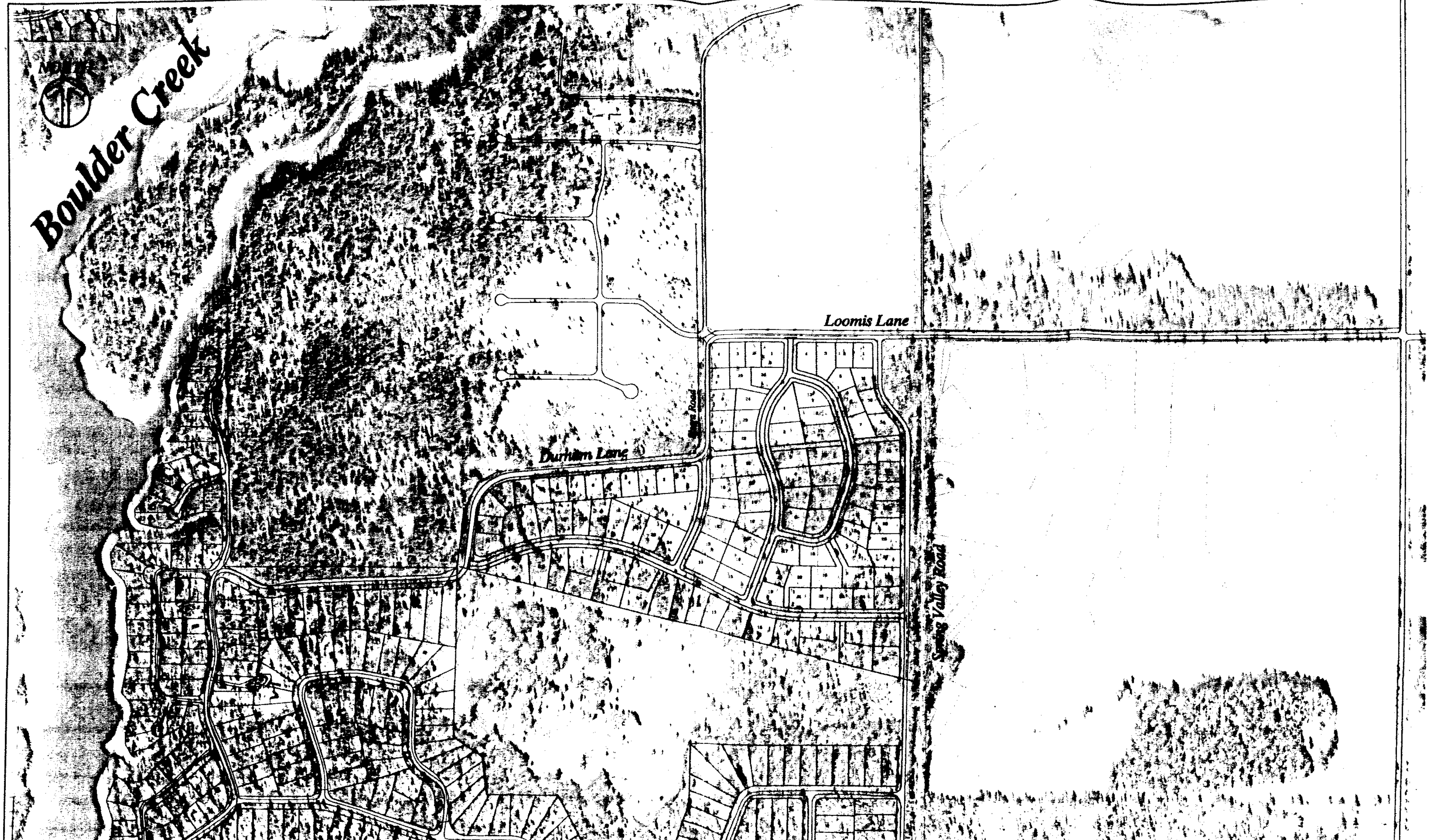

NO.	REVISIONS	BY	DATE

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DESIGNED: MA	APPROVED:
CAD NAME:	SCALE:

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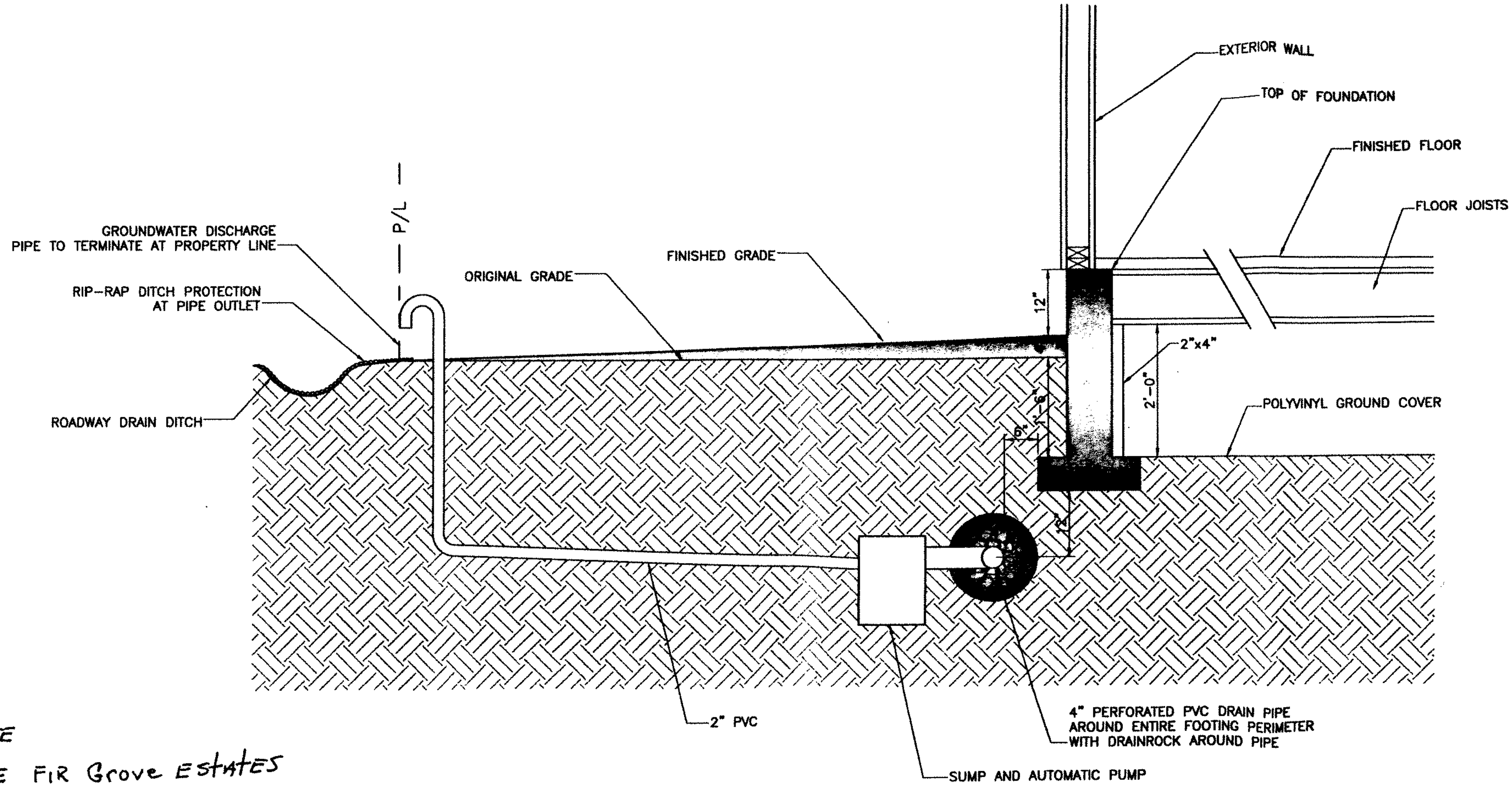
Royal Fork Restaurant Corporation

FIR GROVE ESTATES

PROJECT NO. *104013*

SHEET NO. *1*



NOTE
SEE FIR Grove Estates
DRAINAGE Report.

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Royal Fork Restaurant Corporation

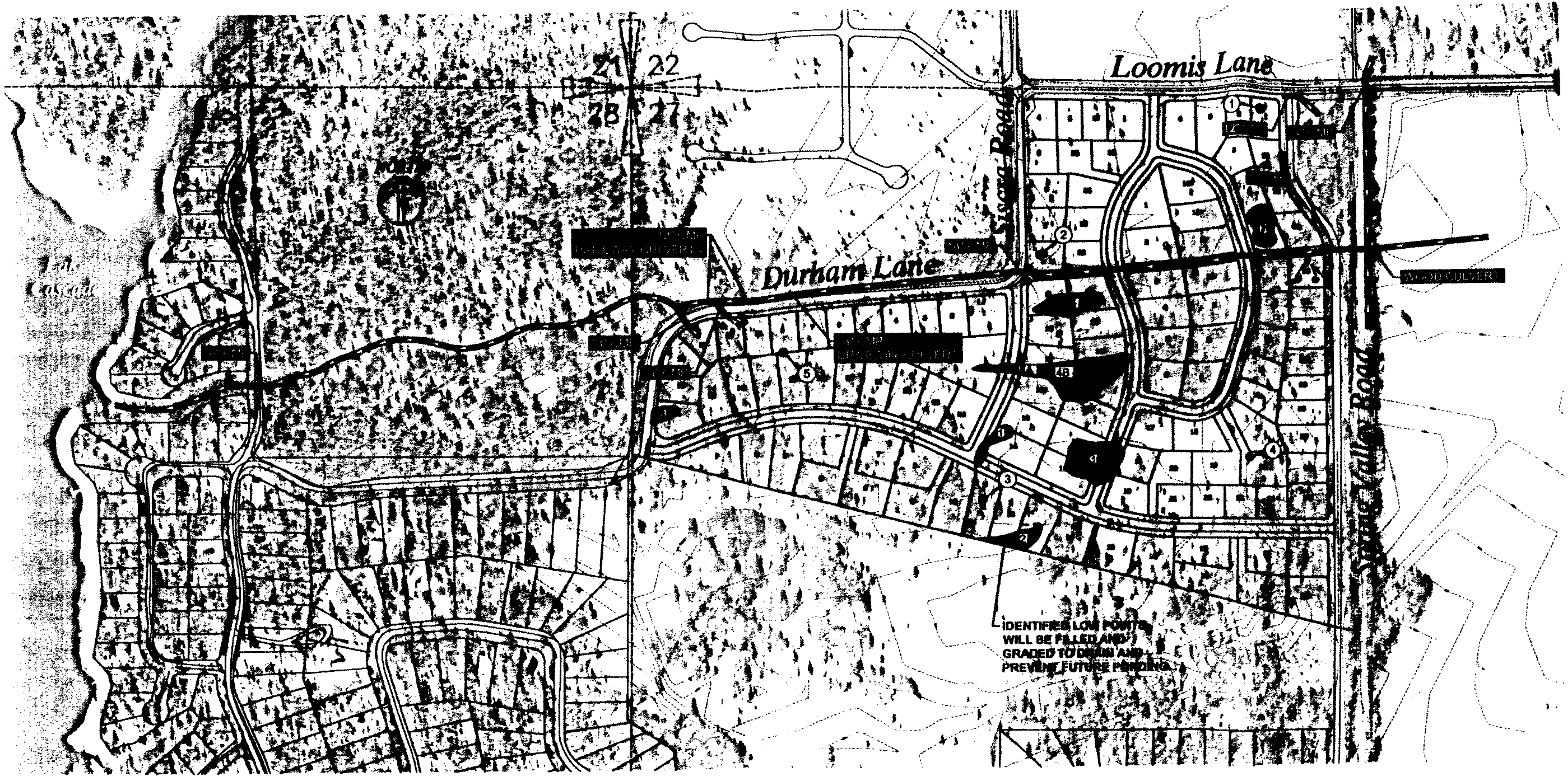
FIR GROVE ESTATES

HOME FOOTING DRAIN

PROJECT NO. 10401

SHEET NO. 4

EXISTING PROPERTY DRAINAGE



LEGEND

- Existing Culvert
- Existing Drainage Path
- Areas of Surface Ponding
- Ground Water Monitoring Hole

GROUNDWATER DEPTH

DATE	HOLE #1	HOLE #2	HOLE #3	HOLE #4	HOLE #5
NOVEMBER 03	9'±	9'±	9'±	9'±	9'±
APRIL 04	6"	12"	6"	24"	8"
MAY 04	28"	30"	30"	30"	26"
JUNE 04	26"	28"	28"	27"	28"

