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Revised Drainage Report For the Oso Lumber Future Development Site Arlington, Washington

Prepared for:
Mike Cook
Oso Lumber
21015 SR 9 NE
Arlington, WA 98272

Prepared by:
John W. Cherry, P.E.

February 26, 2007

hba DESIGN GROUP
land use planning + civil engineering

Revised Drainage Report
For the Oso Lumber
Future Development Site
Arlington, Washington

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2-26-07
#35641
REGISTERED
PROFESSIONAL ENGINEER
EXPIRES 6/21/2007

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REVISION NOTE

Since the last submittal of this drainage report in June 2006, the applicant has obtained a 3.2-acre parcel adjacent to the northwest corner of the Oso Lumber property. A portion of this property has been incorporated into the development plan for the main site, and the drainage plan has been revised accordingly. The current revised report includes the following changes:

- **Revised text indicated in bold type.**
- **Revised basin map.**
- **Revised sizing calculations for StormTech chamber arrays A and B.**

All other components of this report are unchanged.

INTRODUCTION

Oso Lumber proposes to grade and pave approximately nine additional acres of the former Enterprise Lumber site, a 21.8 acre parcel one-third mile southeast of downtown Arlington, **along with paving approximately two acres of an adjacent 3.2-acre parcel to the north**. Much of the site currently is paved, with a railroad spur and several buildings associated with the former lumber yard operation.

As of this writing, the site is expected to be used as a whole sale lumber storage yard, but the configuration of the site has not been decided. For purposes of this drainage design it was assumed that the entire useable area will be impervious, whether buildings or pavement.

The native coarse sands underlying the site are suitable for engineering a system to infiltrate all stormwater runoff from the site, as currently occurs in an uncontrolled manner.

EXISTING CONDITIONS

The **25-acre** project site is currently developed with approximately 7.8 acres of paving encompassing several concrete slabs, a railroad spur crossing the northwest quadrant of the site, and four buildings that formerly served as offices and storage structures. The site has no frontage on city streets, but takes access from the east side of 67th Avenue SE through an adjacent parcel and a Burlington Northern Santa Fe right-of-way. A new access street, 72nd Avenue NE, was extended in 2003 north from 204th Street NE to provide access to the center of the site.

Portage Creek flows east to west along the southern boundary of the site. In the southeast quadrant of the site, a berm has been constructed to buffer the creek from the site. The site topography is relatively flat. At the northeast corner, adjacent residential parcels are approximately 40 feet higher at the top of an engineered embankment recently constructed to maximize available space on the Oso site. The unpaved portions of the site are largely vegetated with weeds and brush.

Geotechnical exploration (see report in the appendix) indicates the site is underlain by coarse sandy soil consistent with the Everett-series SCS classification. No groundwater was encountered in the test pits, to a depth of at least eight feet. The geotechnical report predicts an infiltration rate in excess of 20 inches per hour.

The existing pavement was constructed without an engineered drainage system. Some stormwater runs off into adjacent unpaved areas and soaks into the ground within a short distance of the edge of the pavement. Elsewhere, stormwater puddles in low spots, eventually evaporating or infiltrating into the soil through cracks in the pavement. This does not appear to have been a problem for industrial users of the site in the past.

There is no evidence of significant movement of stormwater onto or off the site or across the surface of the site because of the sandy soil. There does not appear to be any significant surface flow from the site into Portage Creek. No accessible offsite engineered storm drainage systems have been constructed in the immediate vicinity of the site. This appears to be in acknowledgement that most rainfall appears to infiltrate naturally into the soil where it falls, and that collecting it in conveyances would be counterproductive.

DEVELOPED CONDITIONS

Oso Lumber proposes to pave the entire site in anticipation of future use as a wholesale lumber storage yard. The existing buildings and pavement will remain, except where it encroaches within the Portage Creek buffer (75 feet at the east end of the site, 50 feet elsewhere). The areas to receive new paving will be graded to drain toward the north and south edges of the site. Existing pavement will continue to drain as it currently does.

Since the site is essentially level, it precludes design of a conventional stormwater detention system with discharge to an existing storm conveyance. Therefore, we are proposing that all stormwater generated on the site be collected, treated and infiltrated on site.

The site will be graded with an east/west crown through the approximate center, with the surface sloping down at approximately 1% toward the north and south. **The adjacent parcel to the north will be graded to drain south.** Curbing and catch basins will be constructed along the north and south edges of the pavement, designed to convey all runoff from all paved areas in a 24-hour, 100-year recurrence storm. The catch basins will discharge to underground storage chamber arrays manufactured by StormTech®, a division of ADS, Inc. (See literature in the appendix.) The collected stormwater will infiltrate into the sandy soil through the open bottoms of the chambers.

The chamber system was selected for ease of construction, ease of maintenance, efficiency of storage capacity and precision control of design and installation.

The appendix includes detailed basin runoff and sizing calculations for all six chamber arrays. The design infiltration rate is 10 inches per hour, one-half the 20 in/hr actual rate suggested by the geotechnical engineer, and the design storm is a 24-hour, 100-year recurrence storm. The calculations were performed with WaterWorks software by Engenious. The outflow was modeled as a steady rate of infiltration at 10 inches per hour over only the bottom area of each array. The storage configuration is irregular, with ratios of open chamber space to drain rock backfill that vary as the water level rises in the system. The storage was modeled with a stage/storage table, with staged capacity per chamber as provided by the manufacturer.

In the unlikely event of total system failure, stormwater will back up over the pavement, rather than flooding over property boundaries or into Portage Creek. Given the flat terrain, long distances and lack of conveyance systems in the area, an engineered overflow system would not be feasible on this site. As there is no acceptable outlet for an overflow conveyance, we have elected to hold the stormwater on site. All of the arrays have excess storage capacity above the maximum calculated 100-year water level.

Water quality
Because the entire site will be paved, nutrients are not expected to be a pollutant of concern. The primary pollutants will be sediment, which may have metals attached, and oil residues. These pollutants likely will be widely dispersed over the site, rather than concentrated. Some potential future uses of portions of the site may trigger D.O.E. requirements for enhanced treatment, but the locations and runoff volumes of such areas are unknown at this time.

It is anticipated that treated lumber may be stored on the site, but the City of Arlington has conditioned its approval upon treated lumber being stored only under cover. Consequently the treated lumber will generate no polluted runoff. The remainder of the stored lumber will not generate pollutant loadings, and vehicular traffic in this wholesale storage yard will be minimal. The StormTech chamber systems have integral pre-settling chambers (the "isolator row"), and the inlet catch basins will be fitted with oil/water separator tees. This is all that D.O.E. requires for parking lots with less than 20 stalls. We believe that the paved area draining to any one chamber system will generate vehicular pollutant loadings comparable to a parking lot of less than 20 stalls, as there will be no retail traffic. Trucks will load up in the morning and be gone for the rest of the day.

Incoming stormwater will be directed first through catch basins to the center row of chambers within each array, designated an "isolator row". This row has a sealed bottom and serves as a settling chamber for sediments and attached pollutants. From the isolator row the stormwater is slowly dispersed through perforations to the rest of the array. The isolator row is accessible for sediment removal by jet-vac.

Oils in stormwater runoff tend either to float on the water surface or to bind to sediments and sink. At the Oso lumber site, floating oils will be skimmed by oil separator tees within the flow train. Floating and sediment-bound oils not removed by the first element of the treatment train will be separated and retained within the isolator rows.

CONCLUSIONS
We believe the proposed drainage system, with its redundant water quality features and safety factors, will provide complete stormwater management within the confines of the site. No offsite impact is anticipated.

DRAINAGE DESIGN PARAMETERS

Precipitation – 100-year, 24 hour design storm	4.00 inches
Design infiltration rate (1/2 geotech's predicted rate)	10 inches/hour
Soil type	Everett series coarse sand
Assumed % impervious (CN = 98)	100% of defined basin
Method of analysis	Santa Barbara Unit Hydrograph
Infiltration surface per chamber	23.7 sq. ft. (bottom only)
Storage per chamber (variable rate w/ depth)	Per manufacturer's table
Water Quality pollutants of concern:	*Treatment*
Oil	Separator tee Isolator row in chamber array*
Sediments w/ adsorbed metals	Sump in catch basin Isolator row in chamber array

*Oil floats at water surface or binds to sediments, water disperses laterally below surface level through perforations in side of chamber.

APPENDIX

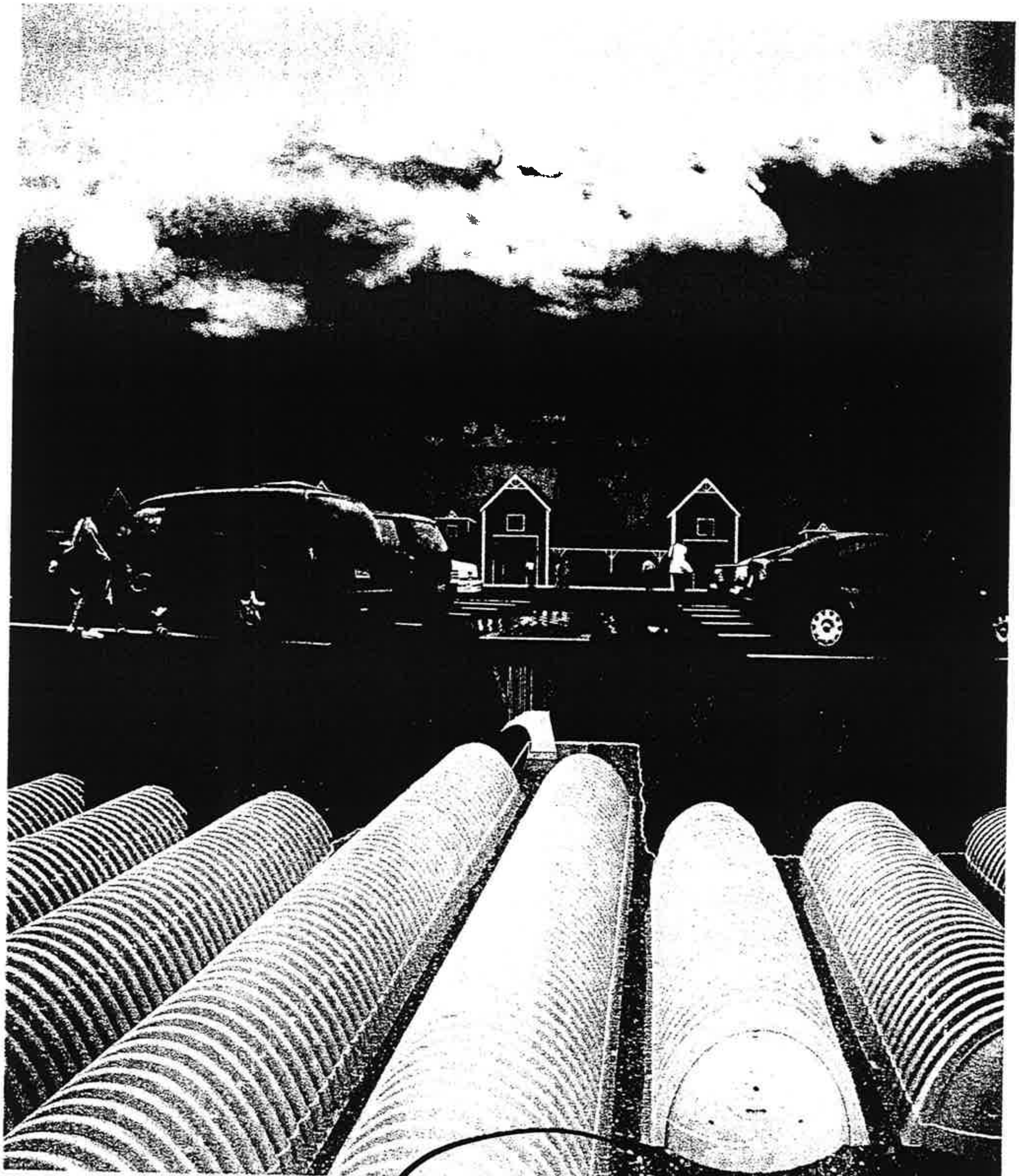
StormTech® Chamber Information
Basin Map & Engineering Design Calculations
Geotechnical Reports & SCS Soils information
Maintenance requirements

StormTech® Chamber Information

StormTech®

Detention • Retention • Recharge

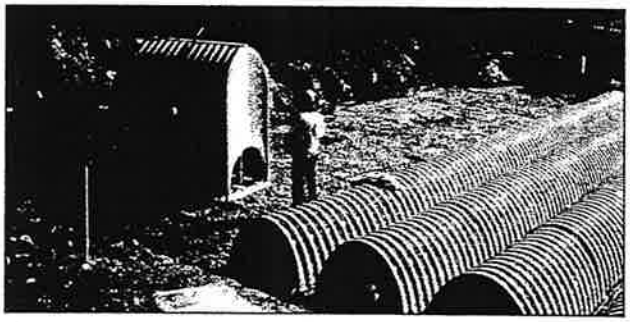
Subsurface Stormwater Management℠



EXCERPTS

Design Manual

StormTech® Chamber Systems for Stormwater Management



Stacked chambers are lifted into the bed and easily put in place.

1.1 INTRODUCTION

StormTech's stormwater management systems allow stormwater professionals to create more profitable, environmentally sound developments. Compared with other subsurface systems, StormTech systems offer lower overall installed cost, superior design flexibility and enhanced performance. Applications include commercial, residential, agricultural and highway drainage.

StormTech has invested over $7.5 million and four years in the development of StormTech chambers. These innovative products exceed the rigorous requirements of the stormwater industry.

1.2 THE GOLD STANDARD IN STORMWATER MANAGEMENT

The advanced designs of StormTech's chambers were created by implementing an aggressive research, development, design and manufacturing protocol. StormTech chamber products establish the new gold standard in stormwater management through:

- Collaborations with experts in the field of buried plastic structures and polyolefin materials
- The development and utilization of new testing methods and proprietary test fixtures
- The use of thermoformed prototypes to verify engineering models, perform in-ground testing and install observation sites
- The investment in custom-designed, injection molding equipment
- The utilization of polypropylene as a manufacturing material
- The design of molded-in features not possible with traditional thermoformed chambers

Section 3.0 of this design manual, *Structural Capabilities*, provides a detailed description of the research, development and design process.

Many of StormTech's unique chamber features can benefit a site developer, stormwater system designer, and installer. Where applicable, StormTech's Product Specifications are referenced throughout this design manual. If StormTech's unique product benefits are important to a stormwater system's design, consider including the applicable StormTech product specifications on the site plans. This can prevent substitutions with inferior products. Refer to Section 15.0, *StormTech Product Specifications*.

1.3 TECHNICAL SUPPORT FOR PLAN REVIEWS

StormTech's in-house technical support staff is available to review proposed plans that incorporate StormTech chamber systems. They are also available to assist with plan conversions from existing products to StormTech. Not all plan sheets are necessary for StormTech's review. Required sheets include plan view sheet(s) with final elevations, any detail sheets with cross sections of the stormwater system including catch basins and any landscape details.

When specifying StormTech Chambers it is recommended that the following items are included in project plans: StormTech chamber system General Notes, applicable StormTech chamber illustrations and StormTech chamber system Product Specifications. These items are available in various formats and can be obtained by contacting StormTech at **1-888-892-2694** or may be downloaded at **www.stormtech.com.**

StormTech's plan review is limited to the sole purpose of determining whether plans meet StormTech chamber systems' minimum requirements. **It is the ultimate responsibility of the design engineer to assure that the stormwater system's design is in full compliance with all applicable laws and regulations.** StormTech products must be designed and installed in accordance with StormTech's minimum requirements.

SEND PLANS TO:

StormTech LLC, Plan Review, 20 Beaver Road, Suite 104, Wethersfield, CT 06109 E-mail: techinfo@stormtech.com. File size should not exceed 2MB.

2.1 PRODUCT APPLICATIONS

StormTech chamber systems may function as stormwater detention, retention, first-flush storage, or some combination of these. The StormTech chambers can be used for commercial, municipal, industrial, recreational, and residential applications including installation under parking lots and commercial roadways.

One of the key advantages of the StormTech chamber system is its design flexibility. Chambers may be configured into beds or trenches of various sizes or shapes. They can be centralized or decentralized, and fit on nearly all sites. Chamber lengths enhance the ability to develop on both existing and pre-developed projects. The systems can be designed easily and efficiently around utilities, natural or man-made structures and any other limiting boundaries.

2.2 CHAMBERS FOR STORMWATER DETENTION

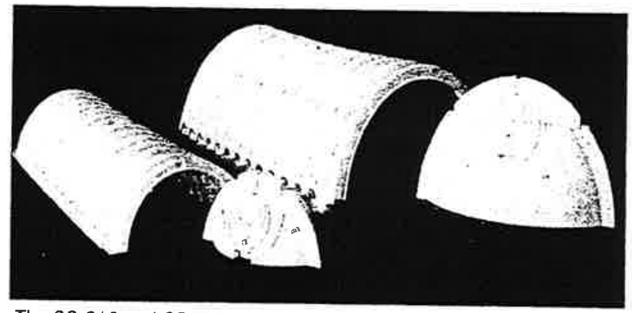
Chamber systems have been used effectively for stormwater detention for over 15 years. A detention system temporarily holds water while it is released at a defined rate through an outlet. While some infiltration may occur in a detention system, it is often considered an environmental benefit and a storage safety factor. Over 70% of StormTech's installations are non-watertight detention systems. There are only a few uncommon situations where a detention system might need to be watertight: The subgrade soil's bearing capacity is significantly affected by saturation such as with expansive clays or karst soils, and; in sensitive aquifer areas where the depth to groundwater does not meet EPA's guidelines of 2 – 4 feet. Adequate pretreatment could eliminate concerns for the latter case. An impermeable liner may be considered for both situations to create a watertight chamber system. Contact StormTech's Technical service department for more information on using Stormtech chambers in your application.

2.3 STONE POROSITY ASSUMPTION

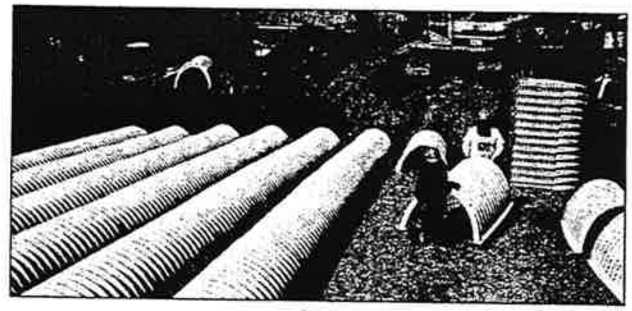
A StormTech chamber system requires the application of washed angular stone below, between and above the chambers. This stone serves as a structural component while allowing conveyance and storage of stormwater. Storage volume examples throughout this Design Manual are calculated with an assumption that the angular stone has a porosity of 40%. Actual stone porosity may vary. Contact StormTech for information on calculating stormwater volumes with varying stone porosity assumptions.

2.4 CHAMBER SELECTION

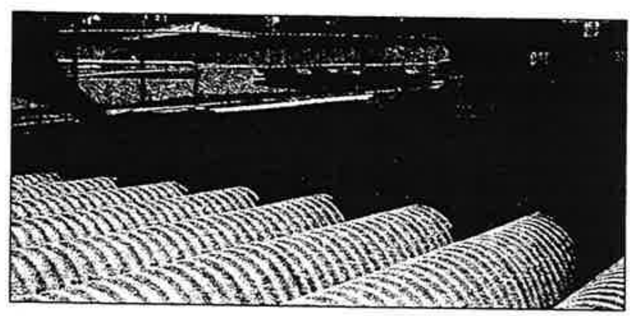
StormTech currently offers two chamber sizes for stormwater management. These chambers have been designed to optimize and balance storage volumes



The SC-310 and SC-740 chambers and end plates.



StormTech systems can be integrated into retrofit and new construction projects.



StormTech chambers may be configured into beds or trenches.

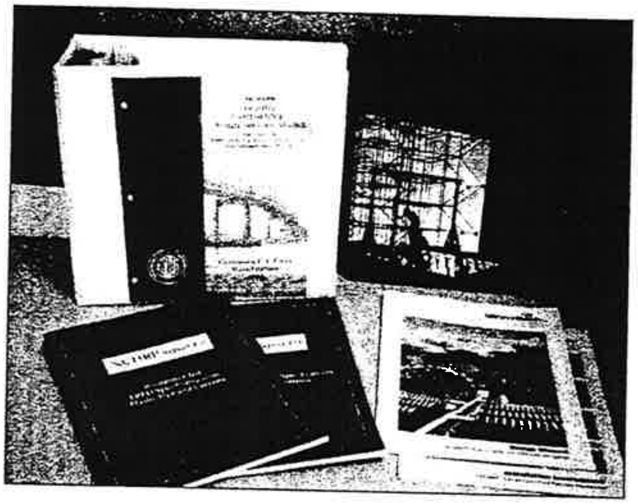
with respect to depth and area constraints.

Primary considerations when selecting between the SC-740™ and SC-310™ chambers are the depth to groundwater, available area for subsurface storage and outfall restrictions.

The StormTech SC-740 chamber shown in **Figure 1** on page 4 optimizes storage volumes in relatively small footprints. By providing 2.2 ft^3/ft^2 (minimum) of storage, the SC-740 chambers can minimize excavation, backfill and associated costs.

The StormTech SC-310 chamber shown in **Figure 2** on page 4 is ideal for systems requiring low-rise and wide-span solutions. This low profile chamber allows the storage of large volumes, 1.3 ft^3/ft^2 (minimum), at minimum depths. *Product Specifications: 2.2 and 2.5*

3.0 Structural Capabilities



3.1 STRUCTURAL DESIGN APPROACH

StormTech's products are designed to exceed AASHTO LRFD recommended design factors for Earth Loads and HS-20 live loads, with consideration for impact and multiple presences, when installed per StormTech's minimum requirements. Structural performance of StormTech's chambers were assessed utilizing current AASHTO procedures for the design of profile wall thermoplastic culverts (AASHTO LRFD Bridge Design Specifications with Interim Specifications through 2001).

Computer models of the chambers under shallow and deep conditions were developed. Utilizing design forces from the computer models, chamber sections were evaluated using AASHTO procedures that consider thrust and moment, and check for local buckling capacity. The procedures also considered the time-dependent strength and stiffness properties of polypropylene.

These procedures were developed in a research study conducted by the National Cooperative Highway Research Program (NCHRP) for AASHTO, and published as NCHRP Report 438 Recommended LRFD Specifications for Plastic Pipe and Culverts.

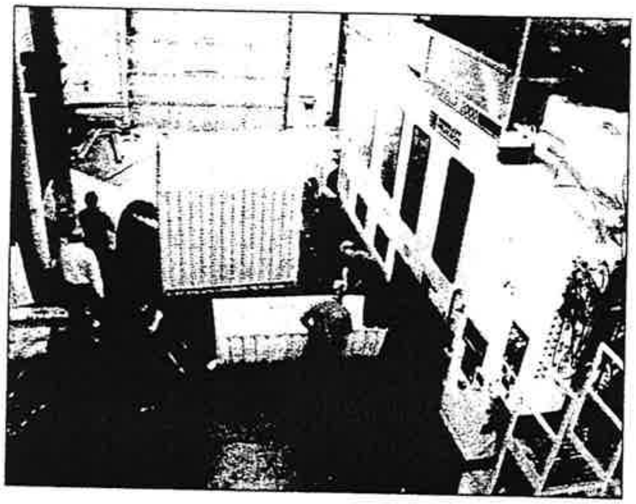
Product Specifications: 2.12

3.2 FULL SCALE TESTING

After developing the StormTech chamber designs, the chambers were subjected to rigorous full-scale testing. The test programs verified the predicted safety factors of the designs by subjecting the chambers to more severe load conditions than anticipated during service life. Capacity under live loads and deep fill was investigated by conducting tests with a range of cover depths.

3.3 INDEPENDENT EXPERT ANALYSIS

StormTech worked closely with the consulting firm Simpson Gumpertz & Heger Inc. (SGH) to develop and evaluate the SC-740 and SC-310 chamber designs. SGH has world-renowned expertise in the design of buried drainage structures. The firm was the principal investigator for the NCHRP research program that developed the structural analysis and design methods recently adopted by AASHTO for thermoplastic culverts. SGH conducted design calculations and computer simulations of chamber performance under various installation and live load conditions. They worked with StormTech to design the full-scale test programs to verify the structural capacity of the chambers. SGH also observed all full-scale tests and inspected the chambers after completion of the tests.



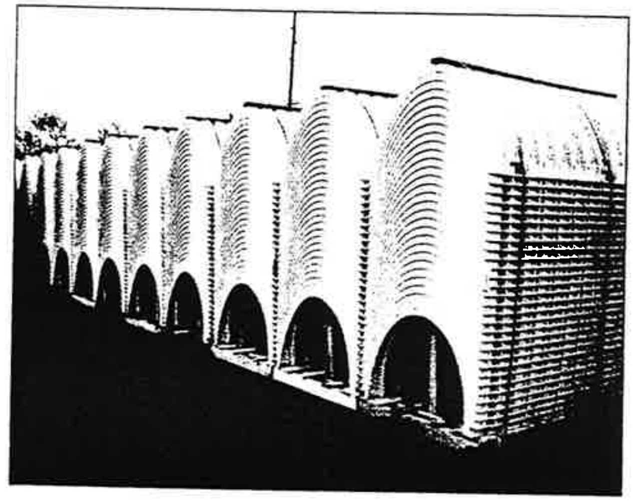
3.4 INJECTION MOLDING

To comply with the structural requirements of AASHTO's LRFD design and analysis methods, StormTech utilizes proprietary injection molding equipment to manufacture the SC-740 and SC-310 chambers and end caps. StormTech invested in this superior process, rather than less precise thermoforming methods, to assure consistent quality and structural performance.

In addition to meeting structural goals, injection molding allows StormTech to design added features and advantages into StormTech's parts including:

- Molded of polypropylene (See Section 3.5)
- Precise control of wall thickness throughout parts
- Precise fit-up of joints and end caps
- Molded-in inspection port fitting
- Molded-in handles on end caps
- Molded-in pipe guides with blade starter slots
- Repeatability for Quality Control (See Section 3.6)

Product Specifications: 2.1, 3.1 and 3.3



3.5 POLYPROPYLENE RESIN

StormTech chambers are injection molded from polypropylene. Polypropylene chambers are inherently resistant to environmental stress cracking and chemicals typically found in stormwater run-off. StormTech's chambers maintain a greater portion of their structural stiffness through higher installation and service temperatures.

3.6 QUALITY CONTROL

StormTech's SC-740 and SC-310 stormwater chambers are manufactured under tight quality control programs. Materials are routinely tested in an environmentally controlled lab that is verified every six months via the external ASTM Proficiency Testing Program. The chambers' material properties are measured and controlled with procedures following ISO 9001:2000 requirements.

Statistical Process Control (SPC) techniques are applied during manufacturing. Established upper and lower control limits are maintained on key manufacturing parameters to maintain consistent product. Additionally, an SPC based finished goods inspection process is used for a number of attributes and variables. StormTech's products are produced in an ISO 9001:2000 certified manufacturing facility.

Product Specifications: 2.13 and 3.6

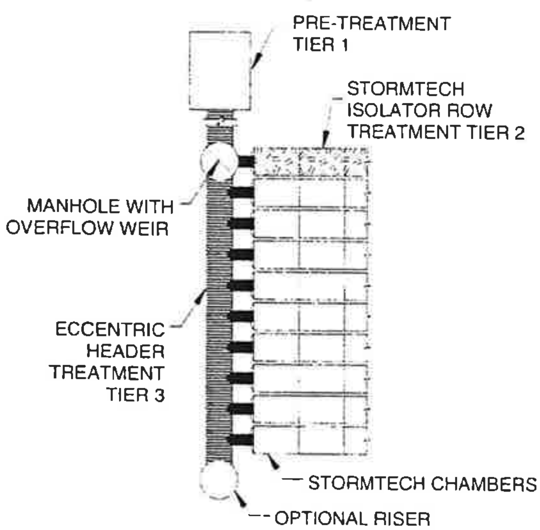
The design flexibility of a Stormtech chamber system includes many inletting possibilities. Contact StormTech's technical service department for guidance on designing an inlet system to meet specific site goals.

