will be used on or applied to the pavement. No vehicles will be permitted to travel from unpaved areas onto the porous pavement. Tires and vehicles will be fully cleaned prior to travel on the porous pavement to protect it from introduction of debris.

METHOD OF MEASUREMENT

402-5.1 Porous friction course shall be measured by the number of tons of mixture used in the accepted work.

Only the areas of the porous friction course meeting the following thickness requirements shall be measured for payment:

To determine the thickness of the finished PFC, the Engineer shall take one core sample, not less than 2 in (5 cm) in diameter, at random from each unit of the completed PFC area. A unit of the completed area shall be one paving lane wide by 1,000 feet (304 m) long. The last unit in any one paving lane shall include any remaining length in addition to the 1,000 feet (304 m).

When the measurement of any core is more than the maximum or less than the minimum allowable thickness, as shown in Table 3, additional cores shall be taken at 20 ft intervals (6 m) (parallel to and at right angles to the project baseline) until the completed PFC is within such maximum or minimum thickness for the subunit being tested. Out-of-tolerance areas shall be deducted from the total tons of PFC for payment. If, in the Engineer's judgment, such out of tolerance areas warrant removal, the PFC shall be removed and the underlying course shall be cleaned (ready for reconstruction), all at the Contractor's expense.

Table 3. Allowable Finished PFC Thickness

	Nominal	Maximum	Minimum
	in	in	in
3/4 in aggregate	1.0	1.50	0.75

BASIS OF PAYMENT

402-6.1 Payment shall be made at the respective contract prices per ton for porous friction course. The prices shall be full compensation for furnishing all materials, including bituminous material; for all preparation and storage of materials; for cleaning the existing surface; for mixing, hauling, placing, and compacting the mixture (including initial test section); for acceptance testing of the mixture as described in section 402-4.14; and for all tools, equipment, and incidentals necessary to complete each item. No separate payment is included in the contract for furnishing and batching mineral filler, or anti-stripping agents, should such items be required.

Payment will be made under:

P-402-6.1	Porous bituminous surface course (1.5” depth)	-per ton

TESTING REQUIREMENTS

ASTM C 88	Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C 127	Density, Specific Gravity, and Absorption of Coarse Aggregates
ASTM C 128	Density, Specific Gravity, and Absorption of Fine Aggregate
ASTM C 131	Resistance to Abrasion of Small Size Coarse Aggregate by Use of the Los Angeles Machine
ASTM C 136	Sieve Analysis of Fine and Coarse Aggregates
ASTM C 566	Total Evaporable Moisture Content of Aggregate by Drying
ASTM D 693	Crushed Aggregate for Macadam Pavements
ASTM D 979	Sampling Bituminous Paving Mixtures
ASTM D 995	Mixing Plants for Hot-Mixed Hot-Laid Bituminous Paving Mixtures
ASTM D 2172	Quantitative Extraction of Bitumen from Bituminous Paving Mixtures
ASTM D 2741	Susceptibility of Polyethylene Bottles to Soot Accumulation
ASTM D 3665	Random Sampling of Paving Materials
ASTM D 3666	Minimum Requirements for Agencies Testing and Inspecting Bituminous Paving Materials
ASTM D 4318	Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D 6307	Standard Test Method for Asphalt Content of Hot Mix Asphalt by Ignition Method

MATERIAL REQUIREMENTS

ASTM D 242	Mineral Filler for Bituminous Paving Mixtures
ASTM D 3381	Viscosity-Graded Asphalt Cement for Use in Pavement Construction

END OF ITEM P-402

Item P-603 Bituminous Tack Coat

DESCRIPTION

603-1.1 This item shall consist of preparing and treating a bituminous or concrete surface with bituminous material in accordance with these specifications and in reasonably close conformity to the lines shown on the plans.

MATERIALS

603-2.1 BITUMINOUS MATERIALS. The bituminous material shall be either cutback asphalt, emulsified asphalt, or tar and shall conform to the requirements of Table 1. The type, grade, controlling specification, and application temperature of bituminous material to be used shall be specified by the Engineer.

Table 1 Bituminous Material

Type and Grade	**Specification**	**Application Temperature**	
		Deg. F	Deg. C
Emulsified Asphalt			
SS-1, SS-1h	ASTM D 977	75-130	25-55
CSS-1, CSS-1h	ASTM D 2397	75-130	25-55
Cutback Asphalt			
RC-70	ASTM D 2028	120-160	50-70
Tar			
RTCB 5, RTCB 6	AASHTO M 52	60-120	15-50

CONSTRUCTION METHODS

603-3.1 WEATHER LIMITATIONS. The tack coat shall be applied only when the existing surface is dry and the atmospheric temperature is above 60 °F (15 °C). The temperature requirements may be waived, but only when so directed by the Engineer.

603-3.2 EQUIPMENT. The Contractor shall provide equipment for heating and applying the bituminous material.

The distributor shall be designed, equipped, maintained, and operated so that bituminous material at even heat may be applied uniformly on variable widths of surface at the specified rate. The allowable variation from the specified rate shall not exceed 10 percent. Distributor equipment shall include a tachometer, pressure gauges, volume-measuring devices or a calibrated tank, and a thermometer for measuring temperatures of tank contents. The distributor shall be self-powered and shall be equipped with a power unit for the pump and full circulation spray bars adjustable laterally and vertically.

If the distributor is not equipped with an operable quick shut off valve, the tack operations shall be started and stopped on building paper. The Contractor shall remove blotting sand prior to asphalt concrete lay down operations at no additional expense to the owner.

A power broom and/or blower shall be provided for any required cleaning of the surface to be treated.

603-3.3 APPLICATION OF BITUMINOUS MATERIAL. Immediately before applying the tack coat, the full width of surface to be treated shall be swept with a power broom and/or air blast to remove all loose dirt and other objectionable material.

Emulsified asphalt shall be diluted by the addition of water when directed by the Engineer and shall be applied a sufficient time in advance of the paver to ensure that all water has evaporated before any of the overlying mixture is placed on the tacked surface.

The bituminous material including vehicle or solvent shall be uniformly applied with a bituminous distributor at the rate of 0.05 to 0.15 gallons per square yard (0.24 to 0.72 liters per square meter) depending on the condition of the existing surface. The type of bituminous material and application rate shall be approved by the Engineer prior to application.

Following the application, the surface shall be allowed to cure without being disturbed for such period of time as may be necessary to permit drying out and setting of the tack coat. This period shall be determined by the Engineer. The surface shall then be maintained by the Contractor until the next course has been placed. Suitable precautions shall be taken by the Contractor to protect the surface against damage during this interval.

603-3.4 BITUMINOUS MATERIAL CONTRACTOR'S RESPONSIBILITY. Samples of the bituminous material that the Contractor proposes to use, together with a statement as to its source and character, must be submitted and approved before use of such material begins. The Contractor shall require the manufacturer or producer of the bituminous material to furnish material subject to this and all other pertinent requirements of the contract. Only satisfactory materials so demonstrated by service tests, shall be acceptable.

The Contractor shall furnish the vendor's certified test reports for each carload, or equivalent, of bituminous material shipped to the project. The report shall be delivered to the Engineer before permission is granted for use of the material. The furnishing of the vendor's certified test report for the bituminous material shall not be interpreted as a basis for final acceptance. All such test reports shall be subject to verification by testing samples of material received for use on the project.

603-3.5 FREIGHT AND WEIGH BILLS. Before the final estimate is allowed, the Contractor shall file with the Engineer receipted bills when railroad shipments are made, and certified weigh bills when materials are received in any other manner, of the bituminous materials actually used in the construction covered by the contract. The Contractor shall not remove bituminous material from the tank car or storage tank until the initial outage and temperature measurements have been taken by the Engineer, nor shall the car or tank be released until the final outage has been taken by the Engineer. Copies of freight bills and weigh bills shall be furnished to the Engineer during the progress of the work.

METHOD OF MEASUREMENT

603-4.1 Bituminous tack coat will not be measured separately for payment. Costs for this item shall be incidental to P-401.

BASIS OF PAYMENT

603.5-1 No separate payment will be made for this item. Bituminous tack coat is incidental to item P-401.

MATERIAL REQUIREMENTS

ASTM D 633	Volume Correction Table for Road Tar
ASTM D 977	Emulsified Asphalt
ASTM D 1250	Petroleum Measurement Tables
ASTM D 2028	Cutback Asphalt (Rapid-Curing Type)
ASTM D 2397	Cationic Emulsified Asphalt
Asphalt Institute Manual MS-6 Table IV-3	Asphalt Pocketbook of Useful Information (Temperature-Volume Corrections for Emulsified Asphalts)

END ITEM P-603

Item P-620 Runway and Taxiway Painting

DESCRIPTION

620-1.1 This item shall consist of the painting of numbers, markings, and stripes on the surface of runways, taxiways, and aprons, in accordance with these specifications and at the locations shown on the plans, or as directed by the Engineer.

MATERIALS

620-2.1 MATERIALS ACCEPTANCE. The Contractor shall furnish manufacturer's certified test reports for materials shipped to the project. The certified test reports shall include a statement that the materials meet the specification requirements. The reports can be used for material acceptance or the Engineer may perform verification testing. The reports shall not be interpreted as a basis for payment. The Contractor shall notify the Engineer upon arrival of a shipment of materials to the site.

620-2.2 PAINT. Paint shall be **waterborne or solvent-base** accordance with the requirements of paragraph 620-2.2-a and 620-2.2b. Paint shall be furnished in white – 37925 and yellow - 33538 or 33655 in accordance with Federal Standard No. 595. Paint shall be furnished in Type II – Fast drying time for no-pickup when tested in accordance with ASTM D711.

a. Waterborne. Paint shall meet the requirements of Federal Specification TT-P-1952E type II.

b. Solvent-Base. Paint shall meet the requirements of Federal Specification A-A-2886A type II.

620-2.3 REFLECTIVE MEDIA. Glass beads shall meet the requirements of Fed. Spec. TT-B-1325, Type I – gradation A. Glass beads used on hold markings will meet the requirements of Federal Specification. TT-B-1325D, Type III. Glass beads shall be treated with adhesion promoting and/or flotation coatings as specified by the manufacturer of the paint.

620.2.4 THERMOPLASTIC PAVEMENT MARKING MATERIAL (Type B, Class I):
Thermoplastic material shall be used for ADA markings and the landside markings in the colors necessary to complete the markings. Thermoplastic material shall not exude fumes that are toxic or injurious to persons or property when heated to the application temperature. It shall be suitable for use on asphalt concrete surfaces, and yellow thermoplastic material shall be selected from the Virginia Department of Transportation's approved products list. Thermoplastic material shall have the pigment, beads, and filler well dispersed in the resin and shall be free from skins, dirt, and foreign objects.

White pavement marking material shall be equivalent in color to Federal Standard (FS) Color No. 595-17886, and yellow pavement marking material shall be equivalent in color to FS Color No. 595-33538. Blue pavement marking material shall be Color No. 15090 in Federal Standard 595B.

a. **Composition:**

Component	White	Yellow
	Percent by Weight	
Binder	18.0 min	18.0 min
Glass beads	25.0 min	25.0 min
Titanium dioxide	8.0 min	-----
Calcium carbonate and inter fillers	49.0 max	-----

The binder shall be either alkyd or hydrocarbon. If an alkyd thermoplastic is used, the binder shall consist of synthetic resins, at least one of which is solid at room temperature, and high-boiling plasticizers. At least one-half of the binder composition shall be a maleic-modified glycerol ester of resin and shall be at least 10 percent by weight of the entire material formulation.

b. **Physical requirements:**

1. **Water absorption:** Materials shall have not more than 0.5 percent retained water by weight when tested in accordance with the requirements of ASTM D570, Procedure A.

2. **Softening point:** Materials shall have a softening point of at least 194 degrees F as determined in accordance with the requirements of ASTM E28.

3. **Specific gravity:** The specific gravity of the thermoplastic compound at 77 degrees F shall be from 1.7 to 2.2.

4. **Impact resistance:** The impact resistance shall be at least 10 inch-pounds at 77 degrees F after the material has been heated for 4 hours at 400 degrees F and cast into bars of 1-inch cross-sectional area, 3 inches long, and placed with 1 inch extending above the vise in a cantilever beam, Izod-type tester conforming to the requirements of ASTM D256 using the 25 inch-pound scale.

5. **Drying time:** Material shall set to bear traffic in not more than 2 minutes when the road temperature is 50 degrees F or above.

6. **Durability and wear resistance:** Material shall be designed to provide a life expectancy of at least 3 years under an average daily traffic count per lane of approximately 9,000 vehicles.

7. **Glass beads:** Glass beads shall conform to the requirements of Section 234.

8. **Flashpoint:** The material flashpoint shall be no less than 500 degrees F when tested in accordance with the requirements of ASTM D92.

CONSTRUCTION METHODS

620-3.1 WEATHER LIMITATIONS. The painting shall be performed only when the surface is dry and when the surface temperature is at least 45 °F (7 °C) and rising and the pavement surface temperature is at least 5 °F (2.7 °C) above the dew point.

620-3.2 EQUIPMENT. Equipment shall include the apparatus necessary to properly clean the existing surface, a mechanical marking machine, a bead dispensing machine, and such auxiliary hand-painting equipment as may be necessary to satisfactorily complete the job.

The mechanical marker shall be an atomizing spray-type or airless-type marking machine suitable for application of traffic paint. It shall produce an even and uniform film thickness at the required coverage and shall apply markings of uniform cross-sections and clear-cut edges without running or spattering and without over spray.

620-3.3 PREPARATION OF SURFACE. Immediately before application of the paint, the surface shall be dry and free from dirt, grease, oil, laitance, or other foreign material that would reduce the bond between the paint and the pavement. The area to be painted shall be cleaned by sweeping and blowing

or by other methods as required to remove all dirt, laitance, and loose materials without damage to the pavement surface. Use of any chemicals or impact abrasives during surface preparation shall be approved in advance by the Engineer.

620-3.4 LAYOUT OF MARKINGS. The proposed markings shall be laid out in advance of the paint application.

620-3.5 APPLICATION. Paint shall be applied at the locations and to the dimensions and spacing shown on the plans. Paint shall not be applied until the layout and condition of the surface has been approved by the Engineer. The edges of the markings shall not vary from a straight line more than 1/2 in (12 mm) in 50 ft (15 m) and marking dimensions and spacings shall be within the following tolerances:

Dimension and Spacing	Tolerance
36 in (910 mm) or less	±1/2 in (12 mm)
greater than 36 in to 6 ft (910 mm to 1.85 m)	± 1 in (25 mm)
greater than 6 ft to 60 ft (1.85 m to 18.3 m)	± 2 in (51 mm)
greater than 60 ft (18.3 m)	± 3 in (76 mm)

The paint shall be mixed in accordance with the manufacturer's instructions and applied to the pavement with a marking machine at the rate shown in Table 1. The addition of thinner will not be permitted. The manufacturer shall recommend a period of time that shall elapse between placement of a bituminous surface course or seal coat and application of the paint and the Contractor shall follow this recommendation. The manufacturer's recommendation must be provided to the engineer prior to paint application.

When painting P-402 porous friction course, the paint shall be mixed in accordance with the manufacturer's instructions and applied to the pavement with a marking machine capable of spraying from two directions simultaneously.

Table 1 Application Rates For Paint And Glass Beads

Paint Type	**Paint Sq ft per gallon, ft^2/gal. (Sq ms per liter, m^2/l)**	**Glass Beads, Type I, Gradation A Pounds per gallon of paint-lb./gal. (Km per liter of paint-kg/l)**	**Glass Beads, Type III Pounds per gallon of paint-lb./gal. (Km per liter of paint-kg/l)**
Waterborne	115 ft^2/gal. max (2.8 m^2/l)	7 lb./gal. min (0.85 kg/l)	10 lb./gal. min (1.2 kg/l)
Solvent Base	115 ft^2/gal. max (2.8 m^2/l)	7 lb./gal. min (0.85 kg/l)	10 lb./gal. min (1. 2 kg/l)

Glass beads shall be distributed upon the marked areas at the locations shown on the plans to receive glass beads immediately after application of the paint. A dispenser shall be furnished that is properly designed for attachment to the marking machine and suitable for dispensing glass beads. Glass beads shall be applied at the rate shown in Table 1. Glass beads shall not be applied to black paint. Glass beads shall adhere to the cured paint or all marking operations shall cease until corrections are made.

All emptied containers shall be returned to the paint storage area for checking by the Engineer. The containers shall not be removed from the airport or destroyed until authorized by the Engineer.

620-3.6 PROTECTION AND CLEANUP. After application of the markings, all markings shall be protected from damage until dry. All surfaces shall be protected from excess moisture and/or rain and from disfiguration by spatter, splashes, spillage, or drippings. The Contractor shall remove from the work area all debris, waste, loose or unadhered reflective media, and by-products generated by the surface preparation and application operations to the satisfaction of the Engineer. The Contractor shall dispose of these wastes in strict compliance with all applicable state, local, and Federal environmental statutes and regulations.

620-3.7 CORRECTIVE ACTION. Areas of defective work will be immediately corrected as directed by the engineer. Markings not in compliance with the contract documents will be removed in an approved method prior to re-marking. "Blacking out" the markings, or overpainting with black paint, is not acceptable.

METHOD OF MEASUREMENT

620-4.1 The quantity of airside pavement markings to be paid for shall be the number of square feet of painting, inclusive of reflective media, performed in accordance with the specifications and accepted by the engineer. The quantity of landside pavement marking shall be the number of square feet of preformed markings performed in accordance with the specifications and accepted by the engineer. The quantity of ADA markings to be paid for shall be each complete item in place, inclusive of thermoplastic access symbol, thermoplastic aisle markings, access sign, and signpost, performed in accordance with the specifications and accepted by the engineer.

BASIS OF PAYMENT

620-5.1 Payment shall be made at the respective contract **price per square foot** for airside pavement markings (paint) and landside pavement markings (thermoplastic), inclusive of reflective media for both. Payment shall be made at the respective contract lump sum price for ADA markings. This price shall be full compensation for furnishing all materials and for all labor, equipment, tools, and incidentals necessary to complete the item.

Payment will be made under:

P-620-5.1-1	Pavement marking – airside paint (yellow)	- per square foot
P-620-5.1-2	Pavement marking – landside thermoplastic (white)	- per square foot
P-620-5.1-3	Pavement marking – ADA (thermoplastic, including sign, sign post, aisle markings, and access symbol)	- per each

TESTING REQUIREMENTS

ASTM C 136	Sieve Analysis of Fine and Coarse Aggregates
ASTM C 146	Chemical Analysis of Glass Sand
ASTM C 371	Wire-Cloth Sieve Analysis of Nonplastic Ceramic Powders
ASTM D 92	Test Method for Flash and Fire Points by Cleveland Open Cup
ASTM D 711	No-Pick-Up Time of Traffic Paint
ASTM D 968	Standard Test Methods for Abrasion Resistance of Organic Coatings by

	Falling Abrasive
ASTM D 1213-54 (1975)	Test Method for Crushing Resistance of Glass Spheres
ASTM D 1652	Test Method for Epoxy Content of Epoxy Resins
ASTM D 2074	Test Method for Total Primary, Secondary, and Tertiary Amine Values of Fatty Amines by Alternative Indicator Method
ASTM D 2240	Test Method for Rubber Products-Durometer Hardness
ASTM G 15453	Operating Light and Water-Exposure Apparatus (Fluorescent Light Apparatus UV-Condensation Type) for Exposure of Nonmetallic Materials.
Federal Test Method Standard No. 141D/GEN	Paint, Varnish, Lacquer and Related Materials; Methods of Inspection, Sampling and Testing
MATERIAL REQUIREMENTS	
ASTM D 476	Specifications for Dry Pigmentary Titanium Dioxide Pigments Products
Code of Federal Regulations	40 CFR Part 60, Appendix A – Definition of Traverse Point Number and Location
Code of Federal Regulations	29 CFR Part 1910.1200 – Hazard Communications
FED SPEC TT-B-1325D	Beads (Glass Spheres) Retroreflective
AASHTO M 247	Glass Beads Used in Traffic Paints
FED SPEC TT-P-1952E	Paint, Traffic and Airfield Marking, Waterborne
Commercial Item Description (CID) A-A-2886B	Paint, Traffic, Solvent Based
FED STD 595	Colors used in Government Procurement

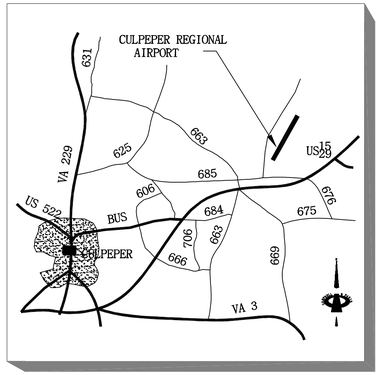
END OF ITEM P-620

B.1.9 Culpeper Regional Airport Porous Asphalt Apron Drawings

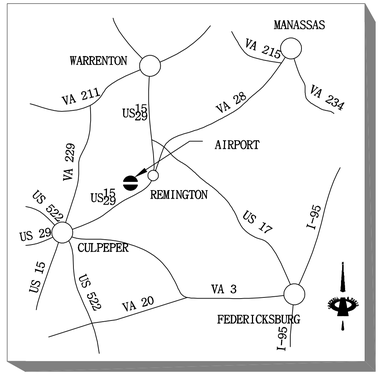
T-HANGAR AND EXECUTIVE HANGAR DEVELOPMENT

CULPEPER REGIONAL AIRPORT,
CULPEPER, VIRGINIA

FEBRUARY 2014
CS 0010-23



LOCATION MAP



VICINITY MAP

SHEET LIST TABLE	
Sheet Number	Sheet Title
G1	COVER SHEET
G2	LEGENDS & ABBREVIATIONS
G3	SITE ACCESS & STAGING PLAN
G4	EXISTING CONDITIONS
G5	BORING LOCATION
G6	BORING LOG
C1.1	DEMOLITION PLAN
C1.2	DEMOLITION PLAN
C2.1	GEOMETRIC PLAN
C3.1	GRADING PLAN
C4.1	DRAINAGE & UTILITY PLAN
C5.1	STORMWATER PROFILES
C5.2	STORMWATER PROFILES
C5.3	SANITARY AND UTILITY PROFILES
C5.4	WATER PROFILES
C5.5	DRAINAGE TABLES
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C7.1	MARKING PLAN
C8.1	EROSION & SEDIMENT CONTROL PLAN
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C9.2	DRAINAGE DETAILS
C9.3	DRAINAGE DETAILS
C9.4	UTILITY DETAILS
C9.5	PAVEMENT DETAILS
C9.6	FENCE DETAILS
C9.7	EROSION & SEDIMENT CONTROL DETAILS
C10.1	STORM WATER MANAGEMENT NARRITIVE
C10.2	STORM WATER MANAGEMENT PLAN - PRE-DEVELOPMENT CONDITIONS

SHEET LIST TABLE	
Sheet Number	Sheet Title
C10.3	STORM WATER MANAGEMENT PLAN - POSTDEVELOPMENT CONDITIONS
A1.1	ELEVATIONS VIEWS AND FLOOR PLAN - T-HANGAR
A1.2	FOUNDATION PLAN - T-HANGAR
A1.3	ELEVATION VIEWS AND FLOOR PLAN - EXECUTIVE HANGAR
A1.4	FOUNDATION PLAN - EXECUTIVE HANGAR
A1.5	HANGAR NOTES
A1.6	WALL DETAILS AND FINISH SCHEDULE
A2.1	RESTROOM LAYOUT, ELEVATION VIEW AND NOTES
XA.1	STA. 10+25-STA. 11+00
XA.2	STA. 11+25-STA. 12+00
XA.3	STA. 12+25-STA. 13+00
XA.4	STA. 13+25-STA. 14+00
XA.5	STA. 14+25-STA. 15+00
XA.6	STA. 15+25-STA. 16+00
XA.7	STA. 16+25-STA. 17+00
XB.1	STA. 0+25-STA. 0+75
XB.2	STA. 1+00-STA. 1+50
XB.3	STA. 1+75-STA. 2+25
XB.4	STA. 2+50-STA. 3+00
XB.5	STA. 3+25-STA. 3+75
XB.6	STA. 4+00-STA. 4+50
XC.1	STA. 50+75-STA. 52+00
XC.2	STA. 52+25-STA. 53+25
XC.3	STA. 54+25-STA. 55+50
XC.4	STA. 55+75-STA. 56+00
XD.1	STA. 60+25-STA. 61+50
XD.2	STA. 61+75-STA. 63+75

CAMPBELL AND PARIS ENGINEERS

COMMONWEALTH OF VIRGINIA
PETER KERR BIGLER CHASE
Lic. No. 047615
2/26/2014
PROFESSIONAL ENGINEER

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DESIGNED BY:	DRAWN BY:	CHECKED BY:	APPROVED BY:
FM	FM	DJ	HDC
SCALE: AS SHOWN		C&P JOB #: 0007-20	PROJECTE PHASE: FINAL

NO.	DATE	REVISIONS	BY	APPR.

COUNTY OF CULPEPER, VIRGINIA
CULPEPER REGIONAL AIRPORT

T-HANGAR AND EXECUTIVE HANGAR
DEVELOPMENT

COVER SHEET

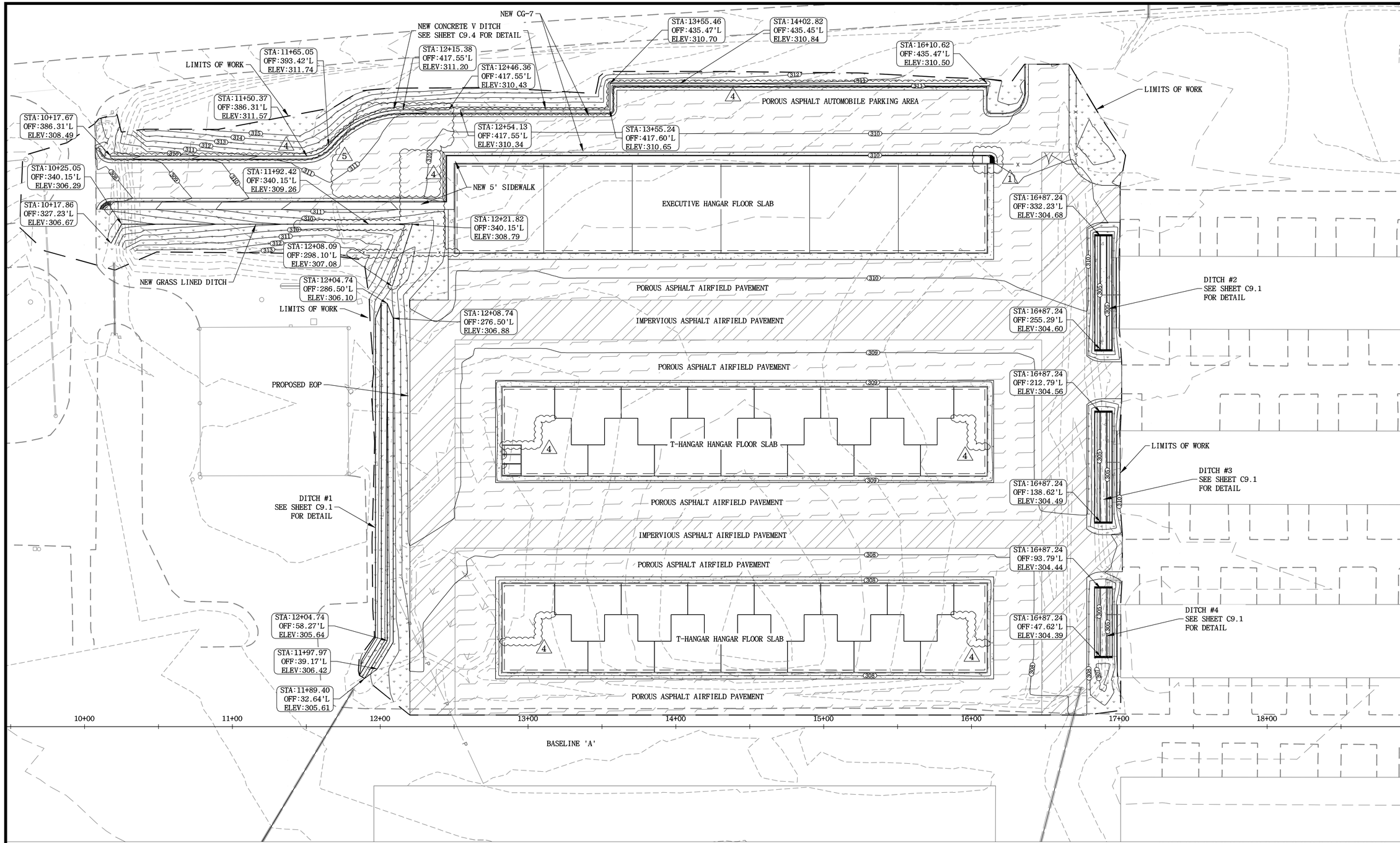
AIP No.
NOT APPLICABLE

State No.
CS-0010-20

SHEET INDEX
G1

SHEET 1 OF 55

FEBRUARY 2014



GRAPHIC SCALE

30 0 15 30 60 120

(IN FEET)
1 inch = 30 ft.

WETLAND NOTES:

1. CONTRACTOR TO COORDINATE WITH RESIDENT ENGINEER TO ENSURE WETLAND MITIGATION CREDITS HAVE BEEN PAID AND ACCEPTED PRIOR TO BEGINNING ANY EARTH WORK DISTURBING ACTIVITIES IN WETLAND AREAS. CONTRACTOR TO ENSURE NECESSARY STORM WATER DISCHARGE PERMIT FOR CONSTRUCTION ACTIVITIES IS OBTAINED PRIOR TO BEGINNING EARTH WORK DISTURBING ACTIVITIES.
2. ALL COST ASSOCIATED WITH STORM WATER PERMITS SHALL BE INCIDENTAL TO ITEM P-152 UNCLASSIFIED EXCAVATION.

GRADING NOTES:

1. ALL REINFORCED CONCRETE PIPE UNDER PAVEMENT SHALL BE CLASS IV WITH BELL AND SPIGOT RUBBER O-RING JOINTS.
2. AFTER COMPLETION OF CONSTRUCTION, ALL AREAS DISTURBED BY THE CONTRACTOR SHALL BE SEEDED AND MULCHED IN ACCORDANCE WITH CONTRACT SPECIFICATIONS SECTIONS T-901 AND T-908.
3. THE FIRST 18" PERIMETER OUTSIDE OF ALL NEW CONCRETE LINED DITCH SHALL BE SODDED IN ACCORDANCE WITH SPECIFICATION SECTION T-904.
4. CONTRACTOR WILL BE RESPONSIBLE FOR GRADING AND DRAINING AREAS AND CONSTRUCTING TEMPORARY DITCHES OR UTILIZING PUMPING SYSTEMS TO ASSURE POSITIVE DRAINAGE IS MAINTAINED THROUGHT THE ENTIRE PROJECT. COSTS ASSOCIATED WITH THIS WORK WILL BE INCIDENTAL TO ITEM P-152 UNCLASSIFIED EXCAVATION. (1)

LEGEND	
SYMBOL	DESCRIPTION
	NEW BITUMINOUS POROUS PAVEMENT
	NEW BITUMINOUS IMPERVIOUS PAVEMENT
	NEW BUILDING APRON, SIDEWALK, REVERSE CURB & GUTTER, BUILDING FLOOR SLAB
	NEW VDOT CONCRETE ENDWALL (EW-1)
	NEW STABILIZED AREA
	NEW EDGE OF PAVEMENT
	LIMITS OF WORK
x	NEW FENCE

COMMONWEALTH OF VIRGINIA
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DESIGNED BY: FM | DRAWN BY: FM | CHECKED BY: DJ | APPROVED BY: HDC
SCALE: AS SHOWN | C&P JOB #: 0007-20 | PROJECTE PHASE: FINAL

NO.	DATE	REVISIONS	BY	APPR.
1	3/19/2014	ADDENDUM #1	FM	KC
-	———	NO REVISIONS DUE TO ADDENDUM #2	FM	KC
-	———	NO REVISIONS DUE TO ADDENDUM #3	FM	KC
4	8/20/2015	CONTRACT MODIFICATION #1	FM	KC
5	9/28/2015	SANITARY MANHOLE RELOCATION	FM	KC

COUNTY OF CULPEPER, VIRGINIA
CULPEPPER REGIONAL AIRPORT

T-HANGAR AND EXECUTIVE HANGAR DEVELOPMENT

GRADING PLAN

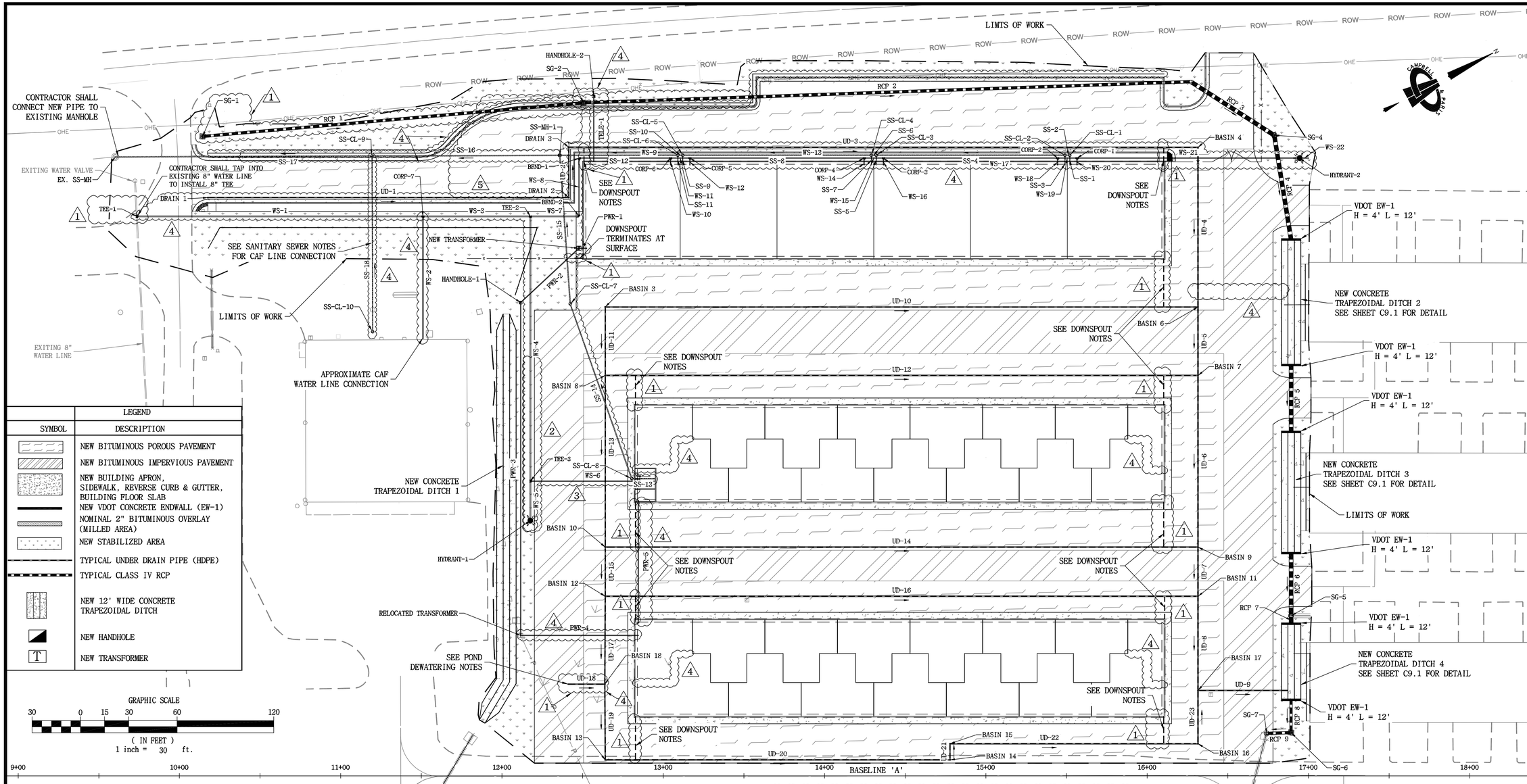
AIP No.
NOT APPLICABLE

State No.
CS-0010-20

SHEET INDEX
C3.1

SHEET 10 OF 55

FEBRUARY 2014



LEGEND	
SYMBOL	DESCRIPTION
	NEW BITUMINOUS POROUS PAVEMENT
	NEW BITUMINOUS IMPERVIOUS PAVEMENT
	NEW BUILDING APRON, SIDEWALK, REVERSE CURB & GUTTER, BUILDING FLOOR SLAB
	NEW VDOT CONCRETE ENDWALL (EW-1)
	NOMINAL 2" BITUMINOUS OVERLAY (MILLED AREA)
	NEW STABILIZED AREA
	TYPICAL UNDER DRAIN PIPE (HDPE)
	TYPICAL CLASS IV RCP
	NEW 12' WIDE CONCRETE TRAPEZOIDAL DITCH
	NEW HANDHOLE
T	NEW TRANSFORMER

GRAPHIC SCALE
30 0 15 30 60 120
(IN FEET)
1 inch = 30 ft.

TRAPEZOIDAL DITCH NOTES:
1. PRIOR TO PLACING CONCRETE DITCHES ON THE NORTHERN SIDE OF THE PROJECT, CONTRACTOR IS TO CONFIRM INVERT ELEVATIONS FOR EXISTING 4" PLASTIC PIPES (3 TOTAL) AND 30" CMP AS SHOWN ON THE EXISTING CONDITIONS. THE 4" PLASTIC PIPES ARE TO BE CUT FLUSH WITH THE SIDE WALL OF THE NEW CONCRETE TRAPEZOIDAL DITCH. THE 30" CMP IS TO CONNECT INTO INLET 5 DRAINAGE STRUCTURE. CONTRACTOR IS TO CONFIRM INVERT ELEVATIONS TO ENSURE THE PLASTIC PIPES CAN CONNECT TO THE TRAPEZOIDAL DITCH AND TO ENSURE INLET 5 ACCOUNTS FOR THE INVERT ELEVATIONS FOR THE NEW RCP AND EXISTING CMP.
2. ALL COSTS ASSOCIATED WITH THE TIE IN OF THE EXISTING 4" PLASTIC PIPES SHALL BE INCIDENTAL TO ITEM P-610 TRAPEZOIDAL CONCRETE DITCH
3. ALL COSTS ASSOCIATED WITH THE TIE IN OF THE EXISTING 30" CMP SHALL BE INCIDENTAL TO ITEM D-751 DI-1 DROP INLET.
4. SEE SHEET C9.1 FOR CONCRETE TRAPEZOIDAL DITCH DETAILS.
5. SEE SHEET C9.4 FOR CONCRETE V DITCH DETAILS.
6. COSTS ASSOCIATED WITH CONCRETE DITCH CONNECTION TO EXISTING BUILDING (6" DEPTH) SHALL BE INCIDENTAL TO ITEM P-610 TRAPEZOIDAL CONCRETE DITCH.

DRAINAGE STRUCTURE NOTES:
1. ALL INLINE DRAINS AND DRAINAGE BASINS SHALL HAVE 12" DUCTILE IRON SOLID COVERS

DOWNSPOUT NOTES:
1. CONTRACTOR SHALL SUBMIT SHOP DRAWING TO RESIDENT ENGINEER FOR APPROVAL FOR DOWNSPOUT OUTFALL PIPE CONNECTION INTO PROPOSED UNDERDRAIN SYSTEM.
2. PIPE SHALL BE 6" N-12 DUAL WALL NON-PERFERATED HDPE PIPE
3. CONTRACTOR SHALL BE RESPONSIBLE FOR ALL COORDINATION ASSOCIATED WITH CONNECTION. ALL COSTS ASSOCIATED WITH DOWNSPOUT PIPE AND PIPE CONNECTION SHALL BE INCIDENTAL TO BUILDING ERECTION.

POND DEWATERING NOTES:
1. CONTRACTOR SHALL DEWATER THE POND.
2. BACKFILL MODIFICATION SHALL TAKE PLACE AT THE OPTION OF THE RESIDENT ENGINEER. SEE SHEET C9.4 FOR DETAIL. (1)
3. COSTS ASSOCIATED WITH THE DEWATERING OF THE POND SHALL BE INCIDENTAL TO ITEM D-701 POND DEWATERING BACKFILL OPTION.