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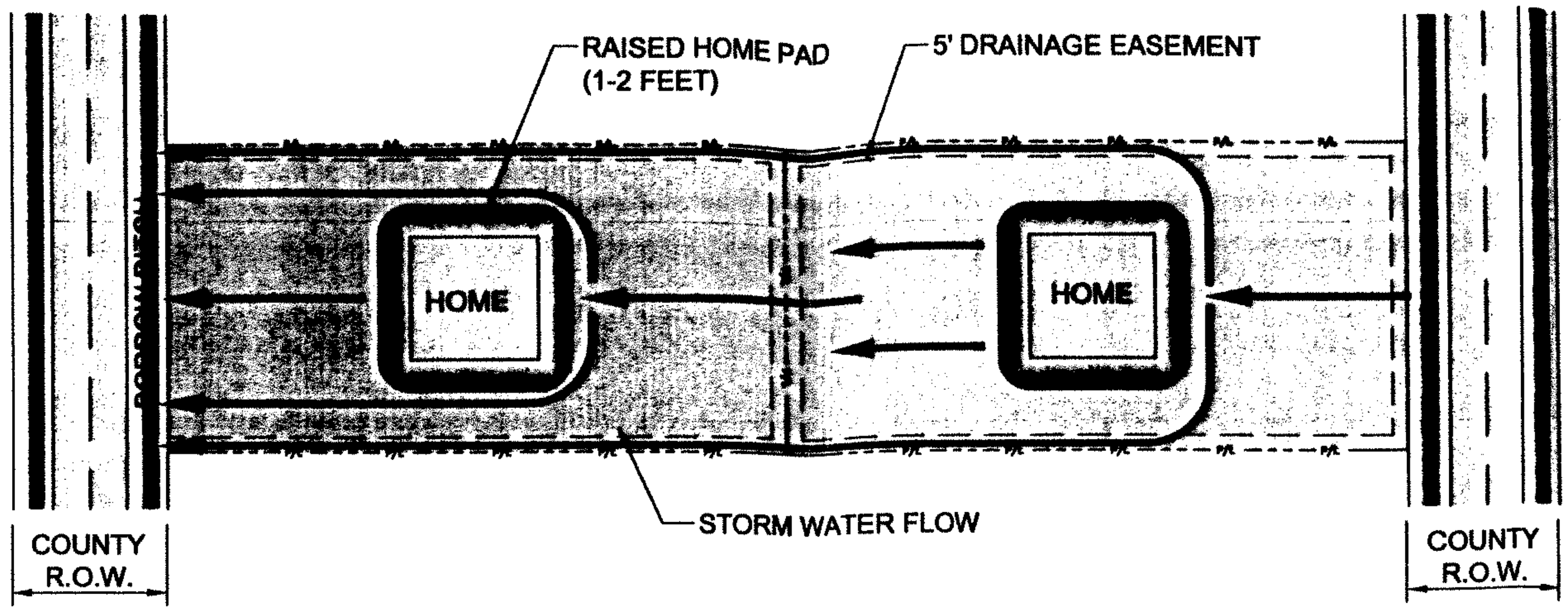
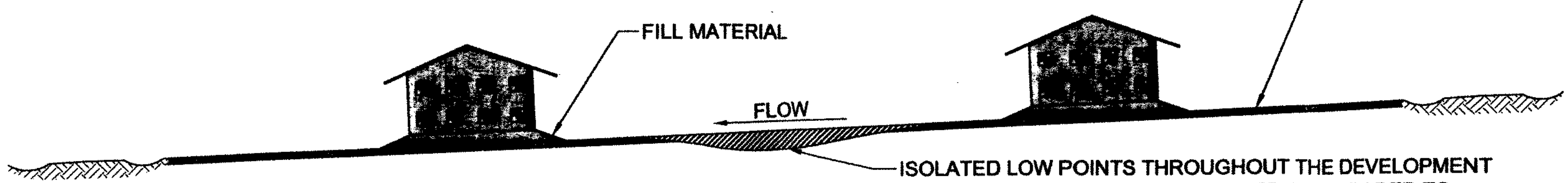
FIR GROVE ESTATES

FIGURE 2

TYPICAL SURFACE DRAINAGE





OBSERVATION POINTE SUBDIVISION
MERIDIAN HOMES
BUILT ON A SLOPE.
DOWNHILL HOME RAISED
TO DIVERT WATER FROM
UPHILL LOT (TYPICAL).

RAISED HOME PAD
TO DIVERT UPHILL
STORMWATER.

W:\Work\104013\Design\Acad\Drainage Figures\104013DRFIG03b.dwg

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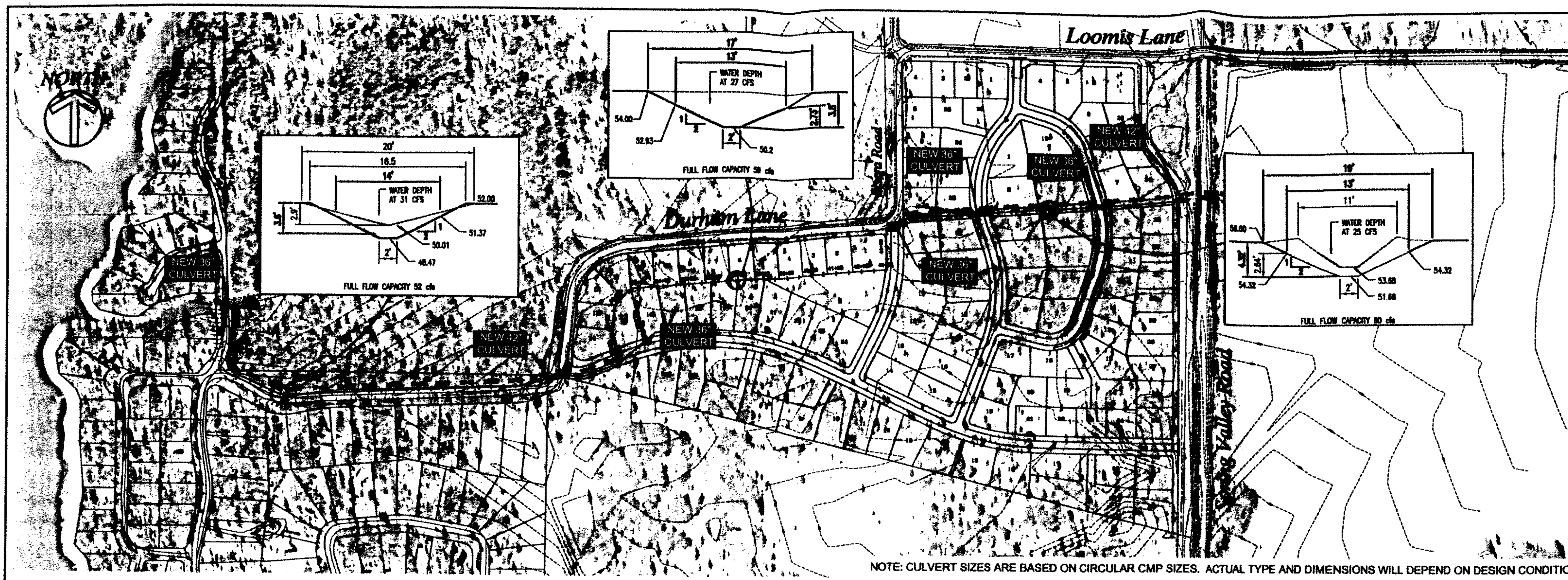
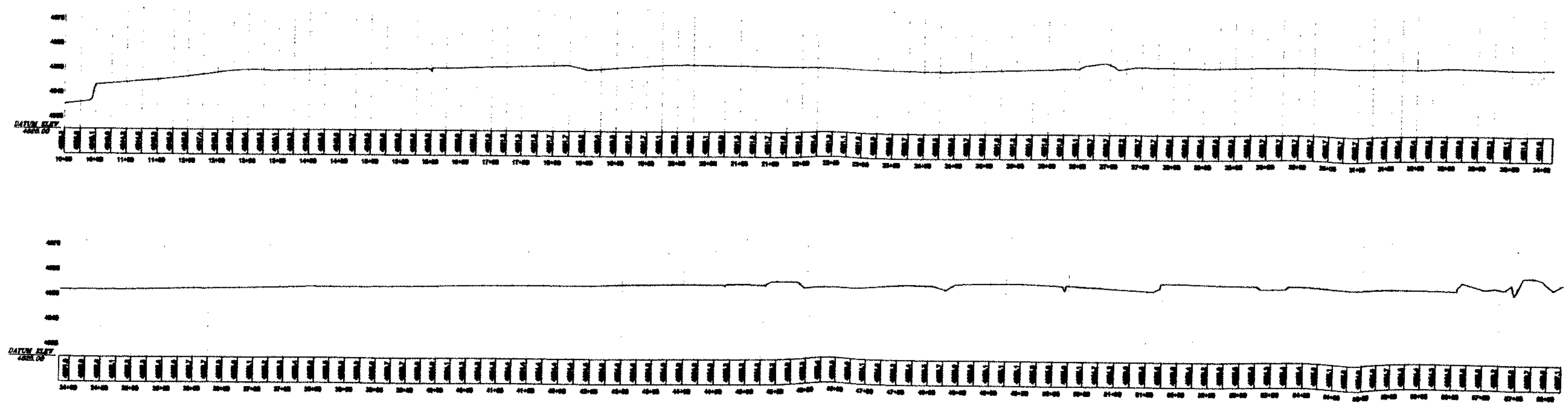
FIR GROVE ESTATES

FIGURE 3



NOTE: CULVERT SIZES ARE BASED ON CIRCULAR CMP SIZES. ACTUAL TYPE AND DIMENSIONS WILL DEPEND ON DESIGN CONDITIONS



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CAD NAME: 104013DRFIG05c.dwg	SCALE: 1"=500' (11x17)

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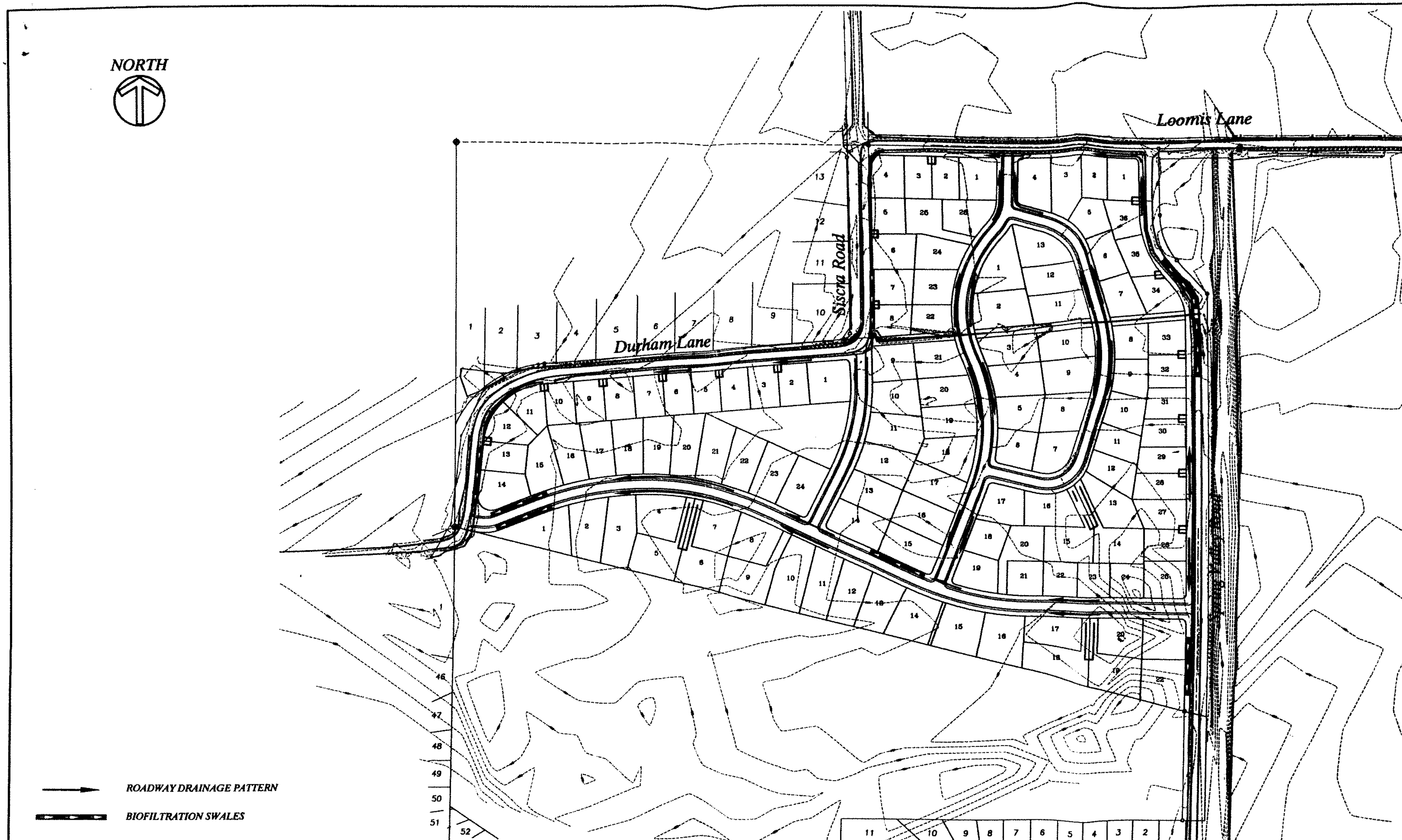
Royal Fork Restaurant Corporation

FIR GROVE ESTATES

MAIN DRAINAGE PROFILE

PROJECT NO. 10401

SHEET NO. 5



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CAD NAME: 104013DRFIG08c.dwg	SCALE: 1'=300' 11x17

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Royal Fork Restaurant Corporation

FIR GROVE ESTATES

BIOFILTRATION SWALES

PROJECT NO. 10401

SHEET NO. 6

FIR GROVE
LANDOWNERS AND CONTRACTORS

The following recommendations are not specific to the individual structures, but rather should be viewed as guidelines for the subdivision wide development.

- Valley County recommends that you read the enclosed pamphlet.
- The Building Department is requiring site inspections for excavation.
- Verification of bearing soils of each residence by a qualified Building official at the time of construction is required. Following this inspection, by a geotechnical engineer may be required, at the discretion of the building official.
- Frost protection: The bottom of the external footings should be 30 inches below finished grade.

We thank you for your cooperation in this matter.

The Valley County Building Department

Special Inspections

Construction Materials Testing

Geotechnical Engineering

Environmental Services

Asbestos/Lead Management Planning

Materials Testing & Inspection

"Assuring the Strength, Safety and Security of Your Future"

GEOTECHNICAL ENGINEERING REPOR

of

Proposed Residential Subdivision

Fir Grove Estates

Donnelly, Idaho

Prepared for:

Royal Fork Restaurant Corporation
6874 Fairview Avenue
Boise, Idaho 83704

MTI File Number B50775g

Mr. Jim Chambers
Royal Fork Restaurant Corporation
6874 Fairview Avenue
Boise, Idaho 83704
(208) 322-5600

Re: **Geotechnical Engineering Report**
Proposed Residential Subdivision
Fir Grove Estates
Boise, Idaho

Gentlemen:

In compliance with your instructions, we have conducted a soils exploration and foundation evaluation for the above mentioned development. Field work for this investigation was conducted on 10 June 2005. Data have been analyzed to evaluate pertinent geotechnical conditions. Provided geotechnical, groundwater and construction recommendations are listed in the **Table of Contents**. Results of this investigation, together with our recommendations, are to be found in the following report. We have provided three copies for your review and distribution.

Often, because of design and construction details that occur on a project, questions arise concerning soil conditions. We would be pleased to continue our role as geotechnical engineers during project implementation. MTI also has great interest in providing materials testing and special inspection services during construction of this project. If you will advise us of the appropriate time to discuss these engineering services, we will be pleased to meet with you at your convenience.

We appreciate this opportunity to be of service to you and we look forward to working with you in the future. If you have questions please call us at (208) 376-4748.

