

December 1, 2016
1578-16-006

Town of Gibsons
474 South Fletcher Rd
Box 340 Gibsons, BC,
V0N 1V0

Attention: Andre Boel, Director of Planning
Dave Newman, Director of Engineering

Dear Messer's. Boel and Newman,

RE: DRAFT - Hydrogeological Review Update for the Proposed "The George" Mixed Use Development at 377, 385 & 407 Gower Point Road, 397 & 689 Winn Road, and Winn Road Right-of-Way, Gibsons, BC

1.0 INTRODUCTION

This memo is part of an ongoing hydrogeological review of the design for the Proposed Mixed Use Development, "The George", located at 377, 385 & 407 Gower Point Road, 397 & 689 Winn Road, and Winn Road Right-of-Way, Gibsons, BC (the Project). Waterline Resources Inc. (Waterline)'s role in this Project is to review the proposed Project design on behalf of the Town and advise of potential risks relating to the protection of the Gibsons Aquifer. It should be noted that Waterline in no way endorses the designs or any technical recommendations made by the proponent or its consultants or representatives, nor does Waterline accept any responsibility for the hydrogeological aspects of this project. In addition, as Waterline's expertise is specifically hydrogeology, the review of geotechnical aspects of the proposed development are being addressed by WSP Canada Inc. (WSP) formerly Levelton Consultants Ltd.

This memo includes hydrogeological review comments and recommendations regarding the following documents:

- The Horizon updated project drawings, *G1 through G6*, dated September/October 2016,
- The Horizon Engineering Inc. (Horizon), *Memorandum Regarding Hydrogeological Review*, dated June 12, 2015, and
- The Keystone Environmental, *Report of Findings-Detailed Site Investigation*, dated October 2016

2.0 UPDATED DRAWING REVIEW COMMENTS

This section summarises Waterline's review of the Horizon updated drawings, as they relate to the on land portion of the proposed development re-design. [REDACTED]

[REDACTED]

Waterline reviewed six drawings received from Horizon on November 25th, 2016 (Horizon 2016). Waterline's main concern with the land portion of the project relates to the possibility of an uncontrollable breach of the Gibsons Aquitard/Aquifer caused by the proposed development as presented in Horizon's Deep Soil Mixing (DSM) Plan. Based on our review of the information, it appears that the currently proposed DSM Plan will in fact penetrate the Gibsons Aquitard to the top of the Gibsons Aquifer, thereby disturbing the protective layer over the Gibsons Aquifer. Waterline understands that the DSM technology involves simultaneous soil auguring and grout injection, which has not been demonstrated to provide control of the artesian pressure in the Gibsons Aquifer if the aquitard is been penetrated. As previously discussed, and required by Horizon during previous drilling programs at the site (see Horizon Drilling Barge Drilling Program, 2014), drilling/well control is required at all times for activities involving ground disturbance within the Town of Gibsons designated Development Permit Area (DPA). The proposed DSM being proposed using auger drilling which penetrates the Gibsons Aquifer/Aquitard may not provide the required control of artesian flow and therefore could result in a detrimental impact to the viability of the Gibsons Aquifer. In addition Waterline has concerns over the potential for development of preferential flow pathways through the aquitard at the margin between the DSM improved soils and the unimproved soils.

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

3.2 Comment 2

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

3.3 Comment 3

[REDACTED]

[REDACTED]

[REDACTED]

3.4 Comment 4

On page 5 under the heading, Section 2.2 – Review Comments on Section 12 (Ground Improvement) Horizon 2015 states:

“On the foreshore, Appendix 1 presents a calculation of the impact on the hydraulic conductivity of the seabed aquitard if 200 pile-shaped “plugs” of permeable sand, rather than solid piles are to be installed. This calculation anticipates an increase in hydraulic conductivity of the seabed aquitard of approximately 5 percent”

It is not entirely clear from the discussion presented in Appendix 1 how the material properties of the aquitard were changed for this analysis. However, it appears the hydrogeologist/modeller simply changed the bulk hydraulic conductivity of the entire aquitard across the property from 5.0×10^{-5} m/s to 5.5×10^{-5} m/s to account for the proposed 200 more permeable (1×10^{-3} m/s) soil columns/holes rather than model these higher permeability "conduits". The presence of these higher permeability conduits would more likely act as preferential pathways and should be modeled as such for the model to simulate a realistic hydraulic response. In this specific case, because the underlying aquifer is known to be flowing artesian, the effect would likely elevate the risk of an uncontrollable discharge from the aquifer.

3.5 Comment 5

On page 5 under the heading, Section 2.2 Review Comments on Section 17.2 (Piles)

Horizon's response to Waterline's concern regarding the pile design and the proposed pile installation procedure references their conclusion that the Gibsons Aquifer is only partially confined at the project site. Horizon goes on to indicate that 200 holes drilled into the aquitard would only slightly affect the integrity of the Gibsons Aquitard. As Waterline pointed out under Comment 1 and Comment 4, neither of these conclusion are supported by the site data presented by Horizon. This demonstrates a fundamental misunderstanding of the hydrogeologic system at the project site. Consequently, the current design and construction plan does not adequately address hydrogeological complexity and potential risk to the Gibsons Aquifer/Aquitard system.

3.6 Comment 6

On page 5 under the heading, Section 2.2 Review Comments on Section 17.3 (Dredging)

Horizon's report does not provide sufficient detail to determine how the proposed dredging plan may impact the Gibsons Aquifer/Aquitard system.

3.7 Comment 7

[REDACTED]

[REDACTED]

4.0 WATERLINE REVIEW OF KEYSTONE REPORT

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

Page 32 (Paragraph 1) of the Keystone report indicates that the excavation and off-site disposal or the soil contamination was not selected as a remediation option due to concerns regarding the disturbance of the Gibson Aquitard. However, the report does not distinguish between soil contamination in the surficial fill, peat, and/or sand and silt deposits above, and possibly within, the aquitard.

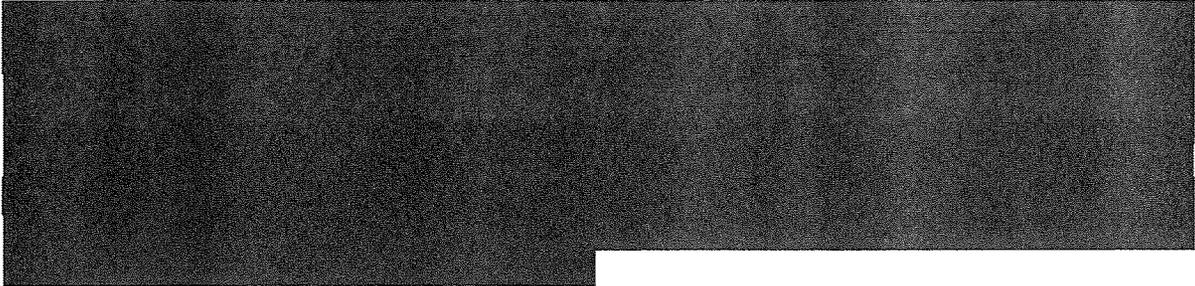
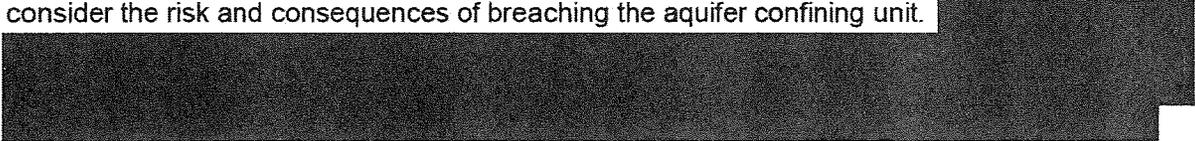
Page 32 (Paragraph 3) states:

"The shallow sediments in the adjacent foreshore area at the Site are comprised primarily of sand and gravel and have been assessed as geotechnical as suitable for use onsite as fill material."

If the contaminated material in the foreshore is removed, the depth and areal extent of excavation should be clearly determined and assurances provided that the excavation will not penetrate the Gibsons Aquitard. Consideration should also be given to how this may affect future erosion of the remaining sediments above the Aquitard.

5.0 CLOSURE

Based on Waterline's review of the various documents provided by Horizon and Keystone regarding the George Hotel Development, it appears that the assessments do not fully recognize the potential risks of the proposed foundation plan to the Gibsons Aquifer. In particular, the conceptual hydrogeological model which Horizon's numerical analysis is based on, does not appear to reflect the natural conditions of the Gibsons Aquifer. Based on the numerical model assessment, Horizon concludes that the Gibsons Aquifer behaves as an unconfined system at the project site. This conclusion contradicts the conceptual hydrogeological model supported by water level data indicating that flowing artesian aquifer pressures exist in Lower Gibsons and reflect the confined nature of the aquifer. Based on the work completed to date for the Town of Gibsons, Waterline is of the opinion that the proposed deep soil mixing program does not adequately consider the risk and consequences of breaching the aquifer confining unit.



Waterline trust that the information provided in this document is sufficient for your requirements. Should you have any questions or concerns, please do not hesitate to contact the undersigned.

Respectfully submitted,

Waterline Resources Inc.

Bernadette Lyons, M.Sc.E., P.Eng
Senior Hydrogeological Engineer

Darren David, M.Sc., P.Geo.
VP Operations and Principal Hydrogeologist

6.0 REFERENCES

Horizon Engineering Inc., 2014. Geotechnical Investigation Report (Revised) for the Proposed "The George" Mixed Use Development at 377, 385 & 407 Gower Point Road, 397 & 689 Winn Road, and Winn Road Right-of-Way, Gibsons, BC. April 7, 2015.

Horizon Engineering Inc., 2016. Drawing G1: Excavation and Shoring Plan Cover Sheet. For the Proposed "The George" Mixed Use Development at 377, 385 & 407 Gower Point Road, 397 & 689 Winn Road, and Winn Road Right-of-Way, Gibsons, BC. September 2016.

Horizon Engineering Inc., 2016a. Drawing G2: Test Hole Location Plan, Section 'A' and Schematic Section. For the Proposed "The George" Mixed Use Development at 377, 385 & 407 Gower Point Road, 397 & 689 Winn Road, and Winn Road Right-of-Way, Gibsons, BC. October 2016.

Horizon Engineering Inc., 2016b. Drawing G3: Section 'B', 'C', 'D' and 'E'. For the Proposed "The George" Mixed Use Development at 377, 385 & 407 Gower Point Road, 397 & 689 Winn Road, and Winn Road Right-of-Way, Gibsons, BC. October 2016.

Horizon Engineering Inc., 2016c. Drawing G4: Excavation and Shoring Plan. For the Proposed "The George" Mixed Use Development at 377, 385 & 407 Gower Point Road, 397 & 689 Winn Road, and Winn Road Right-of-Way, Gibsons, BC. September 2016.

Horizon Engineering Inc., 2016d. Drawing G5: Bulk Excavation Plan. For the Proposed "The George" Mixed Use Development at 377, 385 & 407 Gower Point Road, 397 & 689 Winn Road, and Winn Road Right-of-Way, Gibsons, BC. September 2016.

Horizon Engineering Inc., 2016e. Drawing G6: Deep Soil Mixing Plan. For the Proposed "The George" Mixed Use Development at 377, 385 & 407 Gower Point Road, 397 & 689 Winn Road, and Winn Road Right-of-Way, Gibsons, BC. September 2016.

Keystone Environmental Project, 2016. Report of Findings – Detailed Site Investigation, 377, 385 & 407 Gower Point Road, 689 Winn Road 312845-04, Gibsons BC. Project 12845-04. October 2016.

Waterline Resources Ltd., 2015. Hydrogeological Review of the Revised "The George" Geotechnical Investigation Report (Revised), May 4, 2015

7.0 LIMITATIONS AND USE

The information presented in this document was compiled exclusively for the Town of Gibsons (the Client) by Waterline Resources Inc. (Waterline). This work was completed in accordance with the scope of work for this project that was agreed between Waterline and the Client. Waterline exercised reasonable skill, care and diligence to assess the information acquired during the preparation of this document, but makes no guarantees or warranties as to the accuracy or completeness of this information. The information contained in this document is based upon, and limited by, the circumstances and conditions acknowledged herein, and upon information available at the time of the preparation of this document. Any information provided by others is believed to be accurate but cannot be guaranteed. No other warranty, expressed or implied, is made as to the professional services provided to the Client.

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Date: 14 March 2017
Project No.: 161-16368-00

Town of Gibsons
474 South Fletcher Road
Box 340
Gibsons, BC
V0N 1V0

FOR
CLIENT REVIEW

Attention: **Mr. Andre Boel, RPP**
Director of Planning

Subject: **Geotechnical Review in support of Development Permit Application Stage**
The George Mixed Use Development, Gibsons, BC.

Dear Sir:

1.0 INTRODUCTION

WSP Canada Inc. (WSP – formerly Levelton Consultants Ltd) was retained in February 2014 to provide the Town of Gibsons with geotechnical consulting services related to the proposed "The George" development in Gibsons BC. The purpose of the engagement was to provide the Town with a level of professional due diligence in relation to geotechnical considerations associated with the Town's responsibilities as the approving authority. In conjunction with WSP's appointment, Waterline Resources Inc., of Nanaimo was retained separately by the Town to provide professional due diligence in relation to hydrogeological considerations related to The George. Since the initial appointment, several geotechnical documents have been produced by the Owner's geotechnical consultant, Horizon Engineering Inc. (Horizon) that have been reviewed by WSP, as well as several meetings. The last review document that was produced by WSP was dated 07 May 2015 and pertained to a geotechnical report prepared by Horizon dated 07 April 2015.

A list of documents that have been provided to WSP as part of the current review is provided at the end of this letter. It is noted that further commentary was prepared by Horizon in relation to the WSP 07 May 2015 letter report, but that no further formal review of that or subsequent documents has been conducted by WSP until now.

We understand that the documents that have been provided to WSP for review are in support of a Development Permit Application for the project. From our perspective, pertinent Town of Gibsons reference documents related to the development approval process include:

- Geotechnical Hazard Development Permit Area No 1. This particular Development Permit Area pertains to hazards described as *soil land sliding and wave erosion along beachfront slopes, potential soil landslides and adverse stream erosion and deposition on steep ravine slopes and potential rock fall*. Not specifically listed in Development Permit Area No 1 are adverse seismic

WSP Canada Inc.
1935 Bollinger Road
Nanaimo, BC
V9S 5W9

Tel: 250-753-1077
Fax: 250 753-1203
www.wspgroup.com

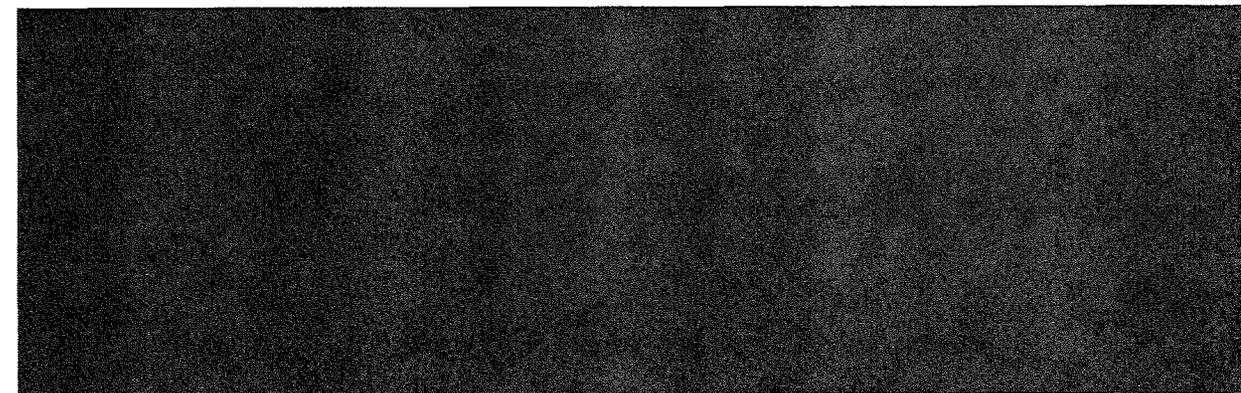
ground response such as liquefaction potential or potential for seismically induced ground movements. However, such hazards may be considered within the intent of the document;

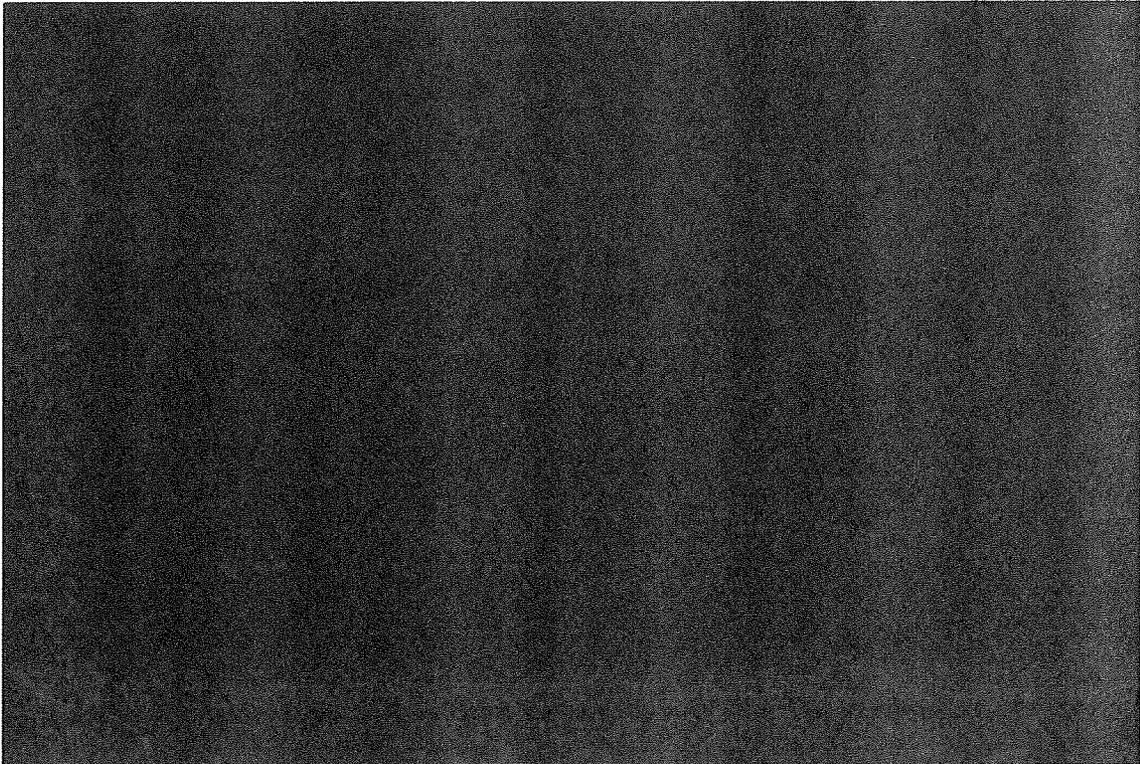
- Environmentally Sensitive Development Permit Area No 2. Relative to the proposed The George development, this primarily relates to historical contaminated soils and groundwater potential; and
- Gibsons Aquifer Development Permit Area No 9. This document was prepared with the intent of protecting the integrity and value of the Gibsons Aquifer, which provides approximately 73% of potable water to the Town. The document indicates that excavation must be undertaken in a manner to avoid contamination and protect sustainable use as a drinking water source. It specifically notes that penetration of the aquitard that confines the aquifer could create an uncontrolled release of large volumes of groundwater under artesian pressure. As such, there is a requirement to protect the integrity of the low permeable till layer (the aquitard) that confines and maintains artesian pressure.

This letter outlines a number of findings and raises several uncertainties related to the documents that have been reviewed. As indicated in further detail herein, our overall conclusion is that we remain of the opinion that the level of subsurface characterization that has been completed to date is not commensurate with the risks associated with a potential uncontrolled breach of the Gibsons Aquifer at this site. We are also of the opinion that the Owner's team has not developed a satisfactory mitigation strategy in the event that the aquifer were to be breached nor has the nature of the measures that would be implemented on a short and long term basis to control a breach and protect the aquifer been adequately described.

2.0 COMPLETENESS OF DOCUMENTATION RELATED TO THE DEVELOPMENT PERMIT APPLICATION

As noted above, the documents that WSP has been provided with are listed in the reference section at the end of the letter. Our general comments on the information in relation to a Development Permit Application are:



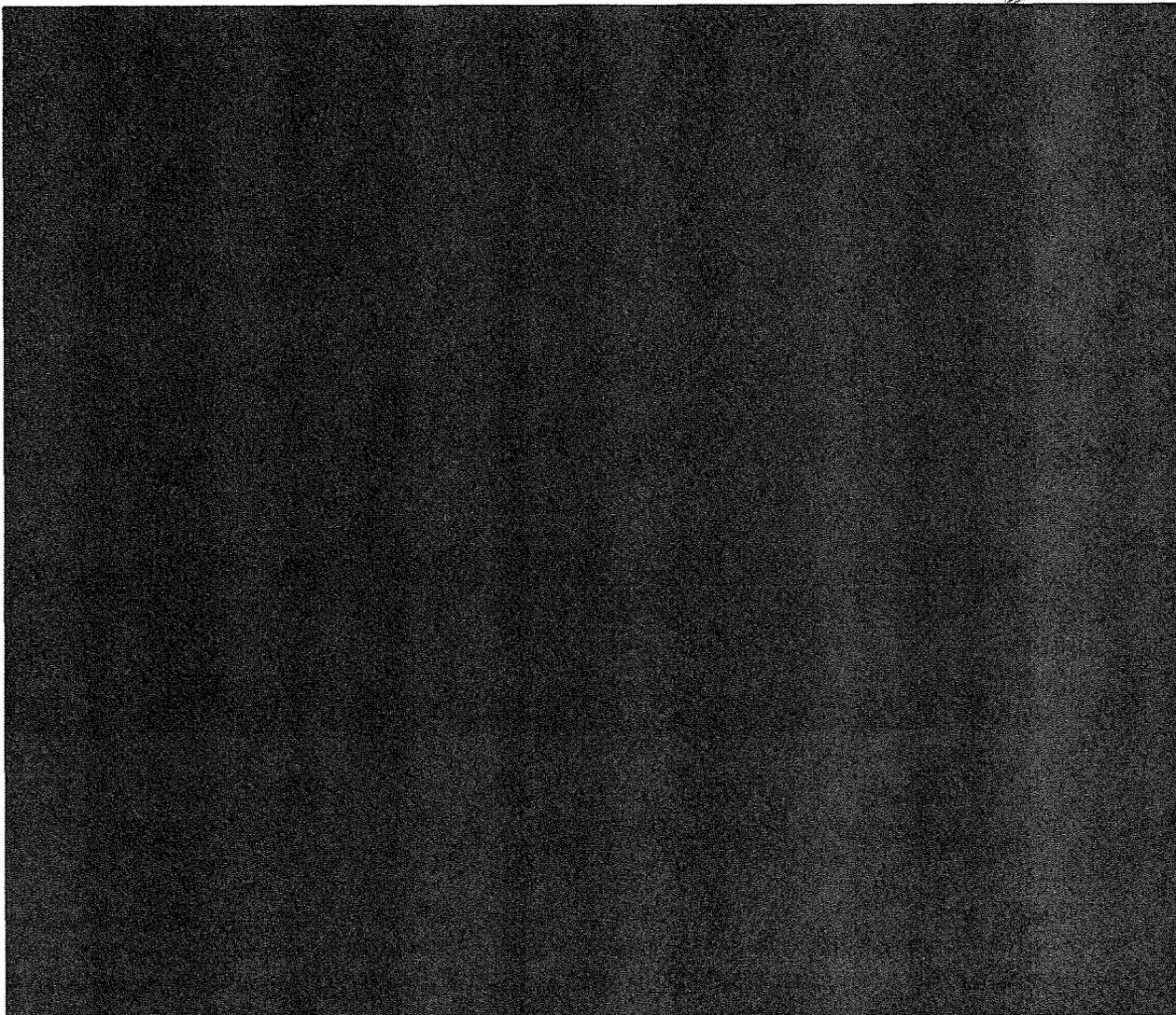


3.0 COMMENTS OF INFORMATION PROVIDED POST WSP 07 MAY 2015 REPORT

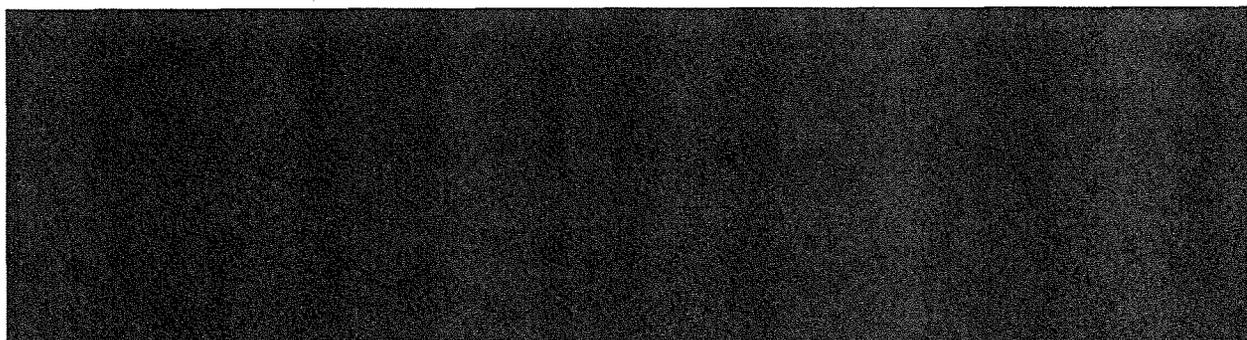
As noted, a number of technical memorandums, letters and construction specifications have been prepared since the WSP review letter in May 2015. A number of these are specific to hydrogeology and have been addressed by Waterline Resources Inc. Commentary on a selection of documents pertinent to the geotechnical aspects is provided below.

