Section 3 Offsite Analysis

A *Level I Downstream Analysis* is included in this section.

3.1 LEVEL I DOWNSTREAM ANALYSIS

TASK 1: DEFINE AND MAP THE STUDY AREA

A *Downstream Drainage Exhibit* and *Downstream Drainage Photographs* are included at the end of this section.

TASK 2: RESOURCE REVIEW

The best available resource information, including King County iMap and City of Kirkland resource maps, were reviewed for existing or potential problems. The following is a summary of the findings from the information used in preparing this report.

- According to the Geotechnical Engineering Report prepared by the Riley Group, Inc, dated April 29,2020, the onsite soils are medium to very dense silty sand with some gravel grading to silty gravely sand (till), overlain by loose to medium dense silty sand with gravel. Please note the Riley Group, Inc prepared a separate LID Infiltration Study, dated June 5, 2018. See Section 6 of this report to reference the Riley Group, Inc reports.

- The existing and proposed drainage configurations are both part of the Yarrow Creek Drainage Basin (City of Kirkland).

- The site does not contain wetlands (City of Kirkland and King County iMap).

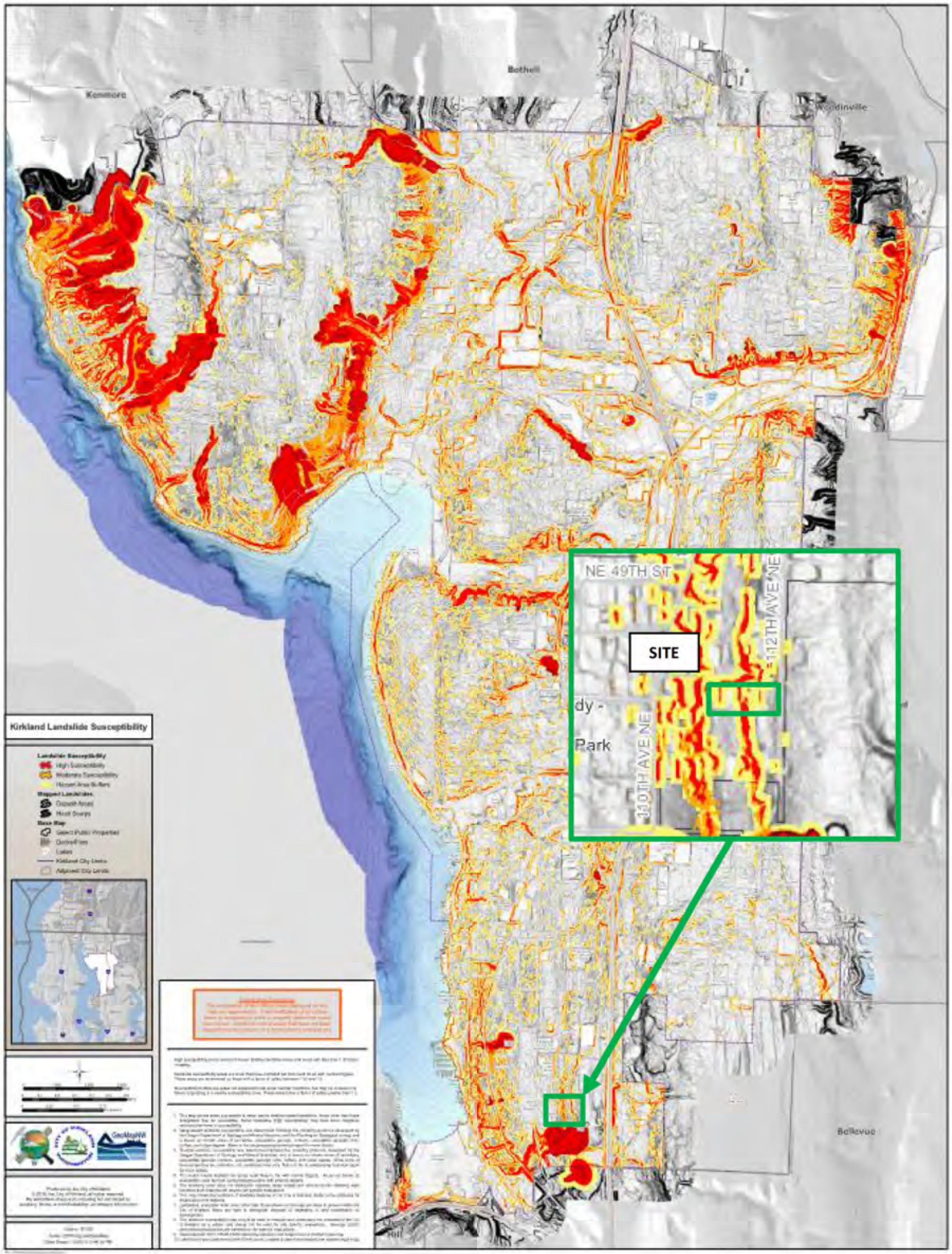
- The site does not contain streams and is not located within a floodplain (City of Kirkland and King County iMap).

- The site is located in a Seismic Hazard Area (City of Kirkland). Please refer to the Geotechnical Engineering Report prepared by the Riley-Group, dated April 29,2020, in Section 6 of this report for detailed analysis and recommendations.

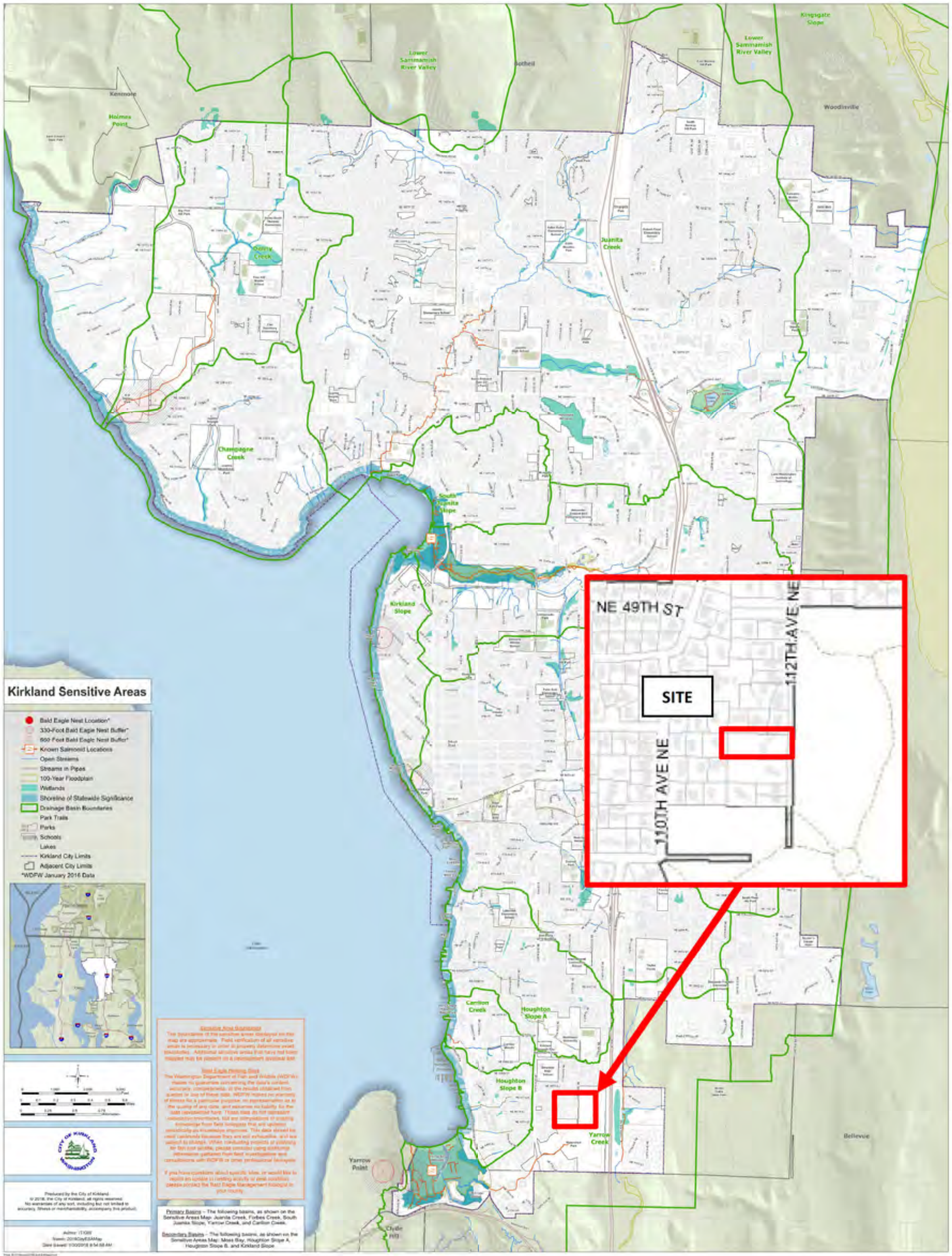
- The site is located in a Landslide Hazard Area (City of Kirkland). Please refer to the Geotechnical Engineering Report prepared by the Riley-Group, dated April 29,2020, in Section 6 of this report for detailed analysis and recommendations.

- The site is located in an Erosion Hazard Area (King County iMap). Please refer to the Geotechnical Engineering Report prepared by the Riley-Group, dated April 29,2020, in Section 6 of this report for detailed analysis and recommendations.

- There are no active drainage complaints near the downstream flow paths. Please refer to the email correspondence with Wes Ayers of the City of Kirkland at the end of this section.



City of Kirkland Landslide and Hazards Area Map



City of Kirkland Sensitive Areas Map

TASK 3 AND TASK 4: FIELD INSPECTION AND DRAINAGE SYSTEM DESCRIPTION

A field inspection was conducted on June 21st, 2016, a sunny day with temperatures around 68°F and April 25th, 2018, a partially cloudy day with temperatures around 60°F. Please reference the *Downstream Drainage Exhibit,* and *Downstream Drainage Photographs* included at the end of this section.

Onsite Basin

The site contains an existing single-family residence with a driveway, lawn, trees, and associated residential landscaping. According to the Geotechnical Engineering Report prepared by the Riley Group, Inc, dated April 29,2020, the onsite soils are medium to very dense silty sand with some gravel grading to silty gravely sand (till), overlain by loose to medium dense silty sand with gravel. Please note the Riley Group, Inc prepared a separate LID Infiltration Study, dated June 5, 2018. See Section 6 of this report to reference the Riley Group, Inc reports. The project contains two drainage basins. The east basin (frontage basin) slopes toward 112th Ave NE and the west basin (onsite basin) slopes to the west. The flow paths eventually converge at a catch basin within the east side of 108th Ave NE and is tributary to the Yarrow Creek drainage basin – see *Existing Conditions Exhibit* in *Section 1* of this report. The drainage path is described below. Refer to the *Downstream Exhibit* at the end of this section for photo locations.

Upstream Basin

A negligible amount of runoff from residential rear yards of adjacent properties runs on the onsite basin. In the developed condition, runoff from the frontage will be conveyed to the drainage swale on the east side of 112th Ave NE. Therefore, no significant upstream flows are tributary to the onsite basin.

