Kindred Hydro

November 15, 2023

Project: Harbor Grove Development Hydrologic Impacts Assessment-Revised
Location: 9110 53rd Ave West, Mukilteo, WA
Job#: SEA-23-1

Sea Pac Homes
120 SW Everett Mall Way Suite #100
Everett, WA 98204
Attn: Glen Belew

Dear Mr. Belew:

I am pleased to submit this revised letter report providing the results of my hydrologic impacts assessment for the Harbor Grove Development (the Site) at 9110 53rd Ave West in Mukilteo, WA. This assessment has been revised to address comments provided by Landau Associates (Landau) in their letter dated September 11, 2023. The Harbor Grove project will create seven single-family lots on 2.43 acres. The City of Mukilteo has requested this assessment to comply with Section 15.16(C.2.b.i.[b]) of the Mukilteo Municipal Code and requested that the assessment "shall include an adequate description of the hydrology of the site, conclusions and recommendations regarding the effect of hydrologic conditions on the proposed development and options and recommendations covering the carrying capabilities of the sites to be developed." The City is primarily concerned with the potential for the development to increase water flow into residential lots west of the Site (the Hargreaves neighborhood). Slope stability is not a concern for this Site, particularly given the plans to build a retaining structure on the west side of the property.

Summary of Conclusions

The Site is located on a topographic high with Smuggler's Gulch Creek ravine located north and west of the Site. The western portion of the property slopes to the west and the eastern portion of the property generally slopes to the southeast. Under existing conditions, runoff and groundwater recharge from the site (in addition to groundwater recharge from higher in the basin) are creating flooding conditions in the Hargreaves neighborhood during periods of high precipitation.

After development, all of the captured stormwater runoff will be directed to a detention vault which will be equipped with flow control to meet the stormwater detention requirements before leaving the Site. Flow from the detention vault will be conveyed to the existing stormwater system at the intersection of 92nd Street Southwest and Hargreaves Place and eventually discharge to Smuggler's Gulch Creek west of the Site. The west side of the Site at the base of the retaining wall will not gravity drain to the detention vault. Therefore, any drainage from the base of the wall will be captured and pumped to a structure at the top of the wall where it can gravity drain to the detention vault. These stormwater measures will eliminate surface water flow towards Hargreaves Place and reduce groundwater recharge.

Based on hydrologic modeling conducted by Atwell, LLC (formerly Blueline Group) and presented in the Storm Drainage Report, the stormwater controls proposed for the Site will reduce peak flows in Smuggler's Gulch Creek compared with fully forested conditions and reduce erosion of the Creek. The Atwell assessment did not address groundwater recharge and did not evaluate how development would impact flooding in the Hargreaves neighborhood. Hydrologic modeling presented in this report includes groundwater recharge and predicts that development of the Site will reduce combined surface water and groundwater flow towards the Hargreaves neighborhood by 49%, even without the pump at the base of the retaining wall.

No groundwater was observed in any of the explorations at the site, including two deep test pits conducted in March of 2022 that extended below the bottom elevation of the proposed retaining wall. Based on these observations, footing drains and the swale associated with the proposed retaining wall on the west side of the property are not expected to intercept surface water runoff or groundwater. Given the concerns regarding maintenance of the retaining wall pump, I recommend that water levels in the retaining wall sump be monitored with a pressure transducer for at least one year after site development. If no water collects in the sump during the year, then the pump may be removed and concerns regarding maintenance will be alleviated. This monitoring approach will only be implemented if approved by the City.

Background

Existing Site conditions are shown on the survey in Figure 1. The Site has a total area of 2.43 acres. There is an abandoned house and garage on the property. There is no formal drainage system on the property, although there is a ditch along the eastern side of the property along 53rd Avenue West.

The proposed development plan is provided in Figure 2. The proposed development plan includes seven single-family residential lots, roads, stormwater drainage, and a detention vault. The Site would be graded relatively flat and a retaining wall would be constructed on the west side of the property. 0.19 acres in the northeast corner of the Site would be left unchanged and preserved as native growth.

After development, all of the captured stormwater runoff will be directed to a detention vault that will be equipped with flow control to meet the stormwater detention requirements before leaving the Site. Flow from the detention vault will be piped south and west to the existing stormwater system at the intersection of 92nd Street Southwest and Hargreaves place and eventually discharges to Smuggler's Gulch Creek west of the Site. The west side of the Site at the base of the retaining wall will not gravity drain to the detention vault. Therefore, any drainage from the base of the wall will be captured and pumped to a structure at the top of the wall where it can gravity drain to the detention vault. Public comments have expressed concern regarding maintenance and operation of the pump.