6.1 TREATMENT TRAIN

A properly designed inlet system can ensure good water quality, easy inspection & maintenance, and a long system service life. StormTech recommends a treatment train approach for inletting an underground stormwater management system under a typical commercial parking area. *Treatment train* is an industry term for a multi-tiered water quality network. As shown in **Figure 6**, a StormTech recommended inlet system can inexpensively have up to 3 tiers of treatment upstream of the StormTech chambers:

Tier 1 – Pre-treatment (BMP)
Tier 2 - StormTech Isolator Row
Tier 3 - Eccentric Pipe Header-Manifold

Figure 6 – Typical StormTech Treatment Train Inlet System



6.2 PRE-TREATMENT (BMP) – TREATMENT TIER 1

Typically, some level of pre-treatment of the stormwater is required prior to entry into a stormwater system. By treating the stormwater prior to entry into the system, the service life of the system can be extended, pollutants such as hydrocarbons may be captured, and local regulations met. Pre-treatment options are often described as a Best Management Practice or simply a BMP.

Pre-treatment devices differ greatly in complexity, design and effectiveness. Depending on a site's characteristics and treatment goals, the simple, least expensive pre-treatment solutions can sometimes be just as effective as the complex systems. Options include a simple deep sumped manholes with a 90° bend on its outlet, baffle boxes, swirl concentrators, sophisticated filtration devices, and devices that combine these processes. Some of the most effective pre-treatment options combine engineered site grading with vegetation such as bio-swales or grassy strips.

The type of pretreatment device specified as the first level of treatment up-stream of a StormTech chamber system can vary greatly throughout the country and from site-to-site. It is the responsibility of the design engineer to understand the water quality issues and design a stormwater treatment system that will satisfy local regulators and follow applicable laws. A design engineer should apply their understanding of local weather conditions, site topography, local maintenance requirements, expected service life, etc...to select an appropriate stormwater pre-treatment system.

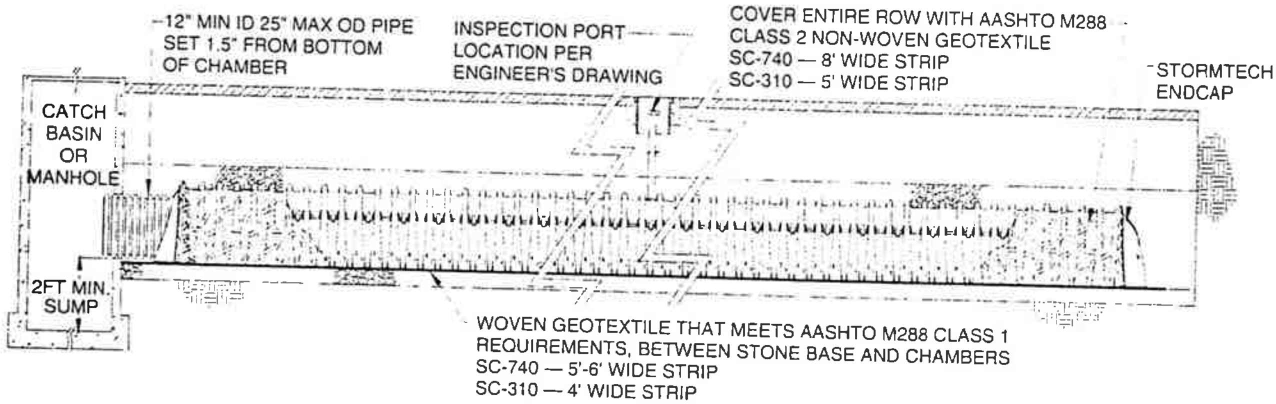
6.3 STORMTECH ISOLATOR ROW – TREATMENT TIER 2

Stormtech has a patent pending technique to inexpensively enhance Total Suspended Solids (TSS) removal and provide easy access for inspection and maintenance. The StormTech Isolator Row is a row of standard StormTech chambers surrounded with appropriate filter fabrics and connected to a manhole for easy access. This application basically creates an extended detention basin that allows water to egress through the surrounding filter fabric while sediment is trapped within. It may be best to think of the Isolator Row as a first-flush treatment device. *First-Flush* is a term typically used to describe the first ½" to 1" of rainfall or runoff on a site. The majority of stormwater pollutants are carried in the sediments of the first-flush, therefore the Isolator Row can be an effective component of a treatment train.

The StormTech Isolator Row should be designed with a manhole with an overflow weir at its upstream end. The manhole is connected to the Isolator Row with a short length of 12" ID through 25" OD pipe set near the bottom of the StormTech SC-740 EndCap. The weired manhole is multi-purposed. It can provide access to the StormTech Isolator row for both inspection and maintenance. The overflow weir with its crest set even with the top of chambers allows stormwater in excess of the Isolator Row's storage/conveyance capacity to bypass into the chamber system through the downstream Eccentric header/manifold system.

Specifying and installing proper geotextiles is essential for efficient operation and to prevent damage to the system during the JetVac maintenance process. A strip of woven geotextile that meets AASHTO M288 Class 1 requirements is required between the chambers and their stone foundation. This strong filter fabric traps sediments and protects the stone base during maintenance. A strip of non-woven AASHTO M288 Class 2 geotextile is draped over the Isolator chamber row. This 6 – 8 oz. non-woven filter fabric prevents sediments from migrating out of the

Figure 7 – StormTech Isolator Row Detail



chambers' perforations while allowing modest amounts of water to flow out of the Isolator Row. **Figure 7** is a detail of the Isolator Row that shows proper application of the geotextiles.

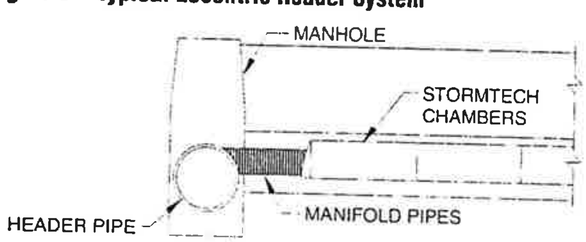
Inspection is easily accomplished through the upstream manhole or optional inspection ports. If specified, inspection ports should be located approximately every tenth chamber along the Isolator row or where practical to facilitate inspection. Maintenance of an Isolator Row is fast and easy using the JetVac process through the upstream manhole. Section 13.0 explains the Inspection and Maintenance process in more detail.

Each SC-740 chamber in an Isolator row will store 45.9 cubic feet of first-flush stormwater. During and between storm events an Isolator Row will allow stormwater to egress at a rate of 0.25 cfs or less per chamber. A bed of StormTech chambers may have multiple Isolator rows to accommodate required first-flush volumes.

6.4 ECCENTRIC HEADER SYSTEM – TREATMENT TIER 3

The third tier of the treatment train is the eccentric header system. This is much like a typical header system except that the inlet pipes are smaller and located at a higher invert than the header pipe. This is accomplished by building the header system with reducer tees installed upside down so a sump is created within the large diameter header pipe as shown in **Figure 8.** A typical eccentric header system might have a 48" header pipe with 18" manifolds creating a 30-inch header sump.

Figure 8 – Typical Eccentric Header System



The upstream end of the eccentric header system will typically be connected directly to the downstream side of the Isolator Row's weired manhole as shown in **Figure 6**. The downstream end of the header pipe may have a riser or manhole to facilitate inspection and maintenance. Pipe companies can provide more detailed information on designing a header system optimized for trapping TSS.

6.5 TREATMENT TRAIN CONCLUSION

The treatment train is a highly effective water-quality approach that does not add significant cost to a StormTech system being installed under commercial parking areas. Some type of pre-treatment device, perhaps as simple as a catchbasin or manhole, is usually required on all stormwater systems. The StormTech Isolator Row adds a significant level of treatment, easy inspection and maintenance, while maintaining storage volume credit for the cost of a modest amount geotextiles. Finally, a pipe header-manifold system is a well recognized component of a chamber inlet system. Inverting the reducer tees creates an eccentric header system that can be easily inspected and maintained. This treatment train concept provides three levels of treatment, inspection and maintenance upstream of the StormTech detention/retention bed with little additional expense.

6.6 OTHER INLET OPTIONS

While the three-tiered treatment train approach is the recommended method of inletting StormTech chambers for typical under-commercial parking application, there are other effective inlet methods that may be considered. For instance, Isolator Rows, while adding an inexpensive level of confidence, are not always necessary. A header system with fewer inlets can be designed to further minimize the cost of a StormTech system. There may be applications where stormwater pre-treatment may not be necessary at all and the system can be inlet directly from the source. In other cases it may make sense to design a system with a treatment device downstream of the StormTech detention system so water can be treated at lower rates prior to releasing from the site. Contact StormTech's Technical Service Department to discuss inlet options.

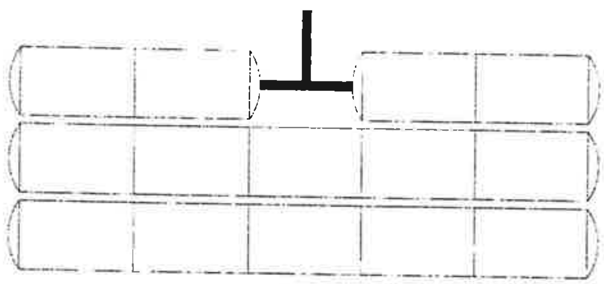
6.7 LATERAL FLOW RATES

The angular stone surrounding the StormTech chambers allows the rapid conveyance of stormwater between chamber rows. Stormwater will rise and fall evenly within a bed of chambers. A single StormTech chamber is able to release or accept stormwater at a rate of at least 0.5 cfs through the surrounding stone.

6.8 INLETTING PERPENDICULAR TO A ROW OF CHAMBERS

There is an easy, inexpensive method to perpendicularly inlet a row of chambers. Simply replace the chamber with a tee where the inlet pipe intersects the row. From the tee, short lengths of pipe may be used to penetrate the endcaps used to terminate the two new openings in the row. **Figure 9** is a typical detail of the perpendicular inlet method.

Figure 9 – Perpendicular Inlet



6.9 MAXIMUM INLET PIPE VELOCITIES TO PREVENT SCOURING OF THE STONE FOUNDATION

This section is applicable to the classic manifold and emergency overflow inlet piping. Isolator Rows are protected from scouring by the woven geotextile.

To prevent scouring of the washed, crushed, angular stone foundation, inlet pipe flow velocities must not exceed those listed in **Table 3**. Flow velocities greater than those listed may cause excess scouring at the inlet water's impact zone, which can be detrimental to the angular stone's performance as a structural foundation. In these cases, scour control measures must be implemented. Simple scour control measures include applying rip-rap, geotextile material or splash dissipators to the inlet water's projected impact zone. Many designers implement scour control measures as a general practice, regardless of flow velocity.

TABLE 3 – Maximum Inlet Velocity in Feet Per Second to Prevent Scouring of an Unprotected 1-inch to 2-inch Angular Stone Foundation.

[illegible]	Inlet Pipe Velocities ([illegible] second)
4	2.43
6	2.61
8	2.73
10	2.44
12	2.19
15	2.00
18	1.88
24	1.74

TABLE 4 – Some Suitable Geotextiles

[illegible]	[illegible]	AASHTO M288 Class 1 Woven**
Amoco Fabrics and Fibers (Part of BP)	ProPex 4506 ProPex 4508 ProPex 4551 ProPex 4552 ProPex 4553	ProPex 2006 ProPex 2016 ProPex 2044
Belton Industries	—	Beltech 315 Style 883
Carthage Mills	FX-60HS, FX-80HS	FX-66
Contech Const. Products	C-70NW	—
GSE Lining Technology	NW6, NW8	—
Maccaferri	MacTex MX245 MacTex MX275	—
Mirafi Const. Products	Mirafi 160N Mirafi 180N	Mirafi 600X Filterweave 403 Filterweave 404 Geolon HP570 Geolon HP665 Geolon HP770
Pavco - Amanco	NT 3000, NT 4000	TR 4000
SI Geosolutions	Geotex 601 Geotex 801	Geotex 315ST
TNS Advanced Tech.	R 060, R070 R 080, R100	M 403
US Fabrics	US 205NW-C	US 315
Webtec	TeraTex N06 TeraTex N08	TeraTex HD

*AASHTO M288 Class 2 Non-Woven Geotextile Application: 1. Separation layer between angular stone cover and fill to prevent fines intrusion. 2. Filter layer over the chambers of the Stormtech Isolator™ Row to prevent fines migration out of row while maintaining adequate hydraulic flows.

**AASHTO M288 Class 1 Woven Geotextile Application: Stabilization layer for the angular stone foundation of the StormTech Isolator™ Row to prevent scouring of the stone base during the JetVac maintenance procedure, modest hydraulic flows maintained.

Figure 13

Plan View Detail – StormTech SC-740 Chamber (not to scale)

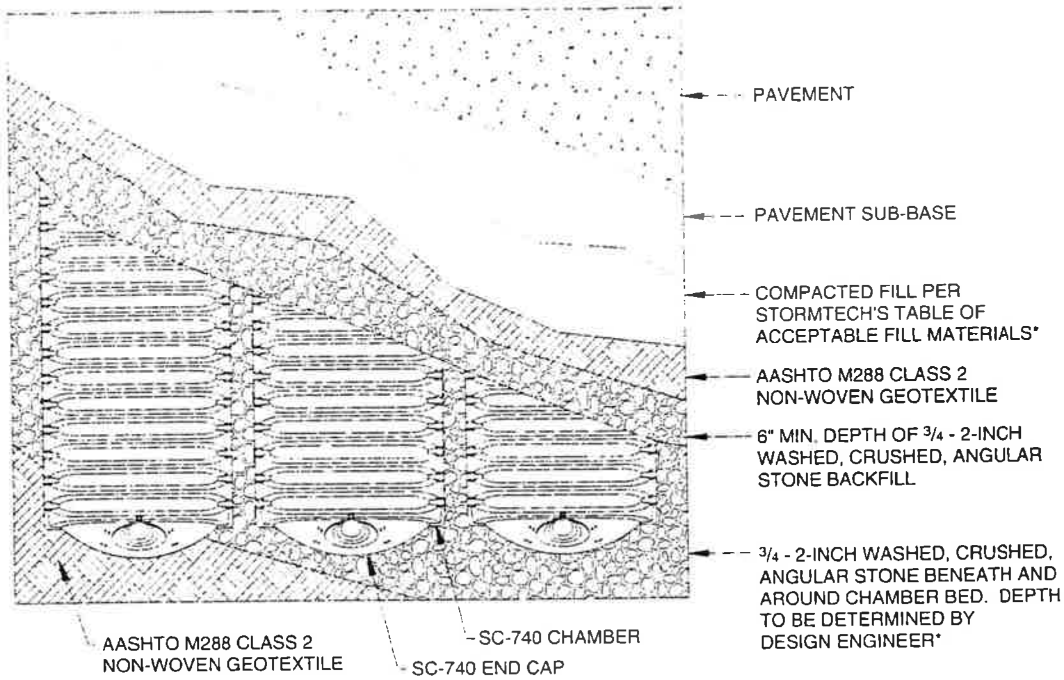
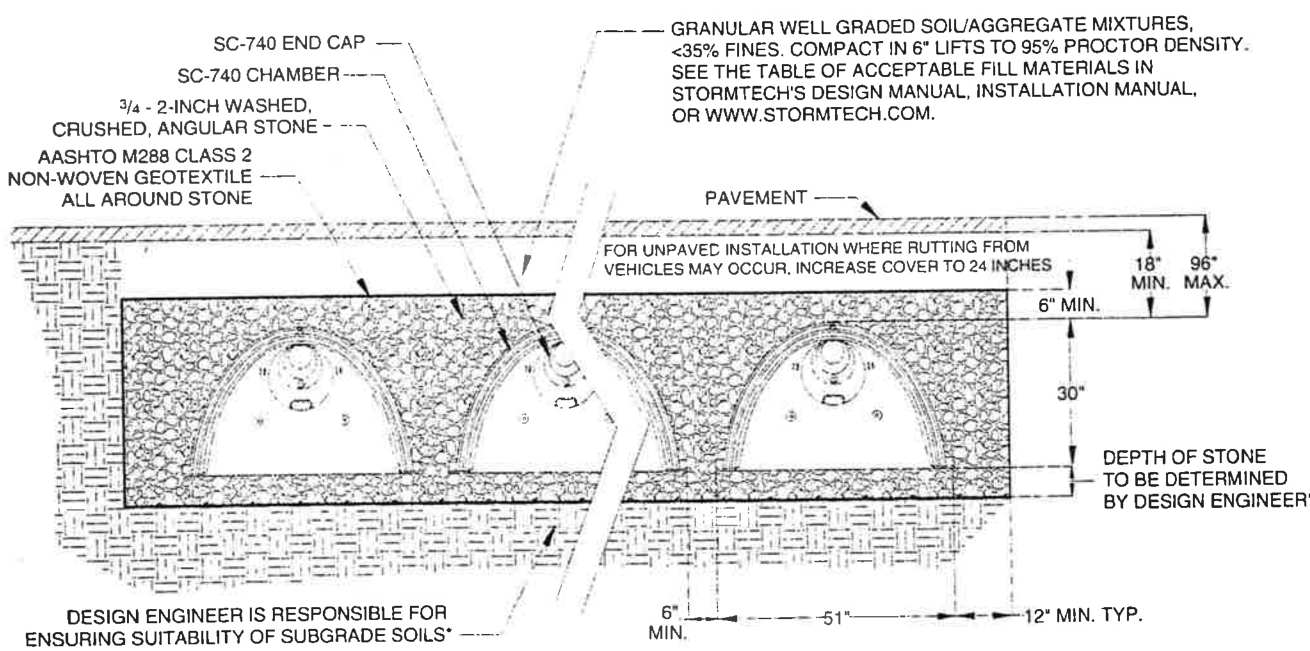


Figure 14

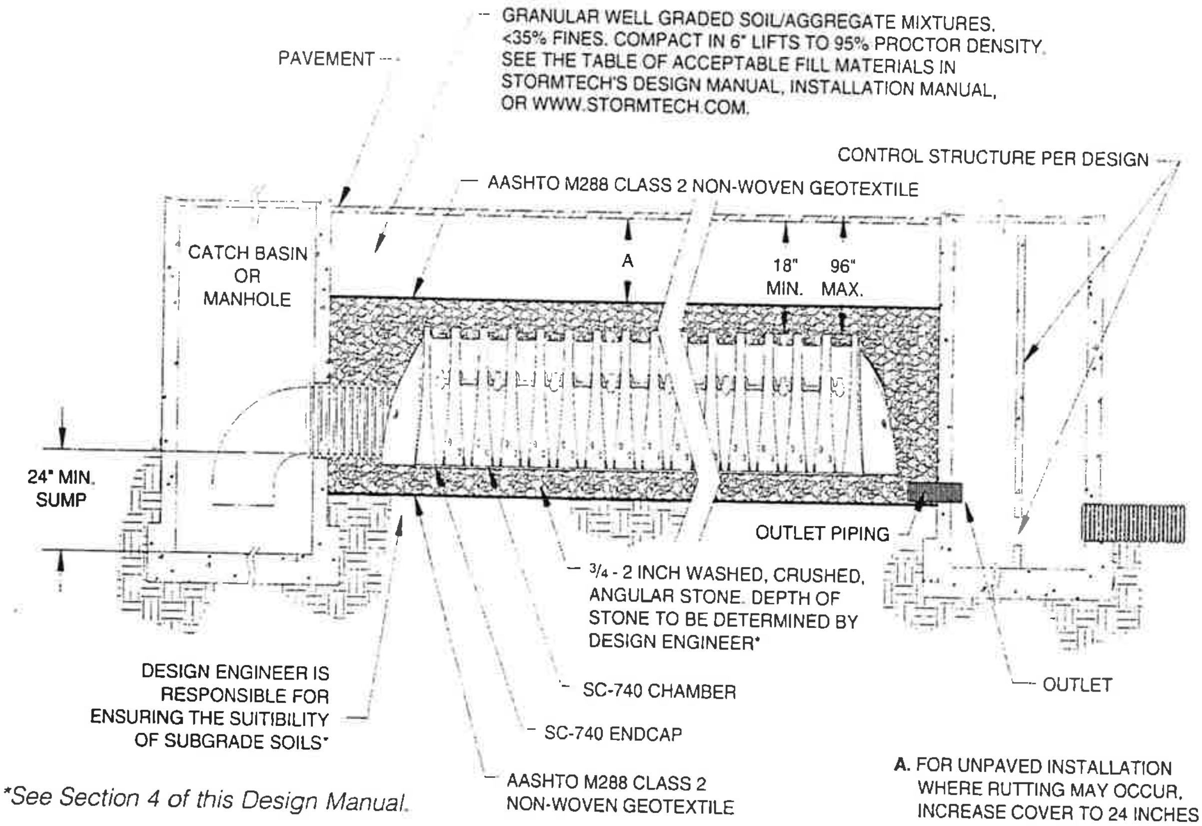
Typical Cross Section Detail – StormTech SC-740 Chamber (not to scale)



*See Section 4 of this Design Manual.

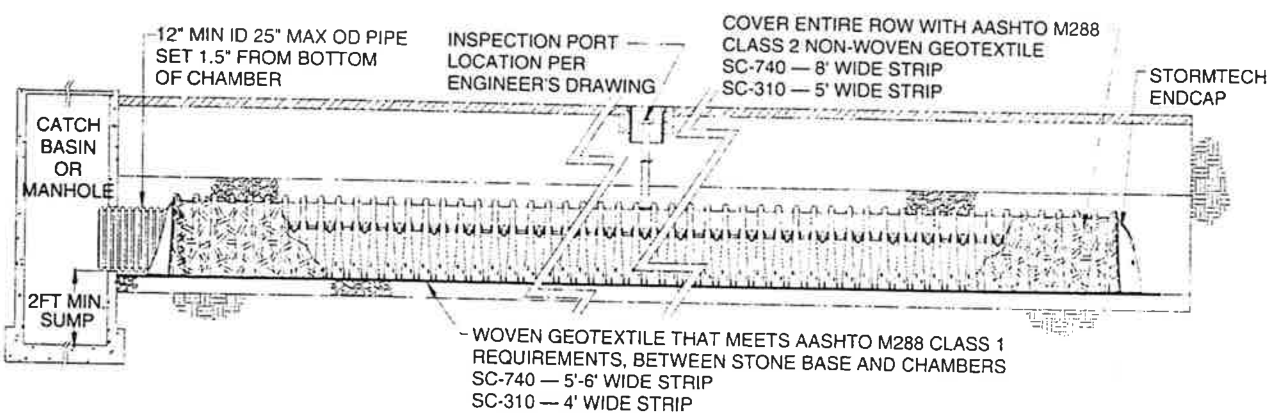
Detail drawings available in AutoCad Rev. 14 format at www.stormtech.com.

Figure 15
Inlet and Outlet Detail – StormTech SC-740 Chamber (not to scale)



**See Section 4 of this Design Manual.*

Figure 16
StormTech Isolator Row (not to scale)



Detail drawings available in AutoCad Rev. 14 format at www.stormtech.com.

13.4 ISOLATOR™ ROW INSPECTION

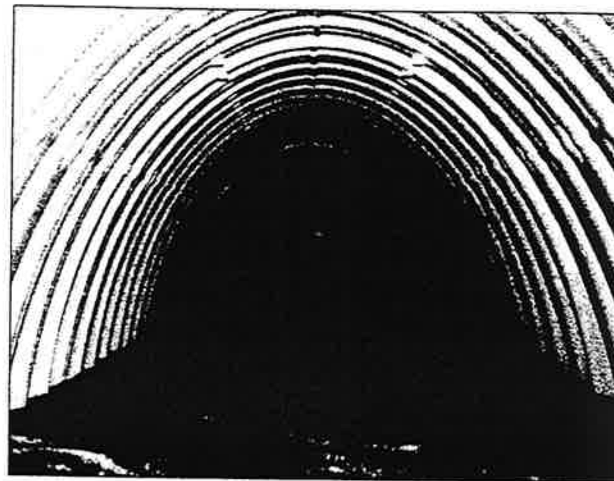
Regular inspection and maintenance are essential to assure a properly functioning stormwater system. Inspection is easily accomplished through the manhole or optional inspection ports of an Isolator Row. Please follow local and OSHA rules for a confined space entry.

Inspection ports can allow inspection to be accomplished completely from the surface without the need for a confined space entry. Inspection ports provide visual access to the system with the use of a flashlight. A stadia rod may be inserted to determine the depth of sediment. If upon visual inspection it is found that sediment has accumulated to an average depth exceeding 3 inches, cleanout is required.

A StormTech Isolator Row should initially be inspected immediately after completion of the site's construction. While every effort should be made to prevent sediment from entering the system during construction, it is during this time that excess amounts of sediments are most likely to enter any stormwater system. Inspection and maintenance, if necessary, should be performed prior to passing responsibility over to the site's owner. Once in normal service, a StormTech Isolator Row should be inspected bi-annually until an understanding of the sites characteristics is developed. The site's maintenance manager can then revise the inspection schedule based on experience or local requirements.

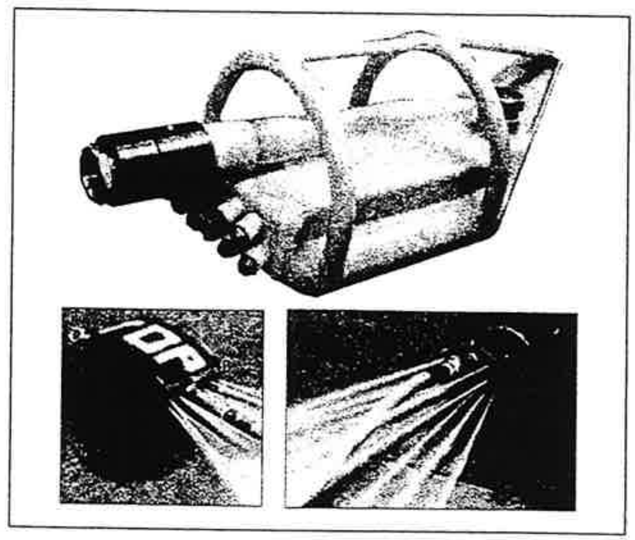
13.5 ISOLATOR ROW MAINTENANCE

JetVac maintenance is required if sediment has been collected to an average depth of 3 inches or more inside the Isolator Row. The JetVac process utilizes a high pressure water nozzle to propel itself down the Isolator Row while scouring and suspending sediments. As the nozzle is retrieved, a wave of suspended sediments is flushed back into the manhole for vacuuming. Most sewer and pipe maintenance companies have vacuum/JetVac combination vehicles. Fixed nozzles designed for culverts or large diameter pipe cleaning are preferable. Rear facing jets with an effective spread of at least 45" are best. Most JetVac reels have a minimum of 400 feet of hose allowing maintenance of an Isolator Row up to 50 chambers long. The JetVac process shall only be performed on StormTech Rows that have AASHTO class 1 woven geotextile over their angular base stone.