Respectfully Submitted
Materials Testing & Inspection, Inc.

Kevin L. Schroeder, P.G.
Geotechnical Services Manager

Reviewed by Michael G. Woodworth, P.E.
Geotechnical Engineer

TABLE OF CONTENTS

INTRODUCTION

This report presents results of a geotechnical investigation and analysis in support of data utilized in desig of structures as defined in the 2003 International Building Code (IBC). Information in support o groundwater and stormwater issues pertinent to the practice of Civil Engineering is included. Observation and recommendations relevant to the earthwork phase of the project are also presented.

Project Description:

The proposed development is south of the City of Donnelly, Valley County, Idaho, and occupies much of the NW¼ of Section 27, Township 16 North, Range 3 East, Boise Meridian. The project will consist of development of approximately 120 residential lots, with associated roadways, open areas, and support facilities. MTI has not been informed of proposed grading.

Authorization:

Authorization to perform this exploration and analysis was given in the form of a written authorization to proceed from Mr. Jim Chambers to Kevin L. Schroeder of Materials Testing and Inspection, Inc. (MTI), on 6 June 2005. Said authorization is subject to terms, conditions, and limitations described in the Professional Services Contract entered into between Royal Fork Restaurant Corporation and MTI. Our scope of services for the proposed development has been provided below.

Purpose:

The purpose of this Geotechnical Engineering Report is to determine various soil profile components and their engineering characteristics for use by either design engineers or architects in:

- Preparing or verifying suitability of foundation design and placement,
- Preparing site drainage designs, and,
- Indicating issues pertaining to earthwork construction.

Scope:

The scope of this investigation included review of geologic literature and existing available geotechnical studies of the area, review of available environmental reports, visual site reconnaissance of the immediate site, subsurface exploration, field and laboratory testing, and an engineering analysis and evaluation of foundation materials. The scope of work did not include design recommendations specific to individual residences.

Warranty And Limiting Conditions:

Field observations and research reported herein are considered sufficient in detail and scope to form reasonable basis for the purposes cited above. MTI warrants that findings and conclusions contained herei have been promulgated in accordance with generally accepted professional engineering practice in the field of foundation engineering, soil mechanics and engineering geology, only for the site and project described i this report.

These engineering methods have been developed to provide the client with information regarding apparent or potential engineering conditions relating to the subject property within the scope cited above and are necessarily limited to conditions observed at the time of the site visit and research. The report is also limited to information available at the time it was prepared. In the event additional information is provided to MTI following the report, it will be forwarded to the client in the form received for evaluation by the client. There is a distinct possibility that conditions may exist which could not be identified within the scope of the investigation or which were not apparent during the site investigation. This report was prepared for the exclusive use of Royal Fork Restaurant Corporation, and their retained design consultants ("Client"). Conclusions and recommendations presented in this report are based upon agreed-upon scope of work outlined in the report and Contract for Professional Services between Client and Materials Testing and Inspection, Inc. ("Consultant"). Use or misuse of this report, or reliance upon findings hereof by parties other than the Client, is at their own risk. Neither Client nor Consultant make representation of warranty to such other parties as to accuracy or completeness of this report or suitability of its use by such other parties for purposes whatever, known or unknown to Client or Consultant. Neither Client nor Consultant shall have liability to, or indemnifies or holds harmless third parties for losses incurred by actual or purported use or misuse of this report. No other warranties are implied or expressed.

General:

Revisions in plans and or drawings for the proposed development from those enumerated in this report should be brought to the attention of the soils engineer to determine if changes in foundation recommendations are required. Deviations from noted subsurface conditions if encountered during construction, should also be brought to the attention of the soils engineer.

DESCRIPTION OF SITE

Site Access:

Access to the site may be gained by exiting I-84 at the Eagle Road off ramp (Exit #46) and traveling north or Eagle Road 6.4 miles to State Highway 44 (State Street). Travel east on State Highway 44, 1.7 miles to State Highway 55, continue traveling north on State Highway 55, 84 miles toward Donnelly, Idaho. Just south of Donnelly, Loomis Lane should be accessed to the west. Continue in this direction to Spring Valley road. The parcel is located south and west of this intersection. The location is depicted in site map plates included in the **Appendix**.

General Geology Of Area:

Within the area of the proposed development, three major groups of Idaho rocks border one another, Granite of the Idaho Batholith, flood-basalt flows of the Columbia River Basalt Group, and metamorphosed island-arc Sedimentary and volcanic rocks of the Seven Devils Group. The Tamarack Resort is in the middle of Long Valley, a major tectonic and structural feature of west central Idaho. The West Mountain escarpment is the high ridge formed along the west side of the Long Valley fault. West Mountain and Long Valley are part of a group of linear north-south ranges and valleys formed by block faulting that occurred during the late Tertiary and Quaternary. The Miocene Columbia River Basalts overlay gneissic and granitic rocks of the Idaho Batholith's west border and are commonly tilted 15°-30° west. As West Mountain rose and Long Valley subsided, as much as 7,000 feet of alluvium accumulated in the valley. The broad, high elevation region north of McCall was mostly buried by an ice cap during Pleistocene glaciations. At this time, cirque and small valley glaciers formed on West Mountain. During at least three periods of glaciations, major valley glaciers flowed in to the north end of Long Valley and formed large arcuate moraines. More recently, during the Pinedale Glaciation, the North Fork Valley Glacier carved the basin and deposited the moraines which form Payette Lake, and the Lake Fork Valley Glacier formed the moraine of Little Payette Lake. During earlier glaciation valley glaciers were thicker and longer, and forming prominent medial moraine, Timber Ridge.

Braided meltwater streams from these glaciers across the valley floor depositing sand, gravel and finer grained sediments. During older, more extensive glaciations, braided streams formed the broad, gently sloping area southwest of Timber Ridge that now is the high terrace above the Payette River. The younger, Pinedale age meltwater formed the lower gravelly terrace on which the McCall airport is located. Glacial deposits are divided into two categories on the basis of origin. "Till" was deposited directly by a melting glacier as it forms a moraine. "Outwash" was deposited by meltwater streams leading away from glacier. Older moraines and outwash plains are not only distinctive because of their position farther out in the valley, but surfaces of these older landforms have since been eroded and weathered to a far greater degree than younger moraines and outwash. The greater weathering is revealed by examining the soils.

Site Topography, Drainage And Vegetation:

The site comprises approximately 70 acres of relatively flat terrain. Development for approximately 12 home sites has already begun with initial installation of roadways, and reportedly the utilities have been placed. Little change in relief was noted across the site. However a shallow canal was noted extending roughly east to west through the central portion of the property.

Regional drainage is west toward Cascade Reservoir. Stormwater drainage for the site is achieved by percolation through surficial sandy soils. Stormwater drainage facilities have been located through the development. Vegetation throughout the area consists primarily of mid-height conifer trees and understory vegetation, brush, and grasses typical of temperate mountain climates.

Site Climatology And Geochemistry:

Average precipitation is on the order of 19-25 inches per year. The annual average temperature ranges from 13° F to 82 ° F with extremes ranging from -26 ° F to 95 ° F. The State Transportation Department has adopted anionic asphalt cements. Nominal frost penetration is typically on the order of 1 foot, with extremes ranging to 3 feet.

Geoseismic Setting:

Soils on-site are classed as Site Class D in accordance with Chapter 16 of the 2003 edition of the IBC. Building structures on this project should be designed as per the IBC requirement for such a seismic classification. Our investigation did not reveal potential hazards resulting from earthquake motions: slope instability, liquefaction, and surface rupture because of faulting or lateral spreading. Incidence and anticipated acceleration of seismic activity in the area is low.

SOILS EXPLORATION

Exploration And Sampling Procedures:

The field exploration to determine engineering characteristics of subsurface materials included a reconnaissance of the project site and investigation by test pit. Test pit sites were located in the field by means of normal taping procedures from on-site features or known locations and are presumed to be accurate to within a few feet. Upon completion of investigation each test pit was backfilled in with loose excavated materials. These loose areas need to be re-excavated and compacted prior to constructing structures over them.

Samples were obtained from representative soil strata encountered in test pits. Samples obtained have been visually classified in the field by a geologist, identified according to test pit number and depth, placed in sealed containers and transported to our laboratory for additional testing. However, because the shallow soils were quite consistent and readily classifiable, no laboratory testing is currently proposed. These materia have been further described in detail on logs provided in the **Appendix**. Results of field tests are als presented on these logs. It is recommended that these logs not be used for estimating quantities because c highly interpretive results.

Soil And Sediment Profile:

A total of eleven test pits were advanced to depths ranging from 3.8 to 7.1 feet. Advancement of these exploration sites were discontinued with interception of the water table, and usually because of sloughing refusal. Because of the areal extent of the studied parcel, the developed soil profile represents only a generalized case, and variations between test pits should be anticipated:

The soil column predominately consisted of silty sands over poorly graded sands. The upper most horizon of the **silty sands (SM)** were commonly field classified as being dark brown, slightly moist in moisture content, and medium dense in relative density. Many areas were grass covered with root materials extending only to about 4 inches in depth. This horizon was noted to extend to depths of 0.5 to 2.8 feet. Beneath this layer soils were commonly light brown to brown, however, the occurrence of hydric soils were also common with coloration tending toward grays. In addition to these noted colors, elevated iron content of the local soils allows for the typical reddish staining of iron-oxides that have coated many horizons. These silty sands were generally field classified as slightly moist to moist, but may have been wet or saturated, with relative densities again of medium dense. Fine sands were not common but observed at several exploration sites. These silty sands were logged extending to depths as shallow as 1.3 feet, and as deep as 8.5 feet. **Silt (ML)** was noted in only one test pit (test pit 1) in the northeastern portion of the site. This soil horizon is light gray to tan, saturated, and of a stiff consistency. Below these soils, saturated, medium dense, brown **poorly graded sands (SP)** classed as tan or brown in color were observed. These low cohesive sediments readily sloughed or caved into the excavation with loss of lateral support. These sediments usually extended beyond termination depths of most of the test pits advanced.

Walls of each test pit were moderately stable through the upper most soils horizons, quite often through the upper 2 feet of depth. However, with added depth these materials commonly contained less fines and gradually lost cohesion. Some caving was noted for these soils or sediments even above the water table. With penetration of the water table the silty sands and poorly graded sands quickly sloughed to the floor of the excavation.

Volatile Organic Scan:

No environmental concerns were identified prior to commencement of the investigation. Therefore, samples obtained during on-site activities were not assessed for volatile organic compounds by portable photoionization detector. Soil and water samples obtained during our exploration activities exhibited no odors or discoloration typically associated with this type contamination.

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SITE HYDROLOGY

General Notes:

Existing surface drainage conditions are defined in the **Description of Site**. Information provided in this section is limited to observations made at the time of the investigation. Regional and/or local ordinances may require information beyond the scope of this report.

Groundwater:

Groundwater was typically encountered within each of the test pits excavated during our field investigation. Depths to groundwater were as shallow as 3.0 feet and as deep as 8.7 feet. This degree of variation is directly tied to the gradational variation of the fine grained particles within the soils formation. Seeps were noted at shallower depths, and are also related to gradational variations within these formations. However, these seeps are not always indicative of shallowest groundwater levels.

Current shallow groundwater levels are related to springtime runoff and snowmelt. Based on geologic conditions, and knowledge of the area, groundwater seepage is likely to be observed during late winter through early summer intermittently near the interface of surficial topsoil and underlying silty sand. Locally, isolated basins of restricted size, may even exhibit standing water for limited periods of time. Therefore, the shallow groundwater depths presently observed should be indicative of yearly shallow levels. MTI recommends that an estimated seasonal high groundwater level of approximately 2½ to 5½ feet below grade, depending on location, be used for design.

Soil Infiltration Rates:

Soil permeability is a measure of the ability of a liquid to move through a soil and was not tested in the field. In this report this parameter is approximated by soil type and gradation. *Of soils comprising the generalized* soil profile for this study, silty sand soils generally exhibit infiltration rates of 2 to 18 inches per hour, though rates will remain low if silt contents are high, or groundwater is reasched. Silts, typically have limited infiltration rates of less then 2 inches per hour. Lastly, the poorly graded sandy sediments typically exhibit infiltration values in excess of 24 per hour, and percolation testing is typically not required within these soils as a result of the free-draining nature of these sediments.

However, note that in some areas, shallow groundwater will result in lower actual infiltration rates. Therefore, MTI recommends that all infiltration facilities constructed on-site should be extended into native poorly graded sand or relatively clean silty sand sediments. Excavation depths of approximately 1 to 8 feet should be anticipated to expose relatively clean sand soils. An infiltration rate of 6 inches per hour should be used for design.

FOUNDATION AND PAVEMENT DISCUSSION AND RECOMMENDATIONS

General Notes:

Presently, approximately 120 lots are proposed for the project site. Considering typical residential construction, and subsurface conditions, it is recommended that the structures be founded upon conventional spread footings and continuous wall footings. **The following recommendations are not specific to the individual structures, but rather should be viewed as guidelines for the subdivision wide development.**

Foundation Design Recommendations:

On the basis of data obtained from the site and test results from various laboratory tests performed, MTI recommends following guidelines be used for the net allowable soils bearing capacity.

Footing Depth	ASTM D 1557 Subgrade Compaction	Net Allowable Soils Bearing Capacity
Footings should bear on competent, native, silty sand soils present at shallow depths across the site. All surficial soils, high in organics, must be removed from below footings.[1]	Not required for native, undisturbed soils.	1,500 lbs/ft^2

[1] **Verification of bearing soils for each residence by a qualified building official at the time of construction is required. Following this inspection, additional inspections by a geotechnical engineer may be required, at the discretion of the building official.**

Footings should be proportioned to meet the stated bearing capacity and/or the IBC 2003 minimum requirements. Total settlement should be limited to about 1 inch with differential settlement of approximately 1/2 inch. Objectionable soil types encountered at the bottom of footing excavations should be removed and replaced with structural fill. Excessively loose or soft areas that are encountered in the footing subgrade will require over-excavation and backfilling with structural fill. To minimize the effects of slight differential movement that may occur because of variations in character of supporting soils, and in seasonal moisture content, MTI recommends continuous footings be suitably reinforced to make them as rigid as possible. For frost protection, the bottom of external footings should be 30 inches below finished grade.