Laudau's primary concerns with the previous hydrologic impacts assessment include:

1. Landau claimed that groundwater recharge from the Site was not included in the analysis. This is incorrect as Table 2 in the original assessment provides estimates of groundwater recharge based on an approach developed by Bidlake and Payne (2001)[1]. The Bidlake and Payne approach illustrated that development of the Site would reduce groundwater recharge by approximately 50%. It is unknown why Landau ignored the Bidlake and Payne estimates of groundwater recharge.
2. Although Landau did not dispute the validity of the Bidlake and Payne estimates, they did recommend that groundwater recharge should be estimated using WWHM. This revised analysis provides groundwater recharge estimates based on the WWHM.
3. The Kindred WWHM simulations of developed conditions assumed till-type ("C") soils rather than outwash ("A/B") soils to be consistent with the Atwell modeling. Portion of the Site are currently above or close to final grades and till-type soils will provide the subgrade in these areas. However, significant portions of the Site will be filled and Landau correctly identified that the import fill soils will likely be outwash soils. Therefore, they recommended that simulation of the developed conditions should assume A/B soils. This revised analysis divides the site into C soils and A/B soils based on the grading plan and estimated areas of cut and fill.

Topography, Geology, and Hydrogeology

Regional topography near the Site is shown in Figure 3. As shown on this figure, the Site is located on a topographic high with Smuggler's Gulch Creek ravine located north and west of the Site. Based on City of Mukilteo mapping, the northern ravine drains into the western ravine. The more refined Site topography provided on Figure 1 indicates that elevations across the Site range from 410 ft above mean sea level (AMSL) in the center of the Site to 378 ft AMSL in the southwest corner of the property. Figure 1 shows the location of the topographic divide that runs north-south through the property. The western portion of the property slopes to the west and the eastern portion of the property generally slopes to the southeast. There is a closed basin (i.e., a bowl where standing water could collect) near the eastern boundary of the Site. Although there is no evidence of surface runoff, any surface runoff from the west basin would flow to the west and any surface runoff from the east basin would flow to the southeast.

Earth Solutions NW, LLC conducted a geotechnical study for the Site dated July 30, 2021. This study included eight

[1] Bidlake, W.R. and Payne, K.L., 2001, Estimating Recharge to Ground Water from Precipitation at Naval Submarine Base Bangor and Vicinity, Kitsap County, Washington, U.S. Geologic Survey, Water-Resources Investigation Report 01-4110.

test pits to depths of 4 to 13 ft and determined that the Site was underlain by dense glacial till. The upper 1-4 feet was a combination of topsoil, fill, and weathered glacial till that is generally relatively permeable and well drained. The underlying unweathered glacial till is usually relatively impermeable and perched water often occurs above and within unweathered glacial till. No perched groundwater was detected during excavation of the test pits in June of 2021, which likely reflects groundwater conditions during the dry season.

Cobalt Geosciences, LLC conducted a groundwater evaluation dated March 14, 2022. This study included two test pits excavated in early March 2022 to a depth of 14 feet. These explorations encountered 4 to 8 feet of weathered glacial till over unweathered glacial till. No perched groundwater was encountered in either test pit, even though the explorations were conducted at the end of the wet season when perched groundwater conditions are likely to occur on unweathered glacial till. Based on these observations, they concluded that saturated groundwater is unlikely to occur above an elevation of 375 feet AMSL during the majority of the year. The footing drains for the proposed retaining wall on the west side of the property, with an elevation of 376 feet AMSL and less than 2 ft below existing grade, are unlikely to intercept significant groundwater. In a letter dated August 4, 2022, Earth Solutions NW, LLC estimated that less than 0.5 gpm would be collected in the retaining wall drain during the peak wet season.

Given the steep slope in the western portion of the Site, it is likely that any perched groundwater on the unweathered glacial till may migrate downhill to the west relatively quickly and be ephemeral in nature. This may explain why perched groundwater was not observed in the Cobalt test pits. Perched groundwater in the relatively flat eastern portion of the Site it more likely to be relatively stagnant and create saturated conditions for much of the winter.