Frontage Downstream Drainage Path

In the developed condition, runoff from the frontage will be conveyed east across 112th Ave NE and enters a drainage swale that conveys flows south along the east side of 112th Ave NE. Flows continue south approximately 250 feet before draining into a stream within Watershed Park. Flows in the stream continue south and southwest to the quarter-mile downstream point. Refer to the *Downstream Drainage Exhibit on the following pages* for map figure locations.

Existing Downstream Drainage Path (Onsite Basin)

Runoff from the site sheet flows west across the property's gravel driveway towards the property's back yard and continues to sheet flow to the western parcel boundary (Photo 2 & 3). Runoff continues to sheet flow onto the adjacent parcel, #954420-0140; this is the starting point of the downstream analysis (Photo 4). Flows continue to sheet flow west approximately 140 feet and enter a 12" SWPE pipe via a Type-I catch basin in the driveway of parcel #954420-0140 and are conveyed approximately 190 feet west to a Type-I catch basin in the ROW of 110th Ave NE (Photo 5 & 6). From this catch basin, flows are conveyed south approximately 550 feet through a series of Type-I catch basins and pipe to a control structure in the intersection of 110th Ave NE and NE 45th Street (Photo 7-12). Flows then travel approximately 191 feet west via 12" PVC pipe to a control structure at the intersection of NE 45th Street and 109TH PL NE (Photo 13). Flows continue south and southwest approximately 290 feet via 12" CAP and concrete pipe on the east side of 109th PL NE (Photo 14 & 15). This is past the quarter-mile downstream point, concluding the analysis. Refer to the *Downstream Drainage Exhibit on the following page* for map figure locations.

Developed Downstream Drainage Path (Onsite Basin)

Runoff from the site will be detained onsite via a detention vault. Flows from the detention system will be conveyed north via a tightline system near the northwestern parcel corner and connect to the Type-II catch basin in the northwestern corner of parcel #954420-0262. From this catch basin, flows continue north to a catch basin located in the southeastern portion of parcel #941360-0170. Flows then travel west to a catch basin in the intersection of NE 47th PL and 110th Ave NE and continue south approximately 100 feet in the east side of 110th Ave NE. Flows are then conveyed west in the north side of NE 47th St through a series of catch basins and pipe to a Type-II catch basin located on the northeastern corner of intersection NE 47th St and 108th Ave NE. Refer to the *Downstream Drainage Exhibit on the following page* for map figure locations.

TASK 5: MITIGATION OF EXISTING OR POTENTIAL PROBLEMS

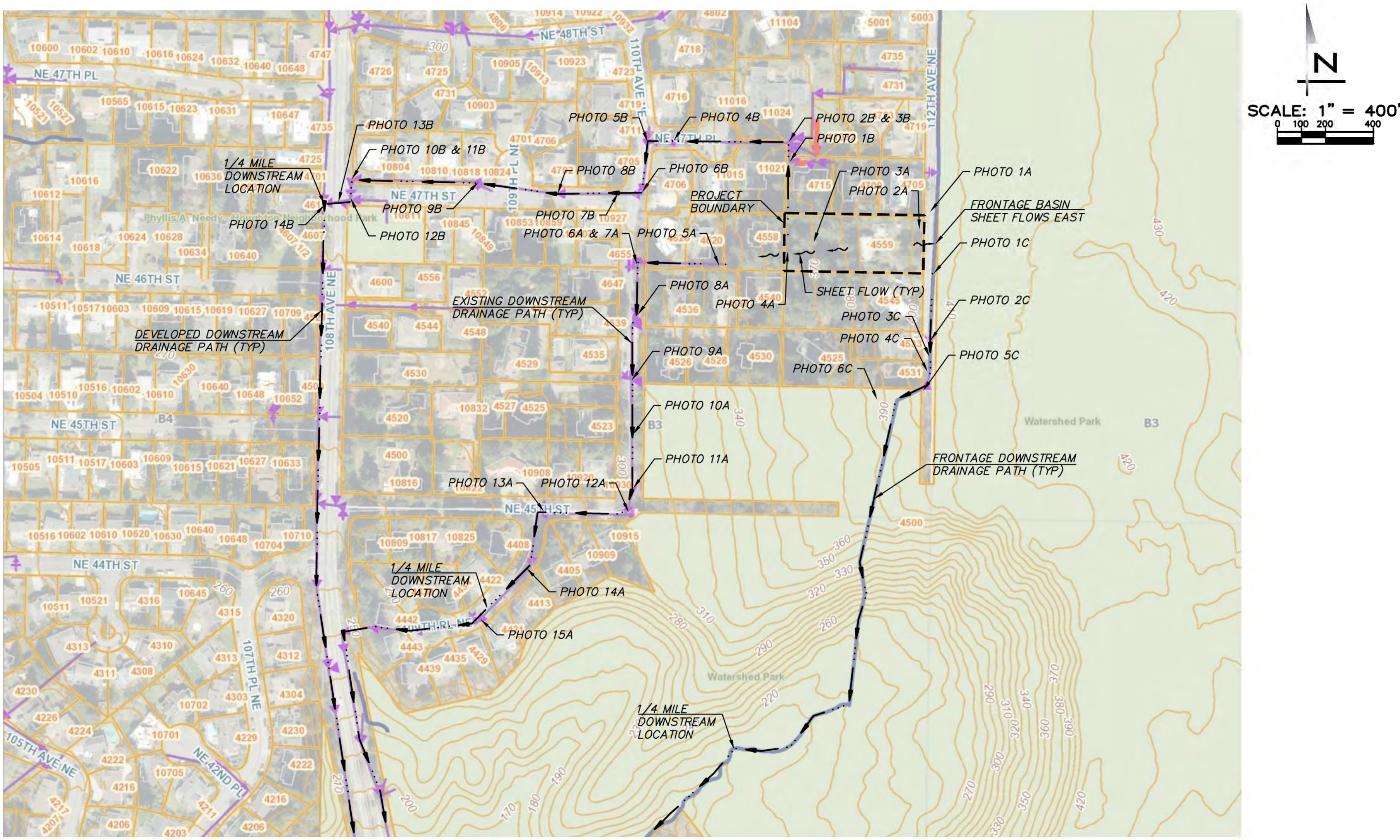
At the time of the site investigation, no problems were found with the existing systems beyond standard maintenance and cleaning. Existing catch basins and pipes require no immediate corrective maintenance.

Based on correspondence with Wes Ayers at City of Kirkland, there are no active drainage complaints near the downstream flow paths. Correspondence with the City of Kirkland regarding downstream drainage complaints is included at the end of this section.

An erosion and sedimentation control plan has been designed to reduce the discharge of sediment-laden runoff from the site. The plan is comprised of temporary measures (rock entrance, filter fence, straw mulch, etc.) as well as permanent measures (hydro seeding and landscaping). All ESC facilities will be periodically inspected and maintained as necessary during construction to minimize impacts to the downstream system.

Attachment 1

DOWNSTREAM DRAINAGE EXHIBIT



DOWNSTREAM DRAINAGE EXHIBIT
4559 112TH AVE NE
FINAL TECHNICAL INFORMATION REPORT

BLUELINE

SCALE	AS NOTED
PROJECT MANAGER	BRETT PUDISTS, PE
DESIGNED BY	NADIA KROUMOVA
DRAWN BY	MICHELLE ROBERGE, PE
PLOT DATE	April 15, 2020

JOB NUMBER: 18-141

FIGURE: DS

Apr 15, 2020 - 4:01pm - User mroberge
E:\Projects\18141\Dwg\Exhibits\18141 DS (1Lot).dwg

Lucas Zirotti

From: Wes Ayers <WAyers@kirklandwa.gov>
Sent: Friday, June 22, 2018 8:50 AM
To: Lucas Zirotti
Subject: RE: 4559 112th Ave NE - Drainage Complaints

Hi Lucas,

I don't see anything along the downstream path that your project needs to be concerned with.

Please let me know if you have any additional questions. Thank you!

Wes Ayers
City of Kirkland Public Works
Surface Water Engineering Analyst
(425) 587-3859
wayers@kirklandwa.gov

Public Works Department
Caring for your infrastructure to keep Kirkland healthy, safe, and vibrant

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From: Lucas Zirotti [mailto:lzirotti@TheBluelineGroup.com]
Sent: Thursday, June 21, 2018 4:54 PM
To: Wes Ayers
Subject: 4559 112th Ave NE - Drainage Complaints

Wes,

I am working on a new project in Kirkland and would like to determine if there are any downstream drainage complaints for the project's few downstream drainage paths. The project is located at 4559 112th Ave NE.

There are three downstream drainage paths for this project: Existing Downstream Drainage Path, Developed Downstream Drainage Path, and Frontage Downstream Drainage Path.

Existing Downstream Drainage Path:
Runoff from the site sheet flows west across the western parcel boundary and continues to sheet flow onto the adjacent parcel, #9544200140. Flows enter a Type-I catch basin in the driveway of parcel #9544200140 and are conveyed west to a catch basin in the ROW of 110th Ave NE. From this catch basin, flows are conveyed south through a series of Type-I catch basins and pipe to a control structure in the intersection of 110th Ave NE and NE 45th Street. Flows then travel west to a control structure at the intersection of NE 45th Street and 109th PL NE. Flows continue south and southwest on the east side of 109th PL NE to the ¼ mile.

Developed Drainage Path:

Runoff from the site will be collected via detention pipes and fully dispersed via a dispersion trench and splash blocks. Flows from the site will be conveyed north via pipe near the northwestern parcel corner, ultimately being tied into the Type-II catch basin in the northwestern corner of parcel #9544200262. From this catch basin, flows continue north to a catch basin located in the southeastern portion of parcel #9413600170. Flows then travel west within the conveyance system in NE 47th St to a catch basin in the west side of intersection NE 47th St and 108th Ave NE. This is the ¼ mile downstream point.

Frontage Downstream Drainage Path:
Runoff from the frontage generally sheet flows east across 112th Ave NE and enters a drainage swale that conveys flows south along the east side of 112th Ave NE. Flows continue south approximately 250 feet before draining into a stream within Watershed Park. Flows in the stream continue south and southwest to the quarter-mile downstream point.

Could you please provide information regarding any downstream drainage complaints along the downstream drainage paths? I have attached an exhibit delineating the downstream path for reference. Let me know if you need additional information or have any questions.

Thanks!

Lucas Zirotti | ENGINEER
BLUELINE | THEBLUELINEGROUP.COM
DIRECT 425.250.7223 | **MAIN** 425.216.4051

EXISTING DOWNSTREAM DRAINAGE PHOTOGRAPHS

Note: See the *Downstream Drainage Exhibit* for numbered locations of pictures.

Photo 1A: Site frontage where flows in the developed condition will be conveyed to the drainage swale along the east side of 112th Ave. – looking south.

Photo 2A: Site runoff sheet flows west across property's gravel driveway

Photo 3A: Site runoff continues to sheet flow west across steep slopes on the western portion of property. – looking west.

Photo 4A: Site runoff sheet flows west onto adjacent property. – looking west.

Photo 5A: Flows enter a Type-I catch basin and continue west. – looking west.

Photo 6A: Flows enter a Type-I catch basin in the east side of 110th Ave NE and continue south. – looking south.

Photo 7A: Flows enter a Type-I catch basin in the east side of 110th Ave NE and continue south. – looking south.

Photo 8A: Flows enter a Type-I catch basin in the east side of 110th Ave NE and continue southwest to the Type-I catch basin in Photo 9. – looking south.