SANITARY SEWER NOTES:
1. ALL SANITARY PIPE AND STRUCTURES SHALL CONFORM TO THE WATER AND WASTEWATER RULES, REGULATIONS, OPERATIONAL PROCEDURES, DESIGN STANDARDS AND DETAILS FOR CULPEPER COUNTY WATER AND SEWER AUTHORITY.
2. CONNECTION TO THE EXISTING MANHOLE SHALL BE COMPLETED IN ACCORDANCE WITH THE CULPEPER COUNTY WATER AND SEWER AUTHORITY STANDARDS. (2)
3. CONTRACTOR IS RESPONSIBLE FOR ANY COORDINATION OR PERMITS REQUIRED FOR THE NEW SANITARY LINE. ANY COSTS FOR THIS WORK AND COORDINATION IS INCIDENTAL TO THE 6" SDR-35 PAY ITEM.
4. ALL COSTS ASSOCIATED WITH CONNECTIONS TO EXITING MANHOLES, CONSTRUCTION OF CLEAN-OUTS, MECHANICAL PLUGS, COORDINATION AND/OR PERMITS, AND ANY OTHER SANITARY SEWER MATERIAL NOT LISTED IN THE SCHEDULE OF UNIT PRICES SHALL BE INCIDENTAL TO ASSOCIATED PIPE. (1)
5. CONTRACTOR SHALL DEMOLISH, REMOVE AND BACKFILL, PER THE SPECIFICATIONS, THE EXISTING CAF HOLDING TANK AND ALL ASSOCIATED ITEMS. THIS INCLUDES, BUT IS NOT LIMITED TO THE INJECTOR PUMP AND ASSOCIATED PIPE. CONTRACTOR SHALL CONNECT THE EXISTING CAF SANITARY LINE FROM DIRECTLY OUTSIDE THE BUILDING INTO THE PROPOSED 6" SDR-35 LINE WITH A NEW 4" SDR-35 LINE AT THE LOCATION SHOWN ON THE PLANS.
6. ALL COST ASSOCIATED WITH DEMOLITION OF THE CAF HOLD TANK AND TESTING FOR THE LINE CONNECTION SHALL BE INCIDENTAL TO THE CAF HOLD TANK DEMOLITION PAY ITEM. (4)

WATER LINE NOTES:
1. ALL WATER PIPE AND FIXTURES SHALL CONFORM TO THE WATER AND WASTEWATER RULES, REGULATIONS, OPERATIONAL PROCEDURES, DESIGN STANDARDS AND DETAILS FOR CULPEPER COUNTY WATER AND SEWER AUTHORITY UNLESS OTHERWISE NOTED.
2. CONTRACTOR SHALL SUBMIT A SHOP DRAWING OF FLUSH MOUNT HYDRANT FOR ENGINEER APPROVAL. (1)
3. ANY DISRUPTION TO EXITING WATER SERVICE SHALL BE COORDINATED WITH RESIDENT ENGINEER TO MINIMIZE DOWNTIME. A SCHEDULE SHALL BE PROVIDED.
4. CONTRACTOR TO PROVIDE AND INSTALL PIPE REDUCERS FROM TEES TO MAINTAIN PIPE SIZES SHOWN ON THE PLAN. COSTS ASSOCIATED WITH REDUCERS SHALL BE INCIDENTAL TO THE ASSOCIATED TEE.
5. CONTRACTOR SHALL INSTALL 3 SHUTOFF GATE VALVES AT EACH TEE LOCATION. THE GATE VALVE SHALL MAINTAIN THE DIAMETER OF THE PIPE AT WHICH IT IS LOCATED.
6. COSTS ASSOCIATED WITH MATERIALS, CLEANING, TESTING, AIR RELEASES, AND BLOWOFFS SHALL BE INCIDENTAL TO ITEM W-110 6" DIP WATER LINE.
7. ALL TEES AND BENDS SHALL BE RESTRAINED WITH APPROVED JOINT RESTRAINTS LISTED IN THE SPECIFICATIONS. SEE SHEET C5.4 FOR JOINT RESTRAINT TABLE. ALL COSTS ASSOCIATED WITH JOINT RESTRAINTS SHALL BE INCIDENTAL TO THE ASSOCIATED TEE.
8. CONTRACTOR SHALL INSTALL NEW 3/4" COPPER WATER PIPE UP TO THE FINAL GRADE OF THE NEW FOUNDATION SLAB AND CAP FOR FUTURE USE.
9. ALL COSTS ASSOCIATED WITH INSTALLATION OF THE WATER LINE AND HYDRANTS NOT LISTED WITH UNIT PRICES SHALL BE INCIDENTAL TO ITEM W-110 6" DIP WATER LINE.

UTILITY NOTES:
1. THE LOCATION OF UNDERGROUND UTILITIES AS INDICATED ON THESE PLANS HAS BEEN OBTAINED FROM EXISTING RECORDS. NEITHER THE OWNER NOR THE ENGINEER ASSUMES ANY RESPONSIBILITY WITH RESPECT TO THE ACCURACY, COMPLETENESS OR SUFFICIENCY OF THE INFORMATION. THERE IS NO GUARANTEE, EITHER EXPRESSED OR IMPLIED, THAT THE LOCATIONS, SIZE, AND TYPE OF MATERIALS OF EXISTING UNDERGROUND UTILITIES INDICATED ARE REPRESENTATIVE OF THOSE TO BE ENCOUNTERED DURING CONSTRUCTION. IT SHALL BE THE CONTRACTOR'S RESPONSIBILITY TO DETERMINE THE ACTUAL LOCATION OF ALL SUCH FACILITIES INCLUDING SERVICE CONNECTIONS TO UNDERGROUND UTILITIES. PRIOR TO CONSTRUCTION, THE CONTRACTOR SHALL NOTIFY THE ENGINEER OF THEIR OPERATIONAL PLANS IN WRITING. IN THE EVENT OF AN UNEXPECTED UTILITY INTERFERENCE IS ENCOUNTERED DURING CONSTRUCTION, THE CONTRACTOR SHALL NOTIFY THE ENGINEER. ANY SUCH UTILITIES AND/OR SERVICES DISTURBED BY THE CONTRACTOR'S OPERATIONS SHALL BE RESTORED IMMEDIATELY AT THE EXPENSE OF THE CONTRACTOR.
2. THE CONTRACTOR SHALL CONTACT MISS UTILITY PRIOR TO BEGINNING ALL UTILITY WORK.
3. ALL DUCTBANK UNDERNEATH PAVEMENT SHALL BE CONCRETE ENCASED. SEE SHEET C9.4 FOR DETAIL. (4)
4. THE CONTRACTOR IS RESPONSIBLE FOR COORDINATION WITH VDOT FOR ANY PERMITS NECESSARY FOR CONSTRUCTION.
5. CONTRACTOR SHALL EMPLOY A FIRM TO FIELD VERIFY LOCATION OF EXISTING POWER LINE ENTERING EXISTING HANDHOLE AT STATION 11+85. DEPENDING ON ELEVATION OF EXISTING UNDERGROUND POWER LINE, CONTRACTOR MAY BE REQUIRED TO INSTALL ADDITIONAL DUCTBANK IN ORDER TO LOWER EXISTING POWER LINE ELEVATION BETWEEN DISTRIBUTION LINE AND EXISTING HANDHOLE AT STATION 11+85. IF REQUIRED DUCTBANK WILL BE PAID FOR AT THE UNIT PRICE FOR DUCTBANK. COORDINATION REQUIRED TO ARRANGE TEMPORARY POWER DURING RELOCATION OF EXISTING LINE SHALL BE INCIDENTAL TO ITEM L-110 MISCELLANEOUS ELECTRICAL COORDINATION.
6. THE CONTRACTOR SHALL FIELD VERIFY AND COORDINATE EXACT LOCATION OF NEW TRANSFORMER AND NEW HANDHOLE WITH DOMINION POWER AND RESIDENT ENGINEER PRIOR TO DUCTBANK INSTALLATION.
7. THE CONTRACTOR SHALL BE RESPONSIBLE FOR PROVIDING NEW HANDHOLES SHOWN ON PLAN.
8. CONTRACTOR IS RESPONSIBLE FOR ANY COORDINATION WITH DOMINION POWER COMPANY AND CULPEPER COUNTY FOR INSTALLATION OF THE PROPOSED ELECTRICAL DUCTBANK AND ASSOCIATED ITEMS. THE UNDERGROUND ELECTRICAL ITEMS MUST BE IN PLACE PRIOR TO PAVING OPERATIONS IN THE AREAS OF THE ELECTRICAL UTILITIES. COSTS SHALL BE INCIDENTAL TO ITEM L-110 MISCELLANEOUS ELECTRICAL COORDINATION. (1)

COMMONWEALTH OF VIRGINIA
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DESIGNED BY:	DRAWN BY:	CHECKED BY:	APPROVED BY:
FM	FM	DJ	HDC
SCALE: AS SHOWN		C&P JOB #: 0007-20	PROJECTE PHASE: FINAL

NO.	DATE	REVISIONS	BY	APPR.
1	3/19/2014	ADDENDUM #1	FM	KC
2	3/26/2014	ADDENDUM #2	FM	KC
-	------	NO REVISIONS DUE TO ADDENDUM #3	FM	KC
4	8/20/2015	CONTRACT MODIFICATION #1	FM	KC
5	9/28/2015	SANITARY MANHOLE RELOCATION	FM	KC

COUNTY OF CULPEPER, VIRGINIA
CULPEPER REGIONAL AIRPORT

T-HANGAR AND EXECUTIVE HANGAR DEVELOPMENT

DRAINAGE & UTILITY PLAN

AIP No.
NOT APPLICABLE

State No.
CS-0010-20

SHEET INDEX
C4.1

SHEET 11 OF 55

FEBRUARY 2014

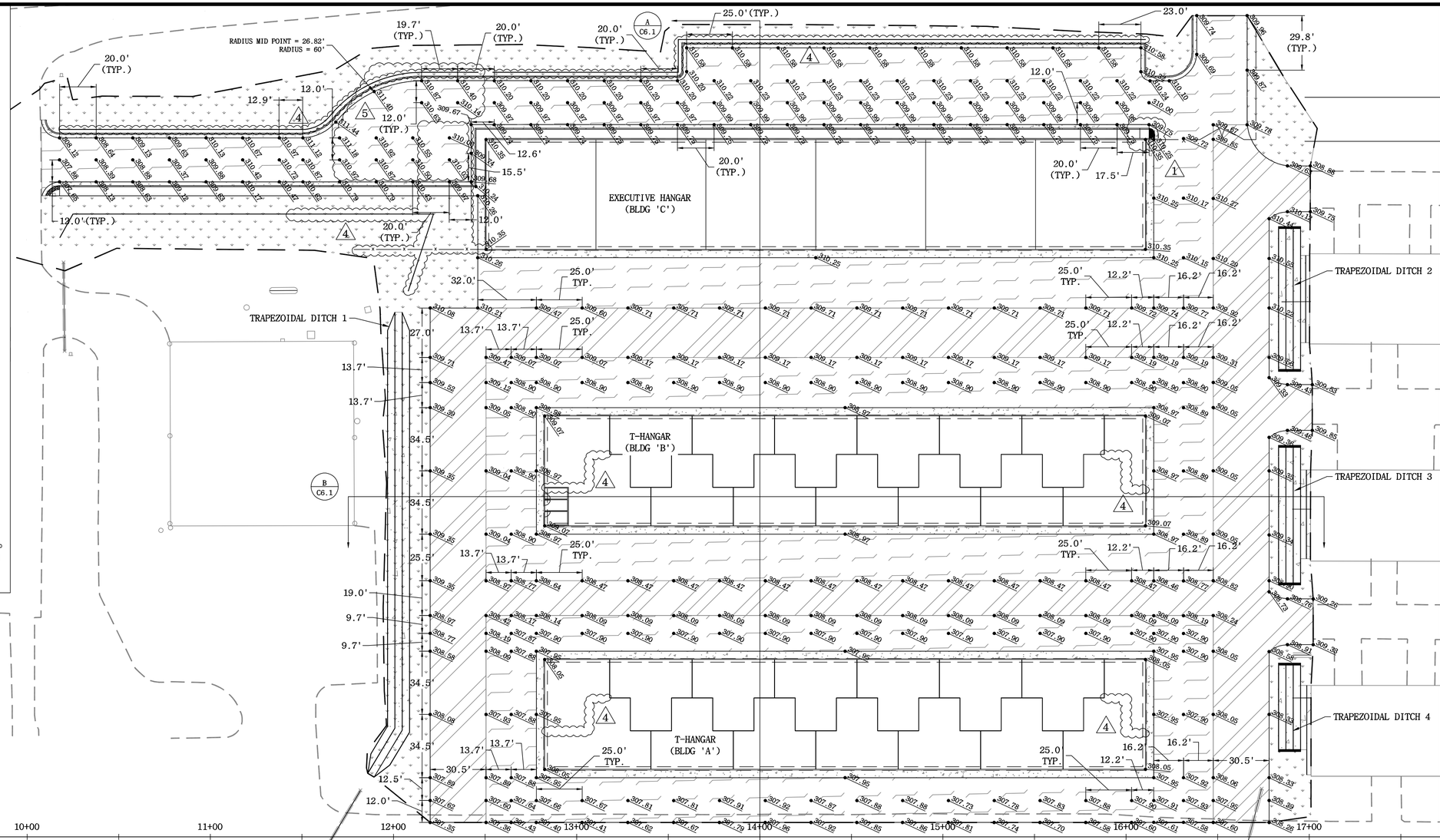
LEGEND	
SYMBOL	DESCRIPTION
308.50	PAVEMENT SPOT ELEVATIONS
— —	CONTROL JOINT

NOTES:
1. SPOT SHOT ELEVATION LOCATED AT GEOMETRIC POINT LOCATIONS. DIMENSIONS SHOW FOR ALL OTHER PAVEMENT SPOT SHOTS.
2. SEE SHEET C9.5 FOR PAVEMENT SECTIONS
3. SEE SHEET A1.2 FOR T-HANGAR FOUNDATION DETAILS & CONTROL JOINT DETAILS
4. SEE SHEET A1.4 FOR EXECUTIVE HANGAR FOUNDATION DETAILS & CONTROL JOINT DETAILS

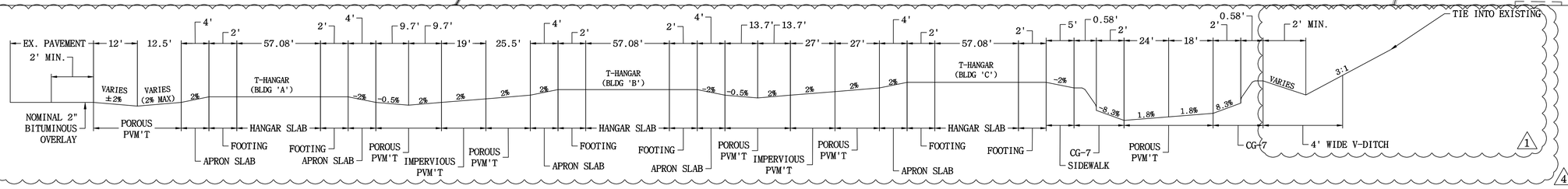
GRAPHIC SCALE

30 0 15 30 60 120

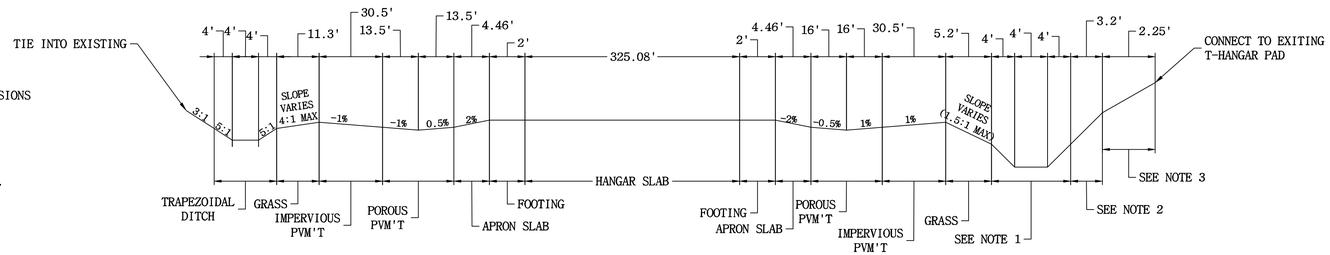
(IN FEET)
1 inch = 30 ft.



A/C6.1 TYPICAL SECTION (NOT TO SCALE)



B/C6.1 TYPICAL SECTION (NOT TO SCALE)



NOTES:
1. TRAPEZOIDAL DITCH, SEE SHEET C9.1 FOR DITCH DIMENSIONS
2. CONCRETE PAVEMENT CONNECTION TO EXISTING T-HANGAR BUILDING.
   - 2.1. 1.5:1 SLOPE FOR DITCH 2
   - 2.2. 1.5:1 SLOPE FOR DITCH 3
   - 2.3. 2:1 SLOPE FOR DITCH 4
3. CONCRETE PAVEMENT CONNECTION TO EXISTING T-HANGAR. SLOPE VARIES. SLOPE SHALL NOT EXCEED 2:1.

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DESIGNED BY:	DRAWN BY:	CHECKED BY:	APPROVED BY:
FM	FM	DJ	HDC
SCALE: AS SHOWN		C&P JOB #: 0007-20	PROJECTE PHASE: FINAL

NO.	DATE	REVISIONS	BY	APPR.
1	3/26/2014	ADDENDUM #2	FM	KC
-	——/——/——	NO REVISIONS DUE TO ADDENDUM #2	FM	KC
-	——/——/——	NO REVISIONS DUE TO ADDENDUM #3	FM	KC
4	8/20/2015	CONTRACT MODIFICATION #1	FM	KC
5	9/28/2015	SANITARY MANHOLE RELOCATION	FM	KC

COUNTY OF CULPEPER, VIRGINIA
CULPEPER REGIONAL AIRPORT

T-HANGAR AND EXECUTIVE HANGAR DEVELOPMENT

PAVING PLAN

AIP No.
NOT APPLICABLE

State No.
CS-0010-20

SHEET INDEX
C6.1

SHEET 17 OF 55

FEBRUARY 2014

LEGEND	
SYMBOL	DESCRIPTION
	NEW BITUMINOUS POROUS PAVEMENT
	NEW BITUMINOUS IMPERVIOUS PAVEMENT
	NEW BUILDING APRON, SIDEWALK, REVERSE CURB & GUTTER, BUILDING FLOOR SLAB
	NEW STABILIZED AREA
IP	INLET PROTECTION
X X	SILT FENCE
CD	ROCK CHECK DAM
	NEW VDOT CONCRETE END WALL (EW-1)
	TYPICAL UNDER DRAIN PIPE (HDPE)
	TYPICAL CLASS IV RCP
	NEW 12' WIDE CONCRETE TRAPEZOIDAL DITCH

NOTES:

1. IF THE CONTRACTOR LEAVES THE SITE UN-STABLIZED FOR A PERIOD LONGER THAN 2 WEEKS, HE/SHE SHALL INSTALL TEMPORARY WIRE SILT FENCE TO PROTECT THE EXISTING CULVERT. APPROXIMATELY 50' IN LENGTH, LOCATED ON BOTH SIDES OF NATURAL CHANNEL. SILT FENCE SHALL NOT OBSTRUCT THE FLOW OF EXISTING PIPES. SILT FENCE SHALL BE INSTALLED AND REMOVED AT THE DIRECTION OF THE RESIDENT ENGINEER.

2. IF THE CONTRACTOR LEAVES THE SITE UN-STABLIZED FOR A PERIOD LONGER THAN 2 WEEKS, HE/SHE SHALL INSTALL TEMPORARY WIRE SILT FENCE TO PROTECT THE EXISTING CULVERT. APPROXIMATELY 200' IN LENGTH, LOCATED ON BOTH SIDES OF NATURAL CHANNEL. SILT FENCE SHALL NOT OBSTRUCT THE FLOW OF EXISTING PIPES. SILT FENCE SHALL BE INSTALLED AND REMOVED AT THE DIRECTION OF THE RESIDENT ENGINEER.

3. WIRE SILT FENCE AROUND CONCRETE DITCHES TO BE PLACED OUTSIDE OF 18" SOD PERIMETER.

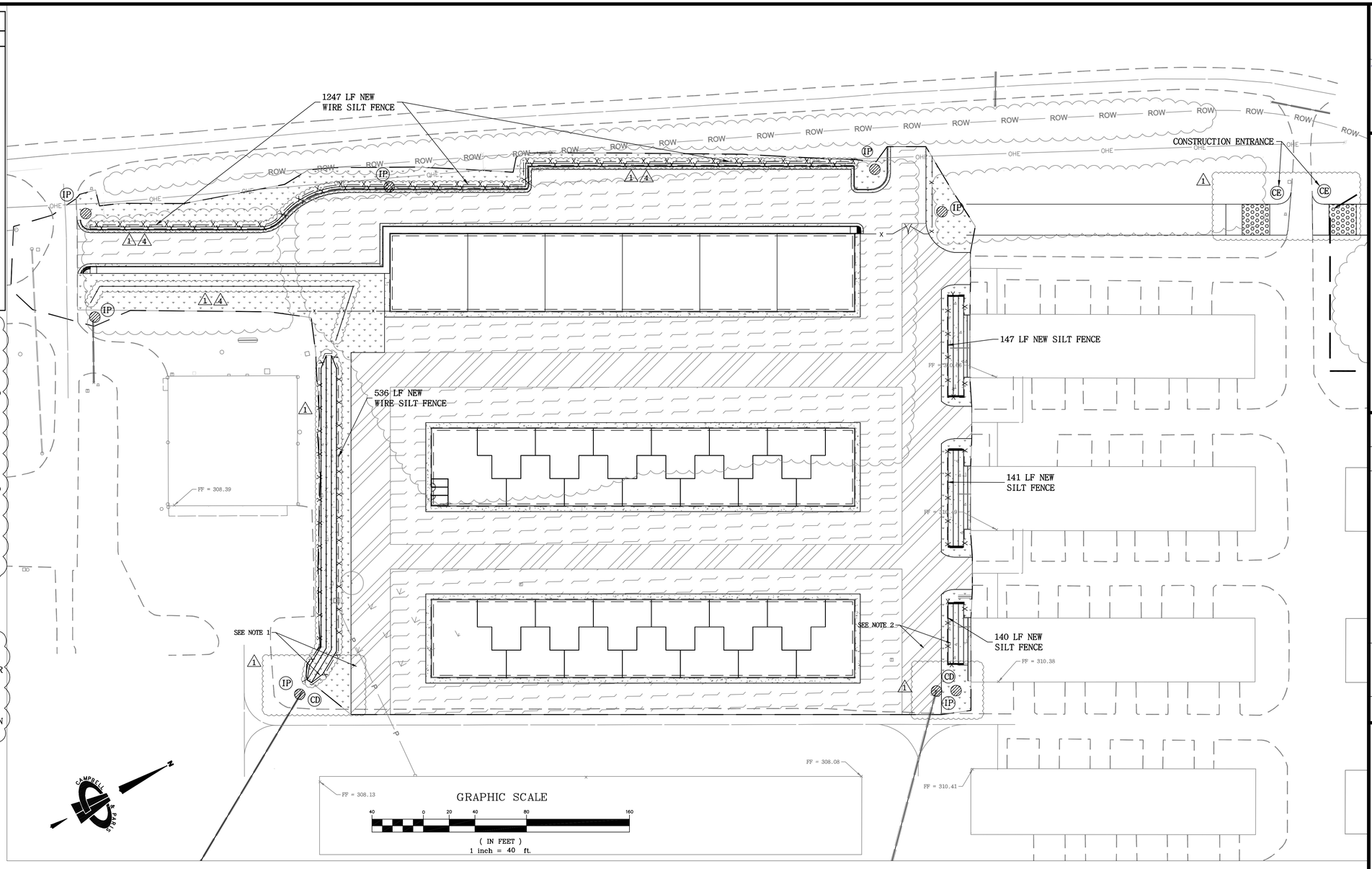
4. CHECK DAM INSTALLATION AND REMOVAL SHALL BE AT THE DIRECTION OF THE RESIDENT ENGINEER

1

A VARIANCE IS BEING REQUESTED TO INSTALL A ROCK CHECK DAM IN FRONT OF THE 2 PROPOSED CULVERT INLET PROTECTION MEASURES AT THE TWO EXISTING CULVERTS IN LIEU OF INSTALLING A CULVERT INLET SEDIMENT TRAP PER THE VIRGINIA EROSION AND SEDIMENT CONTROL HANDBOOK CHAPTER 3.08.

THE CONTRACT DOCUMENT SPECIFICATIONS SHALL BE KEPT ONSITE WITH THE STORMWATER POLLUTION PREVENTION PLAN (SWPPP).

2



EROSION AND SEDIMENT CONTROL NARRATIVE:

PROJECT DESCRIPTION

THIS PROJECT CONSTRUCTS NEW HANGAR FACILITIES AT THE CULPEPER REGIONAL AIRPORT. THE CONSTRUCTION WILL INCLUDE THE PLACEMENT OF CEMENT TREATED BASE COURSE, BITUMINOUS SURFACE COURSE, AS WELL AS A POROUS ASPHALT SECTION FOR STORM WATER DETENTION AND QUALITY PURPOSES. DRAINAGE ITEMS INCLUDE CONCRETE DRAINAGE DITCH, REINFORCED CONCRETE PIPE AND PERFORATED HDPE UNDER DRAIN.

EXISTING SITE CONDITIONS

THE PROPOSED DRAINS FROM WEST TO EAST AND IS PRIMARILY TREE AND VEGETATION COVERED. THE EXISTING SOIL CONDITIONS POORLY DRAIN AND HAVE A NATURAL HIGH RUNOFF COEFFICIENT. PERCHED WATER TABLES ARE COMMON AND A SMALL POND EXISTS AT THE SOUTHEAST CORNER OF THE SITE.

ADJACENT PROPERTY

THE NEW CONSTRUCTION SITE IS SURROUNDED ON ALL SIDES BY AIRPORT PROPERTY AND BEVERLY FORD ROAD.

OFF-SITE AREAS

THERE ARE NO OFF-SITE AREAS SINCE THE STOCKPILE AREA IS LOCATED ON AIRPORT PROPERTY. E&S MEASURES WILL BE INSTALLED AT THE CONSTRUCTION SITE, CONTRACTOR STAGING AREA AND EXCESS EMBANKMENT STOCKPILE AREAS.

SOILS

PLEASE SEE THE APPENDICES OF THE SPECIFICATIONS ENTITLED "BORING LOGS AND SUBSURFACE INFORMATION" FOR A DETAILED DESCRIPTION OF THE SOILS LOCATED IN THE AREA.

CRITICAL EROSION AREAS

THE PROJECT SITE CONSISTS ALMOST ENTIRELY OF CUT EXCAVATION, AS SUCH EROSION RUNOFF FROM THE SITE IS UNLIKELY. THE TWO EXISTING INLETS WILL REQUIRE INITIAL PROTECTION AND AFTER CONSTRUCTION, THE SUBSEQUENT CONCRETE DITCHES WILL BE PROTECTED WITH SILT FENCE UNTIL STABILIZATION IS FINAL.

STRUCTURAL PRACTICES

1. SILT FENCE AND INLET PROTECTION: A SYSTEM OF SILT FENCE AND INLET PROTECTION WILL BE INSTALLED IN ORDER TO PROTECT THE EXISTING INLETS WHICH DRAIN THE SITE. SILT FENCE, DIVERSION DIKE, AND SEDIMENT TRAPS WILL BE INSTALLED AS NEEDED AT THE STOCKPILE AREAS.
2. TEMPORARY CONSTRUCTION ENTRANCE: TWO TEMPORARY CONSTRUCTION ENTRANCES WILL BE INSTALLED FOR THIS PROJECT.

VEGETATIVE PRACTICES

1. TEMPORARY SEEDING: ALL DENUDED AREAS THAT WILL BE LEFT DORMANT FOR EXTENDED PERIODS OF TIME SHALL BE SEEDED WITH FAST GERMINATING TEMPORARY VEGETATION IMMEDIATELY FOLLOWING GRADING. PLEASE REFER TO THE SPECIFICATIONS FOR A MORE PROJECT-SPECIFIC SET OF RULES AND REQUIREMENTS. SODDING WILL ALSO BE PLACED OUTSIDE OF NEW PAVEMENT SECTION AREAS.

MANAGEMENT STRATEGIES

1. CONSTRUCTION WILL BE SEQUENCED SO THAT GRADING OPERATIONS CAN BEGIN AND END AS QUICKLY AS POSSIBLE.
2. SEDIMENT TRAPPING MEASURES WILL BE INSTALLED AS A FIRST STEP IN GRADING AND WILL BE SEEDED AND MULCHED IMMEDIATELY FOLLOWING INSTALLATION.
3. TEMPORARY SEEDING OR OTHER STABILIZATION WILL FOLLOW IMMEDIATELY AFTER GRADING.
4. AREAS WHICH ARE NOT TO BE DISTURBED WILL BE CLEARLY MARKED BY FLAGS, SIGNS, ET.
5. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE INSTALLATION AND MAINTENANCE OF ALL EROSION AND SEDIMENT CONTROL PRACTICES.
6. AFTER ACHIEVING ADEQUATE STABILIZATION, THE TEMPORARY E&S CONTROLS WILL BE CLEANED UP AND REMOVED, AND THE SEDIMENT BASINS WILL BE REMOVED UPON APPROVAL BY THE ENGINEER.

PERMANENT STABILIZATION

ALL AREAS DISTURBED BY CONSTRUCTION SHALL BE STABILIZED WITH PERMANENT SEEDING IMMEDIATELY FOLLOWING FINISHING GRADING OPERATIONS. PERMANENT SEEDING OPERATIONS SHALL BE CONDUCTED IN ACCORDANCE WITH THE APPROPRIATE SPECIFICATION IN THE PROJECT SPECIFICATIONS.

MAINTENANCE

ALL EROSION AND SEDIMENT CONTROL MEASURES WILL BE CHECKED DAILY AND AFTER EACH SIGNIFICANT RAINFALL BY THE CONTRACTOR. THE FOLLOWING ITEMS WILL BE CHECKED IN PARTICULAR:

1. THE SILT FENCE WILL BE CHECKED REGULARLY FOR UNDERMINING OR DETERIORATION OF THE FABRIC. SEDIMENT SHALL BE REMOVED WHEN THE LEVEL OF SEDIMENT DEPOSITION REACHES HALFWAY TO THE TOP OF THE BARRIER.
2. THE SEEDED AREAS WILL BE CHECKED REGULARLY TO ENSURE THAT A GOOD STAND OF GROWTH IS MAINTAINED. AREAS ARE TO BE FERTILIZED AND RE-SEEDED AS NEEDED.
3. THE INSTALLED INLET PROTECTION FOR THE DRAINAGE INLETS WILL BE CHECKED REGULARLY FOR SEDIMENT BUILDUP WHICH WILL PREVENT DRAINAGE. IF THE GRAVEL IS CLOGGED BY SEDIMENT, IT SHALL BE REMOVED AND CLEANED OR REPLACED.
4. THE SEDIMENT TRAPS WILL BE CHECKED REGULARLY FOR SEDIMENT CLEANOUT.
5. THE INTEGRITY AND QUALITY OF THE DIVERSION DIKES AND SILT FENCE WILL BE CHECKED REGULARLY TO ENSURE PROPER OPERATION.

1

RESPONSIBLE LAND DISTURBER (RLD)

AN INDIVIDUAL HOLDING A CERTIFICATE OF COMPETENCE ISSUED BY THE APPROPRIATE STATE AGENCY WHO WILL BE IN CHARGE OF AND RESPONSIBLE FOR CARRYING OUT THE LAND-DISTURBING ACTIVITY IN ACCORDANCE WITH THE APPROVED PLAN. THE RLD SHALL BE THE CONTRACTOR. THE RLD MUST BE DESIGNATED AS A PREREQUISITE FOR OBTAINING COUNTY PERMITS AND PRIOR TO ANY LAND DISTURBING ACTIVITIES.

COMMONWEALTH OF VIRGINIA
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DESIGNED BY: FM | DRAWN BY: FM | CHECKED BY: DJ | APPROVED BY: HDC
SCALE: AS SHOWN | C&P JOB #: 0007-20 | PROJECTE PHASE: FINAL

NO.	DATE	REVISIONS	BY	APPR.
1	3/19/2014	ADDENDUM #1	FM	KC
2	5/12/2014	IN COMPLIANCE WITH 9VAC25-840-50	FM	KC
-	_____	NO REVISIONS DUE TO ADDENDUM #3	FM	KC
4	8/20/2015	CONTRACT MODIFICATION #1	FM	KC

COUNTY OF CULPEPER, VIRGINIA
CULPEPPER REGIONAL AIRPORT

T-HANGAR AND EXECUTIVE HANGAR DEVELOPMENT

EROSION & SEDIMENT CONTROL PLAN

AIP No.
NOT APPLICABLE

State No.
CS-0010-20

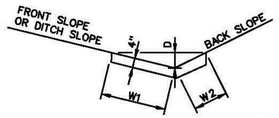
SHEET INDEX
C8.1

SHEET 19 OF 55

FEBRUARY 2014

PG-2A

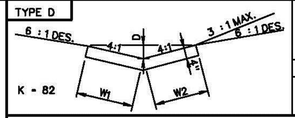
OUTSIDE ROAD DITCHES



TYPE	D	FRONT SLOPE	BACK SLOPE	W1	W2	K	SQ. YDS. SURFACE AREA/LIN. FT.
A1	6"	6:1	4:1	3'-0"	2'-1"	48	0.565
A1	8"	6:1	4:1	4'-1"	2'-9"	104	0.759
A2	6"	6:1	3:1	3'-0"	1'-7"	42	0.509
A2	8"	6:1	3:1	4'-1"	2'-1"	92	0.685
A3	6"	6:1	2:1	3'-0"	1'-2"	38	0.463
A3	8"	6:1	2:1	4'-1"	1'-8"	82	0.620
B1	6"	4:1	4:1	2'-1"	2'-1"	38	0.463
B1	8"	4:1	4:1	2'-9"	2'-9"	82	0.611
B2	8"	4:1	3:1	2'-9"	2'-1"	72	0.537
B2	10"	4:1	3:1	3'-5"	2'-8"	130	0.676
B3	8"	4:1	2:1	2'-9"	1'-6"	60	0.472
B3	10"	4:1	2:1	3'-5"	1'-10"	111	0.583
B4	8"	4:1	1½:1	2'-9"	1'-2"	55	0.435
B4	10"	4:1	1½:1	3'-5"	1'-6"	101	0.546
C1	8"	3:1	2:1	2'-1"	1'-6"	50	0.398
C1	10"	3:1	2:1	2'-8"	1'-10"	92	0.500
C2	10"	3:1	1½:1	2'-8"	1'-6"	80	0.463
C3	10"	3:1	1:1	2'-8"	1'-2"	70	0.426

MEDIAN DITCH

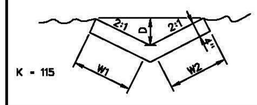
TYPE D



D - DEPTH	W_1	W_2	SQ. YDS. SURFACE AREA PER LIN. FT
8"	2'-9"	2'-9"	0.611

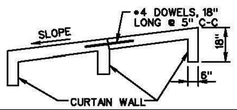
DITCH AT TOE OF FILL OR TOP OF CUT

TYPE E



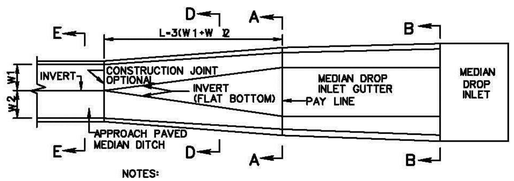
12"	2'-3"	2'-3"	0.500

CURTAIN WALL DETAIL



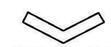
CURTAIN WALL TO BE LOCATED AT BEGINNING AN END OF ALL CHANNELS AND ON THE LOWER END OF EACH EXPANSION JOINT.

PLAN FOR TRANSITION OF PAVED MEDIAN DITCH TO MEDIAN DROP INLET GUTTER



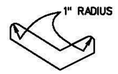
NOTES:
FOR SECTION A-A AND B-B SEE STANDARDS DI-7, 7A AND 7B. TRADITIONAL PORTION OF PAVED DITCH TO BE PAID FOR AT THE SAME PRICE BID PER SQ. YARD FOR APPROACH PAVED MEDIAN DITCH. STANDARD PG-2A DITCHES TO BE CLASS A3 CONCRETE.

SECTION D-D



SECTION E-E

ALTERNATE METHOD OF FORMING DITCHES



NOTE:
ALL DITCHES MAY BE CONSTRUCTED WITH VERTICAL SIDES AT THE OPTION OF THE CONTRACTOR.

SPECIFICATION REFERENCE
502

STANDARD PAVED DITCHES

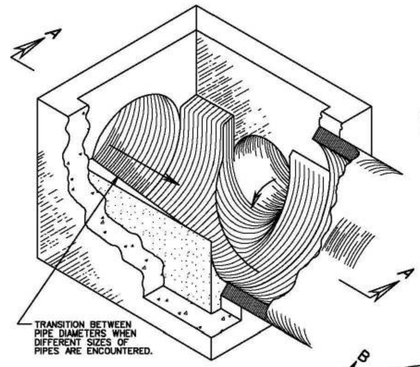
VIRGINIA DEPARTMENT OF TRANSPORTATION

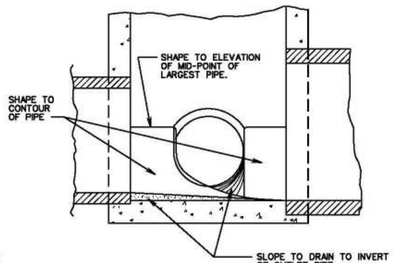
VDOT ROAD AND BRIDGE STANDARDS

REVISION DATE	SHEET 1 OF 1
	109.01

NOTE:
VDOT CONCRETE V DITCH TOTAL WIDTH SHALL BE 4' (2' OFF CENTERLINE ON EACH SIDE). WHERE V DITCH IS LOCATED 2' FROM BACK OF CURB SEE DETAIL THIS SHEET.

IS-1





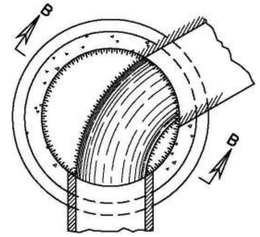
SECTION A-A

METHOD OF TREATMENT IN DROP INLETS

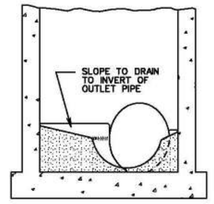
NOTES:
SHAPING OF MANHOLE AND INLET INVERTS IN ACCORDANCE WITH THIS DRAWING IS TO APPLY TO THOSE STRUCTURES SPECIFIED ON PLANS OR WHERE INVERT OF PIPE IS ABOVE INVERT OF STRUCTURE.

MANHOLE OR DROP INLET IS TO BE FORMED AND CONSTRUCTED IN ACCORDANCE WITH APPLICABLE STANDARD OR SPECIAL DRAWING. THE INVERT SHAPING AS DETAILED HEREON IS TO CONSIST OF A PORTLAND CEMENT CONCRETE MIX CONFORMING TO CLASS A3 OR CLASS C1, EXCEPT THAT 25% OF COARSE AGGREGATE MAY BE UP TO 4" IN DIAMETER AND CONSIST OF STONE, BROKEN BRICK, BROKEN CONCRETE OR BROKEN CONCRETE BLOCK. THE SURFACE SHALL BE LEFT SMOOTH BY MEANS OF HAND TROWELLING. NONE OF THE COARSE AGGREGATE SHALL REMAIN EXPOSED.

DETAILS OF INVERT SHAPING AS SHOWN HEREON ARE FOR EXAMPLE PURPOSES ONLY. EACH MANHOLE OR DROP INLET IS TO BE SHAPED INDIVIDUALLY TO BEST FIT THE PARTICULAR INLET AND OUTLET CONFIGURATION AND FLOW LINES.



PLAN

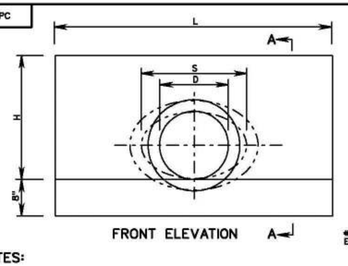


SECTION B-B

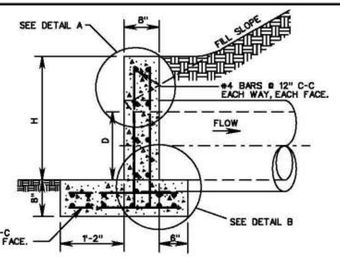
METHOD OF TREATMENT IN MANHOLES

VDOT ROAD AND BRIDGE STANDARDS		STANDARD METHOD OF SHAPING MANHOLE & INLET INVERTS	SPECIFICATION REFERENCE
SHEET 1 OF 1	REVISION DATE	VIRGINIA DEPARTMENT OF TRANSPORTATION	302
106.08			

EW-1, 1 APC

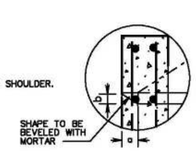


FRONT ELEVATION A

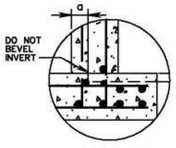


SECTION A-A

NOTES:
1. CONCRETE TO BE 4000 PSI MINIMUM COMPRESSIVE STRENGTH.
2. IF PIPE IS TO BE SKEWED THE OPENING WILL BE ADJUSTED TO ACCOMMODATE ANGLES UP TO 45°.
3. REINFORCING STEEL IN ACCORDANCE WITH ASTM A-615 (REINFORCING BARS).
4. PIPE OPENINGS IN PRECAST DRAINAGE UNITS SHALL NOT EXCEED 4 INCHES AT ANY GIVEN POINT BETWEEN THE PIPE AND THE PRECAST UNIT.
5. DIMENSIONS SHOWN ARE MINIMUM. ACTUAL MEASUREMENTS MAY VARY WITH MANUFACTURER'S TOLERANCE.
6. IN NO CASE SHALL TOP OF ENDWALL PROJECT ABOVE FILL SLOPE, DITCH SLOPE, OR SHOULDER.
7. HEADWALL TO BE BEVELED IN ALL AREAS EXCEPT WHERE A CONFLICT WITH INVERT OR WINGWALL OCCUR.
8. BEVEL EDGE IS REQUIRED ON THE HEADWALL AT THE INLET END OF THE CULVERT. HEADWALL AT OUTLET END MAY BE EITHER SQUARE EDGE OR BEVELED.
9. ¾" CHAMFER MAY BE PROVIDED ON ALL EDGES AT MANUFACTURER'S OPTION.