It is likely that some of the groundwater recharge at the Site will migrate through the unweathered glacial till and eventually reach a deep aquifer below the glacial till. This deep groundwater recharge is likely more significant in the flat eastern portion of the Site where the perched groundwater is expected to be more persistent. The depth to the uppermost deep aquifer is uncertain beneath the Site but it likely discharges to Smuggler's Gulch Creek located north and west of the Site.

Site Visit

I conducted a site visit on March 8, 2022, to observe conditions at and near the Site. The Site is surrounded by single-family homes on the north, west, and south sides, and by 53rd Avenue West on the east side. Currently, the Site is lightly forested with a variety of shrubbery, ferns, and other low vegetation. Portions of the Site were disturbed in places, likely due to traversing the Site with a trackhoe during the geotechnical investigations. There is no evidence of ponding, surface runoff, or erosion on the Site. The ditch along 53rd Avenue West was vegetated with no evidence of erosion.

Hydrologic Changes Associated with Development

Hydrologic conditions are determined by a variety of factors, including precipitation, topography, vegetation, soils, and groundwater flux beneath the site. Precipitation that falls on a site is distributed into four boxes: evapotranspiration back into the atmosphere, surface runoff, interflow within near-surface soils (when perching conditions are present), and deep infiltration to groundwater. Interflow refers to groundwater flow in the weathered soil zone above the unweathered glacial till and generally only occurs during the wet season.

Site development generally includes removal of vegetation and construction of homes and roads. Replacement of forest by impervious surfaces tends to decrease evapotranspiration and increase surface runoff. A study by Bidlake and Payne (2021) determined that site development also tends to decrease groundwater recharge. Before recent stormwater regulations and implementation of appropriate mitigation measures, site development led to increased erosion and flooding during storm events and decreased stream flow during the dry summer months. Current development requirements require low-impact development (LID) to the extent feasible with the goal of both reducing peak stream flows and increasing groundwater recharge. LID measures were not suitable for this Site due to the low permeability soils (glacial till) and the potential to increase flooding issues along Hargreaves Place west of the Site. If LID measures are not feasible, then detention and flow control measures must be implemented to ensure that peak flows are less than from a fully-forested site.

Figures 1 and 4 provide a conceptual illustration of water migration at the Site under current conditions. The eastern portion of the Site drains east and into the ditch that flows north along 53rd Avenue West. This ditch eventually

drains to Smuggler's Gulch Creek. Surface water and interflow from the east basin does not flow into the properties west of the Site on Hargreaves Place. The western portion of the Site does drain westward and both surface water runoff and interflow would flow towards the properties along Hargreaves Place (shown on Figure 3). Any recharge to deep groundwater at the Site flows to the west or north towards Smuggler's Gulch Creek. It is not known if deep groundwater is contributing to the flooding issues in the Hargreaves neighborhood. For this analysis, both interflow and deep groundwater will be considered as potentially contributing to the flooding issues near Hargreaves Place.

As documented in the Storm Drainage Plan dated April 19, 2023 and illustrated in Figures 2 and 5, Atwell has developed a stormwater management plan that will convey almost all the surface water from the Site into a detention vault that will include flow control measures to restrict peak flows from the Site. After flow control, discharge from the detention vault will discharge to Smugglers Gulch Creek west of Hargreaves Place. A small portion of the site (Frontage Basin) along 53rd Avenue West will bypass the detention vault and flow directly to the ditch and eventually discharge to Hargreaves Place. As shown on Figure 5, the retaining wall area on the west side of the Site will drain to the west. The proposed development plan includes a drainage swale at the base of the wall and a pump system to pump any runoff from the swale to a catch basin at the top of the wall. This catch basin gravity drains to the detention vault. Therefore, the only water from the Site that discharges to the west is interflow from the western basin and deep groundwater from the entire Site.

The Storm Drainage Plan includes WWHM hydrologic modeling to demonstrate that these measures will achieve stormwater permit requirements. In compliance with the stormwater permit, Atwell compared surface runoff from a completely forested pre-developed Site (plus the neighboring upstream lot) and the developed Site with the detention vault and the flow control. The modeling included the Frontage basin that bypasses the detention vault. These results are summarized in Table 1 and illustrate that the mitigated surface flows from the Site are less than the forested flows from the Site. Therefore, in terms of impacts to Smuggler's Gulch Creek (the receiving water body) development of the Site will reduce peak flows and erosion in the creek.