Crawl Space Recommendations:

Considering the presence of shallow groundwater during the winter to early summer runoff period, residences constructed with crawl spaces should be designed in a manner that will inhibit water in the crav spaces. Therefore, proper grading should be considered to be critical. MTI recommends that roof drair carry storm water at least 5 feet away from the residence, and grades should be greater than 5% for a distanc of 10 feet away from all residences. In addition, rain gutters should be placed around all sides of residences and backfill around stem walls should be placed and compacted in a controlled manner.

In addition, special construction techniques will be required to prevent groundwater from entering crawlspaces of residential structures. Two alternatives may be used to mitigate this potential hazard, the use of slab on-grade construction in conjunction with typical footings, or ensuring that the crawlspace elevation located above observed groundwater levels. Recommendations for each alternative are as follows:

1. Crawl spaces must be sufficiently elevated above groundwater levels to prevent groundwater infiltration. MTI recommends that all crawl spaces be located a minimum of 24 inches above estimated seasonal high groundwater levels. A vapor barrier will be required above crawl space soils to prevent vapor emissions from exposed soil.

2. Alternatively, structures may be constructed utilizing concrete floor slabs in conjunction with typical footings. If this option is utilized, all fill material must be compacted to a minimum of 95% of the maximum dry density as determined by ASTM D 1557. In addition, a free draining granular mat must be placed over a <u>minimum 10 mil thickness vapor barrier</u>. The mat should consist of a sand in which less than 100% of this aggregate shall pass the ½ inch screen and no more than 10% of the aggregate shall pass the #200 screen. Placement of the sand shall occur in a manner that will not damage the vapor barrier. Further, sand shall remain in a relatively dry condition up to the point of concrete placement to limit vapor emission issues.

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For either option, soft, saturated or nearly saturated soils may be encountered during footing constructio MTI recommends that a geotechnical representative inspect all footing subgrades prior to placement c concrete. The presence of soft soils may require the use of structural fill material and/or stabilization fabrics

CONSTRUCTION CONSIDERATIONS

Earthwork:

Recommendations in this report are based upon structural elements of the project being founded on competent silty sands or compacted structural fill. Structural areas should be stripped to an elevation that exposes these soil types. Excessively organic soils, deleterious materials, and/or disturbed soils generally undergo high volume changes when subjected to loads, which is detrimental to subgrade behavior in the area of pavements, floor slabs, structural fills, and foundations. Mature trees, brush, and thick grasses with associated root systems were noted at the time of our investigation. It is recommended that organic and/or disturbed soils, if encountered, be removed to depths of 1 foot (minimum), and wasted or stockpiled for later use. Stripping depths should be adjusted in the field to assure that the entire root zone and/or disturbed zone and/or topsoil is removed, prior to placement and compaction of structural fill materials. Exact removal depths should be determined during grading operations by a qualified geotechnical representative, and shall be based upon subgrade soil type, composition, and firmness or soil stability. If currently unidentified underground storage tanks (UST), below surface utilities, wells, or septic systems are found during construction activities, these systems must be decommissioned, removed or abandoned as deemed necessary by governing Federal, State, and local agencies. Excavations developed as the result of such removal must be backfilled with structural fill materials as defined below.

After existing subgrade soils are excavated to design grade, proper control of subgrade conditions (i.e., moisture content) and placement and compaction of new fill (if required) should be overseen by a representative of the soils engineer (MTI). Recommendations for structural fill presented within this report can be used to minimize volume changes and differential settlements that are detrimental to the behavior of footings, pavements, and floor slabs. *Sufficient density tests should be performed to properly monitor* compaction. For structural fill beneath building structures one in-place density test per lift for every 5,000 square feet is recommended. In parking and driveway areas this can be decreased to one test per lift for every 10,000 square feet.

Dry Weather:

If construction is to be conducted during what is considered "Dry" seasonal conditions, problems associated with soft soils may be avoided. However, shallow groundwater conditions, related to springtime runoff and/or late summer/early fall irrigation, may induce rutting subgrade soils. Solutions to problems associated with soft subgrade soils are outlined below. Problems may also arise because of lack of moisture in native and fill soils at time of placement. This will require addition of water to achieve near optimum moisture levels. Low cohesive soils exposed in excavations may become friable, increasing chances of sloughing or caving. Measures to control excessive dust should be considered as part of the overall health and safe management plan.

Wet Weather:

If construction is to be conducted during what is considered "Wet" seasonal conditions (commonly fron mid-October to June), problems associated with soft soils must be considered as part of the construction plan. During this time of year, fine grained soils such as silts and clays will become unstable with increased moisture content, and eventually deform or rut. Additionally, constant low temperatures reduce the possibility of drying soils to near optimum conditions.

Soft Subgrade Soils:

Shallow fine grained subgrade soils that are high in moisture content can be expected to pump and rut under construction traffic. The following recommendations and/or options have been included for dealing with anticipated subgrade conditions:

- Track-mounted vehicles should be used to strip subgrade of root matter and other deleterious debris. Heavy rubber-tired equipment should be prohibited from operating directly on native subgrades, and in structural areas such as roadways and foundations. Construction traffic can be restricted to designated roadways that do not cross, or cross on a limited basis, proposed roadway or parking subgrades.
- During periods of wet weather, construction on-site may become very difficult if not impossible. To ensure constructability, access/haul roads should be constructed with a minimum of 2 feet of structural fill material. Fill material should consist of relatively large cobble (4 to 6 inch in diameter) with sufficient fines to fill voids.
- Instead of structural fill placement, scarification and aeration of subgrade soils can be employed to reduce the moisture content. After stripping is complete, the exposed subgrade should be ripped and/or disked to a depth of 1.5 feet and allowed to air dry for 2 to 4 weeks. Further disking should be performed on a weekly basis to aid the aeration process.
- Alternate recommendations can be provided involving lime or cement stabilization and use of geotextiles, upon request.

Frozen Subgrade Soils:

Frozen subgrade soils must be allowed to thaw, or may be stripped prior to placement of structural fill materials or foundation elements. Frozen soils must be removed to depths that expose non-frozen soils and wasted or stockpiled for later use. These soils must be allowed to thaw and return to near optimum conditions prior to use as structural fill.

Structural Fill:

Soils regarded as suitable for use as structural fill are those classified as GW, GP, GM, SW, SP, SM, and ML, in accordance with the Unified Soil Classification System (USCS) (ASTM D 2487). The use of silty soils (USCS designation of GM, SM, and ML) as fill may be acceptable. However, these materials require very high moisture contents for compaction and require a long time to dry out if natural moisture contents are too high. Therefore these materials can be quite difficult to work with as moisture content, lift thickness, and compactive effort becomes difficult to control. If silty soil is used for structural fill, lift thicknesses should not exceed 6 inches (loose), and fill material moisture must be closely monitored at both the working elevation and the elevations of materials already placed. Following placement, silty soils <u>must</u> be protected from degradation resulting from construction traffic or subsequent construction.

Recommended granular structural fill materials, those classified as GW, GP, SW, SP, should consist of a 6 inch minus select, clean, granular soil with no more than 30% oversize (greater than ¾ inch) material and no more than 12% fines (less than #200) and placed in layers not to exceed 9 inches in thickness. Prior to placement of structural fill materials, surfaces must be prepared as outlined in the **Construction Considerations** section. Structural fill material should be moisture-conditioned to achieve optimum moisture content prior to compaction. For structural fill below footings, areas of compacted backfill must extend outside the perimeter of the footing for a distance equal to the thickness of fill between the bottom of foundation and underlying soils, or 5 feet, whichever is less.

Each layer of structural fill must be compacted to a minimum density of 95% of maximum dry density as determined by ASTM D 1557 (for rigid structures) or D 698 (for flexible pavements). The ASTM D 1557 and D 698 test methods shall be used for samples containing up to 40% oversize particles (greater than ¾ inch). If material contains more than 40% but less than 50% oversize particles, compaction of fill shall be confirmed by proof-rolling each lift with a 10-ton vibratory roller (or equivalent) until the *maximum density* has been achieved. Density testing shall be performed after each proof-rolling pass until the in-place density test results indicate a drop (or no increase) in the dry density, defined as the *maximum density* or "break over" point. The number of required passes shall be used as the requirement on the remainder of fill placement. Material shall contain sufficient fines to fill all void spaces, and shall not contain more than 50% oversize particles.

Backfill:

Backfill materials shall ascribe to the requirements of structural fill except that the maximum material size shall be 4 inches. In no case shall material greater than 2 inches in diameter bear directly on structural elements. Placing oversized material against rigid surfaces interferes with proper compaction. Backfill should be compacted in accordance with specifications for structural fill, except in those areas where it is determined that future settlement is not a concern, such as planter areas. In nonstructural areas, backfill must be compacted to a firm and unyielding condition.

Shallow excavations that do not exceed 4 feet in depth may be constructed with side slopes approachin vertical. Below this depth, it is recommended that slopes be constructed in accordance with Occupationa Safety and Health Administration (OSHA) regulations, section 1926, subpart P. Based on these regulations on-site soils are classified as type "C" soil, and excavations within these soil should be constructed at a maximum slope of 1½ foot horizontal to 1 foot vertical (1½H:1V) for excavations up to 20 feet in height. Excavations in excess of 20 feet will require additional analysis. Note that these slope angles are considered stable for short-term conditions only, and will not be stable for long-term conditions.

For deep excavations, native granular soils cannot be expected to remain in position. These materials are prone to failure and may collapse, thereby undermining upper soils layers. This is especially true when working at depths near the water table. Proper care must be taken to protect personnel and equipment. During our subsurface exploration, test pit sidewalls generally exhibited moderate to excessive sloughing especially after encountering the water table. Care must be taken so that excavations are properly backfilled in accordance with procedures outlined in this report. Water and loose debris should be removed from these excavations, prior to placement of fill soils or concrete.

Groundwater Control:

Groundwater was encountered in the investigation, but is anticipated to be below the depth of most construction. Excavations below the water table will require a dewatering program. It may be possible to discharge dewatering effluent to remote portions of the site or to a strategically located sump or pit. This will essentially recycle effluent, thus eliminating the need to enter into agreements with local drainage authorities. Should the scope of the proposed project change, MTI should be contacted to provide more detailed groundwater control measures.

Special precautions may be required for control of surface runoff and subsurface seepage in general. It is recommended that runoff caused by wet weather be directed away from open excavations. On-site silty soils can be expected to become soft and pump if subjected to excessive traffic following periods of wet weather. Ponded surface water areas should be drained to allow construction to take place through methods such as trenching, sloping, crowning grades, nightly smooth drum rolling, or installation of a French-drain system. Additionally, temporary or permanent driveway sections may be constructed should wet weather be forecast.

GENERAL COMMENTS

When plans and specifications are complete, or if significant changes are made in the character or location of the proposed structures, consultation should be arranged as supplementary recommendations may be required. It is recommended that the service of a qualified geotechnical engineering firm, or qualified building official, be engaged to evaluate soils in footing excavations before placement of concrete. Monitoring and testing should also be performed to verify that suitable materials are used for structural fill and that proper placement and compaction is performed.

REFERENCES

American Society for Testing Materials, 1999, Standard Test Method for Materials Finer than 75-μm (No. 200) Sieve in Mineral Aggregates by Washing: C 117 - 95, 3 p.

American Society for Testing Materials, 1999, Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates: C 136 - 96a, 5 p.

American Society for Testing Materials, 1999, Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils, ASTM Designation: D 4318 - 86, 11 p.

APPENDIX

GEOTECHNICAL GENERAL NOTES

UNIFIED SOIL CLASSIFICATION SYSTEM

GEOTECHNICAL TEST PIT LOGS

SITE MAP PLATES

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GEOTECHNICAL GENERAL NOTES

SOIL PROPERTY SYMBOLS

N: Standard "N" penetration: Blows per foot of a 140 pound hammer falling 30" on a 2" O.D. SS.
Qu: Unconfined compressive strength, tons/ft^2
Qp: Penetrometer value, unconfined compressive strength, tons/ft^2
Qc: Cone Penetrometer value, unconfined compressive strength, pounds/in^2
V: Vane value, ultimate shearing strength, tons/ft^2
M: Water content, %
LL: Liquid Limit
PI: Plasticity Index
NP: Non-Plastic
D: Natural dry density, lbs/ft^3
WT: Apparent groundwater level (at time noted after completion).

DRILLING AND SAMPLING SYMBOLS

SS: Split-Spoon - 1 3/8" I.D., 2" O.D., except where noted.
ST: Shelby Tube - 3" O.D., except where noted.
AU: Auger Sample.
DB: Diamond Bit.
CB: Carbide Bit.
GS: Grab Sample.