DETAIL A



DETAIL B

EW-1PC

ENDWALL FOR CIRCULAR PIPE

DIAMETER OF PIPE CULVERT

D	12"	15"	18"	21" OR 24"	27" OR 30"	33" OR 36"
H	2'-0"	2'-3"	2'-6"	3'-2"	3'-10"	4'-4"
L	4'-0"	5'-0"	6'-0"	8'-0"	10'-0"	12'-0"
a	0'-1¼"	0'-1¾"	0'-2"	0'-2½"	0'-3¼"	0'-3¾"
b	0'-1"	0'-1¼"	0'-1½"	0'-2"	0'-2½"	0'-3"

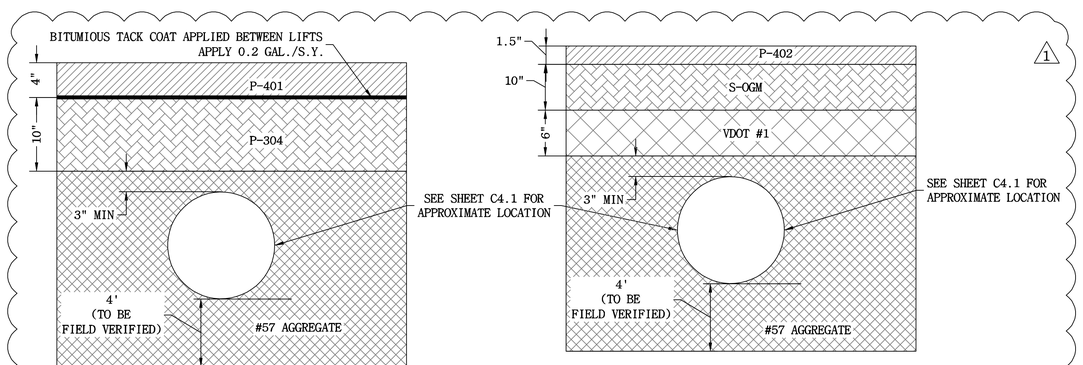
EW-1APC

ENDWALL FOR ELLIPTICAL PIPE

SIZE OF ELLIPTICAL PIPE CULVERT (SPAN x RISE)

S x D	23" x 14"	30" x 19"	34" x 22"	38" x 24"	42" x 27"	45" x 29"	49" x 32"	53" x 34"
H	1'-10"	2'-4"	2'-7"	2'-9"	3'-1"	3'-3"	3'-6"	3'-8"
L	5'-5"	7'-2"	8'-6"	9'-2"	10'-2"	10'-11"	12'-1"	12'-11"
a	0'-2½"	0'-3¼"	0'-3½"	0'-4"	0'-4½"	0'-4¾"	0'-5"	0'-5½"
b	0'-2"	0'-2½"	0'-2¾"	0'-3"	0'-3½"	0'-3¾"	0'-4"	0'-4½"

VDOT ROAD AND BRIDGE STANDARDS		PRECAST ENDWALL FOR PIPE CULVERTS 12" - 36" CIRCULAR AND 23" x 14" - 53" x 34" ELLIPTICAL PIPES	SPECIFICATION REFERENCE
SHEET 1 OF 1	REVISION DATE	VIRGINIA DEPARTMENT OF TRANSPORTATION	105 302
101.02			



POND BACKFILL NOTES:
1. POND SHALL BE DEWATERED
2. AREA SHALL BE EXCAVATED AS DIRECTED BY RESIDENT ENGINEER AND APPROXIMATELY 4' OF #57 STONE SHALL BE BACKFILLED TO RAISE ELEVATION TO 305.4.
3. AFFECTED AREA: APPROXIMATELY 5,250 SF (AREA UNDER IMPERVIOUS PAVEMENT).
4. CONTRACTOR SHALL INSTALL APPROXIMATELY 24' OF 6" N-12 DUAL WALL NON-PEFERATED HDPE PIPE.
5. PIPE SHALL TIE INTO PROPOSED UNDERDRAIN SYSTEM AT PERPENDICULAR LOCATION.
6. ALL COST ASSOCIATED WITH POND BACKFILL MODIFICATION SHALL BE INCIDENTAL TO ITEM D-701 POND DEWATERING BACKFILL OPTION.
7. BACKFILL OPTION SHALL BE REQUIRED ONLY AT THE DIRECTION OF THE RESIDENT ENGINEER.

POND BACKFILL MODIFICATION DETAIL
(NOT TO SCALE)

COMMONWEALTH OF VIRGINIA
PETER KERR BIGLER CHASE
Lic. No. 047615
2/26/2014
PROFESSIONAL ENGINEER

CAMPBELL & PARIS ENGINEERS
SUITE 2 4215 LAFAYETTE CENTER DR.
CHANTILLY, VA. 20151 (703) 802-0093

DESIGNED BY:	DRAWN BY:	CHECKED BY:	APPROVED BY:
FM	FM	DJ	HDC

C&P JOB #: 0007-20
PROJECTE PHASE: FINAL
SCALE: AS SHOWN

NO.	DATE	REVISIONS	BY	APPR.
1	3/19/2014	ADDENDUM#1	FM	KC

COUNTY OF CULPEPER, VIRGINIA
CULPEPER REGIONAL AIRPORT
T-HANGAR AND EXECUTIVE HANGAR
DEVELOPMENT
DRAINAGE DETAILS

AIP No.
NOT APPLICABLE

State No.
CS-0010-20

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C9.3

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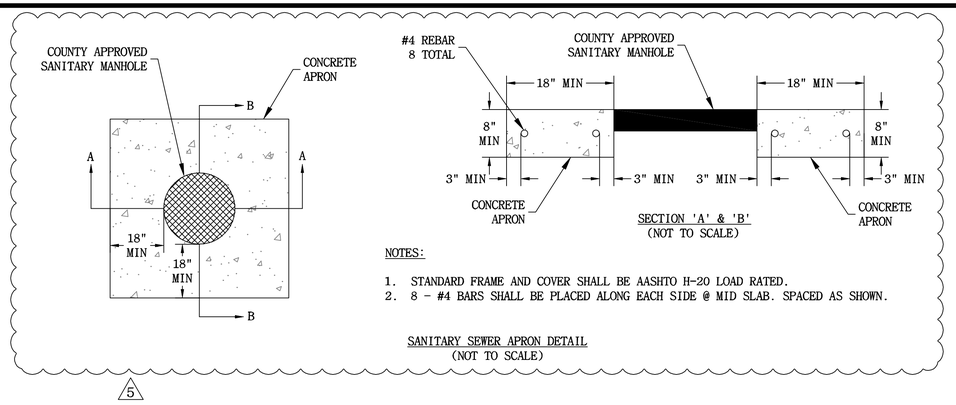
FEBRUARY 2014



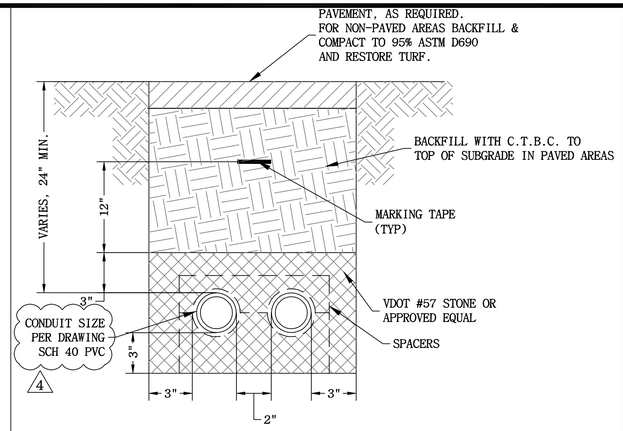
SECTION 'A' & 'B'
(NOT TO SCALE)

NOTES:

1. STANDARD FRAME AND COVER SHALL BE AASHTO H-20 LOAD RATED.
2. 8 - #4 BARS SHALL BE PLACED ALONG EACH SIDE @ MID SLAB. SPACED AS SHOWN.

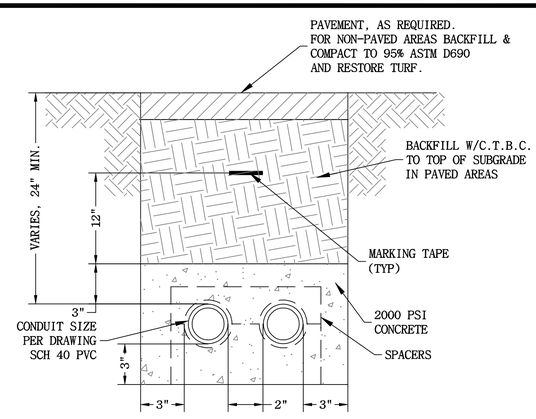
SANITARY SEWER APRON DETAIL
(NOT TO SCALE)

5

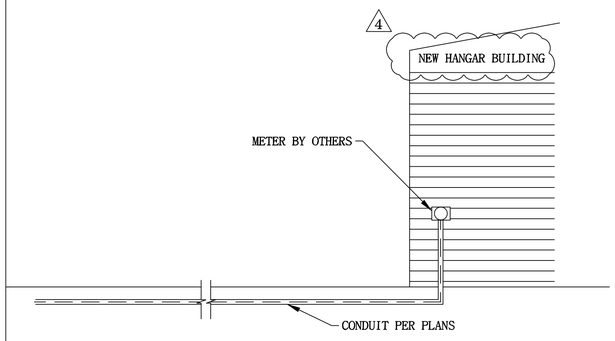


4

2-WAY (TYP) DUCT BANK
(NOT TO SCALE)



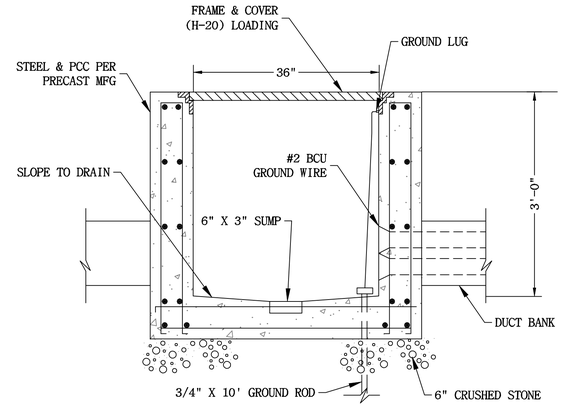
2-WAY (TYP) CONCRETE-ENCASED DUCT BANK UNDER PAVEMENT
(NOT TO SCALE)



NOTES:

1. WEATHERSEAL RISER PIPE OPENING AROUND CABLES WITH DUCT SEALING COMPOUND.
2. THE CONTRACTOR WILL COORDINATE ELECTRICAL CONDUIT INSTALLATION WITH LOCAL ELECTRIC COMPANY AND THE ENGINEER.

CONDUIT DETAIL
(NOT TO SCALE)

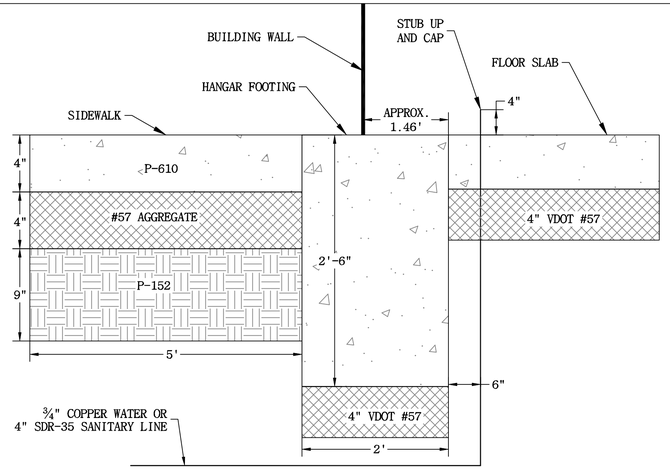


HANDHOLE NOTES:

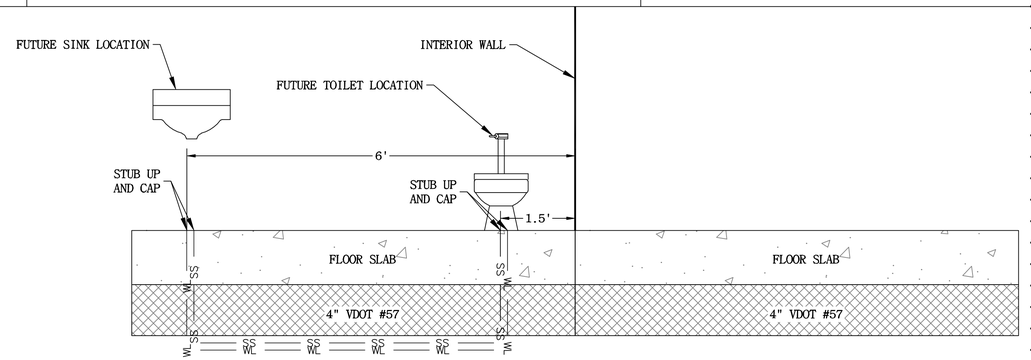
1. LOAD CRITERIA - AASHTO H-20.
2. COVER : HINGED (ROUND ONLY), BOLTS, GASKET & DUCTILE IRON.
3. FRAME & COVER: NEENAH R-6662 SERIES WITH T-TYPE HINGES OR EQUAL. 3' SQUARE OPENING.
4. FRAME AND COVER TO BE CAST IN TOP. INSTALL SO TOP OF HANDHOLE IS EVEN WITH PAVEMENT, OR 1" ABOVE GRADE IN NON-PAVED AREAS.

36" RECTANGULAR ELEC. HANDHOLE - ELEV. SECTION
(NOT TO SCALE)

4



EXECUTIVE HANGAR UTILITY CONNECTION DETAIL
(NOT TO SCALE)



EXECUTIVE HANGAR UTILITY NOTES:

1. 4" SANITARY SEWER LINE SHALL BE OFFSET 1.5' FROM INTERIOR WALL. SANITARY LINE SHALL EXTEND 6" PAST THE INTERIOR OF THE 2' FOOTING AND SHALL BE CAPPED 4" ABOVE THE FLOOR SLAB.
2. 3/4" WATER LINE SHALL BE OFFSET 6' FROM INTERIOR WALL. WATER LINE SHALL EXTEND 6" PAST THE INTERIOR OF THE 2' FOOTING AND SHALL BE CAPPED 4" ABOVE THE FLOOR SLAB.
3. WATER AND SANITARY PIPE LOCATIONS SHOWN ON SHEET C4.1 & A1.3 ARE INTENDED FOR FUTURE EXECUTIVE BATHROOMS.
4. CONTRACTOR SHALL COORDINATE PIPE LOCATIONS WITH COUNTY BUILDING OFFICIAL.
5. ALL FITTINGS NECESSARY FOR THE CONNECTIONS AND STUB OUTS OF THE ¾" COPPER AND 4" SDR-35 UNDERNEATH THE FLOOR SLAB SHALL BE INCIDENTAL TO THE THE ¾" COPPER AND 4" SDR-35 PIPE, RESPECTIVELY.
6. ALL RESTROOM CONSTRUCTION MUST COMPLY WITH THE CURRENT 2012 VIRGINIA CONSTRUCTION CODE.

COMMONWEALTH OF VIRGINIA
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2/26/2014
PROFESSIONAL ENGINEER

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CHANTILLY, VA. 20151 (703) 802-0093

DESIGNED BY:	DRAWN BY:	CHECKED BY:	APPROVED BY:
FM	FM	DJ	HDC
SCALE: AS SHOWN		C&P JOB #: 0007-20	PROJECTE PHASE: FINAL

NO.	DATE	REVISIONS	BY	APPR.
1	3/19/2014	ADDENDUM#1	FM	KC
-	———	NO REVISIONS DUE TO ADDENDUM #2	FM	KC
-	———	NO REVISIONS DUE TO ADDENDUM #3	FM	KC
4	8/20/2015	CONTRACT MODIFICATION #1	FM	KC
5	9/28/2015	SANITARY MANHOLE RELOCATION	FM	KC

COUNTY OF CULPEPER, VIRGINIA
CULPEPPER REGIONAL AIRPORT

T-HANGAR AND EXECUTIVE HANGAR DEVELOPMENT

UTILITY DETAILS

AIP No.
NOT APPLICABLE

State No.
CS-0010-20

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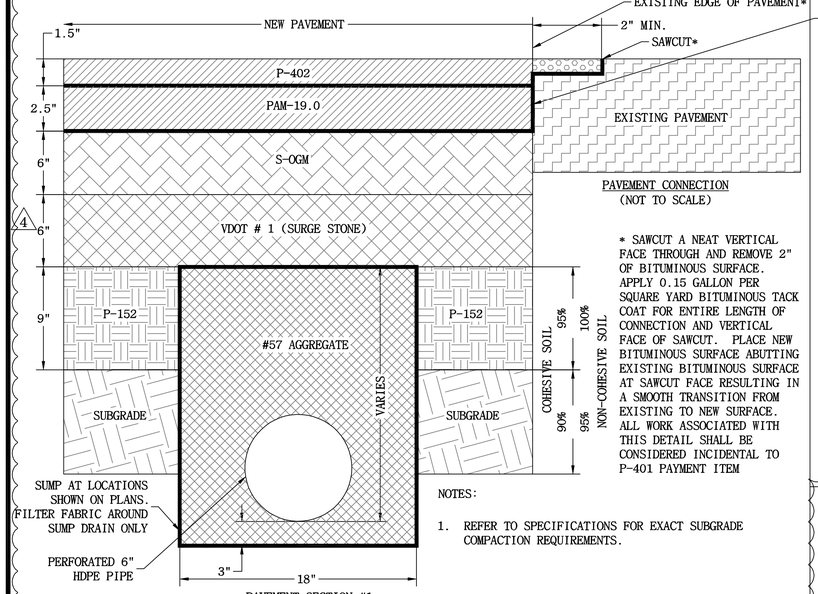
FEBRUARY 2014



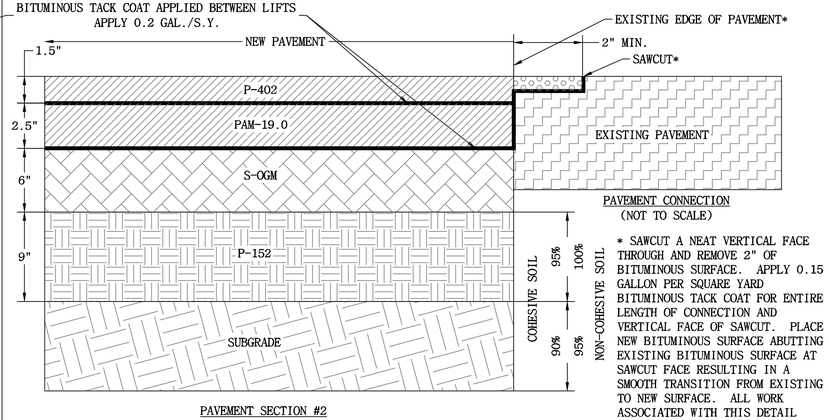
PAVEMENT CONNECTION
(NOT TO SCALE)

* SAWCUT A NEAT VERTICAL FACE THROUGH AND REMOVE 2" OF BITUMINOUS SURFACE. APPLY 0.15 GALLON PER SQUARE YARD BITUMINOUS TACK COAT FOR ENTIRE LENGTH OF CONNECTION AND VERTICAL FACE OF SAWCUT. PLACE NEW BITUMINOUS SURFACE ABUTTING EXISTING BITUMINOUS SURFACE AT SAWCUT FACE RESULTING IN A SMOOTH TRANSITION FROM EXISTING TO NEW SURFACE. ALL WORK ASSOCIATED WITH THIS DETAIL SHALL BE CONSIDERED INCIDENTAL TO P-401 PAYMENT ITEM

NOTES:

1. REFER TO SPECIFICATIONS FOR EXACT SUBGRADE COMPACTION REQUIREMENTS.

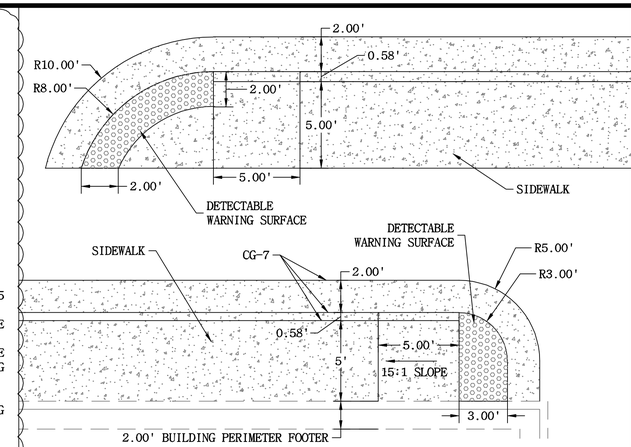
PAVEMENT SECTION #1
(NOT TO SCALE)



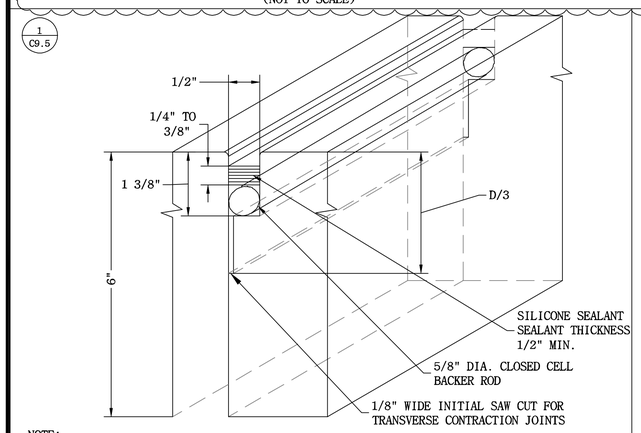
PAVEMENT CONNECTION
(NOT TO SCALE)

* SAWCUT A NEAT VERTICAL FACE THROUGH AND REMOVE 2" OF BITUMINOUS SURFACE. APPLY 0.15 GALLON PER SQUARE YARD BITUMINOUS TACK COAT FOR ENTIRE LENGTH OF CONNECTION AND VERTICAL FACE OF SAWCUT. PLACE NEW BITUMINOUS SURFACE ABUTTING EXISTING BITUMINOUS SURFACE AT SAWCUT FACE RESULTING IN A SMOOTH TRANSITION FROM EXISTING TO NEW SURFACE. ALL WORK ASSOCIATED WITH THIS DETAIL SHALL BE CONSIDERED INCIDENTAL TO P-401 PAYMENT ITEM

PAVEMENT SECTION #2
(NOT TO SCALE)

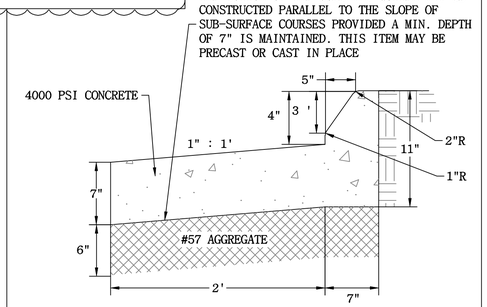


ADA CURB RAMP DETAIL TYPE B PARALLEL
(NOT TO SCALE)

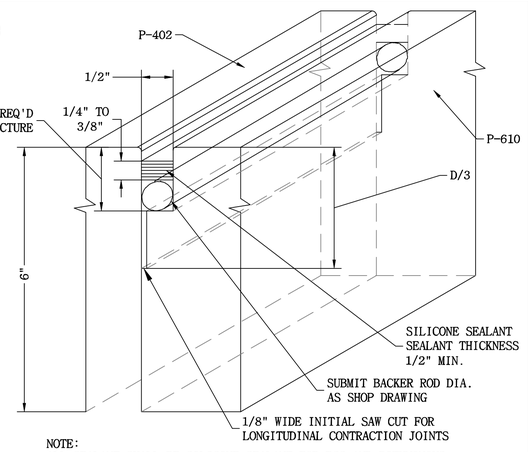


NOTE:
ALL SEALANT SHALL BE SILICONE SEALANT FOR PCC AND BITUMINOUS CONCRETE JOINTS. A SILICONE SEALANT COMPATIBLE WITH BOTH PAVEMENT TYPES IS REQUIRED.

SAW CUT AND JOINT SEALANT
FOR CONCRETE APRON SLAB DETAIL
(NOT TO SCALE)

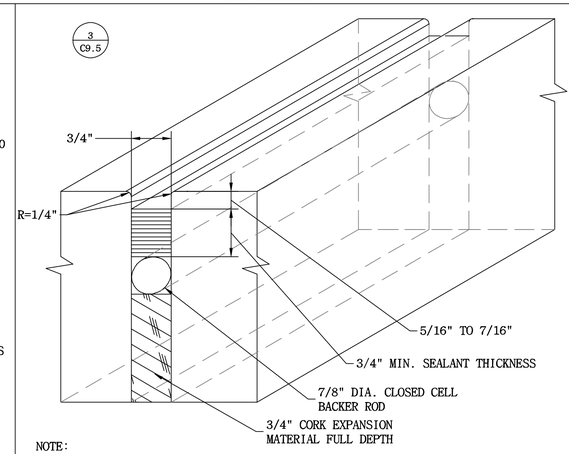


REVERSE 4" CURB AND GUTTER (CG-7)
(NOT TO SCALE)



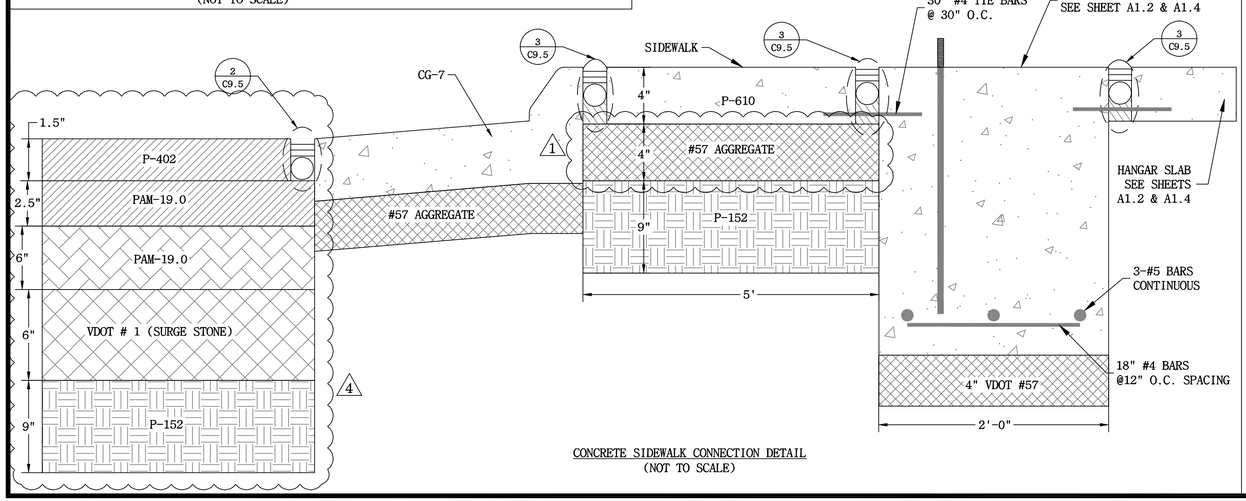
NOTE:
ALL SEALANT SHALL BE SILICONE SEALANT FOR PCC AND BITUMINOUS CONCRETE JOINTS. A SILICONE SEALANT COMPATIBLE WITH BOTH PAVEMENT TYPES IS REQUIRED.

SAW CUT AND JOINT SEALANT FOR PAVEMENT TRANSITION
BETWEEN PCC AND BITUMINOUS DETAIL
(NOT TO SCALE)

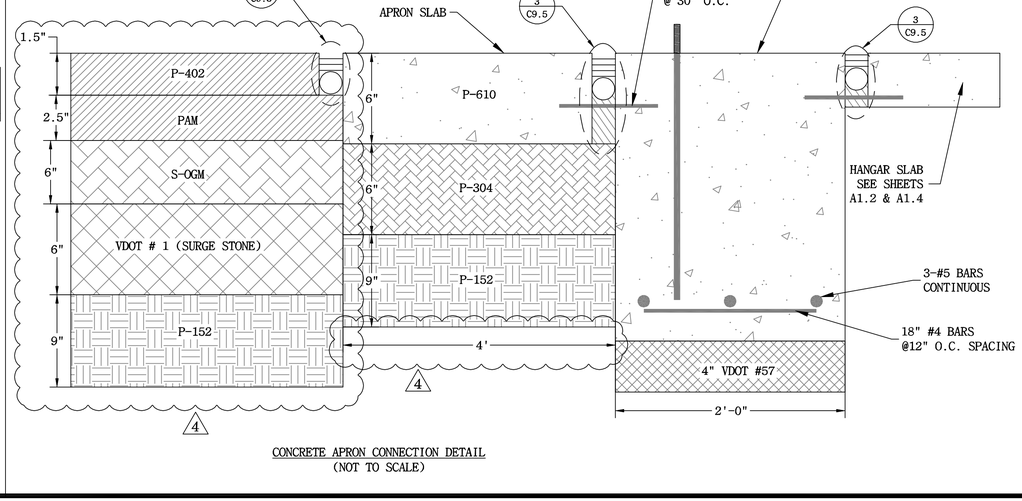


NOTE:
ALL SEALANT SHALL BE SILICONE SEALANT FOR PCC AND BITUMINOUS CONCRETE JOINTS. A SILICONE SEALANT COMPATIBLE WITH BOTH PAVEMENT TYPES IS REQUIRED.

SAW CUT AND JOINT SEALANT
FOR CONCRETE APRON SLAB,
EXPANSION & ISOLATION JOINTS DETAIL
(NOT TO SCALE)



CONCRETE SIDEWALK CONNECTION DETAIL
(NOT TO SCALE)



CONCRETE APRON CONNECTION DETAIL
(NOT TO SCALE)

COMMONWEALTH OF VIRGINIA
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DESIGNED BY:	DRAWN BY:	CHECKED BY:	APPROVED BY:
FM	FM	DJ	HDC
SCALE: AS SHOWN		C&P JOB #: 0007-20	PROJECTE PHASE: FINAL

NO.	DATE	REVISIONS	BY	APPR.
1	3/19/2014	ADDENDUM #1	FM	KC
-	———	NO REVISIONS DUE TO ADDENDUM #2	FM	KC
-	———	NO REVISIONS DUE TO ADDENDUM #3	FM	KC
4	8/20/2015	CONTRACT MODIFICATION #1	FM	KC

COUNTY OF CULPEPER, VIRGINIA
CULPEPPER REGIONAL AIRPORT

T-HANGAR AND EXECUTIVE HANGAR DEVELOPMENT

PAVEMENT DETAILS

AIP No.
NOT APPLICABLE

State No.
CS-0010-20

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FEBRUARY 2014

STORMWATER RUNOFF NARRATIVE

THE STORMWATER COLLECTION, TREATMENT, AND DETENTION SYSTEM FOR THE PROPOSED CULPEPER T-HANGAR AND EXECUTIVE HANGAR DEVELOPMENT HAS BEEN DESIGNED TO EFFECTIVELY TREAT STORMWATER BY MEETING THE REQUIREMENTS FOR THE CULPEPER COUNTY STORMWATER ORDINANCE AND THE REQUIREMENTS FOR A FULL LID DESIGN IN REGARDS TO WATER QUALITY, CHANNEL PROTECTION, AND FLOOD PROTECTION. IN ADDITION THE PROPOSED STORMWATER SYSTEM WILL MAINTAIN PEAK FLOWS FOR THE 1 YEAR, 2 YEAR, AND 10 YEAR STORM EVENTS BELOW PRE DEVELOPMENT LEVELS. 1

NORTHER DRAINAGE AREA

NAME	AREA (ACRES)	RETURN PERIOD (24 HR)	TOTAL RUNOFF (CFS)	RAINFALL DEPTH (IN.)
PRE-DEVELOPMENT 3	5.0	1 YR	9.80	3.00
POST DEVELOPMENT (SUB BASIN 1,2,3,4,7,8,9)	7.36	1 YR	0.73	3.00
PRE-DEVELOPMENT 3	5.0	2 YR	13.17	3.60
POST DEVELOPMENT (SUB BASIN 1,2,3,4,7,8,9)	7.36	2 YR	0.96	3.60
PRE-DEVELOPMENT 3	5.0	10 YR	24.28	5.50
POST DEVELOPMENT (SUB BASIN 1,2,3,4,7,8,9)	7.36	10 YR	1.70	5.50

SOUTHERN DRAINAGE AREA

NAME	AREA (ACRES)	RETURN PERIOD (24 HR)	TOTAL RUNOFF (CFS)	RAINFALL DEPTH (IN.)
PRE-DEVELOPMENT 2	3.33	1 YR	5.71	3.00
POST DEVELOPMENT (SUB BASIN 6)	0.63	1 YR	1.11	3.00
PRE-DEVELOPMENT 2	3.33	2 YR	7.80	3.60
POST DEVELOPMENT (SUB BASIN 6)	0.63	2 YR	1.46	3.60
PRE-DEVELOPMENT 2	3.33	10 YR	14.77	5.50
POST DEVELOPMENT (SUB BASIN 6)	0.63	10 YR	2.56	5.50

2

A "FULL LID DESIGN" IS ONE WHICH:

1) HONORS EXISTING DRAINAGE DIVIDES AND MAINTAINS TIMES OF CONCENTRATION TO EACH DRAINAGE OUTFALL TO AT LEAST THAT OF THE EXISTING SITE;

   a. *NOTE: WE'VE INCLUDED DATA SUPPORTING DRAMATIC INCREASES IN TIME OF CONCENTRATION FOR FLOWS THROUGH A POROUS PAVEMENT SECTION.*

2) EMPLOYS SITE DESIGN TECHNIQUES AND DISTRIBUTED INTEGRATED MANAGEMENT PRACTICES TO RETAIN RUNOFF SO THAT NO MORE STORM WATER LEAVES THE SITE IN THE DESIGN STORM THAN WOULD BE EXPECTED IF LAND COVER WERE WOODS IN GOOD CONDITION;

   a. *NOTE: PER OUR INITIAL MEETING WITH COUNTY STAFF, WE WILL DEMONSTRATE, USING A 45% PERMEABILITY FACTOR FOR THE PAVEMENT SECTION, ADEQUATE STORAGE FOR THE 10 YEAR STORM.*

3) EMPLOYS DISTRIBUTED INTEGRATED MANAGEMENT PRACTICES TO CONTROL RUNOFF PEAK FLOWS OF THE DESIGN STORM TO NO MORE THAN THOSE EXPECTED IF LAND COVER WERE WOODS IN GOOD CONDITION; AND,

   a. *WE'VE INCLUDED DATA FROM AUTOCAD'S STORM AND SANITARY ANALYSIS THAT DEMONSTRATES THE SITE DESIGN POST RUNOFF RATES ARE LOWER THAN THE EXISTING RUNOFF RATES FOR THE SITE.*

4) EMPLOYS DISTRIBUTED INTEGRATED MANAGEMENT PRACTICES TO RETAIN ONE-HALF INCH OF STORM WATER FROM ALL IMPERVIOUS SURFACES. LID DESIGNS WHICH MEET ALL THESE CRITERIA SATISFY ALL WATER QUALITY, STREAM CHANNEL EROSION, AND FLOODING REQUIREMENTS LISTED IN CULPEPER COUNTY CODE SECTIONS 11A-19 THROUGH 11A-24.

   a. *THE TREATMENT VOLUME FOR THE C&PE RESERVOIR COURSE IS 82,414 SF X 1.33 FT = 4,060 CY. IF WE ARE CONSERVATIVE AND ASSUME 45% POROSITY = 1,826 CY. THIS IS ADEQUATE TO RETAIN MORE THAN ONE-HALF INCH OF STORM WATER FROM ALL IMPERVIOUS SURFACES 40,126 SF X 0.042 FT = 62 CY.*

THE SITE IS LOCATED AT 12517 BEVERLY FORD ROAD, BRANDY STATION, VA 22714. IT IS LOCATED WITHIN PARCEL 34-2A AND 34-2B2 3

THE PROPOSED DEVELOPMENT SITE IS UNIQUELY SITUATED WITH EXISTING DEVELOPMENT ON ALL SIDES OF THE PROPOSED SITE LOCATION. AIRFIELD DEVELOPMENTS RESIDE TO THE NORTH, EAST, AND SOUTH OF THE SITE AND BEVERLY FORD ROAD IS WEST OF THE SITE. THE PROPOSED DEVELOPMENT WILL HAVE APPROXIMATELY 12.8 ACRES OF DISTURBED AREA.

THE EXISTING SITE CONSISTS PRIMARILY OF VEGETATED COVER WITH DECIDUOUS TREES AND NATURAL GRASS WITH TYPICAL SLOPES VARYING FROM 1% TO 15%. THERE IS AN EXISTING WET POND AT THE SOUTH END OF THE SITE WHICH OUTFALLS TO AN EXISTING 15" CONCRETE END SECTION AT ELEVATION 305.34'. THE NORTHEAST END OF THE SITE DRAINS TO AN EXISTING 18" CONCRETE END SECTION AT ELEVATION 304.34'.THE SOILS AT THE AIRPORT ARE TYPICALLY CLASSIFIED AS HIGHLY PLASTIC SILTY CLAYS WHICH FALL IN THE GROUP D CATEGORY FOR TR-55 HYDROLOGIC SOILS GROUP. GROUP D SOILS HAVE HIGH RUNOFF POTENTIAL. THEY HAVE VERY LOW INFILTRATION RATES WHEN THOROUGHLY WETTED AND CONSIST CHIEFLY OF CLAY SOILS WITH A HIGH SWELLING POTENTIAL, SOILS WITH A PERMANENT HIGH WATER TABLE, SOILS WITH A CLAYPAN OR CLAY LAYER AT OR NEAR THE SURFACE, AND SHALLOW SOILS OVER NEARLY IMPERVIOUS MATERIAL. THESE SOILS HAVE A VERY LOW RATE OF WATER TRANSMISSION (0-0.05 IN/HR.). 3

THE STORM WATER MANAGEMENT PLAN DEPICTS THE PRE-EXISTING DRAINAGE AREAS AND POST-DEVELOPMENT DRAINAGE AREAS. IN TERMS OF CALCULATING STORM WATER RUNOFF THE DRAINAGE AREAS ARE DESCRIBED AS THE "SOUTH" AND "EAST" DRAINAGE AREAS. THE POST DEVELOPMENT FLOW PATTERNS MAINTAIN SIMILAR SOUTH AND EAST DRAINAGE AREAS AND OUTFALL TO THE EXISTING SOUTH AND EAST END STRUCTURES

WATER QUALITY

WATER QUALITY HAS BEEN MET VIA THE USE OF POROUS PAVEMENT. THE SYSTEM IS DESIGNED TO RETAIN ONE-HALF INCH OF STORM WATER FROM ALL IMPERVIOUS SURFACES. THE SYSTEM HAS BEEN DESIGNED TO RETAIN 100% OF THE 10 YEAR DESIGN STORM TO ALLOW POST RUNOFF RATES TO STAY WELL BELOW EXISTING RUNOFF RATES. THE WATER QUALITY VOLUME FOR THE 10 YEAR STORM WILL BE RELEASED OVER GREATER THAN 24 HOURS.

CHANNEL PROTECTION

CHANNEL PROTECTION HAS BEEN ADDRESSED BY THE USE OF THE POROUS ASPHALT SECTION AS A WATER RETENTION POND AS WELL AS THE INSTALLATION OF CONCRETE DITCHES TO MINIMIZE ANY CHANNEL EROSION.

FLOOD PROTECTION

FLOOD PROTECTION HAS BEEN MET BY LIMITING THE POST DEVELOPMENT PEAK DISCHARGE RATES TO BELOW THE PRE DEVELOPMENT PEAK DISCHARGE RATES FOR THE 10 YEAR, 24 HOUR STORM EVENT VIA THE USE OF THE POROUS PAVEMENT SECTION.

STORMWATER BMP MAINTENANCE PLAN (CULPEPER REGIONAL AIRPORT SHALL BE RESPONSIBLE FOR STORMWATER BMP MAINTENANCE PLAN) 3

THE POROUS PAVEMENT SURFACES SHOULD BE VACUUMED AT LEAST TWICE A YEAR WITH A VACUUM SWEEPER. SIMPLE BROOM SWEEPERS ARE NOT RECOMMENDED FOR POROUS ASPHALT MAINTENANCE. WITH A HIGH VOLUME AIR BLAST, THE AIR IS FORCED OUT AT AN ANGEL, CREATING A 'PEELING' EFFECT, WHICH THEN CAUSES THE DEBRIS TO BE LOOSENED FROM THE ASPHALT AND SUCKED INTO THE UNIT.

IF THE PAVEMENT SURFACE HAS BECOME SIGNIFICANTLY CLOGGED TO THE POINT WHERE THE ROUTINE VACUUM SWEEPING DOES NOT RESTORE PERMEABILITY, IT MAY BE NECESSARY TO WASH THE POROUS PAVEMENT WITH CLEAN, LOW PRESSURE WATER, FOLLOWED BY IMMEDIATE VACUUMING. IF THE PRESSURE OF THE WASHING NOZZLE IS TOO GREAT, CONTAMINANTS MAY BE DRIVEN FURTHER INTO THE POROUS SURFACE.

THE LANDSCAPING ADJACENT TO THE POROUS ASPHALT PAVEMENT SHOULD BE WELL MAINTAINED TO PREVENT SOIL WASHOUT ONTO THE PARKING LOT. IF THERE IS SOIL WASHOUT, IT SHOULD BE CLEANED OFF THE PAVEMENT IMMEDIATELY TO PREVENT CLOGGING OF THE PORES.

DURING THE WINTER, IT IS VERY IMPORTANT THAT SAND AND ABRASIVES NOT BE USED FOR WINTER MAINTENANCE BECAUSE THEY WILL CLOG THE PORES; RATHER, USE DEICING MATERIALS. STANDARD ROAD SALT IS ACCEPTABLE AS A DEICER. IF SNOW PLOWING IS REQUIRED IT SHOULD BE DONE CAREFULLY BY SETTING THE BLADE ABOUT AN INCH HIGHER THAN USUAL.

IF THERE IS DAMAGE TO THE POROUS PAVEMENT, THE AREAS SHOULD BE PATCHED WITH APPROVED POROUS ASPHALT.