Photo 9A: Flows enter a Type-I catch basin in the east side of 110th Ave NE and continue south. – looking south.

Photo 10A: Flows enter a Type-I catch basin in the east side of 110th Ave NE and continue south. – looking south.

Photo 11A: Flows enter a Type-I catch basin in the east side of 110th Ave NE and continue southwest. – looking southwest.

Photo 12A: Flows enter a control structure in intersection 110th Ave NE and NE 45th St and continue west. – looking west.

Photo 13A: Flows enter a control structure in intersection NE 45th St and 109th PL NE and continue south. – looking south.

Photo 14A: Flows enter a Type-I catch basin in the east side of 109th PL NE and continue south. – looking south.

Photo 15A: Flows enter a Type-I catch basin in the east side of 109th PL NE and continue southwest. This is past the quarter-mile downstream point. – looking southwest.

DEVELOPED DOWNSTREAM DRAINAGE PHOTOGRAPHS

Note: See the *Downstream Drainage Exhibit* for numbered locations of pictures.

Photo 1B: Onsite flows will be conveyed via pipe to the Type-II CB in the northeastern portion of parcel #954420-0262 and will continue north. – looking north.

Photo 2B: Flows enter a Type-I catch basin in the southeastern portion of parcel #941360 -0160 and continue west. – looking west.

Photo 3B: Flows enter a Type-I catch basin and continue west. – looking west.

Photo 4B: Flows enter a Type-I catch basin in the south side of NE 47th PL and continue west. – looking west.

Photo 5B: Flows enter a Type-I catch basin within intersection NE 47th PL and 110th Ave NE and continue south. – looking south.

Photo 6B: Flows enter a Type-I catch basin in the east side of 110th Ave NE and continue west. – looking west.

Photo 7B: Flows enter a Type-II catch basin in the northwestern corner of intersection 110th Ave NE and NE 47th St and continue west. – looking west.

Photo 8B: Flows enter a Type-II catch basin in the north side of NE 47th St and continue west. – looking west.

Photo 9B: Flows enter a Type-II catch basin in the south portion of parcel #941360-0570 and continue west. – looking west.

Photo 10B: Flows enter a Type-II catch basin in the southwest portion of parcel #41360-0540 and continue south. – looking southwest.

Photo 11B: Flows enter a Type-I catch basin in the north side of NE 47th St and continue south. – looking west.

Photo 12B: Flows enter a Type-I catch basin in the south side of NE 47th St and continue south. – looking west.

Photo 13B: Flows enter a control structure in intersection NE 47th St and 108th Ave NE and continue southwest. – looking southwest.

Photo 14B: Flows enter a Type-I catch basin on the west side of 108th Ave NE and continue south. This is the quarter-mile downstream point. – looking south.

FRONTAGE DOWNSTREAM DRAINAGE PHOTOGRAPHS

Note: See the *Downstream Drainage Exhibit* for numbered locations of pictures.

Photo 1C: Flows continue south along the open channel V-ditch – looking south.

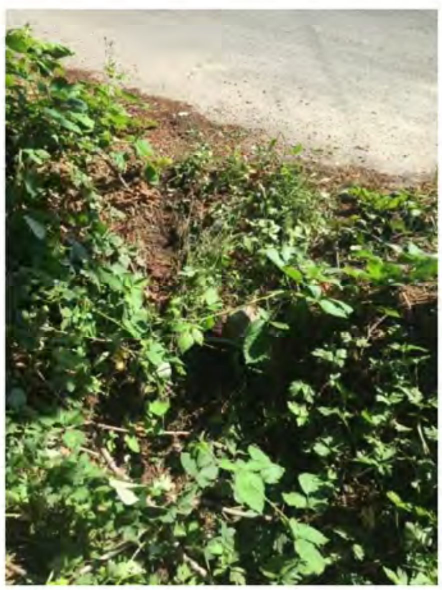


Photo 2C: Flows continue south along the open channel V-ditch and are conveyed through a 12" pvc driveway culvert. Flows continue south – looking south.

Photo 3C: Flows are conveyed through the 12" pvc driveway culvert and outlet into an open channel V-ditch – looking south.

Photo 4C: Flows continue south along V-ditch into a 12" ADS pipe which conveys the stormwater underneath 112th Ave NE toward Watershed Park – looking south.

Photo 5C: Flows are conveyed south under 112th Ave NE to an existing CB Type-1 located along the north perimeter of Watershed Park. Flows continue west. – looking southeast.

Photo 6C: Stormwater flows west along the north perimeter of Watershed Park approximately 100' before out-letting via the 12" ADS pipe with debris cage into Watershed Park. – Looking south.

Section 4 Flow Control and Water Quality Analysis and Design

In the developed condition, onsite runoff from the cottage roofs, driveways and the private access road (pollution-generating impervious areas (PGIS)) will be routed to a 4'x6' BioPod Biofilter System or equivalent, followed by a detention vault located on the western portion of the site, then ultimately entering the tight-line system within NE 47th PL. The remaining onsite, pervious areas unable to be collected will be modeled as bypass. Runoff from the frontage will be routed to the existing ditch along the east side of 112th Ave NE. Please see the *Developed Conditions Exhibit* in Section 1 of this report. A Level I Downstream Analysis is included in Section 3 of this report.

4.1 HYDRAULIC ANALYSIS

The drainage analysis was modeled using the Western Washington Hydrology Model software with 15-minute time steps in accordance with the 2016 KCSWDM and City of Kirkland Addendum. According to the Geotechnical Engineering Report prepared by the Riley Group, Inc, dated April 29,2020, the onsite soils are medium to very dense silty sand with some gravel grading to silty gravely sand (till), overlain by loose to medium dense silty sand with gravel.

The project was modeled with the following parameters:

Rainfall Region: Seatac
Scale Factor: 1.0

EXISTING CONDITIONS

The existing basin boundary consists of the existing parcel boundary, 0.86-acres, and frontage basin, 0.04-acres, for a total of 0.90-acres. The project consists of two drainage basins. In general, site runoff from the west basin sheet flows towards the west property boundary and continues to sheet flow across adjacent properties before entering the conveyance system in 110th Ave NE. The east basin is comprised of the frontage basin and discharges to the existing ditch along the east side of 112th Ave NE. The site contains gravel driveways, fencing, and pasture areas. Please see the Existing Conditions Exhibit in Section 1.

The project lies within a Level 2 Flow Control Area which dictates that the existing condition be modeled in the historic (forested) condition. The areas used to compute the drainage calculations associated with the existing basin conditions are summarized below. Refer to Appendix B for the West Basin WWHM output and Appendix A for the East Basin WWHM output.

EXISTING CONDITIONS - WEST BASIN		
Forest		
Parcel # 9544200250	0.86	ac
Total Forest (Soil Group C - Till)	**0.86**	**ac**
TOTAL EXISTING CONDITIONS – WEST BASIN	**0.86**	**ac**

Flow Frequency Return Periods for Predeveloped.	West Basin POC #1
Return Period	Flow(cfs)
2 year	0.0256
5 year	0.0420
10 year	0.0525
25 year	0.0650
50 year	0.0736
100 year	0.0817

EXISTING CONDITIONS - EAST BASIN

Forest		
Frontage	0.04	ac
Total Forest (Soil Group C - Till)	**0.04**	**ac**
TOTAL EXISTING CONDITIONS – EAST BASIN	**0.04**	**ac**

Flow Frequency Return Periods for Predeveloped.	East Basin POC #1
Return Period	Flow(cfs)
2 year	0.0012
5 year	0.0020
10 year	0.0024
25 year	0.0030
50 year	0.0034
100 year	0.0038

DEVELOPED CONDITIONS

The west basin, 0.86-acres, will include the construction of eight cottages with its associated service utilities, a 4'x6' BioPod Biofilter System or equivalent, a detention vault, and landscaping. 0.70 acres of the developed west basin will be collected and routed to a detention vault, before ultimately discharging to the conveyance system within NE 47th PL. A portion of the developed west basin, 0.16-acres, cannot be physically collected by the proposed detention vault and will be modeled as bypass. The impervious lot coverage was modeled as 60%, the maximum coverage permitted per zoning code + 10% per Policy D-10. The developed site conditions include impervious surfaces such as rooftop, the private access road, driveways, sidewalk and landscaped/lawn area. The total west basin area in the developed condition, 0.86 acres, is equal to the west basin area in the existing condition. Refer to the Developed Conditions Exhibit in Section 1 of the report.

The east basin, 0.04 acres, includes the frontage improvements. The developed frontage area was modeled as 100% impervious. The developed frontage conditions include sidewalks, valley curbing and pavement improvements along 112 Ave NE. Frontage runoff from the developed east basin will be conveyed east to the existing drainage swale along 112th Ave NE. The total east basin area in the developed condition, 0.04 acres, is equal to the east basin area in the existing condition. Refer to the Developed Conditions Exhibit in Section 1 of the report. The areas used to compute the drainage calculations associated with the developed conditions are summarized on the following page.

As the site is within a Level 2 Flow Control Area, the development is required to match developed discharge durations to pre-developed durations for the range of pre-developed discharge rates from 50% of the 2-year peak flow up to the full 50-year peak flow. It is also required to match developed peak discharge rates to pre-developed peak discharge rates for the 2-year and 10-year return periods. The areas used to compute the drainage calculations associated with the developed conditions are summarized on the following page. Refer to Appendix B for the West Basin WWHM output and Appendix A for the East Basin WWHM output.

DEVELOPED CONDITIONS - WEST BASIN		
TRIBUTARY TO DETENTION VAULT		
Impervious		
Parcel # 9544200250 (60% impervious coverage)	0.51	ac
Total Impervious	**0.51**	**ac**
Pervious		
Lawn	0.19	ac
Total Lawn (Soil Group C - Till)	**0.19**	**ac**
Total Tributary to Detention Vault	**0.70**	**ac**
BYPASS BASIN		
Pervious		
Lawn	0.16	ac
Total Lawn (Soil Group C - Till)	**0.16**	**ac**
TOTAL DEVELOPED CONDITIONS – WEST BASIN	**0.86**	**ac**

Flow Frequency Return Periods for Developed. West Basin POC #1	
Return Period	**Flow(cfs)**
2 year	0.0241
5 year	0.0380
10 year	0.0486
25 year	0.0637
50 year	0.0762
100 year	0.0897

Per the WWHM output, included in Appendix B, the provided detention vault volume will meet and exceed the minimum required. The proposed detention vault will provide live storage in the form of 1 – 104' x 18' cell with a live storage depth of 6.5', totaling 12,168 cubic feet. The proposed detention vault is therefore adequately sized to accommodate for the required flow control. Refer to the corresponding WWHM output in Appendix B. See Section 4.3 of this report for additional detail on the enhanced basic water quality treatment facility design.

Live Storage Volume
Required = 11,466 cubic feet
Provided = 12,168 cubic feet

DEVELOPED CONDITIONS - EAST BASIN

Impervious		
Frontage	0.04	ac
Total Impervious	**0.04**	**ac**
TOTAL DEVELOPED CONDITIONS - EAST BASIN	**0.04**	**ac**

Flow Frequency Return Periods for Developed.	East Basin POC #1
Return Period	**Flow(cfs)**
2 year	0.0178
5 year	0.0225
10 year	0.0258
25 year	0.0301
50 year	0.0333
100 year	0.0367

East Basin Mitigated – East Basin Predeveloped = 0.0367 – 0.0038 = 0.0329 cfs

The 100-year east basin runoff for the proposed development when modeled using WWHM software and a 15-minute time-step creates less than 0.15 cfs increase over the historical predeveloped condition, and this therefore exempts the east basin from the stormwater detention requirements per Section 1.2.3.1 of the 2016 KCSWDM. Refer to Appendix A for the east basin output.