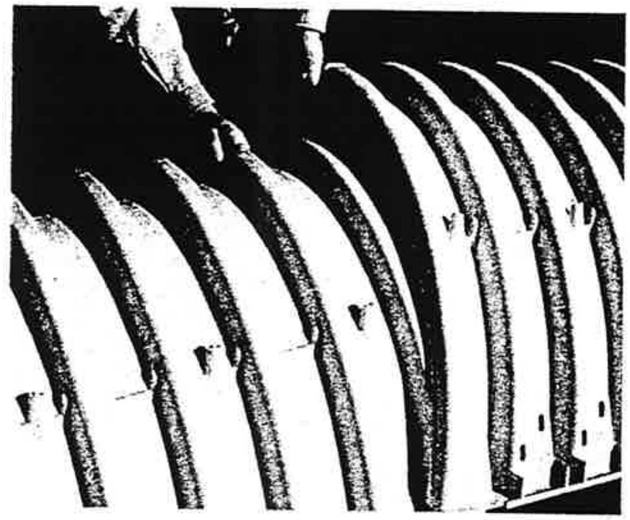


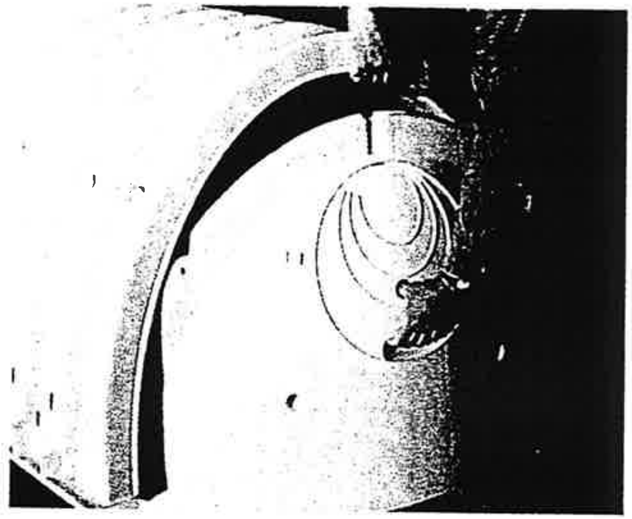
Looking down the Isolator Row.

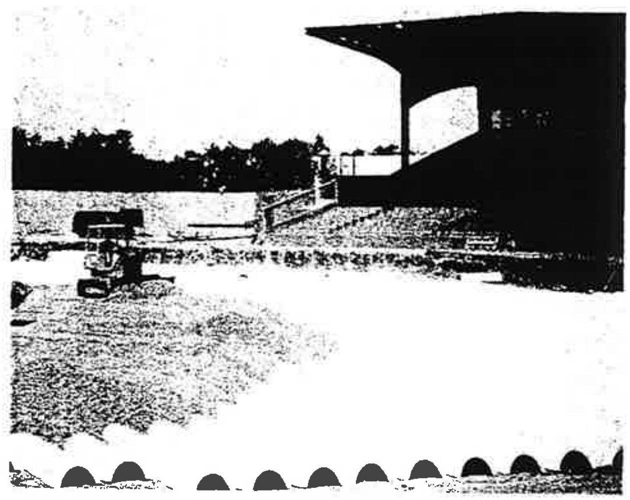
A typical JetVac truck. (This is not a StormTech product.)



Examples of culvert cleaning nozzles appropriate for Isolator Row maintenance. (These are not StormTech products.)







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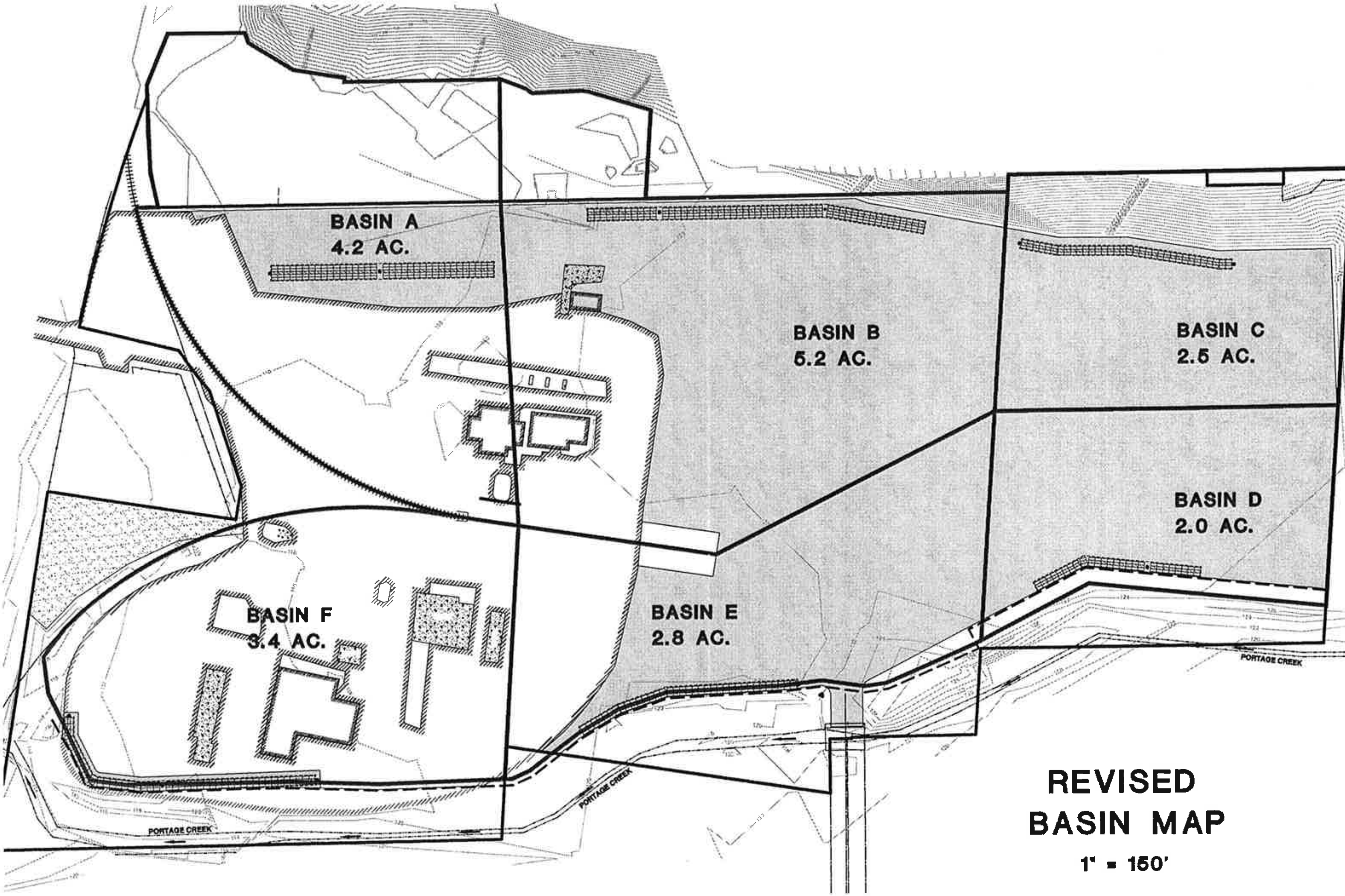
StormTech products are covered by one or more of the following patents: U.S. Patents: 5,401,459; 5,511,903; 5,716,163; 5,588,778; 5,839,844; Canadian Patents: 2,158,418 Other U.S. and Foreign Patents Pending

S070104HP-5

Revised Basin Map
Engineering Design Calculations



REVISED BASIN MAP

1" = 150'

H:\PROJECT FILES\ACTIVE\MILARL\dwg\MILARL.DWG, 2/26/2007 6:09:50 PM, jcherry,

REVISED
STAGE-STORAGE – CHAMBER ARRAY A

SC-310

DIMENSIONS & STORAGE CAPACITIES PROVIDED BY MANUFACTURER

NUMBER OF UNITS	BOTTOM AREA PER UNIT (SF)	INFILTRATION SURFACE (TOTAL)
175	**23.7096**	**4149.2 SF**

STAGE	STORAGE/UNIT (CF)	TOTAL STORAGE (CF)
100.00	0.00	0.00
100.25	3.38	591.50
100.50	6.76	1183.00
100.75	14.09	2465.75
101.00	21.31	3729.25
101.25	28.36	4963.00
101.50	35.23	6165.25
101.75	41.85	7323.75
102.00	48.19	8433.25
102.25	54.17	9479.75
102.33	59.66	10440.50

DESIGN INFILTRATION RATE: 10 IN/HR

TOTAL INFILTRATION RATE: 0.9605 CFS

OSO LUMBER FUTURE DEVELOPMENT SITE

REVISED BASIN A SIZING

==

BASIN SUMMARY

```
BASIN ID: BASINA          NAME: 100 YEAR STORM
SBUH METHODOLOGY
TOTAL AREA.......:   4.20 Acres     BASEFLOWS:   0.00 cfs
RAINFALL TYPE....:    TYPE1A                     PERV          IMP
PRECIPITATION....:   4.00 inches    AREA..:     0.00 Acres    4.20 Acres
TIME INTERVAL....:     10.00 min    CN....:     0.00          98.00
                                    TC....:     0.00 min      6.00 min
ABSTRACTION COEFF:   0.20
PEAK RATE:    3.50 cfs   VOL:    1.32 Ac-ft   TIME:    480 min

BASIN ID: BASINAWQ        NAME: 6-MONTH STORM
SBUH METHODOLOGY
TOTAL AREA.......:   4.20 Acres     BASEFLOWS:   0.00 cfs
RAINFALL TYPE....:    TYPE1A                     PERV          IMP
PRECIPITATION....:   1.22 inches    AREA..:     0.00 Acres    4.20 Acres
TIME INTERVAL....:     10.00 min    CN....:     0.00          98.00
                                    TC....:     0.00 min      6.00 min
ABSTRACTION COEFF:   0.20
PEAK RATE:    0.98 cfs   VOL:    0.35 Ac-ft   TIME:    480 min
```

OSO LUMBER FUTURE DEVELOPMENT SITE

REVISED BASIN A SIZING

HYDROGRAPH SUMMARY

HYD NUM	PEAK RUNOFF RATE cfs	TIME OF PEAK min.	VOLUME OF HYDRO cf\AcFt	Contrib Area Acres
1	0.962	570	57403 cf	4.20

===
STORAGE STRUCTURE LIST

STORAGE LIST ID No. BASINA
Description: 175 SC-310 CHAMBERS

OSO LUMBER FUTURE DEVELOPMENT SITE

REVISED BASIN A SIZING

==

DISCHARGE STRUCTURE LIST

DISCHARGE LIST   ID No. BASINA

Description: INFILTRATION THROUGH BOTTOM

OSO LUMBER FUTURE DEVELOPMENT SITE

REVISED BASIN A SIZING

LEVEL POOL TABLE SUMMARY

<--------DESCRIPTION--------->	MATCH (cfs)	INFLOW (cfs)	-STO- --id-	-DIS- --id-	<-PEAK-> <-STAGE>	id	OUTFLOW (cfs)	STORAGE VOL (cf)
BASIN A	3.50	3.50	BASINA	BASINA	101.97	1	0.96	8283.01 cf

REVISED

STAGE-STORAGE – CHAMBER ARRAY B

SC-310

DIMENSIONS & STORAGE CAPACITIES PROVIDED BY MANUFACTURER

NUMBER OF UNITS	BOTTOM AREA PER UNIT (SF)	INFILTRATION SURFACE (TOTAL)
210	**23.7096**	**4979 SF**

STAGE	STORAGE/UNIT (CF)	TOTAL STORAGE (CF)
100.00	0.00	0.00
100.25	3.38	709.80
100.50	6.76	1419.60
100.75	14.09	2958.90
101.00	21.31	4475.10
101.25	28.36	5955.60
101.50	35.23	7398.30
101.75	41.85	8788.50
102.00	48.19	10119.90
102.25	54.17	11375.70
102.33	59.66	12528.60

DESIGN INFILTRATION RATE: 10 IN/HR

TOTAL INFILTRATION RATE: 1.1526 CFS

OSO LUMBER FUTURE DEVELOPMENT SITE

REVISED BASIN B SIZING

==

BASIN SUMMARY

```
BASIN ID: BASINB        NAME: 100 YEAR STORM
SBUH METHODOLOGY
TOTAL AREA.......:    5.20 Acres    BASEFLOWS:    0.00 cfs
RAINFALL TYPE....:     TYPE1A                     PERV           IMP
PRECIPITATION....:    4.00 inches   AREA..:     0.00 Acres    5.20 Acres
TIME INTERVAL....:      10.00 min   CN....:     0.00          98.00
                                    TC....:     0.00 min      6.00 min
ABSTRACTION COEFF:    0.20
PEAK RATE:    4.34 cfs  VOL:    1.63 Ac-ft  TIME:    480 min

BASIN ID: BASINBWQ      NAME: 6 MONTH STORM
SBUH METHODOLOGY
TOTAL AREA.......:    5.20 Acres    BASEFLOWS:    0.00 cfs
RAINFALL TYPE....:     TYPE1A                     PERV           IMP
PRECIPITATION....:    1.22 inches   AREA..:     0.00 Acres    5.20 Acres
TIME INTERVAL....:      10.00 min   CN....:     0.00          98.00
                                    TC....:     0.00 min      6.00 min
ABSTRACTION COEFF:    0.20
PEAK RATE:    1.21 cfs  VOL:    0.44 Ac-ft  TIME:    480 min
```

OSO LUMBER FUTURE DEVELOPMENT SITE

REVISED BASIN B SIZING

HYDROGRAPH SUMMARY

HYD NUM	PEAK RUNOFF RATE cfs	TIME OF PEAK min.	VOLUME OF HYDRO cf\AcFt	Contrib Area Acres
1	1.154	580	71070 cf	5.20

==
STORAGE STRUCTURE LIST

STORAGE LIST ID No. BASINB
Description: 210 CHAMBERS

OSO LUMBER FUTURE DEVELOPMENT SITE

REVISED BASIN B SIZING

==

DISCHARGE STRUCTURE LIST

DISCHARGE LIST ID No. BASINB

Description: INFILTRATION THROUGH BOTTOM

OSO LUMBER FUTURE DEVELOPMENT SITE

REVISED BASIN B SIZING

LEVEL POOL TABLE SUMMARY

<--------DESCRIPTION--------->	MATCH (cfs)	INFLOW (cfs)	-STO- --id-	-DIS- --id-	<-PEAK-> <-STAGE>	id	OUTFLOW (cfs)	STORAGE VOL (cf)
BASIN B	4.34	4.34	BASINB	BASINB	102.07	1	1.15	10596.56 cf

STAGE-STORAGE – CHAMBER ARRAY C

SC-310

DIMENSIONS & STORAGE CAPACITIES PROVIDED BY MANUFACTURER

NUMBER OF UNITS	BOTTOM AREA PER UNIT (SF)	INFILTRATION SURFACE (TOTAL)
101	**23.7096**	**2394.7 SF**

STAGE	STORAGE/UNIT (CF)	TOTAL STORAGE (CF)
100.00	0.00	0.00
100.25	3.38	341.38
100.50	6.76	682.76
100.75	14.09	1423.09
101.00	21.31	2152.31
101.25	28.36	2864.36
101.50	35.23	3558.23
101.75	41.85	4226.85
102.00	48.19	4867.19
102.25	54.17	5471.17
102.33	59.66	6025.66

DESIGN INFILTRATION RATE: 10 IN/HR

TOTAL INFILTRATION RATE: 0.5543 CFS

```
                 OSO LUMBER FUTURE DEVELOPMENT SITE
BASIN C SIZING
======================================================================
                            BASIN SUMMARY


BASIN ID: BASINC       NAME: 100 YEAR STORM
SBUH METHODOLOGY
TOTAL AREA.......:   2.50 Acres     BASEFLOWS:   0.00 cfs
RAINFALL TYPE....:    TYPE1A                   PERV           IMP
PRECIPITATION....:   4.00 inches    AREA..:    0.00 Acres    2.50 Acres
TIME INTERVAL....:     10.00 min    CN....:    0.00         98.00
                                    TC....:    0.00 min     6.00 min
ABSTRACTION COEFF:   0.20
PEAK RATE:   2.09 cfs  VOL:   0.78 Ac-ft  TIME:    480 min
```

1/2/06

OSO LUMBER FUTURE DEVELOPMENT SITE

BASIN C SIZING

==

STORAGE STRUCTURE LIST

STORAGE LIST ID No. BASINC
Description: 101 SC-310 CHAMBERS

1/2/06

OSO LUMBER FUTURE DEVELOPMENT SITE

BASIN C SIZING

==

STAGE STORAGE TABLE

CUSTOM STORAGE ID No. BASINC
Description: 101 SC-310 CHAMBERS

STAGE	<----STORAGE---->		STAGE	<----STORAGE---->		STAGE	<----STORAGE---->		STAGE	<----STORAGE---->	
(ft)	---cf---	--Ac-Ft-	(ft)	---cf---	--Ac-Ft-	(ft)	---cf---	--Ac-Ft-	(ft)	---cf---	--Ac-Ft-
100.00	0.0000	0.0000	100.70	1271	0.0292	101.40	3277	0.0752	102.10	5218	0.1198
100.10	136.55	0.0031	100.80	1564	0.0359	101.50	3558	0.0817	102.20	5569	0.1279
100.20	273.10	0.0063	100.90	1858	0.0427	101.60	3820	0.0877	102.30	5920	0.1359
100.30	409.66	0.0094	101.00	2152	0.0494	101.70	4082	0.0937	102.33	6026	0.1383
100.40	546.21	0.0125	101.10	2433	0.0559	101.80	4344	0.0997			
100.50	682.76	0.0157	101.20	2715	0.0623	101.90	4605	0.1057			
100.60	976.67	0.0224	101.30	2996	0.0688	102.00	4867	0.1117			

1/2/06

OSO LUMBER FUTURE DEVELOPMENT SITE

BASIN C SIZING

DISCHARGE STRUCTURE LIST

DISCHARGE LIST ID No. BASINC
Description: INFILTRATION THROUGH BOTTOM

1/2/06

OSO LUMBER FUTURE DEVELOPMENT SITE

BASIN C SIZING

STAGE DISCHARGE TABLE

DISCHARGE LIST ID No. BASINC
Description: INFILTRATION THROUGH BOTTOM

STAGE ft)	<--DISCHARGE---> ---cfs-- -------	STAGE (ft)	<--DISCHARGE---> ---cfs-- -------	STAGE (ft)	<--DISCHARGE---> ---cfs-- -------	STAGE (ft)	<--DISCHARGE---> ---cfs-- -------
100.00	0.5520	100.70	0.5534	101.40	0.5548	102.10	0.5563
100.10	0.5522	100.80	0.5536	101.50	0.5550	102.20	0.5566
100.20	0.5524	100.90	0.5538	101.60	0.5552	102.30	0.5569
100.30	0.5526	101.00	0.5540	101.70	0.5554	102.33	0.5570
100.40	0.5528	101.10	0.5542	101.80	0.5556		
100.50	0.5530	101.20	0.5544	101.90	0.5558		
100.60	0.5532	101.30	0.5546	102.00	0.5560		

1/2/06

OSO LUMBER FUTURE DEVELOPMENT SITE

BASIN C SIZING

LEVEL POOL TABLE SUMMARY

<--------DESCRIPTION-------->	MATCH (cfs)	INFLOW (cfs)	-STO- --id-	-DIS- --id-	<-PEAK-> <-STAGE>	id	OUTFLOW (cfs)	STORAGE VOL (cf)
BASIN C	2.09	2.09	BASINC	BASINC	102.06	1	0.56	5094.23 cf

STAGE-STORAGE – CHAMBER ARRAY D

SC-310

DIMENSIONS & STORAGE CAPACITIES PROVIDED BY MANUFACTURER

NUMBER OF UNITS	BOTTOM AREA PER UNIT (SF)	INFILTRATION SURFACE (TOTAL)
78	23.7096	1849.3 SF

STAGE	STORAGE/UNIT (CF)	TOTAL STORAGE (CF)
100.00	0.00	0.00
100.25	3.38	263.64
100.50	6.76	527.28
100.75	14.09	1099.02
101.00	21.31	1662.18
101.25	28.36	2212.08
101.50	35.23	2747.94
101.75	41.85	3264.30
102.00	48.19	3758.82
102.25	54.17	4225.26
102.33	59.66	4653.48

DESIGN INFILTRATION RATE: 10 IN/HR

TOTAL INFILTRATION RATE: 0.4281 CFS

1/2/06

```
                  OSO LUMBER FUTURE DEVELOPMENT SITE
BASIN D SIZING
======================================================================
                            BASIN SUMMARY

BASIN ID: BASIND        NAME: 100 YEAR STORM
SBUH METHODOLOGY
TOTAL AREA.......:    2.00 Acres     BASEFLOWS:    0.00 cfs
RAINFALL TYPE....:     TYPE1A                    PERV          IMP
PRECIPITATION....:    4.00 inches    AREA..:     0.00 Acres    2.00 Acres
TIME INTERVAL....:      10.00 min    CN....:     0.00          98.00
                                     TC....:     0.00 min      6.00 min
ABSTRACTION COEFF:    0.20
PEAK RATE:   1.67 cfs  VOL:   0.63 Ac-ft  TIME:     480 min
```

1/2/06

OSO LUMBER FUTURE DEVELOPMENT SITE

BASIN D SIZING

STORAGE STRUCTURE LIST

STORAGE LIST ID No. BASIND
Description: 78 CHAMBERS

1/2/06

OSO LUMBER FUTURE DEVELOPMENT SITE

BASIN D SIZING

STAGE STORAGE TABLE

CUSTOM STORAGE ID No. BASIND
Description: 78 CHAMBERS

STAGE (ft)	STORAGE ---cf---	STORAGE --Ac-Ft-	STAGE (ft)	STORAGE ---cf---	STORAGE --Ac-Ft-	STAGE (ft)	STORAGE ---cf---	STORAGE --Ac-Ft-	STAGE (ft)	STORAGE ---cf---	STORAGE --Ac-Ft-
100.00	0.0000	0.0000	100.70	981.64	0.0225	101.40	2531	0.0581	102.10	4030	0.0925
100.10	105.46	0.0024	100.80	1209	0.0278	101.50	2748	0.0631	102.20	4301	0.0987
100.20	210.91	0.0048	100.90	1436	0.0330	101.60	2950	0.0677	102.30	4572	0.1050
100.30	316.37	0.0073	101.00	1663	0.0382	101.70	3152	0.0724	102.33	4653	0.1068
100.40	421.82	0.0097	101.10	1880	0.0432	101.80	3354	0.0770			
100.50	527.28	0.0121	101.20	2097	0.0481	101.90	3557	0.0816			
100.60	754.46	0.0173	101.30	2314	0.0531	102.00	3759	0.0863			

1/2/06

OSO LUMBER FUTURE DEVELOPMENT SITE

BASIN D SIZING

==

DISCHARGE STRUCTURE LIST

DISCHARGE LIST ID No. BASIND

Description: INFILTRATION THROUGH BOTTOM

1/2/06

OSO LUMBER FUTURE DEVELOPMENT SITE

BASIN D SIZING

==

STAGE DISCHARGE TABLE

DISCHARGE LIST ID No. BASIND

Description: INFILTRATION THROUGH BOTTOM

STAGE (ft)	<--DISCHARGE---> ---cfs-- -------	STAGE (ft)	<--DISCHARGE---> ---cfs-- -------	STAGE (ft)	<--DISCHARGE---> ---cfs-- -------	STAGE (ft)	<--DISCHARGE---> ---cfs-- -------
100.00	0.4260	100.70	0.4274	101.40	0.4288	102.10	0.4303
100.10	0.4262	100.80	0.4276	101.50	0.4290	102.20	0.4306
100.20	0.4264	100.90	0.4278	101.60	0.4292	102.30	0.4309
100.30	0.4266	101.00	0.4280	101.70	0.4294	102.33	0.4310
100.40	0.4268	101.10	0.4282	101.80	0.4296		
100.50	0.4270	101.20	0.4284	101.90	0.4298		
100.60	0.4272	101.30	0.4286	102.00	0.4300		

1/2/06

OSO LUMBER FUTURE DEVELOPMENT SITE

BASIN D SIZING

LEVEL POOL TABLE SUMMARY

<--------DESCRIPTION--------->	MATCH (cfs)	INFLOW (cfs)	-STO- --id-	-DIS- --id-	<-PEAK-> <-STAGE>	id	OUTFLOW (cfs)	STORAGE VOL (cf)
BASIN D	1.67	1.67	BASIND	BASIND	102.21	1	0.43	4314.81 cf

STAGE-STORAGE – CHAMBER ARRAY E

SC-310

DIMENSIONS & STORAGE CAPACITIES PROVIDED BY MANUFACTURER

NUMBER OF UNITS	BOTTOM AREA PER UNIT (SF)	INFILTRATION SURFACE (TOTAL)
108	**23.7096**	**2560.6 SF**

STAGE	STORAGE/UNIT (CF)	TOTAL STORAGE (CF)
100.00	0.00	0.00
100.25	3.38	365.04
100.50	6.76	730.08
100.75	14.09	1521.72
101.00	21.31	2301.48
101.25	28.36	3062.88
101.50	35.23	3804.84
101.75	41.85	4519.80
102.00	48.19	5204.52
102.25	54.17	5850.36
102.33	59.66	6443.28

DESIGN INFILTRATION RATE: 10 IN/HR

TOTAL INFILTRATION RATE: 0.5927 CFS

1/2/06

```
                    OSO LUMBER FUTURE DEVELOPMENT SITE
BASIN E SIZING
=====================================================================
                           BASIN SUMMARY

BASIN ID: BASINE       NAME: 100 YEAR STORM
SBUH METHODOLOGY
TOTAL AREA.......:   2.80 Acres     BASEFLOWS:   0.00 cfs
RAINFALL TYPE....:    TYPE1A                   PERV          IMP
PRECIPITATION....:   4.00 inches    AREA..:    0.00 Acres    2.80 Acres
TIME INTERVAL....:     10.00 min    CN....:    0.00          98.00
                                    TC....:    0.00 min      6.00 min
ABSTRACTION COEFF:   0.20
PEAK RATE:   2.34 cfs  VOL:   0.88 Ac-ft  TIME:    480 min
```

1/2/06

OSO LUMBER FUTURE DEVELOPMENT SITE

BASIN E SIZING

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STORAGE STRUCTURE LIST

STORAGE LIST ID No. BASINE
Description: 108 CHAMBERS

1/2/06

OSO LUMBER FUTURE DEVELOPMENT SITE

BASIN E SIZING

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STAGE STORAGE TABLE

CUSTOM STORAGE ID No. BASINE
Description: 108 CHAMBERS

STAGE (ft)	<----STORAGE----> ---cf---	--Ac-Ft-	STAGE (ft)	<----STORAGE----> ---cf---	--Ac-Ft-	STAGE (ft)	<----STORAGE----> ---cf---	--Ac-Ft-	STAGE (ft)	<----STORAGE----> ---cf---	--Ac-Ft-
100.00	0.0000	0.0000	100.70	1359	0.0312	101.40	3504	0.0804	102.10	5580	0.1281
100.10	146.02	0.0034	100.80	1673	0.0384	101.50	3805	0.0873	102.20	5955	0.1367
100.20	292.03	0.0067	100.90	1987	0.0456	101.60	4085	0.0938	102.30	6331	0.1453
100.30	438.05	0.0101	101.00	2301	0.0528	101.70	4365	0.1002	102.33	6443	0.1479
100.40	584.06	0.0134	101.10	2602	0.0597	101.80	4645	0.1066			
100.50	730.08	0.0168	101.20	2903	0.0666	101.90	4925	0.1131			
100.60	1044	0.0240	101.30	3203	0.0735	102.00	5205	0.1195			