RELATIVE DENSITY AND CONSISTENCY CLASSIFICATION

Non-Cohesive Soils	Standard Penetration Resistance	Cohesive Soils	Standard Penetration Resistance
Very Loose	<4	Very Soft	<2
Loose	4-10	Soft	2-4
Medium Dense	10-30	Firm (Medium Stiff)	4-8
Dense	30-50	Stiff	8-15
Very Dense	>50	Very Stiff	15-30
		Hard	>30

PARTICLE SIZE

Boulders	12 in. +	**Coarse Sand**	5 mm to 0.6 mm	**Silts**	0.074 mm to 0.005 mm
Cobbles	12 in. to 3 in.	**Medium Sand**	0.6 mm to 0.2 mm	**Clays**	0.005 mm & Smaller
Gravel	3 in. to 5 mm	**Fine Sand**	0.2 mm to 0.074 mm		

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Unified Soil Classification System

Major Divisions		Symbol	Soil Descriptions
Coarse Grained Soils <50% passes #200 sieve	Gravel and Gravelly Soils <50% coarse fraction passes #4 sieve	GW	Well-graded gravels, gravel-sand mixtures, little or no fines
		GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines
		GM	Silty gravels, Poorly-graded gravel-sand-silt mixtures
		GC	Clayey gravels, Poorly-graded gravel-sand-clay mixtures
	Sand and Sandy Soils >50% coarse fraction passes #4 sieve	SW	Well-graded sands, gravelly sands, little or no fines
		SP	Poorly-graded sands, gravelly sands, little or no fines
		SM	Silty sands, Poorly-graded sand-gravel-silt mixtures
		SC	Clayey sands, Poorly-graded sand-gravel-clay mixtures
Fine Grained Soils >50% passes #200 sieve	Silts and Clays LL < 50	ML	Inorganic silts & very fine sands, silty or clayey fine sands, clayey silts
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
		OL	Organic silts and organic silt-clays of low plasticity
	Silts and Clays LL > 50	MH	Inorganic silts, micaceous or diatomaceous fine sand or silt
		CH	Inorganic clays of high plasticity, fat clays
		OH	Organic silts and clays of medium-to-high plasticity
Highly Organic Soils		PT	Peat, humus, hydric soils with high organic content

GEOTECHNICAL INVESTIGATION TEST PIT LOG

Test Pit Log #: **TP-1** Date Advanced: **6/10/05** Logged By: **Kevin L. Schroeder, P.G.**

Excavated By: **Masco** Location: **See Later Site Map Plates**

Depth to Water Table: **3.2 Feet** Depth to Bottom Of Hole: **7.1 Feet**

Depth (Feet)	Field Description, w/USCS Soil and Sediment Classification	Sample Type	Sample Depth (From-To)	Qp	Lab Test ID
0.0-0.5	**Silty Sand (SM):** *Dark brown, slightly moist ,medium dense.*	GS	0.0-0.5		
0.5-2.2	**Silty Sand (SM):** *Brown to red brown, slightly moist to moist, medium dense.*				
2.2-3.7	**Silty Sand (SM):** *Green-gray to red brown, slightly moist to saturated, predominately coarse grained sands.*				
3.7-4.4	**Silt (ML):** *Light gray to tan, wet, stiff, with fine sand.*	GS	3.7-4.4		
4.4-7.1	**Silty Sand to Poorly Graded Sand (SM-SP):** *Brown, to red brown, saturated, medium dense. Sediments at depth readily sloughed as we met with slough refusal at a depth of 7.1 feet.*				

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GEOTECHNICAL INVESTIGATION TEST PIT LOGS

Test Pit Log #: **TP-2** Date Advanced: **6/10/05** Logged By: **Kevin L. Schroeder, P.G.**
Excavated By: **Masco** Location: **See Later Site Map Plates**
Depth to Water Table: **3.5 Feet** Depth to Bottom Of Hole: **6.2 Feet**

Depth (Feet)	Field Description, w/USCS Soil and Sediment Classification	Sample Type	Sample Depth (From-To)	Qp	Lab Test ID
0.0-1.1	**Silty Sand (SM):** *Dark brown, slightly moist ,medium dense.*				
1.1-2.2	**Silty Sand (SM):** *Brown to red brown, slightly moist to moist, medium dense.*				
3.4-6.2	**Poorly Graded Sand (SP):** *Brown, wet to saturated.. Sediments at depth readily sloughed as we met with slough refusal at a depth of 6.2 feet.*				

Test Pit Log #: **TP-3** Date Advanced: **6/10/05** Logged By: **Kevin L. Schroeder, P.G.**
Excavated By: **Masco** Location: **See Later Site Map Plates**
Depth to Water Table: **3.0 Feet** Depth to Bottom Of Hole: **3.8 Feet**

Depth (Feet)	Field Description, w/USCS Soil and Sediment Classification	Sample Type	Sample Depth (From-To)	Qp	Lab Test ID
0.0-0.5	**Silty Sand (SM):** *Dark brown, slightly moist ,medium dense.*				
0.5-1.0	**Silty Sand (SM):** *Tan, slightly moist, medium dense.*				
1.0-3.8	**Silty Sand to Poorly Graded Sand (SM-SP):** *Brown to red brown, saturated, medium dense. Sediments at depth readily sloughed as we met with slough refusal at a depth of 3.8 feet.*				

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GEOTECHNICAL INVESTIGATION TEST PIT LOGS

Test Pit Log #: **TP-4** Date Advanced: **6/10/05** Logged By: **Kevin L. Schroeder, P.G.**
Excavated By: **Masco** Location: **See Later Site Map Plates**
Depth to Water Table: **6.8 Feet** Depth to Bottom Of Hole: **7.1 Feet**

Depth (Feet)	Field Description, w/USCS Soil and Sediment Classification	Sample Type	Sample Depth (From-To)	Qp	Lab Test ID
0.0-0.7	**Silty Sand (SM):** *Dark brown, slightly moist ,medium dense.*				
0.7-1.7	**Silty Sand (SM):** *Brown to gray brown, slightly moist, medium dense A weak seep was noted at a depth of 1.7 feet of depth.*				
1.7-7.1	**Silty Sand (SM):** *Brown to tan, slightly moist, medium dense.*				

Test Pit Log #: **TP-5** Date Advanced: **6/10/05** Logged By: **Kevin L. Schroeder, P.G.**
Excavated By: **Masco** Location: **See Later Site Map Plates**
Depth to Water Table: **4.4 Feet** Depth to Bottom Of Hole: **5.5 Feet**

Depth (Feet)	Field Description, w/USCS Soil and Sediment Classification	Sample Type	Sample Depth (From-To)	Qp	Lab Test ID
0.0-2.8	**Silty Sand (SM):** *Dark brown, slightly moist ,medium dense, with organics through the upper 4 inches.*	GS	0.0-2.8		
2.8-3.0	**Silty Sand (SM):** *Tan, slightly moist, medium dense, predominately fine grained sands.*				
3.0-5.5	**Poorly Graded Sand (SP):** *Brown, slightly moist to saturated, medium dense. Sediments at depth readily sloughed as we met with slough refusal at a depth of 5.5 feet.*				

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GEOTECHNICAL INVESTIGATION TEST PIT LOG

Test Pit Log #: **TP-6** Date Advanced: **6/10/05** Logged By: **Kevin L. Schroeder, P.G.**

Excavated By: **Masco** Location: **See Later Site Map Plates**

Depth to Water Table: **4.4 Feet** Depth to Bottom Of Hole: **5.4 Feet**

Depth (Feet)	Field Description, w/USCS Soil and Sediment Classification	Sample Type	Sample Depth (From-To)	Qp	Lab Test ID
0.0-0.9	**Silty Sand (SM):** *Dark brown, slightly moist ,medium dense.*				
0.9-3.0	**Silty Sand (SM):** *Tan, slightly moist, medium dense, with fine sand.*				
3.0-5.4	**Poorly Graded Sand (SP):** *Brown, slightly moist to saturated, medium dense. Sediments at depth readily sloughed as we met with slough refusal at a depth of 7.1 feet.*				

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GEOTECHNICAL INVESTIGATION TEST PIT LOG

Test Pit Log #: **TP-7** Date Advanced: **6/10/05** Logged By: **Kevin L. Schroeder, P.G.**
Excavated By: **Masco** Location: **See Later Site Map Plates**
Depth to Water Table: **3.0 Feet** Depth to Bottom Of Hole: **4.6 Feet**

Depth (Feet)	Field Description, w/USCS Soil and Sediment Classification	Sample Type	Sample Depth (From-To)	Qp	Lab Test ID
0.0-0.5	**Silty Sand (SM):** *Dark brown, slightly moist ,medium dense. Organic materials present through the upper 4 inches.*				
0.5-1.3	**Silty Sand (SM):** *Brown, slightly moist, medium dense.*				
1.3-4.6	**Poorly Graded Sand (SP):** *Brown to red brown, slightly moist to saturated, medium dense. Sediments at depth readily sloughed as we met with slough refusal at a depth of 4.6 feet.*				

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GEOTECHNICAL INVESTIGATION TEST PIT LOG

Test Pit Log #: **TP-8** Date Advanced: **6/10/05** Logged By: **Kevin L. Schroeder, P.G.**
Excavated By: **Masco** Location: **See Later Site Map Plates**
Depth to Water Table: **4.6 Feet** Depth to Bottom Of Hole: **5.8 Feet**

Depth (Feet)	Field Description, w/USCS Soil and Sediment Classification	Sample Type	Sample Depth (From-To)	Qp	Lab Test ID
0.0-0.5	**Silty Sand (SM):** *Dark brown, slightly moist ,medium dense. Organic materials through the upper 4 inches.*				
2.1-4.4	**Silty Sand (SM):** *Brown, slightly moist to wet, medium dense.*				
4.4-5.8	**Poorly Graded Sand (SP):** *Brown, wet to saturated, medium dense. Sediments at depth readily sloughed as we met with slough refusal at a depth of 4.6 feet.*				

GEOTECHNICAL INVESTIGATION TEST PIT LOG

Test Pit Log #: TP-9 Date Advanced: 6/10/05 Logged By: Kevin L. Schroeder, P.G.
Excavated By: Masco Location: See Later Site Map Plates
Depth to Water Table: 8.7 Feet Depth to Bottom Of Hole: 9.9 Feet

Depth (Feet)	Field Description, w/USCS Soil and Sediment Classification	Sample Type	Sample Depth (From-To)	Qp	Lab Test ID
0.0-0.8	**Silty Sand (SM):** *Dark brown, slightly moist ,medium dense. Organic materials through the upper 4 inches.*				
0.8-3.8	**Silty Sand (SM):** *Brown, slightly moist, medium dense.*				
3.8-8.5	**Silty Sand (SM):** *Tan to light gray, slightly moist, medium dense to dense, with fine grained sand throughout. Re brown mottling apparent through much of this layer.*				
8.5-9.9	**Poorly Graded Sand (SP):** *Light blue-gray, wet to saturated, medium dense to dense.*				

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GEOTECHNICAL INVESTIGATION TEST PIT LOG

Test Pit Log #: **TP-10** Date Advanced: **6/10/05** Logged By: **Kevin L. Schroeder, P.G.**

Excavated By: **Masco** Location: **See Later Site Map Plates**

Depth to Water Table: **4.8 Feet** Depth to Bottom Of Hole: **5.6 Feet**

Depth (Feet)	Field Description, w/USCS Soil and Sediment Classification	Sample Type	Sample Depth (From-To)	Qp	Lab Test ID
0.0-1.2	**Silty Sand (SM):** *Dark brown, slightly moist ,medium dense. Organic materials through the upper 4 inches.*				
1.2-3.2	**Silty Sand (SM):** *Brown, slightly moist ,medium dense.*				
3.2-5.6	**Poorly Graded Sand (SP):** *Light brown, slightly moist to saturated, medium dense.*				

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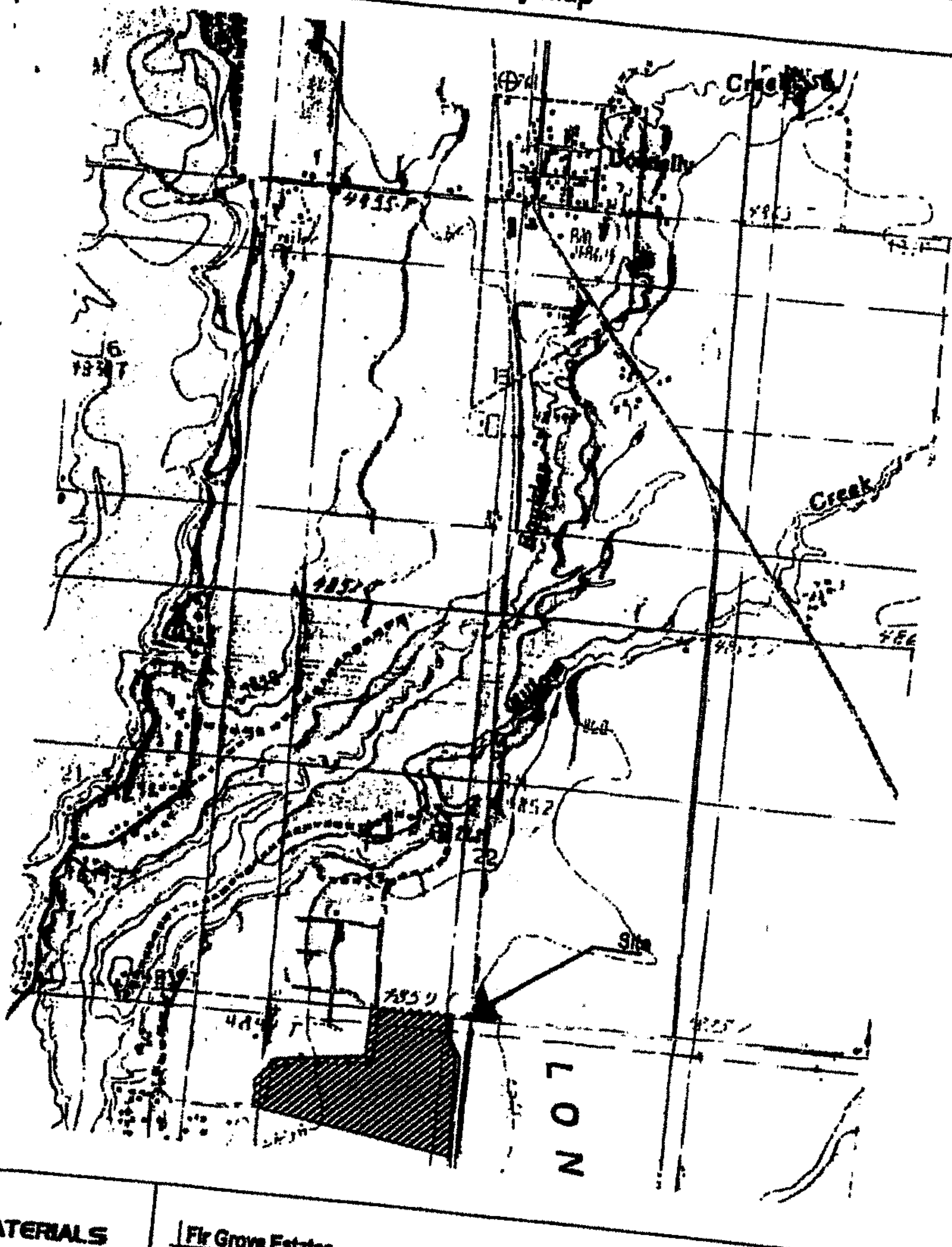
GEOTECHNICAL INVESTIGATION TEST PIT LOG

Test Pit Log #: **TP-11** Date Advanced: **6/10/05** Logged By: **Kevin L. Schroeder, P.G.**
Excavated By: **Masco** Location: **See Later Site Map Plates**
Depth to Water Table: **3.2 Feet** Depth to Bottom Of Hole: **4.2 Feet**