4.2 LOW IMPACT DEVELOPMENT

Core Requirement #9 of the 2016 KCSWDM requires flow control BMPs to be implemented per the "individual lot BMP Requirements" included in Section 1.2.9.2 for all new and replaced impervious surfaces to the maximum extent feasible or meet the Low Impact Development Requirement. The Large Lot BMP requirements will be met by evaluating flow control BMPs for the target areas and apply BMPs to the maximum extent feasible. Each BMP was determined feasible or infeasible as follows.

1. **Full Dispersion** – Due to-onsite slopes, erosion hazards and installation of the required detention facility, there is no native vegetative flow path available to meet the full dispersion requirements.

2. **Full Infiltration** – Per the LID Infiltration Feasibility Study prepared by Riley-Group, dated June 5, 2018, soils toward the eastern portion of the site display the very dense nature of lodgment till soils that limit infiltration potential, therefore full infiltration is infeasible. Groundwater was encountered at approximately 6.5 feet on the western portion of the site. Due to physical constraints such as soil conditions, slopes greater than 15%, proposed utilities, and the proposed site plan, full infiltration is not feasible.

3. **Full Infiltration, Limited Infiltration, Bioretention or Permeable Pavement** – Refer to the LID Infiltration Feasibility Study prepared by Riley Group, dated June 5, 2018. Soils towards the eastern portion of the site display the very dense nature of lodgment till soils which limit infiltration potential. Groundwater was encountered at approximately 6.5 feet on the western portion of the site. Permeable pavers with underdrain are proposed for driveways, walkways and patios to meet the 50% lot coverage requirement, but no LID credit was applied for the permeable pavers in the vault model. Overflow from the pavers will be conveyed along the private access road, which is tributary to the detention vault.

4. **Basic Dispersion** – Due to-onsite slopes, erosion hazards and installation of the required detention facility, there is no native vegetative flow path meeting basic dispersion requirements available.

5. **Reduced Impervious Surface or Native Growth Retention** – BMPs are infeasible for Requirements 1-4, and per City of Kirkland Standard Policy D-10, implementation of the Reduced Impervious Surface Credit for small Lot BMP requirements is not required. Native growth retention is also not required per Policy D-10; therefore, no reduced impervious surface of native growth retention credits will be provided.

6. **Post-Amended Soils** – Amended Soils in accordance with the specifications included in BMP T5.13 of the 2016 KCSWDM will be applied to the landscaped areas on the site.

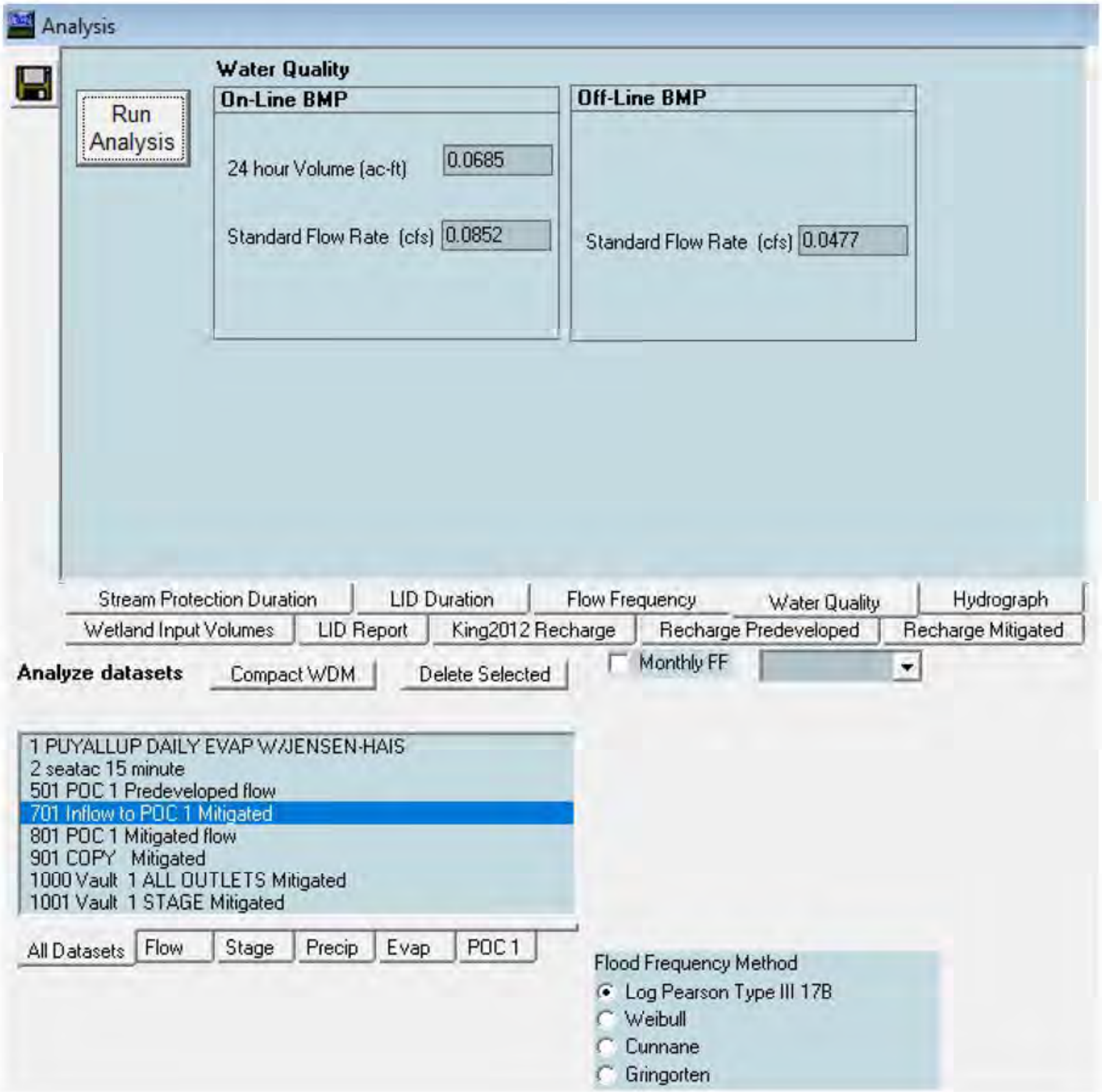
7. **Perforated Pipe Connection** – The City of Kirkland's amendment to the drainage manual (policy D-10) does not require a perforated stub out connection.

4.3 WATER QUALITY AND DESIGN

Per Section 1.2.8.2 of the 2016 KCSWDM, water quality treatment is required if the overall project creates or replaces 5,000 sf or more of pollution generating impervious surface (PGIS) area. The project proposes 9,700 sf of PGIS, which includes 9,600 sf of associated onsite driveways and private access road, and 100 sf of associated frontage improvements (driveway). The site is therefore required to provide water quality treatment. In addition, the site meets the threshold under Section 1.2.8.1.A.1 for an enhanced basic water quality treatment facility since the site is a residential subdivision development in which the actual density of single family units is equal to or greater than 8 units per acre of developed area.

Per Section 6.1.2 of the KCSWDM, Enhanced Basic WQ menu is designed to achieve > 30% dissolved copper removal and > 60% dissolved zinc removal; in addition to Basic treatment (80% TSS removal) for flows up to and including the WQ design flow or volume. The project will provide Enhanced Basic Water Quality Treatment via a 4' x 6' BioPod Biofilter System. The 4' x 6' BioPod is located upstream of the detention vault and will be modeled to include runoff from the access road, overflow from the driveway pavers and turnaround. Refer to the WWHM water quality flow rate in this section. The 100 year design flow was checked for overtopping.

Tributary to BioPod Biofilter System		
Impervious		
Onsite (60% Imp.- Driveways -Access Road)	0.29	ac
Driveways	0.07	ac
Access Road	0.15	ac
Total Impervious	**0.51**	**ac**
Pervious		
Lawn	0.19	ac
Total Lawn (Soil Group C - Till)	**0.19**	**ac**
Total Tributary to BioPod Biofilter System	**0.70**	**ac**



WWHM (15-minute Time Steps) Developed Area Flows (not including bypass areas)

Flow Frequency Return Periods for Developed. West Basin POC #1	
Return Period	**Flow(cfs)**
2 year	0.0241
5 year	0.0380
10 year	0.0486
25 year	0.0637
50 year	0.0762
100 year	0.0897

Per WWHM, the 15 min time step offline design discharge rate is 0.0477 cfs (21.4 gpm). The proposed 4'x6' BioPod Biofilter System can treat a water quality flow rate of 0.0571 cfs (25.6 gpm) and therefore meets the Enhanced Basic Water Quality Treatment.

Section 5 Conveyance Design

Stormwater runoff from the majority of site's impervious and pervious surfaces will enter a catch basin along the private access road and will be conveyed via a subgrade 12-inch conveyance system to a 4'x6' Biol Biofilter System, prior to entering the detention vault.

The 12-inch conveyance system was sized using the Rational Method and Manning's Equation. For the rational method equation, the peak flow rate was calculated using the characteristic of the areas tributary to the 12-inch conveyance system. The site's precipitation factor for the 100-yr 24-hour storm per Figure 3.2.1.D of the 2016 KCSWDM is 3.80. Refer to the Isopluvial Map included on the following pages. The impervious coverage assumed for the lot is consistent with the Kirkland Zoning Code lot coverage standards of 50% plus an additional 10% as required by the City's Standard Policy D-10 Section 3.2.2.1, totaling 60%. The peak flow from impervious surfaces (0.51-acres) and pervious surfaces (0.19-acres), tributary to the 12-inch conveyance system, is 1.59-cfs for the 100-year storm event. Refer to Section 4 for a breakdown of proposed areas in the developed condition. The capacity for the 12-inch conveyance system was calculated using Manning's Equation. Using Manning's equation, a 12-inch pipe at 2% has capacity to convey 5.89-cfs. Therefore, the 12-inch conveyance systems have adequate capacity to convey the 100-year storm. Please see calculations for the conveyance system below and on the following page.