1

SITE DESIGN TECHNIQUE 1 CHECKLIST

ACHIEVED	NOT ACHIEVED	PRACTICE
X		STORMWATER FACILITIES LOCATED OUTSIDE OF STREAMS AND WETLANDS
X		NATURAL DRAINAGE ROUTES MAINTAINED ON SITE.
X		RIPARIAN BUFFERS PRESERVED
X		DISTRIBUTED "INTEGRATED MANAGEMENT PRACTICES" USED IN LIEU OF CENTRALIZED PONDS

DESCRIBE ACTIONS TAKEN:

CONCRETE TRAPEZOIDAL DITCHES WILL BE CONSTRUCTED OUTSIDE STREAMS AND WETLANDS ON THE NORTH AND SOUTH ENDS OF THE SITE TO ALLOW FUTURE STORMWATER TO DRAIN INTO THE EXISTING AIRPORT DRAINAGE SYSTEM. THE DRAINAGE ROUTES HAVE BEEN ALTERED MINIMALLY AND ARE CONSTRUCTED TO KEEP ALL POST DEVELOPMENT FLOW FROM EXCEEDING THE EXISTING FLOW RATES. CLEARING AND GRUBBING IS MINIMAL TO ALLOW FOR RIPARIAN BUFFERS TO BE PRESERVED AS MUCH AS POSSIBLE.

SITE DESIGN TECHNIQUE 2 CHECKLIST

ACHIEVED	NOT ACHIEVED	PRACTICE
X		UTILIZE CLUSTERED DEVELOPMENT DESIGNS THAT PRESERVE A SIGNIFICANT PORTION OF THE SITE IN A NATURAL STATE.
X		UTILIZE "FINGERPRINT" CLEARING...LIMIT THE CLEARING AND GRADING OF FORESTS AND NATIVE VEGETATION TO THE MINIMUM AREA NEEDED FOR THE CONSTRUCTION OF THE LOTS, THE PROVISION OF NECESSARY ACCESS AND FIRE PROTECTION
X		AVOID IMPACTS TO WETLANDS OR VEGETATED RIPARIAN BUFFERS.
X		A & B SOILS PRESERVE IN NATURAL COVER.

DESCRIBE ACTIONS TAKEN:

CLEARING AND GRUBBING IS MINIMAL TO ALLOW FOR RIPARIAN BUFFERS TO BE PRESERVED AS MUCH AS POSSIBLE. GRADING BACK TO EXISTING FOLLOWS A 3:1 SLOPE TO ALLOW FOR MINIMAL IMPACT ON NATIVE VEGETATION.

SITE DESIGN TECHNIQUE 3 CHECKLIST

DESCRIBE ACTIONS TAKEN:

THE ITEMS IN THIS PORTION OF THE CHECKLIST DO NOT PERTAIN TO THIS PROJECT.

SITE DESIGN TECHNIQUE 4 CHECKLIST

ACHIEVED	NOT ACHIEVED	PRACTICE
X		UTILIZE HSG A & B SOILS TO PROMOTE INFILTRATION

DESCRIBE ACTIONS TAKEN:

AN UNDER DRAIN SYSTEM IS BEING INSTALLED TO UTILIZE THE HIGH INFILTRATION SOILS.

SITE DESIGN TECHNIQUE 5 CHECKLIST

ACHIEVED	NOT ACHIEVED	PRACTICE
X		LOCATE IMPERVIOUS AREAS ON LESS PERMEABLE SOILS (HSG C AND D)

DESCRIBE ACTIONS TAKEN:

THE T-HANGAR AND EXECUTIVE HANGAR ARE LOCATED IN AREAS TYPICALLY CLASSIFIED AS GROUP D SOILS.

SITE DESIGN TECHNIQUE 6 CHECKLIST

ACHIEVED	NOT ACHIEVED	PRACTICE
X		DISCONNECT IMPERVIOUS AREAS

DESCRIBE ACTIONS TAKEN:

ALL IMPERVIOUS PAVEMENT AREAS DRAIN TO POROUS PAVEMENT SECTIONS ON SITE.

SITE DESIGN TECHNIQUE 7 CHECKLIST

ACHIEVED	NOT ACHIEVED	PRACTICE
X		FLATTEN GRADES FOR STORMWATER CONVEYANCE TO THE MINIMUM SUFFICIENT TO ALLOW POSITIVE DRAINAGE
X		INCREASE TRAVEL TIME IN VEGETATED SWALES BY USING MORE CIRCUITOUS FLOW ROUTES, ROUGHER VEGETATION IN SWALES AND CHECK DAMS
X		UTILIZE "ENGINEERED" SWALES IN LIEU OF PIPES OR HARDENED CHANNELS. THESE SWALES WILL HAVE SHALLOW GRADES AND WILL HAVE A SAND OR GRAVEL SUBSTRATE BELOW THE SOD TO PROMOTE INFILTRATION

DESCRIBE ACTIONS TAKEN:

DRAINAGE SLOPES HAVE BEEN SET TO THE MINIMUM ALLOWABLE TO CONVEY POSITIVE DRAINAGE. TRAVEL TIME HAS BEEN DRAMATICALLY INCREASED

SITE DESIGN TECHNIQUE 8 CHECKLIST

DESCRIBE ACTIONS TAKEN:

THE ITEMS IN THIS PORTION OF THE CHECKLIST DO NOT PERTAIN TO THIS PROJECT.

SITE DESIGN TECHNIQUE 10 CHECKLIST

ACHIEVED	NOT ACHIEVED	PRACTICE
X		REVEGETATE ALL CLEARED AND GRADED AREAS

DESCRIBE ACTIONS TAKEN:

ALL UNPAVED AREAS WILL BE SEEDED WITH PERMANENT SEEDING TO PROVIDE PERMANENT SITE STABILIZATION

SITE DESIGN TECHNIQUE 12 CHECKLIST

DESCRIBE ACTIONS TAKEN:

THE ITEMS IN THIS PORTION OF THE CHECKLIST DO NOT PERTAIN TO THIS PROJECT. THE POST DEVELOPMENT TIME OF CONCENTRATION IS GREATER THAN THE EXISTING TIME OF CONCENTRATION. POST DEVELOPMENT RUNOFF RATES DO NOT EXCEED THE EXISTING RUNOFF RATES.

SITE DESIGN TECHNIQUE 13 CHECKLIST

DESCRIBE ACTIONS TAKEN:

THE ITEMS IN THIS PORTION OF THE CHECKLIST DO NOT PERTAIN TO THIS PROJECT.

COMMONWEALTH OF VIRGINIA
PETER KERR BIGLER
CHASE
Lic. No. 047615
2/26/2014
PROFESSIONAL ENGINEER

CAMPBELL & PARIS ENGINEERS
4215 LAFAYETTE CENTER DR.
SUITE 2
CHANTILLY, VA. 20151 (703) 802-0093

DESIGNED BY: FM | DRAWN BY: FM | CHECKED BY: DJ | APPROVED BY: HDC
C&P JOB #: 0007-20 | PROJECTE PHASE: FINAL
SCALE: AS SHOWN

NO.	DATE	REVISIONS	BY	APPR.
1	3/19/2014	ADDENDUM #1	FM	KC
2	5/19/2014	IN COMPLIANCE WITH 9VAC25-870-55	FM	KC
3	11/20/2014	RESPONSE TO DEQ SWM COMMENTS	FM	KC

COUNTY OF CULPEPER, VIRGINIA
CULPEPPER REGIONAL AIRPORT

T-HANGAR AND EXECUTIVE HANGAR DEVELOPMENT

STORM WATER MANAGEMENT NARRITIVE

AIP No.
NOT APPLICABLE

State No.
CS-0010-20

SHEET INDEX
C10.1

SHEET 27 OF 55

FEBRUARY 2014

BEVERLY FORD ROAD

PRE-DEVELOPMENT 1
0.29 ACRES

PRE-DEVELOPMENT 2
3.33 ACRES

PRE-DEVELOPMENT 3
5.0 ACRES

100' SHEET FLOW

100' SHEET FLOW

221' SHALLOW CONCENTRATED FLOW

275' SHALLOW CONCENTRATED FLOW

227' CHANNEL FLOW

207' CHANNEL FLOW

EXISTING HANGAR

EXISTING HANGAR

EXISTING HANGAR

EXISTING HANGAR

EXISTING HANGAR

EXISTING OUTFALL PIPE

EXISTING OUTFALL PIPE

LEGEND	
SYMBOL	DESCRIPTION
	TIME OF CONCENTRATION FLOW PATH
	DRAINAGE DIVIDE
	EXISTING CONTOUR

GRAPHIC SCALE

30 0 15 30 60 120

(IN FEET)
1 inch = 30 ft.

COMMONWEALTH OF VIRGINIA
PETER KERR BIGLER CHASE
Lic. No. 047615
PROFESSIONAL ENGINEER
2/26/2014

CAMPBELL & PARIS ENGINEERS
SUITE 2 4215 LAFAYETTE CENTER DR.
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DESIGNED BY: FM
DRAWN BY: FM
CHECKED BY: DJ
APPROVED BY: HDC
SCALE: AS SHOWN
C&P JOB #: 0007-20
PROJECTE PHASE: FINAL

NO.	DATE	BY	APPR.

REVISIONS

COUNTY OF CULPEPER, VIRGINIA
CULPEPER REGIONAL AIRPORT

T-HANGAR AND EXECUTIVE HANGAR DEVELOPMENT

STORM WATER MANAGEMENT PLAN - PRE-DEVELOPMENT CONDITIONS

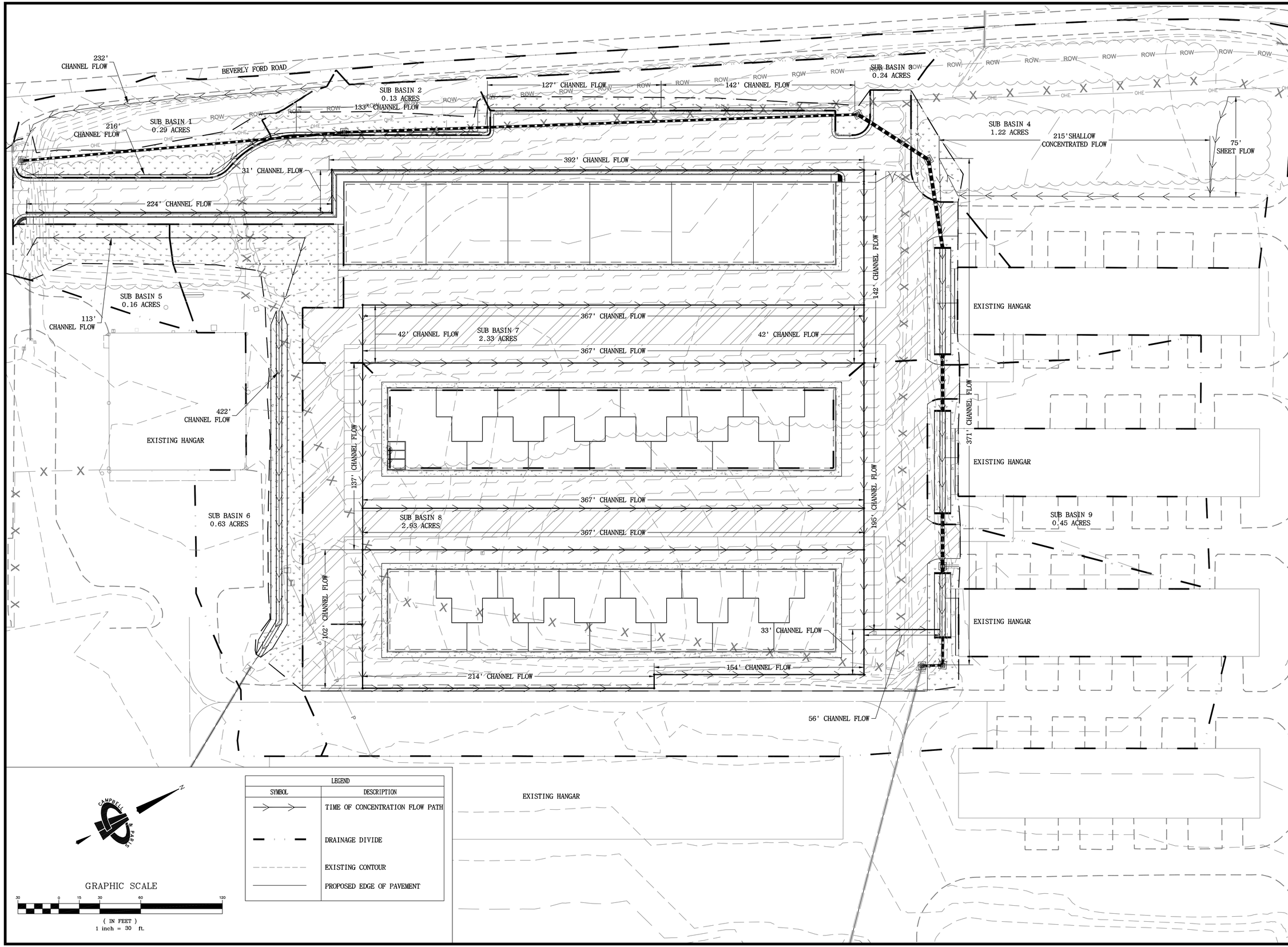
AIP No.
NOT APPLICABLE

State No.
CS-0010-20

SHEET INDEX
C10.2

SHEET 28 OF 55

FEBRUARY 2014



LEGEND	
SYMBOL	DESCRIPTION
	TIME OF CONCENTRATION FLOW PATH
	DRAINAGE DIVIDE
	EXISTING CONTOUR
	PROPOSED EDGE OF PAVEMENT

GRAPHIC SCALE

30 0 15 30 60 120

(IN FEET)
1 inch = 30 ft.

COMMONWEALTH OF VIRGINIA
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PROFESSIONAL ENGINEER
2/26/2014

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DESIGNED BY:	DRAWN BY:	CHECKED BY:	APPROVED BY:
FM	FM	DJ	HDC
SCALE: AS SHOWN		C&P JOB #: 0007-20	PROJECTE PHASE: FINAL

REVISIONS			
NO.	DATE	BY	APPR.

COUNTY OF CULPEPER, VIRGINIA
CULPEPPER REGIONAL AIRPORT

T-HANGAR AND EXECUTIVE HANGAR DEVELOPMENT

STORM WATER MANAGEMENT PLAN - POSTDEVELOPMENT CONDITIONS

AIP No.
NOT APPLICABLE

State No.
CS-0010-20

SHEET INDEX
C10.3

SHEET 29 OF 55

FEBRUARY 2014

B.2 Paine Field Porous Asphalt Apron

PAINE FIELD

POROUS ASPHALT APRON PAVEMENT

B.2.1 Project Overview

Paine Field/Snohomish County Airport (Paine Field) is a county-owned public-use airport located north of Seattle, Washington. The airport was created in 1936 as a public works project. The airport supports a unique aircraft mix, ranging from small, single engine aircraft to corporate-size jets. And it not only serves general aviation, but is also home of the Boeing Company's factories for the B-747, B-767, B-777, and B-787 aircraft. Tenants at the airport also include third-party aircraft inspection and repair facilities, which provide repair and maintenance services for commercial airlines and the Air Force.

The Future of Flight Aviation Center (FFAC) is located at the northwest side of the airport. FFAC is a tourist attraction for touring the Boeing aircraft factory and is used by Boeing for the delivery of new aircraft to clients. The apron adjacent to the FFAC building (shown in figure B-3) is used for aircraft parking. The apron originally contained grass islands near FFAC, but to support delivery events, Boeing desired additional hard surface on the apron. In order to fill in the island areas, the Airport needed to use a permeable pavement to meet stormwater management requirements.

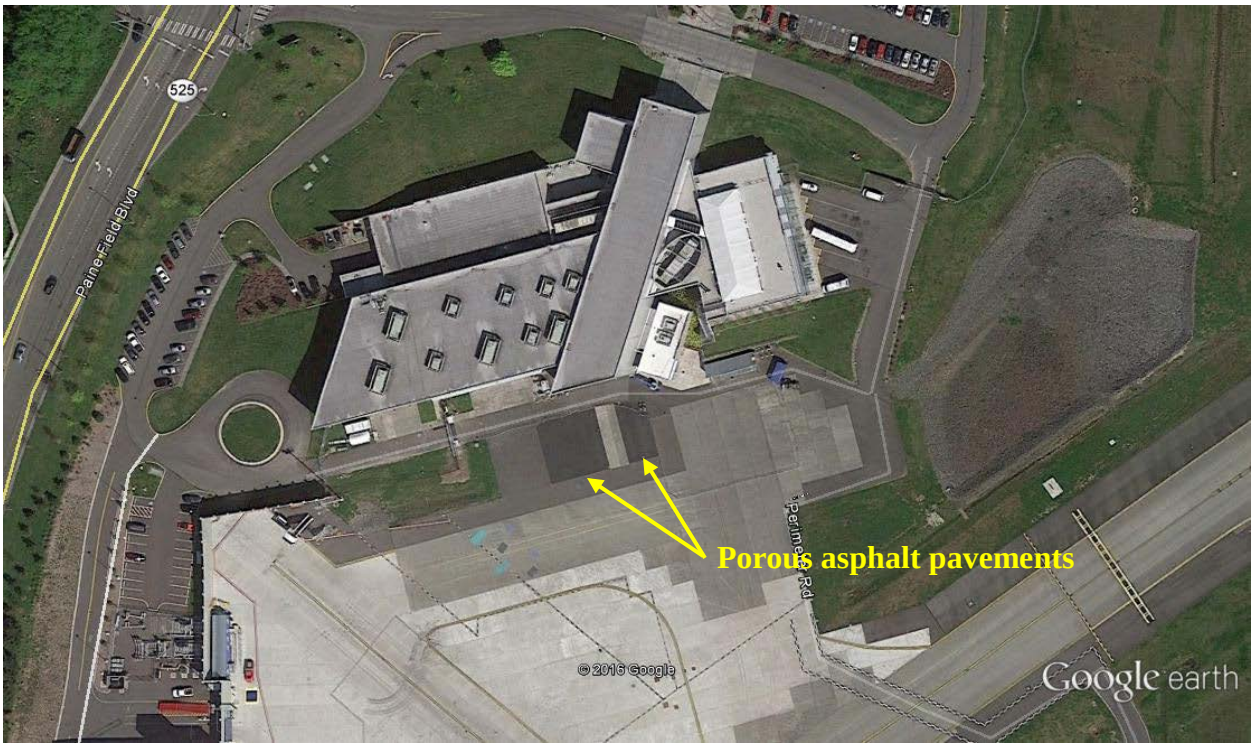


Figure B-3. Overview of Paine Field Future of Flight Aviation Center Apron (map data © 2016 Google).

The County has strict stormwater management requirements, and they are proactive with low-impact design (LID) alternatives. Because of stormwater management requirements, the airport could not use an impermeable surface for the project without somehow addressing the additional runoff. With limited space available for drainage, a permeable pavement system was selected. The airport had previous experience with the use of a grass paving grid in a parking lot, and at the time the Airport was planning the project, porous asphalt was being promoted in the paving industry. The airport engineer and deputy director decided to try porous asphalt as the permeable surface. The airport felt the porous asphalt pavement would also be a good demonstration project for the County's LID initiatives.

The project was funded using Airport funds. The Airport receives revenue from takeoff and landing fees and from tenant lease agreements. The design was performed by the airport engineer, who was also responsible for construction document preparation. The Airport also had construction oversight. The cost for porous asphalt was approximately 30 percent higher than dense-graded hot-mix asphalt, but the remaining work items were primarily materials that followed Washington State Department of Transportation (WSDOT) specifications.

B.2.2 Design Considerations

B.2.2.1 Hydrologic Design

The use of a permeable pavement was based on maintaining the level of runoff from existing impermeable surfaces. Therefore, the design is to provide for the surface infiltration of the rainfall on the areas to be paved and a minimal amount from adjacent run-on. The system uses an underdrain system (see figure B-4) and delays the time of concentration. However, there are no direct calculations. There were also no specific calculations for storage capacity.

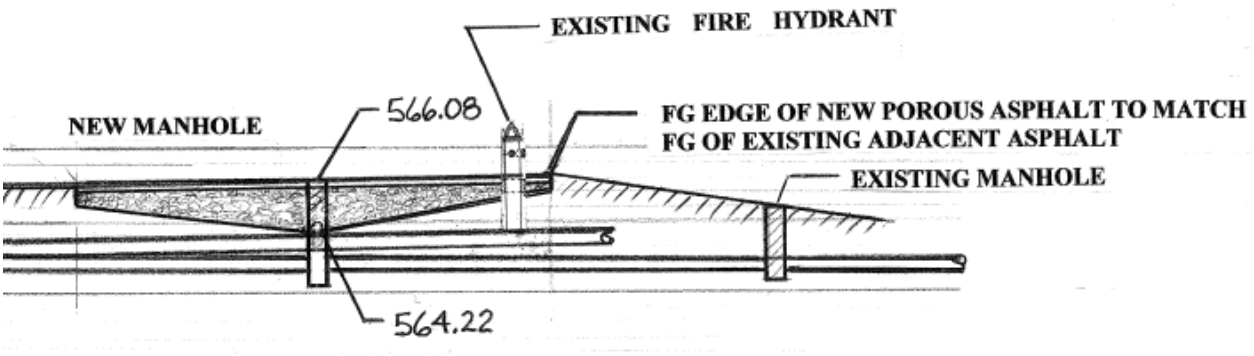


Figure B-4. Porous asphalt pavement cross section (Paine Field 2011).

B.2.2.2 Pavement design

For this project, there was no direct structural design. The apron construction was part of a project that included placing porous asphalt for a nearby parking lot. The apron design was roughly based on the parking lot design.

The parking lot was originally designed and constructed with a grass paving grid system. However, porous asphalt was being used to replace the paving grid. The parking lot cross section is 3 inches of porous asphalt on approximately 18 inches of aggregate. The final cross section for the apron pavement consists of 4 inches of porous asphalt (1 inch greater than the

parking lot) over 8 to 36 inches of aggregate, as shown in figure B-5. The subgrade of the included island areas was sloped toward the center where a drain pipe is located (see figure B-4).

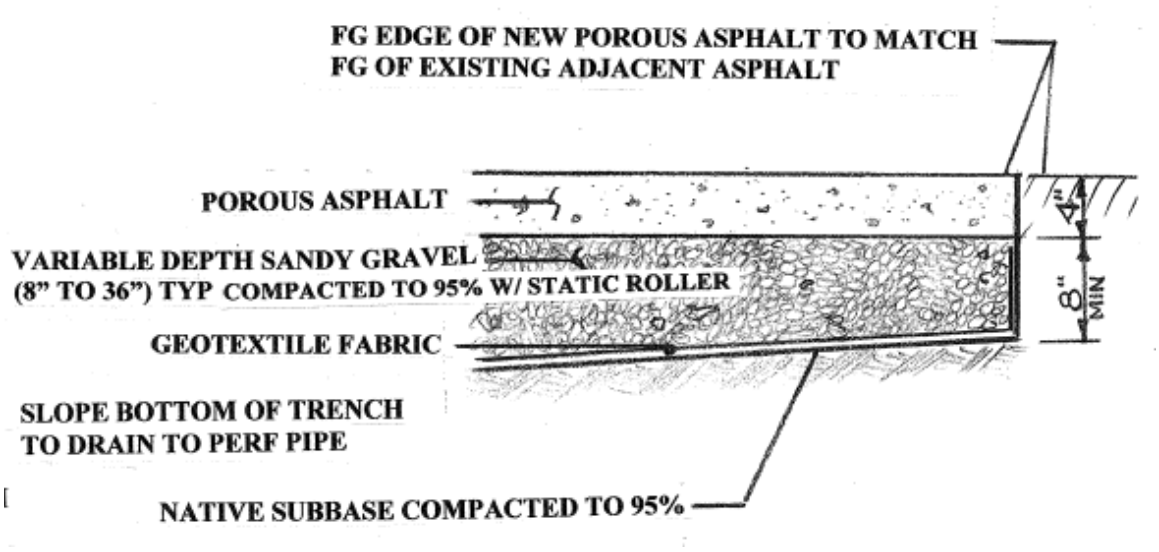


Figure B-5. Porous asphalt typical section (Paine Field 2011).

There was no specific design traffic data for the design. However, shortly after construction heavy tugs began to abrade the surface, so traffic has been restricted to light vehicular traffic.

B.2.3 Material Selection

B.2.3.1 Porous Asphalt

The porous asphalt is based on WSDOT "Hot Mixed Asphalt Concrete (HMAC), 1/2-inch Open Graded Mix." Mix design specifications required the use of NAPA Information Series (IS) 131, *Porous Asphalt Pavements for Stormwater Management*. The mix design criteria are summarized in table B-6.

Table B-6. Porous asphalt mix design criteria.

Sieve Size	Percent Passing
3/4 inch	100
1/2 inch	85 - 100
3/8 inch	55 - 75
No. 4	10 – 25
No. 8	5 – 10
No. 200	2 – 4
Binder Content (AASHTO T164)	6.0 – 6.5%
Air Void Content by Corelok (ASTM D6752)*	16.0 – 20.0%
Air Void Content by Paraffin wax (AASHTO T275)*	18.8 – 22.0%
Draindown (ASTM D6390)	$\leq$ 0.3%
Retained Tensile Strength (AASHTO 283)	$\geq$ 80%

*Either method is acceptable

The asphalt binder content was specified to be between 6.0 and 6.5 percent, which is in line with current standards. However, binder modification (such as with rubber) or the use of fibers was not required at the time of this project. The 4-inch porous asphalt surface was placed in a single lift.

B.2.3.2 Aggregate Layer

The base layer (drainage layer) is a sandy gravel aggregate of variable thickness. The layer was compacted with a static roller to 95 percent compaction. The particle distribution for the sandy gravel aggregate is summarized in table B-7. Additional information regarding the source and type of the material is available in the project specifications.

Table B-7. Particle distribution for sandy gravel base layer.

Sieve	Percent Passing
1 inch	100
3/4 inch	90-100
3/8 inch	70-80
No. 4	55-70
No. 10	45-55
No. 40	25-35
No. 200	3-8

The aggregate drainage layer was placed over an existing compacted subgrade soil, separated with a geotextile fabric.

B.2.4 Construction Considerations

While not required in the bid documents, the contractor selected had previous experience with permeable pavement construction using WSDOT specifications.

The batch plant used to produce the material was shut down to normal asphalt operations and only produced the porous asphalt during paving. It is believed producing only the porous asphalt helped with consistency by not jumping back-and-forth between different types of mixes.

Inspection during construction consisted of visual inspection of the surface for general texture and monitoring temperatures of the mixture during placement to confirm compaction was accomplished above the specified temperature.

B.2.5 Performance and Maintenance Activities

The porous asphalt continues to drain well after 5 years of service (as of the time of the interview). There has been no specific testing for infiltration, but there has been no standing water during or after rainfalls. The surface was being abraded by heavy tugs shortly after construction (figure B-6), so the traffic has since been restricted, as shown in figure B-7. The Airport vacuum sweeps the areas on approximately a weekly basis. Although the airport receives some snow, no deicers have been applied or snow removal equipment used on the pavement.

Figure B-6. Localized abrasion of porous pavement.

Figure B-7. Marking of porous pavement to restrict traffic loads.

B.2.6 Lessons Learned/Barriers

The porous asphalt surface abraded under heavy tug loadings. The mix did not use a modified asphalt binder or fibers, which would more than likely be used with more current specifications.

The porous asphalt helped meet stormwater management requirements and continues to drain as intended.

Although the Airport had other permeable pavement applications, this project was the first porous asphalt project. Therefore, there airport staff needed to learn about the material during the design.

B.2.7 Sources of Information

The project team would like to acknowledge the valuable input and assistance provided by the following individual:

- Jan O'Neill, PE, CM, Airport Engineer, Paine Field Airport

The following documents were provided for information and used in this summary:

- Project specifications and drawings provided by Paine Field Airport.

B.2.8 Paine Field Porous Asphalt Apron Specifications and Drawings

POROUS ASPHALT SPECIFICATIONS FOR FUTURE OF FLIGHT PARKING LOT GRASS-PAVE REPLACEMENT

Performance:

The work shall consist of one (1) single lift of open graded, plant-mixed asphalt concrete to produce a smooth, uniform completed surface that freely drains water through the asphalt pavement and into the existing sand/crushed rock base course.

Porous asphalt concrete shall conform to the requirements of the Washington State Department of Transportation Section on Hot Mixed Asphalt Concrete (HMAC) ½-inch Open Graded Mix, Level 3 HMAC.

The successful installation of porous asphalt pavement over compacted, sand/crushed rock base course with subdrain are key components of the stormwater water quality treatment for the project. Failure of the pavement section to transmit stormwater downward through the asphalt pavement and rock base course shall be grounds for non-acceptance of the pavement. The infiltration properties of the completed pavement section shall be proofed in accordance with this Special Provision.

Porous Asphalt Mix Design Criteria:

1. Coarse Aggregate. Coarse aggregate shall be that part of the aggregate retained on the No. 8 sieve; it shall consist of clean, tough, durable fragments of crushed stone, or crushed gravel of uniform quality throughout. Coarse Aggregate shall be crushed stone or crushed gravel and shall have a percentage of wear as determined by AASHTO T96 of not more that 40 percent. In the mixture, at least 75 percent, by mass (weight), of the material coarser than the 4.75 mm (No. 4) sieve shall have at least two fractured faces, and 90 percent shall have one or more fractured faces (ASTM D5821). Coarse aggregate shall be free from clay balls, organic matter, deleterious substances, and not more than 8.0% of flat or elongated pieces (>3:1) as specified in ASTM D4791.

2. Fine Aggregate. The fine aggregate shall be that part of the aggregate mixture passing the No. 8 sieve and shall consist of sand, screenings, or combination thereof with uniform quality throughout. Fine aggregate shall consist of durable particles, free from injurious foreign matter. Screenings shall be of the same or similar materials as specified for coarse aggregate. The plasticity index of that part of the fine aggregate passing the No. 40 sieve shall be not more that 6 when tested in accordance with AASHTO T90. Fine aggregate from the total mixture shall meet plasticity requirements.

3. Porous Asphalt Mix Design. The Contractor shall submit a mix design at least 10 working days prior to the beginning of production. The Contractor shall make available samples of coarse aggregate, fine aggregate, mineral filler, fibers and a sample of the PGAB that will be used in the design of the mixture. The mixture

will be designed according to the NAPA *IS 131*, with the exception of testing for air void content. Bulk specific gravity (SG) used in air void content calculations shall not be determined and results will not be accepted using AASHTO T166 (saturated surface dry), since it is not intended for open graded specimens (>10% AV). Bulk SG shall be calculated using AASHTO T275 (Paraffin wax) or ASTM D6752 (automatic vacuum sealing, e.g. CoreLok). Air void content shall be calculated from the bulk SG and maximum theoretical SG (AASHTO T209) using ASTM D3203. The materials shall be combined and graded to meet the composition limits by mass (weight) as shown in Table 1.

Table 1. Porous asphalt mix design criteria.

Sieve Size (inch/mm)	**Percent Passing**
0.75/19	100
0.50/12.5	85 - 100
0.375/9.5	55 - 75
No. 4/4.75	10 – 25
No. 8/2.36	5 – 10
No. 200/0.075	2 – 4
Binder Content (AASHTO T164)	6.0 – 6.5%
Air Void Content by Corelok (ASTM D6752)*	16.0 – 20.0%
Air Void Content by Paraffin wax (AASHTO T275)*	18.8 – 22.0%
Draindown (ASTM D6390)**	<= 0.3%
Retained Tensile Strength (AASHTO 283)***	>= 80%

*Either method is acceptable

**Cellulose or mineral fibers may be used to reduce draindown.

***If the TSR (retained tensile strength) values fall below 80% when tested per NAPA IS 131 (with a single freeze-thaw cycle rather than 5), then Step 4, the contractor shall employ an antistrip additive, such as hydrated lime (ASTM C977) or a fatty amine, to raise the TSR value above 80%.

4. Mixing Plants. Mixing plants shall meet the requirements of hot mix asphalt plants as specified in the WSDOT Standard Specifications unless otherwise approved by the Engineer.
5. Preparation of Asphalt Binder. The asphalt material shall be heated to the temperature specified in the WSDOT Standard Specifications in a manner that will avoid local overheating. A continuous supply of asphalt material shall be furnished to the mixer at a uniform temperature.
6. Preparation of Aggregates. The aggregate for the mixture shall be dried and heated at the mixing plant before being placed in the mixer. Flames used for drying and heating shall be properly adjusted to avoid damaging the aggregate and depositing soot or unburned fuel on the aggregate. Mineral filler, if required to meet the grading requirements, shall be added in a manner approved by the Engineer after the aggregates have passed through the dryer. The above preparation of aggregates does not apply for drum-mix plants.
7. Mixing. The dried aggregate shall be combined in the mixer in the amount of each fraction of aggregate required to meet the job-mix formula and thoroughly

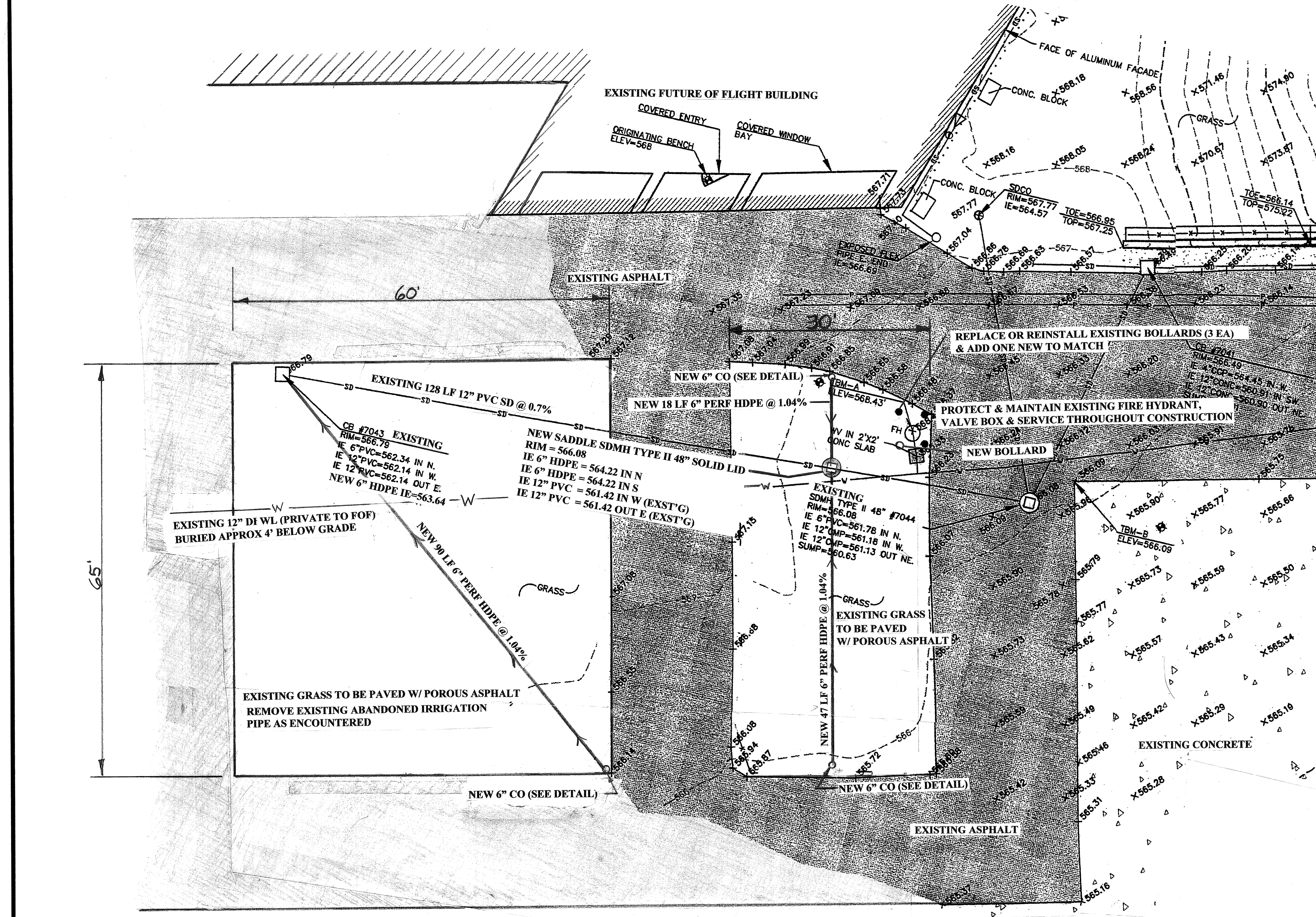
mixed prior to adding the asphalt material. The dried aggregates shall be combined with the asphalt material in such a manner as to produce a mixture that when discharged from the pugmill is at a target temperature in the range that corresponds to an asphalt binder viscosity of 700 to 900 centistokes and within a tolerance of +/- 11degrees Centigrade (+/- 20 degrees Fahrenheit). The asphalt material shall be measured or gauges and introduced into the mixer in the quantity determined by the Engineer for the particular material being used and at the temperature specified in the relevant specification. After the required quantity of aggregate and asphalt material has been introduced into the mixer, the materials shall be mixed until a complete and uniform coating of the particles and a thorough distribution of the asphalt material throughout the aggregate is secured. The mixing time will be regulated by the Engineer, and a suitable locking means shall be provided for these regulations. All plants shall have a positive means of eliminating oversized and foreign material from being incorporated into the mixer.

Sandy Gravel Base Material:

1. Sandy gravel material from local sources commonly used for road base construction, passing the following sieve analysis:

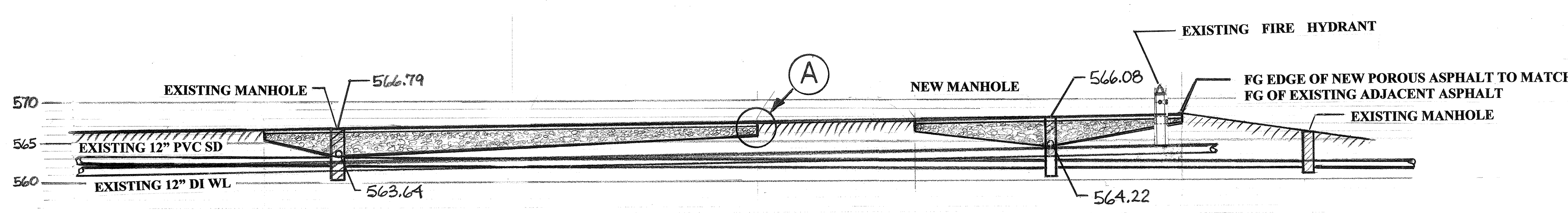
SIEVE	%PASSING
1”	100
¾”	90-100
3/8”	70-80
#4	55-70
#10	45-55
#40	25-35
#200	3-8

2. Sources of the material can include either “pit run” or “crusher run.” Crusher run material will generally require sharp sand to be added to mixture (33% by volume) to ensure long-term porosity. If there is difficulty in finding local sources to meet this sieve analysis, an alternative mixture can be created by mixing 2/3 crushed drainage rock (0.75% dia) with 1/3 coarse, well-draining sand (AASHTO M6 or ASTM C-33).
3. Selected materials should be nearly neutral in pH (range from 6.5 to 7.2) to provide water quality treatment.
4. Alternative materials such as crushed shell, limerock, and/or crushed lava may be considered for base course use, provided they are mixed with sharp sand (33%) and brought to proper compaction. (Crushed shell and limerock alone can set up like concrete without sand added.)