Although consistent with permit requirements, the Atwell modeling does not directly address the potential hydrologic impacts to properties downhill of the Site in the Hargreaves neighborhood. In particular, the Atwell modeling did not provide an estimate of groundwater recharge and changes in total flows to the west. Furthermore, consistent with permit requirements, Atwell modeled 100% forested pre-development conditions, while the Site is currently developed with a single-family home and is not 100% forested with open areas and low-lying vegetation more similar to pasture. Runoff from pasture is generally higher than runoff from forests.

Table 1: Surface Discharge Estimates (in cubic feet/second) from the Site based on Atwell Modeling

Return Period	Entire Site 100% Forested[a]	Entire Site Developed with Flow Control[a]
2 year	0.08	0.04
5 year	0.11	0.05
10 year	0.14	0.06
25 year	0.18	0.08
50 year	0.21	0.10
100 year	0.25	0.11

[a] Based on WWHM modeling provided in the Storm Drainage Report dated April 11, 2023. Includes frontage basin.

Hydrologic Modeling of Existing Conditions

In order to support this hydrologic assessment, additional hydrologic modeling was conducted to estimate surface water flows towards the Hargreaves properties under existing conditions (a mix of pasture and forest on glacial till) and to estimate groundwater recharge. The modeling was conducted using the WWHM model and utilized the same land coverage areas as the Atwell modeling, shown in Table 2 for existing conditions. The frontage basin was not included in the analysis because it would not affect flows to the west. The modeling assumed Type C (glacial till) soils and assumed an equal amount of forest and pasture vegetation for the undeveloped areas. As shown on Figure 1, the west basin includes a small area of impervious surface (the house and a portion of the garage). However, the runoff from these structure discharges to the ground and these surfaces were treated as pervious surface for simplicity. The east basin included the upgradient parcel in the southeast corner of the Site, which was assumed to include a mixture of impervious surface (0.15 acres) and lawn (0.13 acres).

Table 2: WWHM Modeling Assumptions for Existing Conditions (acres)

Sub-Basin	Slope	Soil	Road/Roof	Pasture	Lawn	Total
West Basin	Moderate	Type C	0	1.24	0	1.24
East Basin	Flat	Type C	0.15	1.07	0.13	1.35
Total			**0.15**	**2.31**	**0.13**	**2.59**

The average annual surface water and groundwater flows predicted by WWHM for existing conditions are provided in Table 3. Assuming surface flow from the west basin and all the groundwater recharge across the site flows to the west towards the Hargreaves neighborhood, the total western flow from the Site is 2.85 acre-ft per year. The total eastern flow (which ends up in Smuggler's Gulch Creek) is 1.54 acre-ft/yr. WWHM results for existing conditions are provided in Attachment A.

Table 3: WWHM Average Annual Flows for Existing Conditions (acre-ft/yr)

Sub-Basin	Western Surface Flow	Groundwater Recharge	Total Western Flow	Eastern Flow
West Basin	1.25	0.83	2.08	
East Basin		0.78	0.78	1.54
Total	**1.25**	**1.61**	**2.85**	**1.54**

It should be noted that the total groundwater flow only includes recharge from the Site and does not include groundwater recharge upgradient of the Site, which is likely much greater than recharge from the Site.

Hydrologic Modeling of Proposed Developed Conditions

WWHM modeling of the proposed developed conditions was conducted using the assumptions provided in Table 4. Other than the existing upstream parcel, the pervious land cover was assumed to be pasture (rather than lawn) based on the requirement that amended soils be used in landscaped areas and to be consistent with the Atwell modeling. Based on recommendations from Landau, the modeling assumed Type C soils (till-like) in areas with less than 2 ft of fill and Type A/B (outwash-like) in areas with more than 2-ft of fill. This assumes that relatively clean granular soils (i.e., < 5% fines) would be used for import fill and areas with less than 2 ft of fill would experience near-surface perching on the native glacial till. This is consistent with the Stormwater Manual for Western Washington, which states: "*Outwash soils over high ground water or an impervious soil layer have low infiltration rates and act like till soils. Where ground water or an impervious soil layer is within 5 feet from the surface, outwash soils may be modeled as till soils in the WWHM.*"[2] Using the 5-ft assumption would increase the area of Type C soils used in the modeling. This means the 2-ft assumption is conservative with regards to groundwater recharge.