Depth (Feet)	Field Description, w/USCS Soil and Sediment Classification	Sample Type	Sample Depth (From-To)	Qp	Lab Test ID
0.0-2.1	**Silty Sand (SM):** *Dark brown, slightly moist ,medium dense. Organic materials through the upper 4 inches of soil.*	GS	0.0-2.1		
2.1-4.2	**Silty Sand (SM):** *Brown to red brown, slightly moist to saturated, medium dense. Sediments at depth readily sloughed as we met with slough refusal at a depth of 4.6 feet.*				

Vicinity Map

Pla



Materials Testing & Inspection

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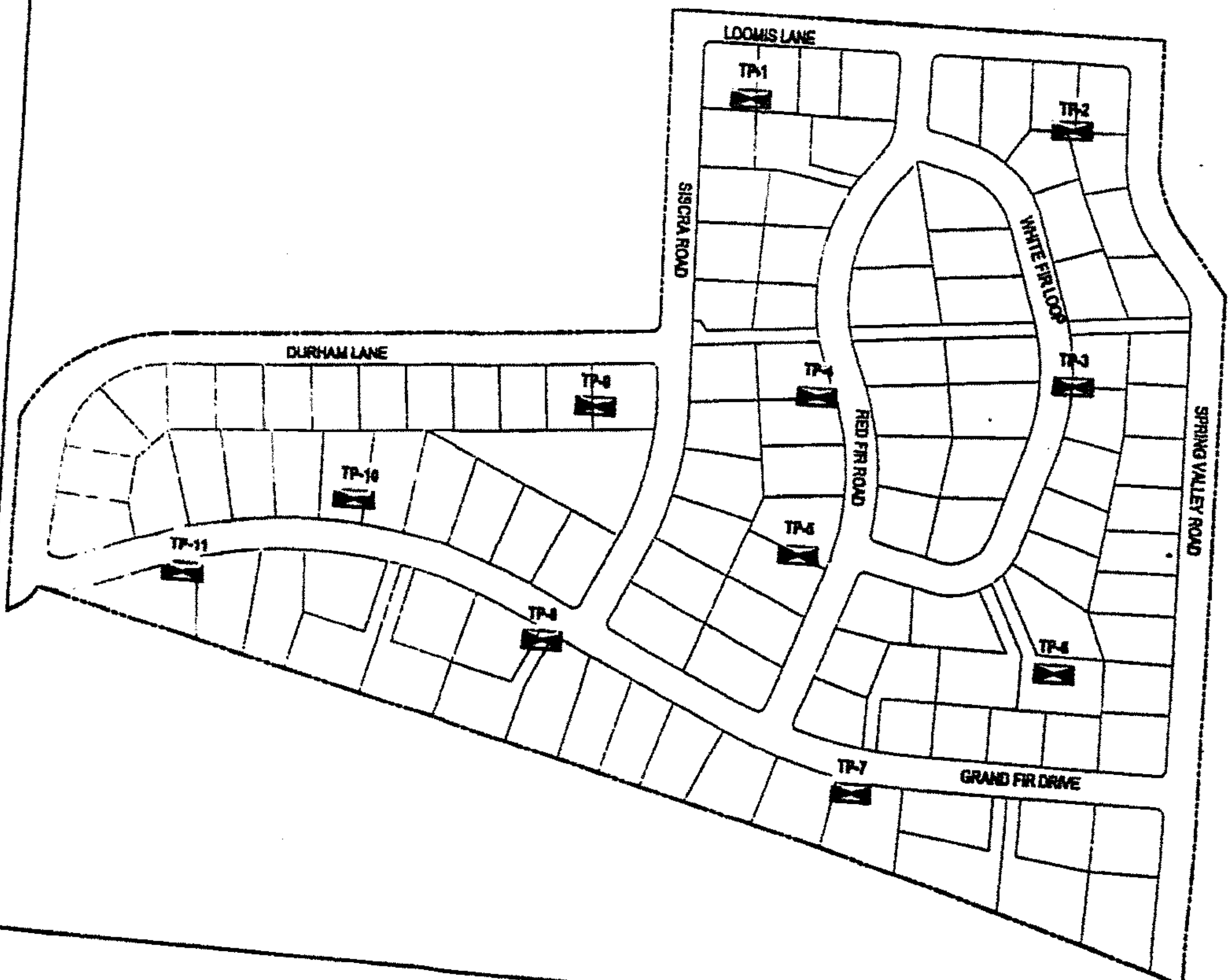
Fir Grove Estates
Valley County, Idaho

Drawn By: JCT
June 13, 2005
DRAWING: B50775g

LEGEND
Property Line

Site Plan with Test Pit Locations



NOTES:

- Not to Scale
- Test pit locations are approximat

LEGEND

Property Boundary

MTI Test Pit

FIR GROVE ESTATES
Valley County, Idaho

Modified by: JCT
June 13, 2005
Drawing: B60775g

MATERIALS TESTING & INSPECTION

INTRODUCTION

The proposed Fir Grove Estates Subdivision (Figure 1) is a residential development in Section 27, T16N, R3E in Valley County. The subdivision encompasses about 71 acres south of Loomis Lane and west of Spring Valley Road. It is a proposed 121 single-family lot subdivision, with access via 28-foot paved roadways.

This report addresses issues of increased stormwater runoff, water quality treatment from increased stormwater runoff, groundwater levels, and existing drainage through the proposed development.

EXISTING CONDITIONS

Soils

The Valley County Soil Survey generally characterizes soils in the area of the project as sandy loam. However, soils on a specific site may vary from this characterization. Based on previous excavations for the construction of sewer lines in the North Lake area, as well as past soil investigations by Terracon, subsurface soil conditions in the vicinity are typically as follows:

- 0-6" topsoil
- 6"-6' medium dense silty sand
- 6'-7' silty clay
- >7 feet medium dense silty sand

Installation of ground water monitoring wells (see next section) has provided additional information specific to the project site. Based on site observations, soils on the project site can generally be described as clayey silt.

Ground Water

Groundwater monitoring wells were installed in the fall of 2003 at ten locations, including eight on the proposed project property. The monitoring wells consist of 10 feet long, 4-inch perforated PVC pipes with drain sock sleeves to keep out soil particles. Both ends are capped, and the top cap is removable for collecting groundwater depth measurements. The pipes were installed at a depth of 7 to 9 feet below ground.

At the time of installation, there was no groundwater in any of the test wells. When observed again in mid-February, the monitoring wells were still dry. Monitoring was continued on a weekly basis until snowmelt, when the observation frequency was increased to several times a week. As expected from past experience with construction of various sewer systems in the region, groundwater levels in most of the wells peaked in April at depths from 6 inches to 2 feet below ground surface. Figure 2 shows the locations of the main monitoring test wells and the recorded groundwater levels. Measurements in May and June appear to be at the same levels. Both of the measurements for these months were recorded after periods of significant rain.

Due to the high groundwater levels in this area, a typical home construction with a crawlspace excavated below ground will create a risk of groundwater and mold in the crawlspace. This potential problem must be avoided and is addressed later in this report.

Drainage

The proposed project area is fairly flat, sloping gently from an elevation of about 4858 on the southeast end to an elevation of around 4852 on the west. A series of culverts and drainage ditches (Figure 2) convey runoff from east to west through the project area to Cascade Reservoir.

A narrow ditch traverses the property from Spring Valley Road to the intersection of Siscra Road and Durham Lane. At Durham Lane, an 18" CMP culvert conveys drainage across Siscra Road into the borrow ditch along the north side of Durham Lane. Flow passes through three culverts at driveways in the Boulder Creek Meadows subdivision, then continues west through a vegetated drainage to a 30" culvert on Hereford Road that flows to Cascade Reservoir. These drainages and culverts are undersized for a 25 year runoff event for which they should be sized. Recommended corrections are discussed later in the report.

Drainage from the northeast section of the property flows into the ditch that traverses the property, through the Siscra Road culvert, and on to Cascade Reservoir. The south half of the property drains to the west into two culverts (15" and 18") that cross Durham Lane at Lots 10 and 11 of Block 4.

Off-site drainage is also transported through the ditches and culverts shown on Figure 2. Runoff from about 135 acres of undeveloped pasture land east of Spring Valley Road and north of Loomis Lane flows through the wood culvert east of Spring Valley Road and then through the 12" Spring Valley Road culvert into the ditch that traverses the project area. The wood culvert has an exit invert that is approximately 2.5 feet lower than the entrance invert of the Spring Valley Road culvert. This creates a serious drainage problem for the new subdivision on the east side of Spring Valley Road. The water ponds between the two culverts and floods the property.

Figure 2 also shows where standing water (representative of low points) has been observed during the spring runoff in April and also after periods of rains in the months of May and June. Since measured groundwater levels have been below the ground surface, the condition appears to be caused by slow drainage of surface snowmelt and rains due to clay soils in the area. (It has not yet been determined if any of these areas represent jurisdictional or non-jurisdictional wetlands; a wetlands delineation has been conducted and is currently being reviewed by the Army Corp of Engineers).

Conveyance Capacity

Conveyance capacities of the existing culverts at full flow (assumed Manning's $n = 0.025$) are noted in the following table. Slopes for the first three culverts shown in the table represent the slopes of the downstream ditches, which control flow through the culvert. The capacity of the culverts at the west end of Durham Lane is based on actual pipe slope, assuming free flow downstream.

Table 1
EXISTING CULVERT CAPACITIES

SIZE	SLOPE, ft/ft	CAPACITY, cfs	LOCATION
18"	0.002	2.5	Spring Valley Road
18"	0.001	1.8	Siscra Rd./Durham Lane
12"	0.001	0.6	Driveways (Boulder Ck. Meadows)
15"	0.0090	3.2	Northwest curve on Durham Lane
18"	0.0092	5.2	Northwest curve on Durham Lane

FUTURE CONDITIONS

Residential Homes

Surface Water Control

In our approach with surface water drainage we have relied on our past experience with many cities in the Treasure Valley. We have also referred to their respective guidelines. Typically, the cities get involved with individual home drainage only during the building inspector's plan review and inspection visit, confirming that positive drainage away from the house exists. This is generally not a problem because the finished floor elevations are a few feet above the existing grade, which provides an opportunity to fill around the foundation with a slope away from the house.

Each property owner for Fir Grove will be required to build their homes above the existing grade (minimum 1-2 feet) and slope the perimeter away from the home to the natural grade. It is requested that the County Building Department enforce this requirement.

We also recommend a five (5) foot drainage easement around the side and rear of the lots for the purpose of providing drainage from one lot to the other (typical of several cities). The easement will allow stormwater to naturally flow unobstructed to the borrow ditch system. Pictures of a typical building lot subdivision in Meridian are found on Figure 3. Note the downhill slope (future home site) towards the newly constructed home. Stormwater originating from the uphill lot will be diverted around the downhill home because of being raised above the natural ground by about a foot.

The Developer will include on the plat the following statement:

> "All side and rear lot lines have a five (5) foot wide permanent easement for the purpose of transporting property drainage. Said easements shall remain free of obstructions and at the natural elevation and shall be maintained by the individual lot owner".

Refer to Figure 3 for a schematic of the proposed residential home surface drainage plan. Based on the flat terrain and low runoff coefficient (0.3) it is unlikely that significant stormwater flows will be generated that would impact a down-gradient neighboring home.

Groundwater Control

Keeping ground water out of future home crawl spaces is a priority concern for this development. In order to keep the residential homes free of potential groundwater problems, it will be required that the homeowners install perimeter footing drain piping and sump pumps. It will also be required that the groundwater be kept a minimum of 12" below the footing (Refer to Figure 4). The footing drain will consist of a 4" perforated PVC pipe surrounding the entire structure footing and drain by pumping into the borrow ditch at the front of the property. The pipeline will terminate at the ROW and will not encroach onto the County road. The ground surface between the property line and the borrow ditch will be sloped to the borrow ditch.

It is anticipated that the dewatering pumps may only operate 2-3 months out of the year, during high groundwater times. Due to the subsurface dewatering system not allowing the groundwater to buildup, it is anticipated that actual groundwater flows will be fairly minimal. Refer to Appendix A for calculations related to estimated groundwater discharge amounts to the nearby ditches.

In a recent discussion with Idaho Department of Water Resources it was confirmed that a well drilling permit will not be required for the sump pump installation if the sump pump is "less than 18 feet deep".

The Developer will include on the plat and CC&R's the following statement:

> "Groundwater elevation shall be kept a minimum of twelve (12) inches below the structural footings. The property owner will be solely responsible to document and prove to the County Building Official that the sump pump will maintain the groundwater level to an approved depth. Individual lot owners will be responsible for construction, operation, and maintenance of private sump pump system (including piping) for dewatering, as required. The roadside ditches shall serve as receiving bodies for groundwater dewatering. Private sump pump systems shall be constructed in accordance with the standards identified in the CC&R's for Fir Grove Estates Subdivision on file and Valley County Records, Instrument No.__________."

Off-Site Surface Drainage Plan

Figure 5 shows the new proposed drainage path for the off-site and on-site drainage conveyance. The new proposed path would follow the existing drainage from Spring Valley Road to Durham Lane. At Durham Lane, a new flow path would be created that would divert the drainage along the new part of Siscra Road and then along the rear of the lots that front Durham Lane and Grand Fir Drive. At Grand Fir Drive, the flow would cross to the south side, cross at the second curve on Durham Lane, follow the north side of Durham Lane, to the east side of Hereford Road and to the existing culvert on Hereford Road. The culvert at Durham Land and Siscra Road, and the two culverts at the first curve on Durham Lane would be abandoned.

Figure 5 also shows the existing ground profile along this new proposed drainage path. Based on this profile, there is enough relief to provide positive drainage. The new proposed drain invert elevation would begin at Spring Valley Road by lowering the culvert at Spring Valley Road (constructed by others) by around 2.5 feet to provide a positive drainage from the existing upstream wood culvert. The drainage would then continue at a 0.1% slope until reaching near the existing culvert at Hereford Road before dropping steeply to that culvert.

The new drainage would be sized to handle the pre-development 100-year storm event for the upstream 134-acre drainage, the post-development 25-year storm event for the Fir Grove Estates, and the groundwater flow from the sump pumps of the residential footing drains. This peak flow that would pass through this drainage is estimated at the amount of 32 to 34 cfs (see Appendix B for flow calculations through the drainage and Appendix C for sizing of the drainage cross sections). Figure 5 also shows three cross sections of this drainage, with the existing and new sections that would be constructed to accommodate the required flow as well as some freeboard depth. These modifications would be made along the entire drainage path from Spring Valley Road to Hereford Road.