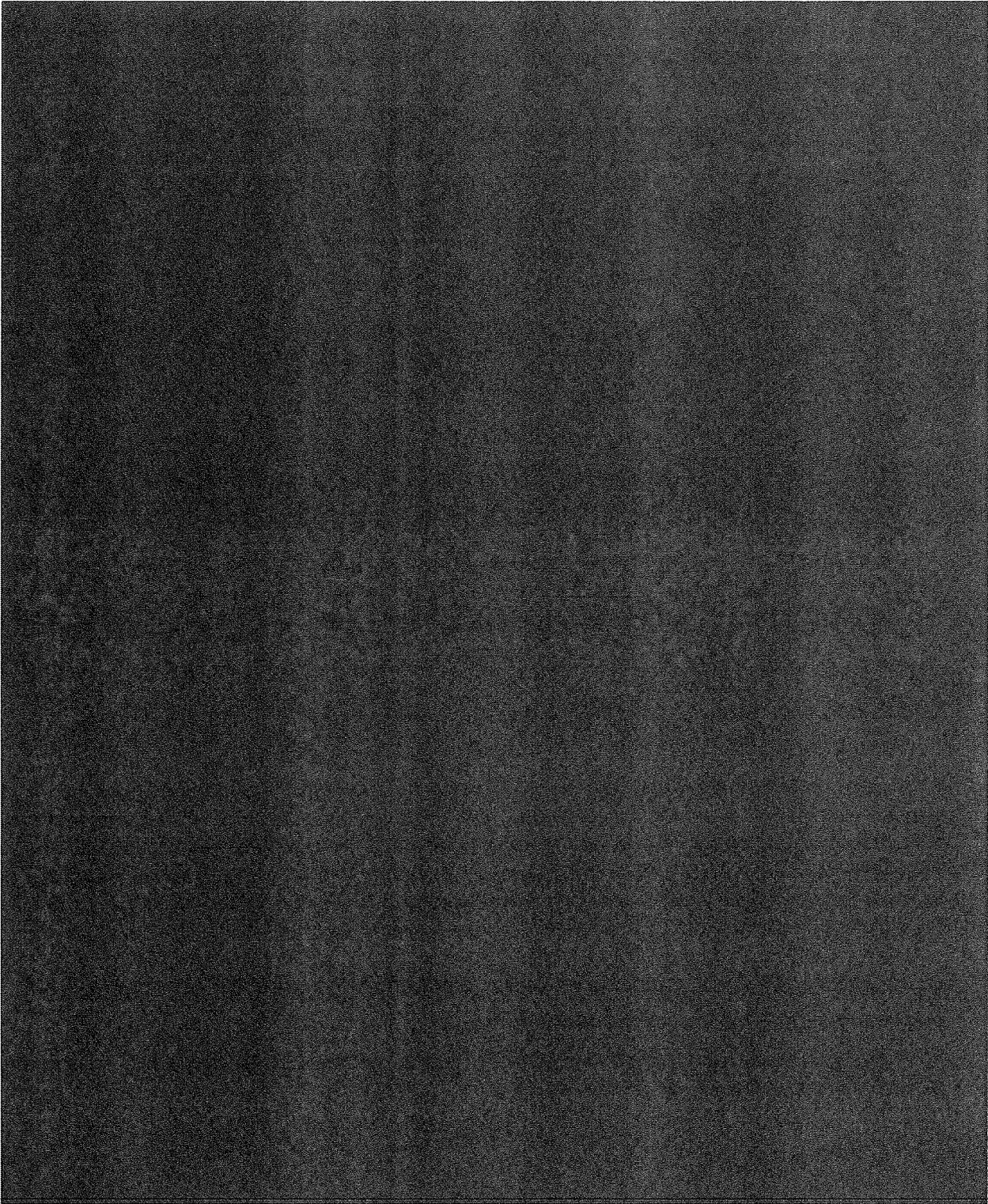
11 June 2015: Memorandum Regarding Geotechnical Review Report. Horizon Engineering Inc.



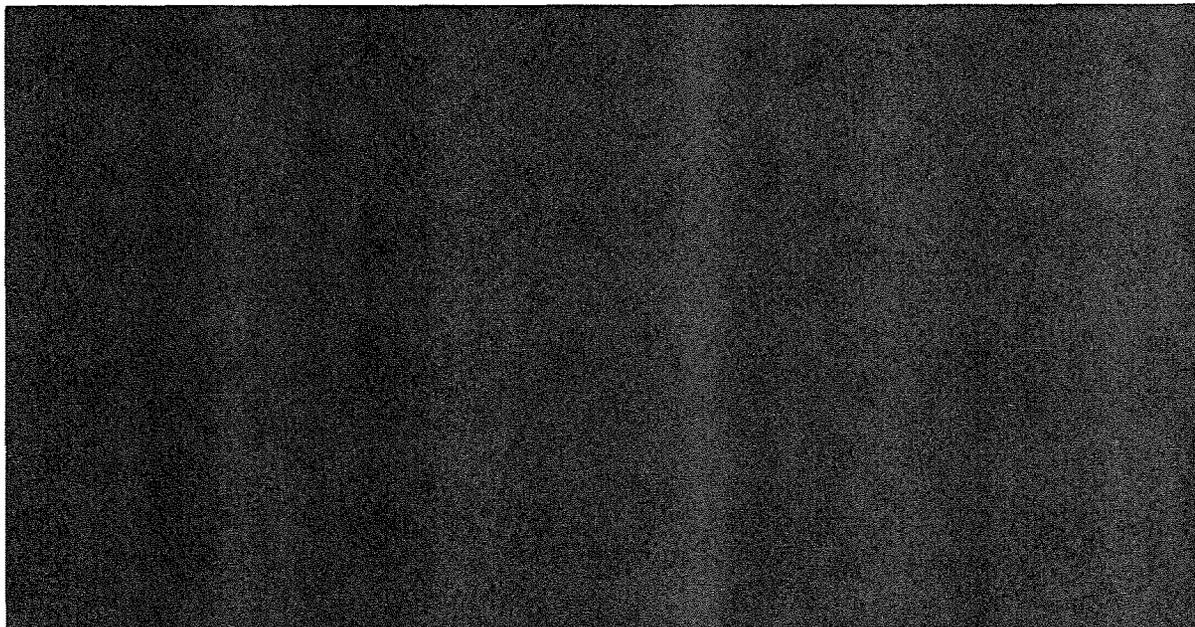


November 1, 2016: Supplementary Memorandum Regarding Geotechnical Review Report. Horizon Engineering Inc.





- Drawing G4 contains details for the shoring and for the sea dike. Notwithstanding comments of encroachment and level of detail required for Development Permit, we have a concern that the anchors as shown will penetrate the aquifer. The implications of artesian flow on design and construction do not appear to be fully addressed in the Specifications and there does not appear to be adequate warning given to the Contractor with respect to potential consequences or the need for a remedial plan. 



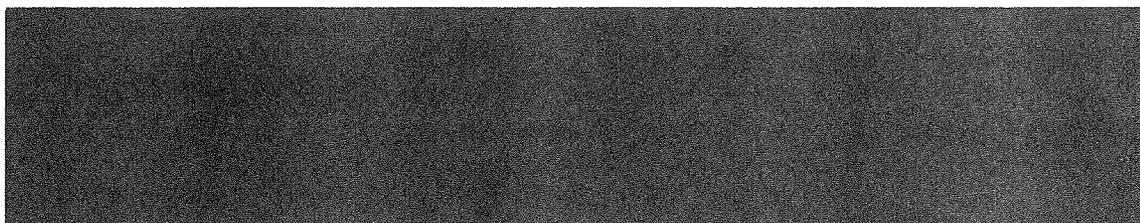
October 2016: Report of findings Detailed Site Investigation. Keystone Environmental Ltd.

WSP briefly reviewed this environmental report outlining the extent of historical hydrocarbon on the site and the proposed method of remediation. We noted that it is proposed to address the on-site contamination through a soil mixing based remedial action combined with a human health and ecological risk assessment as opposed to an excavate and replacement option. This approach appears to have addressed the potential concern that WSP had raised related to the implications of addressing contaminated soils through an excavate and replacement option, which we felt had the potential to compromise the confined aquifer.

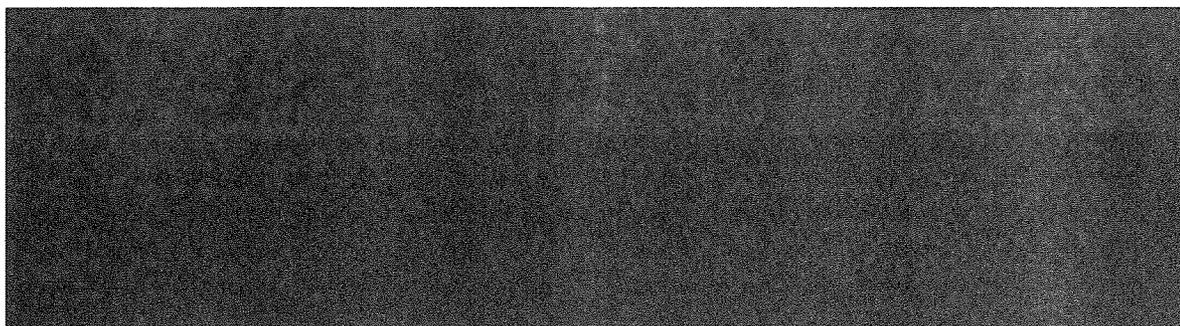
07 February 2017: Memorandum regarding December 1 2016 Hydrogeological Review Report. Horizon Engineering Inc.

While this memorandum is focussed towards the hydrogeological aspects of the project, there are certain geotechnical considerations that are outlined below.

- WSP remains concerned that disturbance of the Gibsons aquitard during the excavation and DSM process remains a risk with high potential consequences that (1) has not been sufficiently quantified and for which (2) a mitigation plan has not developed. Our primary concerns relate to (1) the temporary condition during the mixing process when the soil structure is highly disturbed and a potential hydraulic pathway is created to the aquifer (2) the potential for piping particularly in areas of the site where the fill is missing.



- The case history presented by Horizon does little to alleviate our concerns. We note that in this example the consultant team depressurized the (more modest) artesian pressures in the confined aquifer to avoid concerns of artesian water affecting the quality of the soil-cement columns. While depressurization is considered by WSP to be a credible option for mitigation from a purely geotechnical perspective, its viability is complicated at The George site by the adjacent marine environment and the need to comply with groundwater legislation, an item described in greater detail by Waterline.



10 February 2017: The George – Site Preparation Utilizing DSM:
MRC Total Build LP



We are concerned, however, with their statement that the “use of piles would create deep fissures in the Gibson aquifer and (agreed) the risk was very high that this approach will cause uncontrolled breaches in the aquitard and have a very high probability of causing the aquifer to leak”. Our concern relates to the proposed pile foundation support of the over water portion of the project in an area of the aquifer with proven artesian pressures in a physical location where mitigation of an uncontrolled breach

would be particularly difficult to control. [REDACTED]

The final paragraph of the MRC Total Build letter of 10 February 2017 states that "there are areas of risk in the project related to soil densification requirements", which we presume refers to the deep soil mixing. They further state that that "it is very necessary to review the constructability measures where areas of glacial till are thin or non-existent to ensure that the methods to mitigate these risks are in line with overall project design". We remain concerned that it is not fully appreciated by the proponent that the potential consequences and risk of an uncontrolled breach of the aquifer [REDACTED]

[REDACTED] We remain concerned that no clarity is offered with respect to the nature or strategy of proposed remedial measures should an uncontrolled breach occur.

4.0 CONCLUSIONS

[REDACTED]

Based on our review of the information that has been provided, we remain of the opinion that the level of subsurface characterization that has been completed to date is not commensurate with the risks associated with a potential uncontrolled breach of the Gibsons Aquifer at this site. This breach could result from piling operations, from deep soil mixing or from bulk excavation and while it may not be expected we do not feel that adequate mitigation measures have been developed to demonstrate that a release of water under artesian conditions can be controlled and remedied.

[REDACTED]



5.0 CLOSURE

This letter has been prepared exclusively for the Town of Gibsons with respect to assisting them in a review of the geotechnical aspects of a Development Permit Application for The George. The letter has been prepared in accordance with the attached Terms of reference for geotechnical Reports. We trust that the information provided herein meets your immediate needs. Please do not hesitate to contact the undersigned for further information.

Yours truly,
WSP Canada Inc.

**FOR
CLIENT REVIEW**

Carl Miller, M.Sc., P.Eng.
Senior Geotechnical Engineer

Attachments: Terms of Reference for Geotechnical Reports

REFERENCES

Horizon Engineering Inc., 2014. Geotechnical Investigation Report (Revised) for the Proposed "The George" Mixed Use Development at 377, 385 & 407 Gower Point Road, 397 & 689 Winn Road, and Winn Road Right-of-Way, Gibsons, BC. April 7, 2015.

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Horizon Engineering Inc., 2016c. Drawing G4: Excavation and Shoring Plan. For the Proposed "The George" Mixed Use Development at 377, 385 & 407 Gower Point Road, 397 & 689 Winn Road, and Winn Road Right-of-Way, Gibsons, BC. September 2016.

Horizon Engineering Inc., 2016d. Drawing G5: Bulk Excavation Plan. For the Proposed "The George" Mixed Use Development at 377, 385 & 407 Gower Point Road, 397 & 689 Winn Road, and Winn Road Right-of-Way, Gibsons, BC. September 2016.

Horizon Engineering Inc., 2016e. Drawing G6: Deep Soil Mixing Plan. For the Proposed "The George" Mixed Use Development at 377, 385 & 407 Gower Point Road, 397 & 689 Winn Road, and Winn Road Right-of-Way, Gibsons, BC. September 2016.

Keystone Environmental Project, 2016. Report of Findings – Detailed Site Investigation, 377, 385 & 407 Gower Point Road, 689 Winn Road 312845-04, Gibsons, BC. Project 12845-04. October 2016.

Waterline Resources Ltd., 2015. Hydrogeological Review of the Revised "The George" Geotechnical Investigation Report (Revised), May 4, 2015.

Horizon Engineering Inc., 2016. Excavation & Shoring Specifications Report For the Proposed "The George" Mixed Use Development, Gibsons, BC. October 2016.

Horizon Engineering Inc., 2017. Appendix A, Case History: Deep Soil Mixing in Artesian Conditions For the Proposed "The George" Development Gower Point Road at Winn Road, Gibsons, BC. Response to December 1, 2016 Hydrogeological Review Report. 2017.



2301 McCullough Road, Unit D
Nanaimo, British Columbia
Canada V9S 4M9
Tel: 250.585.0800
Fax: 250.585.0802
Toll Free: 1.888.641.6795
www.waterlineresources.com

March 23, 2017
1578-16-006

Town of Gibsons
474 South Fletcher Rd
Box 340 Gibsons, BC,
V0N 1V0

Attention: Andre Boel, Director of Planning
Dave Newman, Director of Engineering

RE: March 2017, Hydrogeological Review Update for the Proposed "The George" Mixed Use Development at 377, 385 & 407 Gower Point Road, 397 & 689 Winn Road, and Winn Road Right-of-Way, Gibsons, BC

1.0 INTRODUCTION

This memo is part of an ongoing hydrogeological review of the design for the Proposed Mixed Use Development, "The George", located at 377, 385 & 407 Gower Point Road, 397 & 689 Winn Road, and Winn Road Right-of-Way, Gibsons, BC (the Project). Waterline Resources Inc. (Waterline)'s role in this Project is to review the proposed design on behalf of the Town of Gibsons (The Town) and advise of potential risks relating to the protection of the Gibsons Aquifer. It should be noted that in reviewing the developer's documents, Waterline in no way endorses the designs or any technical recommendations made by the proponent or its consultants or representatives, nor does Waterline accept any responsibility for the hydrogeological/engineering aspects of this project. In addition, Waterline's expertise is specifically in the field of hydrogeology and not geotechnical engineering. The review of geotechnical aspects of the proposed development are being addressed by WSP Canada Inc. (WSP) and provided in a separate technical memo.

Although the enclosed memo provides a general overview of comments made as part of previous reviews completed by Waterline, the current comments relate to the following documents:

- The Horizon Engineering Inc. (Horizon), *Memorandum Regarding December 1, 2016 Hydrogeological Review*, dated February 7, 2017, and
- The MRC Total Build LP (Total Build) letter, *The George – Site preparation utilizing DSM*, dated February 10, 2017

2.0 GENERAL COMMENTS

[REDACTED]
[REDACTED]
[REDACTED] we have identified concerns or deficiencies with respect to the proponent's assessment of the potential risks

to the Gibsons Aquifer/Aquitard system. Waterline believes that the Gibsons Aquifer in Lower Gibsons is particularly vulnerable due to its shallow depth and thin protective cover that maintains the flowing artesian pressure, and protects the Gibsons Aquifer from surface activities.

[REDACTED]

- In Waterline's opinion, given the very narrow tolerances at the Site with respect to the depth and thickness of the Gibsons Aquitard versus, the currently proposed building requirements, it is not likely that the risk could ever be reduced to zero. [REDACTED]

[REDACTED]

- At the January 17, 2017 meeting with Horizon, it was agreed that a detailed mitigation plan would be provided. To date, no mitigation plan has been provided by Horizon to control the artesian pressure and flow in the event the Gibsons Aquitard is breached during the DSM column installation or other construction activity involving excavation. Waterline assumes that mitigation planning would include depressurization of the Gibsons Aquifer as described in the DSM case study provided by Horizon. As no testing or evaluation of the Gibsons Aquifer response to depressurization has ever been conducted on the site, it is not possible with the current data to assess the impact to the Town's water supply or the potential to induce salt water intrusion into the aquifer.

- In addition, a further assumption that an aquitard breach could be easily repaired using grout or other sealing strategies to control artesian flow also carries significant uncertainty with respect to the success of a mitigation program. Based on Waterline's experience in BC and Alberta, it may be very difficult (perhaps impossible) and costly, to repair the breach of a natural confining layer like the Gibson Aquitard once disturbed. If a breach cannot be repaired, then long-term mitigation and maintenance would be required. [REDACTED]



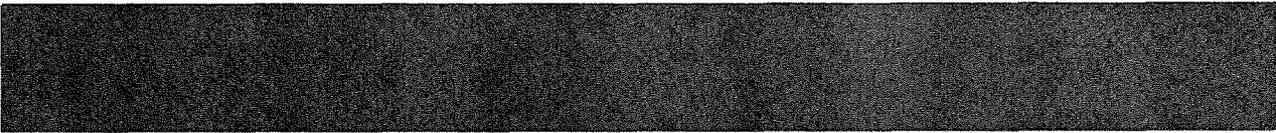
[REDACTED]

- Despite statements by Horizon that environmental aspects of the project have been fully integrated into their engineering designs, Waterline remains concerned that new well data collected in August 2016 (dry period) by Keystone suggests that flowing artesian conditions may exist at shallower depths at The George site than was anticipated based on previous observations. Horizon has stated that the shallow artesian conditions discovered by Keystone are unrelated to the Gibsons Aquifer. However, Waterline is unaware of site conditions that could cause flowing artesian pressure in the shallow Capilano unit. Annual monitoring of the Gibsons Aquifer completed by Waterline in 2016 indicates that flowing artesian pressure (water levels) in some of the monitoring wells completed in the Gibsons Aquifer appear to be rising. This is despite summer drought conditions reported in 2013 and 2015 which would have an overall effect of reducing aquifer recharge and pressure in the aquifer. Waterline and the Town have attributed the rise in water levels to a reduction in groundwater extraction resulting from meter installations (less use by residents as they pay by volume used) and efforts in repairing of leaks in the distribution system. [REDACTED]

[REDACTED]

[REDACTED]

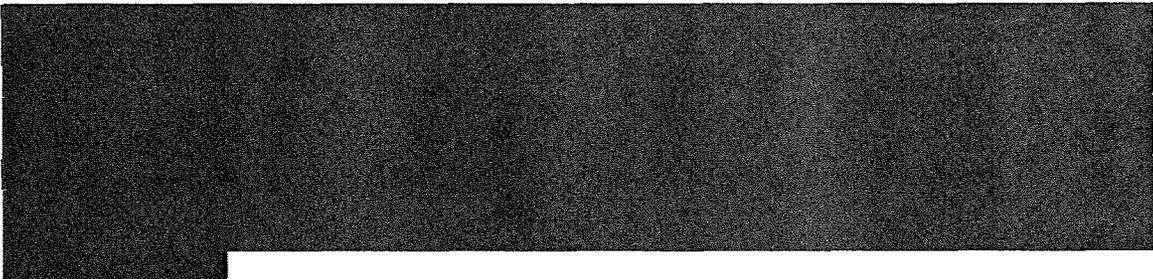
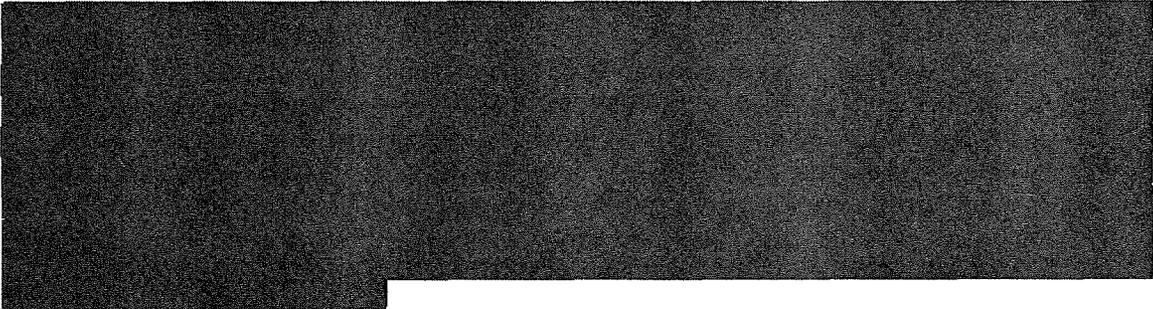
[REDACTED]



3.0 REVIEW OF HORIZON'S FEBRUARY 7, 2017 MEMO

At the Town's request, Waterline reviewed *Memorandum Regarding December 1, 2016 Hydrogeological Review report*, dated February 7, 2017. The memo includes three appendices: Appendix A: Case History: Deep Soil Mixing in Artesian Conditions, Appendix B Piping Analysis, and Appendix C WildCat Subsurface Investigation for Deep Soil Mixing Design. Waterline's comments are as follows.

3.1 Comment 1, Horizon Memo



Horizon goes on to note that:

"To clarify, the procedure does not involve augering. Augers remove soil from the hole, while the DSM procedure uses a mixing paddle that simply churns the soil at the depth of the paddle while grout is injected."

It is Waterline's understanding from the case study provided by Horizon that soil is in fact removed from the hole during the DSM process. The case study provided by Horizon noted that the DSM process produces spoils "equivalent to about 50% of the neat volume of the CDSM installed" (Pooranampillai, S. et al, no year). This clearly indicates that material is being removed as the DSM column is being installed and contradicts the former "clarifying" statement. The case study also noted that there was incomplete mixing observed in the test piles installed. The combination of removing about 50% of the material overlying the aquifer and the potential for incomplete mixing does suggest that there is a degree of uncertainty with the quality control and it may therefore be difficult to maintain the integrity of the Gibsons Aquitard during the DSM column installation and curing process. In Waterline's opinion, contradictory statements and far-reaching assumptions do not provide the requisite level of diligence and assurances to ensure the long-term protection of the Gibsons Aquifer.

3.2 Comment 2, Case History

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

However, the case study author also noted that:

"Maintaining the pressure head of the confined aquifer 5-feet below the ground surface also insured that the site was not engulfed by water from the aquifer during column installation, since such an occurrence would have made it impossible to continue working in the area."

This statement implies that there was a possibility of the DSM column installation opening a pathway for the groundwater from the artesian aquifer. This could result in an uncontrolled discharge of groundwater if not mitigated by depressurization.

Horizon's memo does not discuss depressurization of the Gibsons Aquifer, despite the fact that it was required in the case study they provide to support the DSM technology for The George site. As Waterline indicated previously, if aquifer depressurization was to be used at the George site as a construction or mitigation technique we have identified concern relating to the potential for salt water intrusion and water level interference with the Town water supply wells. Operating a well in a manner that causes, or is likely to cause, the intrusion of saline groundwater is in direct contravention of Section 58 of the *Water Sustainability Act*. Considerable testing and analysis would be required to assess potential impacts if depressurization of the Gibsons Aquifer is being considered.

3.3 Comment 3, Piping Analysis

[REDACTED]

[REDACTED]

[REDACTED]

The piping analyses provided in Horizon's proposes the addition of a working platform of at least 1 m (above ground) to provide additional surcharge (weight) to the underlying Gibsons Aquifer, presumably as a mitigation strategy to prevent possible piping of artesian groundwater from the Gibsons Aquifer. Given the heterogeneous nature of the natural soils and the degree of uncertainty with DSM column, adding weight at the surface in no way guarantees containment of artesian flow from the aquifer should it occur. Notwithstanding the various concerns with an aquifer breach, the *Water Sustainability Act* is clear that artesian flow must be controlled and the DSM technology in the absence of depressurization does not meet the regulatory requirements in BC.

3.4 Comment 4, Wildcat Subsurface Investigation

[Redacted]

[Redacted]

4.0 COMMENTS ON TOTAL BUILD LETTER FEBRUARY 10, 2017

[Redacted]

5.0 CLOSURE

It continues to be Waterline's professional opinion that the proposed DSM program does not adequately consider the risk and consequences of breaching the Gibsons Aquitard unit beneath The George site. [REDACTED]

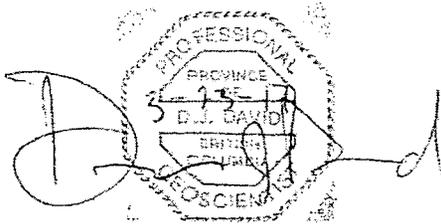
Waterline trusts that the information provided is sufficient for your requirements. The limitations and permitted uses of the enclosed document are provided in Section 7.0. Should you have any questions or concerns, please do not hesitate to contact the undersigned.

Respectfully submitted,

Waterline Resources Inc.



Bernadette Lyons, M.Sc.E., P.Eng
Senior Hydrogeological Engineer



Darren David, M.Sc., P. Geo.
VP Operations and Principal Hydrogeologist



6.0 REFERENCES

Horizon Engineering Inc., 2016. Drawing G3: Section 'B', 'C', 'D' and 'E'. For the Proposed "The George" Mixed Use Development at 377, 385 & 407 Gower Point Road, 397 & 689 Winn Road, and Winn Road Right-of-Way, Gibsons, BC. October 2016.

Suthan Pooranampillai, Ph.D., Dominic Parmantier, P.E, Karen Dawson, P.E. and Seungcheol Shin, Ph.D.. Year Unknown. A Case History on the Design, Construction, and Field Quality Control of Cement Deep Soil Mixing, publication unknown

7.0 LIMITATIONS AND USE

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DRAFT - Gibsons Aquifer Review of Horizon's Updated Geotechnical Drawings
The George, Gower Point at Winn Road, Gibsons, BC
Submitted to the Town of Gibsons

1578-16-006
March 15, 2017
Page 11



GEOSYSTEMS, L.P.