Atwell compared final grading elevations with existing grade (shown on Figure 6) and estimated the pervious areas (lawn and landscaping) with more and less than 2-ft of fill. Areas with less than 2-ft of fill are assumed to be underlain by Type C soils (glacial till) and areas with more than 2-ft of fill are assumed to be underlain by Type A/B soils. This is a conservative assumption since approximately half of the fill soils will be on-site cut material (i.e., glacial till) rather than import material.

Table 4: WWHM Modeling Assumptions for Developed Conditions (acres)

Sub-Basin	Slope	Road/Roof	Pasture/ Type A/B Soils	Pasture/ Type C Soils	Lawn	Total
West Basin	Flat	0.38	0.40	0.22	0	1.00
Retaining Wall	Flat	0	0.12	0.12	0	0.24
East Basin	Flat	0.73	0.31	0.18	0.13	1.35
Total		**1.11**	**0.83**	**0.52**	**0.13**	**2.59**

[2] 2019 Stormwater Management Manual for Western Washington, Volume III, Chapter 2, page 447.

As shown on Figure 2, most of the developed Site will gravity drain to the detention vault and then to the piped stormwater drainage system that discharges directly to Smuggler's Gulch Creek. However, the area associated with the retaining wall on the west side of the property will be captured at the base of the wall and pumped up to the gravity drainage system at the top of the wall. As long as the pump is functioning, any surface water runoff in this area will not flow towards the Hargreaves properties. However, in the unlikely event that the pump was to fail, it is useful to estimate the surface water runoff from this area. As shown on Figure 2, the retaining wall area is 0.24 acres.

The WWHM output files for developed conditions are provided in Attachment B and the results are summarized in Table 5. As shown in the table, average annual surface flow from the retaining wall area is estimated to be 0.26 acre-ft/yr. Average annual groundwater recharge from the entire Site is estimated to be 1.18 acre-ft/year and the total western flow is estimated to be 1.44 acre-ft/year, 49% less than the total western flow for existing conditions, even without the pump at the base of the retaining wall.

Table 5: WWHM Average Annual Flows for Developed Conditions (acre-ft/yr)

Sub-Basin	Western Surface Flow	Groundwater Recharge	Total Western Flow	Detention Flow
West Basin	0	0.50	0.50	1.41
Retaining Wall	0.26	0.21	0.47	0
East Basin	0	0.47	0.47	2.11
Total	**0.26**	**1.18**	**1.44**	**3.52**

Conclusions

The proposed development plan includes seven single-family residential lots, roads, stormwater drainage, and a detention vault. The Site would be graded relatively flat and a retaining wall would be constructed on the west side of the property. 0.19 acres in the northeast corner of the Site would be left unchanged and preserved as native growth. The City of Mukilteo has requested a hydrologic assessment to comply with Section 15.16.0S0(C.2.b.i.[b]) of the Mukilteo Municipal Code. The City is primarily concerned with the potential for the development to increase water flow into residential lots west of the Site.

The Site is located on a topographic high with Smuggler's Gulch Creek ravine located north and west of the Site. The western portion of the property slopes to the west and the eastern portion of the property generally slopes to the southeast. Under existing conditions, runoff and groundwater recharge from the site (in addition to groundwater recharge from higher in the basin) are creating flooding conditions in the Hargreaves neighborhood during periods of high precipitation.

After development, all of the captured stormwater runoff will be directed to a detention vault which will be equipped with flow control to meet the stormwater detention requirements before leaving the Site. Flow from the detention vault will be conveyed to the existing stormwater system at the intersection of 92nd Street Southwest and Hargreaves Place and eventually discharge to Smuggler's Gulch Creek west of the Site. The west side of the Site at the base of the retaining wall will not gravity drain to the detention vault. Therefore, any drainage from the base of the wall will be captured and pumped to a structure at the top of the wall where it can gravity drain to the detention vault. These stormwater measures will eliminate surface water flow towards Hargreaves Place and reduce groundwater recharge.

Based on hydrologic modeling conducted by Atwell, LLC (formerly Blueline Group) and presented in the Storm Drainage Report, the stormwater controls proposed for the Site will reduce peak flows in Smuggler's Gulch Creek compared with fully forested conditions and reduce erosion of the Creek. The Atwell assessment did not address groundwater recharge and did not evaluate how development would impact flooding in the Hargreaves neighborhood. Hydrologic modeling presented in this report includes groundwater recharge and predicts that development of the Site will reduce combined surface water and groundwater flow towards the Hargreaves neighborhood by 49%, even without the pump at the base of the retaining wall.