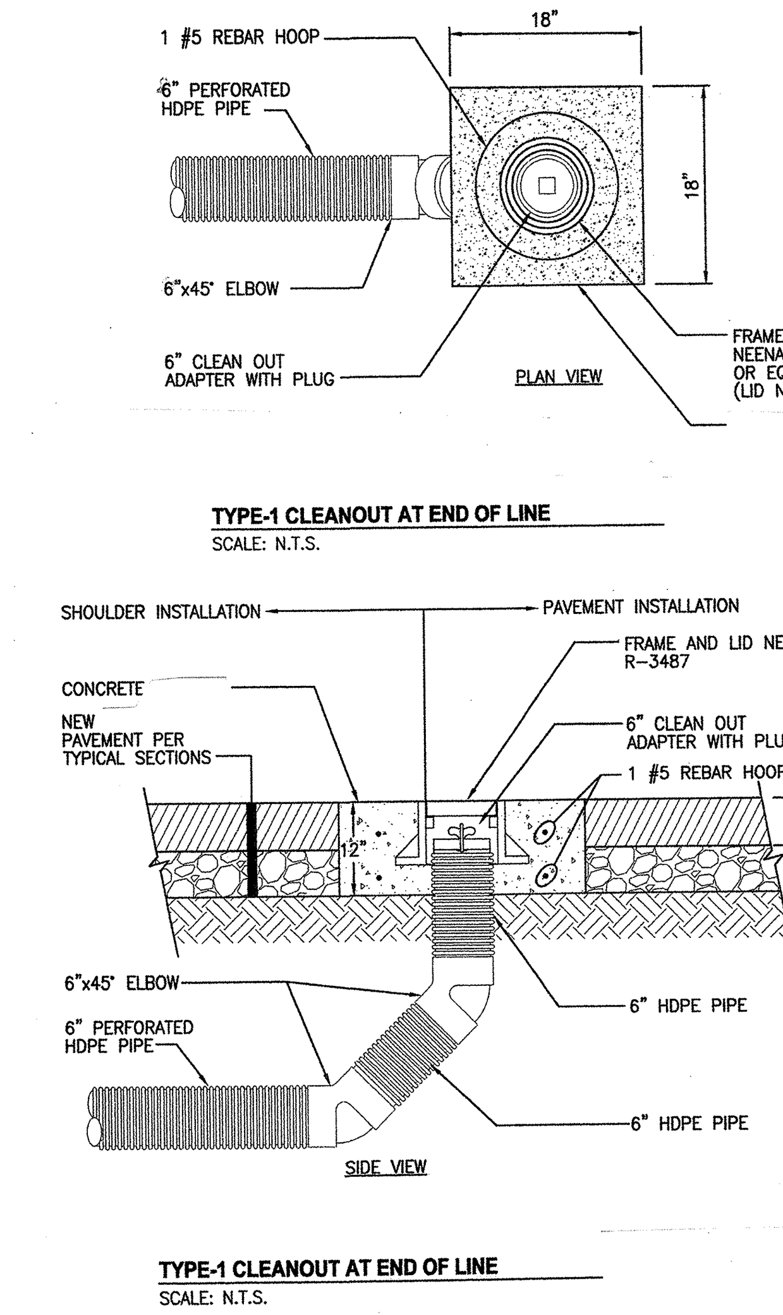
POROUS ASPHALT AT GRASS AREA PLAN (BASE BID)

SCALE: 1" = 10'



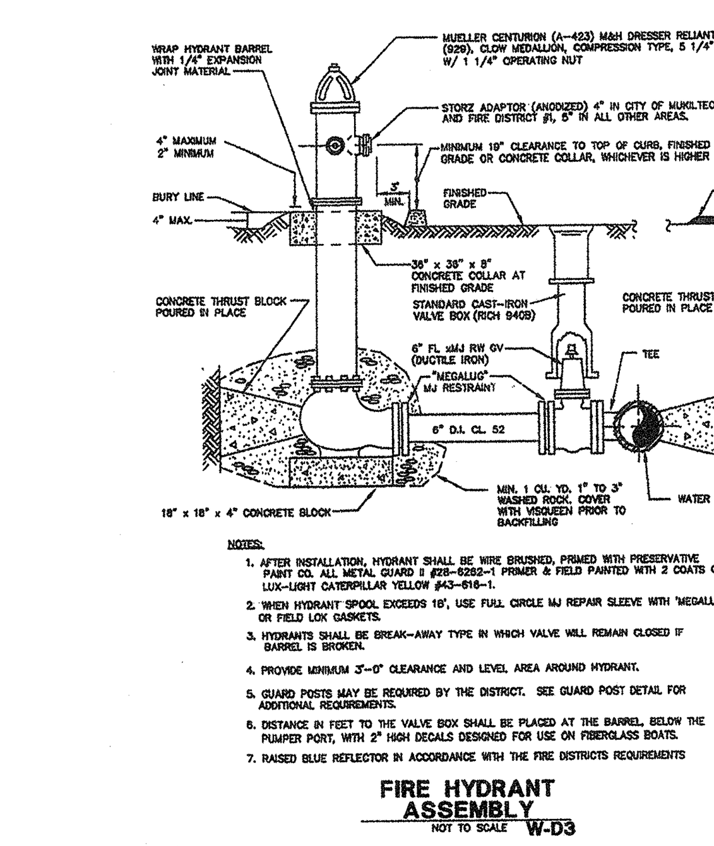
POROUS ASPHALT AT GRASS AREA SECTION

SCALE: 1" = 10'



TYPICAL CLEANOUT DETAIL

NTS



EXISTING FIRE HYDRANT DETAIL

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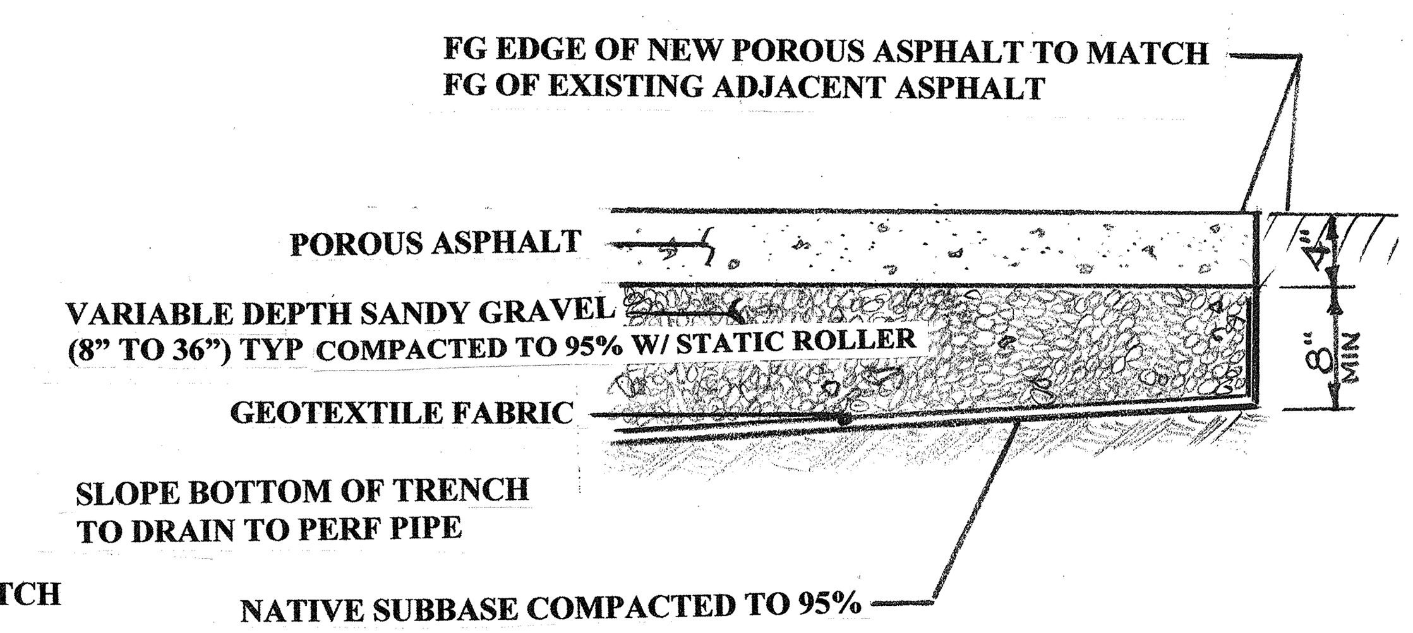
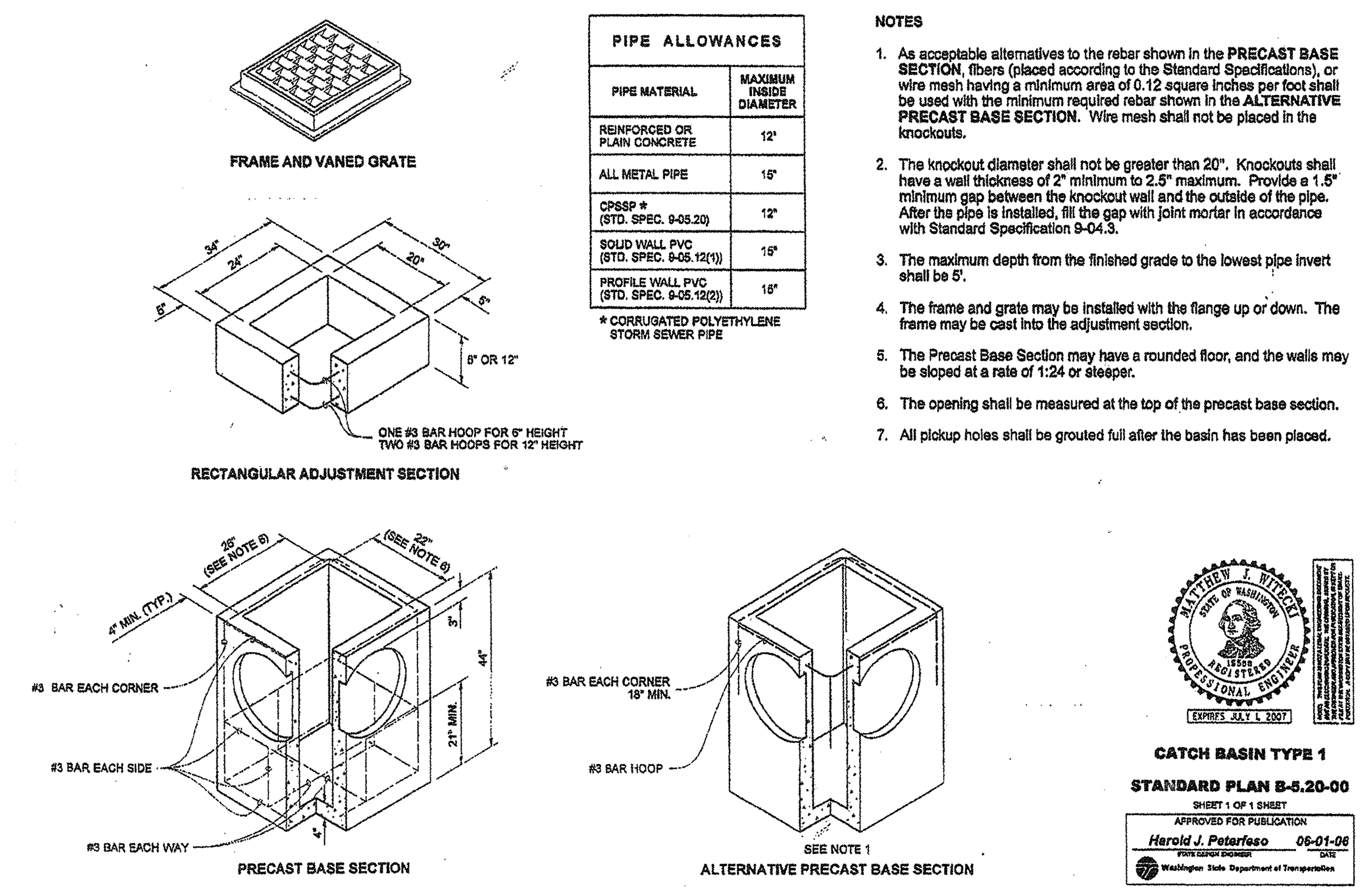


TYP DETAIL (A)

NTS



PIPE ALLOWANCES	
PIPE MATERIAL	MAXIMUM INSIDE DIAMETER
REINFORCED OR PLAIN CONCRETE	12"
ALL METAL PIPE	15"
CPSSP * (STD. SPEC. 9-05.20)	12"
SOLID WALL PVC (STD. SPEC. 9-05.12(1))	15"
PROFILE WALL PVC (STD. SPEC. 9-05.12(2))	15"

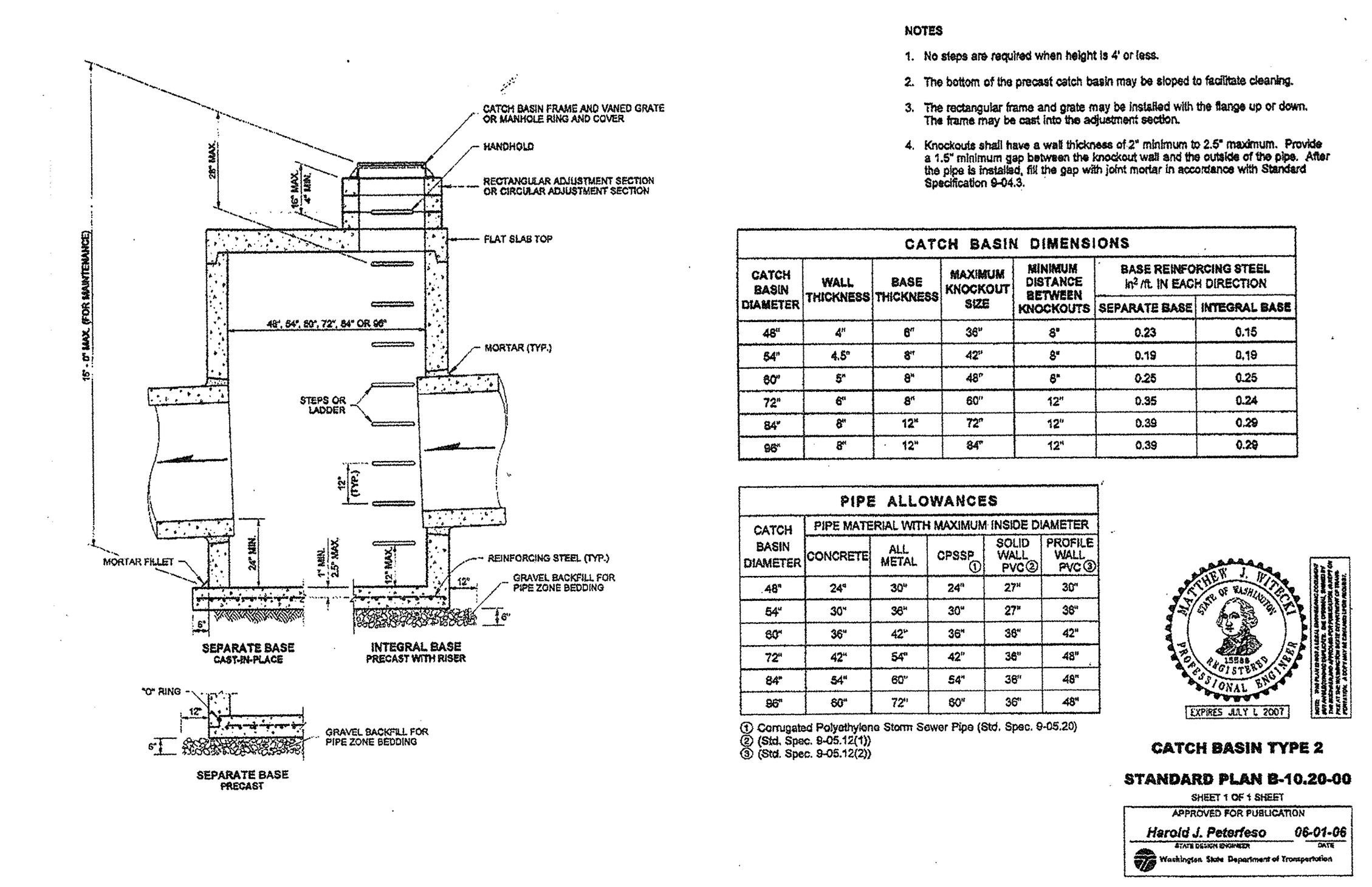
* CORRUGATED POLYETHYLENE STORM SEWER PIPE

NOTES

1. As acceptable alternatives to the rebar shown in the **PRECAST BASE SECTION**, fibers (placed according to the Standard Specifications), or wire mesh having a minimum area of 0.12 square inches per foot shall be used with the minimum required rebar shown in the **ALTERNATIVE PRECAST BASE SECTION**. Wire mesh shall not be placed in the knockouts.
2. The knockout diameter shall not be greater than 20". Knockouts shall have a wall thickness of 2" minimum to 2.5" maximum. Provide a 1.5" minimum gap between the knockout wall and the outside of the pipe. After the pipe is installed, fill the gap with joint mortar in accordance with Standard Specification 9-04.3.
3. The maximum depth from the finished grade to the lowest pipe invert shall be 5'.
4. The frame and grate may be installed with the flange up or down. The frame may be cast into the adjustment section.
5. The Precast Base Section may have a rounded floor, and the walls may be sloped at a rate of 1:24 or steeper.
6. The opening shall be measured at the top of the precast base section.
7. All pickup holes shall be grouted full after the basin has been placed.

SNOHOMISH COUNTY PUBLIC WORKS CATCH BASIN TYPE 1

NTS



NOTES

1. No steps are required when height is 4' or less.
2. The bottom of the precast catch basin may be sloped to facilitate cleaning.
3. The rectangular frame and grate may be installed with the flange up or down. The frame may be cast into the adjustment section.
4. Knockouts shall have a wall thickness of 2" minimum to 2.5" maximum. Provide a 1.5" minimum gap between the knockout wall and the outside of the pipe. After the pipe is installed, fill the gap with joint mortar in accordance with Standard Specification 9-04.3.

CATCH BASIN DIMENSIONS

CATCH BASIN DIAMETER	WALL THICKNESS	BASE THICKNESS	MAXIMUM KNOCKOUT SIZE	MINIMUM DISTANCE BETWEEN KNOCKOUTS	BASE REINFORCING STEEL in²/ft. IN EACH DIRECTION: SEPARATE BASE	INTEGRAL BASE
48"	4"	6"	36"	8"	0.23	0.15
54"	4.5"	8"	42"	8"	0.19	0.19
60"	5"	8"	48"	8"	0.25	0.25
72"	6"	8"	60"	12"	0.35	0.24
84"	8"	12"	72"	12"	0.39	0.29
96"	8"	12"	84"	12"	0.39	0.29

PIPE ALLOWANCES

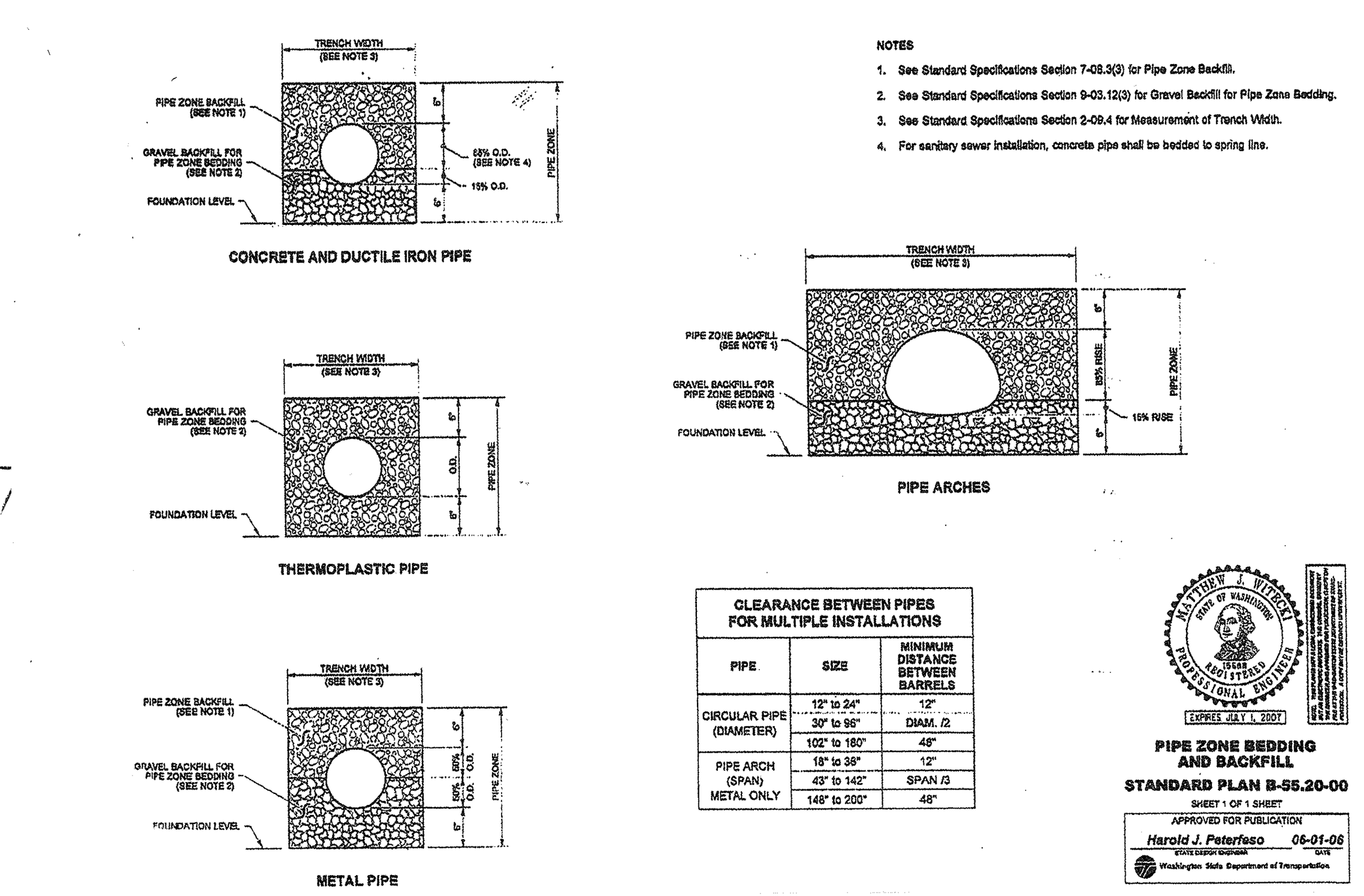
CATCH BASIN DIAMETER	CONCRETE	ALL METAL	CPSSP ①	SOLID WALL PVC ②	PROFILE WALL PVC ③
48"	24"	30"	24"	27"	30"
54"	30"	36"	30"	27"	36"
60"	36"	42"	36"	36"	42"
72"	42"	54"	42"	36"	48"
84"	54"	60"	54"	36"	48"
96"	60"	72"	60"	36"	48"

(Pipe material with maximum inside diameter)

① Corrugated Polyethylene Storm Sewer Pipe (Std. Spec. 9-05.20)
② (Std. Spec. 9-05.12(1))
③ (Std. Spec. 9-05.12(2))

SNOHOMISH COUNTY PUBLIC WORKS CATCH BASIN TYPE 2

NTS



NOTES

1. See Standard Specifications Section 7-08.3(3) for Pipe Zone Backfill.
2. See Standard Specifications Section 9-03.12(3) for Gravel Backfill for Pipe Zone Bedding.
3. See Standard Specifications Section 2-09.4 for Measurement of Trench Width.
4. For sanitary sewer installation, concrete pipe shall be bedded to spring line.

CLEARANCE BETWEEN PIPES FOR MULTIPLE INSTALLATIONS

PIPE	SIZE	MINIMUM DISTANCE BETWEEN BARRELS
CIRCULAR PIPE (DIAMETER)	12" to 24"	12"
	30" to 96"	DIAM. /2
	102" to 180"	48"
PIPE ARCH (SPAN) METAL ONLY	18" to 36"	12"
	43" to 142"	SPAN /3
	148" to 200"	48"

SNOHOMISH COUNTY PUBLIC WORKS PIPE ZONE BEDDING & BACKFILL

NTS

Snohomish County Planning Development Services
APPROVED FOR CONSTRUCTION BY:
for Randolph R. Sleight, P.E., P.L.S.
R/W Permit No.

PAINE FIELD SNOHOMISH COUNTY AIRPORT

SNOHOMISH COUNTY AIRPORT
PAINE FIELD
3220 100TH ST SW, STE A
EVERETT, WA 98204

FUTURE OF FLIGHT GRASS-PAVE REPLACEMENT WITH POROUS ASPHALT

CUT = 450 CY
FILL = 450 CY
NO NEW IMPERVIOUS SURFACE
PFN 10-107242 CG

BASE BID PHASE 1 AREA SOUTH OF FUTURE OF FLIGHT

C-2
SHEET 2 OF 2

B.3 Richmond International Airport Taxiway Porous Asphalt Shoulders

RICHMOND INTERNATIONAL AIRPORT

POROUS ASPHALT SHOULDER PAVEMENTS

B.3.1 Project Overview

The construction of Taxiways A and E at Richmond International Airport included 35-foot wide shoulders. At the same time, the Airport did not have sufficient open area to provide adequate stormwater retention areas for the new taxiway paved areas. To provide a method of reducing the stormwater time of concentration, permeable shoulders were incorporated into the project (see figure B-8).

Figure B-8. Overview of taxiway shoulders after construction (C&P 2010).

At the time of the design (1994), the Virginia Department of Transportation (VDOT) was constructing several porous asphalt parking lots, but to the knowledge of the design consultant, Campbell & Paris Engineers (C&P), there were no previous instances in which porous asphalt was used for taxiway shoulders (or on an airfield in general). The final design utilized the FAA's P-402 porous friction course for the surface layer, a consultant-developed stabilized open-graded base (based on U.S. Army Corps of Engineers [USCOE] specification), and VDOT aggregate materials.

The project was funded through the use of FAA airport improvement program (AIP) and Virginia Department of Aviation (VDOA) grants.

B.3.2 Design Considerations

B.3.2.1 Hydrologic Design

The purpose of the project was to provide adequate stormwater retention areas for the new paved taxiway areas.

Water Quality

While no specific water quality goal was identified, the interception of the first 15 minutes of a rainfall event was assumed to contain the majority of suspended solids from the taxiway pavement.

Infiltration Rates

Borings completed at the permeable pavement location encountered moderately plastic firm to stiff fine sandy clay soil that transitions to firm clayey sands and deeper loose silty sands, which are clearly not free-flowing soils. Borings also indicated a fill layer approximately 3 to 5 feet deep consisting of silty or clayey sand.

The minimum permeability was set for 3,000 feet per day based on a cement-stabilized open-graded layer. This was selected based on the USCOE Engineering Technical Letter 1110-3-435. Lateral underdrains were placed at 300-foot intervals, which drain to a paved ditch.

Storage Capacity

The project consultant designed the porous asphalt to intercept and store the first 15 minutes of run-off. The permeable pavement would increase stormwater quality and would limit the post-development flows. The peak time of flow was calculated to be 17 minutes (see figure B-9).

T_C - CONVENTIONAL PAVED SHOULDER
35' width = 0.16 min (see chart)
T_C - TURF SHOULDER
35' width = 0.40 min (see chart)
T_C - POROUS PAVEMENT
6" CTPP - 35' width exfiltration factor = 3000 fpd 3000 fpd x $^{1\ day}/_{24\ hrs}$ x $^{1\ hr}/_{60\ min}$ = 2.08 fpm (35' + 6"/12)/2.08 = 17.1 min = T_c
10" #57 Aggregate - 35' width exfiltration factor = 8000 fpd 8000 fpd x $^{1\ day}/_{24\ hrs}$ x $^{1\ hr}/_{60\ min}$ = 5.6 fpm (35' + 10"/12)/5.6 = 6.5 min = T_c

Figure B-9. Summary of time of concentration calculations (C&P 1994).

B.3.2.2 Pavement Design

The thickness design was determined using the LEDFAA program (FAA's pavement design software at the time). For the structural design, the porous friction course (PFC) layer was ignored. Although LEDFAA's concrete modulus is higher than the cement-treated open-graded material, the rigid pavement design methodology was used, assuming that the cement-treated open-graded layer had a modulus of at least 2.5 to 3.0 million. The final design section was based on 1 annual loading of a 125,000-lb aircraft and a subgrade CBR of 3 was selected to represent a saturated condition. The final design consisted of:

- 3/4 to 1 inch of PFC.
- 9 inches of cement-treated open-graded material.
- 7 inches open-graded aggregate layer.

An AASHTO 1993 pavement design was also checked with an assumed 1,000 equivalent single axle loadings. This design check determined a thinner pavement requirement.

B.3.3 Material Selection

The pavement surface consisted of P-402 porous friction course. The cement-treated open-graded layer is based on USCOE specifications with slight modifications to the aggregate gradation to make it a more coarse material. The open-graded aggregate layer is also based on USCOE specifications for drainage layers. The gradation for the drainage layer was also slightly modified, as summarized in table B-8.

Table B-8. Aggregate gradation requirements for open-graded material.

Sieve	Percent Passing
1 1/2 in	100
1 in	95-100
1/2 in	25-80
No. 4	0-10
No. 8	0-5

The asphalt cement binder was required to be modified using rubber.

B.3.4 Construction Considerations

Based on the interview, there were no significant construction issues. It was noted that the pavement needs to be protected and remain clean during construction.

B.3.5 Performance and Maintenance Activities

The shoulder pavement was constructed from 1995 to 1996. The porous asphalt pavement still appears to be performing as needed for drainage, but this is confirmed only by no presence of standing water and no direct testing. It is believed that the Airport has not done any maintenance on the pavement. Snow removal operations do not appear to have damaged the pavement surface.

B.3.6 Lessons Learned/Barriers

The permeable pavement shoulder has performed since 1996 without known maintenance. Its performance illustrates that permeable pavements can be used on an airfield.

The permeable pavement layers can be modeled in LEDFAA (now FAARFIELD), but the layer properties need to be verified. AASHTO 1993 flexible design can also be used to determine structural design, but traffic correlations need to be established.

B.3.7 Sources of Information

The project team would like to acknowledge the valuable input and assistance provided by the following individual:

- H. D. Campbell, Jr., P.E., Principal, Campbell & Paris Engineers

The following documents also provided valuable information used in this summary:

- Design report, construction specifications, and project drawings provided by C&P.
- 2010 ACC presentation provided by C&P.

B.3.8 Richmond International Airport Taxiway Porous Asphalt Shoulders Feasibility Study

RICHMOND INTERNATIONAL AIRPORT

Richmond, Virginia

Feasibility Report for Porous Shoulder Pavements

September 8, 1994

Submitted By:

CAMPBELL & PARIS ENGINEERS, P.C.

Chantilly, Virginia

C&P Job No. 9218

1.0 INTRODUCTION

During the 35% design review of the project referenced above the FAA and Campbell & Paris design personnel discussed the possible design of a porous pavement for the paved shoulders to limit our runoff and subsequent storm water management problems associated with the additional paved areas.

Since that time we have completed our feasibility study and have researched possible designs to accomplish this task and now find that a solution can be accomplished utilizing existing AASHTO and FAA pavement design methodology and specifications of the Corps of Engineers, AASHTO, and the FAA.

2.0 DESIGN METHODOLOGY BACKGROUND AND SITE SOIL CONDITIONS

Reviewing existing design methodology for open graded pavements revealed that to date porous pavements were only designed for light automobile traffic. There have been several constructed in the Washington metro area, several being constructed by VDOT as commuter parking lots and some constructed by private developers. The lots were constructed in areas that did not lend themselves to retention or detention ponds or where the existing infrastructure would not accommodate the additional runoff associated with the parking areas. The design guide for such pavements was the Northern Virginia Best Management Practices performed by the Northern Virginia Planning District Commission and the Engineers & Surveyors Institute (Appendix A). To our knowledge there have been no airport pavements constructed such that the stormwater is designed to penetrate the pavement section and saturate the subgrade. In fact this condition has always been the purpose of the design to avoid. If the site were to exhibit a free draining soil (which Richmond International Airport does not) the design may be more simplified. Soil conditions at Richmond International Airport clearly do not represent a free draining soil. The worst soil conditions with regard to soil type suitable for pavements and loss of strength in saturated conditions occur in and around the air carrier

apron. The subsurface profiles based on test boring data from BEC Consultants and S&ME confirm one another. The material encountered represented a moderately plastic firm to stiff fine sandy clay that transitions into firm clayey sands and deeper loose silty sands. These shallow sandy silty clays are classified as CL in the Unified System while the deeper soils are classified as SM or SC, silty or clayey sands. Fill material has been place over the general site of taxiway A and taxiway U during past airport development. This fill is approx. 3 to 5 feet deep and is a silty or clayey sand classified as SM or SC.

2.1 MOISTURE CONTENTS AND WATER TABLE LOCATIONS

The optimum moisture content of the soils ranged from 6 to 12 percent when determined in accordance with ASTM D 1557. The in place moisture contents in some cases were higher than those of the laboratory proctors ranging from 10 to 15 percent. This usually means that the soils were not compacted to maximum density or that possibly a standard proctor (ASTM D 99) was used in the past as field control in lieu of the more stringent modified proctor (ASTM D 1557).
There are also instances of perched water tables where a layer of more permeable material such as the SM and SC exists over a layer of less permeable CL. Regardless of the conditions the water table is not a stabilized level and varies not only from area to area but also from season to season and ranges from 7 feet to 18 feet.

From the above subsurface information it appears that conditions, although not the best, exist that would allow a porous pavement construction based on the fact that the water table is at about 7 feet at a worst condition and that no bedrock exists that would entrap surface runoff in the top 2-3 feet and create a "quick" condition. There would be a negative condition built in at the shoulder edge where the water flowing laterally would emerge at the edge of the shoulder and result in a saturated condition just off the pavement edge in periods of extended precipitation such as early spring. This condition could represent a problem with mowing the grass in the spring and summer but primarily

the spring when equipment had to operate in this transitional area. The same conditions would exist in the late fall and early winter but equipment access would not be as important. The same conditions would be present in the event of an accident requiring access by CFR equipment during the same seasonal conditions. It is also however more probable that similar conditions already exist during the wetter seasons so it is also likely that the conditions would be only slightly worsened than the present stability along the shoulder edges. This edge condition could be minimized by the addition of a drainage system installed at the shoulder edge to intercept the flows and carry them to the main storm drain system.

Considering that the subsurface conditions do not present an impossible set of design considerations, it would be possible to design a system to allow for surface water to penetrate the pavement section and to enter the subgrade with the excess being carried to a collector system and ultimately to the storm drain system in the infield.

3.0 STORM WATER QUALITY AND QUANTITY BENEFITS

From a water quality perspective it would be desirable to intercept the initial 15 minute precipitation (the most critical period with regard to contaminates on the pavement surface) washing across the taxiway pavement surface and provide storage instead of allowing the flow to enter the storm water system and to continue into the onsite retention basis and ultimately to the watershed in White Oak Swamp. Utilizing the porous pavement design methodology, this quality objective could be accomplished in addition to the quantity objectives reducing the storm water runoff associated with the additional 35 foot shoulder along the taxiway. As the precipitation continued and when the runoff filled the volume of voids in the pavement section and exceeded the permeability rate of the subgrade, at some point the system would not prevent runoff from continuing across the shoulders and into the storm drain system. However the same condition would be true of any saturated soil or a rainfall of high intensity and short duration on turf areas. Therefore it would appear that the design of a porous

pavement would benefit both storm water quantity and quality to a great extent that most storms would fall within the intensity level and duration that the voids in the pavement system and the subgrade peculation rate would allow for the storage of contaminants as well as volume of runoff. This design would not prevent a contamination of the surface ground water from contaminants since the subgrade drainage would eventually reach this level. However, the minimum of 7 feet of soil above the water table and the more likely 15 feet of soil above the table would provide a significant level of filtration prior to entering the water table and would be no different than the present conditions. More importantly the use of the porous shoulder pavement would significantly increase the time of concentration for stormwater on both the pavement and shoulder for most short duration low intensity storms and many long duration short intensity storms. This effect would directly benefit the design of the stormwater drainage system by increasing the time of concentration for the pavement runoff and subsequently the impact of the runoff on present storm water retention and detention basins.

4.0 STRUCTURAL DESIGN OF THE PAVEMENT

The final pavement design does not present an especially difficult problem as a result of our study. Since the pavement section above the subgrade is designed for a limited number of repetitions, the key item of the design is to protect the subgrade which will almost always be in a state of semi saturation during seasonally wet periods. Section 803 of the FAA Advisory Circular 150/5300-13 (Exhibit 1), specifies the design standards for shoulders. For a group 5 aircraft a surface thickness of 3 inches bituminous concrete is required for normal paved shoulders. The base should be designed in accordance with VDOT standards which are the current 1993 AASHTO Design of Pavement Structures manual.

4.1 POROUS SURFACE COURSE FUNCTION

To provide a porous pavement structure it would be necessary to reduce the minimum bituminous surface course thickness outlined in the advisory circular from 3 inches to 3/4 to 1 inch. The surface course material would be FAA P-402 Porous Friction course at the standard 3/4 to 1 inch thickness. The porous friction course will allow the stormwater falling on the surface of the main taxiway pavement as well as the paved 35' shoulder to penetrate through the surface course and into the porous base below.

4.2 POROUS BASE COURSE AND SEPARATION LAYER FUNCTIONS

For the base course we would recommend an open graded cement stabilized material. We recommend this material due to the constant exposure of the material to water which would over time destroy the bond for a bituminous stabilized material. The exposure of the portland cement stabilized bond material would not would not degenerate over time due to exposure to moisture as would the bituminous bond. If a mix design utilizing portland cement cannot be formulated then as a second choice we would recommend a open graded bituminous base.

As a subbase or separation layer we would recommend a open graded aggregate to provide as initial work platform as well as an aquifer for the runoff. The AASHTO design manual presents coefficients of permeability for specific gradations of open and dense graded aggregates. The permeability rates for graded aggregates range from 10 foot per day (fpd) for dense graded aggregates such as VDOT 21A to 8000 foot per day (fpd) for non stabilized open graded aggregate such as size #57. The AASHTO research and other data collected in the field (Appendix B) indicate that a rate of 3000 feet or more per day is representative of a size #57 aggregate stabilized with 2% bituminous product. We can assume that the same rate will apply to the same graded aggregate stabilized with portland cement and the literature states that several state DOTs have utilized portland cement with the same results.

Therefore once the stormflow has penetrated the porous friction course the permeability rate through the stabilized base will be a minimum of 3000 fpd and then into the non stabilized separation layer graded to a slightly denser volume also with a rate of 3000 fpd . Considering only the 35' paved shoulder, we have developed a comparison to indicate the differences in time of concentration of the flows to the infield inlets. Table 1 represents the differences in time of concentrations for the standard paved shoulders and the porous paved shoulders. As can be seen the differences are enormous and reflect a major increase in the time of concentration for the design storm. As an example the time of concentration for a conventional pavement shoulder 35' in width is 0.16 minute. The time of concentration for a porous pavement shoulder 17' deep and 35 ' wide is 17.1 minutes. This increase of over 100 percent for the time of concentration will greatly reduce the volume of storm water retention necessary for not only the quantity but also quality.

The underlying subbase or separation layer will prevent intrusion of fines from the subgrade but allow a percentage of the runoff to penetrate the subgrade and reenter the ground water system. The permeability of the silty clays (CL) is extremely low and cannot be expected to contribute greatly to the time of concentration with the coefficient of permeability at 0.0002 fpd. The silty sands (SM) and the clayey sands (SC) are not appreciably better with regard to permeability but will provide some measure of filtration and storage, especially with regard to contaminations of materials with greater specific gravities such as heavy metals.

5.0 FINAL PAVEMENT DESIGN

Figure 1 represents the final recommended pavement section for the porous pavement shoulder . The recommended section contains a 3/4 inch P-402 porous friction course surface course. The porous base course would be 9 inches of cement stabilized #57 aggregate slightly modified to be obtained by crushing the demolished portland cement concrete pavement from existing taxiway A or obtained from off site sources. The separation layer would be a 7 inch section of #68 crushed

aggregate with the gradation modified to be on the coarse side of the gradation band with the exception that this section will not be stabilized.

The design methodology for the final pavement section comes from the Corps of Engineers Engineer Technical Letter 1110-3-435 dated 1 May 1992 (Appendix C). The approach used the design methodology developed for drainage layers underneath both rigid and flexible pavement systems. The purpose for the drainage layer in the Corps of Engineers technical letter is opposite of the goal for our design. The COE purpose was to provide for rapid drainage of water into the pavement system from the surface or other sources. In their case the more rapid rate of drainage the better the system. In addition, their design called for the determination of the layer thickness to handle a finite volume of water. We on the other hand are allowing water to enter our system and the design goal is to contain as much a volume as economically possible in the drainage layer and to release the flows at a rate slow enough to compensate for the additional pavement surface associated with the paved shoulders. Although the goals of each are entirely different the design criteria can be used for the design of each. It appeared that the best approach would be to design a shoulder section with a total pavement section equal to the 17 inch portland cement concrete slab thickness. This would allow for the exterior 3' section of the 8 inch thick P-304 dense graded cement stabilized base to be the impervious layer for prevention of the surface runoff to migrate back underneath the taxiway pavement section . The pavement section designs performed by the new FAA layered elastic software (Appendix D) also confirmed that the overall pavement section for the single pass dual gear aircraft also closely matched the total 17 inch thickness.

5.1 POROUS PAVEMENT DRAINAGE SYSTEM

In addition to the pavement section it became obvious that some form of drain system would be necessary to carry the runoff from major storms and periods of intense snow melt from the drainage layer to the storm drain system. We recognize that this underdrain system in some respects defeats

the intended purpose of a completely captured system. However, some provisions must be available to protect from saturating the subgrade underneath the primary taxiway pavement system which when saturated could lead to a reduced performance life. Therefore we have provided for an edge drain to be installed at the exterior of the shoulder to intercept the lateral flow of the water along the normal cross slope of the pavement and allow normal infield mowing and other maintenance to be accomplished. Our research on this matter revealed that the new 1993 AASHTO Pavement Design manual had significant information included in chapter 1with regard to stabilized drainage layers. We have compared this information with the Corps of Engineers gradations for portland cement stabilized open graded material with the recommendations of the stabilized drainage layers in the AASHTO manual. The gradations are very close with only minor variations in screen size.

5.2 POROUS PAVEMENT DESIGN SOFTWARE AND CONSTRUCTION SPECIFICATIONS

The actual pavement design was generated from the new FAA Layered Elastic Design software available from FAA. Although this design software is not yet fully integrated and approved for use the methodology in the software allows us to simulate very low repetitions by aircraft. Because the pavement section is primarily a portland cement stabilized section (no credit was given the porous friction course at the surface) we have utilized the rigid design procedure for this item.

The initial pavement section was designed utilizing dual gear aircraft loadings of 210,000 pounds at 1 and 2 annual loadings. The section was also designed for 125,000 pounds on dual gear. The designs (Appendix D) were used to determine the sensitivity of the two loadings. As can be expected the heaver aircraft required significantly greater thickness than the 125,000 pound aircraft. The probability of aircraft using the shoulder is rather limited since the pavement width is set for group 4 and 5 aircraft including the radii on all turns. Therefore we have selected the design for the lighter aircraft on dual gear at a loading rate of 1 pass per year.

The design methodology is more sensitive to the subgrade modulus of elasticity. As can be seen from the designs the variations in subgrade modulus ranged from 1000 psi to 5000 psi. The 1000 psi represented a super saturated subgrade condition which may only occur on very rare occasions. AASHTO design procedures recommends that the subgrade modulus be determined by multiplying the CBR value times 1500. The CBR values of two subsurface reports for the apron drainage project and the taxiway A and U project range from 3 to 6. If we select 3 as the worst condition then the design subgrade modulus will be 4500 psi.