Area Tributary to 12- inch Conveyance System

Type of Land Cover	C-Value	Area
Lawn	0.25	0.19
Pavements and Roofs	0.90	0.51
Total	**0.72**	**0.70**

I_R - Peak Rainfall Intensity

Storm Event	P_R Total Precipitation	A_R Coefficient	B_R Coefficient	T_C Time of Concentration	I_R
100-year	**3.8**	2.61	0.63	6.30	**3.11**

Rational Method

Storm Event	C	I_R	A	Q_R
100-year	0.72	3.11	0.71	**1.59**

MANNING'S EQUATION; 12" PIPE @ 2% = 5.89 CFS

$Q = 1.486/n * A * R^{2/3} * S^{1/2}$

n = roughness coefficient = **0.011**

A = cross sectional area of pipe = $\pi\ (D/2)^2 = \pi\ (1\ /2)^2 =$ **0.785**

R = wetted perimeter of pipe

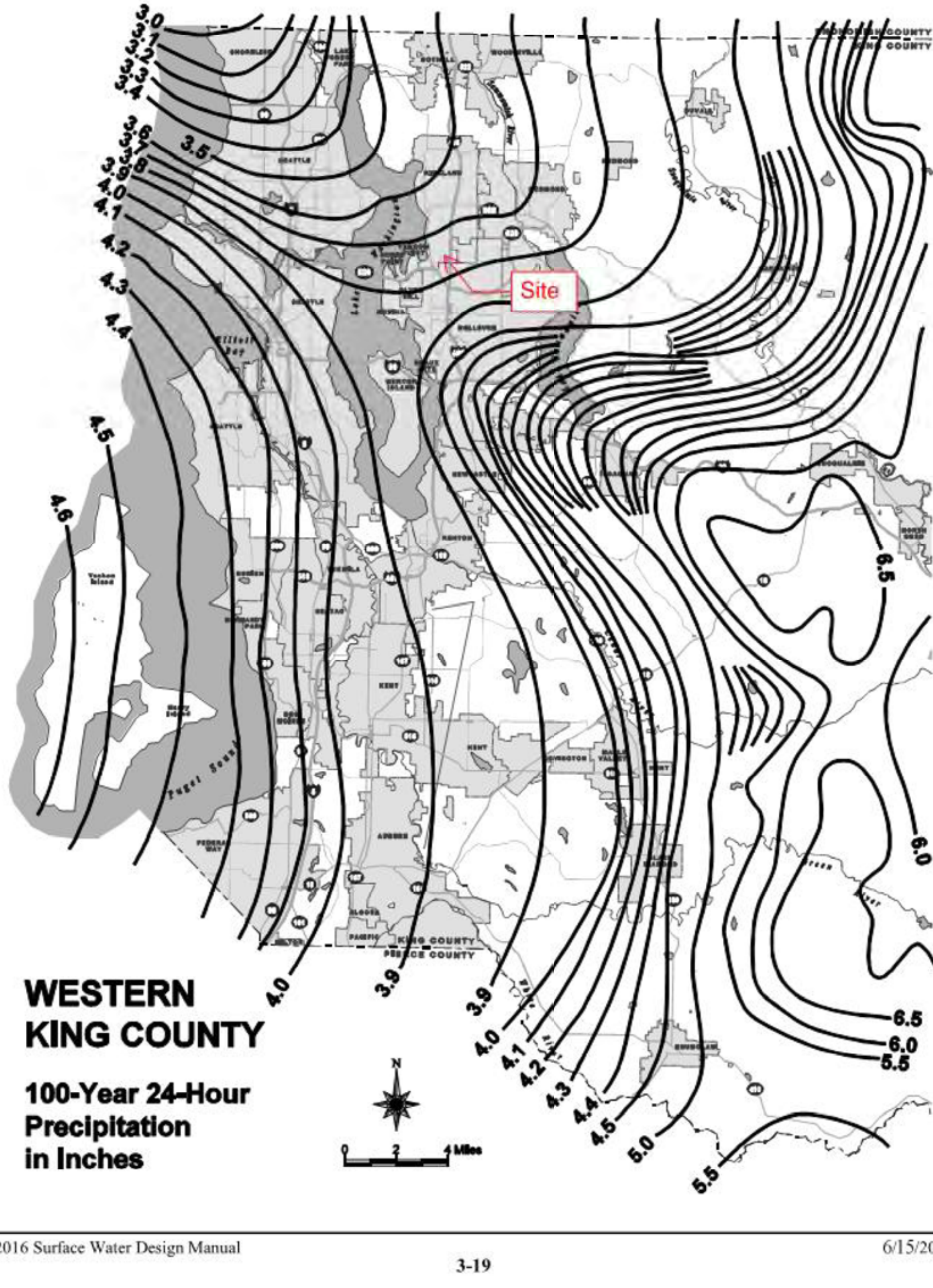
$R^{2/3} = (D/4)^{2/3} = (1\ /4)^{2/3} =$ **.397**

S = slope

$S^{1/2} = (0.02\ ft/ft)^{1/2} =$ **0.14**

Q = (1.486/0.011) * 0.785 * 0.397 * 0.14= **5.89 cfs**

FIGURE 3.2.1.D 100-YEAR 24-HOUR ISOPLUVIALS



Section 6 Special Reports and Studies

The listed items below are included in the following pages.

- Geotechnical Engineering Report prepared by the Riley Group, Inc., dated April 29,2020
- LID Infiltration Feasibility Study prepared by Riley-Group, Inc., dated June 5, 2018

RILEYGROUP

GEOTECHNICAL ENGINEERING REPORT

PREPARED BY:

THE RILEY GROUP, INC.
17522 BOTHELL WAY NORTHEAST
BOTHELL, WASHINGTON 98011

PREPARED FOR:

DC GRANGER HOMES
PO BOX 16438
SEATTLE, WASHINGTON 98116

RGI PROJECT NO. 2018-122

GRAVITY RIDES EVERYTHING
4559 112TH AVENUE NORTHEAST
KIRKLAND, WASHINGTON

APRIL 29, 2020

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RILEYGROUP

April 29, 2020

Mr. Darin Granger
DC Granger Homes
PO Box 16438
Seattle, Washington 98116

Subject: **Geotechnical Engineering Report**
Gravity Rides Everything
4559 112th Avenue Northeast
Kirkland, Washington
RGI Project No. 2018-122

Dear Mr. Granger:

As requested, The Riley Group, Inc. (RGI) has performed a Geotechnical Engineering Report (GER) for the Gravity Rides Everything located at 4559 112th Avenue Northeast, Kirkland, Washington. The information in this GER is based on our understanding of the proposed construction, and the soil and groundwater conditions encountered in the test probes completed by RGI at the site on May 10, 2018.

RGI reviewed the civil plans submitted for the project in preparing this report. RGI recommends that a representative of our firm be present on site during portions of the project construction to confirm that the soil and groundwater conditions are consistent with those that form the basis for the engineering recommendations in this GER.

If you have any questions or require additional information, please contact us.

Respectfully submitted,

THE RILEY GROUP, INC.

KRISTINA MARIE WELLER
STATE OF WASHINGTON
33182
REGISTERED
PROFESSIONAL ENGINEER

4/29/20

FOR:

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LIST OF FIGURES AND APPENDICES

Executive Summary

This Executive Summary should be used in conjunction with the entire Geotechnical Engineering Report (GER) for design and/or construction purposes. It should be recognized that specific details were not included or fully developed in this section, and the GER must be read in its entirety for a comprehensive understanding of the items contained herein. Section 7.0 should be read for an understanding of limitations.

RGI's geotechnical scope of work included the advancement of 5 test probes to approximate depths of 12 feet below existing site grades. RGI previously provided a report entitled LID Infiltration Feasibility Study dated June 5, 2018.

Based on the information obtained from our subsurface exploration, the site is suitable for development of the proposed project. The following geotechnical considerations were identified:

Soil Conditions: The soils encountered during field exploration include medium to very dense silty sand with some gravel grading to silty gravely sand (till), overlain by loose to medium dense silty sand with gravel and organics (fill). Underneath the very dense silty sand with gravel, stiff silt with sand was observed in test probe-1.

Groundwater: Light groundwater seepage was encountered at 6.5 feet below ground surface during our subsurface exploration.

Foundations: Foundations for the proposed building may be supported on conventional spread footings bearing on medium dense to dense native soil or structural fill.

Slab-on-grade: Slab-on-grade floors and slabs for the proposed building can be supported on medium dense to dense native soil or structural fill.

Pavements: The following pavement sections are recommended:

- **For the access roadway**: 2 inches of Hot Mix Asphalt (HMA) over 4 inches of Asphalt Treated Base (ATB) over 4 inches of crushed rock base (CRB)
- **For general parking areas**: 2 inches of HMA over 4 inches of CRB
- **For concrete pavement areas**: 5 inches of concrete over 4 inches of CRB

1.0 Introduction

This Geotechnical Engineering Report (GER) presents the results of the geotechnical engineering services provided for the Gravity Rides Everything in Kirkland, Washington. The purpose of this evaluation is to assess subsurface conditions and provide geotechnical recommendations for the construction of a single family residence with a detention vault, and access roadway. Our scope of services included field explorations, laboratory testing, engineering analyses, and preparation of this GER.

The recommendations in the following sections of this GER are based upon our current understanding of the proposed site development as outlined below. If actual features vary or changes are made, RGI should review them in order to modify our recommendations as required. In addition, RGI requests to review the site grading plan, final design drawings and specifications when available to verify that our project understanding is correct and that our recommendations have been properly interpreted and incorporated into the project design and construction.

2.0 Project description

The project site is located at 4559 112th Avenue Northeast in Kirkland, Washington. The approximate location of the site is shown on Figure 1.

The site currently consists of a single family residence with dense vegetation and trees surrounding the building and driveway. The single family residence on the site will be replaced by a new single family residence.

At the time of preparing this GER, building plans were not available for our review. Based on our experience with similar construction, RGI anticipates that the proposed building will be supported on perimeter walls with bearing loads of two to eight kips per linear foot, and a series of columns with a maximum load up to 30 kips. Slab-on-grade floor loading of 250 pounds per square foot (psf) are expected.

3.0 Field Exploration and Laboratory Testing

3.1 Field Exploration

On May 10, 2018, RGI observed the drilling of 5 test probes. The approximate exploration locations are shown on Figure 2.

Field logs of each exploration were prepared by the geotechnical engineer or geologist that continuously observed the drilling. These logs included visual classifications of the materials encountered during drilling as well as our interpretation of the subsurface conditions between samples. The test probes logs included in Appendix A represent an interpretation of the field logs and include modifications based on laboratory observation and analysis of the samples.

3.2 Laboratory Testing

During the field exploration, a representative portion of each recovered sample was sealed in containers and transported to our laboratory for further visual and laboratory examination. Selected samples retrieved from the test probes were tested for moisture content and grain size analysis, to aid in soil classification and provide input for the recommendations provided in this GER. The results and descriptions of the laboratory tests are enclosed in Appendix A.

4.0 Site Conditions

4.1 Surface

The subject site is a rectangular-shaped parcel of land approximately 0.86 acres in size. The site is bound to the north, south and west by residential property, and to the east by 112th Avenue Northeast.

The existing site is a single family residence covered by trees and other vegetation. The site slopes down from the east to the west with a steep slope about half way through, the total elevation change is approximately 34 feet, with a third of the elevation change happening in the center of the site.

4.2 Geology

Review of the *Geologic Map of the Kirkland Quadrangle, Washington,* by J. P. Minard (1983) indicates that the soil in the project vicinity is mapped as Vashon outwash (Qva) which is a nonsorted mixture of dense sand with varying amount of silt, gravel, and cobbles. Vashon till (Qt), is also located nearby, which is light to dark gray, nonsorted, nonstratified mixture of clay, silt, sand, and gravel. The till deposit is generally very stiff and impermeable, often resulting in poorly drained bogs developing in relatively flat area. The deposit is usually 1 to 2 meters thick, but locally can be as much as 25 meters. These descriptions are generally similar to the findings in our field explorations. The soil conditions were variable across the site, to the east very dense silty sand interpreted as Vashon-age lodgement till, to the west dense silty sand and silty gravelly sand.