P.O. Box 237, Venetia, PA 15367, USA Phone: (724) 942-0570 Fax: (724) 942-1911
Email: dabruce@geosystemsbruce.com Website: www.geosystemsbruce.com

April 18, 2017

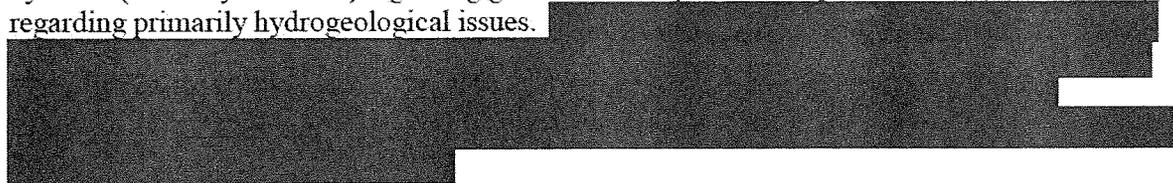
Town of Gibsons
Attn: Mr. Dave Newman, AScT
Director of Engineering
P.O. Box 340
474 South Fletcher Road
Gibsons, BC V0N 1V0
Canada

EVALUATION OF THE VIABILITY OF A DMM OPTION AS FOUNDATION SUPPORT FOR "THE GEORGE" DEVELOPMENT, GIBSONS, BC

Dear Sir:

I have completed my initial review of the 31 Documents you sent me last week dealing with the above-referenced subject. My notes on these Documents are attached to this Letter Report as Appendix 1, and these notes form the basis of the observations and opinions provided in this Letter Report.

You have requested me to address specifically the DSM (more correctly known as the Deep Mixing Method (DMM) as detailed in Sections 2 and 3, below) option for supporting the spread footings, and reducing liquefaction potential in the soils of the upper aquifer. From this first review of the Documents, I am aware that the DMM proposal, introduced by Horizon Engineering Inc. (Horizon) over the course of several of their Reports, has been peer reviewed by WSP (formerly Levelton) regarding geotechnical aspects, and by Waterline Resources Inc., regarding primarily hydrogeological issues.

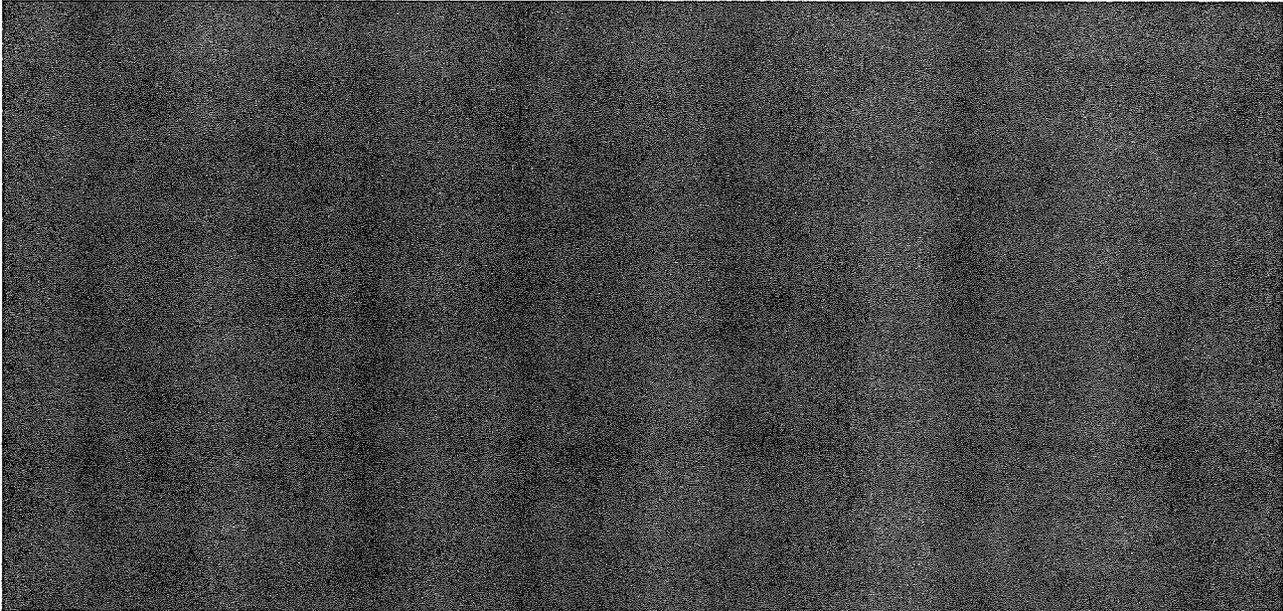


My comments fall into three main categories:

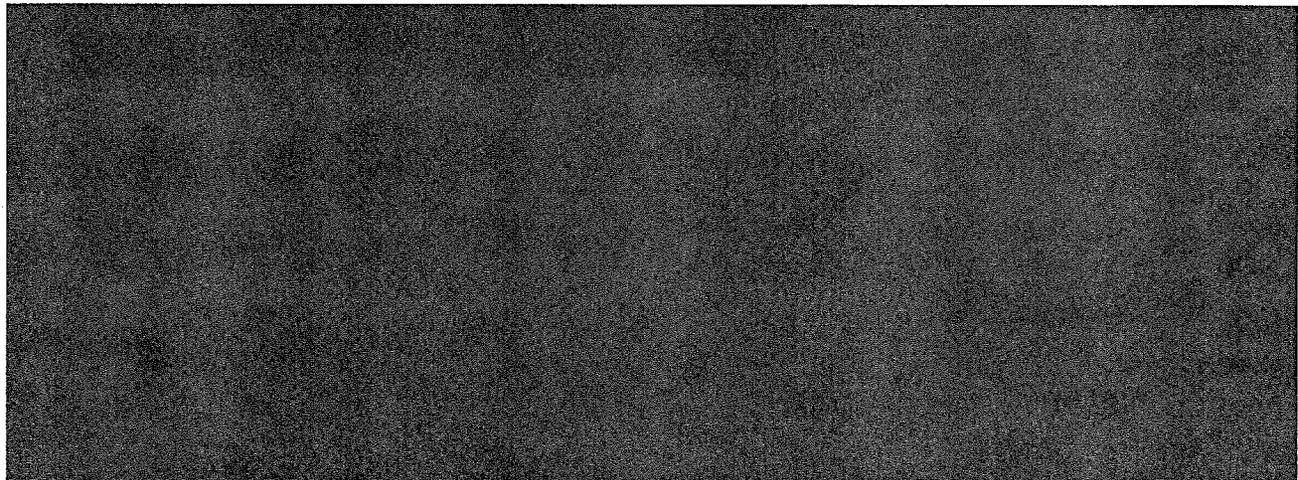
1. General Considerations
2. Evaluation of DMM as an Option
3. 

1. GENERAL CONSIDERATIONS

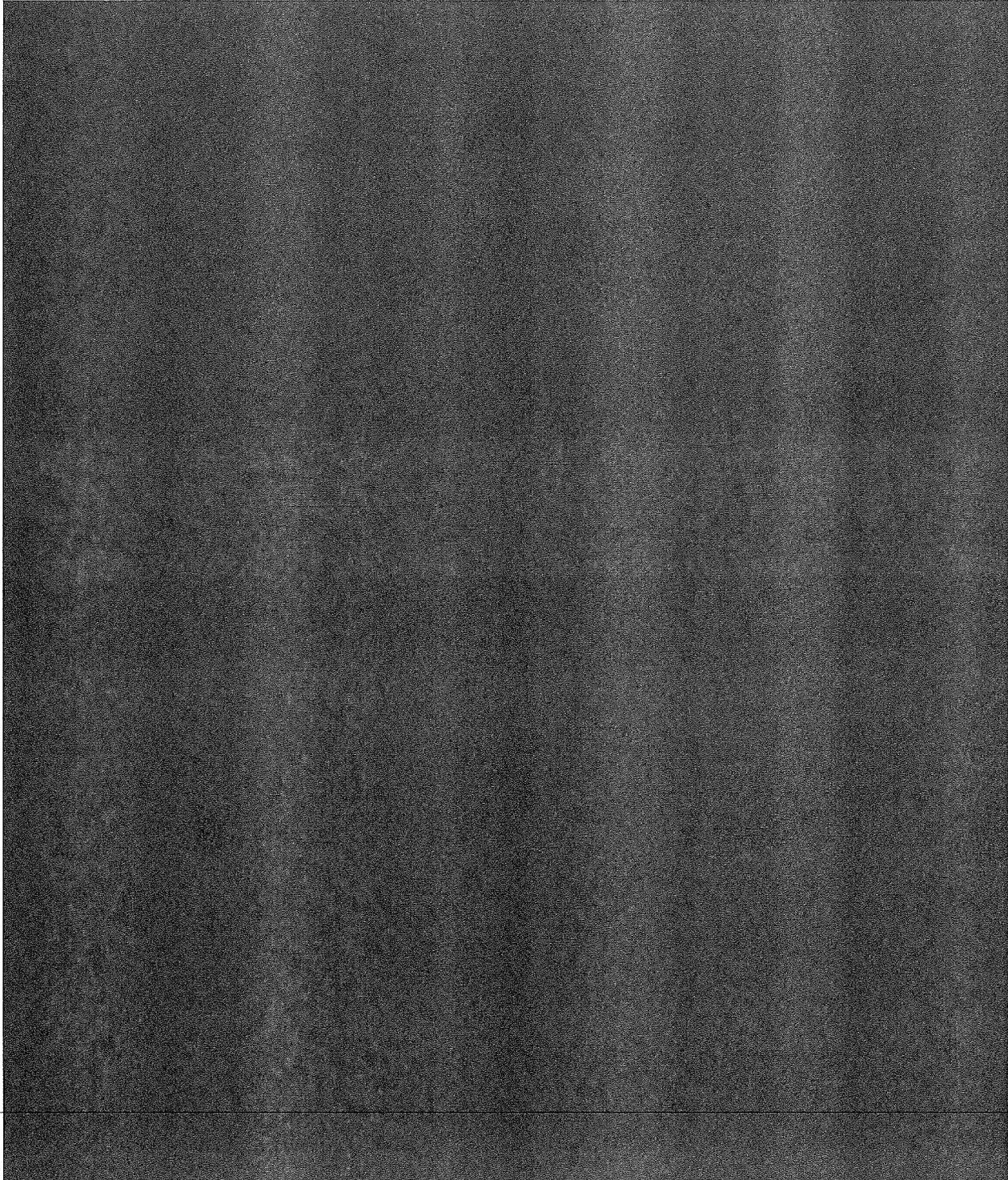
While I do not wish to recite the main findings and details as expounded upon the respective parties, I regard it as fundamental to the design of any foundation system to address the following broad issues. Where appropriate, I have added the most recent relevant Document reference for convenience.

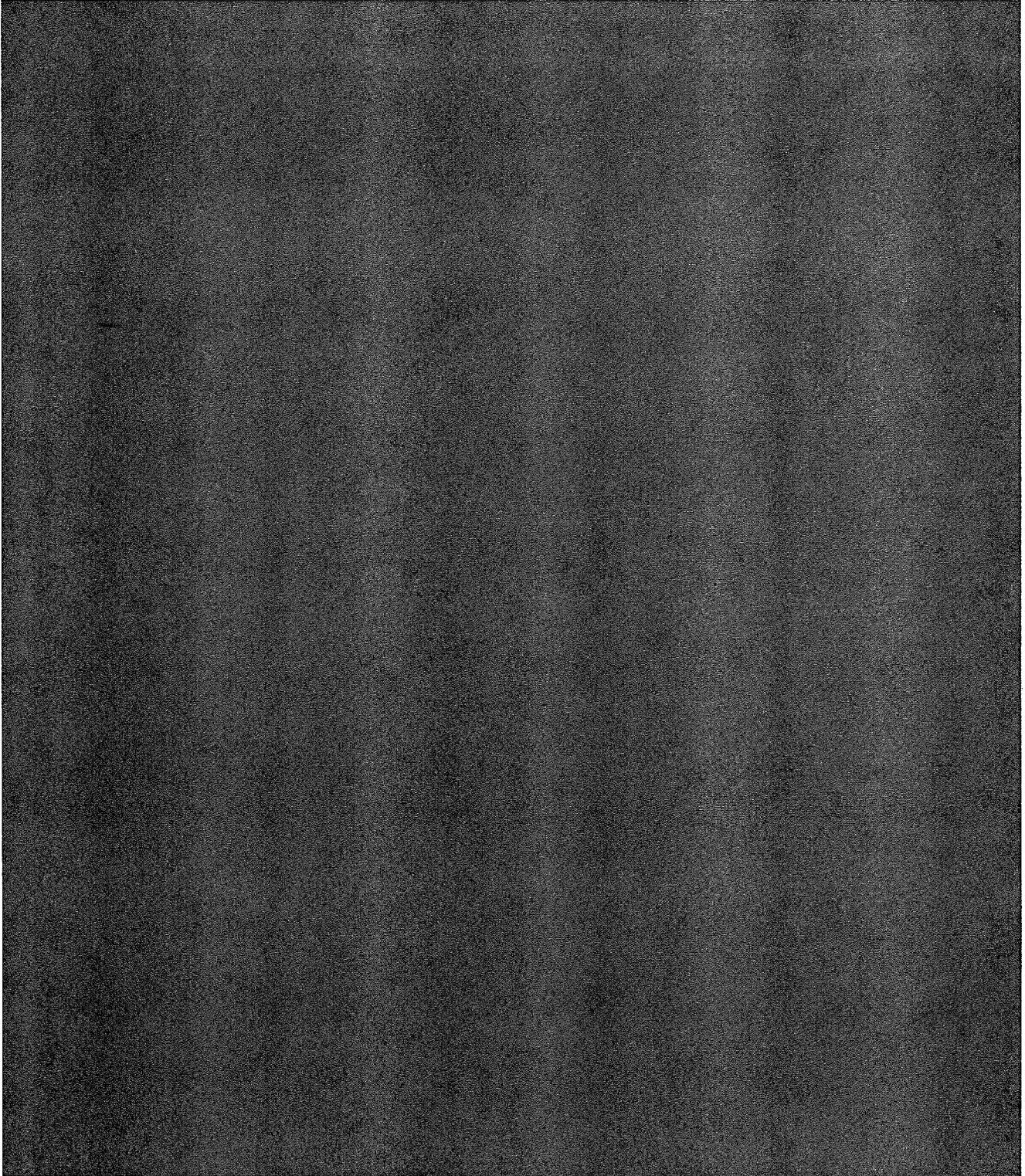


- An Aquifer mitigation plan is essential to develop, regardless of which technique is chosen as a foundation system. Different parts of the site may well need different – or modified – mitigation plans, which will also depend on the ground modification technique actually used, and the sequencing of the various construction processes.

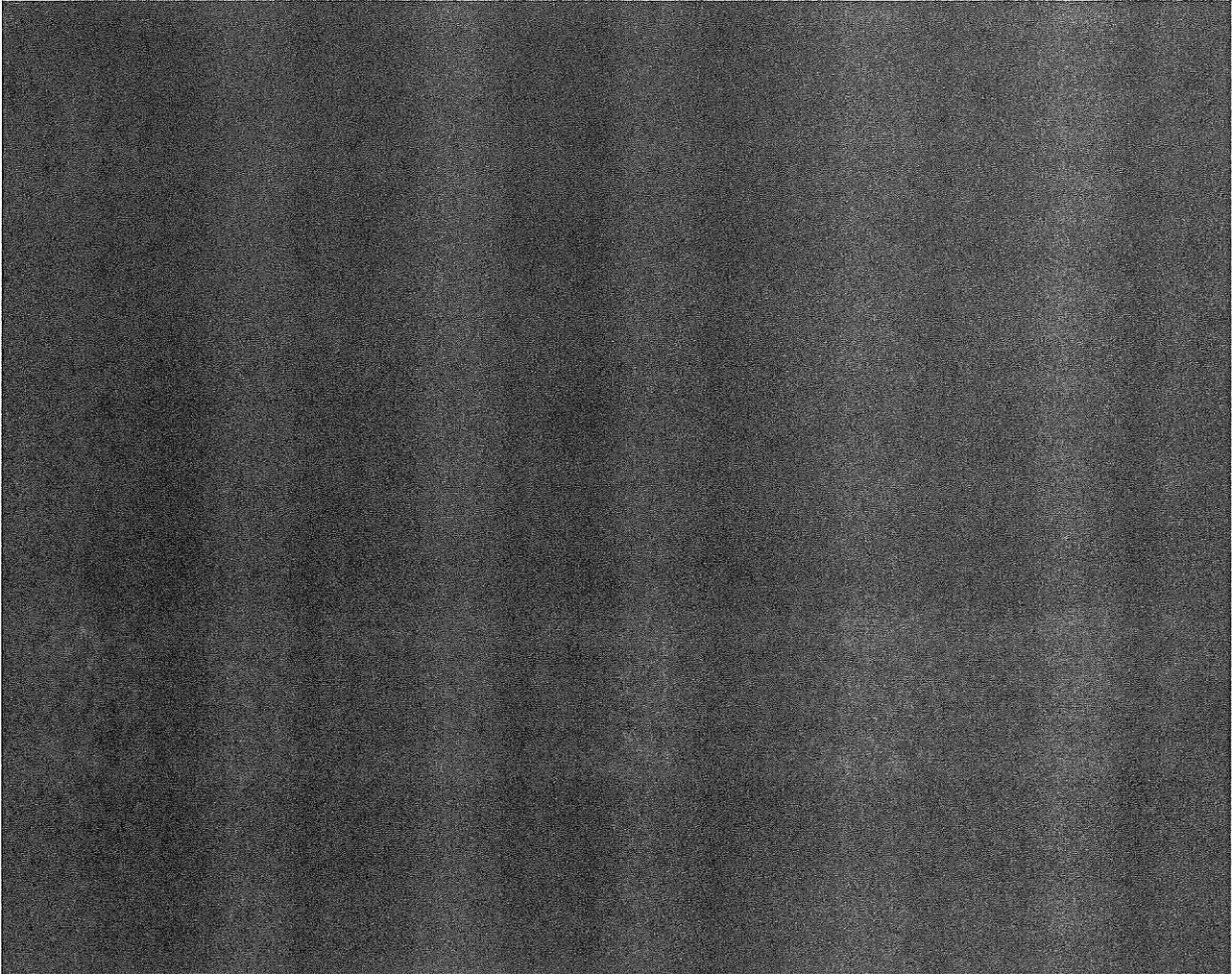


2. EVALUATION OF DMM AS AN OPTION

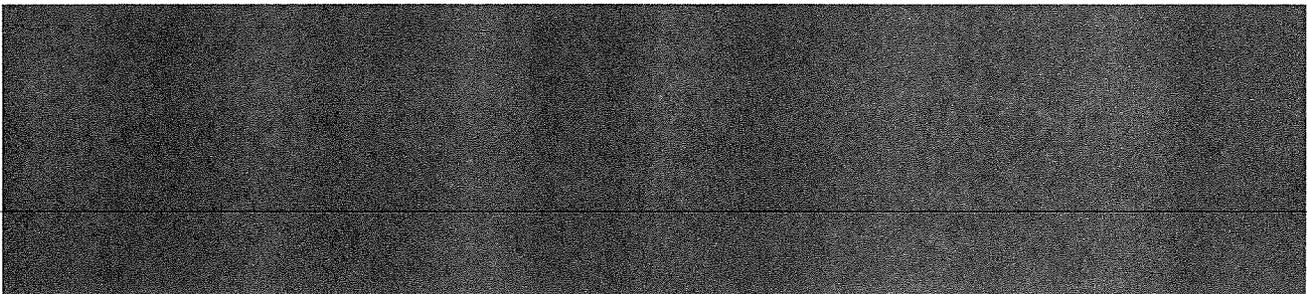
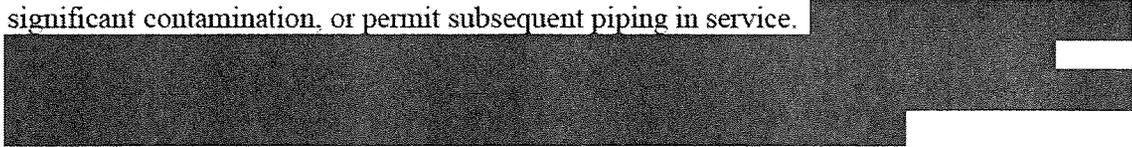


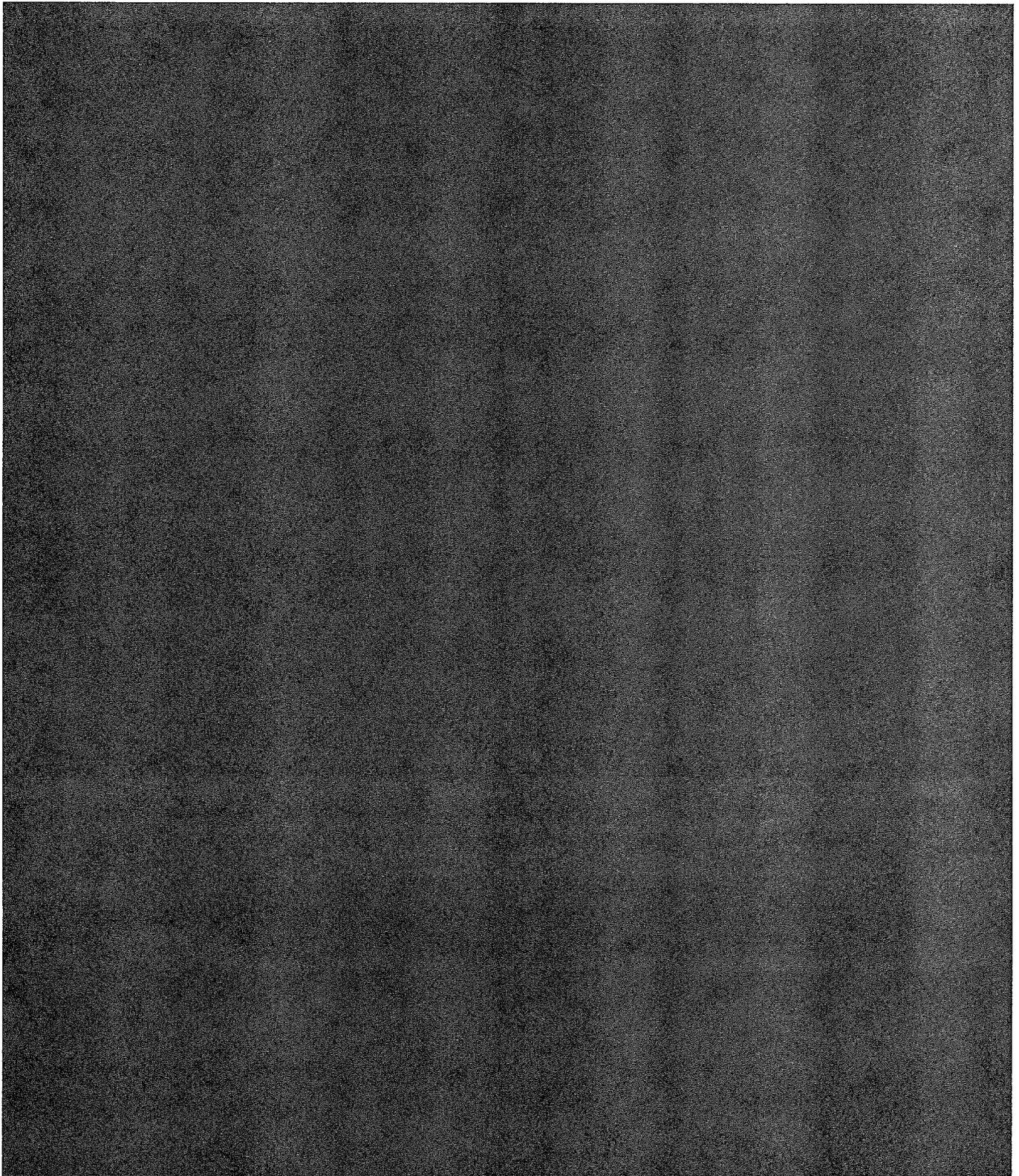


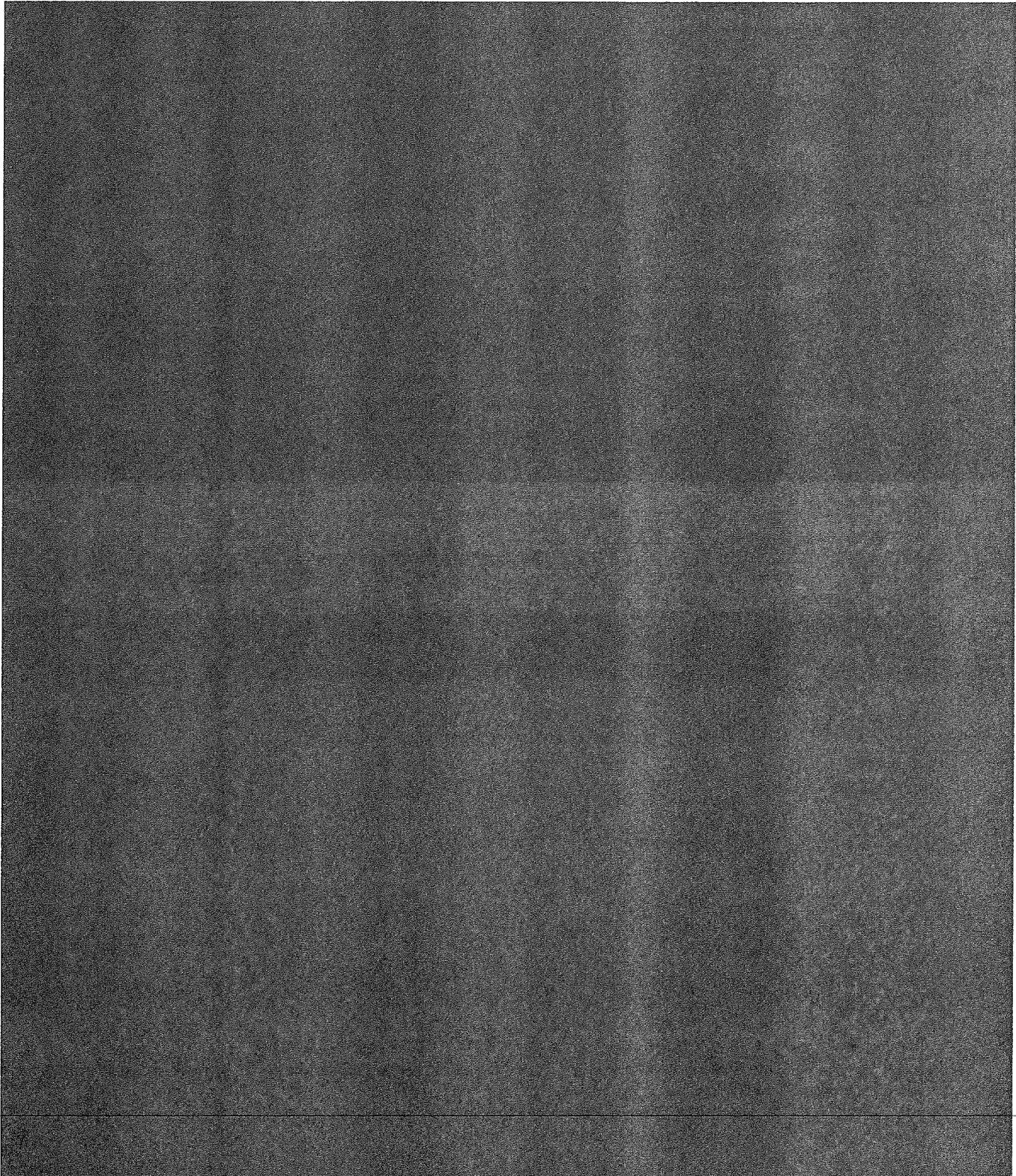
April 18, 2017



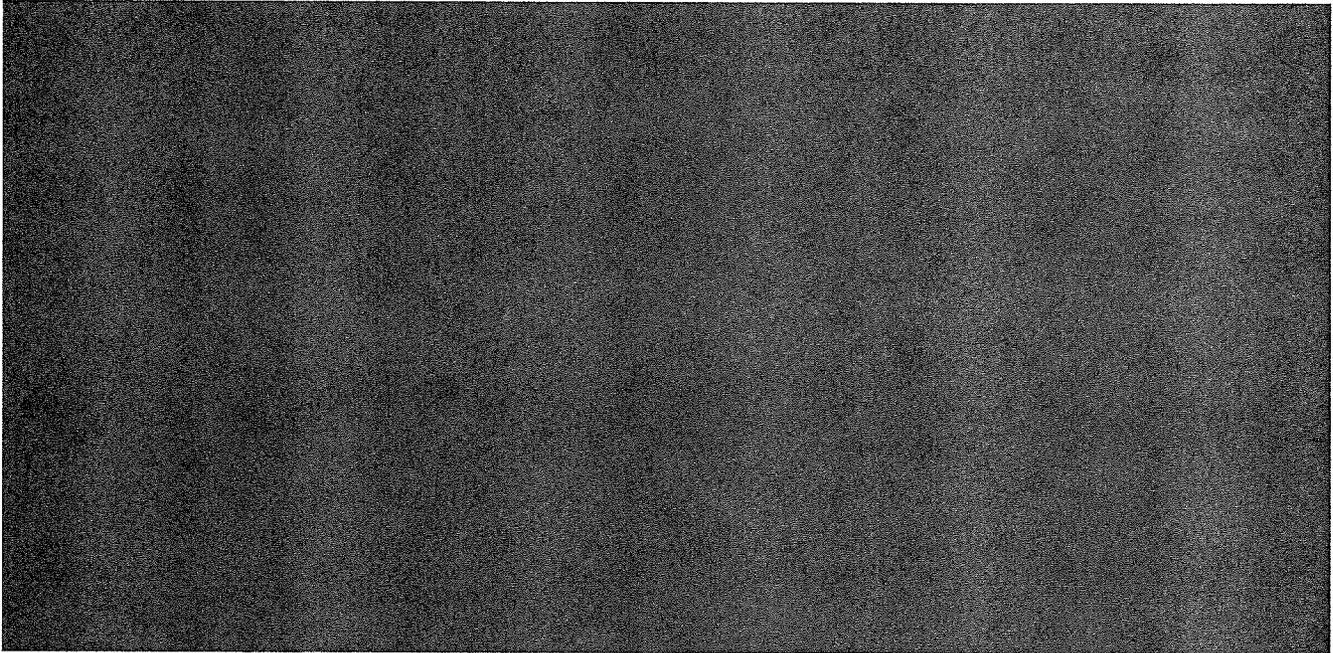
In short, I have confidence that a properly designed, constructed and monitored conventional DMM approach would not cause structural damage to the Aquitard, uncontrollable breach, significant contamination, or permit subsequent piping in service.