1/2/06

OSO LUMBER FUTURE DEVELOPMENT SITE

BASIN E SIZING

DISCHARGE STRUCTURE LIST

DISCHARGE LIST ID No. BASINE
Description: INFILTRATION THROUGH BOTTOM

1/2/06

OSO LUMBER FUTURE DEVELOPMENT SITE

BASIN E SIZING

STAGE DISCHARGE TABLE

DISCHARGE LIST ID No. BASINE
Description: INFILTRATION THROUGH BOTTOM

STAGE (ft)	<--DISCHARGE---> ---cfs--	STAGE (ft)	<--DISCHARGE---> ---cfs--	STAGE (ft)	<--DISCHARGE---> ---cfs--	STAGE (ft)	<--DISCHARGE---> ---cfs--
100.00	0.5910	100.70	0.5924	101.40	0.5938	102.10	0.5952
100.10	0.5912	100.80	0.5926	101.50	0.5940	102.20	0.5954
100.20	0.5914	100.90	0.5928	101.60	0.5942	102.30	0.5956
100.30	0.5916	101.00	0.5930	101.70	0.5944	102.40	0.5958
100.40	0.5918	101.10	0.5932	101.80	0.5946	102.50	0.5960
100.50	0.5920	101.20	0.5934	101.90	0.5948	102.50	0.5960
100.60	0.5922	101.30	0.5936	102.00	0.5950		

1/2/06

OSO LUMBER FUTURE DEVELOPMENT SITE

BASIN E SIZING

LEVEL POOL TABLE SUMMARY

<--------DESCRIPTION--------->	MATCH (cfs)	INFLOW (cfs)	-STO- --id-	-DIS- --id-	<-PEAK-> <-STAGE>	id	OUTFLOW (cfs)	STORAGE VOL (cf)
BASIN E	2.34	2.34	BASINE	BASINE	102.25	1	0.60	6148.90 cf

STAGE-STORAGE – CHAMBER ARRAY F

SC-310

DIMENSIONS & STORAGE CAPACITIES PROVIDED BY MANUFACTURER

NUMBER OF UNITS	BOTTOM AREA PER UNIT (SF)	INFILTRATION SURFACE (TOTAL)
130	**23.7096**	**3082.2 SF**

STAGE	STORAGE/UNIT (CF)	TOTAL STORAGE (CF)
100.00	0.00	0.00
100.25	3.38	439.40
100.50	6.76	878.80
100.75	14.09	1831.70
101.00	21.31	2770.30
101.25	28.36	3686.80
101.50	35.23	4579.90
101.75	41.85	5440.50
102.00	48.19	6264.70
102.25	54.17	7042.10
102.33	59.66	7755.80

DESIGN INFILTRATION RATE: 10 IN/HR

TOTAL INFILTRATION RATE: 0.7135 CFS

```
                 OSO LUMBER FUTURE DEVELOPMENT SITE
BASIN F SIZING
=====================================================================
                            BASIN SUMMARY


BASIN ID: BASINF       NAME: 100 YEAR STORM
SBUH METHODOLOGY
TOTAL AREA.......:   3.40 Acres     BASEFLOWS:   0.00 cfs
RAINFALL TYPE....:    TYPE1A                    PERV          IMP
PRECIPITATION....:   4.00 inches    AREA..:     0.00 Acres    3.40 Acres
TIME INTERVAL....:     10.00 min    CN....:     0.00         98.00
                                    TC....:     0.00 min     6.00 min
ABSTRACTION COEFF:   0.20
PEAK RATE:   2.84 cfs  VOL:   1.07 Ac-ft  TIME:    480 min
```

1/2/06

OSO LUMBER FUTURE DEVELOPMENT SITE

BASIN F SIZING

==

STORAGE STRUCTURE LIST

STORAGE LIST ID No. BASINF
Description: 130 CHAMBERS

1/2/06

OSO LUMBER FUTURE DEVELOPMENT SITE

BASIN F SIZING

==

STAGE STORAGE TABLE

CUSTOM STORAGE ID No. BASINF
Description: 130 CHAMBERS

STAGE (ft)	<----STORAGE----> ---cf---	--Ac-Ft-	STAGE (ft)	<----STORAGE----> ---cf---	--Ac-Ft-	STAGE (ft)	<----STORAGE----> ---cf---	--Ac-Ft-	STAGE (ft)	<----STORAGE----> ---cf---	--Ac-Ft-
100.00	0.0000	0.0000	100.70	1635	0.0375	101.40	4218	0.0968	102.10	6717	0.1542
100.10	175.76	0.0040	100.80	2014	0.0462	101.50	4580	0.1051	102.20	7168	0.1646
100.20	351.52	0.0081	100.90	2392	0.0549	101.60	4917	0.1129	102.30	7620	0.1749
100.30	527.28	0.0121	101.00	2770	0.0636	101.70	5254	0.1206	102.33	7756	0.1780
100.40	703.04	0.0161	101.10	3132	0.0719	101.80	5591	0.1283			
100.50	878.80	0.0202	101.20	3494	0.0802	101.90	5928	0.1361			
100.60	1257	0.0289	101.30	3856	0.0885	102.00	6265	0.1438			

1/2/06

OSO LUMBER FUTURE DEVELOPMENT SITE

BASIN F SIZING

==

DISCHARGE STRUCTURE LIST

DISCHARGE LIST ID No. BASINF
Description: INFILTRATION THROUGH BOTTOM

1/2/06

OSO LUMBER FUTURE DEVELOPMENT SITE

BASIN F SIZING

==

STAGE DISCHARGE TABLE

DISCHARGE LIST ID No. BASINF
Description: INFILTRATION THROUGH BOTTOM

STAGE (ft)	<--DISCHARGE---> ---cfs-- -------	STAGE (ft)	<--DISCHARGE---> ---cfs-- -------	STAGE (ft)	<--DISCHARGE---> ---cfs-- -------	STAGE (ft)	<--DISCHARGE---> ---cfs-- -------
100.00	0.7120	100.70	0.7134	101.40	0.7148	102.10	0.7163
100.10	0.7122	100.80	0.7136	101.50	0.7150	102.20	0.7166
100.20	0.7124	100.90	0.7138	101.60	0.7152	102.30	0.7169
100.30	0.7126	101.00	0.7140	101.70	0.7154	102.33	0.7170
100.40	0.7128	101.10	0.7142	101.80	0.7156		
100.50	0.7130	101.20	0.7144	101.90	0.7158		
100.60	0.7132	101.30	0.7146	102.00	0.7160		

1/2/06

OSO LUMBER FUTURE DEVELOPMENT SITE

BASIN F SIZING

LEVEL POOL TABLE SUMMARY

<--------DESCRIPTION--------->	MATCH (cfs)	INFLOW (cfs)	-STO- --id-	-DIS- --id-	<-PEAK-> <-STAGE>	id	OUTFLOW (cfs)	STORAGE VOL (cf)
BASIN F	2.84	2.84	BASINF	BASINF	102.29	1	0.72	7569.27 cf

Geotechnical Reports
SCS Soils information

Geotechnical Evaluation
Proposed Commercial Site
Arlington, Washington
For
Mr. Brian Abbott

Cornerstone
Geotechnical, Inc.

Geotechnical Evaluation
Proposed Commercial Site
Arlington, Washington
For
Mr. Brian Abbott

Doug Cornerstone Faild Cell 206-300-6816

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17625-130th Ave. NE, C102, Woodinville, WA 98072
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January 17, 2001

Mr. Brian Abbott
c/o Miller Shingle Co., Inc.
PO Box 29
Granite Falls, WA 98252

Geotechnical Evaluation
Proposed Commercial Site
Arlington, Washington
CG File No. 1232

INTRODUCTION

This report presents the results of our geotechnical evaluation at the planned development at the Miller Shingle site in Arlington, Washington. The project is located northeast of the intersection of 67th Avenue NE (Lebanon Street) and 204th Street NE, as shown on the Vicinity Map in Figure 1.

For our use in preparing this report, we have been provided with a topographic plan sheet of the site and the nearby surrounding area. This sheet was prepared by Evergreen Engineering Services, dated November 14, 2001. The site consists of two properties. The western and central portions of the site consist of the recently closed lumber yard that is currently used to store freight cars and houses a propane fuel tank facility. A large portion of the lumber yard area is paved. The eastern portion is a recently purchased five-acre property that contains a single-family residence. Portage Creek flows from east to west along the south side of the property.

PROJECT DESCRIPTION

We understand that the property is planned to be developed for industrial and/or commercial use. We have not been provided with a development plan for the project. We understand that slope in the northeast corner of the site may be cut steeper to create more level area and to generate usable fill material for use on the site and possibly for export.

An access road may be constructed off the site to the south, connecting the project with 204th Street NE. This access road will extend about 600 feet from the site. A bridge or culvert is planned to cross the creek for the access road. Shockey Brent, Inc. requested that we provide recommendations for construction of bridge abutments. We understand that you are considering infiltration of storm water at the site. You indicated that the most likely place for storm water infiltration would be near the north property line. The development plan ultimately chosen may include leaving some or all of the existing asphalt in place.

SCOPE

The purpose of this evaluation is to explore subsurface conditions and provide recommendations for site development. Specifically, our scope of services will include the following tasks:

1. Review available geologic maps of the area.
2. Explore the subsurface conditions at the site with a subcontracted trackhoe.
3. Explore the proposed emergency access route with the trackhoe.
4. Install temporary piezometers in six to eight holes to use to record depth to ground water.
5. Use the trackhoe and/or hand tools to explore conditions at the planned bridge abutments.
6. Visually evaluate the grain-size distribution of soil types encountered and comment on suitable infiltration rates.
7. Provide recommendations for site grading and fill placement.
8. Provide a recommended cut slope angle for the northeast corner of the site.
9. Complete grain-size analysis on three samples for use in classifying the fill type expected from the large cut slope.
10. Provide recommendations foundation subgrade preparation, and geotechnical design parameters for building foundations and retaining walls.
11. Prepare a written report to document our conclusions and recommendations.

SITE CONDITIONS

Surface Conditions

The site is bordered by the Burlington-Northern-Sante Fe (BNSF) Railroad tracks on the west, and by industrial and undeveloped land to the south and east. The west half of the site is bordered by undeveloped land to the north and the east half of the site is bordered by a residential development to the north.

The majority of the site is level or very gently sloping with occasional fill piles and small berms on the east half of the site. Some of these piles appear to be the result of striping of topsoil from portions of the site; other piles contain lumber and other debris. The northeast corner of the site has a steep slope that drops from the adjacent residential community down to the general site grade. A single-family home is located on a mid-slope bench near the east property line. The site is generally cleared of vegetation except the slope in the northeast corner, which is covered with mostly 6- to 8-inch diameter deciduous trees and scattered groups of large firs.

A side spur off of the main BNSF rail track turns into the site from the northwest corner and extends to the center of the site. This track is currently used for temporary storage of railway tank cars. A second side spur track that enters from the southwest corner of the site has been partially demolished and is no longer used. Much of the west half of the site is paved and contains several structures. The paved areas of the site direct surface water flow to pond areas where infiltration appears to be occurring. One of these pond areas is shown near the north property line on Figure 2. Other surface water at the site is directed into small ditches that carry water to the creek along the south property line. We did not observe significant cracking in the pavement. Cold joints where different generations of paving were completed, local asphalt patch areas, and "bird bath" low spots were observed. We do not know the thickness of the asphalt but expect that it varies across the site.

The creek along the south property line is shown on some maps as Portage Creek. At the time of our explorations, the creek was on average about 6 feet across and 2 feet deep. A somewhat wider, grass-covered, low-bank area along the creek was between 8 and 14 feet across. It appeared that the creek may at times rise another 6 to 12 inches to fill this wider area. We do not know the higher water level of the creek. Outside of the low-bank area described above, there is a 2- to 3-foot-high slope up to the surrounding grade.

The east half of the site is mostly undeveloped. An existing residence is located in the northeast corner of the site near the east property line. The northeast corner of the site contains a steep slope that drops down generally to the south. The slope is about 40 feet high with an average slope angle of about 40 percent and localized areas that are steeper than 50 percent. The existing residence is located on a bench within the steep slope area. This bench exists only on the east side of the slope. Outside of the steep slope, the east end of the site is nearly level and covered with grass and weeds with a few scattered piles of brush and debris.

Geology

The Geologic Map of the Arlington West Quadrangle, Snohomish County, Washington by James P. Minard (USGS 1985) was referenced for this report. This map indicated that the majority of the site was underlain by recessional sand of the Marysville Sand Member. The slope in the northeast corner of the site and the terrace above is mapped as recessional sand of the Arlington Gravel Member. Our explorations encountered medium dense to dense sand with gravel and cobbles that suggest the Arlington Gravel covered the entire site. Medium sand similar to the Marysville Sand Member was encountered in only our deepest exploration at the site.

Explorations

Subsurface conditions were explored at the site on December 21, 2002, by excavating 12 test pits with a trackhoe and two hand auger holes. The test pits were excavated to depths of 4.5 to 15.0 feet below the ground surface. The hand augers were completed near the creek and were completed to depths of 4.0 and 4.6 feet. The explorations were located in the field by an engineer from this firm who also examined the soils and geologic conditions encountered, and maintained logs of the test pits. The approximate locations of the explorations are shown on the Site Plan in Figure 2. The soils were visually classified in general accordance with the Unified Soil Classification System, a copy of which is presented as Figure 3. The logs of the explorations are presented in Figures 4 through 7.

Subsurface Conditions

A brief summary of the conditions encountered in our explorations is included below. For a more complete and detailed description of the soils encountered please refer to the logs presented in Figures 4 through 7.

All of our explorations encountered medium dense to dense, gray-brown, fine to coarse sand with gravel and cobbles. This was the most abundant material encountered at the site. The amount of gravel and cobbles varied somewhat with depth. Above this material, a weathered layer of brown to orange-brown sand with silt and gravel, to silty sand with gravel was encountered in many explorations. In the sloping portion of the site, Test Pit 5 and Test Pit 6 encountered a layer of silty fine sand and fine to medium sand with silt that was not encountered in other areas of the site. In undeveloped areas, the surface layer of dark brown to black topsoil was 1.0 to 1.5 feet thick. Where the site had been developed often the topsoil layer was thin or not present.

Our deepest exploration was Test Pit 10 in the potential infiltration area. Below 11 feet we observed fine to medium sand with trace silt. This material is consistent with what is generally described as Marysville Sand.

Test Pit 3 was completed in an area were topsoil stripped from the site had been placed. We did not encounter other areas of fill other than local stockpiles and berms. Some of the fill areas are indicated on Figure 2. This should not be considered a complete inventory of fill areas. This is mostly based on visual surface interpretation.

We completed a hand auger hole on each side of the creek where the proposed road would cross. Hand Auger 1 was located about 8 feet from the edge of the creek and about 3.5 feet above the level of the creek at the time of our explorations. Hand Auger 2 was located about 7 feet from the edge of the creek and about 2.5 feet above the level of the creek. Both explorations were completed in the medium dense, fine to coarse sand with gravel and cobbles found throughout the site.

Hydrologic Conditions

Ground water seepage was not encountered in any explorations at the site. Hand Auger 2 was completed to a depth about 2 feet below the level of the creek at the time of our explorations. We placed temporary piezometer pipes for measuring high ground water elevation at several locations of the site as noted in the logs on Figures 4 through 7. We understand that you have checked the piezometers several times over the past few weeks and have not recorded any water.

Laboratory Results

Grain-size analyses were performed on three samples from the proposed excavation slope in the northeast corner of the site. The sieve results are presented as Figures 8 through 10. The large majority of the soils encountered in our explorations were similar to the grain-size distribution presented in Figures 8 and 9. Minor layers of silty sand were observed in the northeast corner of the site similar to the distribution presented in Figure 10. We did not explore to the full depth of the planned excavation and there is potential for fine-grained soils to be encountered at depth.

CONCLUSIONS AND RECOMMENDATIONS

General

The underlying medium dense to dense sand with gravel and cobbles that underlies the site at shallow depth is suitable for support of shallow foundations and for infiltration of site storm water. We recommend that the foundations for the structures extend through any topsoil, loose, or disturbed soils, and bear on the underlying medium dense or better soils. Based on our site explorations, we anticipate these soils will generally be encountered at depths of 1.5 to 3.0 feet.

The majority of the site soils below the upper topsoil and weathered soil layers are only slightly moisture sensitive and can be expected to be suitable for use as fill in most weather conditions. The upper topsoil and weathered soil layers are moisture sensitive and site grading in wet weather may result in a greater depth of stripping. In developed portions of the site, much of the topsoil has already been removed. In other areas, such as the proposed access road, site stripping would be a minimum of 1.5 feet due to the thick topsoil layer.

We expect that shallow foundations may be used for the proposed creek crossing provided some setback from the creek is used. Our exploration results suggest that foundation excavations for shallow footings to support a bridge most likely will not encounter significant water seepage unless completed at times of very high water level.

Soil generated from the excavation at the northeast corner of the site is expected to consist mainly of well-draining sand and gravel. We did observe minor layers of silty fine to medium sand in explorations in this area (see Figure 10 for sieve results). The large majority of soil in our excavations, however, was sand with gravel and cobbles with only trace amounts of silt (see Figure 8 and 9 for sieve results). This material is generally called "all-weather fill" due to the well-draining properties. We did not explore to the full depth of the proposed excavation and there is potential for finer soils at depth. We caution economic planning for these materials with the current limited data. In our opinion, the excavation could be completed with a 1.75 Horizontal to 1.0 Vertical final slope provided the material is consistent with depth and water seepage is not encountered. For a 40-foot slope height this corresponds to 70 feet of horizontal slope distance. We recommend that the slope be protected against erosion and that the slope begin no closer to the property line than 2 feet. We should visit the site during excavation to evaluate conditions encountered.

Site Preparation and Grading

The first step of site preparation should be to strip the vegetation, topsoil, or loose soils to expose medium dense native soils in pavement and building areas. This material should be removed from the site, or stockpiled for later use as landscaping fill. The actual depth of stripping will be controlled by organics, moisture contents of the subgrade soils, and extent of previous stripping. The resulting subgrade should be compacted to a firm, non-yielding condition. Areas observed to pump or weave should be repaired prior to placing hard surfaces. In dry summer conditions, it may be possible to compact the loose weathered soils to a suitably firm condition, while in wet weather or during the winter, additional stripping depth may be needed.

Structural Fill

General: All fill placed beneath buildings, pavements or other settlement sensitive features, should be placed as structural fill. Structural fill, by definition, is placed in accordance with prescribed methods and standards, and is monitored by an experienced geotechnical professional or soils technician. Field-monitoring procedures would include the performance of a representative number of in-place density tests to document the attainment of the desired degree of relative compaction.

Materials: Imported structural fill should consist of a good quality, free-draining granular soil, free of organics and other deleterious material, and be well graded to a maximum size of about 3 inches. Imported, all-weather structural fill should contain no more than 5 percent fines (soil finer than a Standard U.S. No. 200 sieve), based on that fraction passing the U.S. 3/4-inch sieve. The on-site soils can be used as structural fill. The sand with gravel and cobbles encountered throughout the site is considered only slightly moisture sensitive and is considered suitable for use as fill in most weather conditions. During dry weather, the well-draining soil may require addition of water to achieve proper compaction.

Fill Placement: Following subgrade preparation, placement of the structural fill may proceed. Fill should be placed in 8- to 10-inch-thick uniform lifts, and each lift should be spread evenly and be thoroughly compacted prior to placement of subsequent lifts. All structural fill underlying building areas, and within a depth of 2 feet below pavement and sidewalk subgrade, should be compacted to at least 95 percent of its maximum dry density. Maximum dry density, in this report, refers to that density as determined by the ASTM D 1557 compaction test procedure. Fill more than 2 feet beneath sidewalks and pavement subgrades should be compacted to at least 90 percent of the maximum dry density.

Temporary and Permanent Slopes

Temporary cut slope stability is a function of many factors, such as the type and consistency of soils, depth of the cut, surcharge loads adjacent to the excavation, length of time a cut remains open, and the presence of surface or ground water. It is exceedingly difficult under these variable conditions to estimate a stable temporary cut slope geometry. Therefore, it should be the responsibility of the contractor to maintain safe slope configurations, since the contractor is continuously at the job site, able to observe the nature and condition of the cut slopes, and able to monitor the subsurface materials and ground water conditions encountered.

For planning purposes, we recommend that temporary cuts be no steeper than 1 Horizontal to 1 Vertical (1H:1V). If water seepage is encountered flatter slopes will be necessary.

We recommend that cut slopes be protected from erosion. Measures taken may include covering cut slopes with plastic sheeting and diverting surface runoff away from the top of cut slopes. We do not recommend vertical slopes for cuts deeper than 4 feet, if worker access is necessary. We recommend that cut slope heights and inclinations conform to local and WISHA/OSHA standards.

A permanent excavation slope is planned in the storm water ponds and the steep slope area in the northeast corner of the site. We recommend that pond slopes be no steeper than 2H:1V. We did not complete borings or other deep explorations in the proposed cut area in the northeast corner of the site. Test Pits in this area encountered sand with gravel and cobbles similar to that encountered in the flatter portions of the site but also some layers of finer sand. It is possible that there is a soil layer at depth, which was not encountered in our explorations. For this reason, we recommend that Cornerstone Geotechnical visit the site during excavation to evaluate conditions as the excavation is made. In our opinion, conditions appear to be suitable for a permanent slope angle of as steep as 1.75H:1V. If excavation encounters an unexpected fine-grained soil unit or water seepage, then flatter slopes below that point would be necessary.

The excavation slope should be protected against erosion. Vegetation should be established as soon as possible. Temporary erosion control measures should be used until permanent vegetation is well established. Jute netting with grass seed is one type of temporary erosion control method that may be used. We recommend that the excavation start at least 5 feet away from the property line to provide additional offset for surface raveling or erosion that does occur.

Foundations

Conventional, shallow-spread foundations should be founded on undisturbed, medium dense or better native soils, or be supported on structural fill extending to those soils. If the soil at the planned bottom of footing elevation is not medium dense, it should be overexcavated to expose suitable bearing soil, and the excavation should be filled with structural fill, or the footing may be overpoured with extra concrete. Some compaction of upper loose soil may be appropriate instead of removal, depending on organic and moisture content. This should be evaluated at the time of construction.

Footings should extend at least 18 inches below the lowest adjacent finished ground surface for frost protection and bearing capacity considerations. Minimum foundation widths of 12 and 18 inches should be used for continuous and isolated spread footings, respectively. Standing water should not be allowed to accumulate in footing trenches. All loose or disturbed soil should be removed from the foundation excavation prior to placing concrete.

For foundations constructed as outlined above, we recommend an allowable design bearing pressure of 2,000 pounds per square foot (psf) be used for the footing design. Uniform Building Code (UBC) guidelines should be followed when considering short-term transitory wind or seismic loads. Potential foundation settlement using the recommended allowable bearing pressure is estimated to be less than 1 inch total and 1/2 inch differential between footings or across a distance of about 30 feet. Higher soil bearing values may be appropriate for wider footings. These higher values can be determined after a review of a specific design.

Lateral loads can be resisted by friction between the foundation and subgrade soil, and by passive soil resistance acting on the below-grade portion of the foundation. For the latter, the foundation must be poured "neat" against undisturbed soil or backfilled with clean, free-draining, compacted structural fill. Passive resistance may be calculated as a triangular equivalent fluid pressure distribution. We recommend that an equivalent fluid density of 350 pounds per cubic foot (pcf) be used to calculate the lateral passive resistance for the case of a level ground surface adjacent to the footing. The upper 1 foot of soil should be ignored for passive resistance unless covered by a hard surface such as asphalt or concrete. In the case of the bridge abutments at the creek crossing, passive resistance should be reduced to 200 pcf in addition to ignoring the upper 1 foot. A coefficient of friction between footings and soil of 0.7 may be used in all cases, and should be applied to the vertical dead load only. An appropriate factor of safety should be applied to the passive pressure and friction coefficient.

At the creek crossing, we expect that shallow footings may be suitable. The excavation depth for footings near the creek is expected to be 3 to 4 feet. We recommend that the footing excavation be separated from the lateral extent of the creek during seasonal high water levels to protect against erosion and scouring. We recommend a minimum offset of 10 feet from the embankment face. This may be reduced to 5 feet if suitable armament is placed on the face of the slope below the footings to act as erosion protection. The alternative is to place the foundation below the bottom of the creek elevation to reduce the risk of scour impacting the bridge performance.

Slabs-On-Grade

Slab-on-grade areas should be prepared as recommended in the **Site Preparation and Grading** subsection. Slabs should be supported on medium dense native soils, or on structural fill extending to these soils. The clean native sand may be expected to act a as a capillary break. If silty soil is encountered at the subgrade level, a 6-inch-thick layer of clean sand or pea gravel should be placed to act as a capillary break. A suitable vapor barrier, such as heavy plastic sheeting, should be placed over the subgrade. If desired, a sand blanket could be placed over the vapor barrier to aid in curing of the concrete.

Retaining Walls

The lateral earth pressure acting on retaining walls is dependent on the nature and density of the soil behind the wall, the amount of lateral wall movement that can occur as backfill is placed, and the inclination of the backfill. Walls that are free to yield at least one-thousandth of the height of the wall are in an "active" condition. Walls restrained from movement by stiffness or bracing are in an "at-rest" condition. Active earth pressure and at-rest earth pressure can be calculated based on equivalent fluid density. Equivalent fluid densities for active and at-rest earth pressure of 33 pounds per cubic foot (pcf) and 50 pcf, respectively, may be used for design for a level backslope. These values assume that the on-site free-draining granular soils are used for backfill, and that the wall backfill is drained. The preceding values do not include the effects of surcharges due to foundation loads, traffic or other surface loads. Surcharge effects and sloping backfills should be considered where appropriate.

The above lateral pressures may be resisted by friction at the base of the wall and passive resistance against the foundation. These values are presented in the **Foundation** section of this report.

All wall backfill should be well compacted. Care should be taken to prevent the buildup of excess lateral soil pressures due to overcompaction of the wall backfill. This can be accomplished by placing wall backfill in 8-inch loose lifts and compacting with small, hand-operated compactors.

Infiltration

We have used the United States Department of Agriculture (U.S.D.A.) soil group classification (Figure III-3.1) as presented in the "Storm Water Management Manual for the Puget Sound Basin", (Ecology 1992) to classify the soil samples analyzed. Based on our visual evaluation, this material is classified as a coarse sand or gravel. Based on this manual, an infiltration rate of 20 inches per hour may be used for the design of the infiltration system, as indicated on Table III-3.1 for soils classified as a coarse sand or gravel. It is our opinion that the permeability numbers provided in this manual are conservative. It has been our experience that higher infiltration rates may be obtained from field infiltration tests. We understand that a safety factor of 2 is commonly used by civil engineers for infiltration system design. This would result in an actual design rate of 10 inches per hour. It is possible that siltier zones in the deposit may exist. We recommend that the soils in the specific infiltration areas be evaluated and the excavation depth changed if finer-grained soils are encountered.

It is very important that infiltration areas be kept free of silt laden runoff which can dramatically reduce the actual infiltration rate achieved. Therefore, infiltration areas should not be used to collect runoff during site grading. We recommend that storm water be directed through a catch basin to aid in removal of sediment.

Drainage

We recommend that runoff from impervious surfaces, such as roofs, driveway and access roadways, be collected and routed to an appropriate storm water discharge system. Surface water should be collected by permanent catch basins and drain lines, and be discharged into a storm drain system.

The site appears to be well draining at the shallow subsurface level. For this reason, footing drains may be optional around the structures. If footing drains are not used, the ground surface should slope away from the structures at a gradient of 3 percent minimum for a distance of at least 10 feet away from the buildings.

Footing drains, if used, should consist of 4-inch-diameter, perforated PVC pipe that is surrounded by free-draining material, such as pea gravel. Footing drains should discharge into tightlines leading to an appropriate collection and discharge point. Roof drains should not be connected to wall or footing drains.