Figure 5 also shows the new culverts that would be required for this drainage. These culverts were sized using the same flows that were used to size the new drainage (see Appendix B)

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Stormwater Quality Treatment

There are two alternatives that were considered to provide treatment of the on-site drainage. Alternative No. 1 considered the use of vegetated Biofiltration Swales (BMP #38, State Catalog of Storm Water Best Management Practices) and Alternative No. 2 considered the use of a Wet Detention Treatment Pond (BMP #46). Both alternatives are acceptable means for transporting and treating stormwater runoff and both were found to be applicable to this development. Further discussion is presented below.

Alternative No. 1 – Biofiltration Swales

This analysis took into account both the surface water runoff from a 1/3 of a 2-year storm event as well as groundwater generated from the residential home dewatering systems. Off-site water that drains through the existing ditch will flow through and will not be accounted for in the treatment process by the bio-swales. Please refer to Appendix D for calculations of sizing the bio-swales.

It was concluded through design calculations in Appendix D that bio-swales would work for this application. Figure 6 illustrates the locations and lengths of the bio-swales. It was found that the recommended minimum lengths of 200 feet will be more than sufficient based on the recommended detentions times and velocities. These biofiltration swales would be located in the 'borrow ditch areas along the new paved roadways and along Durham Lane and Siscra Road.

Vegetated biofiltration swales would be constructed in accordance with the BMP Catalog. The treatment portion of the swales would be designed to convey the peak flow from 1/3rd of the 2-year, one-hour design storm. Runoff velocities in the swales would be limited to a maximum of 1.5 fps, and a minimum hydraulic residence time of 5-9 minutes would be provided. Where swale slopes are less than 2 percent or high water tables are expected, a finely-divided wetland vegetation would be used in place of grass.

In this manner, runoff generated from the proposed development would be treated before exiting the site.

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This alternative would provide a wet detention pond at the location of Lot 1 in the southwest corner of the development. Because of the difficulty in separating on-site and off-site (from upstream land) flows, this pond would provide treatment for the runoff from the Fir Grove Estates as well as pre-development flows from the 134 acre drainage to the east. The pond would also include groundwater pumping flows from the home footing drains and sump pumps. The storm event required for treatment is 1/3rd of the two year storm of one-hour duration. The total flow accounted for from these three factors is 24,400 cubic feet (see Appendix E).

Using the design requirements for BMP #46 the pond would be sized for a volume of 24,400 cubic feet with a surface area of approximately 9,000 square feet. This would require a pond depth of about 3.5 feet. Flows up to 1/3rd of a 2-year storm would pass through the pond volume, which is design by the BMP #46 standards to remove nutrients and sedimentation from the stormwater runoff. Flows above the 1/3rd of a 2-year storm and up to the entire 2-year storm would exit the pond through a 24-inch orifice pipe. Flows above the 2-year storm and up to the 25-year storm (and the 100-year storm for the east 134 acres) would pass through an overflow weir and an emergency spillway would pass flows above those allowed by the weir. Appendix E shows a plan and profile view of the required pond.

Preferred Alternative

Of the two alternatives discussed above, it is the Developer's preference to install biofiltration swales as the method of stormwater treatment. Flows and conditions are such that this alternative is viable and reasonable. One major concern to the Developer is the aesthetic and nuisance impacts that a pond would create, namely the breeding and infestation of mosquitos. Already, the surrounding area has discussed the possibilities of creating a mosquito abatement district to control the rampant infestation that currently exists. A pond would only add to the problem. A pond is believed not to be in the best interest of the surrounding area nor the residences of this development.

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Due to the silt and clay on portions of the upper soils on the site, surface drainage corrections need to be made to remove the ponding that occurs during snowmelt at the locations noted in Figure 2. The existing ditch that passes through the development has created part of the problem with the surface drainage. The diggings from this ditch were piled onto the sides of the excavation, creating a dam that stops surface water from moving into the ditch. This would be corrected by reforming the sides of the ditch to slope from the ground surface and into the ditch. Low points identified on Figure 2 will be filled and graded to drain. By regarding these low locations through the addition of fill material, stormwater runoff from an up-gradient lot will be able to reach the down-gradient roadside borrow ditch by following natural drainage pathways through the subdivision (see Figure 3) and not ponding.

Roadway Borrow Ditches

Appendix A shows the engineering calculations for sizing of the roadway borrow ditches. Different locations of these ditches will contain different quantities of flow. However, all roadway borrow ditches will be sized for the location receiving the highest flow. The contributing flow into these ditches includes the 25-year storm event as well as the quantity of water that is being pumped from the home footing drains. It is estimated that each of the footing drains would pump around 10 gpm of flow and that all the homes could potentially be pumping at the same time. The sample calculations in Appendix A show that a 19 inch deep roadway ditch would accommodate the drainage flow from 25 lots (25% impervious area assumed per lot, including the paved county roads). However, all borrow ditches would be sized with a depth of 24 inches which would accommodate the flow from much more than 25 lots (see Appendix A page 3)

Appendix F also includes a sample roadway and borrow ditch cross section and the water levels in that borrow ditch during the spring when the home footing drain pumps are operating. The water level in the drains during continual pumping of the footing drains will be low enough to avoid saturation of the road base sections.

Construction Erosion Control

Temporary erosion control measures would also be provided to address water quality issues during construction. Control measures would be outlined on the design plans and a detailed plan would be required from the contractor. *Design plans will require erosion control methods for* preservation of existing vegetation (BMP #3) where possible, mulching (BMP #11), straw bales (BMP #24), and silt fences (BMP #25). Lot 1 on the southwest corner of the development will be used as a temporary (or permanent if selected) construction runoff basin until vegetation is grown in the roadside borrow ditches, biofiltration swales, and the new drainage path.

Fir Grove Estates Subdivision

Drainage Report Appendix A

ASSOCIATES
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(208) 288-1992

[ ] Pocatello Office
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(208) 238-2146

Project Name: Fir Grove Estates

Calculated By: Mike Anderson Date:

Project No. 104013 Sheet: 1 of:

Roadway Barrow Ditches - sizing and design calculations

FLOW

1. From 25-yr storm flows with a duration of one hour

- Largest flow in a roadside drain ditch would occur from a drainage basin equal to approximately half of the development (60 lots or 35 acres)
- Calculate 25-year storm with Rational method runoff equation

$Q = CiA$

$c = 0.3$ (post development runoff coefficient)

$A = 35$ Acres

i = rainfall intensity from IDF curve for this area (Zone C)

$= .77$ in/hr

$Q = (.3)(.77)(35) = 8.09$ cfs

2. From groundwater footing drain sump pumps

- Using the same large drainage basin as worst case.
- 35 Acres, or 60 lots
- Assume each home pumps 10 gpm
- With all home pumping, flow = 60 x 10 gpm = 600 gpm = 1.33 cfs

Largest borrow ditch sized to accept 8.09 + 1.33 = 9.4 cfs

SIZE

Use Manning's Eq. to size borrow ditch.

$$Q = \frac{1.49}{n} R^{2/3} S^{1/2} A$$

cont → next page

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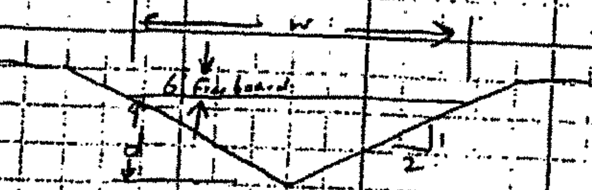
Project Name: Fir Grove Estates

Calculated By: Mike Anderson Date:

Project No. 16-013 Sheet: 2 of:

$$Q = \frac{1.49}{n} R^{2/3} S^{1/2} A$$



$R = \frac{A}{P} = \frac{\text{cross sectional area}}{\text{wetted perimeter}}$

$A = wd/2 = 4d^2/2 = 2d^2$

$P = 2d\sqrt{5}$

$w = 4d$

$$Q = \frac{1.49}{n} \left(\frac{d}{\sqrt{5}}\right)^{2/3} S^{1/2}\, 2d^2$$

$$R = \frac{2d^2}{2d\sqrt{5}} = \frac{d}{\sqrt{5}}$$

$S = .005$ (typical minimum slope in Fir Grove roads and drainage)

$n = 0.04$ (p 109, Design Hydrology and Sedimentology for Small Catchments, Haan, 1994)

$Q = 9.4$ cfs

$$9.4 = \frac{1.49}{.04} \frac{d^{2/3}}{(\sqrt{5})^{2/3}} (.005)^{1/2}\, 2d^2$$

$$9.4 = 3.08\, d^{8/3}$$

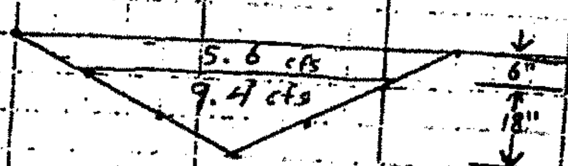
$$d = \left(\frac{9.4}{3.08}\right)^{3/8} = 1.5 \text{ ft} = 18 \text{ inches}$$

Add 6" of freeboard

Borrow Ditch Depth = 24 inches

Then total ditch capacity $= \frac{1.49}{.04} \frac{\left(\frac{24}{12}\right)^{2/3}}{\sqrt{5}} (.005)^{1/2}\, 2 \left(\frac{24}{12}\right)^2 = 15$ cfs

Therefore, ditch has 9.4 cfs capacity in the 1.5 ft depth (18 inches) and (15 − 9.4 = 5.6) cfs capacity in the top 6" depth.



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Calculated By: ______ Date: ______

Project No. ______ Sheet: 1 of: ______

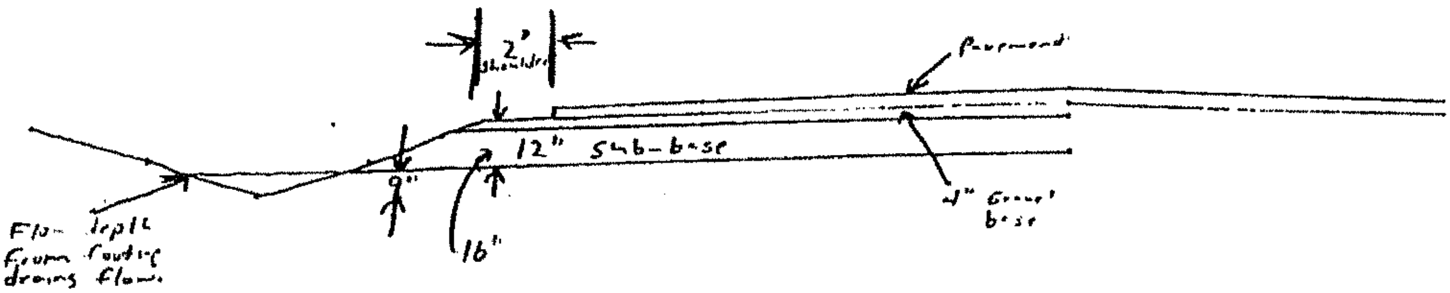
- From Appendix A, p. 1: Continuous flow in the spring while footing drains are pumping would be 1.33 cfs for largest drainage basin.

- Solve for depth of 1.33 cfs in bottom ditch

$$Q = \frac{1.49}{n}\left(\frac{d}{\sqrt{5}}\right)^{2/3} S^{1/2}\, 2d^2$$

$$1.33 = \frac{1.49}{.04}\left(\frac{d}{\sqrt{5}}\right)^{2/3} (.005)^{1/2}\, 2d^2$$

$$1.33 = 3.08\, d^{2/3} d^2 \qquad d = \left(\frac{1.33}{3.08}\right)^{3/8} \qquad d = .73 \text{ ft} = 8.75''$$



Total required depth to avoid saturation of road sub-base is

$$9'' + 16'' = 25''$$

Previously calculated depth of 24" should be adequate

FIR GROVE ESTATES SUBDIVISION

DRAINAGE REPORT

JULY, 2004

KELLER ASSOCIATES

131 SW 5TH AVENUE, SUITE A
MERIDIAN, ID 83642

INTRODUCTION

The proposed Fir Grove Estates Subdivision (Figure 1) is a residential development in Section 27, T16N, R3E in Valley County. The subdivision encompasses about 71 acres south of Loomis Lane and west of Spring Valley Road. It is a proposed 121 single-family lot subdivision, with access via 28-foot paved roadways.

This report addresses issues of increased stormwater runoff, water quality treatment from increased stormwater runoff, groundwater levels, and existing drainage through the proposed development.

EXISTING CONDITIONS

Soils

The Valley County Soil Survey generally characterizes soils in the area of the project as sandy loam. However, soils on a specific site may vary from this characterization. Based on previous excavations for the construction of sewer lines in the North Lake area, as well as past soil investigations by Terracon, subsurface soil conditions in the vicinity are typically as follows:

- 0-6" topsoil
- 6"-6' medium dense silty sand
- 6'-7' silty clay
- >7 feet medium dense silty sand

Installation of ground water monitoring wells (see next section) has provided additional information specific to the project site. Based on site observations, soils on the project site can generally be described as clayey silt.

Ground Water

Groundwater monitoring wells were installed in the fall of 2003 at ten locations, including eight on the proposed project property. The monitoring wells consist of 10 feet long, 4-inch perforated PVC pipes with drain sock sleeves to keep out soil particles. Both ends are capped, and the top cap is removable for collecting groundwater depth measurements. The pipes were installed at a depth of 7 to 9 feet below ground.

At the time of installation, there was no groundwater in any of the test wells. When observed again in mid-February, the monitoring wells were still dry. Monitoring was continued on a weekly basis until snowmelt, when the observation frequency was increased to several times a week. As expected from past experience with construction of various sewer systems in the region, groundwater levels in most of the wells peaked in April at depths from 6 inches to 2 feet below ground surface. Figure 2 shows the locations of the main monitoring test wells and the recorded groundwater levels. Measurements in May and June appear to be at the same levels. Both of the measurements for these months were recorded after periods of significant rain.

Due to the high groundwater levels in this area, a typical home construction with a crawlspace excavated below ground will create a risk of groundwater and mold in the crawlspace. This potential problem must be avoided and is addressed later in this report.