April 18, 2017



CLOSURE

Given the urgency of this review, and the voluminous information provided for review, kindly regard this Letter Report as a Preliminary Document for Review.



I look forward to our further communication.

Very truly yours,
GEOSYSTEMS, L.P.

Donald A. Bruce, Ph.D., D.GE, C.Eng., P.G. L.G., L.E.G.
President

Attachment – Appendix 1

REFERENCES

- Bruce, D.A. (2010). "Seepage Cutoffs for Levees and Dams: The Technology Review," Deep Foundations Institute Technical Lectures: Use of Slurry Walls for Cutoffs, July 22, Sacramento, CA, 28 pp.
- Bruce, D.A. (2012). "Specialty Construction Techniques for Dam and Levee Remediation," Spon Press, an imprint of Taylor and Francis, 304 pp.
- Bruce, D.A. (2017). "Seepage Cut-Offs for Levees and Dams," 38th Annual Short Course, Grouting Fundamentals, The University of Texas at Austin, May 15-19, 72 slides.

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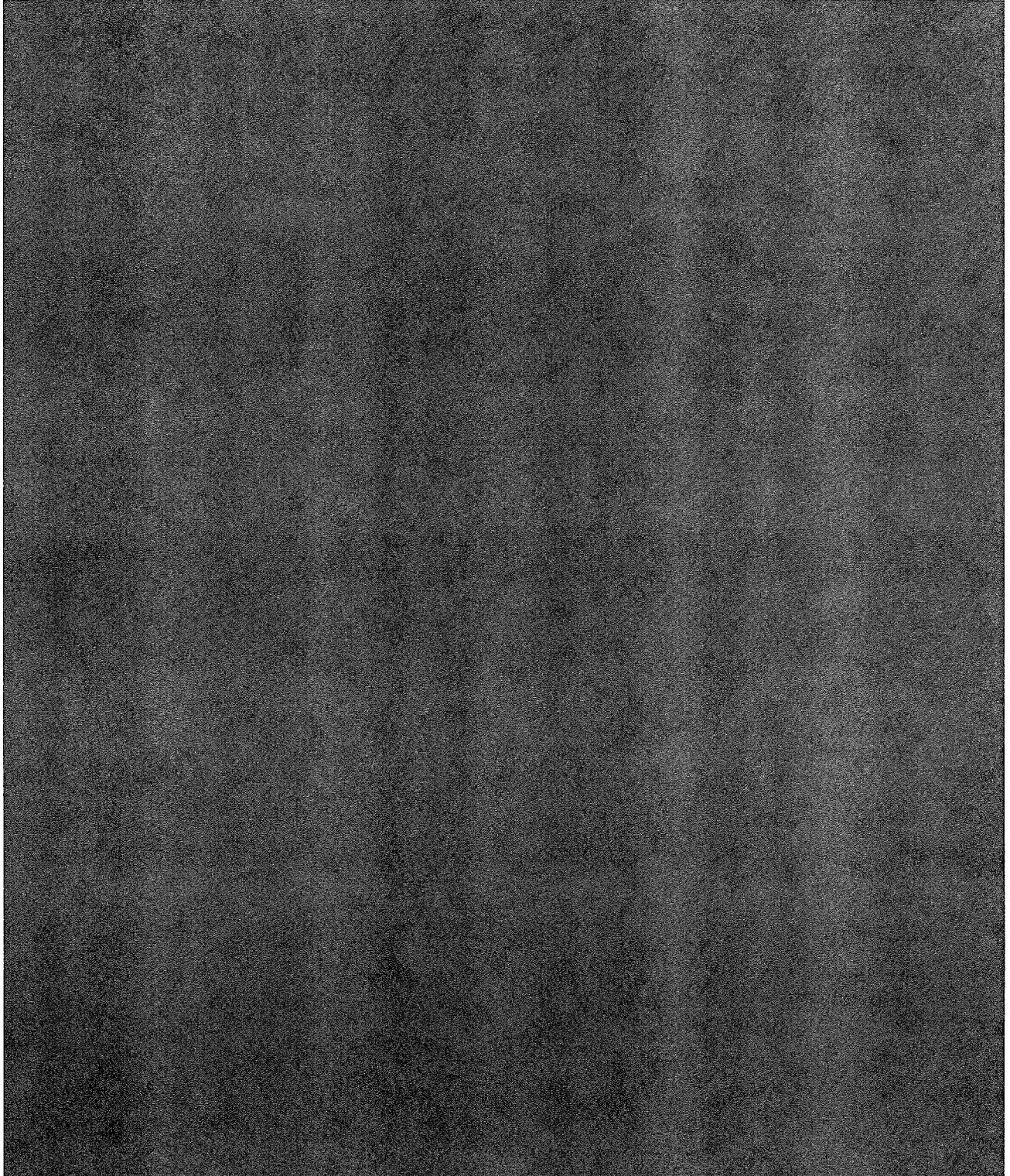
APPENDIX 1

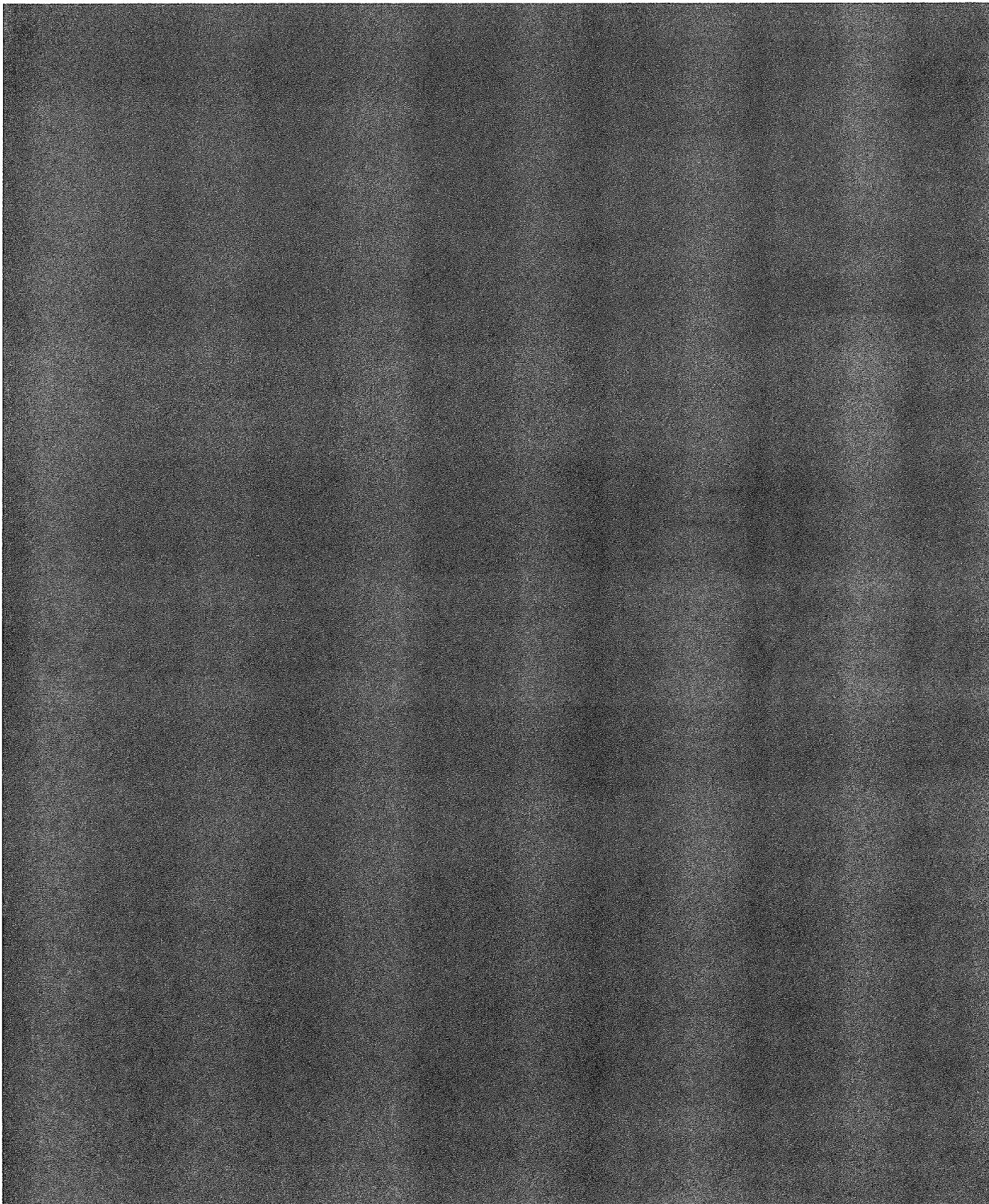
DR. BRUCE'S NOTES ON THE 31 DOCUMENTS RECEIVED FOR REVIEW

GEOSYSTEMS, L.P.

DOCUMENT 1 – Aquifer Mapping Study (Waterline Resources, Inc., May 13, 2013)

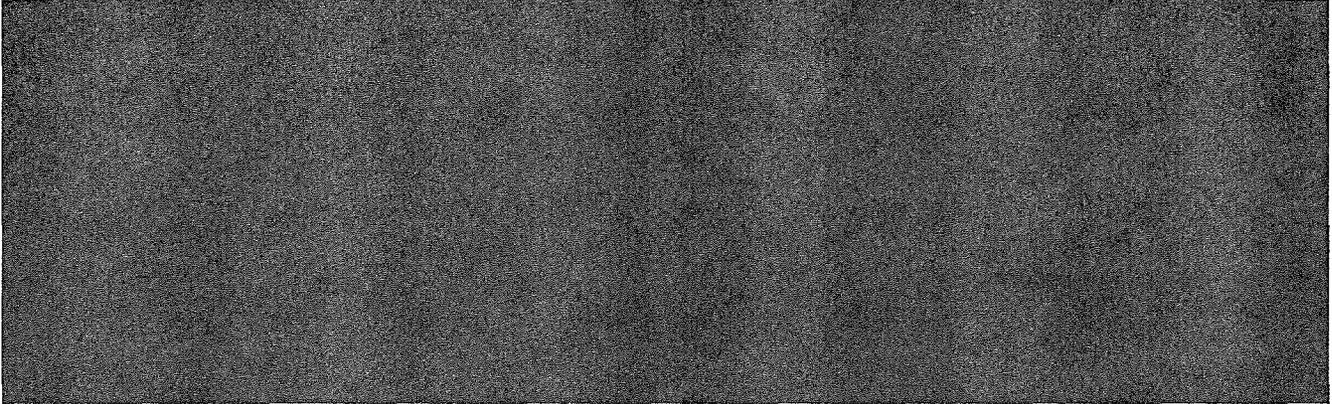
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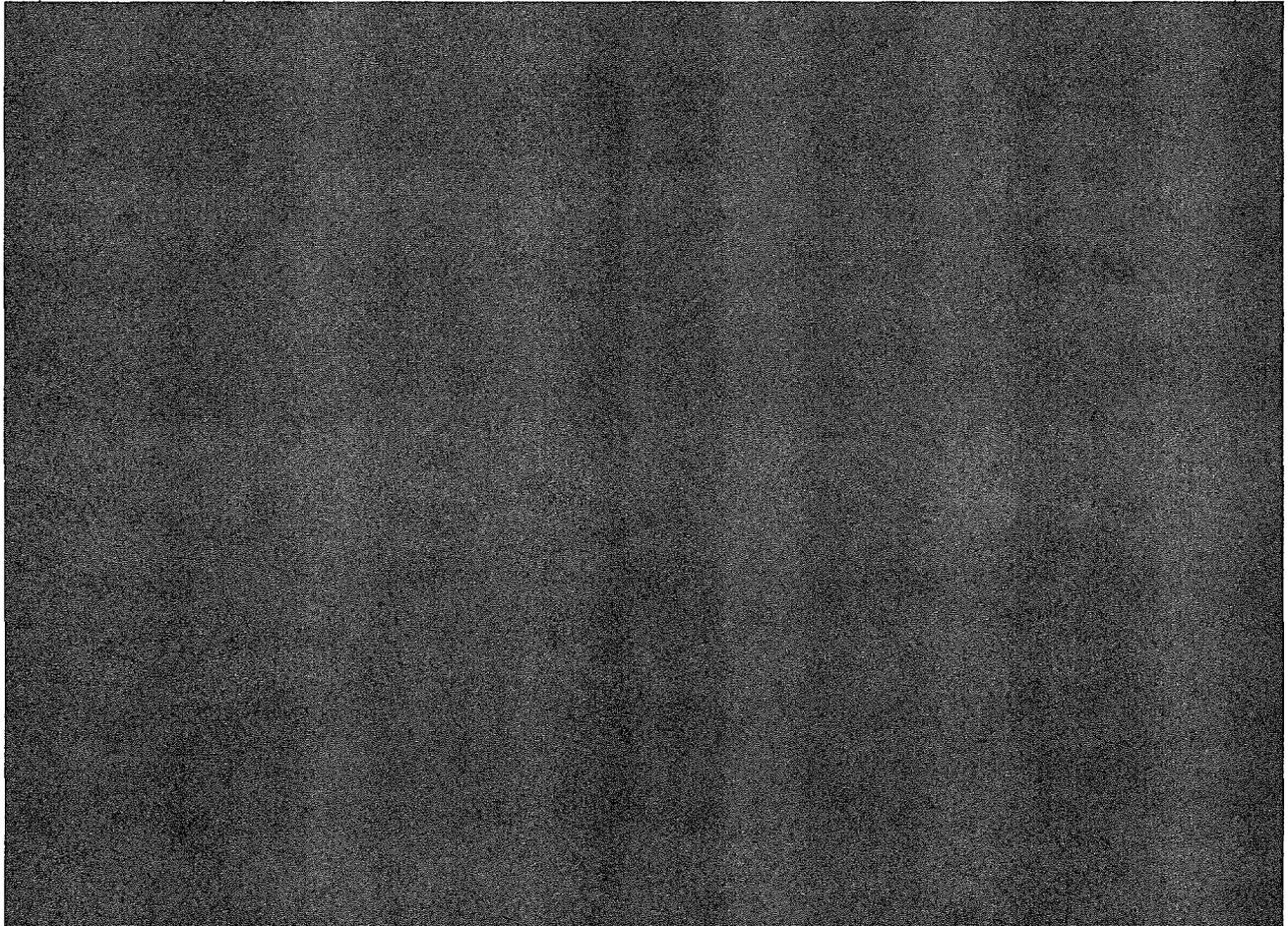
GEOSYSTEMS, L.P.

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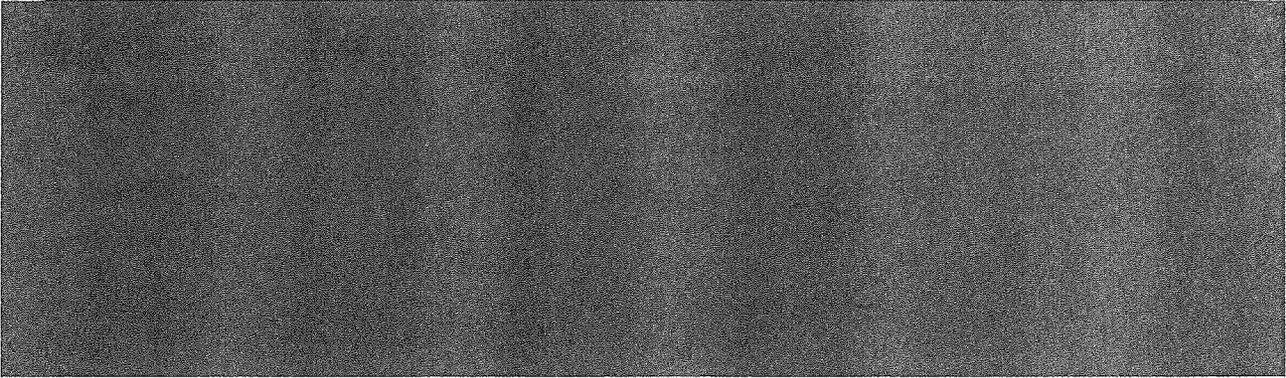
DOCUMENT 2 – Geotechnical Investigation Report (Horizon, November 26, 2012)

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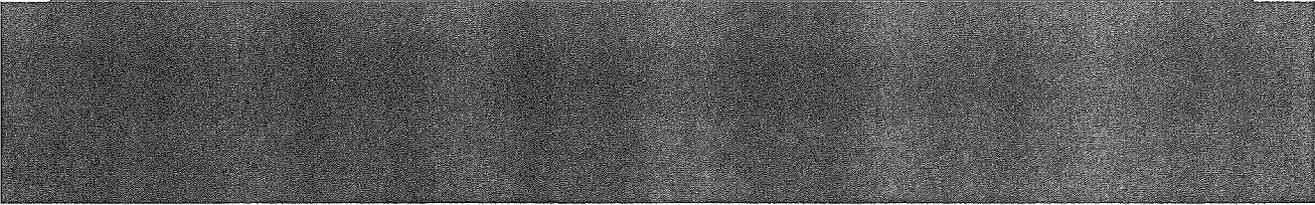
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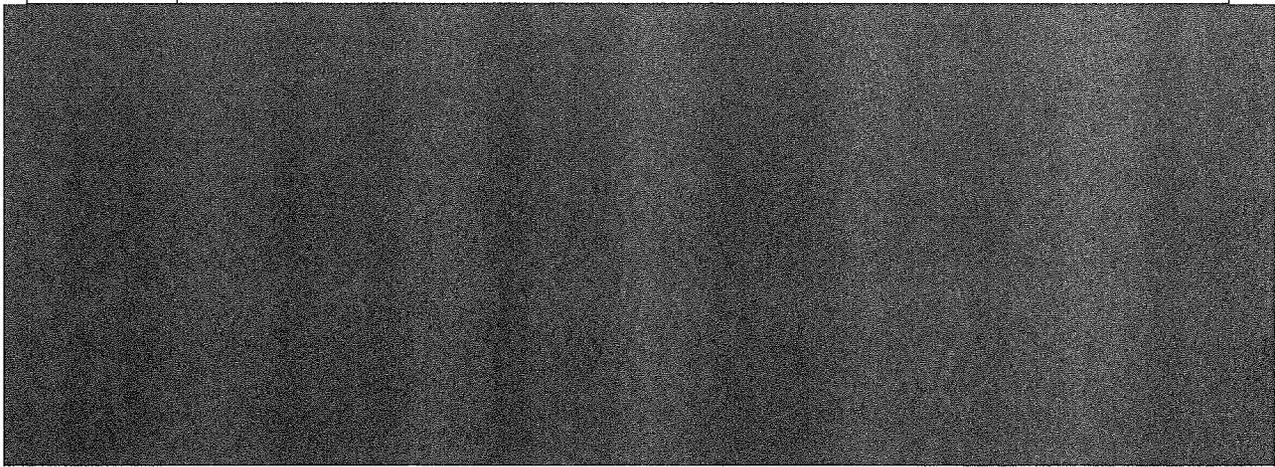
DOCUMENT 3 – Revised Geotechnical Investigation Report (Horizon, February 12, 2014)

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DOCUMENT 4 – Hydrogeological Review (Waterline, March 10, 2014)

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GEOSYSTEMS, L.P.

DOCUMENT 5 – Geotechnical Review of Horizon’s Report (2014) (Levelton, March 2014)

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DOCUMENT 6 – Geotechnical Review of Horizon’s Report of June 5, 2014 (Levelton, June 23, 2014)

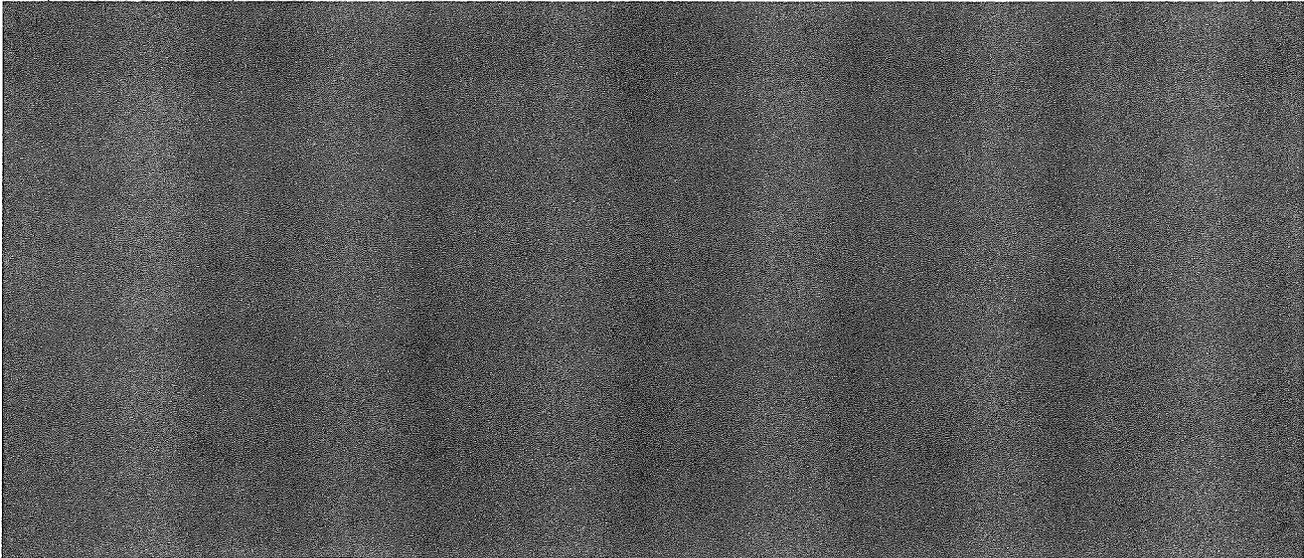
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DOCUMENT 7 – Hydrogeological Review of Horizon’s Report of June 5, 2014 (Waterline, June 25, 2014)

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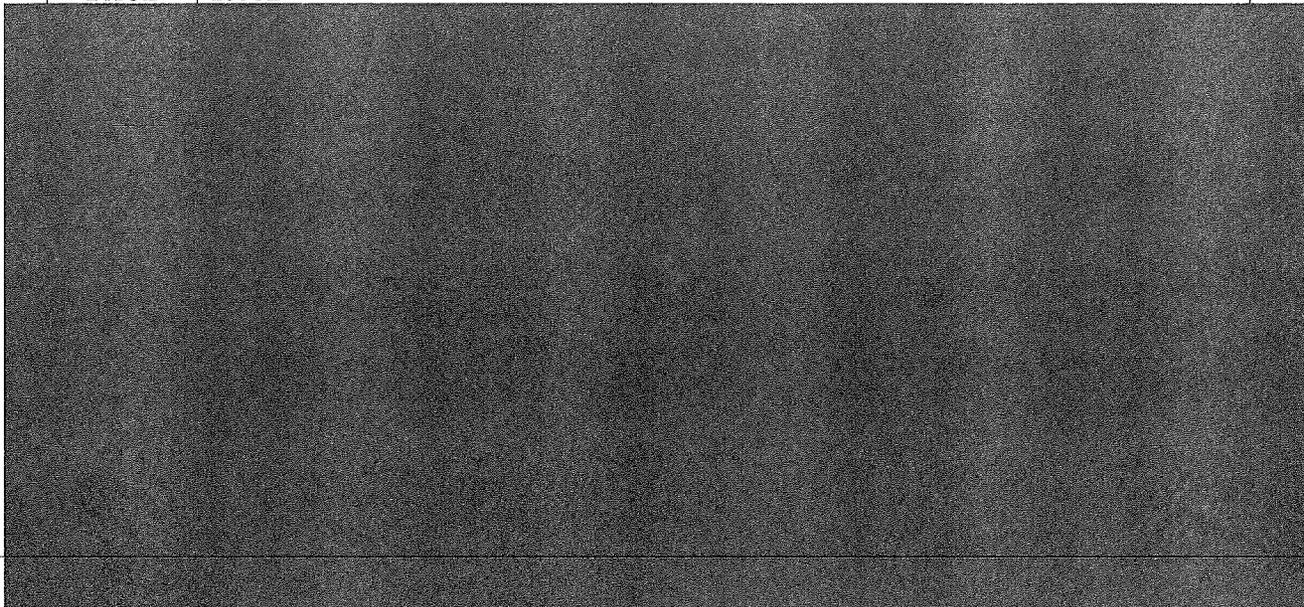
DOCUMENT 8 – Staff Report on Geotechnical Reviews (Gibsons, September 30, 2014)