4.3 Soils

The soils encountered during field exploration include medium to very dense silty sand with some gravel grading to silty gravely sand (till), overlain by loose to medium dense silty sand with gravel. Underneath the very dense silty sand with gravel, stiff silt with sand was observed in test probe-1.

More detailed descriptions of the subsurface conditions encountered are presented in the test probes included in Appendix A. Sieve analysis was performed on two selected soil samples. Grain size distribution curves are included in Appendix A.

4.4 GROUNDWATER

Light groundwater seepage was encountered 6.5 feet below the ground surface during our subsurface exploration. The groundwater appears to be perched over the top of the dense glacial till layer.

It should be recognized that fluctuations of the groundwater table will occur due to seasonal variations in the amount of rainfall, runoff, and other factors not evident at the time the explorations were performed. In addition, perched water can develop within seams and layers contained in fill soils or higher permeability soils overlying less permeable soils following periods of heavy or prolonged precipitation. Therefore, groundwater levels during construction or at other times in the future may be higher or lower than the levels indicated on the logs. Groundwater level fluctuations should be considered when developing the design and construction plans for the project.

4.5 SEISMIC CONSIDERATIONS

Based on the International Building Code (IBC), RGI recommends the follow seismic parameters for design.

Table 1 2015/2018 IBC

Parameter	2015 Value	2018 Value
Site Soil Class[1]	D[2]	
Site Latitude	47.6516417	
Site Longitude	-122.1915685	
Short Period Spectral Response Acceleration, S_S (g)	1.27	1.281
1-Second Period Spectral Response Acceleration, S_1 (g)	0.487	0.445
Adjusted Short Period Spectral Response Acceleration, S_{MS} (g)	1.27	1.281
Adjusted 1-Sec Period Spectral Response Acceleration, S_{M1} (g)	0.737	0.826[3]
Numeric seismic design value at 0.2 second; S_{DS}(g)	0.846	0.854
Numeric seismic design value at 1.0 second; S_{M1}(g)	0.492	0.551[3]

1. Note: In general accordance with Chapter 20 of ASCE 7-10 and 7-16, the Site Class is based on the average characteristics of the upper 100 feet of the subsurface profile.

2. Note: ASCE 7-10 and 7-16 require a site soil profile determination extending to a depth of 100 feet for seismic site classification. The current scope of our services does not include the required 100 fcot soil profile determination. Test probes extended to a maximum depth of 12 feet, and this seismic site class definition considers that similar soil continues below the maximum depth of the subsurface exploration. Additional exploration to deeper depths would be required to confirm the conditions below the current depth of exploration.

3. Note: In accordance with ASCE 11.4.8, a ground motion hazard analysis is not required for the following cases:

- Structures on Site Class E sites with S_S greater than or equal to 1.0, provided the site coefficient Fa is taken as equal to that of Site Class C.
- Structures on Site Class D sites with S_1 greater than or equal to 0.2, provided that the value of the seismic response coefficient Cs is determined by Eq. 12.8-2 for values of $T \leq 1.5Ts$ and taken as equal to 1.5 times the value computed in accordance with either Eq. 12.8-3 for $T_L \geq T > 1.5T_s$ or Eq. 12.8-4 for $T > TL$.
- Structures on Site Class E sites with S_1 greater than or equal to 0.2, provided that T is less than or equal to T_s and the equivalent static force procedure is used for design.

The above exceptions do not apply to seismically isolated structures, structures with damping systems or structures designed using the response history procedures of Chapter 16.

Liquefaction is a phenomenon where there is a reduction or complete loss of soil strength due to an increase in water pressure induced by vibrations from a seismic event. Liquefaction mainly affects geologically recent deposits of fine-grained sands that are below the groundwater table. Soils of this nature derive their strength from intergranular friction. The generated water pressure or pore pressure essentially separates the soil grains and eliminates this intergranular friction, thus reducing or eliminating the soil's strength.

RGI reviewed the results of the field and laboratory testing and assessed the potential for liquefaction of the site's soil during an earthquake. Since the site is underlain by glacial till, RGI considers that the possibility of liquefaction during an earthquake is minimal.

4.6 Geologic Hazard Areas

Regulated geologically hazardous areas include erosion, landslide, earthquake, or other geological hazards. Based on the definition in the Kirkland Zoning Code and City of Kirkland GIS mapping, portions of the site meet the criteria of a landslide hazard area. In order to discuss all of the aspect of the Kirkland Code, the code section and our response to each item is provided in the following section or referenced to the appropriate section of this report.

KZC 85.15.1. A topographic survey of the subject property, or the portion of the subject property specified by the Planning Official, with two (2) foot contour intervals. This mapping shall contain the following information:

a. Delineation of areas containing slopes 15 percent or greater, and identification of slopes 40 percent or greater.
b. Wetlands, streams and lakes on or adjacent to the subject property.
c. The location of storm drainage facilities on the subject property.
d. Existing vegetation, including size and type of significant trees.

Response: The general site topography slopes from east to west, with a total grade change of 34 feet with an elevation of approximately 400 feet along 112th Avenue Northeast to an elevation of approximately 366 feet at the west property line. This overall grade change it equivalent to the slope of 12 percent. There is a steeper grade change in the middle of the site which separates the east and west portions of the site.

The areas of greater than 15 percent and greater than 40 percent slope areas are shown on Figure 2. This area will be regraded to a flat grade less than 15 percent and a retaining wall will be constructed as part of the first home construction as shown on Figure 2.

No wetlands, streams, or lakes are on or adjacent to the property. No storm drainage facilities are located on the slope. The site is wooded with mature trees which show no signs of slope movement.

KZC 85.15.2. A geotechnical investigation, prepared by a geotechnical engineer licensed in Washington State or engineering geologist licensed in Washington State, to determine if a landslide hazard area or seismic hazard area exists on the subject property.

Response: The slope on the central portion of the is mapped as Moderate Susceptibility on the City of Kirkland Landslide Susceptibility Map with small areas mapped as high due to the small area with over 40 percent slope. The majority of the mapped area is less than 15 percent with a small area as shown on Figure 2 with greater than 15 percent slopes and the small area of greater than 40 percent slopes. The greater than 40 percent slope area is general 10 feet in height or less and appears to have been modified to create a flat yard area for the existing house including a small wall. Based on the topography and the subsurface conditions, the potential for landslides on the site in the current condition is low.

The site is mapped as moderate or mixed liquefaction potential on the City of Kirkland Liquefaction Potential Map. Based on the subsurface conditions, in our opinion the potential for liquefaction is low.

KZC 85.15.3. A geotechnical report, prepared by a geotechnical engineer licensed in Washington State or engineering geologist licensed in Washington State, showing and including the following information:

a. A description of how the proposed development will or will not affect slope stability, surface and subsurface drainage, erosion, and seismic hazards on the subject property and other potentially impacted properties.
b. Evidence, if any, of holocene or recent landsliding, sloughing, or soil creep.
c. The location of springs, seeps, or any other surface expression of groundwater, and the location of surface water or evidence of seasonal runoff or groundwater.
d. Identification of existing fill areas.
e. Soil description in accordance with the Unified Soil Classification Systems.
f. Depth to groundwater and estimates of potential seasonal fluctuations, if applicable to the project.
g. Subsurface exploration logs that assess geologic hazards at the site, meaning that soil descriptions on the logs shall be in accordance with the Unified Soil Classification System. In addition, the logs shall also identify each of the geologic units encountered (e.g., fill, Vashon lodgement till, Vashon advance outwash).

h. If the subject property is located within 100 feet of a high landslide hazard area, then a current LiDAR-based shaded relief map of the project area and a discussion of the licensed geotechnical professional interpretation of this mapping must be provided.

i. Results of a quantitative slope stability analysis for any project involving development within a horizontal distance "H" of a high landslide hazard area where "H" is equal to the height of the slope within the high landslide hazard area or 50 feet, whichever is greater. The evaluation of slope stability under seismic conditions shall be based on a horizontal ground acceleration equal to one-half of the peak horizontal ground acceleration with a two (2) percent in 50-year probability of exceedance as defined in the current version of the International Building Code.

j. A discussion of the presence or absence of site features potentially indicative of historic landslide activity or increased risk of future landslide activity. Such features include, but are not limited to, tree trunk deformation, emergent seepage, landslide scarps, tension cracks, reversed slope benches, hummocky topography, vegetation patterns, and area stormwater management practices.

k. Estimate of the magnitude of seismically induced settlement that could occur during a seismic event for any project involving development within a seismic hazard area. Estimation of the magnitude of seismically induced settlement shall be based on a peak horizontal ground acceleration based on a seismic event with a two (2) percent in 50-year probability of exceedance as defined in the current version of the International Building Code. This requirement may be waived if it can be demonstrated that construction methods will mitigate the risk of seismically induced settlement such that there will be no significant impacts to life, health, safety and property.

l. A summary or abstract of the geotechnical report for the property where the development activity is proposed. The abstract shall at a minimum include the type of hazard, extent of the hazard, hazard analysis and geologic conditions.

m. The geotechnical report shall state that the project can be undertaken safely as long as the measures/recommendations of the geotechnical report are incorporated into the project plans.

Response: The central portion of the site where the slope is located will be modified to create a level yard area including a retaining wall for grade changes. The finished grades will be less than 15 percent in this area. This construction will remove the landslide potential area on the site.

There is no indication of landsliding, sloughing or soil creep. No springs, seeps, or any surface expression of groundwater were observed. No surface water was observed. No significant fill soils were observed at the site in our explorations. The soils encountered are interpreted to be Vashon-age advance outwash deposits. Soils at the site are predominantly silty gravelly sand (SM). Groundwater was not encountered on the eastern

1/3 of the property. Perched groundwater seepage was encountered at approximately 6.5 feet on the western portion of the site.

Subsurface logs for test probes TP-1 through TP-5 are attached, soils encountered in all of the test probes consisted of soils interpreted to be of Vashon-age advance outwash deposits. No indication of historic landslide activity or increased risk to future landslide activity was observed.

Given the soil and groundwater conditions and the site topography, in our opinion, the potential for landslides or slope movement are very low. Based on the subsurface conditions, in our opinion the potential for liquefaction is low. Soils at the site are mapped as Alderwood gravelly sandy loam, 8 to 15 percent slopes. These soils may experience severe to very severe erosion hazard when they occur on slopes greater than 15 percent. RGI did not observe any signs of severe/very severe erosion at the site.

The site development can be undertaken safely as long as the measures and recommendations of this geotechnical report are incorporated into the project plans. Based on review of the plans prepared by Blueline dated April 16, 2020, the recommendations have been incorporated into the plans for the project including erosion control and retaining walls for grade changes.

5.0 Discussion and Recommendations

5.1 Geotechnical Considerations

Based on our study, the site is suitable for the proposed construction from a geotechnical standpoint. Foundations for the proposed residences can be supported on conventional spread footings bearing on medium dense to dense native soil or structural fill. Slab-on-grade floors and pavements can be similarly supported.

Detailed recommendations regarding the above issues and other geotechnical design considerations are provided in the following sections. Based on reviewing the plans prepared by Blueline dated April 16, 2020, these recommendations have been incorporated into the civil drawings for the project.