Construction Monitoring

We recommend we be retained to monitor the earthwork phase of construction. Our services would include evaluating the conditions encountered during construction for conformance with those expected during the design phase. If needed, we will provide alternatives if conditions differ from those that are expected. In particular, CG should evaluate conditions in the proposed slope excavation in the northeast corner of the site during grading.

USE OF THIS REPORT

We have prepared this report for Miller Shingle Co., Inc. and their agents, for use in planning and design of this project. The data and report should be provided to prospective contractors for their bidding and estimating purposes, but our report, conclusions, and interpretations should not be construed as a warranty of subsurface conditions.

The scope of our work does not include services related to construction safety precautions, and our recommendations are not intended to direct the contractors' methods, techniques, sequences or procedures, except as specifically described in our report, for consideration in design. There are possible variations in subsurface conditions. We recommend that project planning include contingencies in budget and schedule, should areas be found with conditions that vary from those described in this report.

We should be retained to provide monitoring and consultation services during construction to confirm that the conditions encountered are consistent with those indicated by the explorations, and to provide recommendations for design changes, should the conditions revealed during the work differ from those anticipated. As part of our services, we would also evaluate whether or not earthwork and foundation installation activities comply with contract plans and specifications.

Within the limitations of scope, schedule and budget for our work, we have strived to take care that our work has been completed in accordance with generally accepted practices followed in this area at the time this report was prepared. No other conditions, expressed or implied, should be understood.

We appreciate the opportunity to be of service to you. If there are any questions concerning this report or if we can provide additional services, please call.

Sincerely,

Cornerstone Geotechnical, Inc.

Doug Bath
Project Engineer

CHARLES P. COUVRETTE
STATE OF WASHINGTON
20285
REGISTERED
PROFESSIONAL ENGINEER
1/17/02
EXPIRES 6/17/02

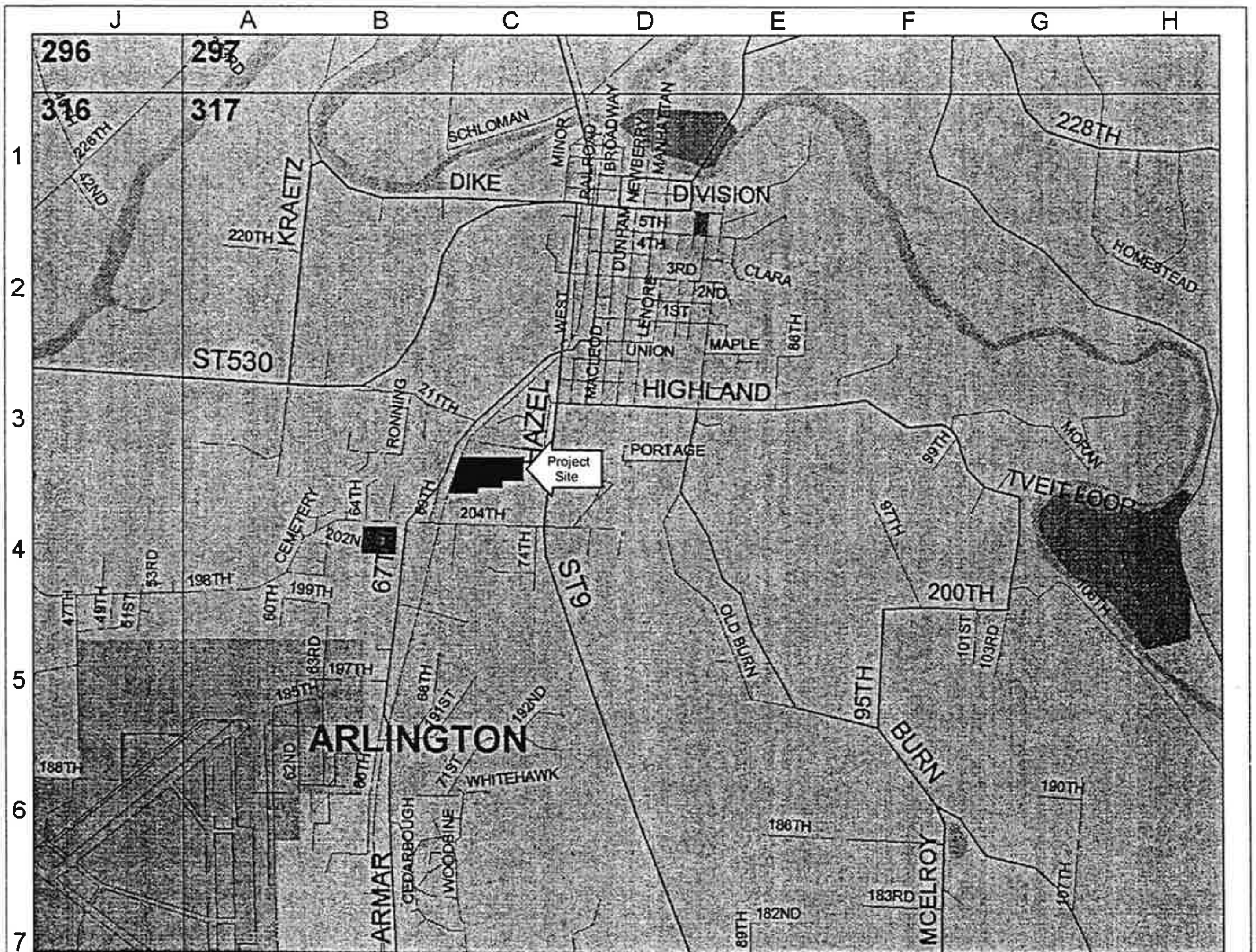
Charles P. Couvrette, PE
Principal Engineer

DJB:CPC:nt

Three Copies Submitted
Six Figures

cc: Mr. Rick McArdle, Shockey Brent, Inc.
Mr. Alan Murray, Evergreen Engineering

Vicinity Map



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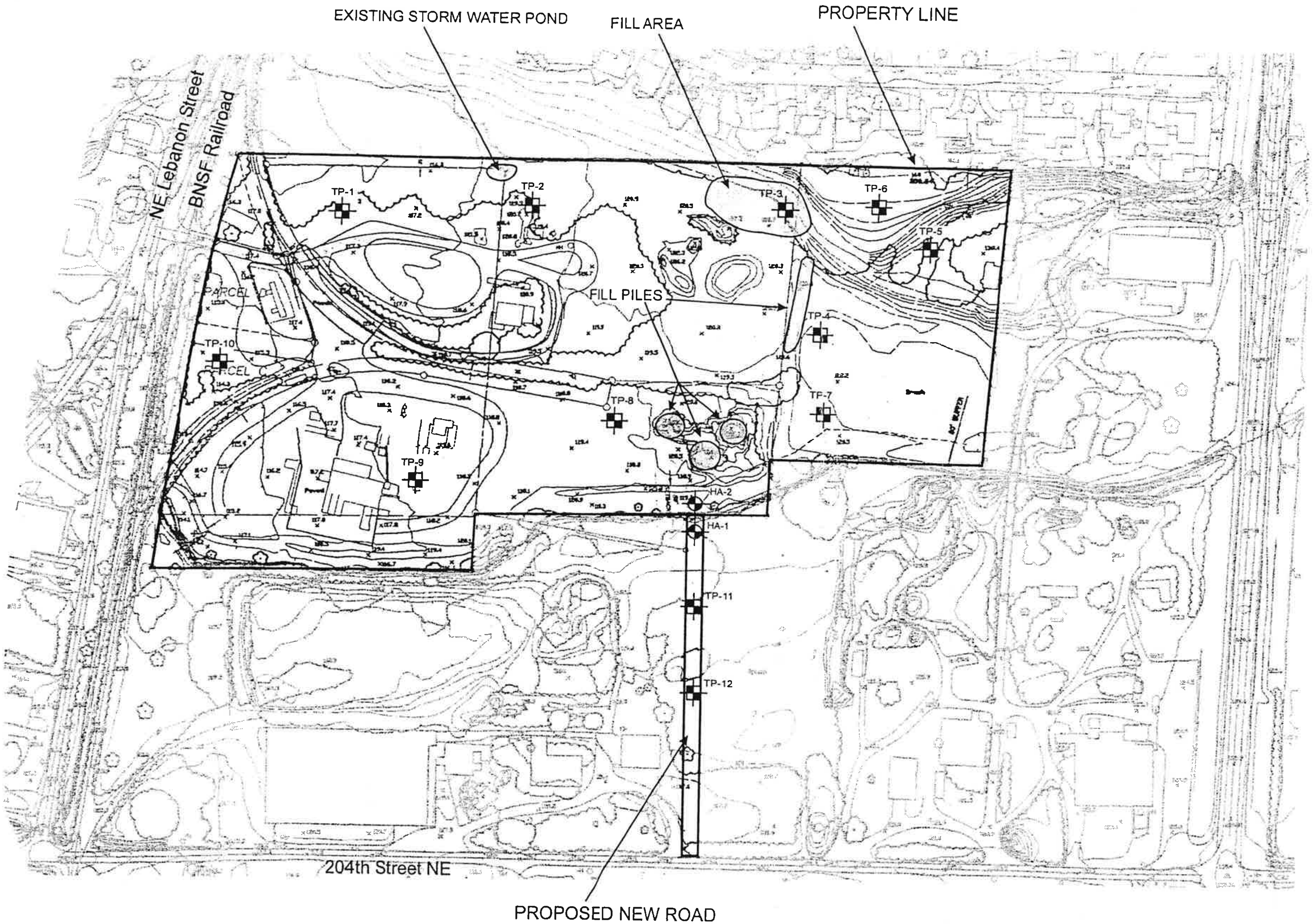
Miller Shingle	
File Number 1232	**Figure** 1

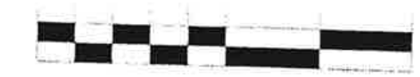
SITE PLAN



LEGEND

TP-1 Test Pit Number and Approximate Location

HA-1 Hand Auger Number and Approximate Location



Scale 1" = 200'

Reference: Site Plan based on drawing prepared by Evergreen Engineering Services, Inc.

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Miller Shingle company

File Number	Figure
1232	2

Unified Soil Classification System

MAJOR DIVISIONS			GROUP SYMBOL	GROUP NAME
COARSE - GRAINED SOILS MORE THAN 50% RETAINED ON NO. 200 SIEVE	GRAVEL MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVEL	GW	WELL-GRADED GRAVEL, FINE TO COARSE GRAVEL
			GP	POORLY-GRADED GRAVEL
		GRAVEL WITH FINES	GM	SILTY GRAVEL
			GC	CLAYEY GRAVEL
	SAND MORE THAN 50% OF COARSE FRACTION PASSES NO. 4 SIEVE	CLEAN SAND	SW	WELL-GRADED SAND, FINE TO COARSE SAND
			SP	POORLY-GRADED SAND
		SAND WITH FINES	SM	SILTY SAND
			SC	CLAYEY SAND
FINE - GRAINED SOILS MORE THAN 50% PASSES NO. 200 SIEVE	SILT AND CLAY LIQUID LIMIT LESS THAN 50%	INORGANIC	ML	SILT
			CL	CLAY
		ORGANIC	OL	ORGANIC SILT, ORGANIC CLAY
	SILT AND CLAY LIQUID LIMIT 50% OR MORE	INORGANIC	MH	SILT OF HIGH PLASTICITY, ELASTIC SILT
			CH	CLAY OF HIGH PLASTICITY, FAT CLAY
		ORGANIC	OH	ORGANIC CLAY, ORGANIC SILT
HIGHLY ORGANIC SOILS			PT	PEAT

NOTES:

1) Field classification is based on visual examination of soil in general accordance with ASTM D 2488-83.
2) Soil classification using laboratory tests is based on ASTM D 2487-83.
3) Descriptions of soil density or consistency are based on interpretation of blowcount data, visual appearance of soils, and/or test data.

SOIL MOISTURE MODIFIERS

Dry- Absence of moisture, dusty, dry to the touch

Moist- Damp, but no visible water

Wet- Visible free water or saturated, usually soil is obtained from below water table

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Unified Soil Classification System

Figure 3

LOG OF EXPLORATION

DEPTH	USC	SOIL DESCRIPTION
TEST PIT ONE		
0.0 – 1.8	SW-SM	GRAY-BROWN FINE TO COARSE SAND WITH SILT, GRAVEL, AND SCATTERED COBBLES (MEDIUM DENSE, MOIST) (FILL)
1.8 – 3.2	SM	ORANGE-BROWN SILTY FINE TO COARSE SAND WITH TRACE GRAVEL (LOOSE TO MEDIUM DENSE, MOIST)
3.2 – 6.0	SP	GRAY-BROWN MEDIUM TO COARSE SAND WITH TRACE SILT, GRAVEL, AND SCATTERED COBBLES (MEDIUM DENSE, MOIST)
6.0 – 8.8	SP	GRAY-BROWN MEDIUM TO COARSE SAND WITH GRAVEL, TRACE SILT, AND SCATTERED COBBLES (MEDIUM DENSE TO DENSE, MOIST)
		SAMPLES WERE COLLECTED AT 1.0, 2.5, 4.0, AND 8.8 FEET GROUND WATER SEEPAGE WAS NOT ENCOUNTERED SLIGHT TEST PIT CAVING OBSERVED BETWEEN 3.0 AND 6.0 FEET TEST PIT WAS COMPLETED AT 8.8 FEET ON 12/21/01 PIEZOMETER INSTALLED TO A DEPTH OF 8.8 FEET
TEST PIT TWO		
0.0 – 1.4	SM	DARK BROWN SILTY FINE TO COARSE SAND WITH ROOTS AND GRAVEL (LOOSE, MOSIT) (FILL)
1.4 – 3.0	SM	ORANGE-BROWN SILTY FINE TO MEDIUM SAND WITH GRAVEL (MEDIUM DENSE, MOIST)
3.0 – 7.0	SP	GRAY-BROWN MEDIUM TO COARSE SAND WITH GRAVEL AND SCATTERED COBBLES (MEDIUM DENSE, MOIST)
		SAMPLES WERE NOT COLLECTED GROUND WATER SEEPAGE WAS NOT ENCOUNTERED SLIGHT TEST PIT CAVING WAS OBSERVED TEST PIT WAS COMPLETED AT 7.0 FEET ON 12/21/01
TEST PIT THREE		
0.0 – 6.0	SM	DARK BROWN TO BLACK SILTY FINE TO MEDIUM SAND WITH WOOD, ROOTS, OTHER ORGANICS AND TRACE GRAVEL (LOOSE, MOIST TO WET) (FILL)
6.0 – 6.5	SP-SM	BROWN FINE TO COARSE SAND WITH SILT, AND GRAVEL (LOOSE TO MEDIUM DENSE, MOIST)
6.5 – 7.5	SP	GRAY FINE TO COARSE SAND WITH TRACE SILT AND GRAVEL (MEDIUM DENSE, MOIST)
		SAMPLE WAS COLLECTED AT 3.0 FEET GROUND WATER SEEPAGE WAS NOT ENCOUNTERED TEST PIT CAVING WAS NOT OBSERVED TEST PIT WAS COMPLETED AT 7.5 FEET ON 12/21/01

LOG OF EXPLORATION

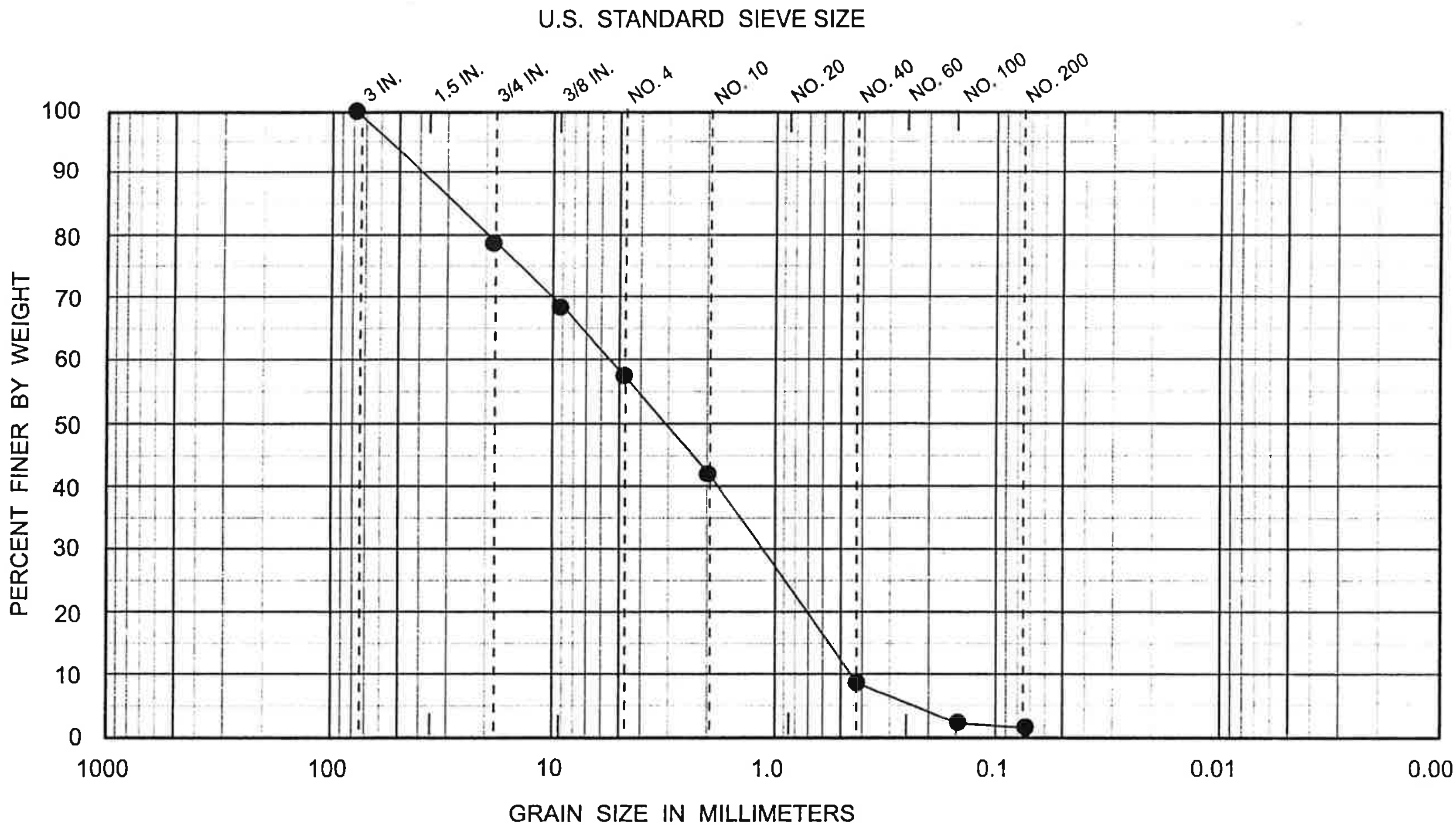
DEPTH	USC	SOIL DESCRIPTION
TEST PIT FOUR		
0.0 – 1.0	SM	DARK BROWN SILTY FINE SAND WITH ROOTS (LOOSE, MOIST TO WET) (TOPSOIL)
1.0 – 2.0	SP-SM	BROWN FINE TO MEDIUM SAND WITH SILT AND GRAVEL (LOOSE TO MEDIUM DENSE, MOIST TO WET)
2.0 – 8.0	SP	GRAY-BROWN MEDIUM TO COARSE SAND WITH TRACE GRAVEL AND SCATTERED COBBLES WITH A LENSE OF ROUNDED FINE GRAVEL WITH FINE TO COARSE SAND FROM 6.5 TO 7.0 FEET (MEDIUM DENSE, MOIST)
		SAMPLES WERE NOT COLLECTED GROUND WATER SEEPAGE WAS NOT ENCOUNTERED TEST PIT CAVING WAS NOT OBSERVED TEST PIT WAS COMPLETED AT 8.0 FEET ON 12/21/01 PIEZOMETER INSTALLED TO A DEPTH OF 7.5 FEET
TEST PIT FIVE		
0.0 – 1.4	SM	ORANGE-BROWN SILTY FINE TO MEDIUM SAND WITH TRACE ROOTS (LOOSE, MOIST)
1.4 – 4.0	SM	TAN SILTY FINE TO MEDIUM SAND WITH TRACE ROOTS (MEDIUM DENSE, MOIST)
4.0 – 9.5	SP	GRAY MEDIUM TO COARSE SAND WITH TRACE SILT, GRAVEL, AND SCATTERED COBBLES WITH A 5-INCH THINK LAYER OF SILTY FINE SAND AT 7.0 FEET (MEDIUM DENSE, MOIST)
		SAMPLES WERE COLLECTED AT 1.0, 2.5, AND 4.5 FEET GROUND WATER SEEPAGE WAS NOT ENCOUNTERED TEST PIT CAVING WAS NOT OBSERVED TEST PIT WAS COMPLETED AT 9.5 FEET ON 12/21/01
TEST PIT SIX		
0.0 – 1.0	SM	ORANGE-BROWN SILTY FINE SAND WITH TRACE ROOTS (LOOSE, MOIST)
1.0 – 1.5	SP-SM	BROWN FINE TO MEDIUM SAND WITH SILT AND GRAVEL (LOOSE TO MEDIUM DENSE, MOIST)
1.5 – 10.5	SP/GW	GRAY-BROWN MEDIUM TO COARSE SAND WITH GRAVEL AND COBBLES, AMOUNT OF GRAVEL AND COBBLES VARIES (MEDIUM DENSE TO DENSE, MOIST) - (SEE SIEVE RESULTS)
		SAMPLES WERE COLLECTED AT 4.0 AND 10.5 FEET GROUND WATER SEEPAGE WAS NOT ENCOUNTERED TEST PIT CAVING WAS NOT OBSERVED TEST PIT WAS COMPLETED AT 10.5 FEET ON 12/21/01
TEST PIT SEVEN		
0.0 – 1.3	SM	BLACK SILTY VERY FINE SAND WITH ROOTS (LOOSE, MOIST TO WET) (TOPSOIL)
1.3 – 2.2	SP-SM	BROWN FINE TO MEDIUM SAND WITH SILT, GRAVEL, AND ROOTS (LOOSE, MOIST)
2.2 – 9.2	SW	BROWN FINE TO COARSE SAND WITH GRAVEL AND COBBLES, STOPPED ON A BOULDER AT THE BOTTOM OF THE HOLE (MEDIUM DENSE, MOIST)
		SAMPLES WERE NOT COLLECTED GROUND WATER SEEPAGE WAS NOT ENCOUNTERED TEST PIT CAVING WAS NOT OBSERVED TEST PIT WAS COMPLETED AT 9.2 FEET ON 12/21/01 PIEZOMETER INSTALLED TO A DEPTH OF 9.2 FEET

LOG OF EXPLORATION

DEPTH	USC	SOIL DESCRIPTION
TEST PIT EIGHT		
0.0 – 0.4	SP-SM	BROWN FINE TO COARSE SAND WITH SILT, GRAVEL, AND COBBLES (LOOSE TO MEDIUM DENSE, MOIST) (FILL)
0.4 – 0.8	SP-SM	BLACK FINE TO COARSE SAND WITH SILT AND TRACE GRAVEL (LOOSE TO MEDIUM DENSE, MOIST)
0.8 – 5.0	SP-SW	GRAY-BROWN FINE TO COARSE SAND WITH TRACE GRAVEL AND SCATTERED COBBLES (MEDIUM DENSE, MOIST)
		SAMPLE WAS COLLECTED AT 0.6 FEET GROUND WATER SEEPAGE WAS NOT ENCOUNTERED TEST PIT CAVING WAS NOT OBSERVED TEST PIT WAS COMPLETED AT 5.0 FEET ON 12/21/01
TEST PIT NINE		
0.0 – 0.3	SW-SM	BROWN FINE TO COARSE SAND WITH SILT, GRAVEL, AND COBBLES (LOOSE TO MEDIUM DENSE, MOIST) (FILL)
0.3 – 1.6	SM	DARK BROWN SILTY FINE TO COARSE SAND WITH GRAVEL AND COBBLES (MEDIUM DENSE ,MOIST)
1.6 – 4.5	SW	GRAY-BROWN FINE TO COARSE SAND WITH GRAVEL AND SCATTERED COBBLES (MEDIUM DENSE, MOIST)
		SAMPLES WERE NOT COLLECTED GROUND WATER SEEPAGE WAS NOT ENCOUNTERED TEST PIT CAVING WAS NOT OBSERVED TEST PIT WAS COMPLETED AT 4.5 FEET ON 12/21/01
TEST PIT TEN		
0.0 – 0.3	SM	BLACK SILTY FINE SAND (LOOSE, MOIST) (TOPSOIL)
0.3 – 11.0	SW	GRAY-BLACK FINE TO COARSE SAND WITH GRAVEL AND COBBLES (MEDIUM DENSE, MOIST)
11.0 – 15.0	SP	LIGHT BROWN FINE TO MEDIUM SAND WITH TRACE SILT GRADES TO FINE TO COARSE SAND WITH TRACE SILT AND GRAVEL (MEDIUM DENSE, MOIST)
		SAMPLES WERE COLLECTED AT 4.5, 8.5, 12.0, AND 15.0 FEET GROUND WATER SEEPAGE WAS NOT ENCOUNTERED TEST PIT CAVING WAS NOT OBSERVED TEST PIT WAS COMPLETED AT 15.0 FEET ON 12/21/01 PIEZOMETER WAS INSTALLED TO A DEPTH OF 15.0 FEET
TEST PIT ELEVEN		
0.0 – 1.3	SM	DARK BROWN TO BLACK SILTY SAND WITH TRACE ROOTS (LOOSE, MOIST TO WET) (TOPSOIL)
1.3 – 5.0	SW	GRAY-BROWN FINE TO COARSE SAND WITH GRAVEL AND SCATTERED COBBLES (MEDIUM DENSE, MOIST)
		SAMPLES WERE NOT COLLECTED GROUND WATER SEEPAGE WAS NOT ENCOUNTERED TEST PIT CAVING WAS NOT OBSERVED TEST PIT WAS COMPLETED AT 5.0 FEET ON 12/21/01

LOG OF EXPLORATION

DEPTH	USC	SOIL DESCRIPTION
TEST PIT TWELVE		
0.0 – 1.4	SM	BLACK SILTY FINE SAND WITH ROOTS (LOOSE, MOIST) (TOPSOIL)
1.4 – 2.0	SM	BROWN SILTY FINE TO COARSE SAND WITH GRAVEL AND SCATTERED COBBLES (MEDIUM DENSE ,MOIST)
2.0 – 5.0	SW	GRAY-BROWN FINE TO COARSE SAND WITH GRAVEL AND SCATTERED COBBLES (MEDIUM DENSE, MOIST)
		SAMPLES WERE NOT COLLECTED GROUND WATER SEEPAGE WAS NOT ENCOUNTERED TEST PIT CAVING WAS NOT OBSERVED TEST PIT WAS COMPLETED AT 5.0 FEET ON 12/21/01
HAND AUGER ONE		
0.0 – 1.9	SM	BLACK SILTY FINE TO MEDIUM SAND (LOOSE, MOIST) (TOPSOIL)
1.9 – 3.3	SM	DARK BROWN SILTY FINE TO MEDIUM SAND WITH GRAVEL AND SCATTERED COBBLES (LOOSE TO MEDIUM DENSE, MOIST)
3.3 – 4.0	SW	GRAY-BROWN FINE TO COARSE SAND WITH GRAVEL AND COBBLES (MEDIUM DENSE, MOIST)
		SAMPLES WERE NOT COLLECTED GROUND WATER SEEPAGE WAS NOT ENCOUNTERED (LOCATED 8 FEET FROM CREEK, SURFACE 3.5 FT ABOVE CREEK LEVEL) HAND AUGER WAS COMPLETED AT 4.0 FEET ON 12/21/01
HAND AUGER TWO		
0.0 – 0.8	SW-SM	BROWN FINE TO COARSE SAND WITH SILT AND GRAVEL (LOOSE, MOIST) (FILL)
0.8 – 2.5	SM	BLACK SILTY FINE TO MEDIUM SAND (LOOSE, MOIST) (TOPSOIL)
2.5 – 3.2	SP-SM	BROWN FINE TO COARSE SAND WITH SILT AND GRAVEL (LOOSE TO MEDIUM DENSE, MOIST)
3.2 – 4.6	SW	GRAY-BROWN FINE TO COARSE SAND WITH GRAVEL AND COBBLES (MEDIUM DENSE, MOIST)
		SAMPLE WAS COLLECTED AT 1.5 FEET GROUND WATER SEEPAGE WAS NOT ENCOUNTERED (LOCATED 7 FEET FROM CREEK, SURFACE 2.5 FT ABOVE CREEK LEVEL) HAND AUGER WAS COMPLETED AT 4.6 FEET ON 12/21/01



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	EXPLORATION NUMBER	SAMPLE DEPTH	SOIL DESCRIPTION
●	TP-6	4.0 feet	SP - Gray-brown medium to coarse sand with gravel and cobbles

Note: Does not include cobbles over 3 inches in diameter, which are scattered in the unit.