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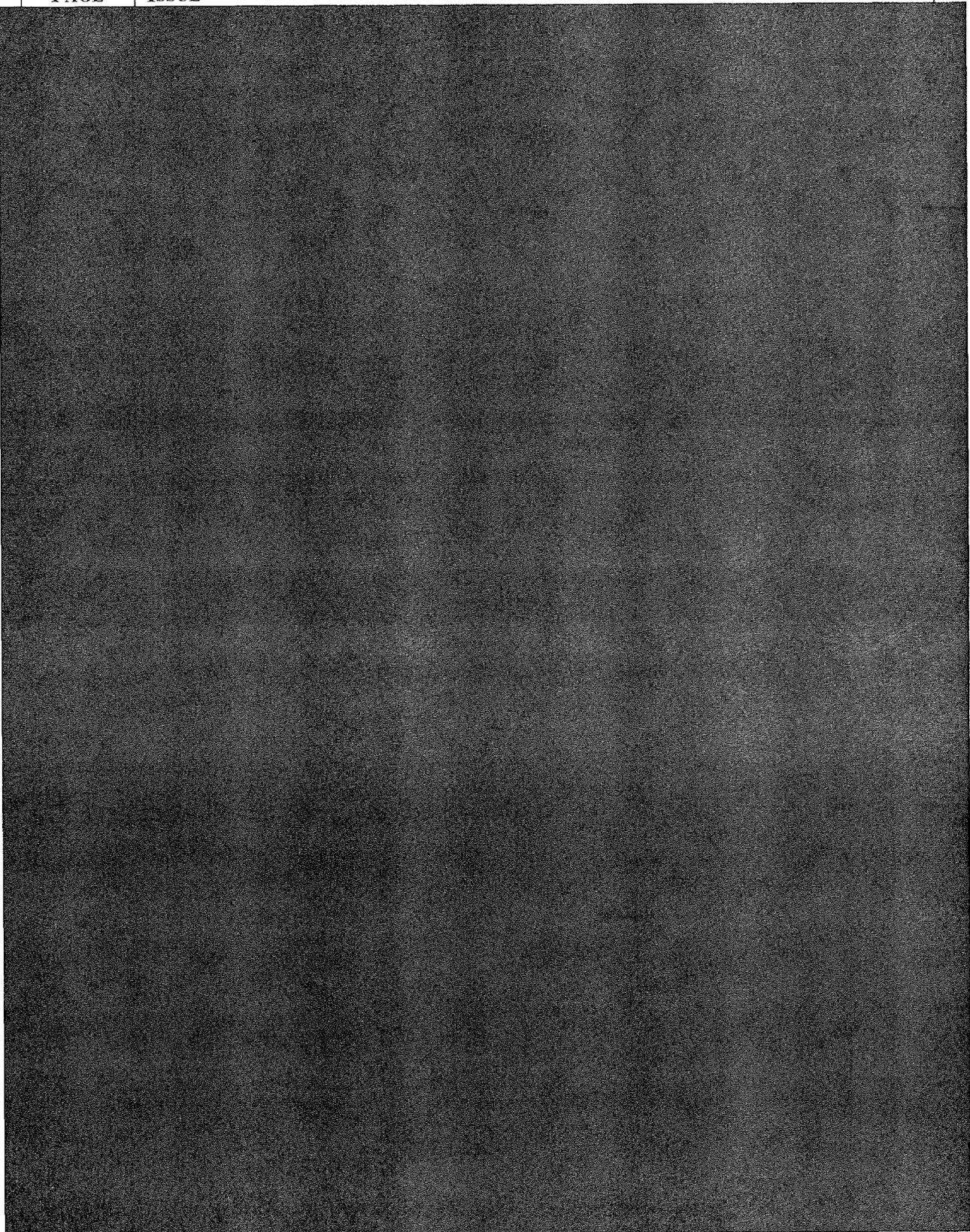
DOCUMENT 9 – Geotechnical Investigation Report (Revised) (Horizon, April 7, 2015)

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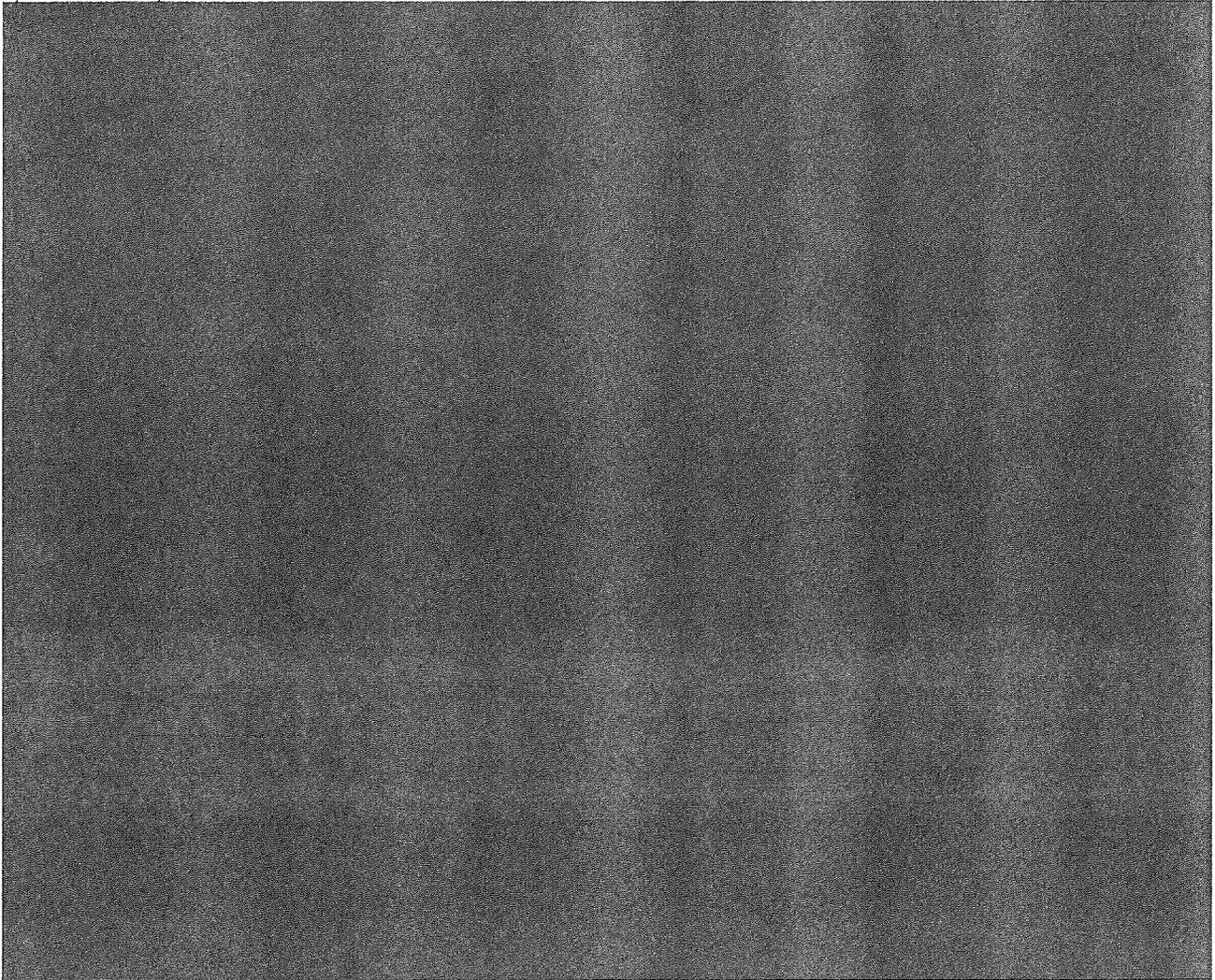
GEOSYSTEMS, L.P.

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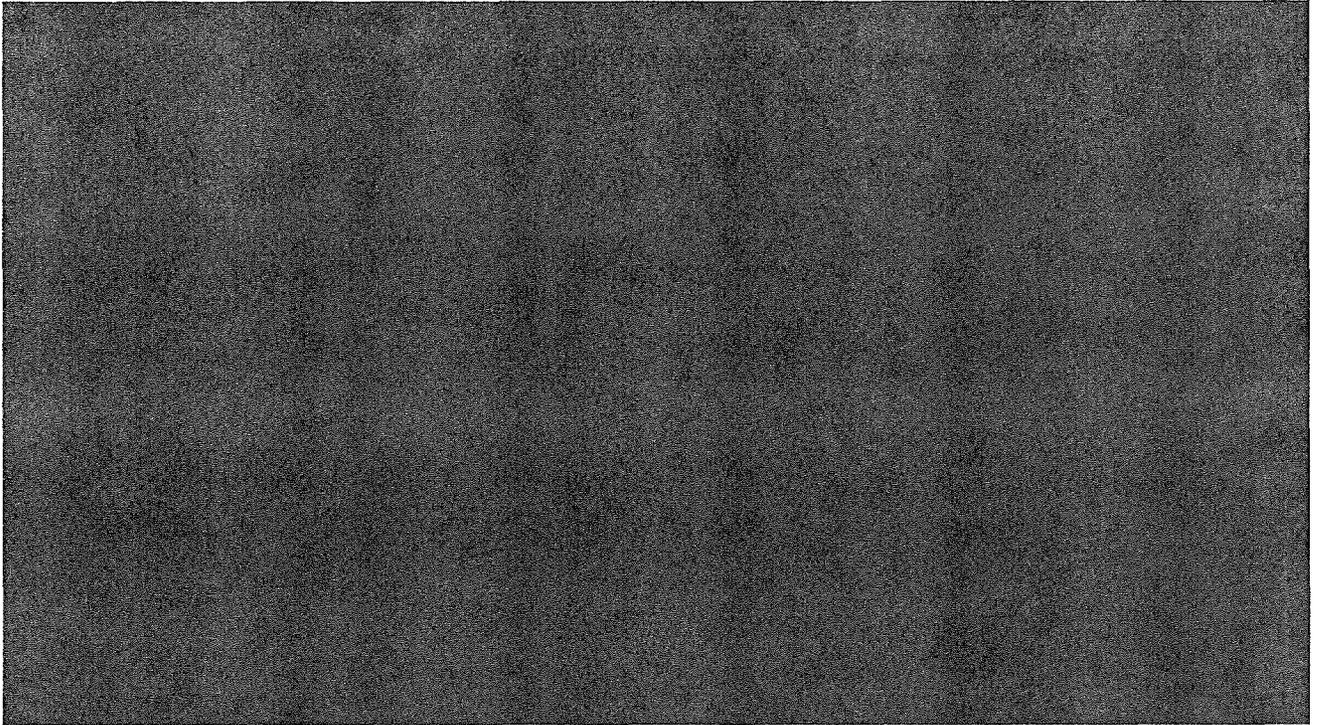


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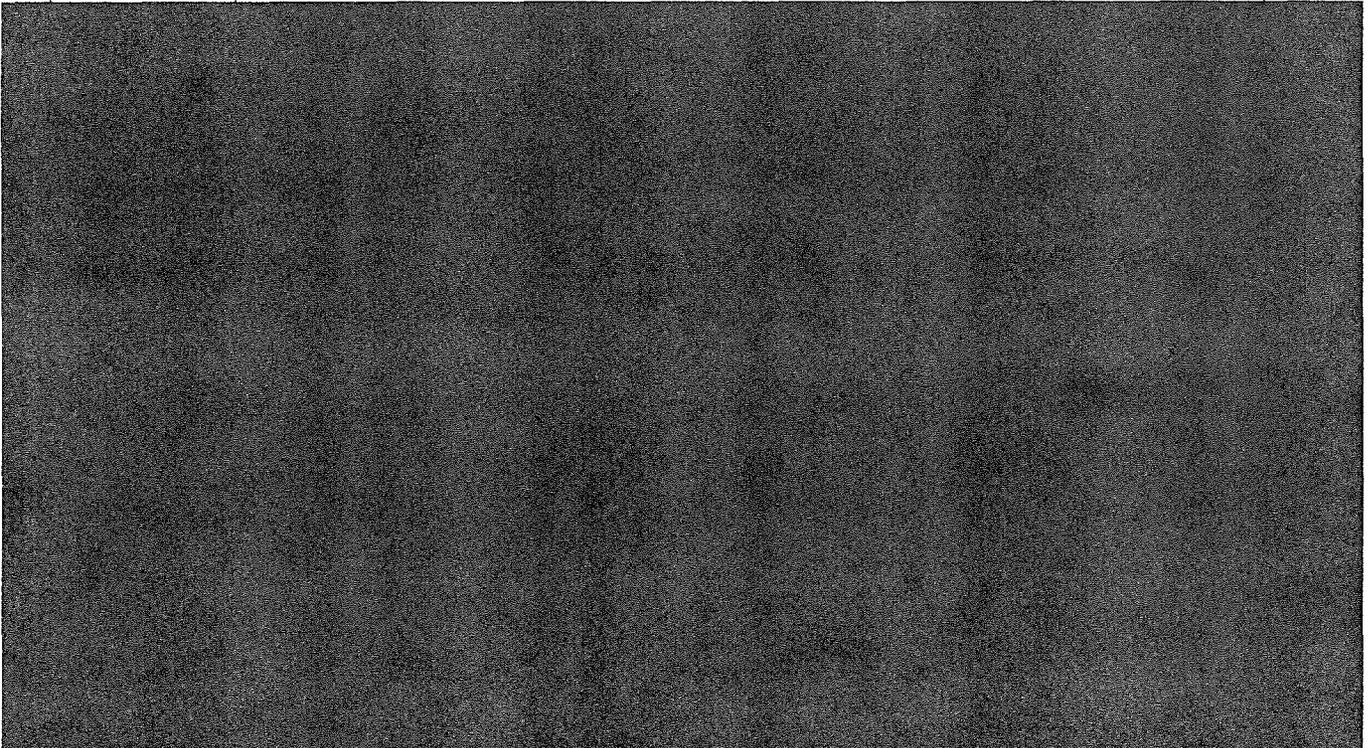


GEOSYSTEMS, L.P.



**DOCUMENT 10 – Presentation: Summary of Geotechnical Investigation Report
(Revised April 7, 2015) (Horizon, May 12, 2015)**

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**DOCUMENT 11 – Gibsons Aquifer Review of Revised Horizon GIR (April, 2015)
(Waterline, May 4, 2015)**

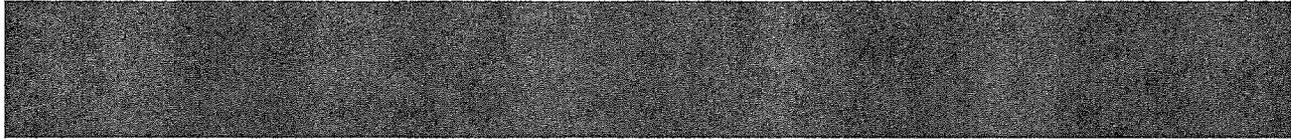
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**DOCUMENT 12 – Geotechnical Review of Horizon’s Revised GIR (April, 2015)
(Levelton, May 7, 2015)**

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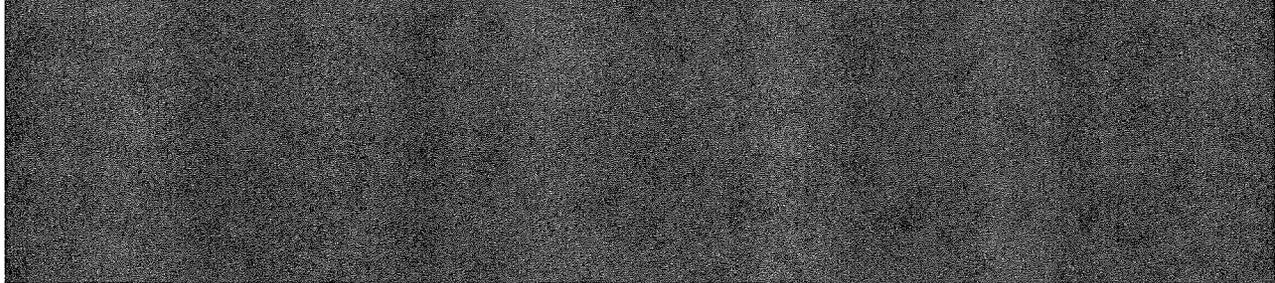
GEOSYSTEMS, L.P.

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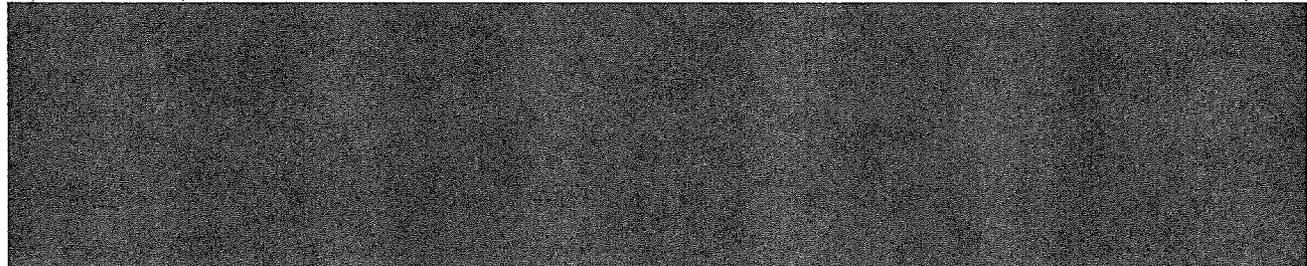
DOCUMENT 13a and 13b – Staff Report (May 12, 2015)

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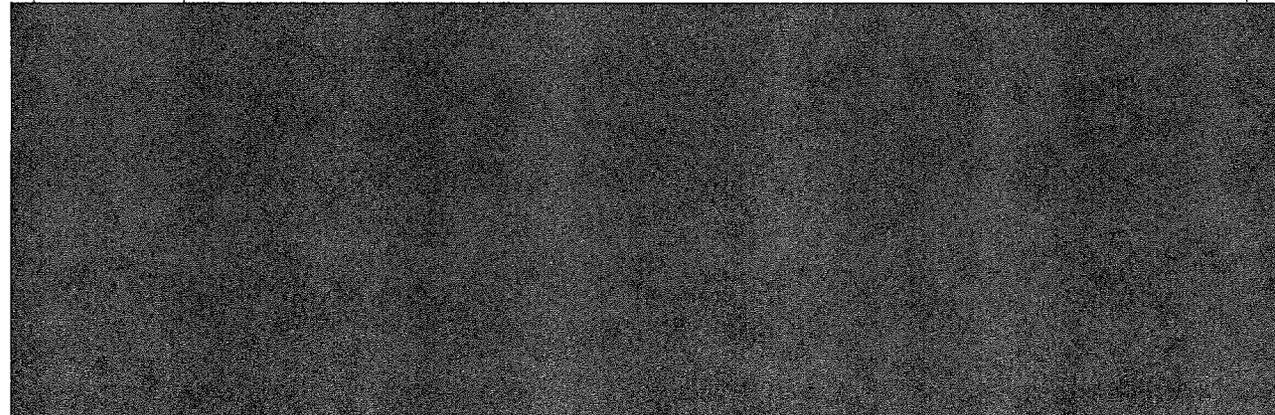
DOCUMENT 14 – Memorandum Regarding the Geotechnical Review Report (Horizon, June 11, 2015)

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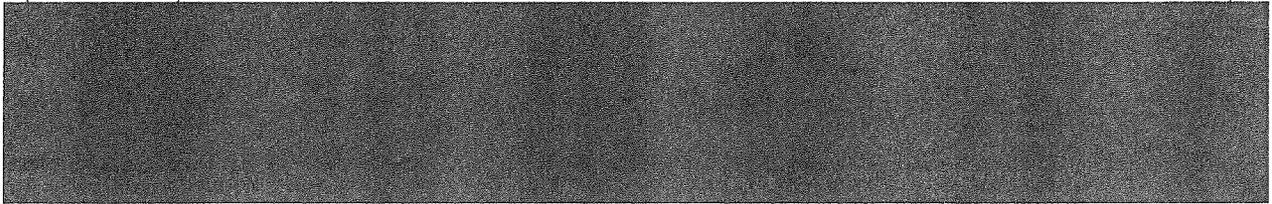
DOCUMENT 15 – Memorandum Regarding the Hydrogeological Redevelopment (Horizon, June 12, 2015)

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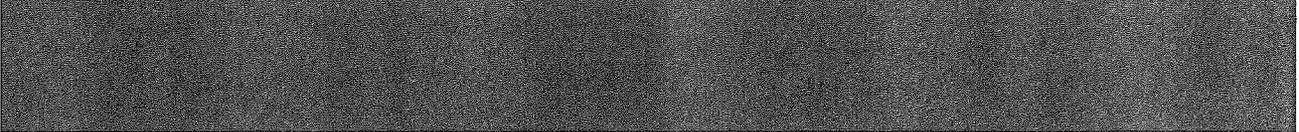
DOCUMENT 16 – Staff Report (July 21, 2015)

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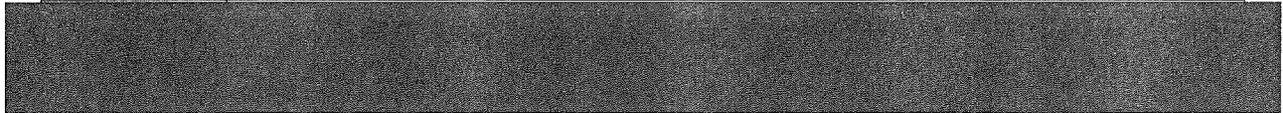
DOCUMENT 17 – Staff Report (July 28, 2015)

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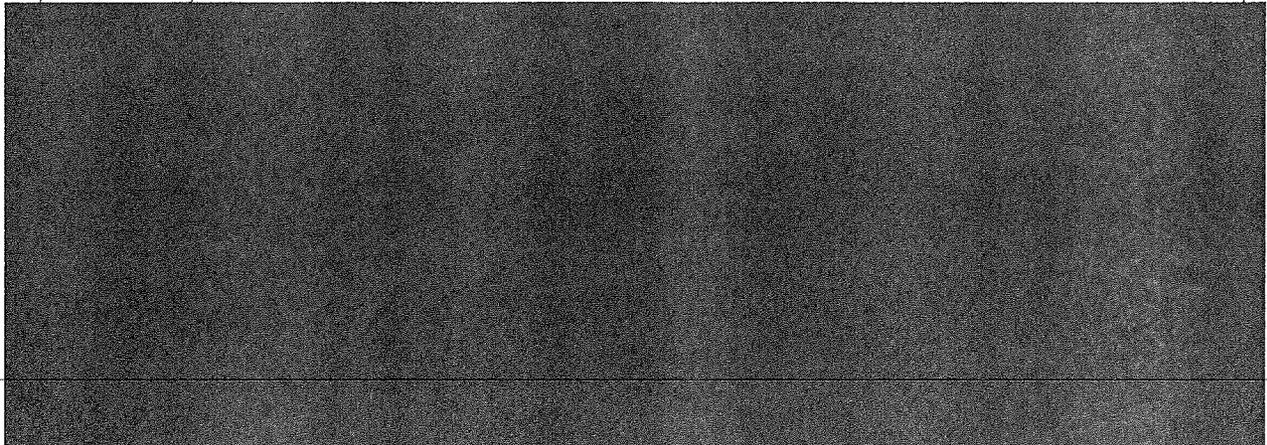
DOCUMENT 18 – Omicrons Revised Design (May 6, 2015)

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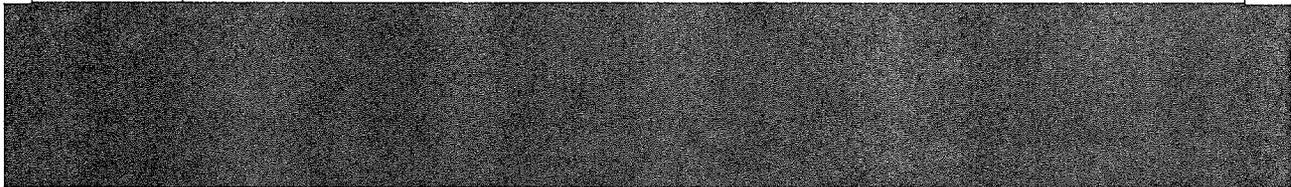
DOCUMENT 19 – Report of Findings – Detailed Site Investigation (Keystone Environmental, October 31, 2016)