Due to built in default values for the portland cement stabilized section we were not able to vary the modulus of elasticity for this particular section. The FAA layered elastic software uses approx 4,000,000 psi as the modulus of elasticity. The cement treated open graded material may not be as great but certainly within the 2.5-3 million range. The actual mix design will be determined at the time of construction utilizing materials either from local quarries or from crushed and recycled portland cement concrete pavement demolished and removed from existing taxiway A. The design specifications will include a minimum cement content of 376 lb. of cement per cubic yard and a maximum water cement ratio of 0.37. Based on mix designs used in California and Wisconsin this mix should give the desired strength as well as maintain the 3000 fpd permeability used in the drainage analysis. With the above in consideration we are still confident that the final design of 9 inches of porous portland cement stabilized pavement on 7 inches of open graded separation layer will perform for the intended purpose.

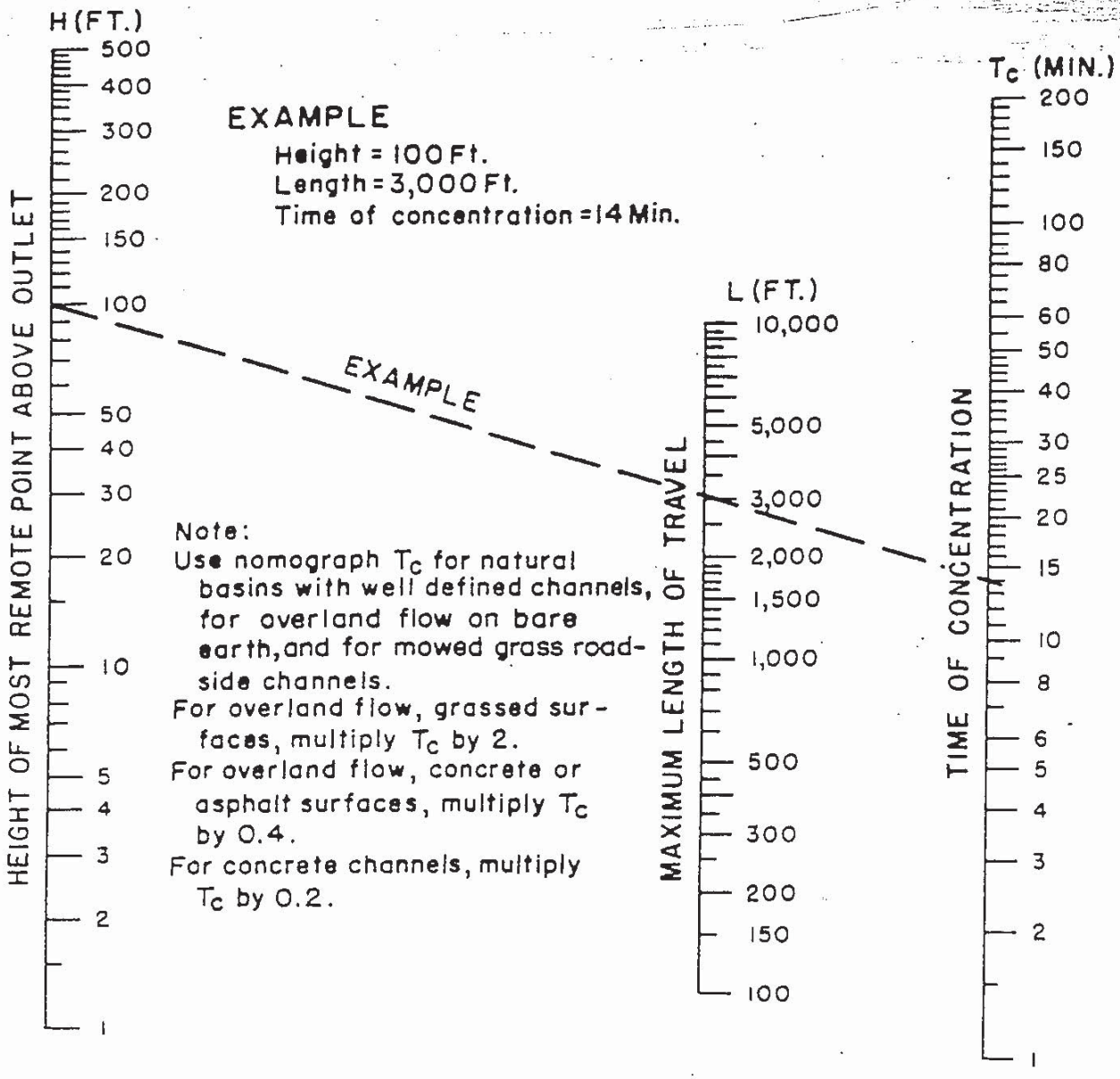
It appears that the porous pavement specification would be better served by using the COE specification Section 02243 DRAINAGE LAYER. We will however revise the specification title to reflect or original title POROUS SHOULDER PAVEMENT. We have attached the COE guide specification as Appendix E. The guide specification dated December 1992 is a relatively recent document containing all test requirements necessary for field placement and acceptance.

An additional design was performed on the AASHTO pavement design software (Appendix F). The AASHTO design was based on 1000 E 18 wheel load over the 20 year pavement life. The AASHTO design for a rigid pavement resulted in a 4 inch portland cement concrete surface on a 6 inch crushed aggregate base. To compensate for the fact that we are using a open graded portland cement concrete material as the performance surface, our design is for double the AASHTO design with respect to surface and total pavement thickness.

TABLE 1

TIME OF CONCENTRATION COMPARISONS

TABLE 1
T_C - CONVENTIONAL PAVED SHOULDER
35' width = 0.16 min (see chart)
T_C - TURF SHOULDER
35' width = 0.40 min (see chart)
T_C - POROUS PAVEMENT
6" CTPP - 35' width exfiltration factor = 3000 fpd 3000 fpd x $^{1\ day}/_{24\ hrs}$ x $^{1\ hr}/_{60\ min}$ = 2.08 fpm (35' + 6"/12)/2.08 = 17.1 min = T_C
10" #57 Aggregate - 35' width exfiltration factor = 8000 fpd 8000 fpd x $^{1\ day}/_{24\ hrs}$ x $^{1\ hr}/_{60\ min}$ = 5.6 fpm (35' + 10"/12)/5.6 = 6.5 min = T_C



Based on study by P. Z. Kirpich,
Civil Engineering, Vol. 10, No. 6, June 1940, p. 362

TIME OF CONCENTRATION OF SMALL DRAINAGE BASINS

35' shoulder uses a factor of 3 to fit on graph

$3 \times 35' = 105'$ $T_C = {}^{1.2}/_{3} = 0.40$ min x $0.40 = 0.16$ min

B.4. Paine Field Pervious Concrete Roadway

PAINE FIELD/SNOHOMISH COUNTY AIRPORT

PERVIOUS CONCRETE ROADWAY PAVEMENT

B.4.1 Overview

Paine Field/Snohomish County Airport (Paine Field) is a county-owned public-use airport located north of Seattle, Washington. The airport was created in 1936 as a public works project. The airport supports a unique aircraft mix, ranging from small, single engine aircraft to corporate-size jets. And it not only serves general aviation, but is also home of the Boeing Company's factories for the B-747, B-767, B-777, and B-787 aircraft. Tenants at the airport also include third-party aircraft inspection and repair facilities, which provide repair and maintenance services for commercial airlines and the Air Force.

The airport is rehabilitating their Central Ramp area in a multi-phase project. In the first phase, water quality enhancements and stormwater detention needed to be addressed to meet stormwater management requirements as part of the rehabilitation. As part of the first phase of the rehabilitation, in 2013 a pervious concrete roadway was constructed to provide detention and infiltration. Thirtieth Street, shown vertically in the center of figure B-10, is an entrance road to the ramp area and four industrial buildings' parking lots.

Figure B-10. Overview of 30th Street West pervious concrete roadway (map data ©2016 Google).

The Central Ramp had previously been grandfathered out of stormwater management requirements. However, with the planned rehabilitation, stormwater requirements needed to be met. The drainage basin the ramp is located in does not have sufficient open space to consider traditional surface ponds. The first phase of the rehabilitation project was initiated with the intention of combining stormwater detention and water quality management to meet County requirements. The project initially targeted 30 percent on stormwater detention for a 100-year storm and 30 percent on water quality (total suspended solids) enhancement. The project ended up getting 80-100 percent on detention and 20-30 percent on the stormwater quality.

As part of the planning, a permeable pavement was considered for the roadway pavement—other low impact design (LID) alternatives were used elsewhere. The airport was familiar with permeable pavements, and the County promotes the use of LID. The airport also had a strong champion for the project in the Airport Engineer. With this support, there were few hurdles in planning and implementing the permeable pavement design.

One of the major hurdles the project did have was funding. The Designer (CH2M) and Airport had to perform a significant amount of conceptual engineering work in seeking a grant from the Washington State Department of Ecology (WSDOE). They began their quest for a grant in 2009 and obtaining the funding took several years. The first couple of applications were unsuccessful, in part because of the number of other projects being considered. Their third application in 2012 was successful in obtaining a grant from WSDOE.

Once the project was funded and designs were completed, the project was put to bid. In the selected bid, pervious concrete was $64 per square yard, which was about twice the cost of standard concrete. Other materials were based on WSDOT specifications and had costs typical to the area.

B.4.2 Design Considerations

B.4.2.1 Hydrologic design

The design of the system was driven by stormwater management requirements. It was designed to provide as much stormwater management benefit as was possible, including both detention and retention.

Water Quality Standards

The basic treatment targets the removal of 80 percent of the total suspended solids (TSS) from stormwater. However, this value is at the outfall of the larger system that the pervious pavement feeds into, which includes a stormfilter vault. Monitoring of water quality is performed at the outfall.

Infiltration Rates

An infiltration test was performed to determine subgrade infiltration rate at the project site. The existing soil was found to have very low permeability, with infiltration rates below 0.3 inches per hour. For system design, a long-term infiltration rate of 0.1 inches per hour was used. Because of the low infiltration rate, the use of underdrains was also needed in addition to the crushed stone ballast layer.

The system provides both retention and detention. Subsurface berms (figure B-11) within the crushed stone ballast, were placed every 50 feet longitudinally to allow the system to have a greater storage capacity to infiltrate a larger volume of stormwater. The system provides a bypass for larger storm events with underdrain pipes near the top of the aggregate, with the pipe perforations located at the top of the pipe (see figure B-12).

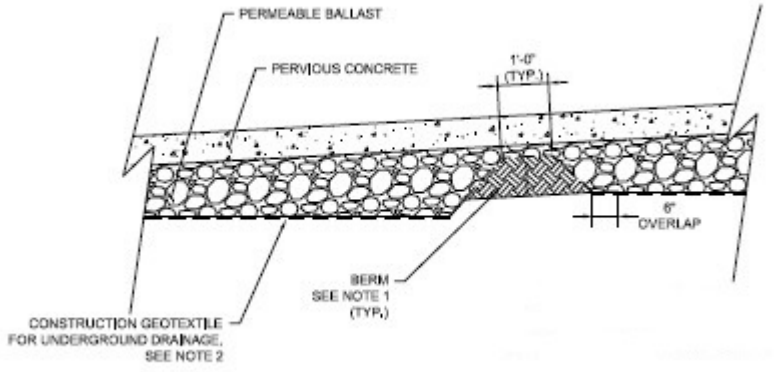


Figure B-11. Pervious concrete roadway cross section (CH2M 2014).

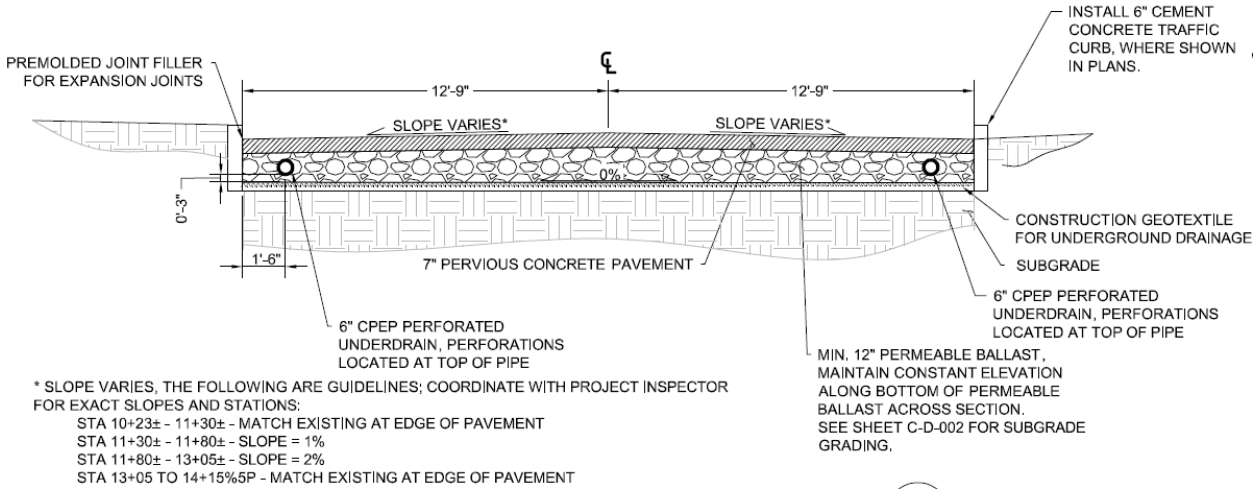


Figure B-12. Underdrain detail (CH2M 2014).

Infiltration rates of the final system have not been tested.

Storage Capacity

Infiltration capacity requirements were determined based on a 100-year storm. The project goal was to accomplish the greatest storage capacity feasible, given cost constraints. The final design of the aggregate layer thickness provided capacity in excess of a 100-year storm.

B.4.2.2 Pavement design

Traffic on 30th Street is primarily automobiles. However, because it provides access to several buildings and the apron, larger trucks do use the roadway. Thickness design is based on light to medium weight traffic. Guidance provided by American Concrete Institute (ACI) (522R-10, *Report on Pervious Concrete*) was used for the design. A saturated subgrade CBR was used in the design.

B.4.3 Material Selection

B.4.3.1 Pervious Concrete

The wearing course consists of a 7-inch pervious concrete layer. The project specification requires American Concrete Institute (ACI) 522.1-08, *Specification for Pervious Concrete Paving* (ACI 2008) be used for the project. However, the following revisions were made to the pervious concrete materials for the project:

- Aggregates: Nominal maximum aggregate size meeting No 8 coarse 31 aggregate (3/8" to No. 16) per ASTM C 33.
- Cementitious Materials: Portland cement Type I or II conforming to 36 ASTM C 150 or portland cement Type IP or IS conforming to ASTM C 595.

B.4.3.2 Base layer

The project specifications revised the ACI specification for subbase material to use WSDOT-based specifications. The requirement was changed to require that the subbase material comply with Section 4-04 – Ballast and Crushed Surfacing, Permeable Ballast of the 2012 edition of the WSDOT *Standard Specifications for Road, Bridge, and Municipal Construction*. The base layer is a minimum of 12 inches thick, but varies in thickness because of the roadway longitudinal grade and the use of check dams. The grading requirements for permeable ballast are provided in table B-9.

Table B-9. Grading requirements for permeable ballast (WSDOT 2012).

Sieve size	Percent passing
2 1/2 inch	99-100
2 inch	65-100
3/4 inch	40-80
No. 4	5 max.
No. 100	0-2
% Fracture	75 min.

B.4.3.3 Drainage Materials

Two 6-inch corrugated polyethylene pipe (CPEP) perforated underdrains are used within the permeable ballast base layer along the pavement edges for drainage, as shown in figure B-12. The perforations were installed facing up for overflow from the ballast layer during heavy rainfalls.

B.4.3.4 Geotextiles

The pervious concrete roadway required two separate geotextiles: a separation fabric between the subgrade and drainage layer and a plastic liner for the check dams. The required properties for the plastic liner are summarized in table B-10.

Table B-10. Summary of plastic liner requirements (CH2M 2013).

Property	Required Values	Test Method
Thickness	40 mils, plus or minus 2%	ASTM D1593
Specific Gravity	1.20 min.	ASTM D792
Elongation at Break	430% min.	ASTM D882, Method A
Tensile Strength	97lb/in width, min.	ASTM D882, Method A
Tear Resistance, Each Direction	10 lbs, min.	ASTM D1004, Die C
100% Modulus	40lbs/in	ASTM D882, Method A
Water Extraction, as compared to Blanks of Same Nominal Thickness	0.2% loss, max.	ASTM D1239
Volatility	0.5% loss, max.	ASTM D1203, Method A
Low Temperature, Pass	Minus 29 degrees F	ASTM D1790
Dimensional Stability, Each Direction	3% change, max.	ASTM D1204 (MD and TD)

B.4.4 Construction Considerations

As mentioned previously, the pervious concrete complies with ACI 522.1-08. The Contractor was required to meet the experience and certification requirements of the specification as a condition of award. The specification was revised to include:

> *If the Contractor has insufficient experience with pervious concrete pavement the Contractor shall, at their own expense, retain an experienced consultant to monitor production, handling, and placement operations. The selection of the consultant shall be subject to the acceptance of the Architect/Engineer.*

The contractor placing the pervious concrete had the National Ready Mixed Concrete Association's (NRMCA's) certifications, including the workers placing the materials being certified. The local concrete industry representative was also on site during placement of the test section. The producer of the pervious concrete was also NRMCA-certified.

Strength samples were taken during construction. However, no infiltration testing was conducted.

The joints were tooled during placement and were not sawcut. The designer noted later that the joints were possibly not as well defined using tooling as they would have been with sawcutting. No other significant construction issues were identified during the interview.

B.4.5 Performance and Maintenance Activities

Since the completion of construction in 2013, the permeability of the pavement appears to be maintained. The airport vacuum sweeps the pavement approximately weekly. There are cracks in a couple of panels, as shown in figure B-13. While not known if the cracks are related, among the lessons learned, CH2M, the Airport's consultant, suggested the contractor could have done better with constructing the joints. The joints were troweled, not sawcut, and as a result were not very well defined. The surface appears to be holding up to traffic, but it is mostly a straight section of roadway with few turning movements.

Figure B-13. Longitudinal cracking in pervious concrete panel (courtesy CH2M 2016).

B.4.6 Lessons Learned/Barriers

Based on the interviews, some of the lessons learned include the following:

- Strong champions within the County helped with the project being implemented. Repeated attempts were required to obtain the necessary funding to move beyond the preliminary planning.
- The project required the contractor to purchase an adequate number of ACI specifications. Developing a standard specification that does not require purchase is needed.
- The joints in the pervious concrete were tooled during placement, and the joints did not appear to be well defined. CH2M believes sawcutting the joints would provide a better joint.
- In the Airport's opinion, the pervious concrete appears to have a more durable surface compared to the abrasion they have observed in porous asphalt areas.

B.4.7 Sources of Information

The project team would like to acknowledge the valuable input and assistance provided by the following individuals:

- Kevin Cooley, P.E., Principal Project Manager, Senior Airfield Engineer, CH2M
- Jan O'Neill, P.E., C.M., Airport Engineer, Paine Field Airport

The following documents also provided valuable information used in this summary:

- Design report, construction specifications, and project drawings provided by Paine Field Airport.
- Photographs provided by CH2M (May 2016).

B.4.8 Paine Field Pervious Concrete Roadway Design Report

Final Report

Full Drainage Plan
Paine Field Airport
Central Ramp Phase 1
Paine Field PFN: 13-104448

Prepared for

Snohomish County Department of Planning and Development Services

May 14, 2013

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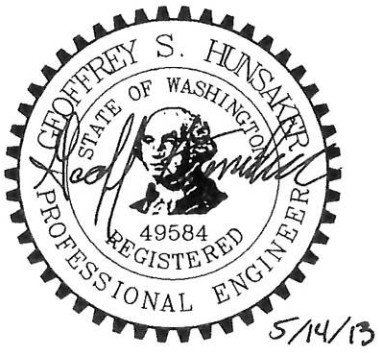


Executive Summary

Paine Field/Snohomish County Airport plans to rehabilitate the Central Ramp area of the airport. The first phase of this rehab is the construction of a stormwater detention facility and water quality enhancements. The Central Ramp is an approximately 20-acre asphalt ramp containing hangars and aircraft tiedowns for small light aircraft. The ramp is located within Subbasin SC-5 of the Swamp Creek basin, which also contains four large industrial buildings with parking lots. Currently, Subbasin SC-5 has no stormwater detention, or runoff control, and only a portion of the basin receives water quality treatment.

Analysis of the subbasin in its current condition shows that approximately 14 acre-ft of detention is required to meet flow duration requirements and pre-development release rates. Stormwater quality requirements for the currently untreated portions of the subbasin are 4.31 cfs of on-line flow or 2.48 cfs of off-line flow.

Due to limitations within the site and conveyance system, the runoff will be treated in a proprietary filter cartridge treatment system. This project will construct a flow diversion structure and off-line water quality treatment vault that will use a mechanical filtration system to treat all the water from Subbasin SC-5 that is currently untreated. All runoff that is currently treated will enter the conveyance system downstream of the treatment vault.

There is no location within Subbasin SC-5 that can be feasibly developed to provide 14 acre-ft of detention within the budget of this project. Currently, the airport is performing further study involving the use of a wetland downstream of the subbasin for detention. The airport is also exploring ways to further reduce the detention requirements of the subbasin.

The airport has identified pervious pavements as a form of LID improvement that can be used to reduce the detention requirements of Subbasin SC-5. As part of this project, a 390-foot stretch of 30th Ave W will be repaved with pervious concrete. A large section of drain rock will be placed under the pavement section to detain stormwater as it infiltrates into the subgrade.

Contents

Drainage Information Summary Form

Project Name: Central Ramp Phase 1 Stormwater Improvements **ZA or PFN:** 13-104448

Project Engineer: Geoff Hunsaker, CH2M HILL

Project Applicant: Jan O'Neil, Snohomish County Airport

Project Total Area: 39.93 acres

Project Development Area: 39.93 Number of Lots (if applies): N/A

Summary Table

Drainage Basin Information	Individual Basin Information
	Swamp Creek Subbasin SC-5
On-Site Sub-basin Area (acres)	39.93
Type of Storage Proposed	Underground Storage Facility
Approx. Storage Volume (acre-ft)	14.17
Soil Type(s)	Disturbed
Pre-developed Runoff Rates	
Q (cfs) 2 yr	0.74
10 yr	1.38
100 yr	2.48
Redevelopment Area	
Post-development Runoff Rates	
Q (cfs) 2 yr	9.38
10 yr	15.29
100 yr	24.19
Offsite Upstream Area	
Number of acres	0
Offsite Downstream Flow	
Q (cfs) 100 yr	--

SECTION 1

Description of Existing Site Conditions

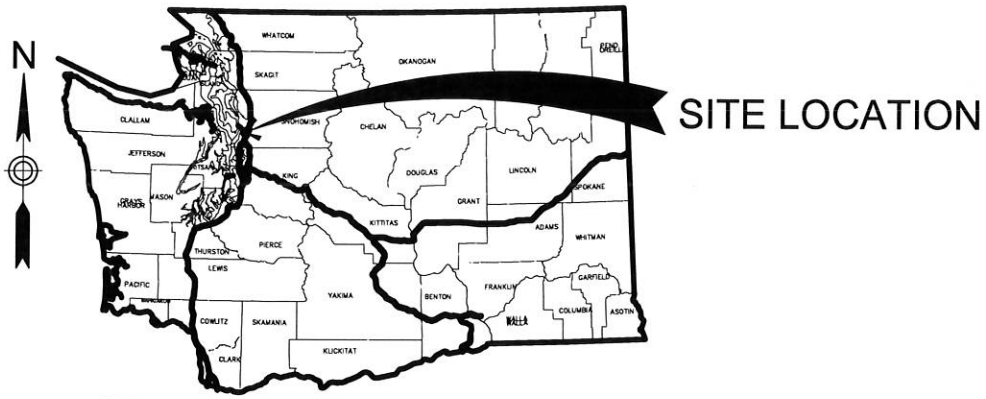
This section describes the current conditions of the Central Ramp and drainage basin SC-5.

Paine Field is located on a plateau 5 miles southwest of the City of Everett. The Central Ramp is located in the east-central portion of the airfield. See Figure 1-1 for a vicinity map of the area. Basin SC-5 is a 39.9 acre of the Swamp Creek Drainage Basin, which consists mostly of the Central Ramp. Basin SC-5 has slopes between zero and 15 percent, but the basin is generally flat. The basin is located between Runway 11/29 to the west and south, 100th Street SW to the north, and Runway 16L/34R to the east. Only a small portion of Subbasin SC-5 receives water quality treatment. The rest of the basin has no existing treatment facilities or stormwater detention.

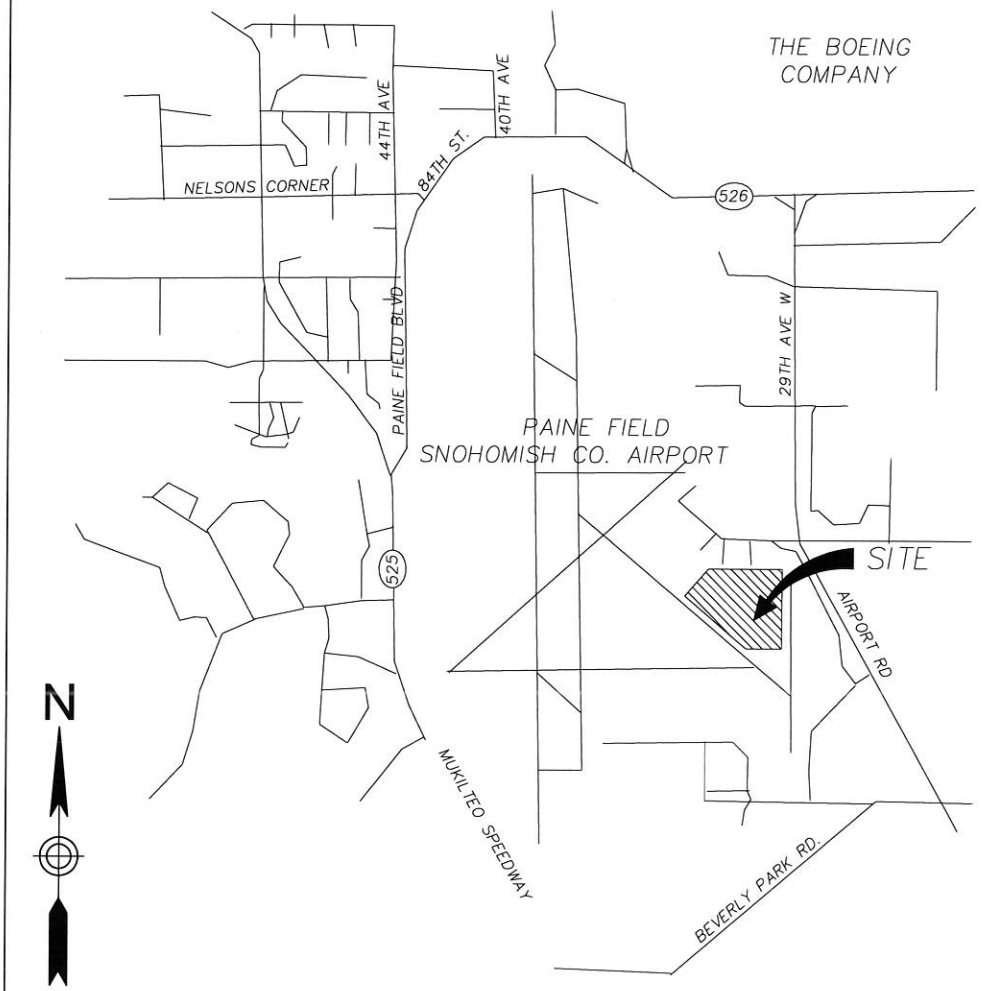
Subbasin SC-5 discharges to a culvert that runs underneath Airport Road to the east. This culvert releases into a wetland area in Basin SC-4 (Wetland ERR) which is located directly to the east of SC-5 on the opposite side of Airport Road.

Prior to development of the Central Ramp, Subbasin SC-5 was second-growth forest. The soils prior to that time were Alderwood soils characterized by a shallow cemented till layer that restricts infiltration of rainfall. As a result, a shallow water table often builds up during the wet winter season. Generally, the soils have a relatively low erosion factor. Alderwood soils belong in Hydrologic Group C, consisting of soils that have a low overall infiltration rate and consequently produce a relatively high amount of runoff during a rainstorm. See Appendix D for a soils map of the area.

Currently, most of Subbasin SC-5 is a 20 acre general aviation ramp with 16 hangar buildings and over 150 Group I aircraft tiedowns. The basin area also contains 4 large industrial buildings with parking lots and cross street pavement. In addition, a portion of Taxiway G and Runway 16L-34R are located within the basin. There is currently no stormwater water quality treatment, runoff control systems, or fuel spill valve control in the basin. See Figure 1-2 for the existing basin boundary.



STATE OF WASHINGTON



VICINITY MAP
NTS

CENTRAL RAMP - PHASE 1
STORMWATER IMPROVEMENTS
SNOHOMISH COUNTY AIRPORT - PAINE FIELD
EVERETT, WASHINGTON

FIGURE 1-1

FIGURE 1-2 SUBBASIN SC-5 BOUNDARY

CH2MHILL

SECTION 2

Description of Developed Site Conditions

This Full Drainage Plan has been prepared under the following applicable codes and regulations:

- Snohomish County Code Chapter 30.63A: Drainage
- Snohomish County Code Chapter 30.63B: Grading
- Snohomish County Code Chapter 30.63C: Low Impact Development

In addition stormwater quality treatment and stormwater detention for the Central Ramp have been prepared under the current county drainage manual and standards:

- Snohomish County Drainage Manual dated September 30, 2010
- 2010 Snohomish County Engineering Design and Development Standards (EDDS), Chapter 5 Drainage

This section describes the Central Ramp Phase 1 Stormwater Improvements construction project and the stormwater management system proposed for the project.

2.1 Project Description

Snohomish County Airport (Paine Field) has an approved Master Drainage Plan that was developed to guide stormwater management for the future development and build-out of Paine Field. The Master Drainage Plan identified existing deficiencies in the stormwater system and capital improvements to provide for near-term and long-term needs. One of the areas identified as having a stormwater detention and treatment deficiency is the Central Ramp. This project is the first phase of a planned capital improvement project that will rehabilitate the central ramp and provide stormwater detention and treatment for the drainage basin.

The Central Ramp was constructed in the 1980's and at that time the Santa Barbara Unit Hydrology (SBUH) method was the preferred method for hydrologic analysis. However, the Washington State Department of Ecology (WSDOE) will not allow the treatment and detention modeling for the Central Ramp to be grandfathered in under this method of analysis. The WSDOE requires all future development of the Central Ramp requiring runoff and treatment be evaluated using the current hydrologic analysis method, the Western Washington Hydrology Model (WWHM version 4), which is a continuous hydraulic model.

Due to limitations within the site and conveyance system, the runoff will be treated in a mechanical treatment system. This project will construct a flow diversion structure and off-line water quality treatment vault that will use a mechanical filtration system to treat all the water from Subbasin SC-5 that is currently untreated. The runoff from that portion of the subbasin that is currently treated (primarily Runway 16L/13R) will enter the conveyance system downstream of the treatment vault.

As discussed in Section 2.3, there is no location within Subbasin SC-5 that can be feasibly developed to provide 14 acre-ft of detention within the budget of this project. Currently, the airport is doing further study in the use of a wetland downstream for detention. The airport is also beginning to look into ways to further reduce the detention requirements of the subbasin.

The airport has identified pervious pavements as a form of LID improvement that can be used to reduce the detention requirements of Subbasin SC-5. As part of this project, a 390 ft stretch of 30th Ave W will be repaved with pervious concrete. Drain rock will be placed under the pavement section to detain stormwater as it infiltrates into the subgrade.

2.2 Stormwater Treatment

The primary activity occurring on the Central Ramp is aircraft movement. There is no bulk materials storage or storage tanks at the site. There is a single permanent aircraft fueling location on the ramp. Fueling can take place in other locations on the ramp using fueling trucks, as well. For the Central Ramp, basic stormwater treatment will be provided. Basic treatment targets the removal of 80 percent of total suspended solids (TSS) from stormwater.

In addition, a positive shut-off valve will be provided on the downstream end of the conveyance system, so that in the event of a fuel spill, the potential contamination will be prevented from leaving the site.

Due to the large impervious areas of the Central Ramp and the deep, below-grade depth of the conveyance system a shallow bioswale or Filterra-type water quality system is not feasible for most of the basin. Water quality treatment will instead be provided by Stormfilter cartridges in a large underground vault.

The Western Washington Hydrology Model (WWHM) (see Section 2.3) has been used to size the stormwater treatment facilities for this project. The continuous model, WWHM, was used to ensure the requirement that 91 percent of annual stormwater runoff receives water quality treatment. See Appendix A for the WWHM model output.

Currently, 8.57 acres of Subbasin SC-5 receives water quality treatment from overland flow through filter strips. This area is located around Runway 16L/34R and Taxiway G. As part of a current rehabilitation project, the treated water from this area will be conveyed into a new pipe that will merge with the conveyance system from the rest of the basin after the stormwater treatment vault.

The stormwater facility capable of handling 91 percent of the annual stormwater runoff for the remaining 31.37 acres of the subbasin will need to be able to handle 2.48 cfs of off-line flow. A stormwater treatment vault with the capacity for 99 Stormfilter cartridges will be built to treat this flow rate. The storm filters will be 27" tall and have a treatment capacity of 1 GPM/ft2. The stormfilter vault has an internal overflow bypass that can handle 1.8 cfs more than the treatment rate, thus the maximum flow rate the vault is capable of handling is 4.28 cfs. A high flow bypass structure will be constructed so that flow rates over 3.14 cfs will overtop the weir and start flowing through the bypass pipe. This will allow the vault to be able to handle more cfs in the future by just increasing the amount of stormfilters in the vault and the high flow bypass structure will not need to be modified.

2.3 Stormwater Detention

Basin SC-5 basin contains 39.93 acres, 30.74 acres of which is impervious, and has no stormwater detention before releasing to Swamp Creek. According to Snohomish County Drainage Code and the Washington State Department of Ecology, the runoff shall be detained before releasing.

Stormwater runoff and detention modeling were performed using the Western Washington Hydrology Model (WWHM version 4), a continuous simulation model from the Washington State Department of Ecology. As model input, the proposed land cover input into the model was either impervious (pavement or roof) or till pasture (grass areas and lawns). The pre-developed land cover was till forest, which is the standard pre-developed condition. The parameters used in the WWHM model can be found in the model output in Appendix B.

The areas requiring flow control are shown in Figure 1-2. As shown in Table 2-1, under the post-project conditions, 30.74 acres will be impervious and 9.19 acres will be pervious. With these parameters, a detention facility that meets the Washington Department of Ecology flow duration requirements and the peak volume release rate requirements would need to have a volume of approximately 14 ac-ft.

TABLE 2-1
Project Site Land Cover

	Acres	
	Pre-Developed (Target)	**Post-Project**
Forest	39.93	0
Pasture (grass)	0	9.19
Impervious Area	0	30.74

Note:
[a] Impervious area was broken down to 25.83 acres of parking (flat) and 4.91 acres of roof tops (flat)

There is currently no feasible location within SC-5 that can provide the required 14 ac-ft of storage. There is approximately 1 acre of area just to the north of Runway 16L/34R that could hold a detention facility, but the facility would be required to be underground and does not have enough hydraulic grade to achieve the necessary storage requirements.

There is a five-acre wetland east of Basin SC-5, on the far side of Airport Road. Named Wetland ERR, this wetland lies in Subbasins SC-3 and SC-4 and is being evaluated to determine if it is viable for hydrologic modification for stormwater detention. The wetland is a Category III wetland, and is potentially available for use for stormwater detention. This project will provide full stormwater water treatment for Subbasin SC-5 before discharge into the wetland. In addition, the airport is also evaluating ways to reduce impervious area within Subbasin SC-5 in the future.

2.4 Low Impact Development Measures

As part of the future development and rehabilitation of the Central Ramp project, the airport is committed to implementing low impact development (LID) features where feasible. Numerous opportunities for LID features were identified for the Central Ramp and are shown in Figure 2-2. These possible LID features were presented to the airport, and permeable pavement was selected as a viable LID improvement for this project since it will help to lower the airports detention requirements.

As part of this project, 30th Ave W will be repaved using pervious concrete pavement. An infiltration test was performed on April 23, 2013 to determine the infiltration rates at the location of 30th Ave. Modeling was done using WWHM 3 to determine the required reservoir rock layer thickness that will detain the 100 year storm as it infiltrates into the native subgrade. The results of the infiltration tests and WWHM modeling are included in Appendix C. A long-term infiltration rate of 0.10 inches per hour was used in the model, and it was determined that a minimum of 6 inches of gravel base would be required to hold runoff from the 100 year storm as it infiltrates assuming the gravel base uses permeable ballast with 30% voids. WSDOT states that typical void space in base layers can range from 20-40 percent. Using the lowest percentage of voids in the gravel base (20%) would require a rock depth of 9 inches.

This project will construct a pervious concrete section of 7" of concrete and a minimum 12" of gravel base. Since the infiltration rates of the soil are below 0.3 in/hr the gravel base will require underdrains. The underdrains will be placed with the top of the pipe 3" below the base of the concrete, and the underdrain will only have perforations at the top of the pipe. The 9" of gravel base below the perforations in the pipes will act as a detention reservoir for the stormwater. Despite the longitudinal slope of the road being less than 2%, check dams and benches in the subgrade grading will be placed to encourage infiltration in the low infiltration rate soil.

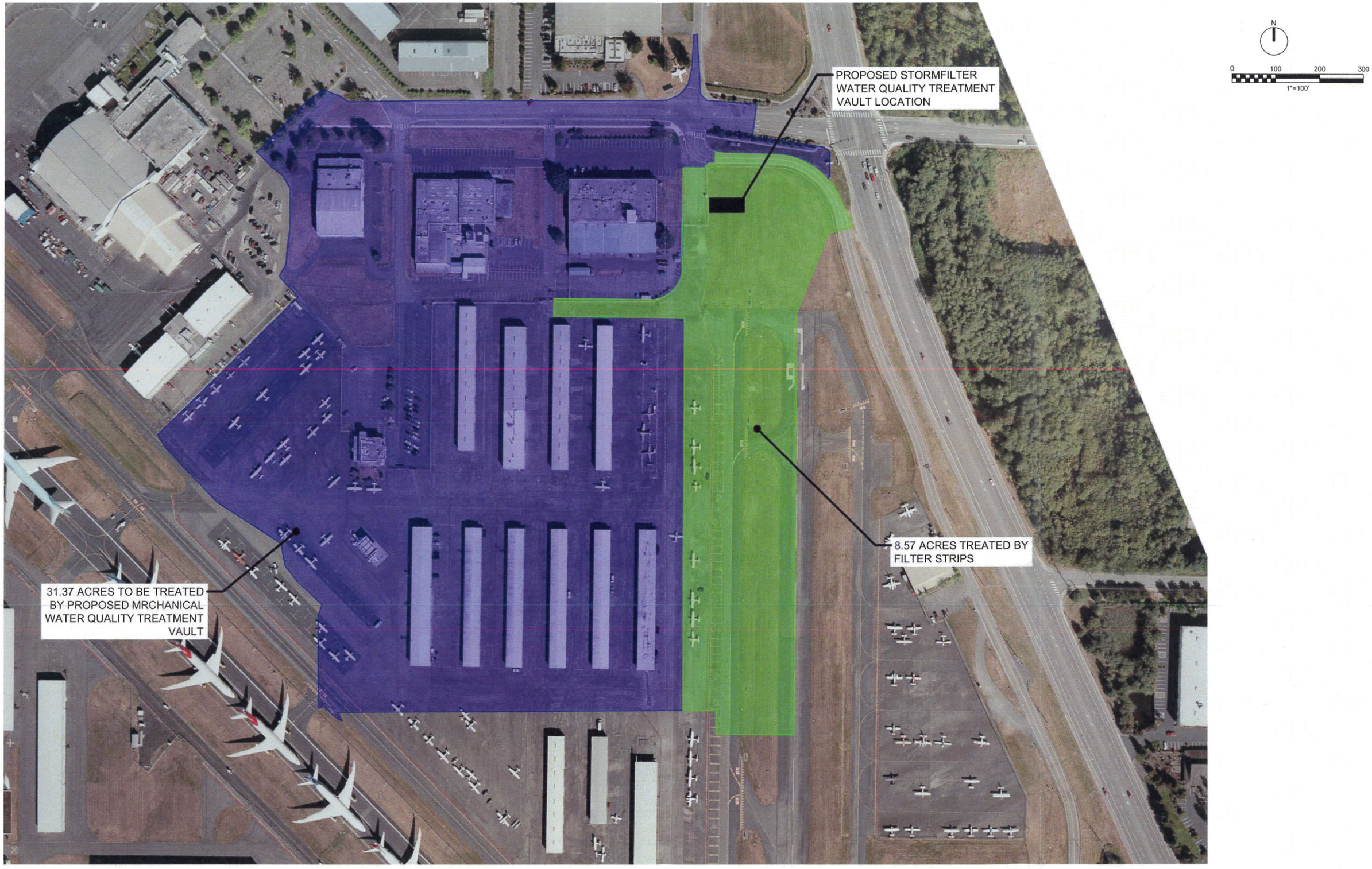


FIGURE 2-1 SUBBASIN SC-5 WATER QUALITY TREATMENT

CH2MHILL

SECTION 3

Risk Assessment Analysis and Erosion Control

The project site originally consisted of Alderwood soils, but most of the site has been disturebed and paved in the past. The slope within the project site is mostly gentle to moderate, ranging up to about 10 percent. Grass covers most of the existing construction area for the water treatment vault, and pervious concrete roadway construction area is currently paved. Where left undisturbed, the existing grass fully covers the ground surface and no signs of soil erosion are evident. The project site does not lie within an erosion hazard area or a landslide hazard area.