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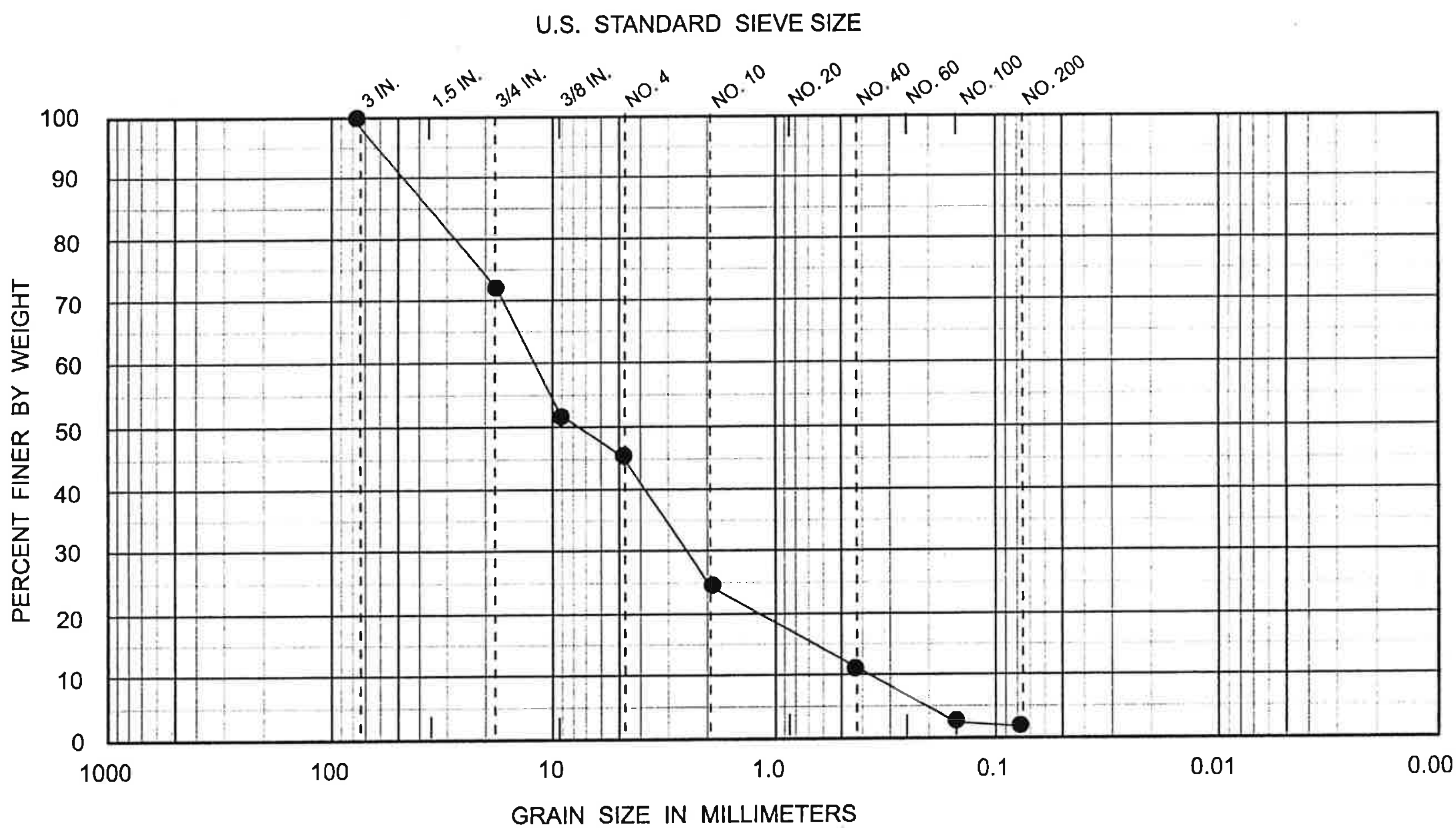
Milleer Shingle Company

FILE NO. 1232

FIGURE 8



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	EXPLORATION NUMBER	SAMPLE DEPTH	SOIL DESCRIPTION
●	TP-6	10.5 feet	GW - Brown gravel with sand and cobbles

Note: Does not include cobbles over 3 inches in diameter, which are scattered in the unit.

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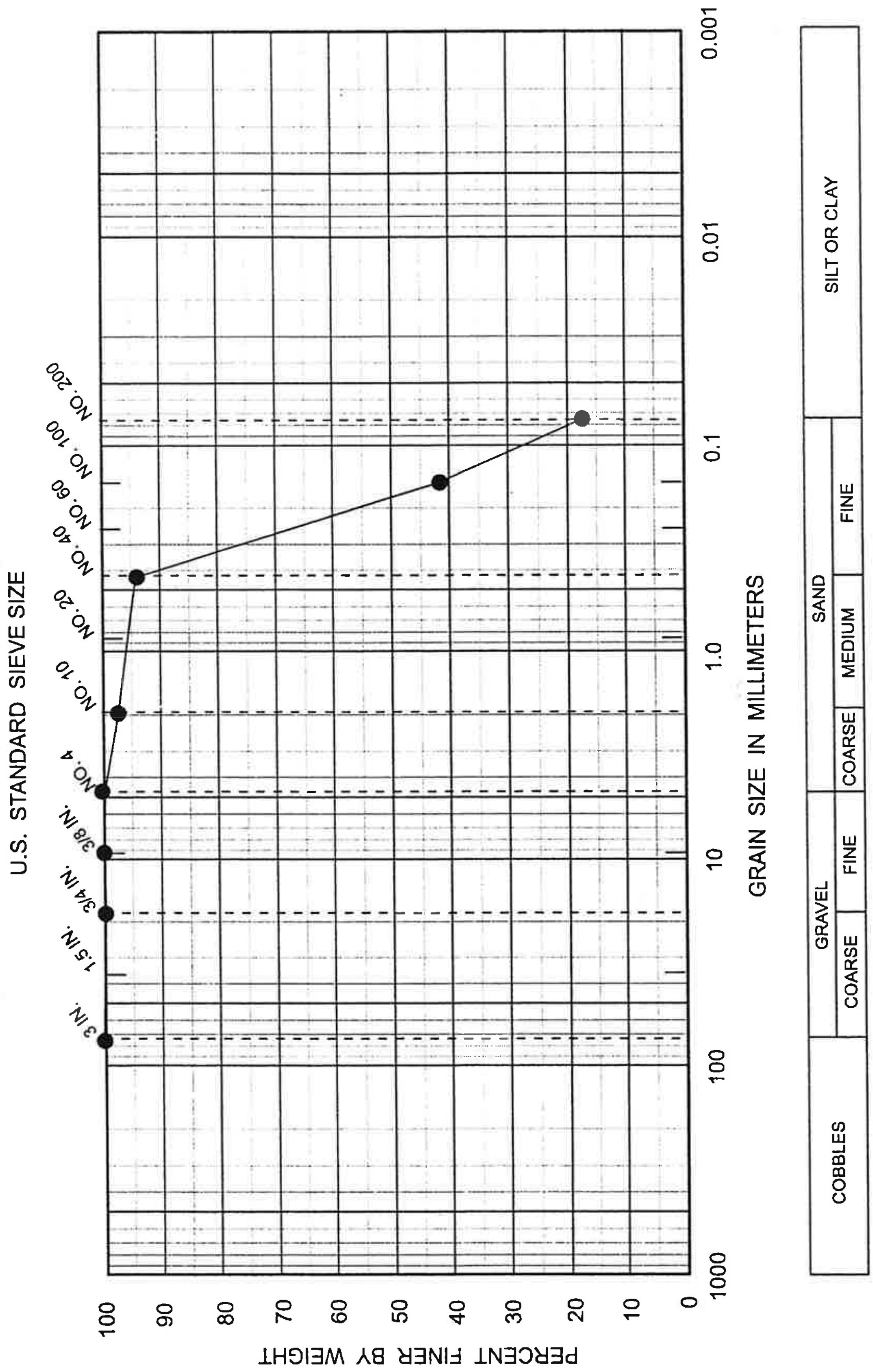
FIGURE 9



SYMBOL	EXPLORATION NUMBER	SAMPLE DEPTH	SOIL DESCRIPTION
●	TP-5	2.5 feet	SM - Light brown silty fine to medium sand

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Milleer Shingle Company	
FILE NO. 1232	FIGURE 10

Geotechnical Evaluation
Proposed Commercial Site
Arlington, Washington
For
Miller Shingle Co., Inc.

Cornerstone Geotechnical, Inc.

17625-130th Ave. NE, C102, Woodinville, WA 98072
Phone: 425-844-1977
Fax: 425-844-1987

May 13, 2003

Mr. Brian Abbott
c/o Miller Shingle Co., Inc.
PO Box 29
Granite Falls, WA 98252

Geotechnical Evaluation
Proposed Commercial Site
Arlington, Washington
CG File No. 1232.1

INTRODUCTION

This report presents the results of our geotechnical evaluation of the proposed cut slope near the north property line at the Miller Shingle site in Arlington, Washington. We previously prepared a geotechnical report for the project dated January 17, 2002. You have requested that we complete this additional report to focus more specifically on the proposed cut slope area. The cut slope is planned in the northeast portion of the Miller Shingle property. There were letters by local citizens and comments by the planning commissioners regarding this cut. You have requested that we address some of those comments.

For our use in preparing this report, you have provided us with an electronic site plan, a copy of a peer review report, and copies of letters prepared by homeowners of properties along Jensen Street, which is located north of the project and Hazel Street located to the northeast of the project. The electronic file shows the existing site grade and the planned grades in the area of the proposed cut. Also shown on this file are the structures on the residential properties near the proposed cut. The peer review report is a geotechnical review of our report prepared by Robert M. Pride, Inc., dated December 9, 2002. The homeowner letters were addressed to the City of Arlington and are part of the public record. Some of the letters are prepared by homeowners adjacent to the planned excavation and some are located a considerable distance from the planned excavation. You have also told us of comments by the commissioners, one regarding recessional outwash and the other regarding driveway distress in the neighborhood.

The subject property is located on a valley floor with a terrace to the north. A steep slope is located between the terrace and the valley floor. This terrace trends to the west-northwest near the property line. On the east side of the site, the property line is actually on the top of the terrace, whereas on the west side of the site, the steep slope is located north of the property line and is not on the project site. The proposed cut is to be made near the north property on the east side of the site. The planned cut will be at 1.75:1 (H:V) or 30 degrees, with a total height of about 40 feet. A site plan of the proposed cut is shown on Figure 1.

SITE CONDITIONS

Surface Conditions

General: A development is located on the terrace just north of the site. Jensen Street is located just north of the steep slope and runs roughly parallel to the top of the slope. Since the steep slope trends west-northwest, and Jensen is east west, the steep slope is closer to Jensen to the west. This allows the houses on the east end of Jensen to be set back 35 feet or more from the edge of slope and the proposed cut, whereas on the west end of Jensen, the residences are built adjacent to the slope, with little or no setback. The northeast corner of the site where the cut is to be made, and the majority of the slope around the edge of the terrace are wooded with a mixture of mature conifer trees and alder trees.

We visited the site, observed site conditions and measured local slope inclinations using a Brunton Compass, at spot locations. We present our hand measurement data in discussions throughout this text.

We reviewed air photos of the site dating back to 1947. The trees currently o the planned cut area did not exist in 1947. The terrace area was heavily treed at that time. Old growth stumps on the slope indicates that the terrace probably had old growth forests in the past. We expect the trees on the terrace in 1947 were probably a second growth forest.

234 Jensen and the properties to the west: The residences on these properties are all located well to the west of the planned excavation and are separated from the Miller Shingle property by a 20-foot-wide unopened right-of-way. These residences are all located very close to or at the top of the slope. We did not walk the slope entirely in this area. We traversed west of the proposed cut to behind the residence located at 238 West Jensen. We observed a few lots in this area where it was apparent that fill was placed on the top of the slope to increase lot size. Structures were also built on this fill. The steepest portions of the original slope, in this area, was inclined on the order of 30 degrees with some of the fill being at a steeper inclination.

A 12-inch storm water pipe that receives water from Jensen Street empties out near the base of the steeper slope between 234 Jensen and 236 Jensen. This pipe appears to be part of the original development and has been in place for tens of years. During our visit it was raining and we observed a significant flow from this pipe. The flow traveled overland down the slope for about 20 feet where it disappeared, being infiltrated into the underlying sand and gravel deposit. We did not observe significant amount of erosion on the slope from this pipe. The photograph below shows this storm water outfall. We did not observe signs of slope movement. The evergreen trees on the slope were fairly mature and did not show signs of past hillside movement. These trees were estimated to be over 40 years old.

Storm water outfall between Lots 234 and 236 Jensen

Properties along the Top of the Planned Cut: These residences include 232 Jensen to 220 Jensen and are shown on the Site Plan attached as Figure 1. Each of these residences are located at least 50 feet from the top of the planned cut. The slope in this area has been graded, most likely during past usage of the site. We measured slope inclination of two areas on the order of 40 degrees (1.2H:1V), with one slope having an estimated height of 20 feet. The predominant angle of the steep slopes was more on the order of 30 degrees (1.75H:1V). We did not observe signs of slope movement. The evergreen trees on the slope were fairly mature and did not show signs of past hillside movement. These trees were estimated to be over 40 years old.

Explorations

Subsurface conditions were explored at the site on December 21, 2002, by excavating 12 test pits with a trackhoe. Two of these test pits were located near the planned slope cut area (TP-5 and TP-6) and are shown on the Site Plan and presented in the attached logs. Additional test pits were completed on May 6, 2003. These test pits (TP-13, TP-14, and TP-15) were completed along the top of the planned cut as shown on Figure 1. Two borings with a track-mounted, limited access drill rig were also completed on May 6, 2003. The borings were completed to a depth of 41.5 feet, below the planned cut elevation. The boring samples were obtained at 5-foot intervals with additional samples planned if drilling appeared to encounter a change in material type. The samples were obtained using the Standard Penetration Test (SPT) method in general accordance with ASTM D 1586. The SPT consists of driving a 2-inch-outside-diameter sampler using a 140-pound hammer falling 30 inches. The standard method is to drive the sampler 18 inches and record the blows for each 6 inches of penetration. The total number of blows for the last 12 inches of penetration (unless otherwise noted) is termed the Standard Penetration Resistance blow count or "N-value" (units: blows per foot).

The explorations were located in the field by an engineer from this firm who also examined the soils and geologic conditions encountered, and maintained logs of the explorations. The approximate locations of the explorations are shown on the Site Plan in Figure 1. The soils were visually classified in general accordance with the Unified Soil Classification System, a copy of which is presented as Figure 2. The logs of the test pit explorations are presented in Figures 3 and 4. The boring logs are presented in Figures 5 through 8.

Subsurface Conditions

A brief summary of the conditions encountered in our explorations near the planned slope cut is included below. For a more complete and detailed description of the soils encountered please refer to the logs presented in Figures 4 through 9.

Below the thin topsoil layer was a weathered layer of brown to orange-brown sand with silt and gravel that extended to a depth of about 2 feet. The test pits near the north property line (TP-13 through TP-15 encountered fine to coarse sand with trace to moderate amounts of gravel to a depth of 3 to 7.5 feet. All of the explorations encountered medium dense to dense, gray-brown, fine to coarse sand with gravel and cobbles. This soil was encountered as shallow as 1.5 feet and as deep as 7.5 feet. In the borings, the high gravel content soil extended to a depth of 15 feet in Boring 1 and 20 to 25 feet in Boring 2. Below this high gravel content layer was medium dense to dense, fine to medium sand with trace gravel. This soil extended to the bottom of the borings at 41.5 feet. The drilling conditions did not suggest any significant fine soil layers were present. There was no water encountered in the test pits or the borings.

DISCUSSION OF HOMEOWNER LETTERS AND OTHER COMMENTS

General

The letters prepared by the homeowners along Jensen Street and Hazel Street included a variety of concerns and comments. Some of these comments addressed issues of settlement, slope stability, erosion, and vibrations. These are discussed below. We also understand that comments were made by members of the planning commission in regards to driveway performance in the neighborhood. This is also discussed.

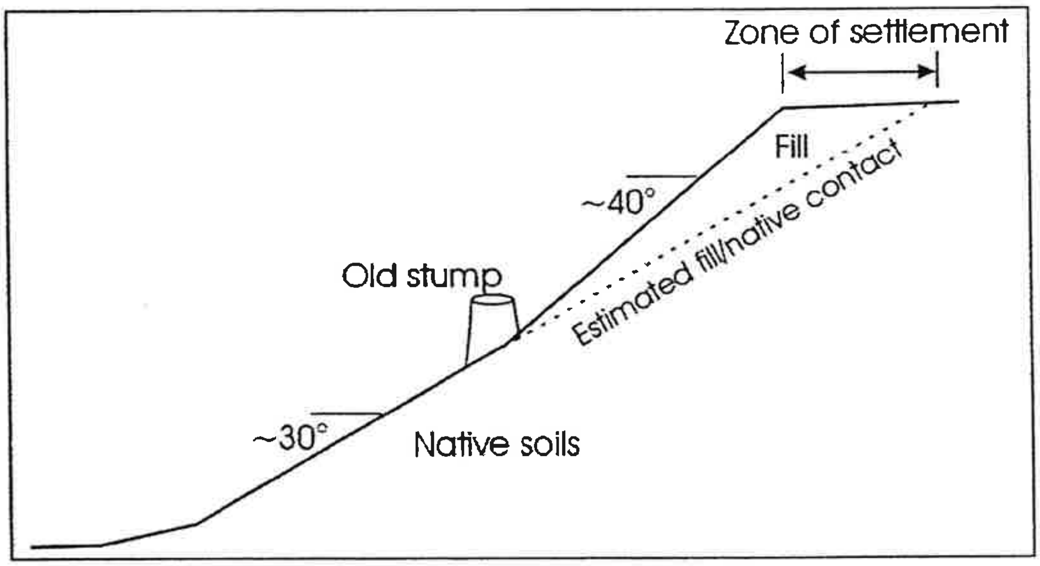
Another comment by a commission member expressed concern with the term recessional outwash. This was reported in the Everett Harold in the following quote: "the slope on the NE corner is mapped as recessional sand, that sounds like a slippery slope to me!" The term recessional is used to describe a geologic process where sand and gravel is deposited during the recessing of a glacier. Large glaciers have high energy rivers under and downstream of them. These rivers deposit higher energy soils such as sand and gravels. As the continental ice sheet advances south, it deposited these sands and gravels, which are so named "advance" sand and gravel deposits. Essentially the same thing works in reverse. As the glacier recedes or recesses, it again deposits sand and gravel, which are named "recessional" sand and gravel. Since both of these deposits are essentially "washed out" of the foot of the glacier, a more common term is advance or recessional outwash deposits. The main difference between the two is that the advance deposit is overridden by the ice sheet and compacted to a more dense configuration. Both deposits are typically considered stable with drainage characteristics ranging from fair to excellent. The on-site recessional deposit has evidence of excellent drainage with good performance of slope stability.

Settlement at the Top of a Slope

Some of the comments included a discussion of settlement along the top of the slope. In particular, the residence at 238 Jensen Street indicated that there is evidence of soil shifting on that property. The letter indicated that there are structures in the backyard tilting due to this soil shifting. We evaluated the slope condition in this area. Since it is not on the Miller Shingle property or adjacent to the planned excavation, we did not complete explorations. We did observe a break in slope that indicates fill was placed on the slope when the house lot was developed. Based on the site geometry, some structures were built on this fill. We observed one location in the general area where a virgin timber stump was located on the slope. We created a general schematic cross section of the slope in this area and present it below as our interpretation of conditions in this area. This condition of fill on the slope with close structures occurs west of 232 Jensen.

We have evaluated many residences with similar conditions. It is very common to see settlement where structures are placed near the top of an uncontrolled fill slope. The term uncontrolled refers to a fill placed without engineering evaluation and proper keying in and compaction of the fill. Fill placed without adequate compaction will likely settle even without building loads. The amount of settlement is generally greater closer to the slope as would be expected since the fill thickness is greater. This can result in "tipping" of the structure due to variance in the amount of settlement. This condition, while unfortunate for the homeowner of this property, is related to the construction and earthwork associated with the development of the lot and is not indicative of the stability of the native soils that core the slope. Fill will not be placed on the slope as part of the planned site improvements.

Schematic of fill placed on top of slope:



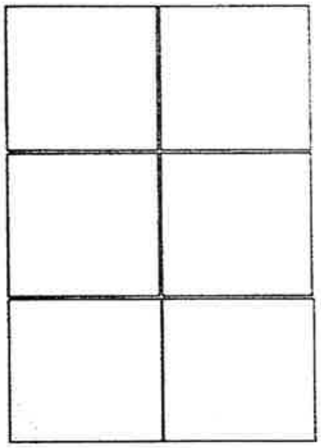
General Settlement within the Subdivision

The resident at 230 Jensen reported stuck windows and poorly performing doors. This residence is located at least 50 feet from the top of the existing and future slope cut. There are three large evergreen trees located between the slope and the residence. In our opinion, this structure is well outside of the influence of the slope. These types of problems can be related to general foundation settlement. It is not uncommon to see foundation settlement in homes of this age and it is possible that foundations were not deep enough, wide enough, or were placed on top of fill soil. The old growth stump observed on site indicates that that size of tree existing on the terrace in the past. Our experience is that soils can be disturbed on the order of 8 feet deep when removing these types of stumps. If the soils used to fill these types of voids are not properly compacted, some settlement can occur over time. Since the house is trying to "bridge" over these loose areas, it is not uncommon to have movement due to relaxation occur over tens of years. Most of the time, these movements are subtle over time in wood structures, although they can represent several inches of settlement. However, if a brittle structural unit such as a concrete foundation or driveway is involved, nothing will be noticed until a complete failure occurs causing an immediate response.

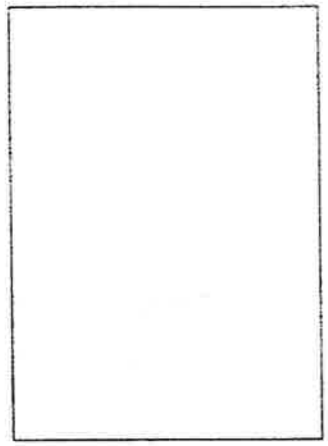
Driveway Cracking and Settlement

Several letters indicated problems with their driveways. This was also mention by members of the planning commission. The driveways are generally 100 to 200 feet from the top of the slope. We visually evaluated the driveways in the area. The crack patterns fit two general conditions. The first is relatively large square cracking patterns over a large pour driveway slab without control joints. The second was severe cracking in a localized area.

Concrete tends to crack into roughly square shapes due to shrinkage. The distances between cracks are controlled by several conditions which relate to concrete strength. These conditions include cement content, and water content of the mix when poured in addition to the daytime temperature when poured. This type of cracking can be controlled by placing joints in the slab creating relatively square panels. We have shown sketches of crack patterns for self cracking and properly jointed slabs below. For the most part, the slabs on Jensen show the self cracking condition. We note that there is usually minimal vertical displacement at the edge of the crack joint in this type of cracking. We did observe a driveway properly jointed, as shown in the diagram at 240 Jensen. This driveway did not exhibit any cracking that we could easily see. Properly sectioned driveways may occasional show corner cracking over time as a result of large loads placed on the corner of that section as shown below on the left sketch.



Properly sectioned driveway with typical minor cracking on corners.



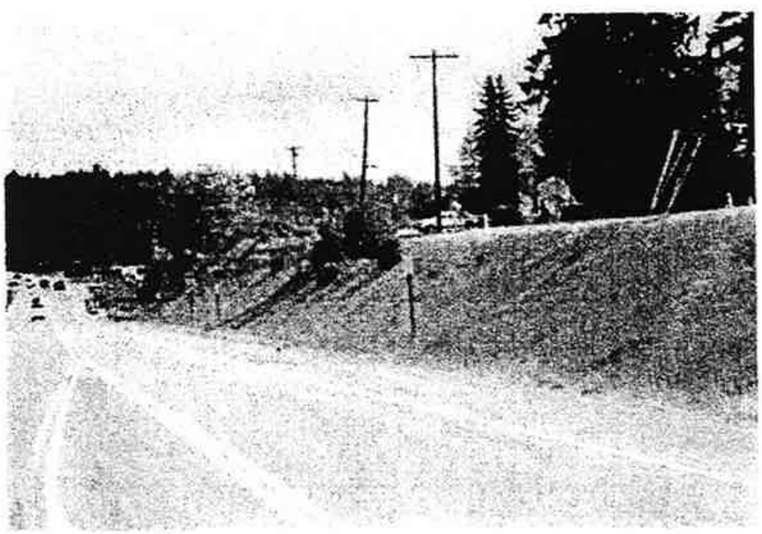
Single pour driveway without sections for crack control showing common self-cracking pattern.

A second failure type occurs where a section of a driveway becomes unsupported. This can occur when a trench under the driveway is not adequately compacted or a depression is not filled with adequately compacted material. In this type of setting, the depression often results from a large tree removed from the area during construction of the driveway. This is similar to the discussion of the house performance described previously. This could also occur when a large tree located next to the driveway lifts the slab with its roots. A large stump can have a major rootball extending down 6 to 8 feet. This can result in vertical offsets and rather severe looking crack problems where a fill was poorly placed. In some cases, organic matter left in place can decompose over time along with fill settlement to create a condition that continues long after initial construction. This type of cracking was observed at 212 Jensen. We can see no connection of these driveway problems to the past or future performance of the slope.

Slope Stability

Some of the letters expressed concerns about slope stability. As we discussed in our report, a 1.75H to 1.0 Vertical slope is considered to have adequate safety factors with respect to slope stability. The deep borings did not encounter a significant change in conditions from those anticipated at the time of our report. We evaluated performance of the slopes near the site at various slope angles. We observed places where the existing slope angle is at 40 degrees or slightly steeper. We did not observe evidence of instability of these 40 degree slopes. Since the

40 degrees is the maximum slope inclination found on site for slopes of significant heights, we interpret this to be near its "angle of repose". For a 40 degree (internal friction angle) sand and gravel with no water in the slope, the 30 degree slope proposed for this site will provide a factor of safety of 1.5. The 40 degree internal frictional angle is consistent with the type of material found on site. A peer review report completed as required by the City of Arlington came to the same conclusion. The Highway 9 slope cut just east of Hazel Street, created by Washington DOT, was measured to be near the 30 degree inclination. A photograph of this cut is shown below. This cut is in the same geologic unit and at the same inclination of the proposed cut. This slope cut was created sometime around 1965 based on our air photo review. The slope does not show signs of instability.