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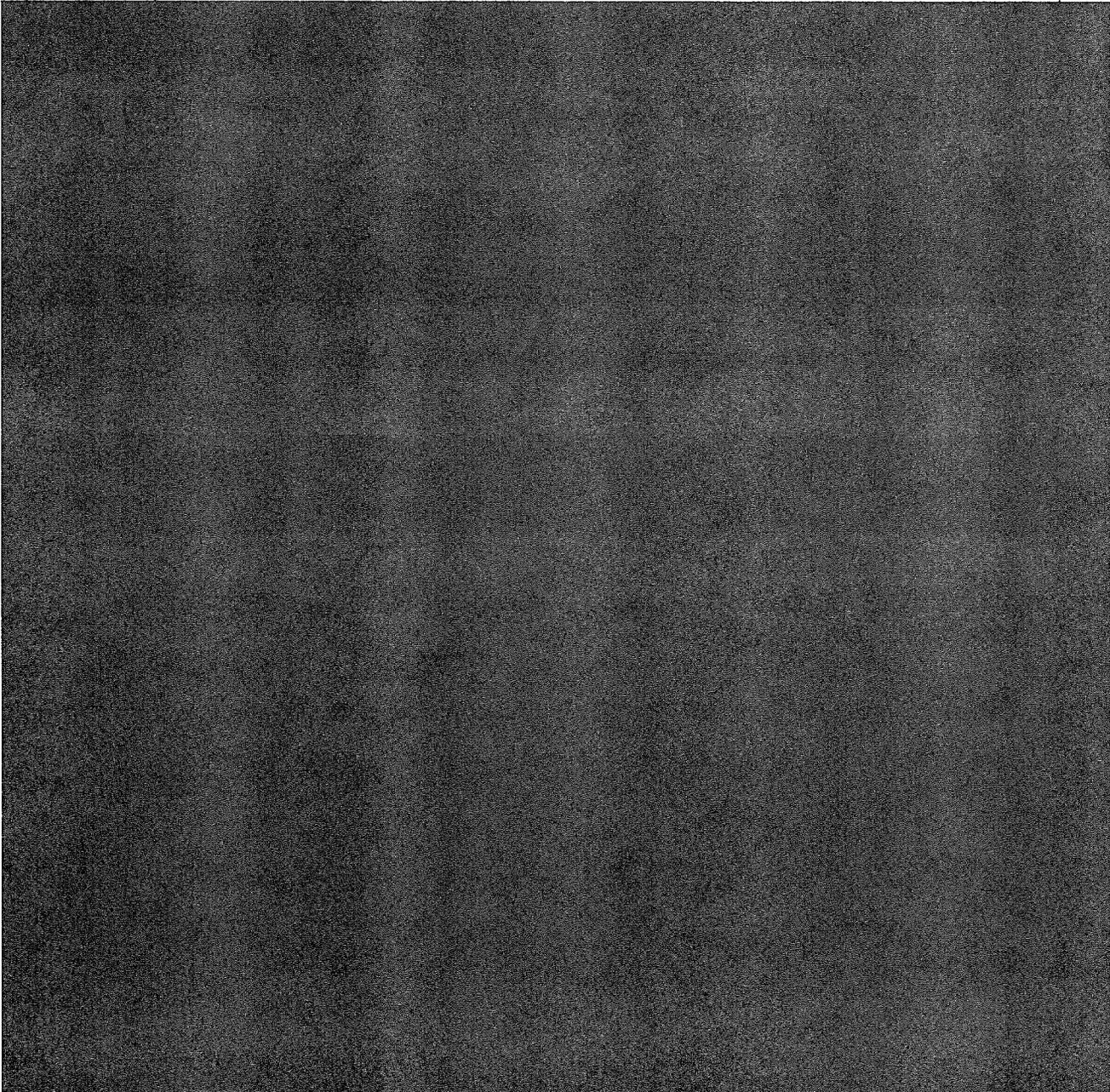
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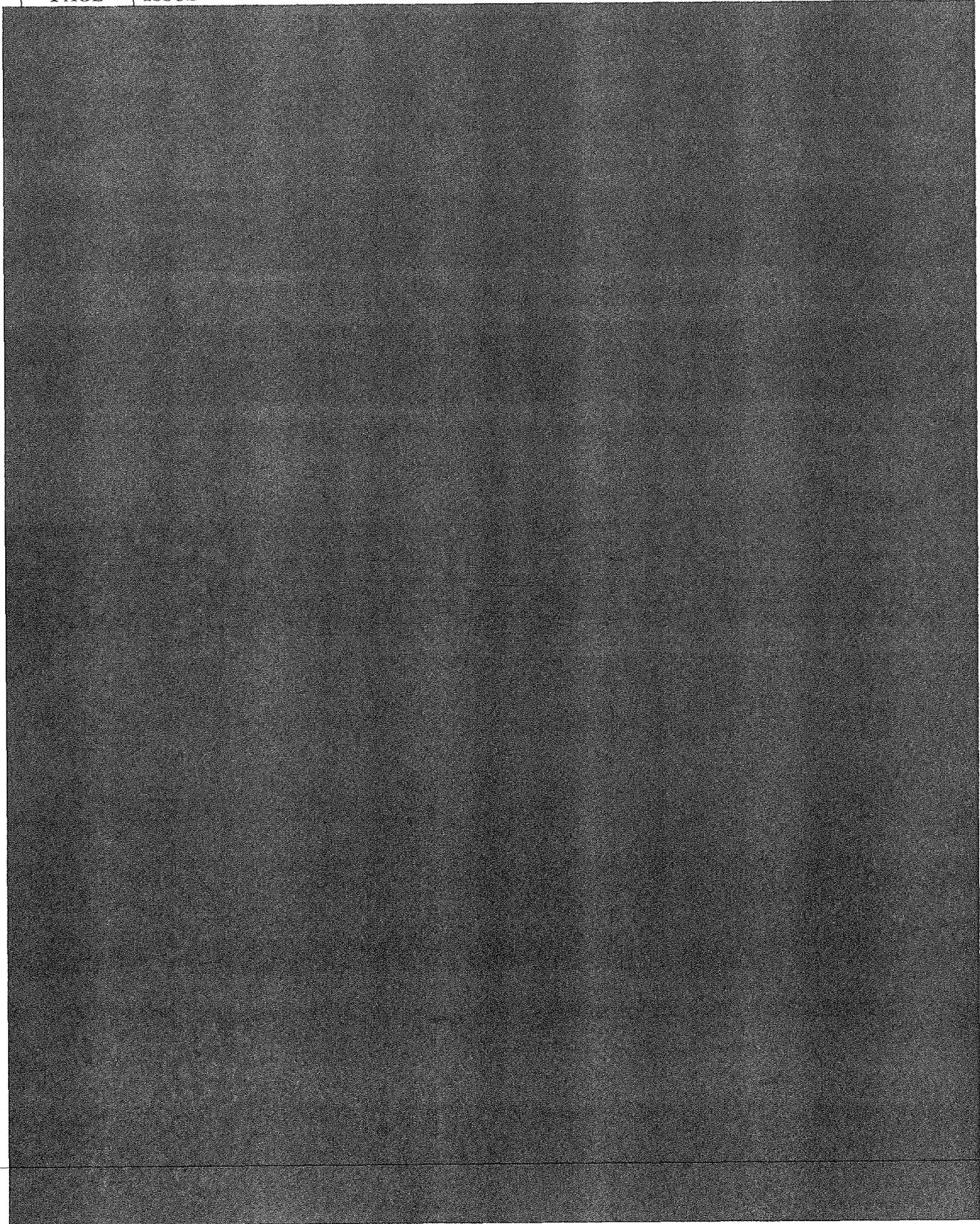
DOCUMENT 20 – Supplementary Memorandum Regarding Geotechnical Review Report (Horizon, November 1, 2016)

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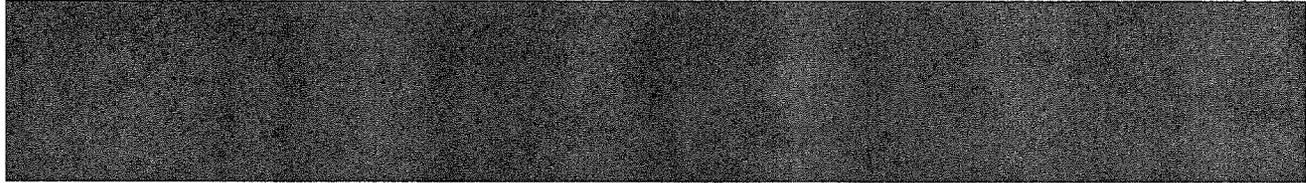
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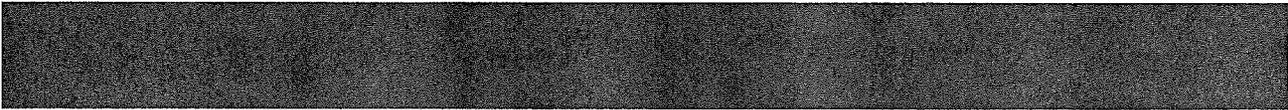


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DOCUMENT 21 – Architectural Drawings (November, 2016)

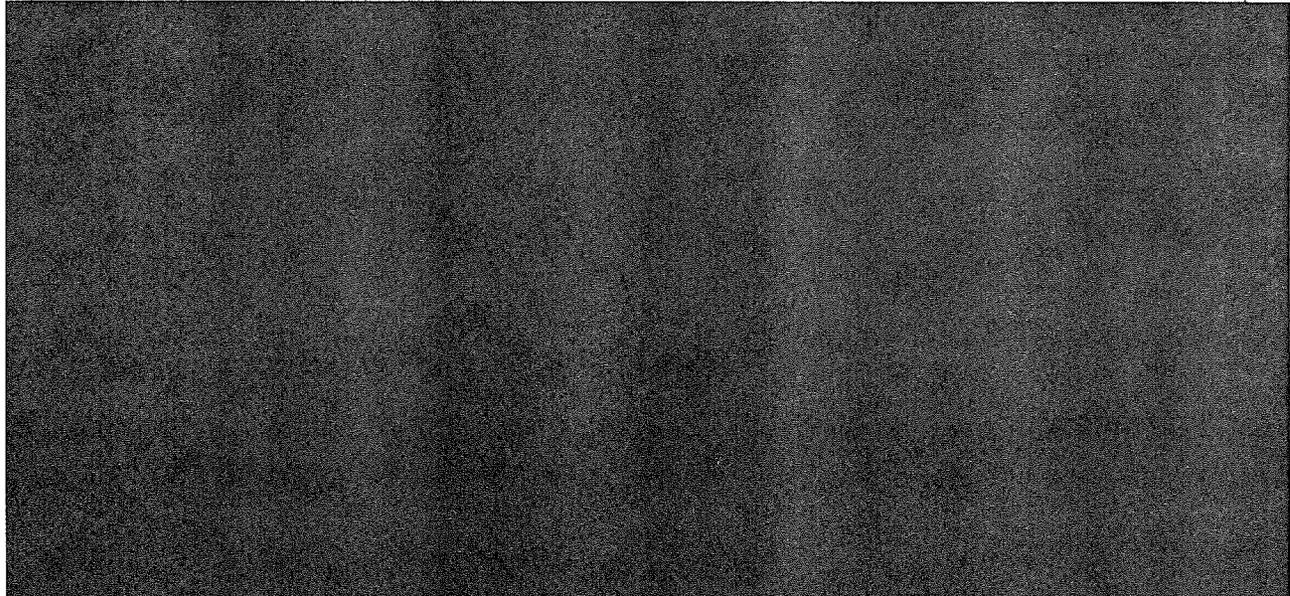


DOCUMENT 22 – Structural Drawings (November, 2016)



DOCUMENT 23 – Draft Hydrogeological Review Update (Waterline, December 1, 2016)

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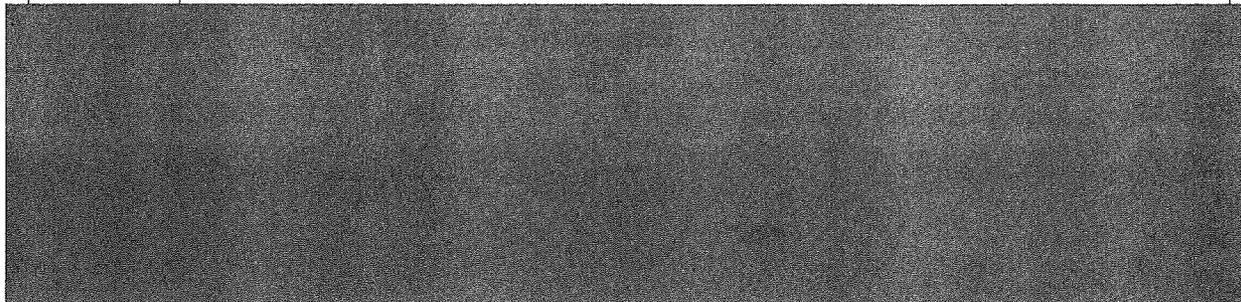
DOCUMENT 24 – Geotechnical Peer Review (Town of Gibsons, December 19, 2016)

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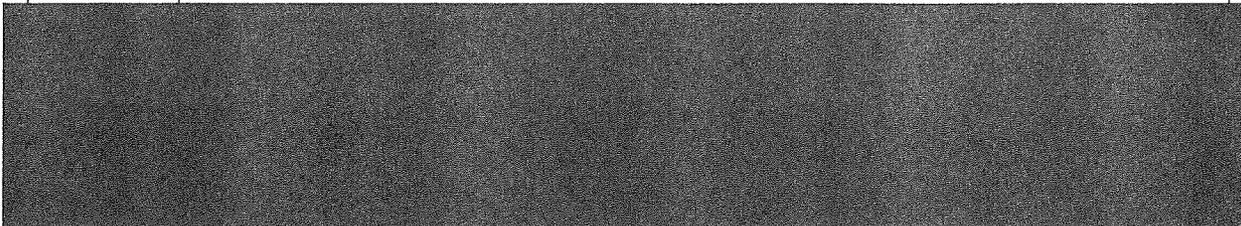
GEOSYSTEMS, L.P.

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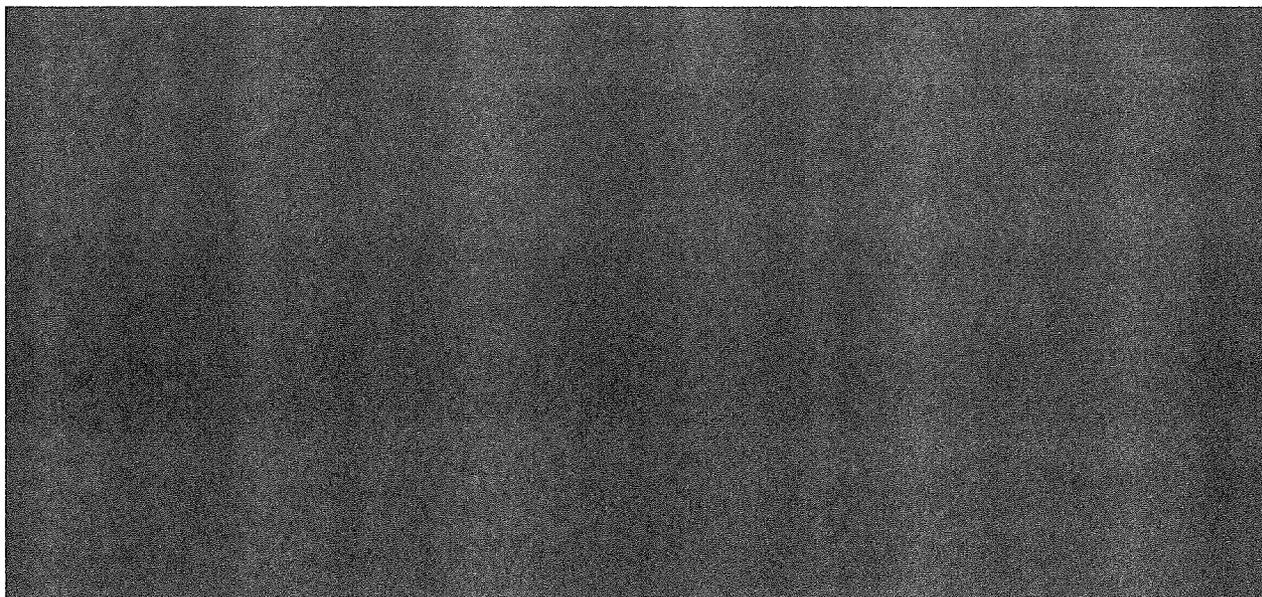


DOCUMENT 25 – Geotechnical Review (Town of Gibsons, January 17, 2017)

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DOCUMENT 26 – Geotechnical Peer Review (Town, February 7, 2017)



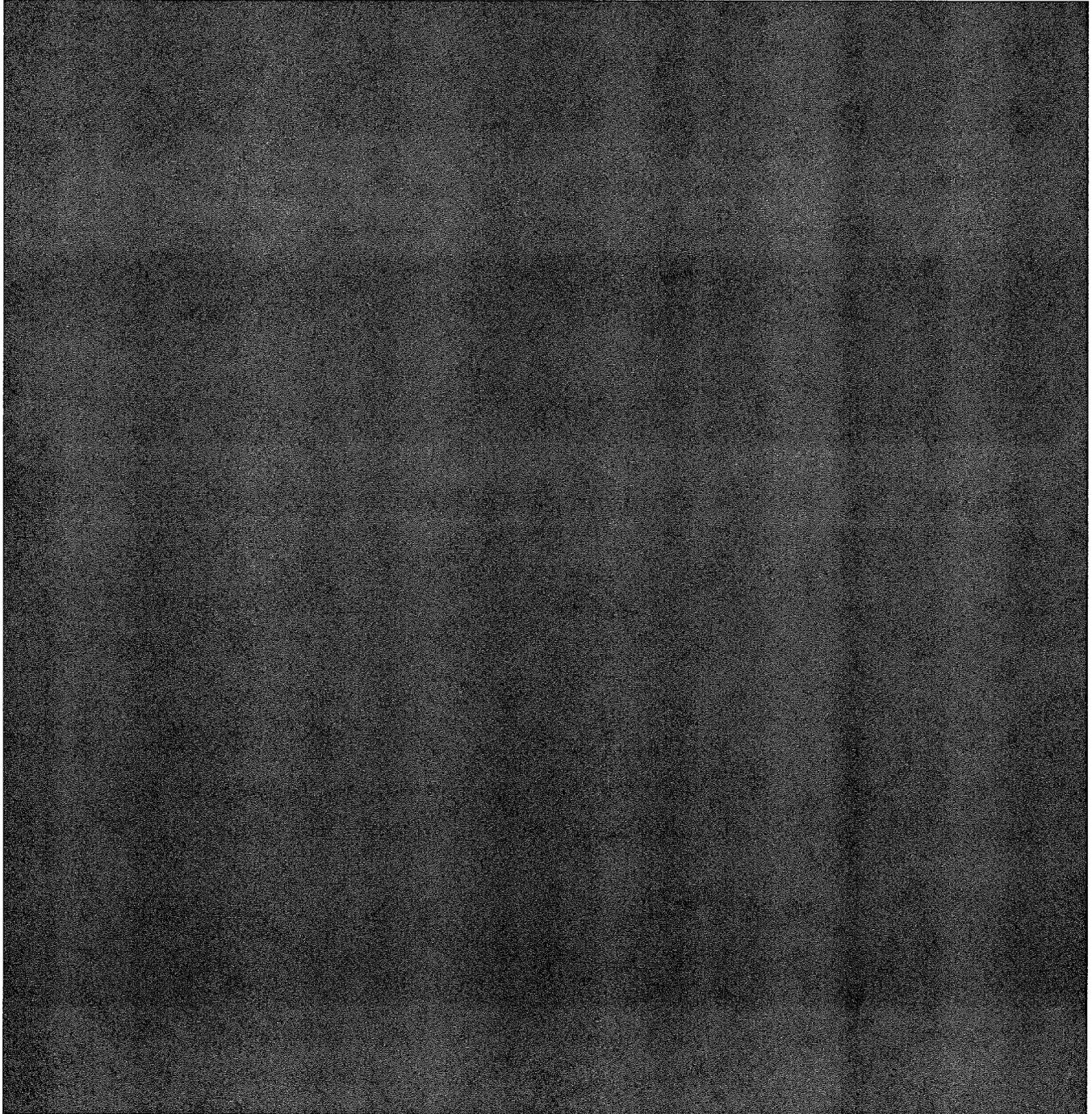
DOCUMENT 27 – Site Preparation Using DSM (Total, February 10, 2017)

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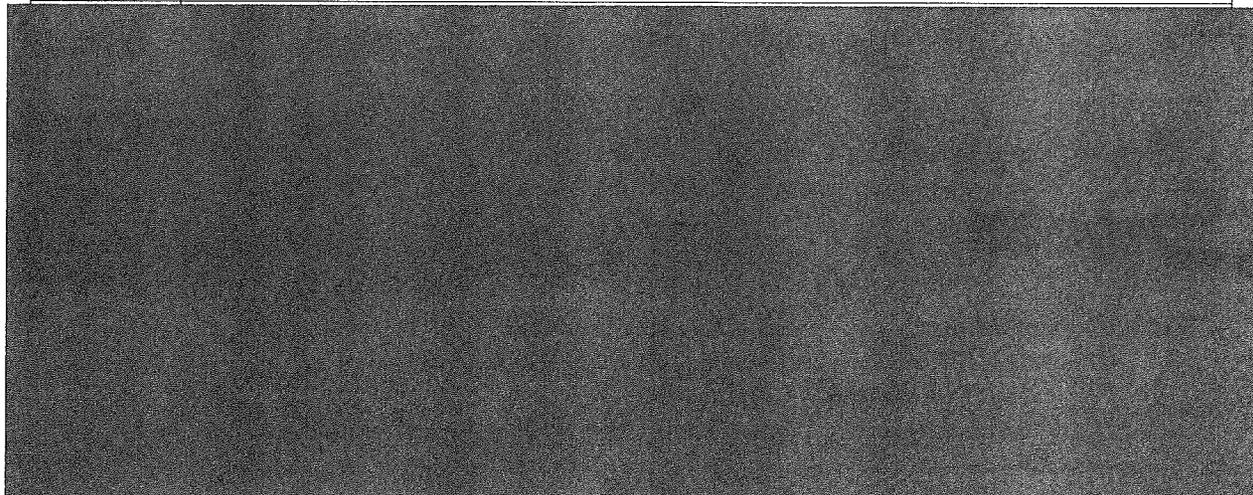
DOCUMENT 28 – Memorandum Regarding December 1, 2016 Hydrogeological Review Report (Horizon, February 7, 2017)



GEOSYSTEMS, L.P.

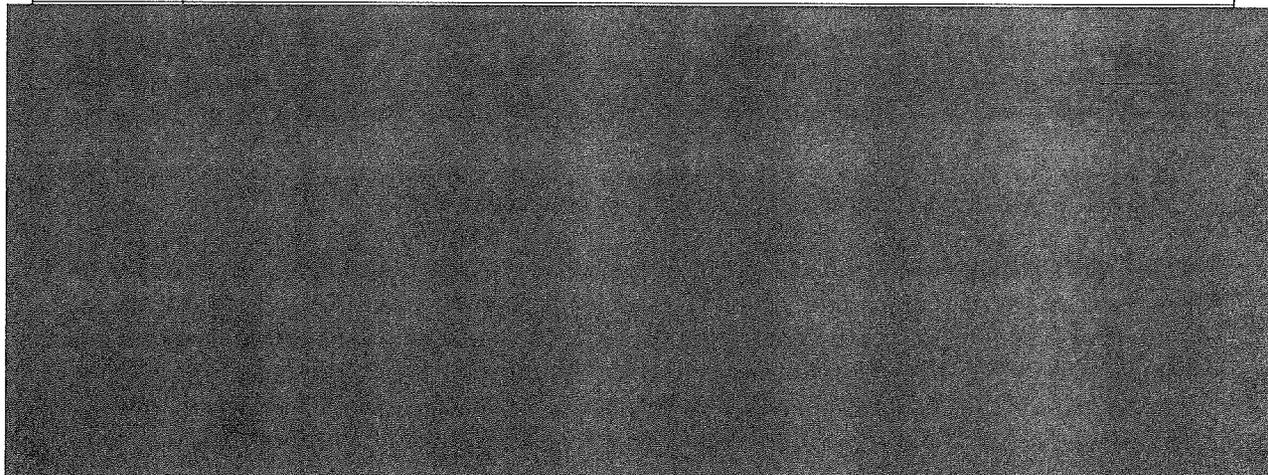
DOCUMENT 29 – Geotechnical Review (WSP, March 14, 2017)

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DOCUMENT 30 – Hydrogeological Review (Waterline, March 23, 2017)

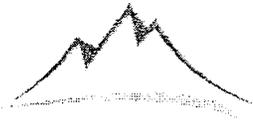
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DOCUMENT 31 – Geotechnical Peer Review Next Steps (Town, March 24, 2017)

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HORIZON
ENGINEERING INC

220 - 18 Gostick Place
North Vancouver, BC
Canada V7M 3G3

Phone 604-990-0546
Fax 604-990-0583
www.horizoneng.ca

May 15, 2017

Our File: 112-3155

TOWN OF GIBSONS
474 South Fletcher Road
Gibsons, BC V0N 1V0

Re: Proposed "The George" Mixed Use Development
377, 385 & 407 Gower Point Road, 397 & 689 Winn Road, and
Winn Road Right-of-Way, Gibsons, BC
Memorandum Regarding Geosystems Peer Review Report dated April 18, 2017

1.0 INTRODUCTION

This report provides initial response to concerns stated in the peer review report prepared by Geosystems LP, titled "Evaluation of the Viability of a DMM Option as Foundation Support for The George Development, Gibsons, BC", dated April 18, 2017. [REDACTED]

This report is not a complete response to peer reviewer's comments but intends to provide additional information as discussed in our meeting dated May 8, 2017.

Based on the results of the subsurface investigations and extensive analyses and modelling of Aquifer characteristics, Horizon Engineering does not expect interference (specifically significant breach) with the Aquifer to occur during the construction. The construction will be carried out in stages, and will be supervised full-time by Horizon Engineering engineer on site. The installed piezometers will be monitored daily for changes in water level across the subject site. Therefore, any signs of potential heave or impact on the aquifer will be identified immediately and mitigation procedure could be engaged.

[REDACTED]

[REDACTED]



[REDACTED]

[REDACTED]

[REDACTED] The deep soil mixing (DSM) method maintains the aquitard's properties that resist the underlying artesian pressures of the Gibsons Aquifer throughout the installation and curing process. The DSM procedure uses a mixing paddle that simply churns the soil at the depth of the paddle while grout is injected. No voids would be created during this process (which could otherwise create a potential preferential flow path for artesian groundwater) and although the aquitard material would be disturbed, its hydraulic conductivity would never increase. In fact, grout injection would decrease the hydraulic conductivity of the aquitard and increase the overburden pressure over the Gibsons Aquifer. As a result, we do not envisage that there is a physical mechanism possible during DSM installation that would allow artesian groundwater from the underlying Gibsons Aquifer to enter the DSM column. [REDACTED]

[REDACTED]

[REDACTED]

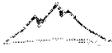
[REDACTED]

[REDACTED] A contingency plan to protect the Aquifer has been prepared and is presented in Appendix B.