Most of the project site will be graded during the Runway 16L/34R reconstruction. However, additional grading and other land disturbing activities during construction of this project carry the risk of erosion and subsequent transport of sediment into the nearby drainage swale. Soils disturbed during construction will be susceptible to erosion.

Best management practices (BMPs) will be implemented during construction to minimize these erosion risks. Silt fencing will be used to limit offsite movement of eroded soil.

No construction activities are planned during the wet season (October 1 through April 30). If any unforeseen construction activities occur during the wet season, appropriate BMPs, such as temporary ceasing of grading activities and the interim stabilization or the physical cover of disturbed areas, will be implemented. The application of these and other BMPs for managing large volumes of construction runoff will be developed in further detail in the Stormwater Pollution Prevention Plan (SWPPP) prepared for this project.

Other erosion and sediment control measures will be used for this project. The following temporary measures are included:

- Inlet Protection will be installed on all inlets downstream for construction areas
- Clearing limits will be established using high-visibility clearing limits fencing, which will be installed prior to any earth-disturbing activity.
- Silt fences will be installed where disturbed area runoff might leave the site.
- Clearing will be restricted to areas scheduled for grading during the next week.
- Mulch or another type of ground cover will be applied on disturbed areas that are left unworked for more than 7 days during the dry season (2 days during the remainder of the year).

The erosion control measures will be inspected at least once per week and after every storm event greater than one-quarter inch in 24 hours.

The temporary erosion and sediment control measures will be removed after construction is completed and the disturbed areas have been stabilized.

The following construction sequence illustrates the application and the removal of erosion control BMPs for the project:

- Install construction entrance
- Install construction fences, silt fences, and inlet protection
- Carry out the site grading and install the project drainage system
- Stabilize disturbed soils
- Install landscaping
- Remove inlet protection
- Remove silt fencing, construction limits fencing and construction entrance

Permanent erosion control measures that will be used include the following:

- All of the disturbed areas will be planted with grass at the end of the dry season.

The regular runoff monitoring program at the outfall to the Swamp Cree basin will continue through the construction period, with the frequency increased to weekly monitoring during construction. The site will be visually monitored during the wet season following construction. Areas where grass or landscaping fails to establish will be replanted the following spring. Any areas showing signs of substantial erosion will be addressed immediately. As a result of these erosion and sediment control measures, the risk of substantial, project-related erosion at the project site within will be minimal.

SECTION 4

Downstream and Upstream Drainage Path Analysis

4.1 Downstream Analysis

Basin SC-5 outlets at the southeast corner of Airport Road and 100th St SW. It flows into an existing wetland (Wetland ERR) situated along the east side of Airport Road. The wetland extends south for approximately 1,000 ft before turning south and discharging under 103rd Street in an 18-inch storm pipe. The flow heads east on 103rd Street in a storm pipe for approximately 600 feet before discharging to a swale. This swale continues to flow southeast through forested open space eventually merging with the main stem of Swamp Creek.

On December 4, 2012 CH2M Hill staff walked approximately 1,500 feet immediately downstream of the discharge pipe into the wetland. No areas of erosion problems were observed during the inventory.

4.2 Upstream Analysis

The project lies along the upstream boundary of the Swamp Creek Basin.

SECTION 5

References

O'Neil, Jan 2012, personal communication, Snohomish County Airport, November 1, 2012.

Otak. 2008. *Paine Field Snohomish County Airport Master Drainage Plan*, Everett, Washington.

Dolan, Bill, personal communication, November 14, 2012, Snohomish County Airport, Everett, Washington.

Soil Conservation Service. 1983. *Soil Survey of Snohomish County Area, Washington*. U.S. Government Printing Office, Washington, D.C.

Washington State Department of Ecology (Ecology). 2012. *Stormwater Management Manual for Western Washington* . Lacey, Washington.

Washington State Department of Ecology (Ecology). 1992. *Stormwater Management Manual for the Puget Sound Basin*. Lacey, Washington.

Snohomish County. 2010. *Snohomish County Drainage Manual*. Everett, WA

Puget Sound Action Team. 2012. *Low Impact Development Technical Guidance Manual for Puget Sound*. Olympia, WA

B.4.9 Paine Field Pervious Concrete Roadway Specifications

2-03 Roadway Excavation and Embankment

2-03.3(14) Embankment Construction

2-03.3(14)C Compacting Earth Embankments

Section 2-03.3(14)C is supplemented with the following:

(March 13, 1995)
All embankments, except waste embankments, shall be compacted using Method A.

2-09.3(1)D Disposal of Excavated Material

The second paragraph of 2-09.3(1)D is revised to read:

All costs for disposing of excavated material shall be included in the unit Contract price for Structure excavation, Class A or B. Material shall be disposed of at an approved offsite facility. Cost to haul material to the offsite facility shall be included in the contract unit price for Structure Excavation Class A or B. No additional payment will be made to transport the material to the offsite facility. The Contracting Agency will not pay for handling at the disposal site. Any such disposal shall meet the requirements of Section 2-03.3(7)C.

2-13 Plastic Liner

Add the following section:

2-13.1 Description

The Contractor shall furnish and place plastic liner in accordance with the details shown in the Plans.

2-13.2 Materials

The Plastic Liner shall be made by compounds from domestic virgin polyvinyl chloride resin and high quality ingredients to produce flexible, durable, watertight product. Uniform throughout in color, thickness, and size, and surface texture and quality.

The liner shall be free from dirt, oil, foreign matter, scratches, cracks, creases, bubbles, pits, tears, holes, or other defects that may affect its serviceability.

Physical Properties for Plastic Liner: Meet or exceed the following requirements:

30-mil PVC Geomembrane Physical Properties

Property	Required Values	Test Method
Thickness	40 mils, plus or minus 2%	ASTM D1593
Specific Gravity	1.20 min.	ASTM D792
Elongation at Break	430% min.	ASTM D882, Method A
Tensile Strength	97lb/in width, min.	ASTM D882, Method A
Tear Resistance, Each Direction	10 lbs, min.	ASTM D1004, Die C
100% Modulus	40lbs/in	ASTM D882, Method A
Water Extraction, as compared to Blanks of Same Nominal Thickness	0.2% loss, max.	ASTM D1239
Volatility	0.5% loss, max.	ASTM D1203, Method A
Low Temperature, Pass	Minus 29 degrees F	ASTM D1790
Dimensional Stability, Each Direction	3% change, max.	ASTM D1204 (MD and TD)

2-13.3 Construction Requirements

The area to be covered by the plastic liner shall be graded to a smooth, uniform condition free from ruts, potholes, and protruding objects such as rocks or sticks. The plastic liner shall be spread immediately ahead of the covering operation. The plastic liner shall not be left exposed to sunlight during installation for a total of more than 14 calendar days. The plastic liner shall be laid smooth without excessive wrinkles. Under no circumstance shall the plastic liner be dragged over sharp objects which could damage the liner.

Placement of aggregate on the plastic liner shall start at the toe of the slope and proceed upwards. The plastic liner shall be secured to the slope but shall be secured loosely enough so that the plastic liner will not tear when aggregate is placed on the liner.

Should the plastic liner be torn, punctured, or the overlaps disturbed as evidence by visible plastic liner damage, the backfill around the damaged or displaced area shall be removed and the damaged area repaired or replaced, to the satisfaction of the Engineer, by the Contractor at no expense to the Contracting Agency. The repair shall consist of a patch of the same type of plastic liner placed over the

damaged area. The patch shall overlap the existing plastic liner from the edge of any part of the damaged area by the minimum overlap for the application.

2-13.4 Measurement

Plastic liner will be measured by the square yard for the approved ground surface area actually covered, not including overlaps.

2-13.5 Payment

Payment will be made in accordance with Section 1-04.1, for each of the following Bid items that are included in the Proposal:

"Plastic Liner", per square yard

DIVISION 5
SURFACE TREATMENTS AND PAVEMENTS

5-06 PERVIOUS CONCRETE PAVEMENT - *NEW SECTION*

5-06.1 Description

The work in this section is based on American Concrete Institute Specification for Pervious Concrete Paving ACI 522.1-08 dated March 2008 and the February 15, 2010 Errata sheet which are copyrighted documents. Contractor will be required to meet the experience and certification requirements of this specification as a condition of award. Contractor shall pay all fees associated with obtaining sufficient copies of the specification for bidding and construction from the ACI Website (http://www.concrete.org/BookstoreNet/ProductDetail.aspx?itemid=522108).

5-06.2 Materials

Materials shall conform to all requirements of ACI 522.1-08, "Specifications for Pervious Concrete Pavement" and all subsequent Errata published by the American Concrete Institute, Farmington Hills, Michigan except as modified by the following:

Section 2 – Products

Section 2.1 – Subbase: Delete the first paragraph and replace with the following:

Subbase material shall comply with Section 4-04 – Ballast and Crushed Surfacing, Permeable Ballast of the 2012 edition of the Standard Specifications for Road, Bridge, and Municipal Construction published by the Washington Department of Transportation.

Section 2.2 – Pervious Concrete: Delete the first paragraph only and replace with the following:

Comply with ASTM C94/C94M, Option A, and the following requirements:

Delete the subsection and replace with the following:

2.2.1 Aggregates: Nominal maximum aggregate size meeting No 8 coarse aggregate (3/8" to No. 16) per ASTM C 33.

Add following subsection:

2.2.5 Cementitious Materials: Portland Cement Type I or II conforming to ASTM C 150 or Portland Cement Type IP or IS conforming to ASTM C 595.

5-06.3 Construction Requirements

Work to install Pervious Concrete Pavement sections on the Central Ramp – Phase 1 project shall conform to all requirements of ACI 522.1, "Specifications for Pervious Concrete Pavement" and subsequent Errata published by the American Concrete Institute, Farmington Hills, Michigan except as modified by the following:

Section 1 – General

Section 1.6.1.1 - Contractor Qualifications: Add the following to the end of the paragraph:

Documentation of qualifications shall be provided to the Engineer for approval at least two weeks prior to commencing work under this section.

Add the following paragraph:

If the Contractor has insufficient experience with pervious concrete pavement the Contractor shall, at their own expense, retain and experienced consultant to monitor production, handling, and placement operations. The selection of the consultant shall be subject to the acceptance of the Architect/Engineer.

Section 1.6.3 – Testing Agencies: Add the following to the end of the paragraph:

Identify the testing agency and provide to the Engineer for review/acceptance at least two weeks prior to starting work requiring testing.

5-06.4 Measurement

Pervious concrete pavement shall be measured by the square yard, completed according to the Contract Drawings and Specifications and accepted by the Engineer.

5-06.5 Payment

Payment will be made in accordance with Section 1-04.1, for each of the following bid items that are included in the proposal:

"Pervious Concrete Pavement", per square yard.

The unit contract price per square yard for "Pervious Concrete Pavement", shall be full compensation for all labor, materials and equipment needed to complete the work in accordance with Contract Drawings and Specifications including: subgrade preparation, jointing, sealing, testing, placing and finishing pervious concrete.

B.4.10 Paine Field Pervious Concrete Roadway Drawings

SEC 22/23 T.28 N., R. 4 E.

RECORD DRAWING SET
CENTRAL RAMP - PHASE I DRAINAGE IMPROVEMENTS
SNOHOMISH COUNTY AIRPORT - PAINE FIELD
EVERETT, WASHINGTON

SNOHOMISH COUNTY BID NO. 050-013

AIRPORT MANAGEMENT

DAVE WAGGONER, Airport Director

BILL DOLAN, Deputy Director, Airfield

JAN O'NEILL, Airport CESCL (425)388-5117

PROJECT CONTACTS

OWNER:
SNOHOMISH COUNTY AIRPORT
3220 100th Street S.W.
Everett, WA 98204-1390
TEL: (425)353-2110
FAX: (425)355-9883

Contact:
Jan O'Neill, P.E., Airport Engineer

ENGINEER:
CH2M HILL
2020 SW 4TH Ave, suite 300
Portland, OR 97201
TEL: (503)235-5000
FAX: (503)736-2000

Contact:
Kevin Cooley, P.E.
503-872-4710

Funded in part by the Washington State Department of Ecology.

PROPERTY TAX ACCOUNT NUMBER

280422-001-001-00 280423-002-004-00

LEGAL DESCRIPTION

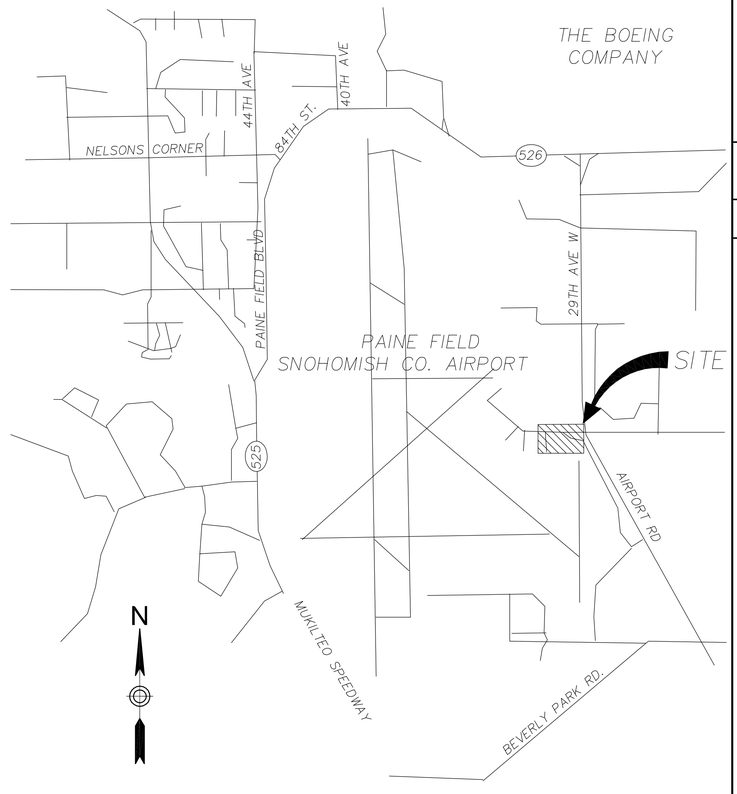
A PORTION OF THE NE 1/4 OF SECTION 22,
& THE NW 1/4 OF SECTION 23,
T28N, R4E WILLAMETTE MERIDIAN

SITE ADDRESS

3220 100TH ST. SW
EVERETT, WA 98204

EARTHWORK QUANTITIES

CUT = 685 CY
FILL = 0 CY



THESE RECORD DRAWINGS ARE SUBMITTED FOR REVIEW ON A TRUE COPY OF THE COUNTY-APPROVED CONSTRUCTION PLANS SIGNED FOR APPROVAL 15-MAY-13.

BY: PROJECT ENGINEER Kevin L. Cooley DATE: 3/7/2014

OWNER'S REP: _____ DATE: _____

Snohomish County Planning Development Services

APPROVED FOR CONSTRUCTION BY:

_____

FOR RANDOLPH R. SLEIGHT, P.E., P.L.S.

LDA PERMIT NO. 13-104448

3/7/2014

NO.	DATE	REVISION	BY	APVD
DSGN	GSH	DR JRC CHK KLC		APVD
				GSH

THESE RECORD DRAWINGS HAVE BEEN PREPARED, IN PART, ON THE BASIS OF INFORMATION COMPILED BY OTHERS. THEY ARE NOT INTENDED TO REPRESENT IN DETAIL THE EXACT LOCATION, TYPE OF COMPONENT, NOR MANNER OF CONSTRUCTION. THE ENGINEER WILL NOT BE RESPONSIBLE FOR ANY ERRORS OR OMISSIONS WHICH HAVE BEEN INCORPORATED INTO THE RECORD DRAWINGS.

CENTRAL RAMP
PHASE I DRAINAGE IMPROVEMENTS
SNOHOMISH COUNTY - PAINE FIELD AIRPORT
SNOHOMISH COUNTY
EVERETT, WA

CH2MHILL®

COVER SHEET

VERIFY SCALE

BAR IS ONE INCH ON ORIGINAL DRAWING. 0 1"

DATE	2014/03/07
PROJ	458317
DWG	G-001
SHEET	1 of 14

SEC 22/23 T.28 N., R. 4 E.

SITE GRADING AND TEMPORARY EROSION AND SEDIMENT CONTROL (TESC) NOTES:

1. ALL GRADING ON AIRPORT PROPERTY SHALL COMPLY WITH SNOHOMISH COUNTY CODE (CURRENT EDITION) TITLE 30.63B, TITLE 30.63A, AND TITLE 7.53.
2. THE IMPLEMENTATION OF ALL TESC AND THE CONSTRUCTION, MAINTENANCE, REPLACEMENT, AND UPGRADING OF THESE TESC PLAN FACILITIES IS THE RESPONSIBILITY OF THE CONTRACTOR UNTIL ALL CONSTRUCTION IS APPROVED.
3. CONTRACTOR SHALL SCHEDULE A PRECONSTRUTION MEETING WITHIN 10 CALENDAR DAYS OF CONTRACT SIGNATURE. CONTRACTOR SHALL SUBMIT A PHASING PLAN, CONSTRUCTION SCHEDULE AND SWPPP AT THE PRE-CON MEETING. THE CONTRACTOR SHALL IDENTIFY AND PROVIDE CONTACT INFORMATION FOR CONTRACTOR'S CESCL WHO SHALL ATTEND THE PRE-CON MEETING AND WHO SHALL BE AVAILABLE 24 HOURS PER DAY, 7 DAYS PER WEEK DURING THE CONSTRUCTION DURATION TO INSPECT, MONITOR, MAINTAIN AND ADAPT EROSION CONTROL BMP'S SUCH THAT NO STORMWATER RUNOFF GREATER THAN 25 NTU LEAVES THE CONSTRUCTION SITE AND/OR ENTERS WETLANDS OR WATERS OF THE AIRPORT.
4. THE AIRPORT MAINTAINS AN ACTIVE NPDES CONSTRUCTION STORMWATER GENERAL PERMIT. CONTRACTOR SHALL PERFORM REQUIREMENTS OF PERMIT WITH CONTRACTOR'S CESCL WITH DAILY MONITORING REPORTS. THE AIRPORT CESCL SHALL SUPERVISE AND PROVIDE MONTHLY REPORTING TO ECOLOGY.
5. THE CONTRACTOR SHALL BE RESPONSIBLE FOR ANY AND ALL COSTS ASSOCIATED WITH "DIRTY" WATER (>25 NTU) LEAVING THE CONSTRUCTION SITE WHICH SHALL INCLUDE BUT NOT BE LIMITED TO; FINES, CLEANUP, MITIGATION, AND LEGAL EXPENSES. PAYMENT FOR ANY AND ALL COSTS SHALL BE MADE TO THE AIRPORT BY DEDUCTION FROM PROGRESS PAYMENTS OR DIRECT BILLING. AIRPORT LEGAL EXPENSES DUE TO DISAGREEMENT REGARDING EROSION CONTROL SHALL BE PAID BY CONTRACTOR.
6. APPROVAL OF THIS TEMPORARY EROSION/SEDIMENTATION CONTROL (TESC) PLAN DOES NOT CONSTITUTE AN APPROVAL OF PERMANENT ROAD OR DRAINAGE DESIGN (E.G. SIZE AND LOCATION OF ROADS, PIPES, RESTRICTORS, CHANNELS, RETENTION FACILITIES, UTILITIES…)
7. CONTRACTOR SHALL ENSURE THAT ALL PAVED SURFACES, SIDEWALKS, AND FLOWLINES ON SITE AND IN THE PUBLIC RIGHT-OF-WAYS ARE KEPT CLEAR OF DIRT AND DEBRIS AT THE END OF EACH WORK DAY FOR THE DURATION OF THE PROJECT. STREETS SHALL BE SWEPT IMMEDIATELY WHEN DIRT OR MUD HAS BEEN TRACKED ONTO THE PAVED SURFACES. VACUUM SWEEPERS OR OTHER MEANS APPROVED BY THE CERTIFIED EROSION AND SEDIMENT CONTROL LEAD (CESCL) MAY BE REQUIRED.
8. NONCOMPLIANCE WITH THE EROSION CONTROL REQUIREMENTS, WATER QUALITY REQUIREMENTS OR CLEARING LIMITS VIOLATIONS MAY RESULT IN CORRECTION NOTICES OR A STOP WORK ORDER UNTIL THE VIOLATIONS OR REQUIREMENTS ARE MET OR SATISFIED.
9. FROM OCTOBER 1 TO APRIL 30, SOIL SHALL BE EXPOSED FOR A MAXIMUM OF 2 DAYS.
10. FROM MAY 1 TO SEPTEMBER 30, SOIL SHALL BE EXPOSED FOR A MAXIMUM OF 7 DAYS, OTHERWISE, APPROVED TESC MEASURES SHALL BE IMMEDIATELY USED TO STABILIZE THE SOIL.
11. SOIL STOCKPILES SHALL BE STABILIZED WITHIN 24 HOURS, OR UNTIL RAIN EVENTS GREATER THAN 0.1 IN/HR, WHICHEVER IS LESS. WHEN ACTIVELY WORKING WITH THE SOIL STOCKPILE, STABILIZATION SHALL OCCUR AT THE END OF EACH WORKDAY.
12. SILTATION BARRIERS AND ALL OTHER TESC MEASURES SHALL BE INSPECTED IMMEDIATELY AFTER EACH RAINFALL EVENT GREATER THAN 0.1" RAINFALL, AND AT LEAST DAILY DURING PROLONGED RAINFALL EVENTS. DURING ALL OTHER TIMES, TESC FACILITIES AT ACTIVE AREAS SHALL BE INSPECTED AND MAINTAINED DAILY BY THE CONTRACTOR TO ENSURE CONTINUED FUNCTIONALITY. TESC FACILITIES AT INACTIVE AREAS OF THE SITE SHALL BE INSPECTED AND MAINTAINED A MINIMUM OF ONCE PER WEEK.
13. MAINTENANCE AND REPAIR OF TESC FACILITIES AND STRUCTURES SHALL BE CONDUCTED IMMEDIATELY UPON RECOGNITION OF A PROBLEM OR WHEN THE TESC MEASURES BECOME DAMAGED.
14. SEDIMENT DEPOSITS SHALL BE REMOVED FROM TEMPORARY DRAINAGE FACILITIES AND STRUCTURES UPON REACHING $\frac{1}{3}$ OF THE DEPTH. CATCH BASIN INSERTS SHALL BE PROVIDED AND PROPERLY MAINTAINED IN ALL EXISTING AND NEW CATCH BASINS WITHIN THE CONSTRUCTION LIMITS AND SHALL NOT BE ALLOWED TO ACCUMULATE MORE THAN 6 INCHES OF SEDIMENT. THESE FACILITIES SHALL BE MAINTAINED SUCH THAT SEDIMENT-LADEN WATER DOES NOT ENTER THE NATURAL OR PUBLIC DRAINAGE SYSTEM. ALL CATCH BASINS AND CONVEYANCE LINES SHALL BE CLEARED PRIOR TO PLACING RIGID OR FLEXIBLE PAVEMENT. THE CLEARING OPERATION SHALL NOT FLUSH SEDIMENT-LADEN WATER INTO DOWNSTREAM SYSTEM.
15. SUFFICIENT TESC BMP MATERIALS AND SUPPLIES TO PROTECT THE ENTIRE SITE SHALL BE STOCKPILED ON-SITE.
16. CONSTRUCTION ACCEPTANCE WILL BE SUBJECT TO A WELL-ESTABLISHED GROUND COVER THAT FULFILLS THE REQUIREMENT OF THE APPROVED CONSTRUCTION PLANS AND TITLE 30.63A, SNOHOMISH COUNTY DRAINAGE ORDINANCE AND CONSTRUCTION STORMWATER GENERAL PERMIT (2011)..
17. ALL DISTURBED AREAS SUCH AS RETENTION FACILITIES, ROADWAY BACK-SLOPES, ETC. SHALL BE SEEDED WITH THE AIRPORT HYDROSEED MIX (SEE SPECIFICATIONS) MINIMIZE EROSION. GRASS SEEDING WILL BE DONE USING AN APPROVED HYDROSEEDER OR AS OTHERWISE APPROVED BY SNOHOMISH COUNTY.
18. ALL AREAS TO BE SEEDED SHALL BE CULTIVATED TO THE SATISFACTION OF THE COUNTY INSPECTOR. THIS MAY BE ACCOMPLISHED BY DISKING, RAKING, HARROWING, ADDING TOPSOIL OR OTHER ACCEPTABLE MEANS. PERFORM ALL CULTURAL OPERATIONS ACROSS OR AT RIGHT ANGLES TO THE SLOPE. IF NECESSARY, SURFACE RUNOFF CONTROL MEASURES SUCH AS GRADIENT TERRACES, INTERCEPTOR DIKE/SWALES, LEVEL SPREADERS, AND SEDIMENT BASINS SHALL BE INSTALLED PRIOR TO SEEDING.
19. PERMANENT VEGETATION CONSISTING OF AIRPORT HYDROSEED MIX (SEE SPECIFICATIONS) SHALL BE APPLIED IMMEDIATELY FOLLOWING FINISH GRADING, HYDROSEED REQUIRED.
20. EXCESS EXCAVATION SHALL BE PLACED ON THE UPHILL SIDE OF TRENCHES, UNLESS INCONSISTENT WITH SITE CONSTRAINTS, OR BE DISPOSED OF AT A PERMITTED SITE OR COMMERCIAL TOPSOIL COMPANY.
21. TEMPORARY CUT AND FILL SLOPES SHALL BE A MAXIMUM OF 1.5:1 IN SHORT SECTIONS. PERMANENT CUT AND FILL SLOPES SHALL BE A MAXIMUM OF 2:1 OR AS SHOWN ON PLANS. SLOPES SHALL BE PROTECTED FROM EROSIVE FLOWS AND CONCENTRATED FLOWS UNTIL PERMANENT COVER AND DRAINAGE CONVEYANCE SYSTEMS ARE IN PLACE.
22. THE EROSION MEASURES SHOWN ON THE TESC DRAWINGS ARE GENERALLY THE MINIMUM MEASURES TO BE IMPLEMENTED. HEAVY RAINFALL OR UNFORESEEN CONDITIONS MAY REQUIRE ADDITIONAL ESC MEASURES. THEREFORE, DURING THE COURSE OF CONSTRUCTION, THE CONTRACTOR SHALL ADDRESS ANY CHANGED OR NEW CONDITIONS THAT MAY BE CREATED BY THE CONTRACTOR'S ACTIVITIES AND PROVIDE ADDITIONAL FACILITIES THAT MAY BE NEEDED TO PROTECT ADJACENT PROPERTIES AS NEEDED, DUE TO WEATHER AND/OR FIELD CONDITIONS. THE CONTRACTOR SHALL UPDATE THE STORMWATER POLLUTION PREVENTION PLAN (SWPPP) ACCORDINGLY.
23. FOR PH AND TURBIDITY NON-COMPLIANCE ISSUES, THE CONTRACTOR SHALL CONTACT SNOHOMISH COUNTY ENVIRONMENTAL COMPLIANCE INSPECTOR JAN O'NEILL (425-754-0008), OR SNOHOMISH COUNTY ENVIRONMENTAL SPECIALIST ANDREW RARDIN (425-508-7472) FOR SPILLS. FOR LARGE SPILLS OF IMMEDIATE DANGER TO LIFE AND HEALTH, THE CONTRACTOR SHALL CONTACT EMERGENCY PROVIDERS (911). ALSO SEE SWPPP FOR FURTHER GUIDELINES.
24. THE BOUNDARIES OF THE CONSTRUCTION LIMITS SHOWN ON THIS PLAN SHALL BE CLEARLY FLAGGED WITH HIGH VISIBILITY FENCING IN THE FIELD PRIOR TO CONSTRUCTION. DURING THE CONSTRUCTION PERIOD, NO DISTURBANCE AND/OR MATERIAL/EQUIPMENT STAGING SHALL BE PERMITTED BEYOND THE FLAGGED CONSTRUCTION LIMITS. THE FLAGGING SHALL BE MAINTAINED BY THE CONTRACTOR FOR THE DURATION OF CONSTRUCTION
25. TESC FACILITIES AND MEASURES SHALL BE CONSTRUCTED AND/OR INSTALLED PRIOR TO ANY GRADING, EARTH-DISTURBING ACTIVITY, OR EXTENSIVE LAND CLEARING IN ACCORDANCE WITH THE APPROVED TEMPORARY EROSION SEDIMENTATION CONTROL PLAN (SEE ATTACHED DETAILED DRAINAGE PLAN ON SHEETS C-ESC-002 AND C-ESC-003). THESE FACILITIES MUST BE SATISFACTORILY MAINTAINED UNTIL CONSTRUCTION WORK IS COMPLETE AND THE PROJECT SITE IS FULLY STABILIZED.
26. IF INSTALLATION OF SILT FENCE IS NOT POSSIBLE ON PAVED AREAS, CONTRACTOR SHALL IMPLEMENT ALTERNATE EROSION AND SEDIMENT CONTROL MEASURES TO CONTROL SEDIMENT.
27. WHERE POSSIBLE MAINTAIN NATIVE VEGETATION AND GROUNDCOVER AS A MEANS TO FILTER RUNOFF OR DISPERSE THROUGH THE NATURAL VEGETATION .
28. IF NECESSARY FOR SEDIMENT CONTROL, THE CONTRACTOR SHALL PROVIDE SEDIMENT SETTLING BASINS PER SNOHOMISH COUNTY ENGINEERING DESIGN & DEVELOPMENT STANDARDS (EDDS) MANUAL.
29. THE CONTRACTOR SHALL IMPLEMENT LINEAR RUN-ON CONTROLS TO PREVENT WATER FROM ENTERING THE CONSTRUCTION AREA.
30. PROCESS WATER, SUCH AS WATER USED IN CONCRETE WORK OR PUMPED FROM A TRENCH AFTER A RAIN EVENT, SHALL BE COLLECTED AND HAULED TO AN APPROPRIATE DISPOSAL SITE. PROCESS WATER SHALL NOT BE DISCHARGED TO THE STORM DRAIN.
31. THE CONTRACTOR SHALL REFER TO "WASHINGTON DEPARTMENT OF ECOLOGY STORMWATER MANUAL FOR WESTERN WASHINGTON, APRIL 2005" FOR ANY EROSION AND SEDIMENTATION CONTROLS. THE FOLLOWING LIST CONTAINS SOME COMMON BEST MANAGEMENT PRACTICES (BMPS) , BUT ARE NOT LIMITED TO THE ONES LISTED BELOW:
    A. BMP C103: HIGH VISIBILITY PLASTIC FENCE
    B. BMP C123: PLASTIC COVERING
    C. BMP C203: WATER BARS
    D. BMP C220: STORM DRAIN INLET PROTECTION
    E. BMP C233: SILT FENCE
32. STATIONARY EQUIPMENT CONTAINING OIL/FUELS NEEDS SECONDARY CONTAINMENT.
33. FUEL-POWERED STATIONARY EQUIPMENT REGARDLESS OF OIL/FUEL CAPACITY (E.G. GENERATORS, LIGHT STANDS, COMPRESSORS, ETC.) SHALL BE PROVIDED WITH SECONDARY CONTAINMENT.
34. PORTABLE SANITARY FACILITIES SHALL BE LOCATED AT LEAST 25 FEET FROM ANY STORM SEWER INLET OR WATER BODY AND SHALL BE SERVICED REGULARLY AS NEEDED.
35. THERE SHALL BE NO CONCRETE WASHOUT AREA ON SITE, EXCEPT IF AUTHORIZED BY ENGINEER. IF AUTHORIZED, THOSE AREAS SHALL BE APPROVED AND MONITORED BY THE CESCL AND MAINTAIN A PH METER LEVEL OF 6.5-8.5, BE ECO PAN OR APPROVED EQUAL, AND BE CONTAINED AND SERVICED ADEQUATELY. SEE THE SWPPP FOR TREATMENT OPTIONS
36. CONSTRUCTION RUNOFF DISPERSAL AREAS WILL BE USED TO TREAT CONSTRUCTION RUNOFF AND ARE LABELED IN THE EROSION AND SEDIMENT CONTROL PLANS FOLLOWING THIS SHEET. THEY MAY BE USED FOR THE TREATMENT OF CONSTRUCTION RUNOFF, PROVIDED THAT THE REQUIREMENTS IN THE CSGP ARE FOLLOWED.
37. FORESEEABLE DELAYS TO ACTIVITIES SUCH AS NORMAL SEASON WEATHER SHALL BE CONSIDERED AND INCLUDED IN THE PLANNING AND SCHEDULE OF ALL WORK.

TEMPORARY CONSTRUCTION ENTRANCE NOTES:

1. INSTALLATION: THE AREA OF THE ENTRANCE SHOULD BE CLEARED OF ALL VEGETATION, ROOTS AND OTHER OBJECTIONABLE MATERIAL. THE AGGREGATE SHALL BE PLACED TO THE SPECIFIED DIMENSIONS AT THE BEGINNING OF CONSTRUCTION AND MAINTAINED FOR THE DURATION OF THE PROJECT. ANY DRAINAGE FACILITIES REQUIRED BECAUSE OF WASHING SHOULD BE CONSTRUCTED ACCORDING TO SPECIFICATIONS IN THE PLAN. IF TIRE WASH FACILITY IS USED, IT SHOULD BE INSTALLED ACCORDING TO MANUFACTURER'S SPECIFICATIONS AND APPROVAL OF AIRPORT CESCL.
2. ENTRANCE DIMENSIONS: THE AGGREGATE LAYER MUST BE AT LEAST 12 INCHES THICK, AND MADE UP OF 4" - 8" QUARRY SPALLS. THE WIDTH OF THE ENTRANCE MUST BE AT LEAST 25 FEET. THE LENGTH OF THE ENTRANCE MUST BE AT LEAST 50 FEET PER WSDOT STANDARD PLAN I-80.10-01.
3. WASHING: IF CONDITIONS ON THE SITE ARE SUCH THAT MOST OF THE MUD IS NOT REMOVED FROM VEHICLE TIRES BY CONTACT WITH THE GRAVEL, THEN THE TIRES MUST BE WASHED BEFORE VEHICLES ENTER A PUBLIC ROAD. WASH WATER MUST BE CARRIED AWAY FROM THE ENTRANCE TO A SETTLING AREA TO REMOVE SEDIMENT. A TIRE WASH FACILITY MAY ALSO BE USED TO MAKE WASHING MORE CONVENIENT AND EFFECTIVE.
4. MAINTENANCE: THE ENTRANCE SHALL BE MAINTAINED IN A CONDITION WHICH WILL PREVENT TRACKING OR FLOW OF MUD ONTO THE PUBLIC TRAVELED WAYS. THIS MAY REQUIRE PERIODIC TOP DRESSING WITH 2-INCH STONE, AS CONDITIONS DEMAND, AND REPAIR AND/OR CLEAN OUT ANY STRUCTURES USED TO TRAP SEDIMENT. ALL MATERIALS SPILLED, DROPPED, WASHED OR TRACKED FROM VEHICLES ONTO ROADWAY OR INTO STORM DRAINS MUST BE REMOVED IMMEDIATELY.

TYPICAL TESC SEQUENCING

1. INSTALL HIGH VISIBILITY FENCE AND SILT FENCE TO DELINEATE CLEARING LIMITS.
2. INSTALL INLET PROTECTION AS SHOWN IN THE PLANS.
3. GRADE AND INSTALL STABILIZED CONSTRUCTION ENTRANCES AND STORAGE AREA BASES.
4. CONSTRUCT SURFACE WATER CONTROLS (CHECK DAMS) SIMULTANEOUSLY WITH CLEARING AND GRADING FOR PROPER DEVELOPMENT.
5. COVER/STABILIZE ALL AREAS THAT WILL BE UNWORKED IN ACCORDANCE WITH TESC GENERAL NOTES.
6. SEED OR SOD ANY AREAS TO REMAIN UNWORKED FOR MORE THAN 7 DAYS IN DRY SEASON (MAY 1 - SEPT 30) OR COVER WITH APPROVED EROSION CONTROL FABRIC.
7. REMOVE HIGH VISIBILITY FENCE, SILT FENCE, AND OTHER TESC MEASURES AFTER THE WORK IS COMPLETED AND AS DIRECTED BY THE ENGINEER.

LEGEND

- DITCH
- SILT FENCE
- HIGH VISIBILITY CONSTRUCTION FENCE
- WATTLE CHECK DAM
- EROSION CONTROL BLANKET
- WETLAND
- MULCH
- WETLAND BUFFER
- CONSTRUCTION TRAFFIC ROUTE
- 550 EXISTING CONTOUR
- INLET PROTECTION
- CLEARANCE LIMITS
- CUT LINE
- FILL LINE
- WATER QUALITY MONITORING LOCATIONS

THESE RECORD DRAWINGS ARE SUBMITTED FOR REVIEW ON A TRUE COPY OF THE COUNTY-APPROVED CONSTRUCTION PLANS SIGNED FOR APPROVAL 15-MAY-13.

BY: PROJECT ENGINEER Kirk L. Cooley DATE: 3/7/2014

OWNER'S REP: _____ DATE: _____

Snohomish County Planning Development Services

APPROVED FOR CONSTRUCTION BY:

_____

FOR RANDOLPH R. SLEIGHT, P.E., P.L.S.

LDA PERMIT NO. 13-104448

3/7/2014

NO.	DATE	REVISION	BY	APVD
DSGN	GSH	DR JRC CHK KLC APVD	GSH	

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SNOHOMISH COUNTY
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EROSION AND SEDIMENT CONTROL NOTES AND LEGEND

VERIFY SCALE

BAR IS ONE INCH ON ORIGINAL DRAWING. 0 1"

DATE	2014/03/07
PROJ	458317
DWG	C-ESC-001
SHEET	5 of 14

FILENAME: 458317.A1.10.11_05-ESC-NOTES.dwg PLOT DATE: 3/7/2014 PLOT TIME: 2:53 PM

SEC 22/23 T.28 N., R. 4 E.

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BY: PROJECT ENGINEER Kristi L. Cooley DATE: 3/7/2014

OWNER'S REP: _____ DATE: _____

0 40 80 120
1"=40'

N

CONTRACTOR STORAGE AREA (NOT USED)

100TH ST SW

30TH AVE W

29TH AVE W

AIRPORT RD.

EAST PERIMETER RD.

RPZ

RSA

ROFA

(1) (TYP. OF 19)

(2) 57 LF

74 LF (2)

(2) 194 LF

215 LF (2)

(3) N 334235.64
E 1287444.13

POSSIBLE SEDIMENT TRAP LOCATION

POSSIBLE FLOW DISPERSION AREA FOR WATER QUALITY TREATMENT OF SMALL WATER LOADS

(2) 158 LF

EXCAVATION AREA

(4) 163 LF

LEGEND

- SILT FENCE
- INLET PROTECTION
- STABALIZED CONSTRUCTION ENTRANCE
- HIGH-VISIBILITY FENCE

KEY NOTES

1. INSTALL INLET PROTECTION IN EXISTING STORM DRAIN, SEE WSDOT STANDARD PLAN I-40.20-00.
2. INSTALL SILT FENCE, SEE WSDOT STANDARD PLAN I-30.15-01.
3. INSTALL 50' OF STABILIZED CONSTRUCTION ENTRANCE, SEE WSDOT STANDARD PLAN I-80.10-01. CONSTRUCTION ENTRANCE TO REMAIN AFTER PROJECT COMPLETION.
4. INSTALL HIGH-VISIBILITY FENCE 2' OUTSIDE OF SILT FENCE.

Snohomish County Planning Development Services

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FOR RANDOLPH R. SLEIGHT, P.E., P.L.S.

LDA PERMIT NO. 13-104448

PLAN
1"=40'

3/7/2014

NO.	DATE	REVISION	BY	APVD
DSGN		GSH		GSH
		DR		APVD
		CHK		KLC
		JRC		

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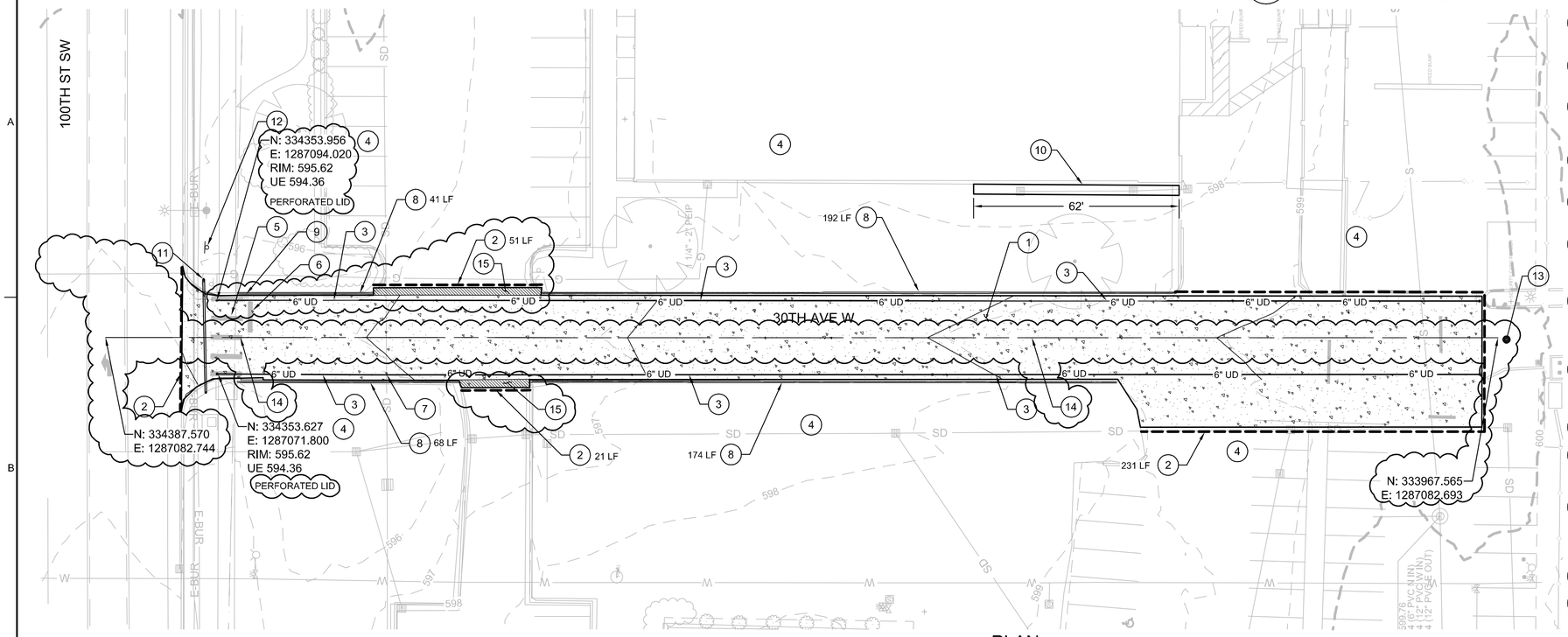
EROSION AND SEDIMENT CONTROL PLAN

1"=40'
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	2014/03/07
PROJ	458317
DWG	C-ESC-002
SHEET	6 of 14

FILENAME: 458317.A1.10.11_06-ESCP.dwg PLOT DATE: 3/7/2014 PLOT TIME: 2:54 PM

SEC 22/23 T.28 N., R. 4 E.