Highway 9 slope cut adjacent to Hazel Street.

Erosion

A comment in several letters was concern about potential for erosion. There is potential for erosion on cleared steep slopes. Erosion potential can be minimized with proper erosion control prevention measures. In our conversations with Miller Shingle, it appears that significant erosion control measures are planned. The slope is to be hydro-seeded and planted with evergreen trees. The past performance of the slope with respect to erosion and ability to regenerate reasonably mature forest indicates that this will be a good solution. Once the vegetation is established, there should be little potential for erosion except if concentrated surface water is directed to discharge onto the slope face. However, even with the concentrated flow below 236 Jensen, we observed minimal evidence of erosion due to the high permeability of the on site soils. We did not observe any other signs of erosion on the slope. We still recommend that concentrated flows not be allowed to occur on the slope.

In our opinion, the proposed erosion control measures, as we understand them, should be suitable. We do not consider the erosion potential of the sand and gravel soils to be something that cannot be properly managed with suitable erosion control measures during construction. An additional safety factor against erosion and raveling affecting the property line is provided by the planned minimum 5-foot offset from the property line. In our opinion, this should be a suitable offset distance.

CONCLUSIONS AND RECOMMENDATIONS

General

The conditions encountered in our recent explorations suggest the recommendations of our original report are appropriate. Conditions at depth did not suggest that the planned slope cut would be unstable. The performance of the native soils suggest the planned slope angle of 30 degrees (1.75H to 1.0 V) are appropriate. In our opinion, conditions appear to be suitable for a permanent slope angle of as steep as 1.75H:1V. A 5-foot minimum setback from the property line should be suitable to protect the property line from minor raveling or erosion while the vegetation is established.

The geotechnical related issues discussed in the homeowner letters to the City do not appear to represent a problem related to the planned excavation. The noted driveway cracking and settlement of structures placed on fill do not appear relevant to a future engineered cut slope with a proper setback from structures. We saw no evidence in the field or offered in letters to the City that suggest there is any significant slope movement on the native slopes near the planned slope angle or even at the steeper areas found to have inclinations of 40 degrees (1.2H:1V).

USE OF THIS REPORT

We have prepared this report for Miller Shingle Co., Inc. and their agents, for use in planning and design of this project. The data and report should be provided to prospective contractors for their bidding and estimating purposes, but our report, conclusions, and interpretations should not be construed as a warranty of subsurface conditions.

The scope of our work does not include services related to construction safety precautions, and our recommendations are not intended to direct the contractors' methods, techniques, sequences or procedures, except as specifically described in our report, for consideration in design. There are possible variations in subsurface conditions. We recommend that project planning include contingencies in budget and schedule, should areas be found with conditions that vary from those described in this report.

Within the limitations of scope, schedule and budget for our work, we have strived to take care that our work has been completed in accordance with generally accepted practices followed in this area at the time this report was prepared. No other conditions, expressed or implied, should be understood.

o O o

We appreciate the opportunity to be of service to you. If there are any questions concerning this report or if we can provide additional services, please call.

Sincerely,

Cornerstone Geotechnical, Inc.

Doug Bath
Project Engineer

EXPIRES 6/17/04

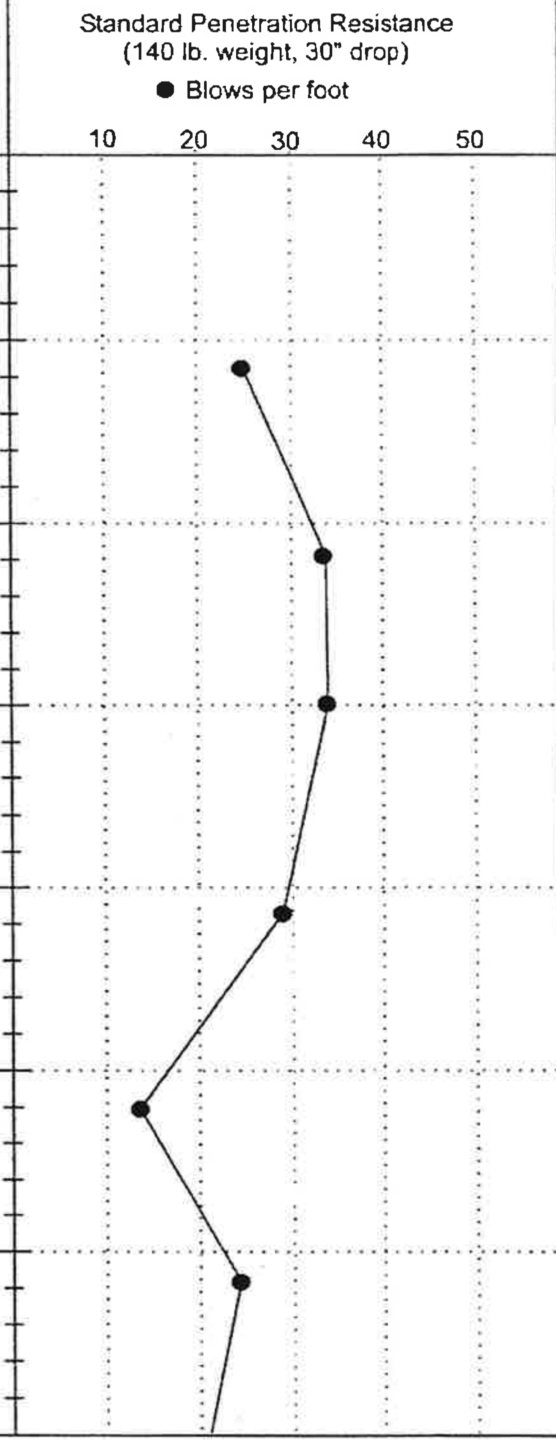
Charles P. Couvrette, PE
Principal Engineer

DJB:CPC:nt

Twelve Copies Submitted
Eight Figures

cc: Mr. Rick McArdle, Shockey Brent, Inc.
Mr. Alan Murray, Evergreen Engineering

SOIL DESCRIPTION **B-2** Surface Elevation:	U.S.C.	SAMPLES	GROUND WATER	DEPTH, ft.
Topsoil				
Orange-brown silty sand with trace roots	SP-SM	I		
Gray-brown fine to coarse sand with gravel and cobbles (medium dense, dry to moist)	SW/GW	I		5
Gray-brown fine to coarse sand with gravel and cobbles (medium dense to dense, dry to moist)		I		10
Gray-brown fine to coarse sand with gravel and cobbles (medium dense to dense, dry to moist)		I		15
Gray fine to coarse sand with gravel (medium dense to dense, dry to moist)	SW	I		20
Gray fine to coarse sand with trace gravel (medium dense, dry to moist)	SP	I		25
Gray fine to coarse sand with trace gravel (medium dense, dry to moist)		I		30



LEGEND

I Depth 2" O.D. split spoon sample driven.	* Liquid limit	Impervious seal	P Sample pushed
II 3" O.D. thin-wall sample	■ Moisture content	∇ Water level	TV Torvane reading, tons/ft²
	+ Plastic limit	Piezometer tip	PP Pocket penetrometer reading, tons/ft²

NOTE: The stratification lines represent the approximate boundaries between soil types and the transition may be gradual.

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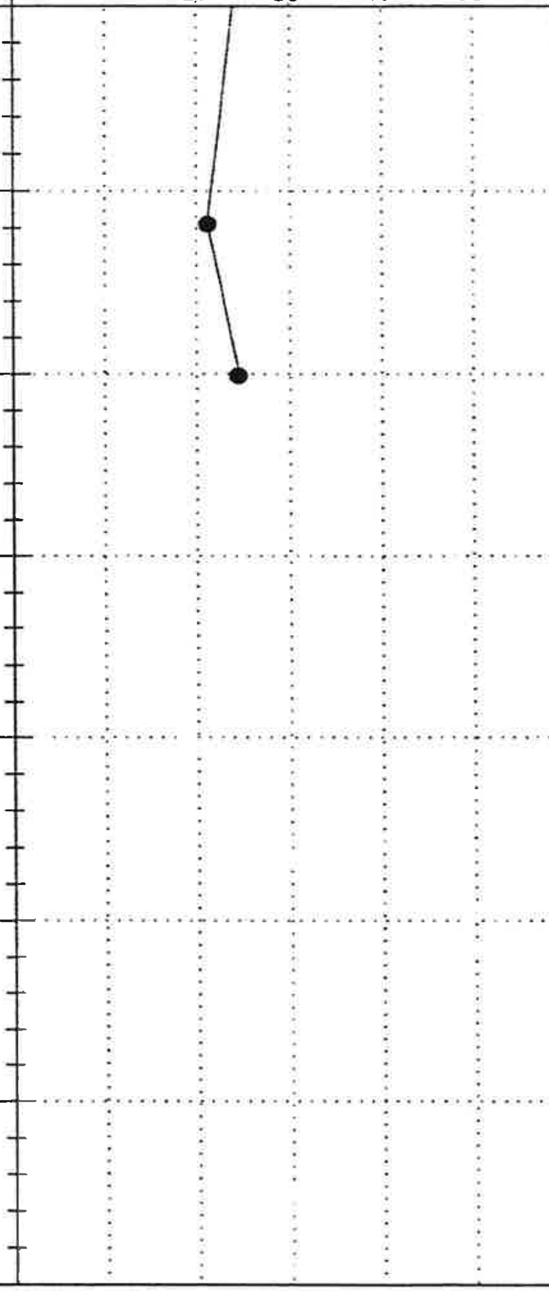
Miller Shingle	
File Number 1322.1	Figure 7

SOIL DESCRIPTION **B-2** (Cont'd) Surface Elevation:	U.S.C.	SAMPLES	GROUND WATER	DEPTH, ft.
Gray fine to coarse sand with trace gravel (medium dense, dry to moist)	SP	I		35
Gray fine to coarse sand with trace gravel (medium dense, moist)		I		40
Boring completed at 41.5 feet on 5/6/03				45, 50, 55, 60

Standard Penetration Resistance (140 lb. weight, 30" drop)

● Blows per foot



LEGEND

- I Depth 2" O.D. split spoon sample driven.
- II 3" O.D. thin-wall sample
- * Liquid limit
- ■ Moisture content
- + Plastic limit
- Impervious seal
- ∇ Water level
- Piezometer tip
- P Sample pushed
- TV Torvane reading, tons/ft^2
- PP Pocket penetrometer reading, tons/ft^2

NOTE: The stratification lines represent the approximate boundaries between soil types and the transition may be gradual.

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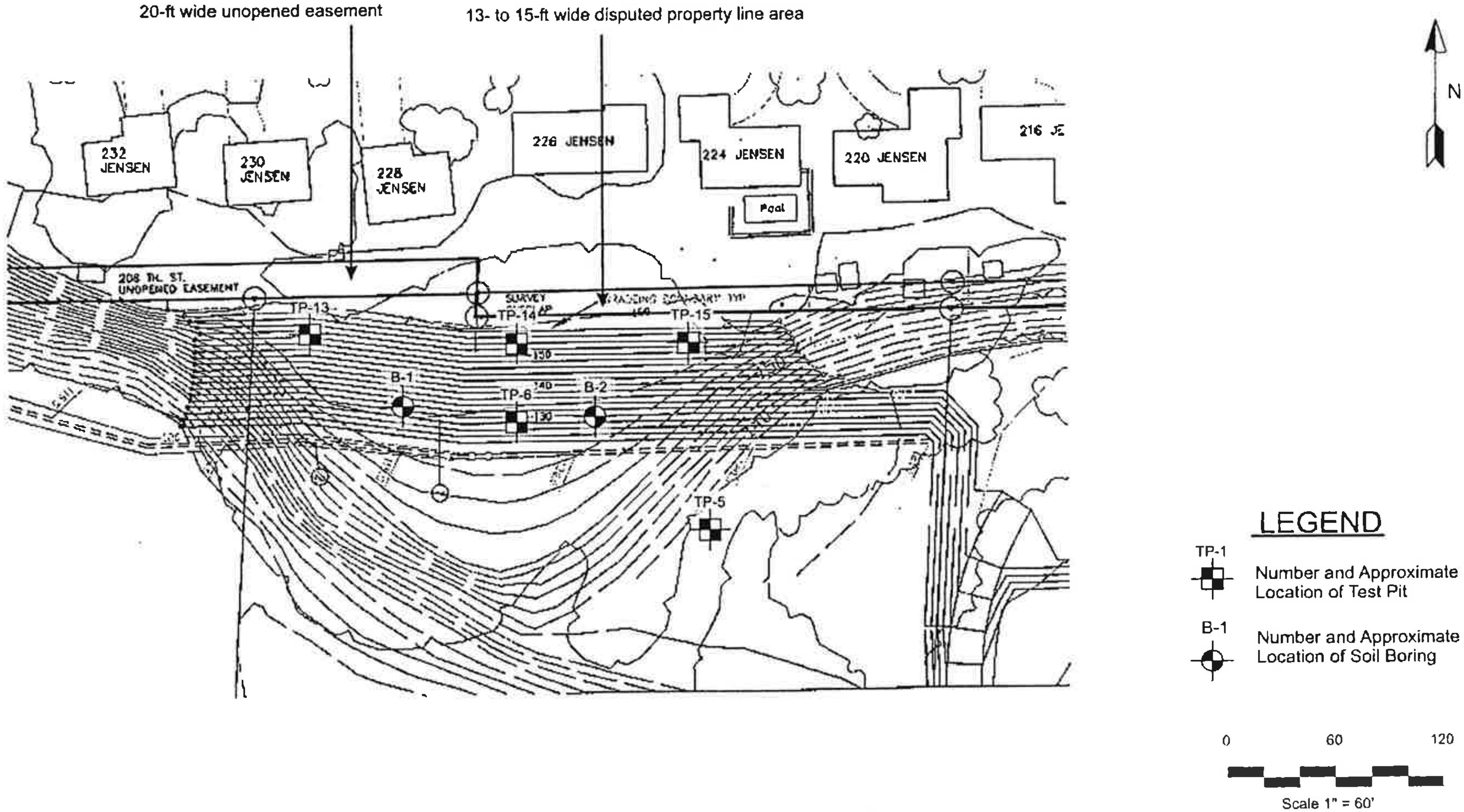
Miller Shingle

File Number 1232.1

Figure 8

Site Plan



Reference: Site Plan based on electronic file provided by Miller Shingle.

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File Number	Figure
1232.1	1

Unified Soil Classification System

MAJOR DIVISIONS			GROUP SYMBOL	GROUP NAME
COARSE - GRAINED SOILS MORE THAN 50% RETAINED ON number 200 SIEVE	GRAVEL MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVEL	GW	WELL-GRADED GRAVEL, FINE TO COARSE GRAVEL
			GP	POORLY-GRADED GRAVEL
		GRAVEL WITH FINES	GM	SILTY GRAVEL
			GC	CLAYEY GRAVEL
	SAND MORE THAN 50% OF COARSE FRACTION PASSES NO. 4 SIEVE	CLEAN SAND	SW	WELL-GRADED SAND, FINE TO COARSE SAND
			SP	POORLY-GRADED SAND
		SAND WITH FINES	SM	SILTY SAND
			SC	CLAYEY SAND
FINE - GRAINED SOILS MORE THAN 50% PASSES NO. 200 SIEVE	SILT AND CLAY LIQUID LIMIT LESS THAN 50%	INORGANIC	ML	SILT
			CL	CLAY
		ORGANIC	OL	ORGANIC SILT, ORGANIC CLAY
	SILT AND CLAY LIQUID LIMIT 50% OR MORE	INORGANIC	MH	SILT OF HIGH PLASTICITY, ELASTIC SILT
			CH	CLAY OF HIGH PLASTICITY, FAT CLAY
		ORGANIC	OH	ORGANIC CLAY, ORGANIC SILT
HIGHLY ORGANIC SOILS			PT	PEAT

NOTES:

1) Field classification is based on visual examination of soil in general accordance with ASTM D 2488-83.
2) Soil classification using laboratory tests is based on ASTM D 2487-83.
3) Descriptions of soil density or consistency are based on interpretation of blowcount data, visual appearance of soils, and/or test data.

SOIL MOISTURE MODIFIERS

Dry- Absence of moisture, dusty, dry to the touch

Moist- Damp, but no visible water

Wet- Visible free water or saturated, usually soil is obtained from below water table

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Unified Soil Classification System

Figure 2

LOG OF EXPLORATION

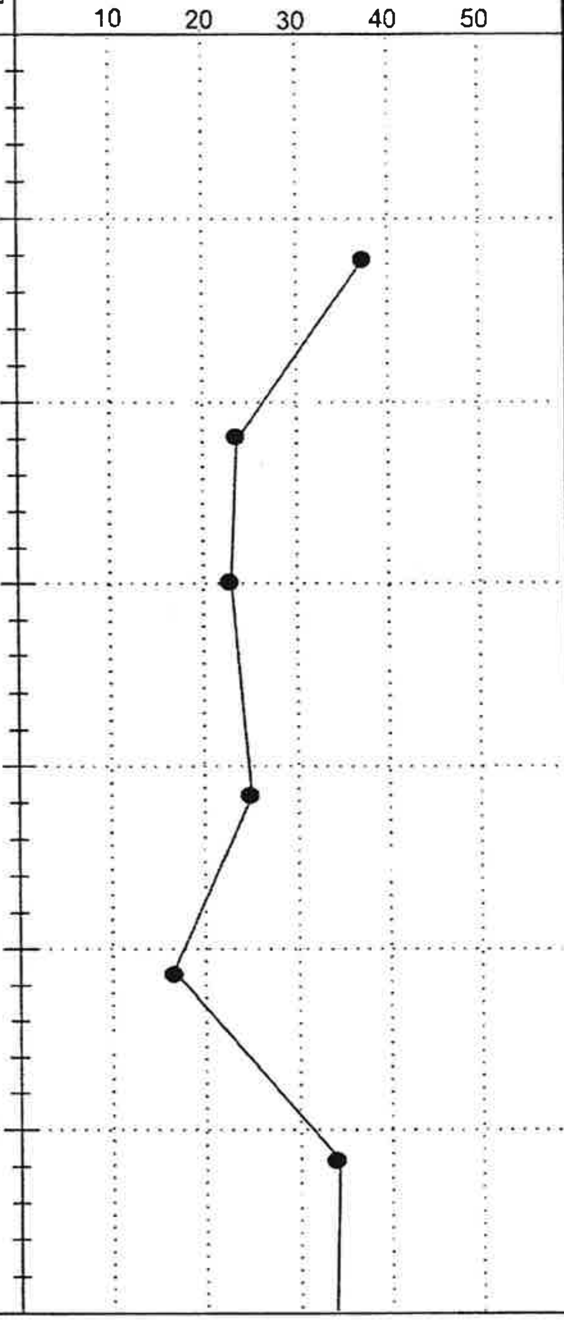
DEPTH	USC	SOIL DESCRIPTION
TEST PIT FIVE		
0.0 – 1.4	SM	ORANGE-BROWN SILTY FINE TO MEDIUM SAND WITH TRACE ROOTS (LOOSE, MOIST)
1.4 – 4.0	SM	TAN SILTY FINE TO MEDIUM SAND WITH TRACE ROOTS (MEDIUM DENSE, MOIST)
4.0 – 9.5	SP	GRAY MEDIUM TO COARSE SAND WITH TRACE SILT, GRAVEL, AND SCATTERED COBBLES WITH A 5-INCH THINK LAYER OF SILTY FINE SAND AT 7.0 FEET (MEDIUM DENSE, MOIST)
		SAMPLES WERE COLLECTED AT 1.0, 2.5, AND 4.5 FEET GROUND WATER SEEPAGE WAS NOT ENCOUNTERED TEST PIT CAVING WAS NOT OBSERVED TEST PIT WAS COMPLETED AT 9.5 FEET ON 12/21/01
TEST PIT SIX		
0.0 – 1.0	SM	ORANGE-BROWN SILTY FINE SAND WITH TRACE ROOTS (LOOSE, MOIST)
1.0 – 1.5	SP-SM	BROWN FINE TO MEDIUM SAND WITH SILT AND GRAVEL (LOOSE TO MEDIUM DENSE, MOIST)
1.5 – 10.5	SP/GW	GRAY-BROWN MEDIUM TO COARSE SAND WITH GRAVEL AND COBBLES, AMOUNT OF GRAVEL AND COBBLES VARIES (MEDIUM DENSE TO DENSE, MOIST)
		SAMPLES WERE COLLECTED AT 4.0 AND 10.5 FEET GROUND WATER SEEPAGE WAS NOT ENCOUNTERED TEST PIT CAVING WAS NOT OBSERVED TEST PIT WAS COMPLETED AT 10.5 FEET ON 12/21/01
TEST PIT THIRTEEN		
0.0 – 0.3	SM	DARK BROWN SILTY FINE TO MEDIUM SAND WITH ROOTS (LOOSE, MOIST)
0.3 – 2.0	SP-SM	ORANGE-BROWN FINE TO MEDIUM SAND WITH SILT AND TRACE ROOTS (LOOSE, MOIST)
2.0 – 5.0	SP	GRAY FINE TO COARSE SAND WITH TRACE GRAVEL (LOOSE GRADES TO MEDIUM DENSE AT 3.5 FEET, DRY TO MOIST)
5.0 – 8.0	SW	GRAY FINE TO COARSE SAND WITH GRAVEL AND SCATTERED COBBLES(MEDIUM DENSE, DRY TO MOIST)
8.0 – 11.0	SW-GW	GRAY FINE TO COARSE SAND WITH GRAVEL TO GRAVEL WITH SAND (DENSE, DRY TO MOIST)
		SAMPLES WERE COLLECTED AT 1.6, 3.3, 6 0, AND10.5 FEET GROUND WATER SEEPAGE WAS NOT ENCOUNTERED SLIGHT CAVING OF VERTICAL SIDEWALLS WAS OBSERVED FROM 2 TO 5 FEET TEST PIT WAS COMPLETED AT 11.0 FEET ON 5/6/03

LOG OF EXPLORATION

DEPTH	USC	SOIL DESCRIPTION
TEST PIT FOURTEEN		
0.0 – 0.2	SM	DARK BROWN SILTY FINE TO MEDIUM SAND WITH ROOTS (LOOSE, MOIST)
0.2 – 2.0	SP-SM	ORANGE-BROWN FINE TO MEDIUM SAND WITH SILT AND TRACE ROOTS (LOOSE, MOIST)
2.0 – 7.5	SP	GRAY-BROWN FINE TO COARSE SAND WITH GRAVEL (LOOSE GRADES TO MEDIUM DENSE AT 3.5 FEET, DRY TO MOIST)
7.5 – 11.0	SW/GW	GRAY FINE TO COARSE SAND WITH GRAVEL AND COBBLES (DENSE, MOIST)
		SAMPLES WERE COLLECTED AT 3.0 AND 8.0 FEET GROUND WATER SEEPAGE WAS NOT ENCOUNTERED SLIGHT CAVING OF VERTICAL SIDEWALLS WAS OBSERVED FROM 2 TO 7.5 FEET TEST PIT WAS COMPLETED AT 11.0 FEET ON 5/6/03
TEST PIT FIFTEEN		
0.0 – 0.2	SM	DARK BROWN SILTY FINE TO MEDIUM SAND WITH ROOTS (LOOSE, MOIST)
0.2 – 1.0	SM	BROWN SILTY FINE TO MEDIUM SAND WITH TRACE ROOTS (LOOSE, MOIST)
1.0 – 3.0	SW	GRAY BROWN FINE TO COARSE SAND WITH GRAVEL AND SCATTERED COBBLES (LOOSE TO MEDIUM DENSE, DRY TO MOIST)
3.0 – 10.5	GW/SW	GRAY GRAVEL WITH FINE TO COARSE SAND AND COBBLES TO SAND WITH GRAVEL AND COBBLES (DENSE, DRY TO MOIST)
		SAMPLES WERE COLLECTED AT 2.4, 6.0, AND 10.0 FEET GROUND WATER SEEPAGE WAS NOT ENCOUNTERED SLIGHT CAVING OF VERTICAL SIDEWALLS WAS OBSERVED FROM 2 TO 5 FEET TEST PIT WAS COMPLETED AT 10.5 FEET ON 5/6/03

SOIL DESCRIPTION **B-1** Surface Elevation:	U.S.C.	SAMPLES	GROUND WATER	DEPTH, ft.
Topsoil		I		
Orange-brown silty sand with trace roots	SP-SM			
Gray fine to coarse sand with gravel and trace silt (dense, dry to moist)	SW	I		5
Gray medium to coarse sand with gravel (Medium dense, dry to moist)		I		10
Gray fine to coarse sand with trace gravel (medium dense, dry to moist)	SP	I		15
Gray fine to coarse sand with trace gravel (medium dense, dry to moist)		I		20
Gray fine to coarse sand with trace gravel (medium dense, dry to moist)		I		25
Gray fine to coarse sand with trace gravel (medium dense to dense, dry to moist)		I		30

Standard Penetration Resistance
(140 lb. weight, 30" drop)
● Blows per foot



LEGEND

I Depth 2" O.D. split spoon sample driven.	* Liquid limit	Impervious seal	P Sample pushed
II 3" O.D. thin-wall sample	■ Moisture content	∇ Water level	TV Torvane reading, tons/ft²
	+ Plastic limit	Piezometer tip	PP Pocket penetrometer reading, tons/ft²

NOTE: The stratification lines represent the approximate boundaries between soil types and the transition may be gradual.

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Miller Shingle

File Number	Figure
1232.1	5

SOIL DESCRIPTION

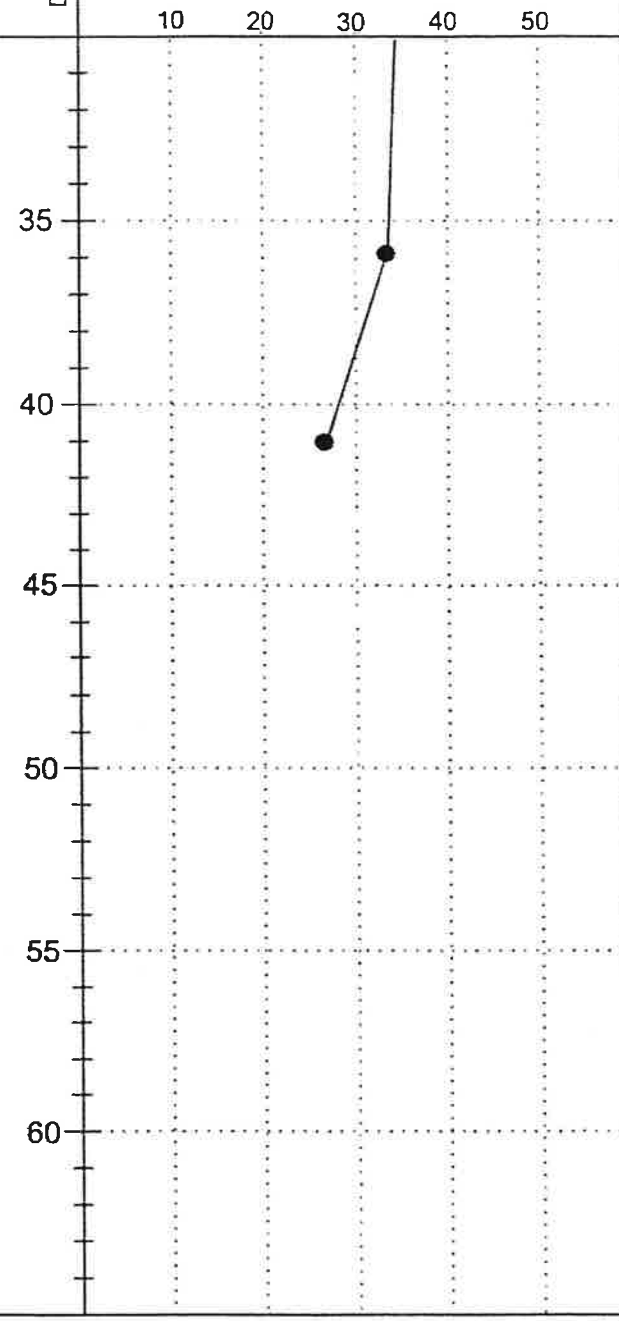
B-1 (Cont'd)

Surface Elevation:

SOIL DESCRIPTION	U.S.C.	SAMPLES	GROUND WATER	DEPTH, ft.
Gray fine to coarse sand with trace gravel (medium dense to dense, dry to moist)	SP	I		35
Gray fine to coarse sand with trace gravel (medium dense, moist)		I		40
Boring completed at 41.5 feet on 5/6/03				

Standard Penetration Resistance (140 lb. weight, 30" drop)

● Blows per foot



LEGEND

- I Depth 2" O.D. split spoon sample driven.
- II 3" O.D. thin-wall sample
- * Liquid limit
- ■ Moisture content
- + Plastic limit
- Impervious seal
- ▽ Water level
- Piezometer tip
- P Sample pushed
- TV Torvane reading, tons/ft²
- PP Pocket penetrometer reading, tons/ft²

NOTE: The stratification lines represent the approximate boundaries between soil types and the transition may be gradual.