The site can be categorized into the following three areas, with respect to risk of breach into the Aquifer and mitigation plan:

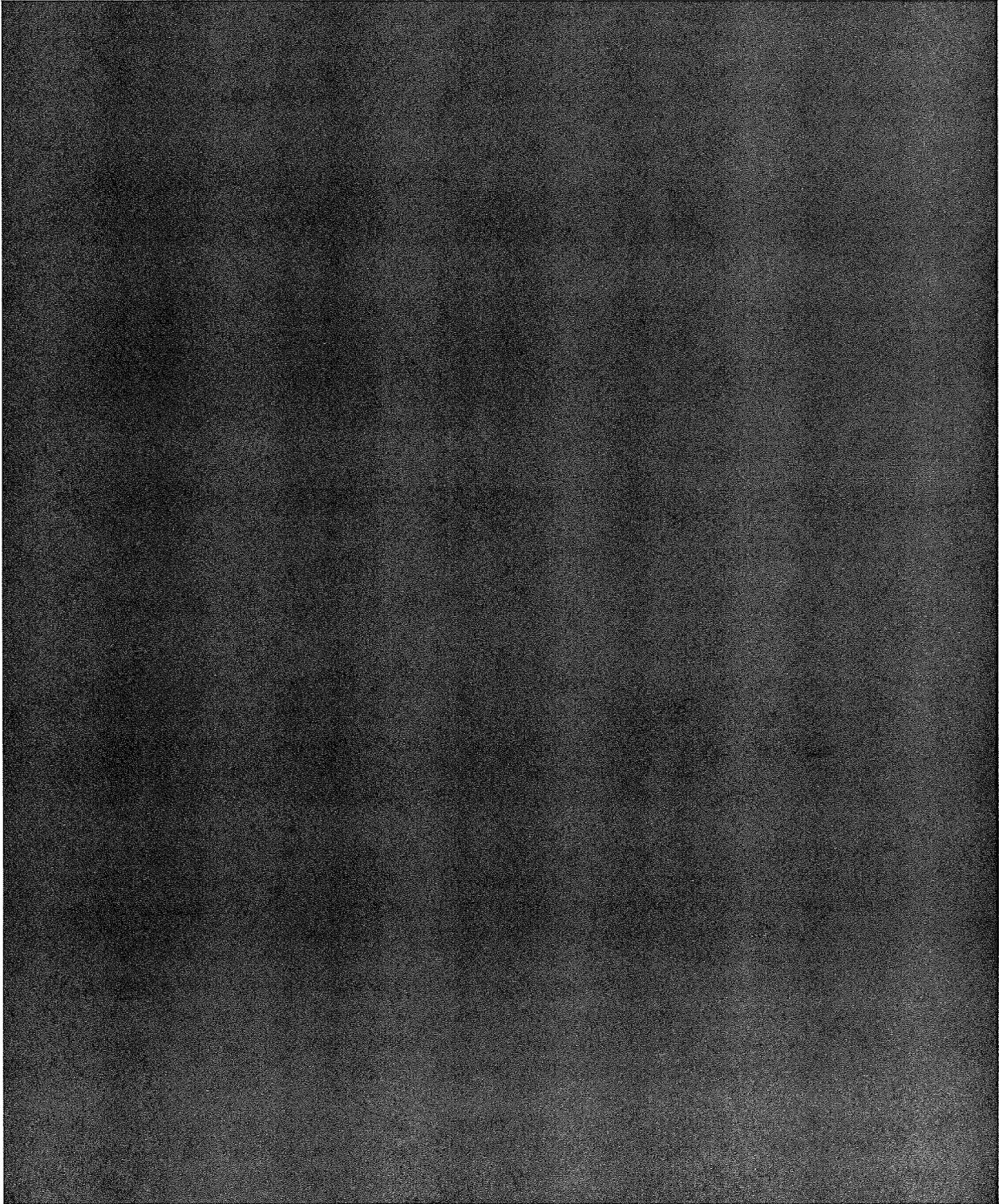
- **Area 1 (Northwest portion of the site):** A bulk excavation would be carried out through the fill material at this portion of the site. Peat material would be removed in stages prior to the DSM installation. Temporary excavation support would be installed. Based on the results of our subsurface investigations, the dense to very dense, till-like soil presents at this portion of the site. The presence of the above-mentioned till-like soil reduces the risk of breach into the Aquifer;
- **Area 2 (Northwest portion of the site):** Excavation for removing the peat and organic materials would be carried out at this portion of the site, prior to DSM installation. Based on the results of our subsurface investigations, the dense to very dense, till-like soil presents at this portion of the site. The presence of the above-mentioned till-like soil reduces the risk of breach into the Aquifer;
- **Area 3 (Central and east portions of the site):** Excavation for removing the peat and organic materials would be carried out at this portion of the site. Based on the results of our subsurface investigations, the thickness of the dense to very dense, till-like soil reduces towards the east and may not present at portions of this area.

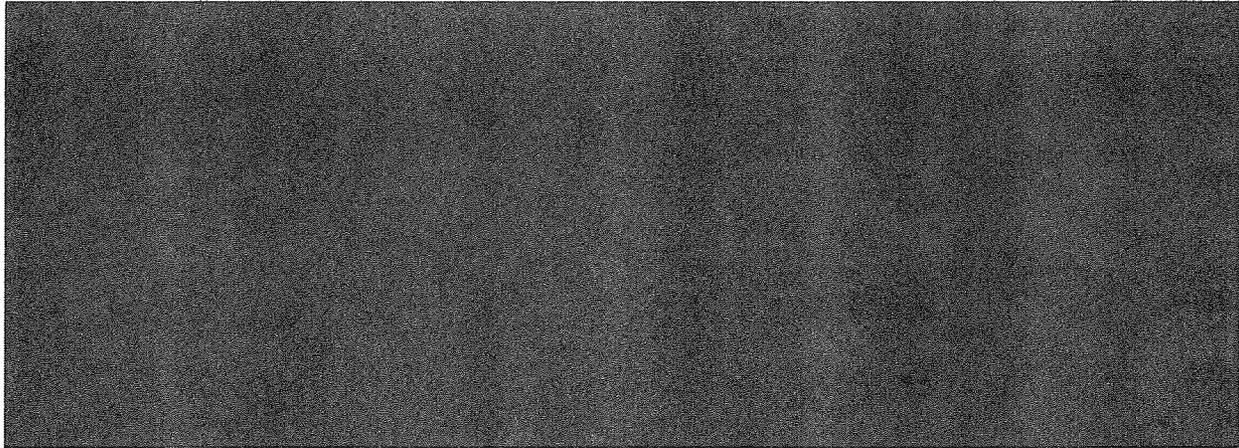
We expect that, due to presence of till-like soil above the Aquifer at the areas 1 and 2, the risk of breach into the Aquifer to be significantly less. The contingency plan, as presented in Appendix B, provides recommendations with respect to the risk of breach into the aquifer at above-stated areas.



2.0 GENERAL CONCERNS AS STATED IN THE PEER REVIEW REPORT

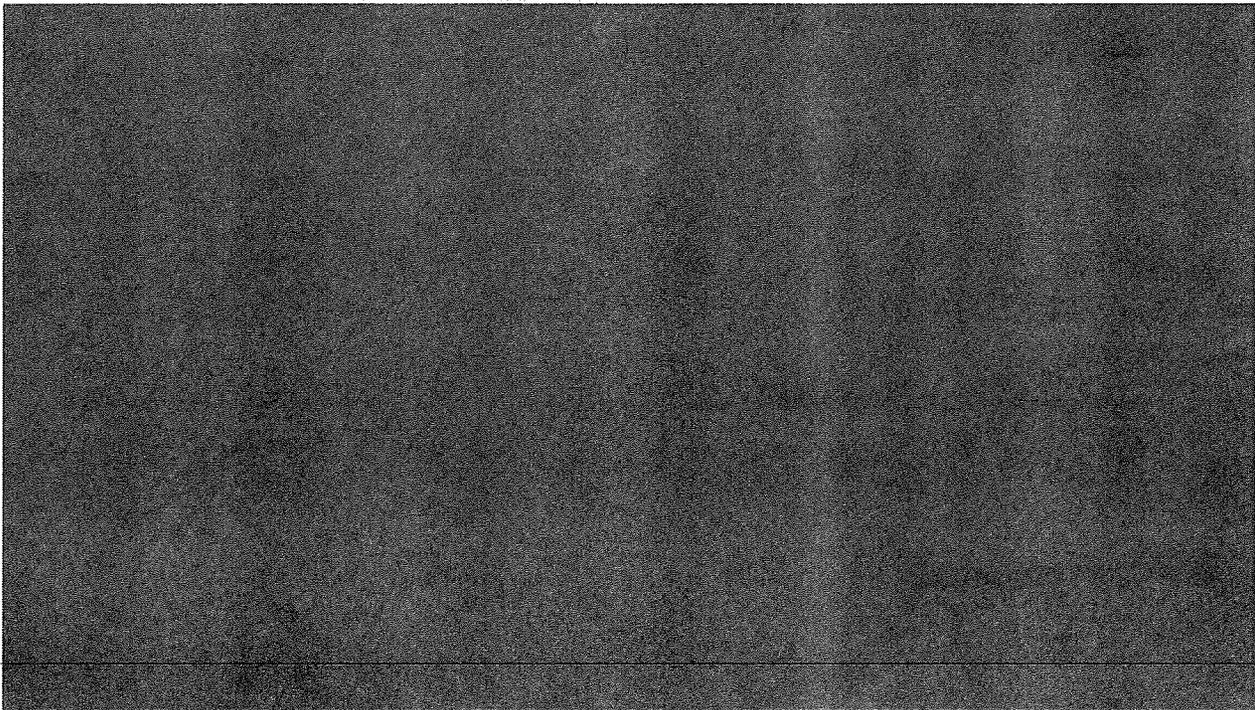
This section summarizes the concerns as stated in the Geosystems Peer Review report and the responses prepared by Horizon Engineering.

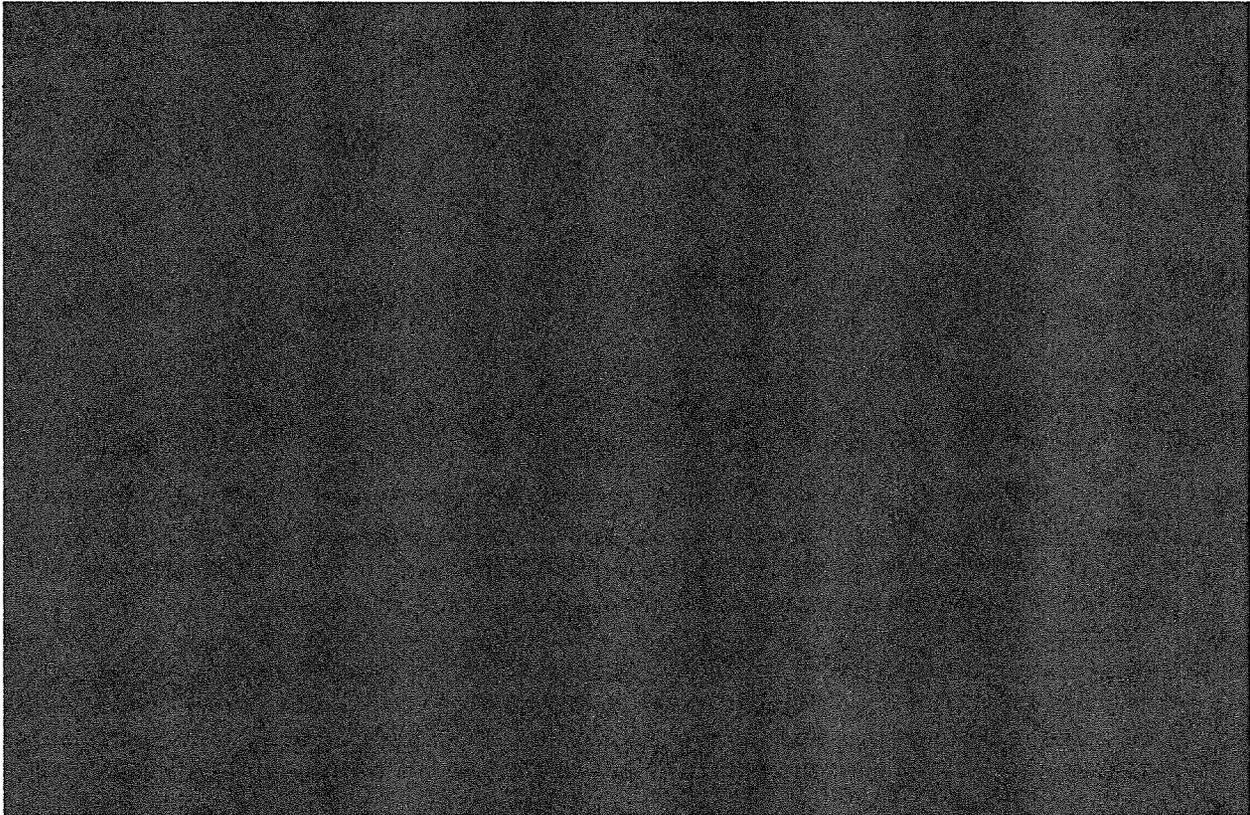
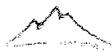




5) An Aquifer mitigation plan is essential to develop, regardless of which technique is chosen as a foundation system. Different parts of the site may well need different - or modified - mitigation plans, which will also depend on the ground modification technique actually used, and the sequencing of the various construction processes.

The objective of the investigation and design, carried out by Horizon Engineering, has been to minimize the risk of impact on Aquifer. However, in case of a breach to the Aquifer during the construction, a contingency plan to protect the Aquifer has been prepared and is presented in Appendix B. As mentioned in Section 1.0, three areas have been identified with respect to the construction procedure, and presence of till-like soil. We expect that, due to presence of till-like soil above the Aquifer at the areas 1 and 2, the risk of breach into the Aquifer to be significantly less.



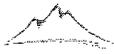


We trust that our comments and recommendations are both helpful and sufficient for your current purposes. If you would like further details or require clarification of the above, please do not hesitate to contact us

For
HORIZON ENGINEERING INC

Karim Karimzadegan, M.A.Sc., P.Eng.
Principal

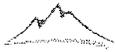
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APPENDIX A

CONSTRUCTION PROCEDURE AND
PROTECTION OF AQUIFER DURING CONSTRUCTION

DRAFT



CONSTRUCTION PROCEDURE AND PROTECTION OF AQUIFER DURING CONSTRUCTION

Excavation and Shoring

We propose the following preventative measures during the excavation and shoring at the northwest portion of the site:

- The excavation will be carried out in stages such that maximum excavation increments will be limited to 0.8 metre (2.5 feet) between each stage below the elevation of 7.0 metres (23 feet);
- Following bulk excavation to each stage, the ground surface should be reviewed by Horizon Engineering to investigate if any visible signs of heaving or upward groundwater seepage are observed;
- During and subsequent to installation of excavation support, it will be monitored by a series of survey points. The survey to be carried out by a BC Land Surveyor weekly for the first month and bi-weekly thereafter. Any signs of ground movement or deterioration will be reported immediately and appropriate actions will be instructed to the contractor.

DSM Installation

In general, the intent of the ground improvement construction methodology is to remove existing peat and organic soils which cannot be effectively improved then install cement-soil mixed ground improvement as required to support future building loads. By removing the organics prior to deep soil mixing, all soil on the site can be included in the soil mix and used as a construction material. This eliminates mass excavation above the aquifer and greatly reduces the amount of soil import and export which will minimize construction time and traffic. Risk management measures are added to minimize the potential for breaches in the aquifer.

The construction procedure for installation of DSM system will be reviewed with the contractor in details prior to construction. However, the following procedure has been communicated mutually between the Southwest Contracting and Horizon Engineering as the concept of DSM construction.

Location of the application of DSM area will be accurately surveyed and staked in ground prior to construction. Soil treatment shall be installed at pre-determined locations below the footprint of the planned building. Vertical alignment, mixing shaft speed, penetration rate would be controlled and monitored throughout the DSM installation. As stated in the specifications, a test panel will be carried out to verify the construction procedure and target strength, as set by the design. Modifications to the construction process and mix design may be required based on the results of the test panel.

DSM equipment will be mobilized after site clearing and grubbing and partial excavation and shoring installation as specified along the west wall. Excavation spoils will be used to level out the site and build a working pad for the DSM equipment. This overburden will create an additional factor of safety in resisting possible uplift pressures. DSM batch plant equipment will be set up on site in an area accessible to bulk cement transfer trucks entering from Gower Point Road. Survey points will be installed on batter boards for layout along the site perimeter. Pre-production probing will be performed under the supervision of the Engineer in order to verify soil conditions and elevations of competent bearing soils.

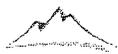
Daily production DSM work will be performed in the following order:

- An elevated working platform, approximately 1.5 m thick, will be created using excavation and/or DSM spoils. The 1.5 m thick working platform will be maintained above the planned bottom of footing elevation (prior to excavation). After the DSM is installed, the elevation of treated zone will be adjusted to the underside elevation of the footing;
- A 6'-wide trench will be locally excavated to contain DSM spoils for the current day's work. The trench will be excavated to the depth of the bottom of peat. The excavated footprint must not exceed approximately 1.8 m by 3 m at a time. After removal of the peat, all but the upper 1.5m of the trench will be immediately backfilled using excavation and/or DSM spoils. The upper 1.5 m has been the platform placed above the existing grade;
- DSM columns will be installed within the trench to the depths verified by the Engineer through pre-production probing. Where the column reaches the suitable dense bearing soil, the mixing torque will increase and penetration rate will decrease sharply. The operator will attempt to penetrate approximately 1 foot into bearing soils then pull out the mixing head;
- DSM spoils will fill in the trench. Excess DSM spoils will be stockpiled for future use;
- At the end of the shift, equipment will be cleaned and all trenching will be filled with DSM spoils (no trench excavations will be left open overnight);
- After completion of DSM production in an area, DSM spoils will be stockpiled and top elevations will be maintained at rough finish grades.

The proposed procedure mainly intends to maintain and re-use the site excavated, non-contaminated material to minimize construction traffic and makes the project more feasible.

The proposed construction procedure, specifically installation of the 1.5 m thick working platform over the DSM footprint, will ensure that the total stress above the aquifer is maintained to original levels and prevent any potential upward heave and internal piping.

Survey points will be installed around DSM installation footprint to monitor deformation of the ground during peat removal and DSM installation. Monitoring program and procedure shall be developed prior to excavation.



HORIZON
ENGINEERING INC

Proposed Development - "The George"
Gower Point Road at Winn Road, Gibsons, BC
Memorandum Regarding Geosystems Peer Review

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APPENDIX B

CONTINGENCY PLAN TO PROTECT AQUIFER

DRAFT

CONTINGENCY PLAN TO PROTECT AQUIFER

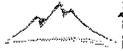
Horizon Engineering does not expect a significant breach / disturbance of the aquifer. The proposed preventative measures and remedial actions presented in this report, would provide a reasonable assurance that the construction process consider protection of aquifer during the course of ground preparation and improvements. However, this section provides conceptual details for a contingency procedure if there would be a breach of aquifer. The proposed contingency plans can be detailed based on the extent of breach and risk associated with potential internal piping.

In an event that minor ground heaving and/or upward groundwater seepage are observed during the excavation/construction (potentially at areas 1 and 2, as mentioned in Section 1.0):

- The affected area would be backfilled to the previous stage and then surveyed to facilitate monitoring of the area;
- The contractor must mobilize to the site with suitable equipment and granular backfill material to restore grades of areas with signs of potential heave. Backfill material should be stockpiled on site during the installation of the temporary excavation support;
- Due to the local / near surface perched groundwater table, seepage from the excavation face may be expected. Implementation of filter fabric and pea gravels will be considered at seepage locations to prevent internal erosion.

In an event of any potential breach in aquifer, with a typical indication of water flow to the surface (potentially at area 3, as mentioned in Section 1.0):

- The area of breach could be backfilled to the original grade, and additional fill equivalent to the pressure head of the water at the location of the breach could be placed. The footprint of the backfill area must be extended beyond the edge of the breach area equal to the height of the fill above the grade. Bentonite will be kept on site and can be immediately mixed and installed at the breached area;
- Depending on the extent of breach, 2 to 4 cased auger holes to de-pressurize the aquifer will be advanced at locations surrounding the subject breach area. Drawdown pumps to be installed at each auger hole locations to lower the water table within the stand pipe to a depth approximately 1.5 metres below the existing grade at the time of breach. Pump rate is estimated to be 60 litres per minute in order to achieve equilibrium at the depth of 1.5 metres provided that the wells are installed with 10 metres distance. It is recommended that this pump rate can be adjusted based on the locations and number of wells. The estimated pumping rate is based on our computer model simulating subsurface conditions and aquifer pressures. This simulation was carried out at the area where there is no presence of glacial till encountered at the test holes;
- After successfully lowering down the water table within stand pipes, top 60 to 90 centimetres of material at the area of the aquifer breach shall be sub-excavated and backfilled with either compacted DSM spoil or control density fill / lean concrete to provide a cap. Extend of the excavation and backfill area shall be at least 3 metres in all directions beyond the breached area. Drawdown pumps at stand pipe locations are remained active until DSM spoil are fully compacted or control density fill / lean concrete are adequately cured. Water table within a well shall be monitored during this operation;
- After the cap is adequately compacted/cured, drawdown pumps shall be deactivated such that water table reaches an equilibrium within the stand pipe. Provided that local groundwater seepage to the surface was observed, the pumps can be re-activated and the capping



material can be extended in plan. Based on our analysis, water table would be stabilized at El. 5.3 metres, which is approximately 1.4 metres from the preconstruction grades. After the above-stated procedure is complete, the depressurizing wells can be grouted and de-commissioned. This operation shall be carried out one stand pipe at a time. Water table within other stand pipes shall be monitored during the first stand pipe grouting.

DRAFT

GEOSYSTEMS, L.P.

P.O. Box 237, Venetia, PA 15367, USA Phone: (724) 942-0570 Fax: (724) 942-1911
Email: dabruce@geosystemsbruce.com Website: www.geosystemsbruce.com

May 29, 2017

Town of Gibsons
Attn: Mr. Dave Newman
Director of Engineering
P.O. Box 340
474 South Fletcher Road
Gibsons, BC V0N 1V0

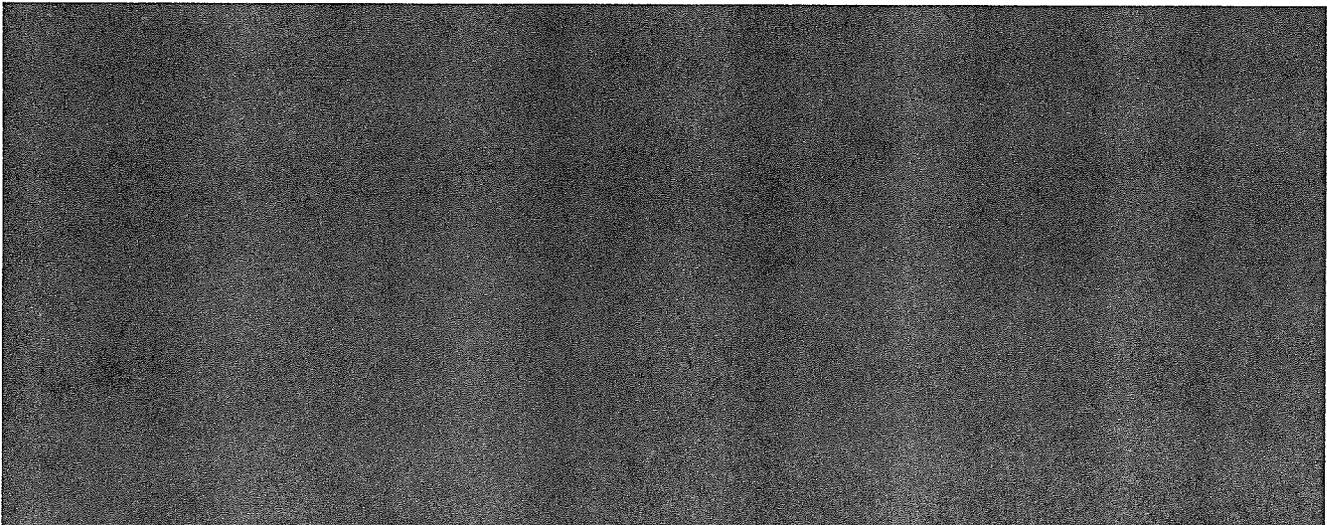
THE PROPOSED "THE GEORGE" MIXED USE DEVELOPMENT **SUMMARY OF ITEMS REQUIRED AS PERMITTING CONDITIONS**

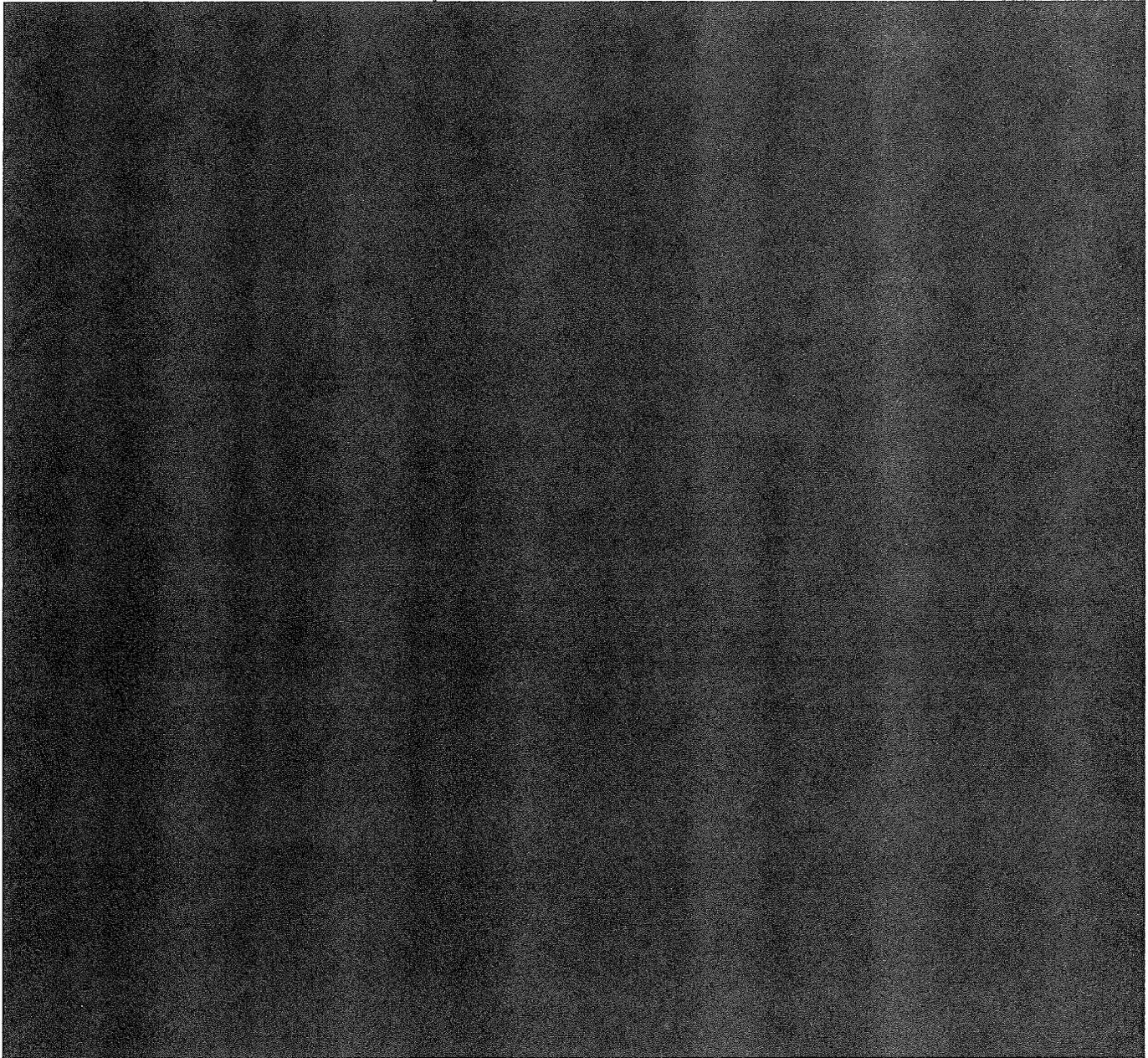
Dear Sir:

As requested during our teleconference of Tuesday, May 23, 2017, I provide herein a list of actions and initiatives I regard as essential for the Proponent (and his Engineer-of-Record) to commit to undertake as conditions for permit approval. Kindly note there will be some overlap between this letter and my other letter of today's date (reviewing Horizon Engineering Inc.'s Draft Report of May 15, 2017), but there should be no inconsistencies. [REDACTED]

Kindly note the following list applies solely to the engineering and construction aspects of the project, and does not address other spheres (e.g., environmental protection or well head protection) which are also integral to your permitting process.