No groundwater was observed in any of the explorations at the site, including two deep test pits conducted in March

of 2022 that extended below the bottom elevation of the proposed retaining wall. Based on these observations, footing drains and the swale associated with the proposed retaining wall on the west side of the property are not expected to intercept surface water runoff or groundwater. Given the concerns regarding maintenance of the retaining wall pump, I recommend that water levels in the retaining wall sump be monitored with a pressure transducer for at least one year after site development. If no water collects in the sump during the year, then the pump may be removed and concerns regarding maintenance will be alleviated. This monitoring approach will only be implemented if approved by the City.

Limitations and Closure

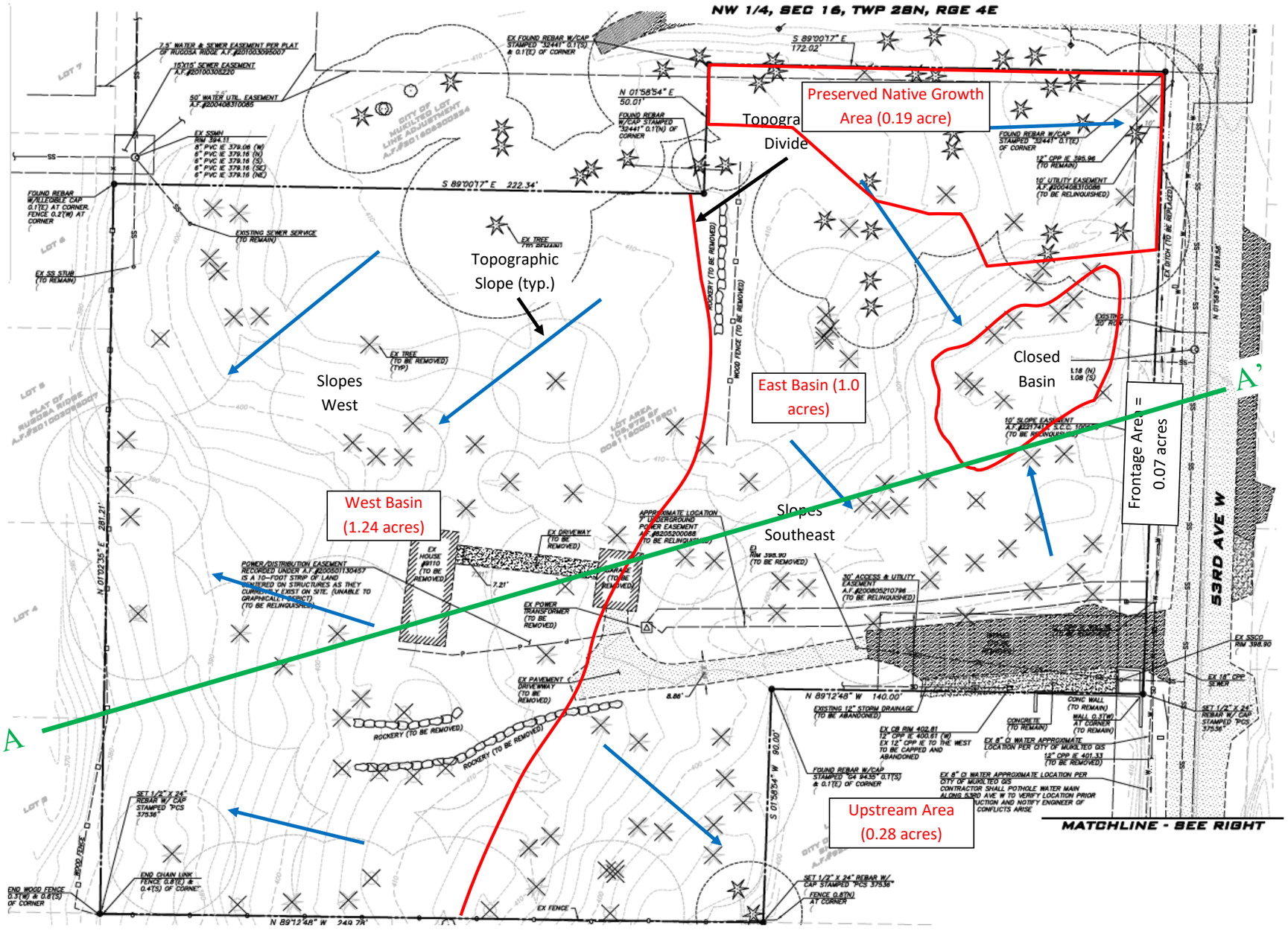
Work for this project was performed and this report prepared in accordance with generally accepted professional practices for the nature and conditions of work completed in the same or similar localities at the time the work was performed. It is intended for the exclusive use of Sea Pac Homes for specific application to the referenced matter. No other warranty, expressed or implied, is made.