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Miller Shingle

File Number	Figure
1232.1	6

this unit. Steep yarding paths, skid trails, and firebreaks are subject to rilling and gullying unless adequate water bars are provided or they are protected by plant cover. Establishing plant cover on steep cut and fill slopes reduces erosion.

Seedling establishment and windthrow hazard are the main concerns in the production of timber. If seed trees are present, natural reforestation of cutover areas by western hemlock and Pacific silver fir occurs periodically. Reforestation can be accomplished by planting Douglas-fir seedlings. When openings are made in the canopy, invading brushy plants, if not controlled, can delay reforestation. Rock outcrop limits the even distribution of reforestation.

Because the rooting depth is restricted by the hardpan or bedrock, trees are occasionally subject to windthrow. Western hemlock, a shallow-rooted species, is more commonly subject to windthrow than are more deeply rooted trees.

The main limitations for homesites and septic tank absorption fields are steepness of slope and depth to bedrock or the hardpan. A seasonal high water table is perched above the hardpan or bedrock; therefore, drainage is needed if buildings with basements and crawl spaces are constructed. Deep cuts in-the Olomount soil can expose bedrock.

This map unit is in capability subclass VIIs.

→ **17-Everett gravelly sandy loam, 0 to 8 percent slopes.** This very deep, somewhat excessively drained soil is on terraces and outwash plains. It formed in glacial outwash. Areas are long and narrow and are oriented in a northwest to southeast direction. They are 10 to 40 acres in size. The native vegetation is mainly conifers. Elevation is near sea level to 500 feet. The average annual precipitation is about 40 inches, the average annual air temperature is about 50 degrees F, and the average frost-free season is 170 to 190 days.

Typically, the surface layer, where mixed to a depth of about 6 inches, is dark brown gravelly sandy loam. The subsoil is dark brown very gravelly sandy loam about 12 inches thick. The upper part of the substratum is brown very gravelly loamy sand about 5 inches thick. The lower part to a depth of 60 inches or more is dark brown extremely gravelly sand. In some areas the substratum is weakly cemented.

Included in this unit are small areas of Alderwood soils on till plains, Indianola soils on terraces and outwash plains, and Ragnar soils on outwash plains. Included areas make up about 15 percent of the total acreage.

Permeability of this Everett soil is rapid. Available water capacity is low. Effective rooting depth is 60 inches or more. Runoff is slow, and the hazard of water erosion is slight.

This unit is used mainly as woodland and for urban development. It is also used for pasture.

Douglas-fir is the main woodland species on this unit. On the basis of a 100-year site curve, the mean site index is 141. On the basis of a 50-year site curve, the mean site index is 111. The mean annual increment at culmination (CMAI) for Douglas-fir at age 65 is 146 cubic feet per acre. Among the trees of limited extent are western hemlock, western redcedar, and red alder. The common forest understory plants are salal, brackenfern, red huckleberry, common rose, and Oregon-grape.

This unit is well suited to year-round logging. Logging roads require suitable surfacing for year-round use. Rock for road construction is readily available on this unit.

Seedling mortality is the main limitation for the production of timber. Reforestation can be accomplished by planting Douglas-fir seedlings. High soil temperature and low soil moisture content during the growing season cause a high mortality of seedlings. When openings are made in the canopy, invading brushy plants, if not controlled, can delay the establishment of seedlings.

If this unit is used for pasture, the main limitations are low available water capacity and low soil fertility. Proper grazing practices, weed control, and fertilizer are needed for maximum quality of forage. Supplemental irrigation is also needed. Periodic mowing and spreading of droppings help to maintain uniform growth and discourage selective grazing.

This unit is suited to urban development; however, if the density of housing is moderate to high, community sewage systems are needed in places to prevent contamination of water supplies as a result of seepage from onsite sewage disposal systems.

This map unit is in capability subclass VIs.

18-Everett gravelly sandy loam, 8 to 15 percent slopes. This very deep, somewhat excessively drained soil is on terraces and outwash plains. It formed in glacial outwash. Areas are long and narrow and are oriented in a northwest to southeast direction. They are 10 to 40 acres in size. The native vegetation is mainly conifers. Elevation is near sea level to 500 feet. The average annual precipitation is about 40 inches, the average annual air temperature is about 50 degrees F, and the average frost-free season is 170 to 190 days.

Typically, the surface layer, where mixed to a depth of about 6 inches, is dark brown gravelly sandy loam. The subsoil is dark brown very gravelly sandy loam about 12 inches thick. The upper part of the substratum is brown very gravelly loamy sand about 5 inches thick. The lower part to a depth of 60 inches or more is dark brown extremely gravelly sand. In some areas the substratum is weakly cemented.

Included in this unit are small areas of Alderwood soils on till plains, Indianola soils on terraces and outwash plains, and Ragnar soils on outwash plains. Included areas make up about 15 percent of the total acreage.

Permeability of this Everett soil is rapid. Available water capacity is low. Effective rooting depth is 60 inches or more. Runoff is slow, and the hazard of water erosion is slight.

This unit is used mainly as woodland. It is also used for urban development and for hay and pasture.

ArcIMS HTML Viewer Map

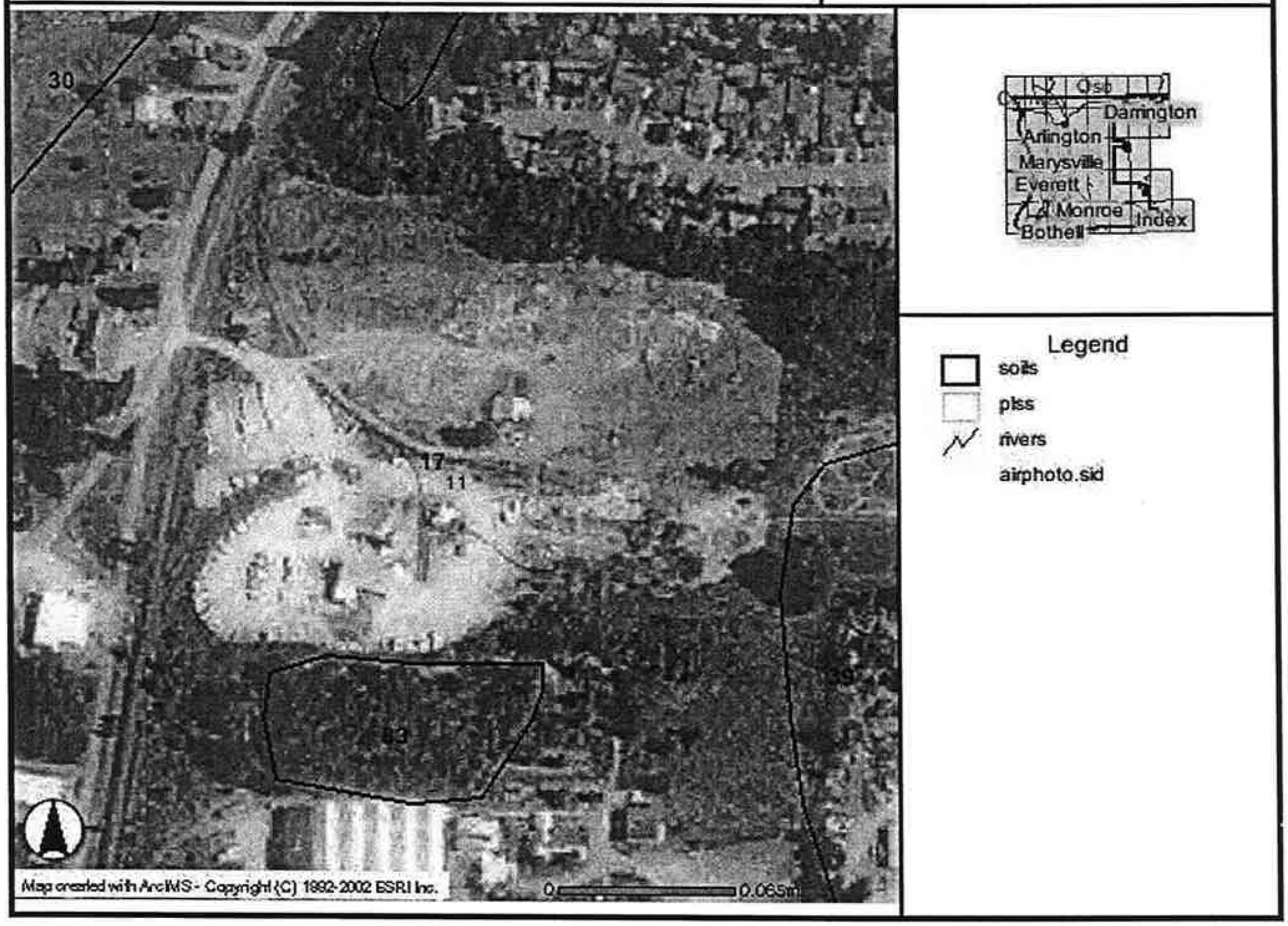


Table III-3.1 Soil Properties Classified by Soil Texture

Texture Class	Infiltration Rate Hydrologic (inches/hr.)	Cation Exchange Capacity (milliequivalents/100 grams)	Effective Water Capacity (inches per inch)	Hydrologic Soil Group
Coarse Sands or Cobbles	20.00	<5.0	—	A
Sand	8.27	<5.0	0.35	A
Loamy Sand	2.41	5.0	0.31	A
Sandy Loam	1.02	>5.0	0.25	B
Loam	0.52	>5.0	0.19	B
Silt Loam	0.27	>5.0	0.17	C
Sandy Clay Loam	0.17	>5.0	0.14	C
Clay Loam	0.09	>5.0	0.14	D
Silty Clay Loam	0.06	>5.0	0.11	D
Sandy Clay	0.05	>5.0	0.09	D
Silty Clay	0.04	>5.0	0.09	D
Clay	0.02	>5.0	0.08	D

Source (except for cation exchange capacity): Rawls, Brakensiek, and Saxton, 1982 (16)

Cation exchange capacity values are estimated from Buckman and Brady, 1969, (23)

Maintenance Requirements

13.1 TREATMENT TRAIN INSPECTION AND MAINTENANCE

The StormTech recommended treatment train inlet system has three tiers of treatment upstream of the StormTech chambers. It is recommended that inspection and maintenance (I&M) be initiated at the furthest upstream treatment tier and continue downstream as necessary. The following I&M procedures follow this approach providing I&M information in the following order: Tier 1 – Pretreatment (BMP); Tier 2 – StormTech Isolator Row, and ; Tier 3 – Eccentric Pipe Header System.

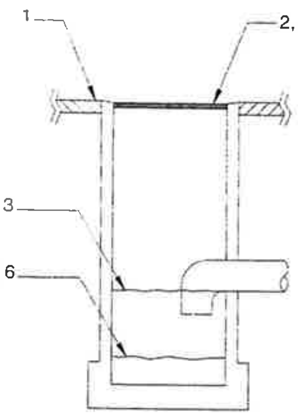
13.2 CATCHBASIN/MANHOLE I&M

Typically a stormwater system will have catchbasins and manholes upstream of the detention/retention system. In some cases these may be the only pre-treatment devices. Regular I&M of catchbasins and manholes should be scheduled and performed as part of a site's routine maintenance plan.

Catchbasin/Manhole – Step-by-Step Maintenance Procedures

1) Inspect catch basins and manholes upstream of StormTech chambers for sediment
2) Remove grate or cover
3) Skim off oils and floatables
4) Using a stadia rod, measure the depth of sediment
5) If sediment is at a depth greater than 6" proceed to step 6. If not proceed to step 7.
6) Vacuum or manually remove sediment
7) Replace grate
8) Record depth & date and schedule next inspection

Figure 17 – Catchbasin/Manhole I&M Steps



13.3 PRE-TREATMENT DEVICE I&M

Manufacturer's I&M procedures should be followed for proprietary pretreatment devices such as baffle boxes, swirl concentrators, oil-water separators, and filtration units. **Table 10** provides some general guidelines but is not a substitute for a manufacturer's specific instructions.

TABLE 10 – Pretreatment Inspection and Maintenance Guidelines

[illegible]	INSPECTION	MAINTENANCE
StormTech Isolator™ Row	Bi-Annually	JetVac - Culvert Cleaning Nozzle Preferred
Sediment Basin	Quarterly or after large storm event	Excavate sediment
Catch Basin Sump	Quarterly	Excavate,pump, or vacuum
Sedimentation Structure	Quarterly	Excavate,pump, or vacuum
Catch Basin Filter Bags	After all storm events	Clean and/or replace filter bags
Porous Pavement	Quarterly	Sweep Pavement
Pipe Header Design	Quarterly	Excavate,pump, or vacuum
Water Quality Inlet	Quarterly	Excavate,pump, or vacuum
Sand Filters	Quarterly or after storm event	Remove & replace sand filter

** This schedule does not account for regional or site variables. Local municipal guidelines should be followed for inspection when available.*
*** The methods stated are minimum guidelines for removal and cleaning of system. Other methods may apply.*

13.4 ISOLATOR™ ROW INSPECTION

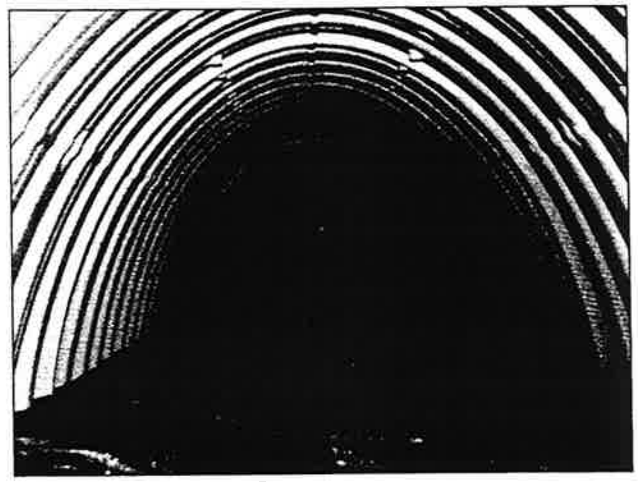
Regular inspection and maintenance are essential to assure a properly functioning stormwater system. Inspection is easily accomplished through the manhole or optional inspection ports of an Isolator Row. Please follow local and OSHA rules for a confined space entry.

Inspection ports can allow inspection to be accomplished completely from the surface without the need for a confined space entry. Inspection ports provide visual access to the system with the use of a flashlight. A stadia rod may be inserted to determine the depth of sediment. If upon visual inspection it is found that sediment has accumulated to an average depth exceeding 3 inches, cleanout is required.

A StormTech Isolator Row should initially be inspected immediately after completion of the site's construction. While every effort should be made to prevent sediment from entering the system during construction, it is during this time that excess amounts of sediments are most likely to enter any stormwater system. Inspection and maintenance, if necessary, should be performed prior to passing responsibility over to the site's owner. Once in normal service, a StormTech Isolator Row should be inspected bi-annually until an understanding of the sites characteristics is developed. The site's maintenance manager can then revise the inspection schedule based on experience or local requirements.

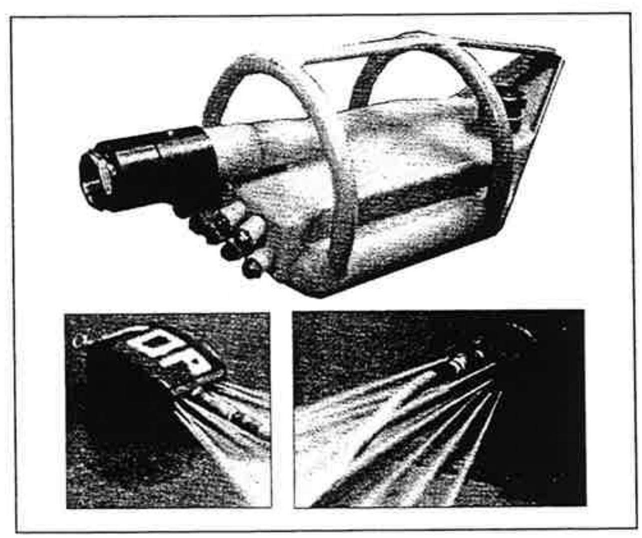
13.5 ISOLATOR ROW MAINTENANCE

JetVac maintenance is required if sediment has been collected to an average depth of 3 inches or more inside the Isolator Row. The JetVac process utilizes a high pressure water nozzle to propel itself down the Isolator Row while scouring and suspending sediments. As the nozzle is retrieved, a wave of suspended sediments is flushed back into the manhole for vacuuming. Most sewer and pipe maintenance companies have vacuum/JetVac combination vehicles. Fixed nozzles designed for culverts or large diameter pipe cleaning are preferable. Rear facing jets with an effective spread of at least 45" are best. Most JetVac reels have a minimum of 400 feet of hose allowing maintenance of an Isolator Row up to 50 chambers long. The JetVac process shall only be performed on StormTech Rows that have AASHTO class 1 woven geotextile over their angular base stone.



Looking down the Isolator Row.

A typical JetVac truck. (This is not a StormTech product.)



Examples of culvert cleaning nozzles appropriate for Isolator Row maintenance. (These are not StormTech products.)

STORMTECH ISOLATOR™ ROW - STEP-BY-STEP MAINTENANCE PROCEDURES

Step 1) Inspect Isolator Row for sediment

- A) Inspection ports (if present)
  - i. Remove lid from floor box frame
  - ii. Remove cap from inspection riser
  - iii. Using a flashlight and stadia rod, measure depth of sediment
  - iv. If sediment is at, or above, 3 inch depth proceed to Step 2. If not proceed to step 3.
- B) All Isolator Rows
  - i. Remove cover from manhole at upstream end of Isolator Row
  - ii. Using a flashlight, inspect down Isolator Row through outlet pipe
    1. Mirrors on poles or cameras may be used to avoid a confined space entry
    2. Follow OSHA regulations for confined space entry if entering manhole
  - iii. If sediment is at or above the lower row of sidewall holes (approximately 3 inches) proceed to Step 2. If not proceed to Step 3.

Step 2) Clean out Isolator Row using the JetVac process

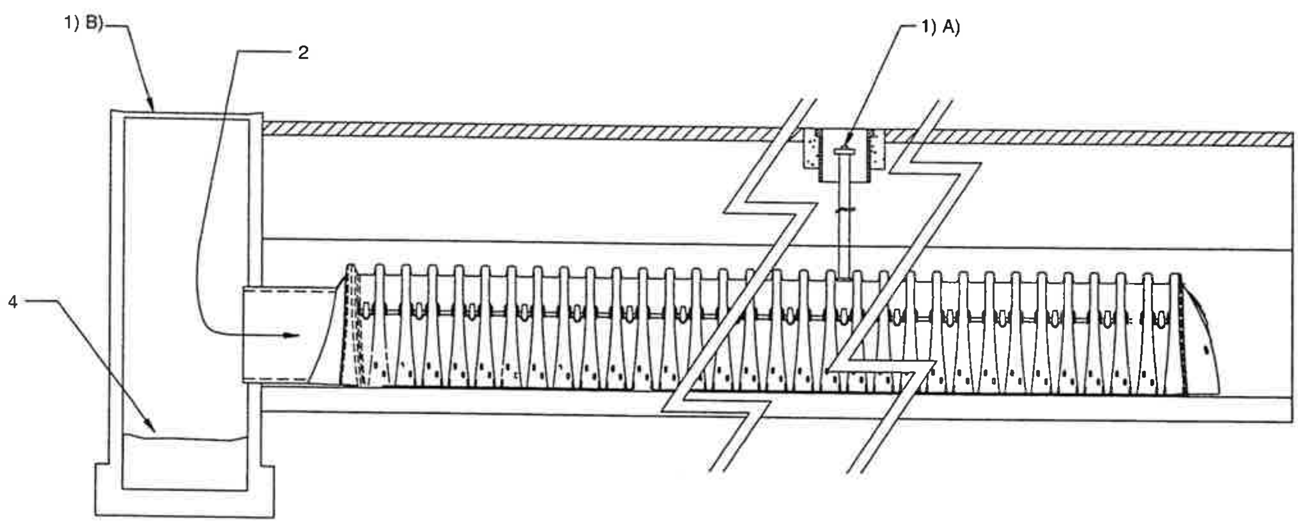
- A) A fixed culvert cleaning nozzle with rear facing nozzle spread of 45 inches or more is preferable
- B) Apply multiple passes of JetVac until backflush water is clean
- C) Vacuum manhole sump as required

Step 3) Replace all caps, lids and covers

Step 4) Inspect & clean catch basins and manholes upstream of the StormTech system following the procedures for Classic Manifold Inlet System

Figure 18

StormTech Isolator Row (not to scale)



13.6 ECCENTRIC PIPE HEADER INSPECTION

Theses guidelines do not supercede a pipe manufacturer's recommended I&M procedures. Consult with the manufacturer of the pipe header system for specific I&M procedures. Inspection of the header system should be carried out quarterly. On sites which generate higher levels of sediment more frequent inspections may be necessary. Headers may be accessed through risers, access ports or manholes. Measurement of sediment may be taken with a stadia rod or similar device. Cleanout of sediment should occur when the sediment volume has reduced the storage area by 25% or the depth of sediment has reached approximately 25% of the diameter of the structure.

13.7 ECCENTRIC PIPE HEADER MAINTENANCE

Cleanout of accumulated material should be accomplished by vacuum pumping the material from the header. Cleanout should be accomplished during dry weather. Care should be taken to avoid flushing sediments out through the outlet pipes and into the chamber rows.

Eccentric Header Step-by-Step Maintenance Procedures

1. Locate manholes, access ports or risers connected to the header system
2. Remove grates or covers
3. Using a stadia rod, measure the depth of sediment
4. If sediment is at a depth of about 25% pipe volume or 25% pipe diameter proceed to step 5. If not proceed to step 6.
5. Vacuum pump the sediment. Do not flush sediment out inlet pipes.
6. Replace grates and covers
7. Record depth & date and schedule next inspection

Figure 19 – Manifold Maintenance

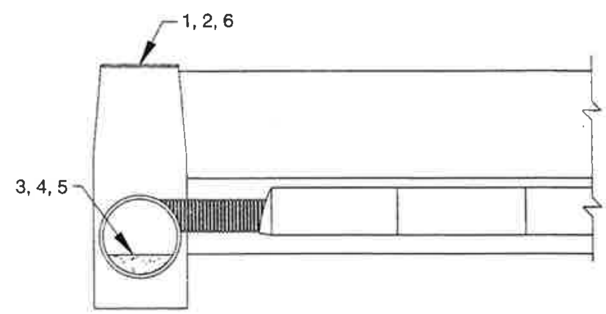


Table 3.5
Maintenance of Control Structures and Catchbasins

CATCH BASINS			
General	Trash & Debris	Trash or debris which is located immediately in front of the catch basin opening or is blocking inletting capacity of the basin by more than 10%.	No Trash or debris located immediately in front of catch basin or on grate opening.
		Trash or debris (in the basin) that exceeds 60 percent of the sump depth as measured from the bottom of basin to invert of the lowest pipe into or out of the basin, but in no case less than a minimum of six inches clearance from the debris surface to the invert of the lowest pipe.	No trash or debris in the catch basin.
		Trash or debris in any inlet or outlet pipe blocking more than 1/3 of its height.	Inlet and outlet pipes free of trash or debris.
		Dead animals or vegetation that could generate odors that could cause complaints or dangerous gases (e.g., methane).	No dead animals or vegetation present within the catch basin.
	Sediment	Sediment (in the basin) that exceeds 60 percent of the sump depth as measured from the bottom of basin to invert of the lowest pipe into or out of the basin, but in no case less than a minimum of 6 inches clearance from the sediment surface to the invert of the lowest pipe. Measured from the bottom of basin to invert of the lowest pipe into or out of the basin.	No sediment in the catch basin
	Structure Damage to Frame and/or Top Slab	Top slab has holes larger than 2 square inches or cracks wider than 1/4 inch (Intent is to make sure no material is running into basin).	Top slab is free of holes and cracks.
		Frame not sitting flush on top slab, i.e., separation of more than 3/4 inch of the frame from the top slab. Frame not securely attached	Frame is sitting flush on the riser rings or top slab and firmly attached.
	Fractures or Cracks in Basin Walls/ Bottom	Maintenance person judges that structure is unsound.	Basin replaced or repaired to design standards.
		Grout fillet has separated or cracked wider than 1/2 inch and longer than 1 foot at the joint of any inlet/outlet pipe or any evidence of soil particles entering catch basin through cracks.	Pipe is regrouted and secure at basin wall.
	Settlement/ Misalignme nt	If failure of basin has created a safety, function, or design problem.	Basin replaced or repaired to design standards.
	Vegetation	Vegetation growing across and blocking more than 10% of the basin opening.	No vegetation blocking opening to basin.
		Vegetation growing in inlet/outlet pipe joints that is more than six inches tall and less than six inches apart.	No vegetation or root growth present.

Table 3.5 Maintenance of Control Structures and Catchbasins			
Maintenance Component	**Defect**	**Condition When Maintenance is Needed**	**Results Expected When Maintenance is Performed**
	Contamination and Pollution	See "Detention Ponds"	No pollution present.
Catch Basin Cover	Cover Not in Place	Cover is missing or only partially in place. Any open catch basin requires maintenance.	Catch basin cover is closed
	Locking Mechanism Not Working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have less than 1/2 inch of thread.	Mechanism opens with proper tools.
	Cover Difficult to Remove	One maintenance person cannot remove lid after applying normal lifting pressure. (Intent is keep cover from sealing off access to maintenance.)	Cover can be removed by one maintenance person.
Ladder	Ladder Rungs Unsafe	Ladder is unsafe due to missing rungs, not securely attached to basin wall, misalignment, rust, cracks, or sharp edges.	Ladder meets design standards and allows maintenance person safe access.
Metal Grates (If Applicable)	Grate opening Unsafe	Grate with opening wider than 7/8 inch.	Grate opening meets design standards.
	Trash and Debris	Trash and debris that is blocking more than 20% of grate surface inletting capacity.	Grate free of trash and debris.
	Damaged or Missing.	Grate missing or broken member(s) of the grate.	Grate is in place and meets design standards.