Drainage

The proposed project area is fairly flat, sloping gently from an elevation of about 4858 on the southeast end to an elevation of around 4852 on the west. A series of culverts and drainage ditches (Figure 2) convey runoff from east to west through the project area to Cascade Reservoir.

A narrow ditch traverses the property from Spring Valley Road to the intersection of Siscra Road and Durham Lane. At Durham Lane, an 18" CMP culvert conveys drainage across Siscra Road into the borrow ditch along the north side of Durham Lane. Flow passes through three culverts at driveways in the Boulder Creek Meadows subdivision, then continues west through a vegetated drainage to a 30" culvert on Hereford Road that flows to Cascade Reservoir. These drainages and culverts are undersized for a 25 year runoff event for which they should be sized. Recommended corrections are discussed later in the report.

Drainage from the northeast section of the property flows into the ditch that traverses the property, through the Siscra Road culvert, and on to Cascade Reservoir. The south half of the property drains to the west into two culverts (15" and 18") that cross Durham Lane at Lots 10 and 11 of Block 4.

Off-site drainage is also transported through the ditches and culverts shown on Figure 2. Runoff from about 135 acres of undeveloped pasture land east of Spring Valley Road and north of Loomis Lane flows through the wood culvert east of Spring Valley Road and then through the 12" Spring Valley Road culvert into the ditch that traverses the project area. The wood culvert has an exit invert that is approximately 2.5 feet lower than the entrance invert of the Spring Valley Road culvert. This creates a serious drainage problem for the new subdivision on the east side of Spring Valley Road. The water ponds between the two culverts and floods the property.

Figure 2 also shows where standing water (representative of low points) has been observed during the spring runoff in April and also after periods of rains in the months of May and June. Since measured groundwater levels have been below the ground surface, the condition appears to be caused by slow drainage of surface snowmelt and rains due to clay soils in the area. (It has not yet been determined if any of these areas represent jurisdictional or non-jurisdictional wetlands; a wetlands delineation has been conducted and is currently being reviewed by the Army Corp of Engineers).

Conveyance Capacity

Conveyance capacities of the existing culverts at full flow (assumed Manning's $n = 0.025$) are noted in the following table. Slopes for the first three culverts shown in the table represent the slopes of the downstream ditches, which control flow through the culvert. The capacity of the culverts at the west end of Durham Lane is based on actual pipe slope, assuming free flow downstream.

Table 1
EXISTING CULVERT CAPACITIES

SIZE	SLOPE, ft/ft	CAPACITY, cfs	LOCATION
18"	0.002	2.5	Spring Valley Road
18"	0.001	1.8	Siscra Rd./Durham Lane
12"	0.001	0.6	Driveways (Boulder Ck. Meadows)
15"	0.0090	3.2	Northwest curve on Durham Lane
18"	0.0092	5.2	Northwest curve on Durham Lane

FUTURE CONDITIONS

Residential Homes

Surface Water Control

In our approach with surface water drainage we have relied on our past experience with many cities in the Treasure Valley. We have also referred to their respective guidelines. Typically, the cities get involved with individual home drainage only during the building inspector's plan review and inspection visit, confirming that positive drainage away from the house exists. This is generally not a problem because the finished floor elevations are a few feet above the existing grade, which provides an opportunity to fill around the foundation with a slope away from the house.

Each property owner for Fir Grove will be required to build their homes above the existing grade (minimum 1-2 feet) and slope the perimeter away from the home to the natural grade. It is requested that the County Building Department enforce this requirement.

We also recommend a five (5) foot drainage easement around the side and rear of the lots for the purpose of providing drainage from one lot to the other (typical of several cities). The easement will allow stormwater to naturally flow unobstructed to the borrow ditch system. Pictures of a typical building lot subdivision in Meridian are found on Figure 3. Note the downhill slope (future home site) towards the newly constructed home. Stormwater originating from the uphill lot will be diverted around the downhill home because of being raised above the natural ground by about a foot.

The Developer will include on the plat the following statement:

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Refer to Figure 3 for a schematic of the proposed residential home surface drainage plan. Based on the flat terrain and low runoff coefficient (0.3) it is unlikely that significant stormwater flows will be generated that would impact a down-gradient neighboring home.

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Due to the silt and clay on portions of the upper soils on the site, surface drainage corrections need to be made to remove the ponding that occurs during snowmelt at the locations noted in Figure 2. The existing ditch that passes through the development has created part of the problem with the surface drainage. The diggings from this ditch were piled onto the sides of the excavation, creating a dam that stops surface water from moving into the ditch. This would be corrected by reforming the sides of the ditch to slope from the ground surface and into the ditch. Low points identified on Figure 2 will be filled and graded to drain. By regarding these low locations through the addition of fill material, stormwater runoff from an up-gradient lot will be able to reach the down-gradient roadside borrow ditch by following natural drainage pathways through the subdivision (see Figure 3) and not ponding.

Roadway Borrow Ditches

Appendix A shows the engineering calculations for sizing of the roadway borrow ditches. Different locations of these ditches will contain different quantities of flow. However, all roadway borrow ditches will be sized for the location receiving the highest flow. The contributing flow into these ditches includes the 25-year storm event as well as the quantity of water that is being pumped from the home footing drains. It is estimated that each of the footing drains would pump around 10 gpm of flow and that all the homes could potentially be pumping at the same time. The sample calculations in Appendix A show that a 19 inch deep roadway ditch would accommodate the drainage flow from 25 lots (25% impervious area assumed per lot, including the paved county roads). However, all borrow ditches would be sized with a depth of 24 inches which would accommodate the flow from much more than 25 lots (see Appendix A page 3)

Appendix F also includes a sample roadway and borrow ditch cross section and the water levels in that borrow ditch during the spring when the home footing drain pumps are operating. The water level in the drains during continual pumping of the footing drains will be low enough to avoid saturation of the road base sections.

Construction Erosion Control

Temporary erosion control measures would also be provided to address water quality issues during construction. Control measures would be outlined on the design plans and a detailed plan would be required from the contractor. Design plans will require erosion control methods for preservation of existing vegetation (BMP #3) where possible, mulching (BMP #11), straw bales (BMP #24), and silt fences (BMP #25). Lot 1 on the southwest corner of the development will be used as a temporary (or permanent if selected) construction runoff basin until vegetation is grown in the roadside borrow ditches, biofiltration swales, and the new drainage path.

Fir Grove Estates Subdivision

Drainage Report Appendix A

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Project Name: Fir Grove Estates

Calculated By: Mike Anderson Date:

Project No. 104013 Sheet: 1 of: 2

Roadway Borrow Ditches - sizing and design calculation

FLOW

1. From 25-yr storm flows with a duration of one hour

- Largest flow in a roadside drain ditch would occur from a drainage basin equal to approximately half of the development (60 lots or 35 acres)

- Calculate 25-year storm with Rational method runoff equation

$$Q = CiA$$

c = 0.3 (post development runoff coefficient)

A = 35 Acres

i = rainfall intensity from IDF curve for this area (Zone C)

= .77 in/hr

$Q = (.3)(.77)(35) = $ **8.09 cfs**

2. From groundwater footing drain sump pumps

- Using the same large drainage basin as worst case.
- 35 Acres, or 60 lots
- Assume each home pumps 10 gpm
- With all home pumping flow = 60 x 10 gpm = 600 gpm = 1.33 cfs

Largest borrow ditch sized to accept 8.09 + 1.33 = 9.4 cfs

SIZE

Use Manning's eq to size borrow ditch.

$$Q = \frac{1.49}{n} R^{2/3} S^{1/2} A$$

cont → next page

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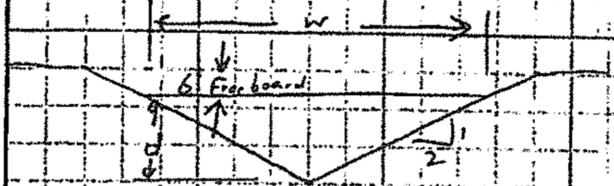
Project Name: Fir Grove Estates

Calculated By: Mike Anderson   Date: ______

Project No. 16-013   Sheet: 2 of: 2

$$Q = \frac{1.49}{n} R^{2/3} S^{1/2} A$$



$$R = \frac{A}{P} = \frac{\text{cross sectional area}}{\text{wetted perimeter}}$$

$$A = wd/2 = 4d^2/2 = 2d^2$$
$$P = 2d\sqrt{5}$$

$$w = 4d$$

$$R = \frac{2d^2}{2d\sqrt{5}} = \frac{d}{\sqrt{5}}$$

$$Q = \frac{1.49}{n}\left(\frac{d}{\sqrt{5}}\right)^{2/3} S^{1/2}\, 2d^2$$

$S = .005$ (typical minimum slope in Fir Grove roads and drainages)
$n = 0.04$ (p 109, Design Hydrology and Sedimentology for Small Catchments, Haan, 1994)
$Q = 9.4$ cfs

$$9.4 = \frac{1.49\, d^{2/3}}{.04\,(\sqrt{5})^{2/3}} (.005)^{1/2}\, 2d^2$$

$$9.4 = 3.08\, d^{8/3}$$

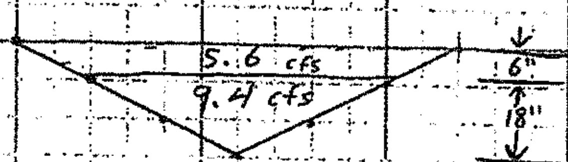
$$d = \left(\frac{9.4}{3.08}\right)^{3/8} = 1.5 \text{ ft} = 18 \text{ inches}$$

Add 6" of freeboard

Borrow Ditch Depth = 24 inches

Then total ditch capacity $= \frac{1.49}{.04}\frac{(\frac{24}{12})^{2/3}}{\sqrt{5}}(.005)^{1/2}\, 2\left(\frac{24}{12}\right)^2 = 15$ cfs

Therefore, ditch has 9.4 cfs capacity in the 1.5 ft depth (18 inches) and (15 - 9.4 = 5.6) cfs capacity in the top 6" depth.



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Project No. ______ Sheet: 1 of: 1

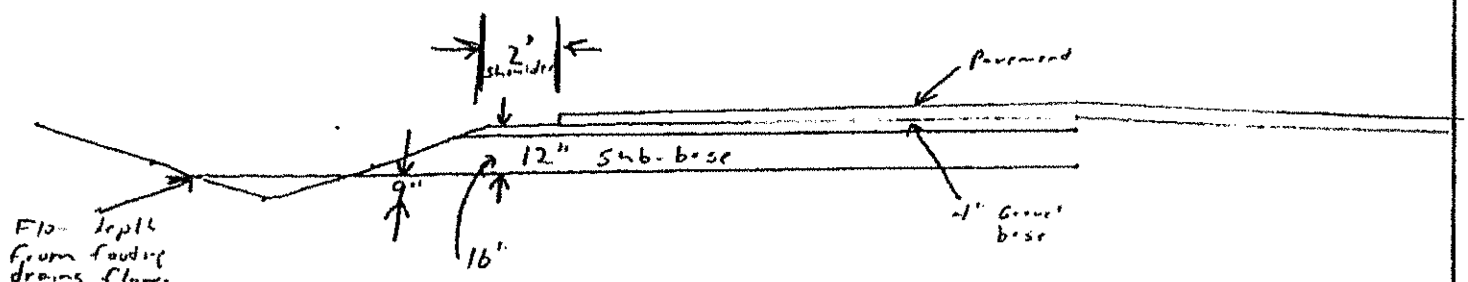
- From Appendix A, p. 1: Continuous flow in the spring while footing drains are pumping would be 1.33 cfs for largest drainage basin.

- Solve for depth of 1.33 cfs in borrow ditch

$$Q = \frac{1.49}{n}\left(\frac{d}{\sqrt{5}}\right)^{2/3} S^{1/2}\, 2d^2$$

$$1.33 = \frac{1.49}{.04}\left(\frac{d}{\sqrt{5}}\right)^{2/3}(.005)^{1/2}\, 2d^2$$

$$1.33 = 3.08\, d^{2/3} d^2 \qquad d = \left(\frac{1.33}{3.08}\right)^{3/8} \qquad d = .73 \text{ ft} = 8.75''$$



Total required depth to avoid saturation of road sub-base is

$$9'' + 16'' = 25''$$

Previously calculated depth of 24" should be adequate

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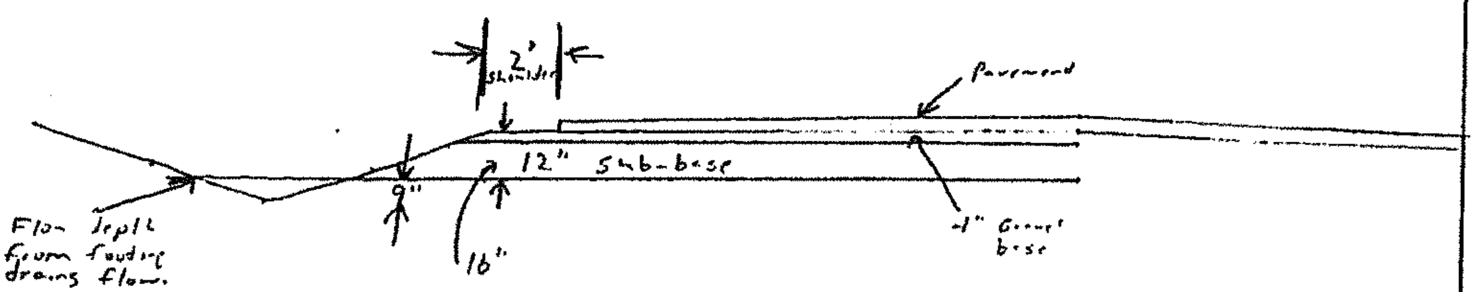
- From Appendix A, p. 1: Continuous flow in the spring while footing drains are pumping would be 1.33 cfs for largest drainage basin.
- Solve for depth of 1.33 cfs in borrow ditch

$$Q = \frac{1.49}{n}\left(\frac{d}{\sqrt{s}}\right)^{2/3} S^{1/2}\, 2d^2$$

$$1.33 = \frac{1.49}{.04}\left(\frac{d}{\sqrt{5}}\right)^{2/3} (.005)^{1/2}\, 2d^2$$

$$1.33 = 3.08\; d^{2/3} d^2 \qquad d = \left(\frac{1.33}{3.08}\right)^{3/8} \qquad d = .73 \text{ ft} = 8.75''$$



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