I am pleased to provide this letter report. If you have any questions or concerns, please contact the undersigned.

Sincerely,

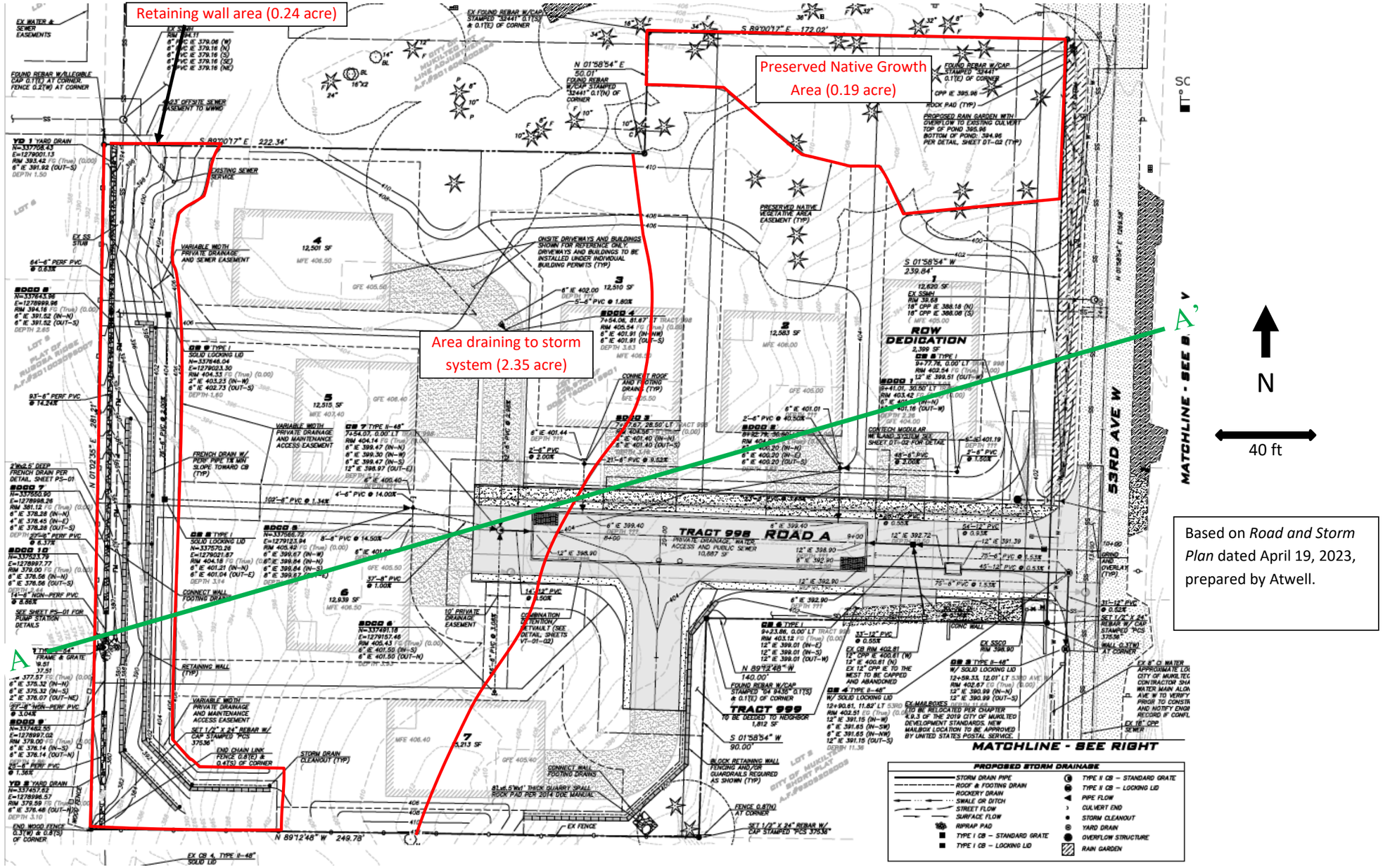
J. Scott Kindred, PE, LHG
President
Kindred Hydro, Inc.
Date: ___November 15, 2023_____

Kindred Hydro



Based on *Existing Conditions & Demo Plan* dated April 19, 2023, prepared by Atwell.