PLAN
1"=20'

KEY NOTES:

1. INSTALL PERVIOUS CONCRETE PAVEMENT, SEE DETAIL 2 / C-DET-001
2. INSTALL PCC/ASPHALT JOINT, MATCH EXISTING, SEE DETAIL 6 / C-DET-003
3. INSTALL 6" CPEP PERFORATED UNDERDRAIN PIPE, SEE DETAIL 4 / C-DET-001
4. INSTALL UNDERDRAIN CLEANOUT, SEE DETAIL 4 / C-DET-001
5. REPLACE EXISTING PAINTED CROSSWALK BARS, SEE SNOHOMISH COUNTY DETAIL 7-110.
6. REPLACE EXISTING PAINTED STOP BAR WITH THERMO PLASTIC MARKINGS, SEE SNOHOMISH COUNTY DETAIL 7-100.
7. CONNECT 6" UNDERDRAIN PIPE TO EXISTING 18" CONCRETE PIPE USING INSERTA-TEE CONNECTION, SEE DETAIL 4 / C-DET-003
8. INSTALL 6" CEMENT CONCRETE TRAFFIC CURB, SEE DETAIL 2 / C-DET-003
9. PROTECT EXISTING INLET TO REMAIN.
10. INSTALL DRAIN ROCK TRENCH AROUND EXISTING PIPE. SEE DETAIL 5 / C-DET-003
11. INSTALL 4 - 4" SCHEDULE 80 PVC CONDUIT PIPES FOR FUTURE USE. INSTALL CONDUIT MARKER AT CONDUIT TERMINATION. SEE DETAILS 3 / C-DET-004, 4 / C-DET-004
12. INSTALL TEMPORARY PROJECT SIGN. SEE DETAIL 2 / C-DET-004
13. PROTECT ALL EXISTING GATE COMPONENTS TO REMAIN, INCLUDING LOOP DETECTORS. ANY DAMAGE TO GATE COMPONENTS SHALL BE REPAIRED IMMEDIATELY.
14. ADDED PAINTED CENTERLINE MARKINGS VIA CHANGE ORDER #1
15. ASPHALT PATH BETWEEN PERVIOUS CONCRETE AND EXISTING ACP

LEGEND:

- PERVIOUS CONCRETE PAVEMENT
- CEMENT CONCRETE TRAFFIC CURB
- PCC/ASPHALT JOINT

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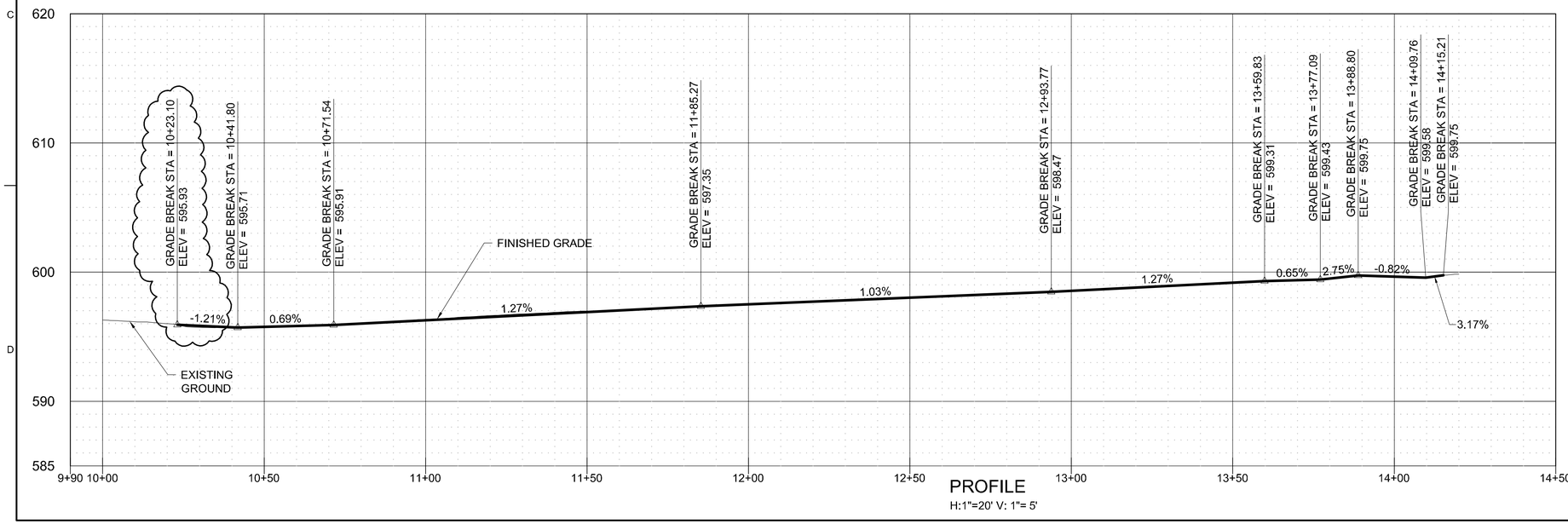
BY: PROJECT ENGINEER Eric L. Cooley DATE: 3/7/2014

OWNER'S REP: _____ DATE: _____



PROFILE
H:1"=20' V: 1"= 5'

GENERAL NOTES:

1. MAXIMUM JOINT SPACING IN PERVIOUS CONCRETE PAVEMENT SHALL BE 12.5'.
2. SEE SHEET C-RD-002 FOR SUBGRADE GRADING PROFILE.

Snohomish County Planning Development Services

APPROVED FOR CONSTRUCTION BY:

_____
FOR RANDOLPH R. SLEIGHT, P.E., P.L.S.

LDA PERMIT NO. _____

3/7/2014

NO.	DATE	DSGN	DR	CHK	APVD	BY	APVD
		GSH	JRC	KLC	APVD		GSH

REVISION

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ROADWAY PLAN AND PROFILE

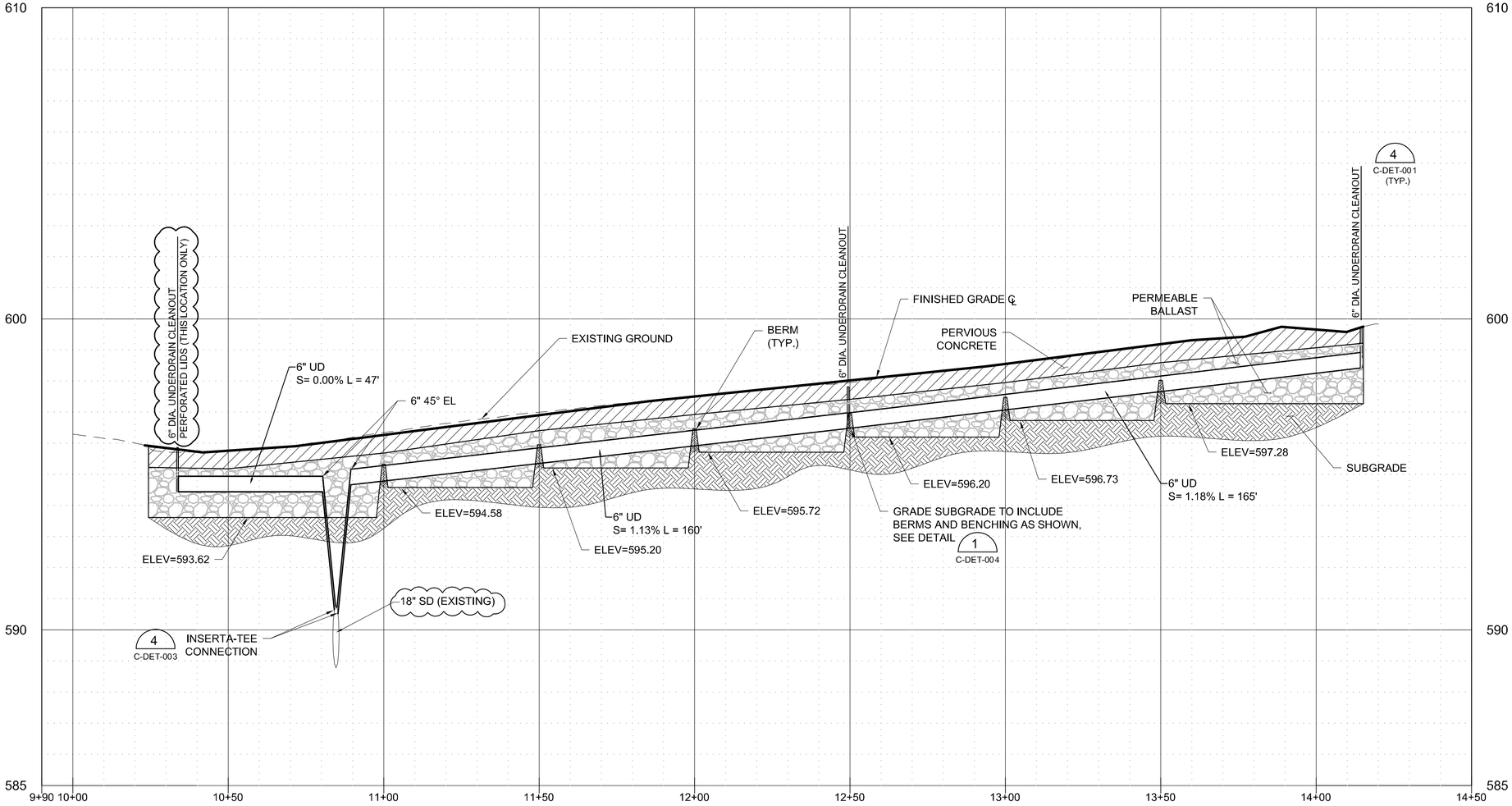
H:1"=20';V:1"=5'
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"

DATE	2014/03/07
PROJ	458317
DWG	C-RD-001
SHEET	08 of 14

FILENAME: 458317.A1.10.11-RD-PNP.dwg PLOT DATE: 3/7/2014 PLOT TIME: 2:55 PM

SEC 22/23 T.28 N., R. 4 E.

0 20 40 60
1"=20'



NOTE:
SUBGRADE BERMS NOT CONSTRUCTED OF NATIVE SUBGRADE MATERIAL. LINER WAS USED TO SEPARATE DRAINAGE AREAS.

PROFILE
H:1"=20' V: 1"= 2'

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BY: PROJECT ENGINEER _____ DATE: 3/7/2014

OWNER'S REP: _____ DATE: _____

Snohomish County Planning Development Services

APPROVED FOR CONSTRUCTION BY:

_____

FOR RANDOLPH R. SLEIGHT, P.E., P.L.S.

LDA PERMIT NO. 13-104448

3/7/2014

NO.	DATE	DSGN	DR	CHK	APVD	BY	REVISION
		GSH	JRC	KLC	APVD	GSH	

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ROADWAY PROFILE
UNDERDRAINS AND CHECK DAMS

H:1"=20';V:1"=5'
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

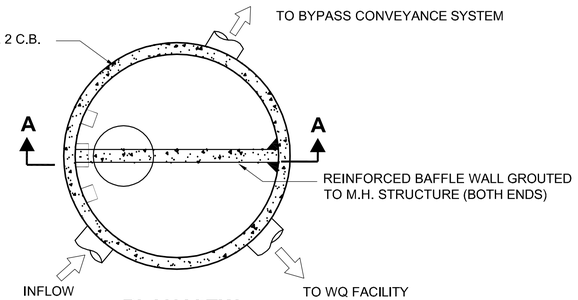
DATE	2014/03/07
PROJ	458317
DWG	C-RD-002
SHEET	09 of 14

FILENAME: 458317.A1.10.11_09-RD-PNP2.dwg PLOT DATE: 3/7/2014 PLOT TIME: 2:56 PM

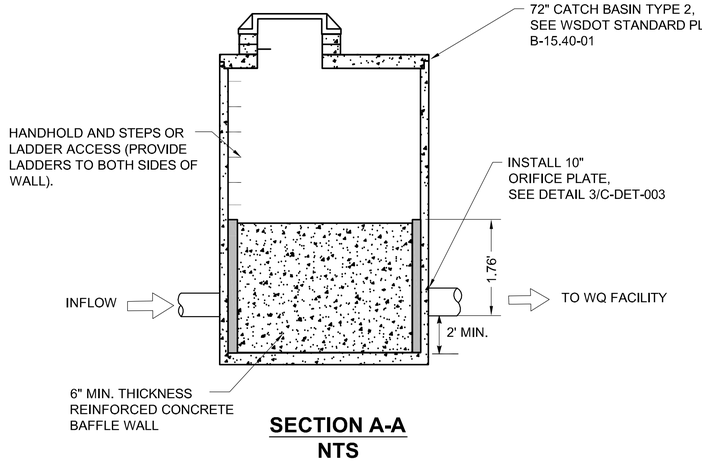
SEC 22/23 T.28 N., R. 4 E.

NOTES

1. BAFFLE WALL SHALL HAVE #4 BAR AT 12" SPACING EACH WAY.
2. PRECAST BAFFLE WALL SHALL BE KEYED AND GROUTED IN PLACE.
3. SEE SHEET C-SD-001 FOR SIZE AND LOCATION OF ALL PIPES.
4. BAFFLE WALL SHALL BE CLASS 4000 CONCRETE PER WSDOT SPECIFICAITON 6-02



PLAN VIEW
NTS



SECTION A-A
NTS

FLOW CONTROL STRUCTURE — 1 / C-SD-001
SCALE: NTS

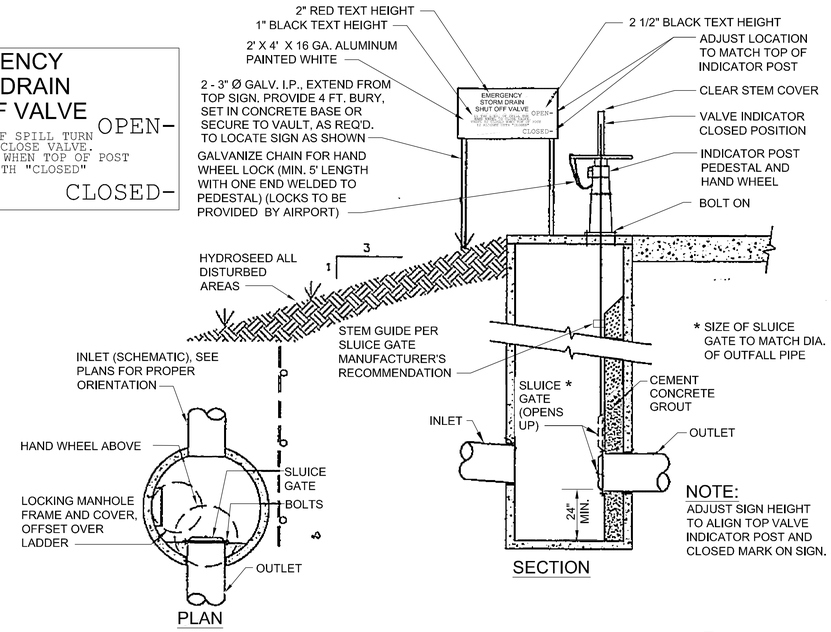
**

EMERGENCY STORM DRAIN SHUT OFF VALVE

IN THE EVENT OF SPILL TURN HAND WHEEL TO CLOSE VALVE. VALVE IS CLOSED WHEN TOP OF POST IS ALIGNED WITH "CLOSED"

OPEN–

CLOSED–

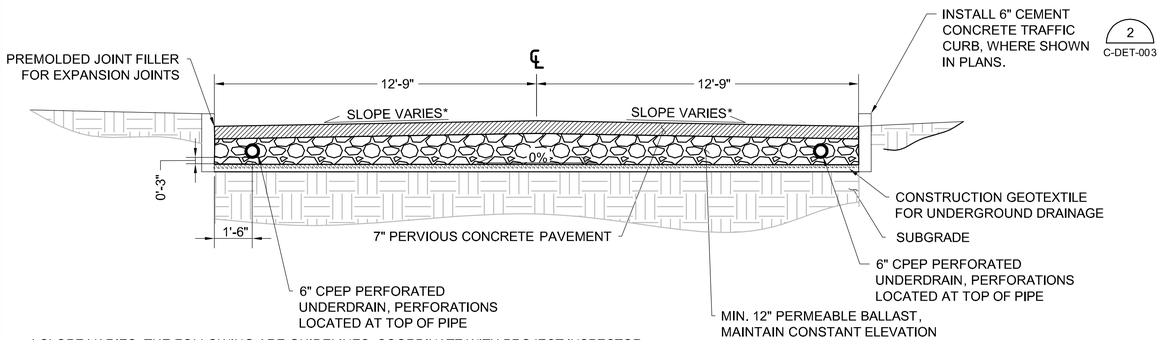


PLAN

SECTION

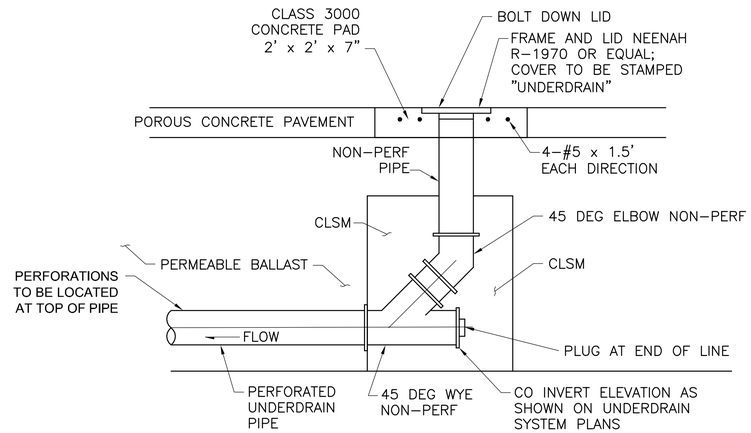
NOTE:
ADJUST SIGN HEIGHT TO ALIGN TOP VALVE INDICATOR POST AND CLOSED MARK ON SIGN.

EMERGENCY SHUTOFF VALVE — 3 / C-SD-001
SCALE: NTS



* SLOPE VARIES, THE FOLLOWING ARE GUIDELINES; COORDINATE WITH PROJECT INSPECTOR FOR EXACT SLOPES AND STATIONS:
- STA 10+23± - 11+30± - MATCH EXISTING AT EDGE OF PAVEMENT
- STA 11+30± - 11+80± - SLOPE = 1%
- STA 11+80± - 13+05± - SLOPE = 2%
- STA 13+05 TO 14+15%5P - MATCH EXISTING AT EDGE OF PAVEMENT

POROUS PCC PAVEMENT SECTION — 2 / C-RD-001
SCALE: NTS



NOTES:
1. STABILIZE VERTICAL CLEANOUT TO PREVENT PIPE DAMAGE OR MOVEMENT DURING PAVING.
2. CLSM SHALL ENCASE ALL JOINT ELBOWS AND WYES.
3. CLSM SHALL NOT BE IN CONTACT WITH PERFORATED PIPE.

UNDERDRAIN & UNDERDRAIN CLEANOUT WITH CONCRETE PAD — 4 / C-RD-001, C-RD-002
SCALE: NTS

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BY: PROJECT ENGINEER _____ DATE: 3/7/2014

OWNER'S REP: _____ DATE: _____

Snohomish County Planning Development Services

APPROVED FOR CONSTRUCTION BY:

FOR RANDOLPH R. SLEIGHT, P.E., P.L.S.

LDA PERMIT NO. 13-104448

3/7/2014

NO.	DATE	REVISION	DR	CHK	APVD	BY	APVD
DSGN			GSH	JRC	KLC		GSH

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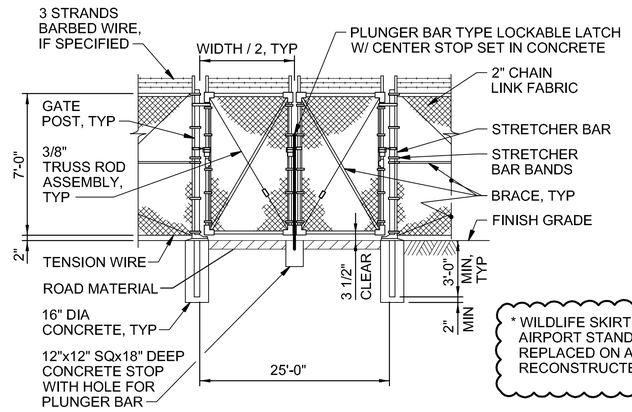
DETAILS

VERIFY SCALE	
BAR IS ONE INCH ON ORIGINAL DRAWING. 0 1"	
DATE	2014/03/07
PROJ	458317
DWG	C-DET-001
SHEET	11 of 14

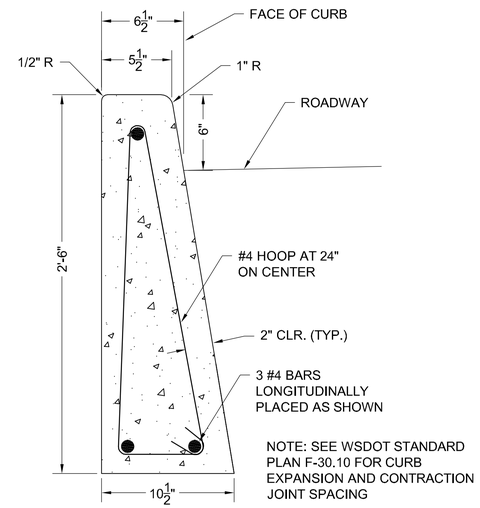
SEC 22/23 T.28 N., R. 4 E.



* WILDLIFE SKIRTING PER AIRPORT STANDARDS WAS REPLACED ON ALL RECONSTRUCTED FENCE.

DOUBLE SWING GATE DETAIL — 1 / C-SD-001

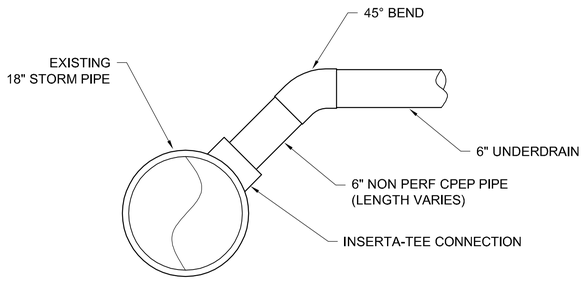
SCALE: NOT TO SCALE



NOTE: SEE WSDOT STANDARD PLAN F-30.10 FOR CURB EXPANSION AND CONTRACTION JOINT SPACING

CEMENT CONCRETE TRAFFIC CURB — 2 / C-RD-001

SCALE: NOT TO SCALE



INSERTA-TEE CONNECTION — 4 / C-RD-001, C-RD-002

SCALE: NOT TO SCALE

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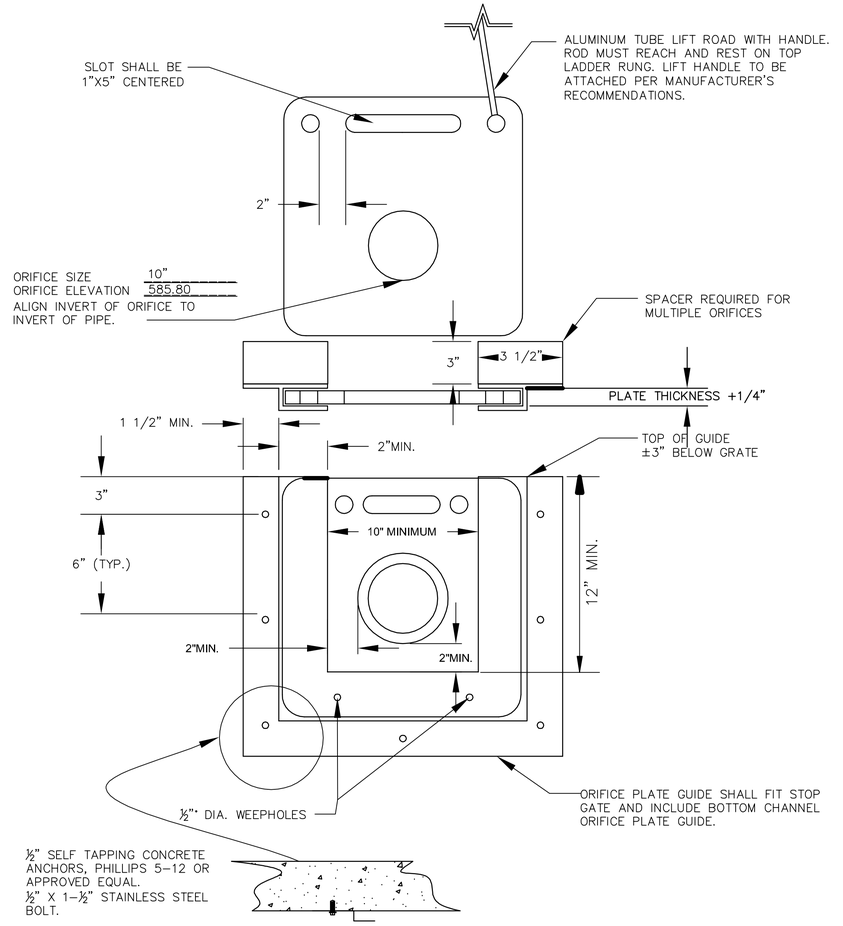
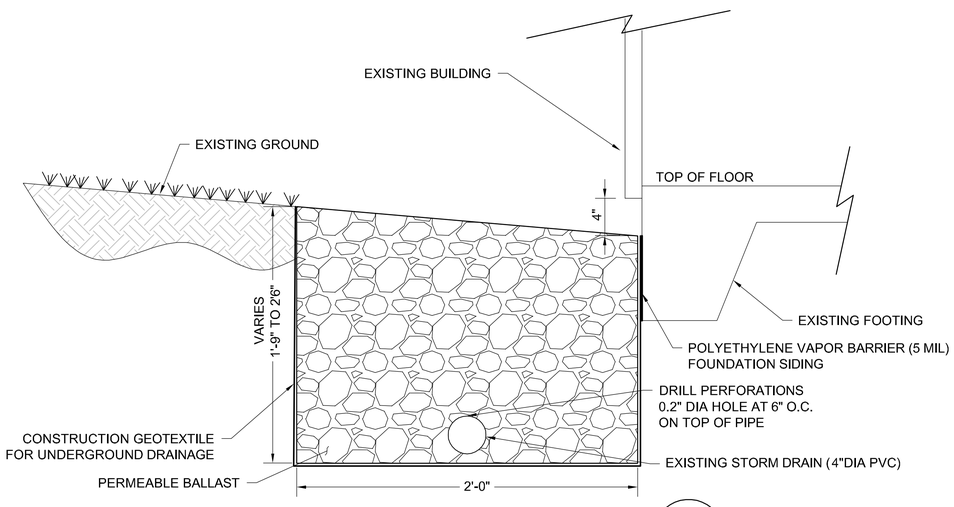
BY: PROJECT ENGINEER Randolph R. Sleight DATE: 3/7/2014

OWNER'S REP: _____ DATE: _____



ORIFICE PLATE AND GUIDE — 3 / C-DET-001

SCALE: NOT TO SCALE



DRAIN ROCK TRENCH — 5 / C-RD-001

SCALE: NOT TO SCALE

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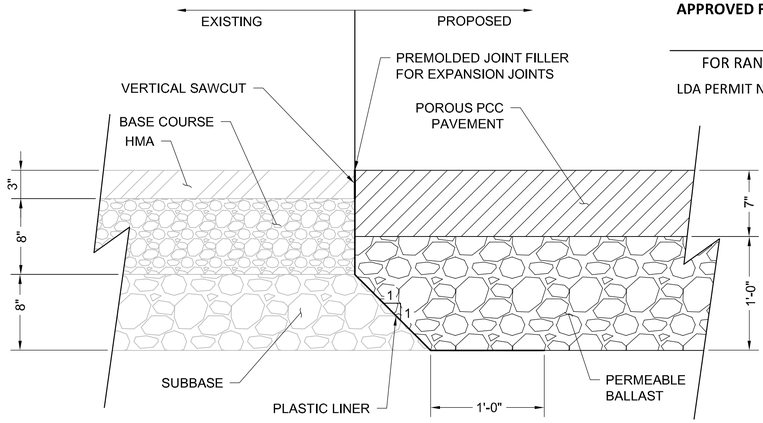

PCC/ASPHALT JOINT — 6 / C-RD-001

SCALE: NOT TO SCALE

3/7/2014

NO.	DATE	DSGN	DR	CHK	APVD	BY	REVISION
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DETAILS

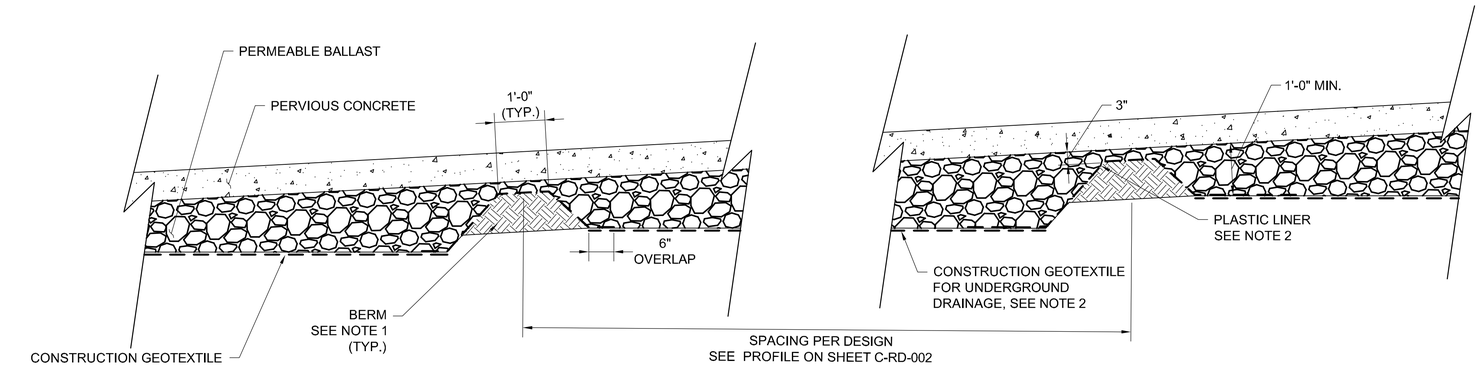
VERIFY SCALE

BAR IS ONE INCH ON ORIGINAL DRAWING. 0 1"

DATE	2014/03/07
PROJ	458317
DWG	C-DET-003
SHEET	13 of 14

FILENAME: 458317.A1.10.11_13-SD-DETAILS3.dwg PLOT DATE: 3/7/2014 PLOT TIME: 3:36 PM

SEC 22/23 T.28 N., R. 4 E.



NOTES:
1. BERM SHALL BE CONSTRUCTED WITH PLASTIC LINER. REQUIREMENT FOR NATIVE MATERIAL WAS DELETED FROM PROJECT.
2. PLASTIC LINER SHALL COVER BERMS INCLUDING A 6" OVERLAP OF LINER AND GEOTEXTILE ON EACH SIDE. GEOTEXTILE FOR UNDERGROUND DRAINAGE SHALL LINE THE BASE OF THE REMAINING PERMEABLE BALLAST LAYER.

SUBGRADE BERMS

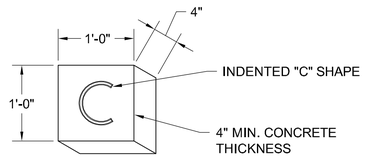
SCALE: NOT TO SCALE

1 C-RD-002

THESE RECORD DRAWINGS ARE SUBMITTED FOR REVIEW ON A TRUE COPY OF THE COUNTY-APPROVED CONSTRUCTION PLANS SIGNED FOR APPROVAL 15-MAY-13.

BY: PROJECT ENGINEER Eric R. Cooley DATE: 3/7/2014

OWNER'S REP: _____ DATE: _____

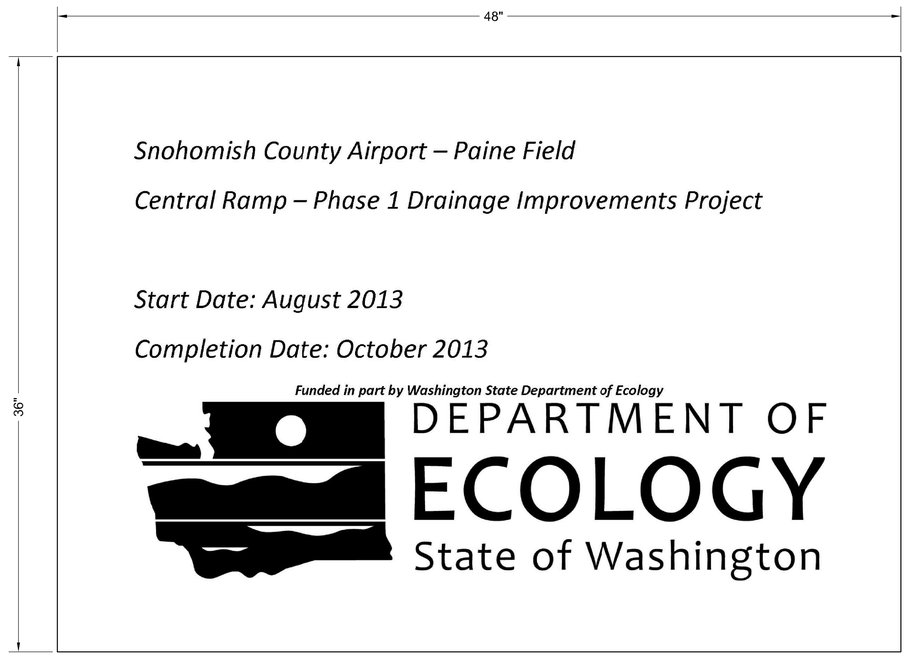


NOTES:
1. PLACE MARKER SO TOP IS FLUSH WITH SURROUNDING GROUND WITH "C" VISIBLE.
2. CREATE 6" TALL INDENTED "C" SHAPE IN CONCRETE.

CONDUIT MARKER DETAIL

SCALE: NOT TO SCALE

3 C-RD-001

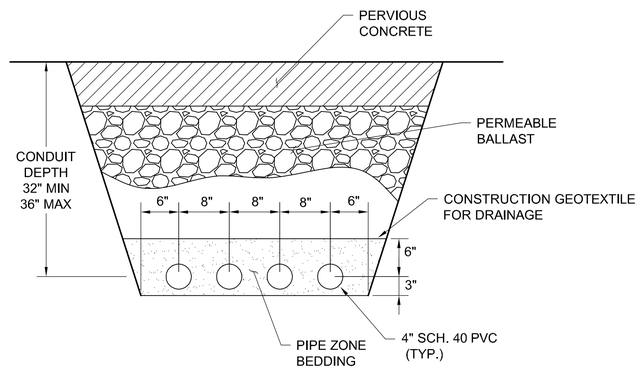


NOTES:
1. CONTRACTOR SHALL PROVIDE A SIGN LAYOUT TO ENGINEER FOR REVIEW PRIOR TO FABRICATION.
2. SIGN SHALL BE INSTALLED WITHIN 1 WEEK OF MOBILIZATION

TEMPORARY PROJECT SIGN

SCALE: NOT TO SCALE

2 C-RD-001



NOTES:
1. PLACE SAND BEDDING 3" BELOW CONDUIT AND 6" OVER CONDUIT, HAND TAMP.

CONDUIT TRENCH

SCALE: NOT TO SCALE

4 C-RD-001

Snohomish County Planning Development Services

APPROVED FOR CONSTRUCTION BY:

FOR RANDOLPH R. SLEIGHT, P.E., P.L.S.

LDA PERMIT NO. 13-104448

3/7/2014

NO.	DATE	REVISION	DR	CHK	APVD	BY	APVD
			GSH	JRC	KLC		GSH

THESE RECORD DRAWINGS HAVE BEEN PREPARED, IN PART, ON THE BASIS OF INFORMATION COMPILED BY OTHERS. THEY ARE NOT INTENDED TO REPRESENT IN DETAIL THE EXACT LOCATION, TYPE OF COMPONENT, NOR MANNER OF CONSTRUCTION. THE ENGINEER WILL NOT BE RESPONSIBLE FOR ANY ERRORS OR OMISSIONS WHICH HAVE BEEN INCORPORATED INTO THE RECORD DRAWINGS.

CENTRAL RAMP
PHASE I DRAINAGE IMPROVEMENTS
SNOHOMISH COUNTY - PAINE FIELD AIRPORT
SNOHOMISH COUNTY
EVERETT, WA

CH2MHILL®

DETAILS

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"

DATE	2014/03/07
PROJ	458317
DWG	C-DET-004
SHEET	14 of 14

FILENAME: 458317.A1.10.11_14-SD-DETAILS4.dwg PLOT DATE: 3/7/2014 PLOT TIME: 3:55 PM

APPENDIX C. Bibliography

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ASTM C1747/C1747M-13, *Standard Test Method for Determining Potential Resistance to Degradation of Pervious Concrete by Impact and Abrasion*
ASTM C1754/C1754M-12, *Standard Test Method for Density and Void Content of Hardened Pervious Concrete*
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International Standards Organization (ISO)

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SOFTWARE/APPLICATION TOOLS

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International Green Construction Code (IGCC). International Code Council (ICC) software for sustainability measures for the construction project and site.

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Permeable Design Pro. Interlocking Concrete Pavement Institute (ICPI) software for hydrologic and structural design of PICP.

PerviousPave: American Concrete Pavement Association (ACPA) software for hydrologic and structural design of pervious PCC pavement.

WWHM4: Continuous Simulation Stormwater Modeling software for use by Stormwater Engineers in meeting stricter EPA standards.

GENERAL PERMEABLE PAVEMENT RESOURCES

National Asphalt Pavement Association – www.hotmix.org
Interlocking Concrete Pavement Institute – www.icpi.org
Portland Cement Association – www.cement.org
National Ready Mixed Concrete Association – www.nrmca.org
BMP Database – www.bmpdatabase.org
Low Impact Development Center – www.lowimpactdevelopment.org
Center for Watershed Protection – www.cwp.org; www.stormwatercenter.net
Stormwater Manager's Resource Center – www.sustainable.org/environment/water/319-stormwater-managersresource-center-smrc

HYDROLOGIC DESIGN MODELS (FOR CONSIDERATION)

BMPDSS (Prince George's County, MD's Best Management Practice – Decision Support System)
http://www.epa.gov/region1/npdes/stormwater/assets/pdfs/BMP-Performance-Analysis-Report.pdf

Haestad Method (PondPack) (Bentley Systems)
http://www.bentley.com/en-US/Products/Water+and+Wastewater+Network+Analysis+and+Design/stormwater.htm

HSPF (EPA's Hydrological Simulation Program)
http://water.usgs.gov/software/HSPF/

HydroCAD (Computer Aided Design tool for modeling stormwater runoff)
http://www.hydrocad.net/

IDEAL (StormOps)
http://www.stormopssoftware.com/

LOCKPAVE PRO, UNI-GROUP USA
www.uni-groupusa.org

LID Quicksheet (Milwaukee, WI MSD)
http://www.indy.gov/eGov/City/DPW/SustainIndy/WaterLand/Documents/Appendix%203%20MMSD%20Quicksheet.pdf

P8 (USEPA, Minnesota PCA & Wisconsin DNR's Program for Predicting Polluting Particle Passage thru Pits, Puddles, & Ponds)
http://wwwalker.net/p8/

Permeable Design Pro (ICPI)
http://www.icpi.org/node/1298

PerviousPave (ACPA)
http://acpa.org/PerviousPave/

PCSMWW (Computational Hydraulics International)
www.chiwater.com

STEPL (EPA's Spreadsheet Tool for Estimating Pollutant Load)
http://it.tetratech-ffx.com/steplweb/models$docs.htm

SUSTAIN (EPA's System for Urban Stormwater Treatment and Analysis Integration)
http://www.epa.gov/nrmrl/wswrd/wq/models/sustain/
SWMM (EPA's Storm Water Management Model)
http://www.epa.gov/athens/wwqtsc/html/swmm.html

WinSLAMM (Source Loading and Management Model)
http://winslamm.com/winslamm_updates.html

WTM (Center for Watershed Protection's Watershed Treatment Model)
http://www.cwp.org/documents/cat_view/83-watershed-treatment-model.html

Win-TR20 (USDA)
http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/null/?cid=stelprdb1042793

Win- TR55 (USDA)
http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/water/?&cid=stelprdb1042901

XPSWMM
www.xpsolutions.com

WORKS IN PROGRESS

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