In my opinion, the Proponent should commit to implementing the following items as conditions of being awarded the relevant permits.





Please advise if you require clarification on any of these proposed conditions.

Very truly yours,
GEOSYSTEMS, L.P.

A handwritten signature in black ink, appearing to read 'D. Bruce', is written over a horizontal line.

Donald A. Bruce, Ph.D., D.GE, C.Eng., P.G. L.G., L.E.G.
President

GEOSYSTEMS, L.P.

P.O. Box 237, Venetia, PA 15367, USA Phone: (724) 942-0570 Fax: (724) 942-1911
Email: dabruce@geosystemsbruce.com Website: www.geosystemsbruce.com

May 29, 2017

Town of Gibsons
Attn: Mr. Dave Newman
Director of Engineering
P.O. Box 340
474 South Fletcher Road
Gibsons, BC V0N 1V0

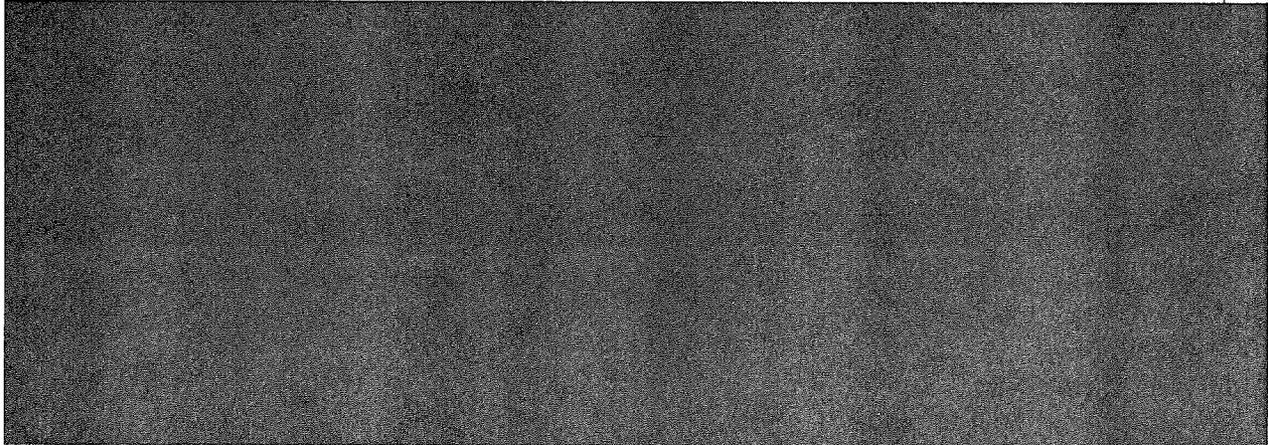
THE PROPOSED "THE GEORGE" MIXED USE DEVELOPMENT
REVIEW OF DRAFT REPORT FROM HORIZON ENGINEERING INC.
MAY, 15, 2017

Dear Sir:

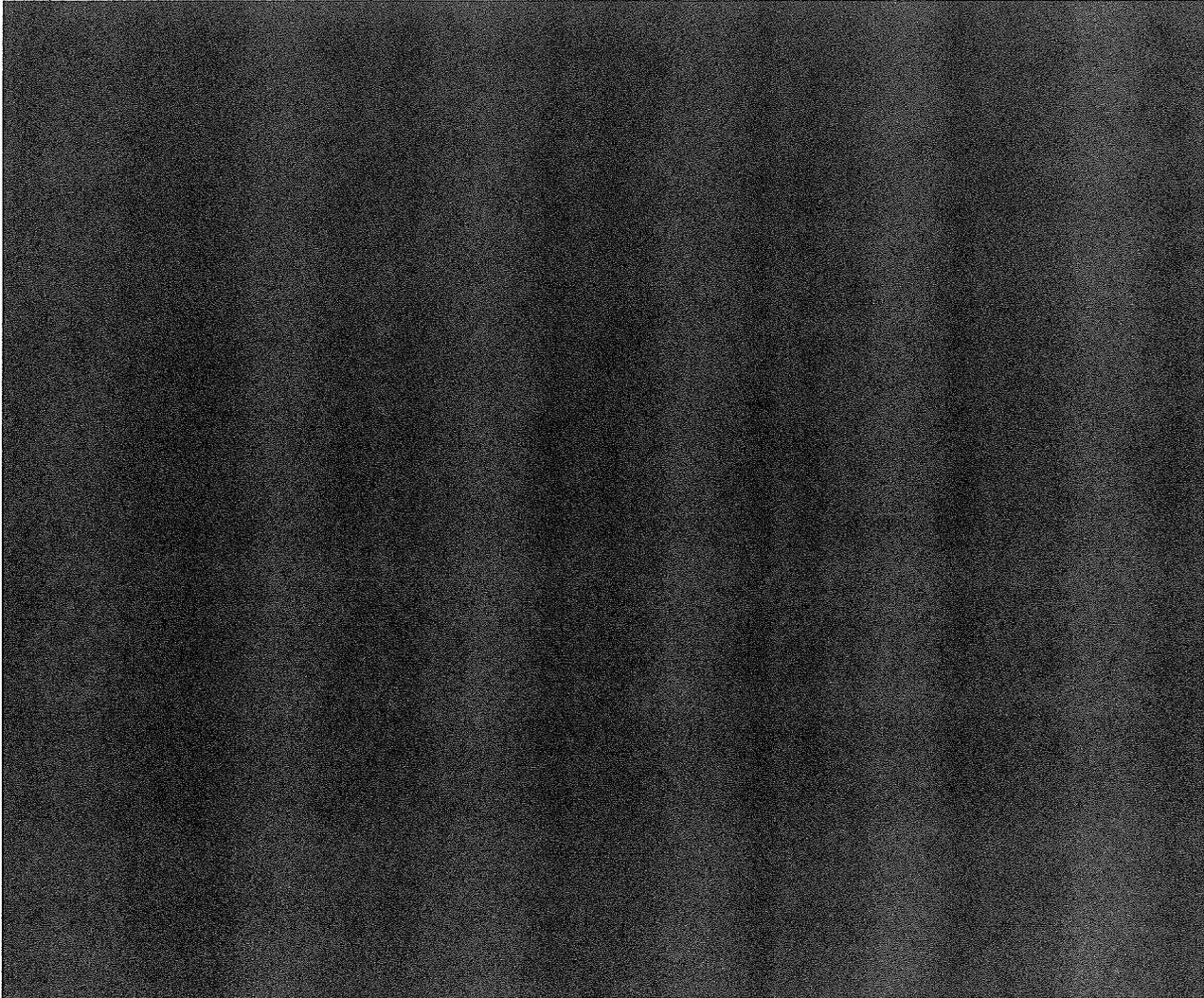
I am in receipt of the above-referenced Draft Report, which Horizon Engineering Inc. ("Horizon") have authored in response to my Report of April 18, 2017, and our meeting on Monday, May 8, 2017. [REDACTED]

For convenience and brevity, I provide my comments on Horizon's Draft Report in tabular form.

PAGE	FULL PARA	COMMENT
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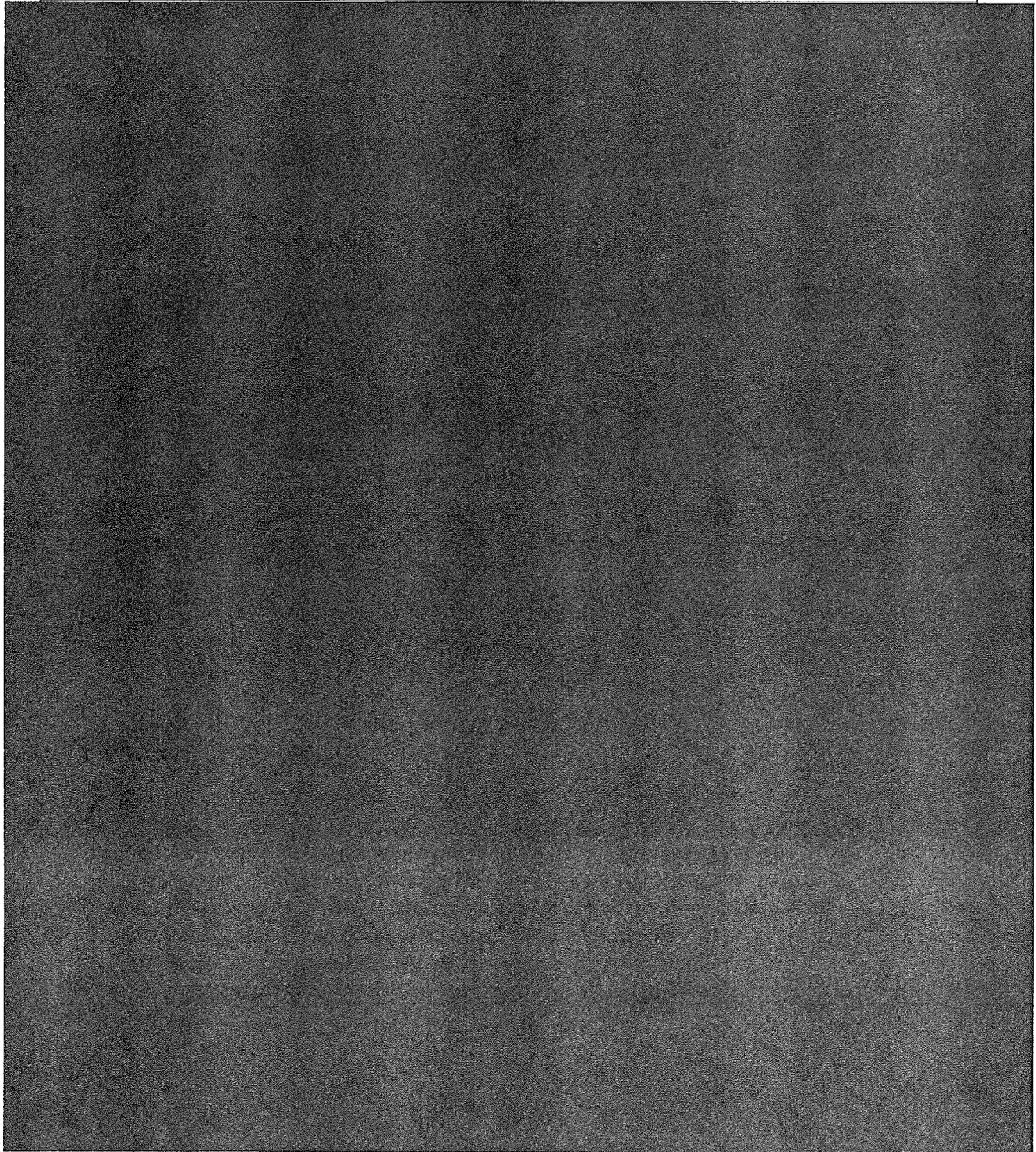
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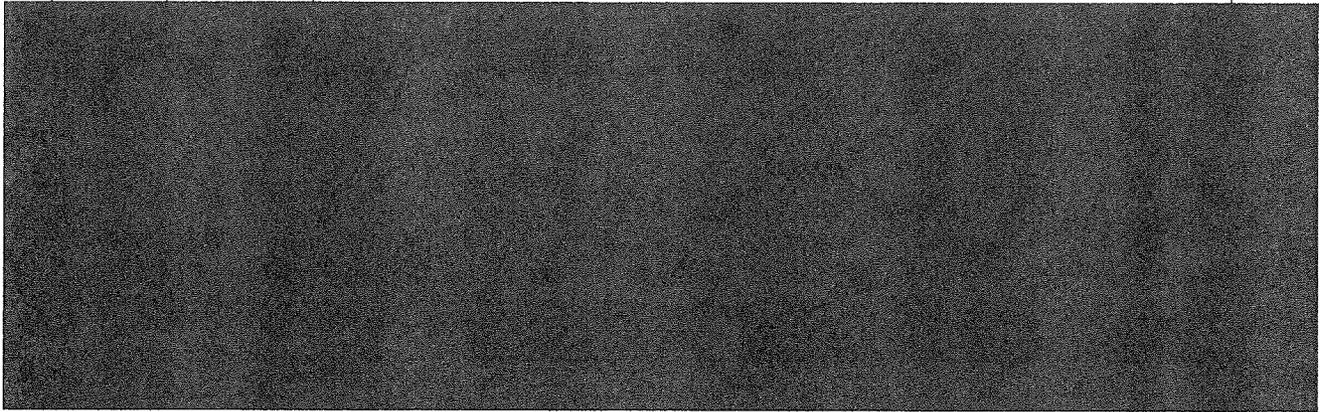
		Appendix B should contain similar details, together with the commitment that the rig and other essential equipment foreseen for remediating any breaches will be present on site during excavation and foundation treatment works. Given the understandable sensitivity to the term “depressurization,” it would be appropriate to explain this term simply, and to put “local” and “regional” impacts into proper perspective.
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Very truly yours,
GEOSYSTEMS, L.P.

Donald A. Bruce, Ph.D., D.GE, C.Eng., P.G. L.G., L.E.G.
President

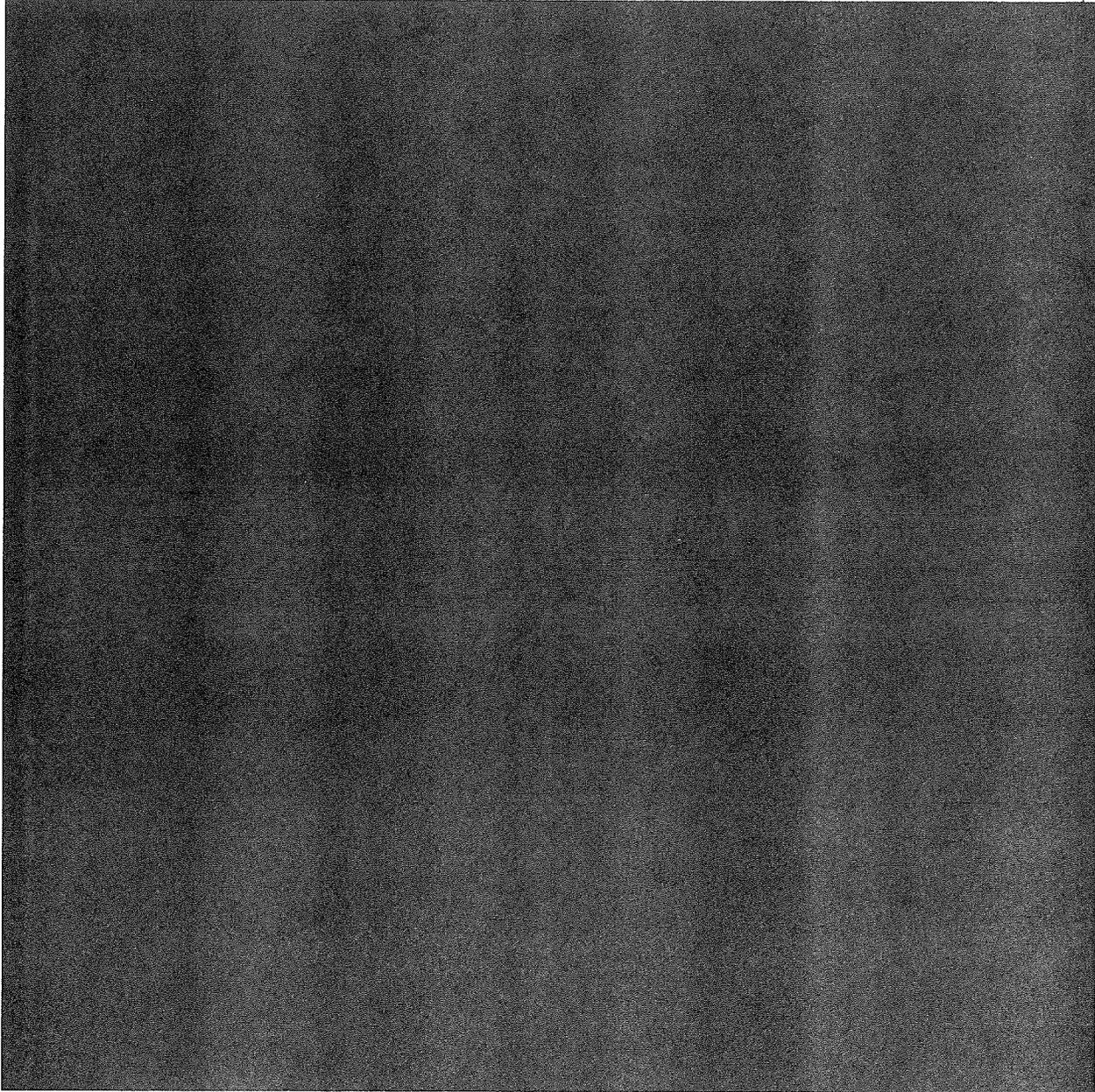
MEMORANDUM

Gibsons
Horizon Engineering Inc. "For Coordination" Geotechnical
Investigation Report (Revised) June 30, 2017 – Specific
Comments
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GEOSYSTEMS, L.P.

July 17, 2017

SECTION	COMMENT
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Best Regards,
GEOSYSTEMS, L.P.

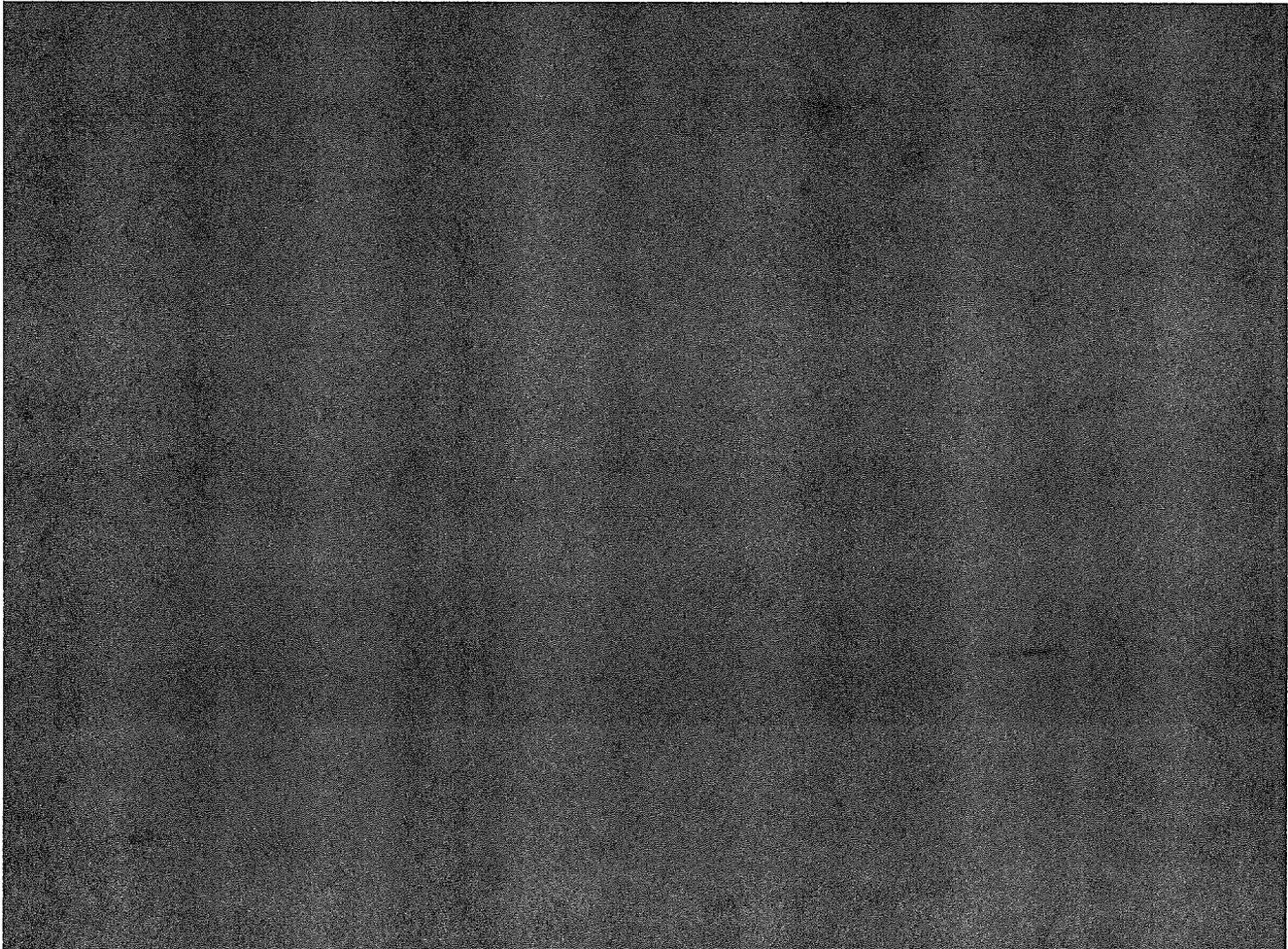
Donald A. Bruce, Ph.D., D.GE, C.Eng., L.G., L.E.G.
President

MEMORANDUM

TO: Andre Boel – Gibsons
FROM: Dr. Donald A. Bruce
CC: Dave Newman and Emanuel Machado – Gibsons
DATE: July 17, 2017
RE: Horizon Engineering Inc. “For Coordination” Geotechnical Investigation Report
(Revised) June 30, 2017 – Summary of Opinions

Dear Sirs,

I refer to the Report cited above, and our teleconference at 1000 hours (PDT) Friday, July 14, 2017. As agreed, this Memo is the first of two on the subject. It is intended to be a “high level” summary of my opinions which I hope will guide you in your preparation of an agenda for the proposed upcoming conference call between the respective engineering parties. The second, companion, Memo provides detailed comments on the Report referenced above, and hopefully will be of value to all parties in agreeing the final report, bearing in mind the current version is “For Coordination” and is unsigned by the Engineer-of-Record. My “high level” observations are as follows:

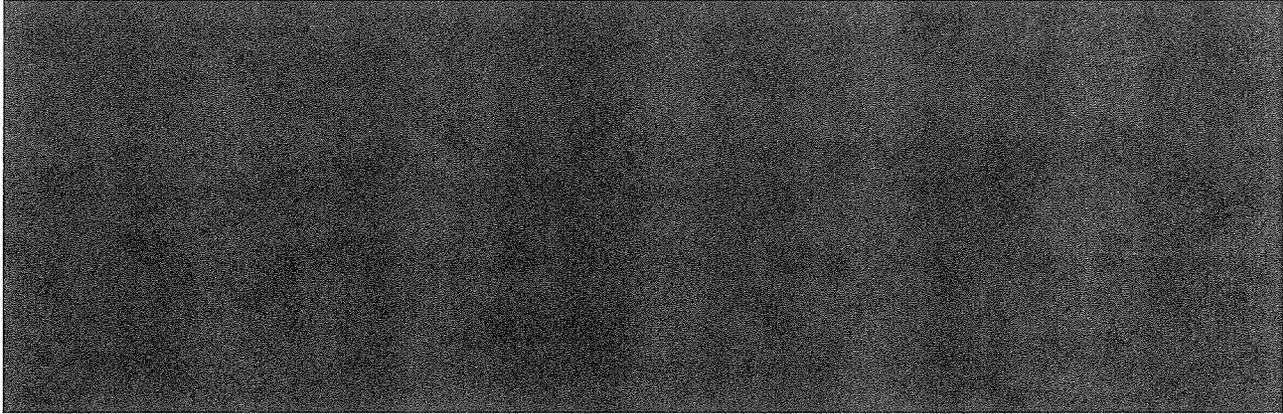


MEMORANDUM

Gibsons
Horizon Engineering Inc. "For Coordination" Geotechnical
Investigation Report (Revised) June 30, 2017 – Summary of
Opinions
Page 2

GEOSYSTEMS, L.P.

July 17, 2017



Best Regards,
GEOSYSTEMS, L.P.

Handwritten signature of Donald A. Bruce.

Donald A. Bruce, Ph.D., D.GE, C.Eng., L.G., L.E.G.
President

Andre Boel

From: GeosystemsLP <dabruce@geosystemsbruce.com>
Sent: August-04-17 5:20 AM
To: Andre Boel
Cc: Dave Newman
Subject: Proposed "The George" Mixed Ue Development

Dear Sir,

I have reviewed the following two documents:

- "Geotechnical Investigation Report (Revised)" prepared by Horizon Engineering Inc. (July 27, 2017).
- "Proposed drilling program for 'The George' Project" prepared by Horizon Engineering Inc. (July 20, 2017).

I discussed my views with you by telephone on Wednesday, August 2, 2017.

[REDACTED]

[REDACTED]

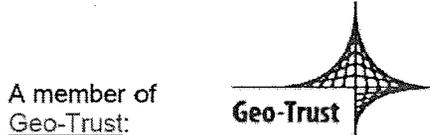
[REDACTED]

I look forward to being able to assist you and the project in the future.

Best Regards, Donald

Donald A. Bruce, Ph.D., D.GE, C.Eng., L.G., L.E.G., President
Direct: 724-942-0570 | Cell: 412-997-1784 | Fax: 724-942-1911

GEOSYSTEMS, L.P.
161 Bittersweet Circle | P.O. Box 237 | Venetia, PA 15367 | U.S.A.
dabruce@geosystemsbruce.com | www.geosystemsbruce.com



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