5.2 Earthwork

The earthwork is expected to include installation of erosion control measures, clearing the site areas, excavation and backfilling of the detention vault, installing underground utilities, grading the roadway, and constructing residences on the lots.

5.2.1 Erosion and Sediment Control

Potential sources or causes of erosion and sedimentation depend on construction methods, slope length and gradient, amount of soil exposed and/or disturbed, soil type, construction sequencing and weather. The impacts on erosion-prone areas can be reduced by implementing an erosion and sedimentation control plan. The plan should be designed in accordance with applicable city and/or county standards.

RGI recommends the following erosion control Best Management Practices (BMPs):

- Scheduling site preparation and grading for the drier summer and early fall months and undertaking activities that expose soil during periods of little or no rainfall
- Retaining existing vegetation whenever feasible
- Establishing a quarry spall construction entrance
- Installing siltation control fencing or anchored straw or coir wattles on the downhill side of work areas
- Covering soil stockpiles with anchored plastic sheeting
- Revegetating or mulching exposed soils with a minimum 3-inch thickness of straw if surfaces will be left undisturbed for more than one day during wet weather or one week in dry weather
- Directing runoff away from exposed soils and slopes
- Minimizing the length and steepness of slopes with exposed soils and cover excavation surfaces with anchored plastic sheeting (Graded and disturbed slopes should be tracked in place with the equipment running perpendicular to the slope contours so that the track marks provide a texture to help resist erosion and channeling. Some sloughing and raveling of slopes with exposed or disturbed soil should be expected.)
- Decreasing runoff velocities with check dams, straw bales or coir wattles
- Confining sediment to the project site
- Inspecting and maintaining erosion and sediment control measures frequently (The contractor should be aware that inspection and maintenance of erosion control BMPs is critical toward their satisfactory performance. Repair and/or replacement of dysfunctional erosion control elements should be anticipated.)

Permanent erosion protection should be provided by reestablishing vegetation using hydroseeding and/or landscape planting. Until the permanent erosion protection is established, site monitoring should be performed by qualified personnel to evaluate the effectiveness of the erosion control measures. Provisions for modifications to the erosion control system based on monitoring observations should be included in the erosion and sedimentation control plan.

5.2.2 STRIPPING

Stripping efforts should include removal of pavements, vegetation, organic materials, and deleterious debris from areas slated for building, pavement, and utility construction. The test probes encountered 6-12 inches of topsoil and rootmass. Deeper areas of stripping may be required in forested or heavily vegetated areas of the site.

5.2.3 EXCAVATIONS

All temporary cut slopes associated with the site and utility excavations should be adequately inclined to prevent sloughing and collapse. The site soils consist mostly of medium to very dense silty gravely sand, though this does vary slightly over the site.

Accordingly, for excavations more than 4 feet but less than 20 feet in depth, the temporary side slopes should be laid back with a minimum slope inclination of 1H:1V (Horizontal:Vertical). If there is insufficient room to complete the excavations in this manner, or excavations greater than 20 feet in depth are planned, using temporary shoring to support the excavations should be considered. For open cuts at the site, RGI recommends:

- No traffic, construction equipment, stockpiles or building supplies are allowed at the top of cut slopes within a distance of at least five feet from the top of the cut
- Exposed soil along the slope is protected from surface erosion using waterproof tarps and/or plastic sheeting
- Construction activities are scheduled so that the length of time the temporary cut is left open is minimized
- Surface water is diverted away from the excavation
- The general condition of slopes should be observed periodically by a geotechnical engineer to confirm adequate stability and erosion control measures

In all cases, however, appropriate inclinations will depend on the actual soil and groundwater conditions encountered during earthwork. Ultimately, the site contractor must be responsible for maintaining safe excavation slopes that comply with applicable OSHA or WISHA guidelines.

5.2.4 SITE PREPARATION

RGI anticipates that some areas of loose or soft soil will be exposed upon completion of stripping and grubbing. Proofrolling and subgrade verification should be considered an essential step in site preparation. After stripping, grubbing, and prior to placement of structural fill, RGI recommends proofrolling building and pavement subgrades and areas to receive structural fill. These areas should moisture conditioned and compacted to a firm and unyielding condition in order to achieve a minimum compaction level of 95 percent of the modified proctor maximum dry density as determined by the American Society of Testing and Materials D1557-09 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (ASTM D1557).

Proofrolling and adequate subgrade compaction can only be achieved when the soils are within approximately ± 2 percent moisture content of the optimum moisture content. Soils which appear firm after stripping and grubbing may be proofrolled with a heavy compactor, loaded double-axle dump truck, or other heavy equipment under the observation of an RGI representative. This observer will assess the subgrade conditions prior to filling. The need for or advisability of proofrolling due to soil moisture conditions should be determined at the time of construction. In wet areas it may be necessary to hand probe the exposed subgrades in lieu of proofrolling with mechanical equipment.

Subgrade soils that become disturbed due to elevated moisture conditions should be overexcavated to reveal firm, non-yielding, non-organic soils and backfilled with compacted structural fill. In order to maximize utilization of site soils as structural fill, RGI recommends that the earthwork portion of this project be completed during extended periods of warm and dry weather if possible. If earthwork is completed during the wet season (typically November through May) it will be necessary to take extra precautionary measures to protect subgrade soils. Wet season earthwork will require additional mitigative measures beyond that which would be expected during the drier summer and fall months.

5.2.5 Structural Fill

Once stripping, clearing and other preparing operations are complete, cuts and fills can be made to establish desired lot and roadway grades. Prior to placing fill, RGI recommends proof-rolling as described above.

RGI recommends fill below the foundation and floor slab, behind retaining walls, and below pavement and hardscape surfaces be placed in accordance with the following recommendations for structural fill. The structural fill should be placed after completion of site preparation procedures as described above.

The suitability of excavated site soils and import soils for compacted structural fill use will depend on the gradation and moisture content of the soil when it is placed. As the amount of fines (that portion passing the U.S. No. 200 sieve) increases, soil becomes increasingly sensitive to small changes in moisture content and adequate compaction becomes more difficult or impossible to achieve. Soils containing more than about 5 percent fines cannot be consistently compacted to a dense, non-yielding condition when the moisture content is more than 2 percent above or below optimum. Optimum moisture content is that moisture that results in the greatest compacted dry density with a specified compactive effort.

Non-organic site soils are only considered suitable for structural fill provided that their moisture content is within about two percent of the optimum moisture level as determined by ASTM D1557. Excavated site soils may not be suitable for re-use as structural fill depending on the moisture content and weather conditions at the time of construction. If soils are stockpiled for future reuse and wet weather is anticipated, the stockpile should be protected with plastic sheeting that is securely anchored. Even during dry weather, moisture conditioning (such as, windrowing and drying) of site soils to be reused as structural fill may be required.

Even during the summer, delays in grading can occur due to excessively high moisture conditions of the soils or due to precipitation. If wet weather occurs, the upper wetted portion of the site soils may need to be scarified and allowed to dry prior to further earthwork, or may need to be wasted from the site.

The site soils are moisture sensitive and may require moisture conditioning prior to use as structural fill. If on-site soils are or become unusable, it may become necessary to import clean, granular soils to complete site work that meet the grading requirements listed in Table 2 to be used as structural fill.

Table 2 Structural Fill Gradation

U.S. Sieve Size	Percent Passing
4 inches	100
No. 4 sieve	22 to 100
No. 200 sieve	0 to 5*

*Based on minus 3/4 inch fraction.

Prior to use, an RGI representative should observe and test all materials imported to the site for use as structural fill. Structural fill materials should be placed in uniform loose layers not exceeding 12 inches and compacted as specified in Table 3. The soil's maximum density and optimum moisture should be determined by ASTM D1557.

Table 3 Structural Fill Compaction ASTM D1557

Location	Material Type	Minimum Compaction Percentage	Moisture Content Range	
Foundations	On-site granular or approved imported fill soils:	95	+2	-2
Retaining Wall Backfill	On-site granular or approved imported fill soils:	92	+2	-2
Slab-on-grade	On-site granular or approved imported fill soils:	95	+2	-2
General Fill (non-structural areas)	On-site soils or approved imported fill soils:	90	+3	-2
Pavement – Subgrade and Base Course	On-site granular or approved imported fill soils:	95	+2	-2

Placement and compaction of structural fill should be observed by RGI. A representative number of in-place density tests should be performed as the fill is being placed to confirm that the recommended level of compaction is achieved.

5.2.6 Cut and Fill Slopes

All permanent cut and fill slopes should be graded with a finished inclination no greater than 2H:1V. Upon completion of construction, the slope face should be trackwalked, compacted and vegetated, or provided with other physical means to guard against erosion. All fill placed for slope construction should meet the structural fill requirements as described in Section 5.2.5.

Final grades at the top of the slopes must promote surface drainage away from the slope crest. Water must not be allowed to flow in an uncontrolled fashion over the slope face. If it is necessary to direct surface runoff towards the slope, it should be controlled at the top of the slope, piped in a closed conduit installed on the slope face, and taken to an appropriate point of discharge beyond the toe of the slope.

5.2.7 Wet Weather Construction Considerations

RGI recommends that preparation for site grading and construction include procedures intended to drain ponded water, control surface water runoff, and to collect shallow subsurface seepage zones in excavations where encountered. It will not be possible to successfully compact the subgrade or utilize on-site soils as structural fill if accumulated water is not drained prior to grading or if drainage is not controlled during construction. Attempting to grade the site without adequate drainage control measures will reduce the amount of on-site soil effectively available for use, increase the amount of select import fill materials required, and ultimately increase the cost of the earthwork phases of the project. Free water should not be allowed to pond on the subgrade soils. RGI anticipates that the use of berms and shallow drainage ditches, with sumps and pumps in utility trenches, will be required for surface water control during wet weather and/or wet site conditions.

5.3 Foundations

Following site preparation and grading, the proposed residence foundations can be supported on conventional spread footings bearing on medium dense to dense native soil or structural fill. Loose, organic, or other unsuitable soils may be encountered in the proposed building footprint. If unsuitable soils are encountered, they should be overexcavated and backfilled with structural fill. If loose soils are encountered, the soils should be moisture conditioned and compacted to the requirements of structural fill.

Perimeter foundations exposed to weather should be at a minimum depth of 18 inches below final exterior grades. Interior foundations can be constructed at any convenient depth below the floor slab. Finished grade is defined as the lowest adjacent grade within 5 feet of the foundation for perimeter (or exterior) footings and finished floor level for interior footings.

Table 4 Foundation Design

Design Parameter	Value
Allowable Bearing Capacity	2,500 psf[1]
Friction Coefficient	0.30
Passive pressure (equivalent fluid pressure)	250 pcf[2]
Minimum foundation dimensions	Columns: 24 inches Walls: 16 inches

1. psf = pounds per square foot
2. pcf = pounds per cubic foot

The allowable foundation bearing pressures apply to dead loads plus design live load conditions. For short-term loads, such as wind and seismic, a 1/3 increase in this allowable capacity may be used. At perimeter locations, RGI recommends not including the upper 12 inches of soil in the computation of passive pressures because they can be affected by weather or disturbed by future grading activity. The passive pressure value assumes the foundation will be constructed neat against competent soil or backfilled with structural fill as described in Section 5.2.5. The recommended base friction and passive resistance value includes a safety factor of about 1.5.

With spread footing foundations designed in accordance with the recommendations in this section, maximum total and differential post-construction settlements of 1 inch and 1/2 inch, respectively, should be expected.

5.4 Retaining Walls

If retaining walls are needed for the residences or for the detention vault, RGI recommends cast-in-place concrete walls be used. Modular block wall may be used for grade changes outside of the proposed structures consisting either gravity or geogrid reinforced walls.

The magnitude of earth pressure development on cast in place retaining walls will partly depend on the quality of the wall backfill. RGI recommends placing and compacting wall backfill as structural fill. Wall drainage will be needed behind the wall face. A typical retaining wall drainage detail is shown in Figure 3.

With wall backfill placed and compacted as recommended, and drainage properly installed, RGI recommends using the values in the following table for cast in place retaining wall design. The subgrade for the detention vault is expected to consist of dense native soils and the higher bearing capacity may be used for the vault foundation deign. The vault drainage should be tied into the storm system downstream of the vault as shown on Sheet 7 of the plans.

Table 5 Retaining Wall Design

Design Parameter	Value
Allowable Bearing Capacity - Structural Fill Dense native soils	2,500 psf 4,000 psf
Active Earth Pressure (unrestrained walls)	35 pcf
At-rest Earth Pressure (restrained walls)	50 pcf

For seismic design, an additional uniform load of 7 times the wall height (H) for unrestrained walls and 14H in psf for restrained walls should be applied to the wall surface. Friction at the base of foundations and passive earth pressure will provide resistance to these lateral loads. Values for these parameters are provided in Section 5.3.

5.5 Slab-on-Grade Construction

Once site preparation has been completed as described in Section 5.2, suitable support for slab-on-grade construction should be provided. RGI recommends that the concrete slab be placed on top of medium dense native soil or structural fill. Immediately below the floor slab, RGI recommends placing a four-inch thick capillary break layer of clean, free-draining sand or gravel that has less than five percent passing the U.S. No. 200 sieve. This material will reduce the potential for upward capillary movement of water through the underlying soil and subsequent wetting of the floor slab. Where moisture by vapor transmission is undesirable, an 8- to 10-millimeter thick plastic membrane should be placed on a 4-inch thick layer of clean gravel.

For the anticipated floor slab loading, we estimate post-construction floor settlements of 1/4- to 1/2-inch. For thickness design of the slab subjected to point loading from storage racks and fork lift vehicle traffic, RGI recommends using a subgrade modulus (K_S) of 150 pounds per square inch per inch of deflection.

5.6 Drainage

5.6.1 Surface

Final exterior grades should promote free and positive drainage away from the building area. Water must not be allowed to pond or collect adjacent to foundations or within the immediate building area. For non-pavement locations, RGI recommends providing a minimum drainage gradient of 3 percent for a minimum distance of 10 feet from the building perimeter. In paved locations, a minimum gradient of 1 percent should be provided unless provisions are included for collection and disposal of surface water adjacent to the structure.

5.6.2 Subsurface

RGI recommends installing perimeter foundation drains. A typical footing drain detail is shown on Figure 4. The foundation drains and roof downspouts should be tightlined separately to an approved discharge facility. Subsurface drains must be laid with a gradient sufficient to promote positive flow to a controlled point of approved discharge.

5.6.3 Infiltration

The site infiltration evaluation was provided under separate cover.

5.7 Utilities

Utility pipes should be bedded and backfilled in accordance with American Public Works Association (APWA) specifications. For site utilities located within the right-of-ways, bedding and backfill should be completed in accordance with City of Kirkland specifications. At a minimum, trench backfill should be placed and compacted as structural fill, as described in Section 5.2.5. Where utilities occur below unimproved areas, the degree of compaction can be reduced to a minimum of 90 percent of the soil's maximum density as determined by the referenced ASTM D1557. As noted, soils excavated on site will be suitable for use as backfill material proved the soils can be moisture conditioned. Imported structural fill meeting the gradation provided in Table 2 may be necessary for trench backfill if the native soils cannot be moisture conditioned or if the backfill take place in wet weather.

5.8 Pavements

Pavement subgrades should be prepared as described in Section 5.2 and as discussed below. Regardless of the relative compaction achieved, the subgrade must be firm and relatively unyielding before paving. The subgrade should be proof-rolled with heavy construction equipment to verify this condition.

5.8.1 Flexible Pavements

With the pavement subgrade prepared as described above, RGI recommends the following pavement sections for parking and drive areas paved with flexible asphalt concrete surfacing.

- **For access roadway areas**: 2 inches of Hot Mix Asphalt (HMA) over 4 inches of Asphalt Treated Base (ATB) over 4 inches of crushed rock base (CRB)

5.8.2 Concrete Pavements

With the pavement subgrade prepared as described above, RGI recommends the following pavement sections for parking and drive areas paved with concrete surfacing.

- **For concrete pavement areas**: 5 inches of concrete over 4 inches of CRB

The paving materials used should conform to the WSDOT specifications for HMA, ATB concrete paving, and CRB surfacing (9-03.9(3) Crushed Surfacing).

Long-term pavement performance will depend on surface drainage. A poorly-drained pavement section will be subject to premature failure as a result of surface water infiltrating into the subgrade soils and reducing their supporting capability.

For optimum pavement performance, surface drainage gradients of no less than 2 percent are recommended. Also, some degree of longitudinal and transverse cracking of the pavement surface should be expected over time. Regular maintenance should be planned to seal cracks when they occur.

6.0 Additional Services

RGI is available to provide further geotechnical consultation throughout the design phase of the project. RGI should review the final design and specifications in order to verify that earthwork and foundation recommendations have been properly interpreted and incorporated into project design and construction.

RGI is also available to provide geotechnical engineering and construction monitoring services during construction. The integrity of the earthwork and construction depends on proper site preparation and procedures. In addition, engineering decisions may arise in the field in the event that variations in subsurface conditions become apparent. Construction monitoring services are not part of this scope of work. If these services are desired, please let us know and we will prepare a cost proposal.

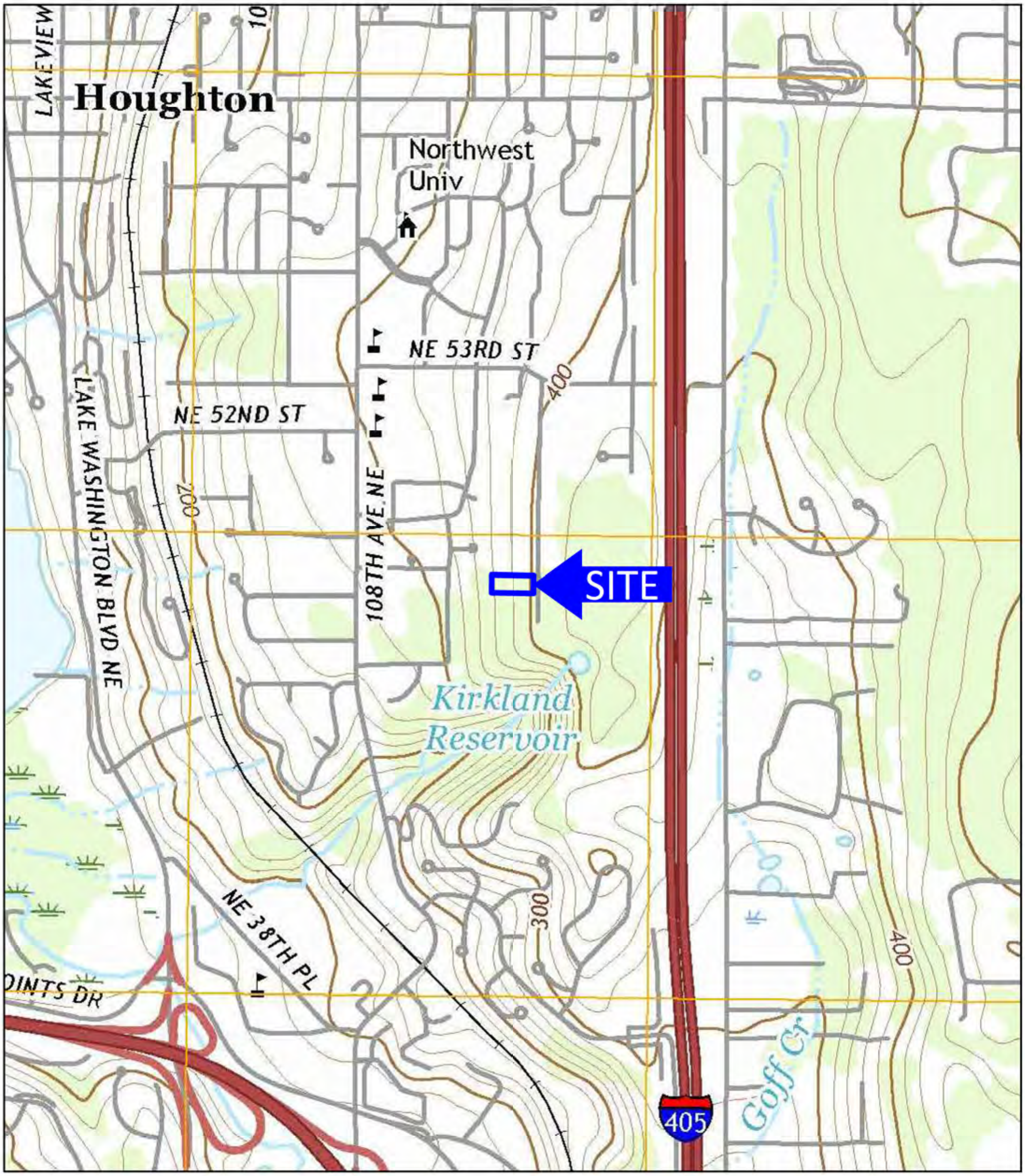
7.0 Limitations

This GER is the property of RGI, DC Granger Homes, and its designated agents. Within the limits of the scope and budget, this GER was prepared in accordance with generally accepted geotechnical engineering practices in the area at the time this GER was issued. This GER is intended for specific application to the Gravity Rides Everything project in Kirkland, Washington, and for the exclusive use of DC Granger Homes and its authorized representatives. No other warranty, expressed or implied, is made. Site safety, excavation support, and dewatering requirements are the responsibility of others.

The scope of services for this project does not include either specifically or by implication any environmental or biological (for example, mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, we can provide a proposal for these services.

The analyses and recommendations presented in this GER are based upon data obtained from the explorations performed on site. Variations in soil conditions can occur, the nature and extent of which may not become evident until construction. If variations appear evident, RGI should be requested to reevaluate the recommendations in this GER prior to proceeding with construction.

It is the client's responsibility to see that all parties to the project, including the designers, contractors, subcontractors, are made aware of this GER in its entirety. The use of information contained in this GER for bidding purposes should be done at the contractor's option and risk.



USGS, 2017, Kirkland, Washington
7.5-Minute Quadrangle

Approximate Scale: 1"=1000'

0 500 1000 2000

N

RILEYGROUP Corporate Office 17522 Bothell Way Northeast Bothell, Washington 98011 Phone: 425.415.0551 Fax: 425.415.0311	Blueprint 112th		Figure 1
	RGI Project Number 2018-122	Site Vicinity Map	Date Drawn: 04/2020
	Address: 4559 112th Avenue Northeast, Kirkland, Washington 98033		