Figure 1: Existing Conditions



Based on *Road and Storm Plan* dated April 19, 2023, prepared by Atwell.

Figure 2: Site Plan Showing Grading and Stormwater Plan

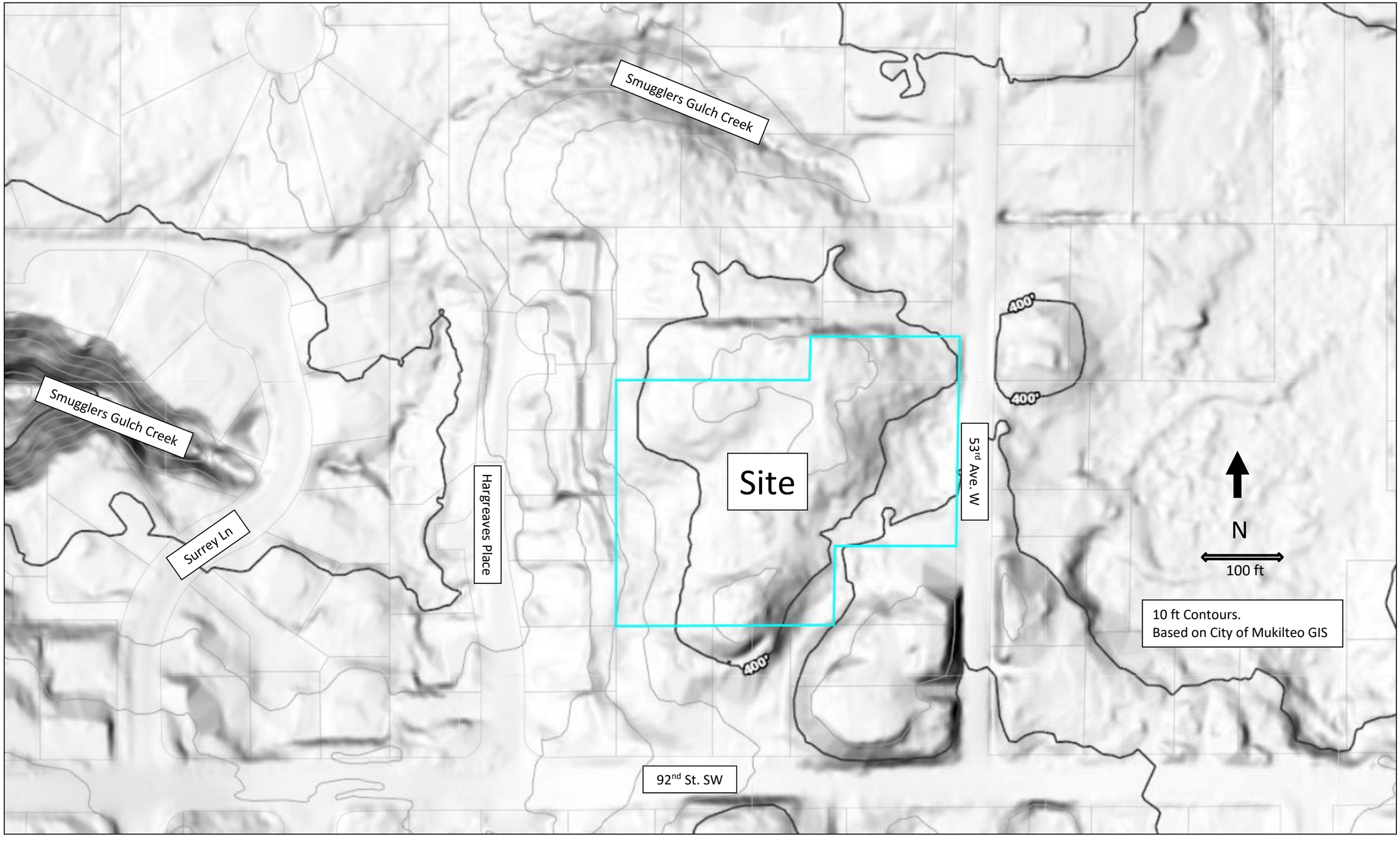


Figure 3: Regional Topography

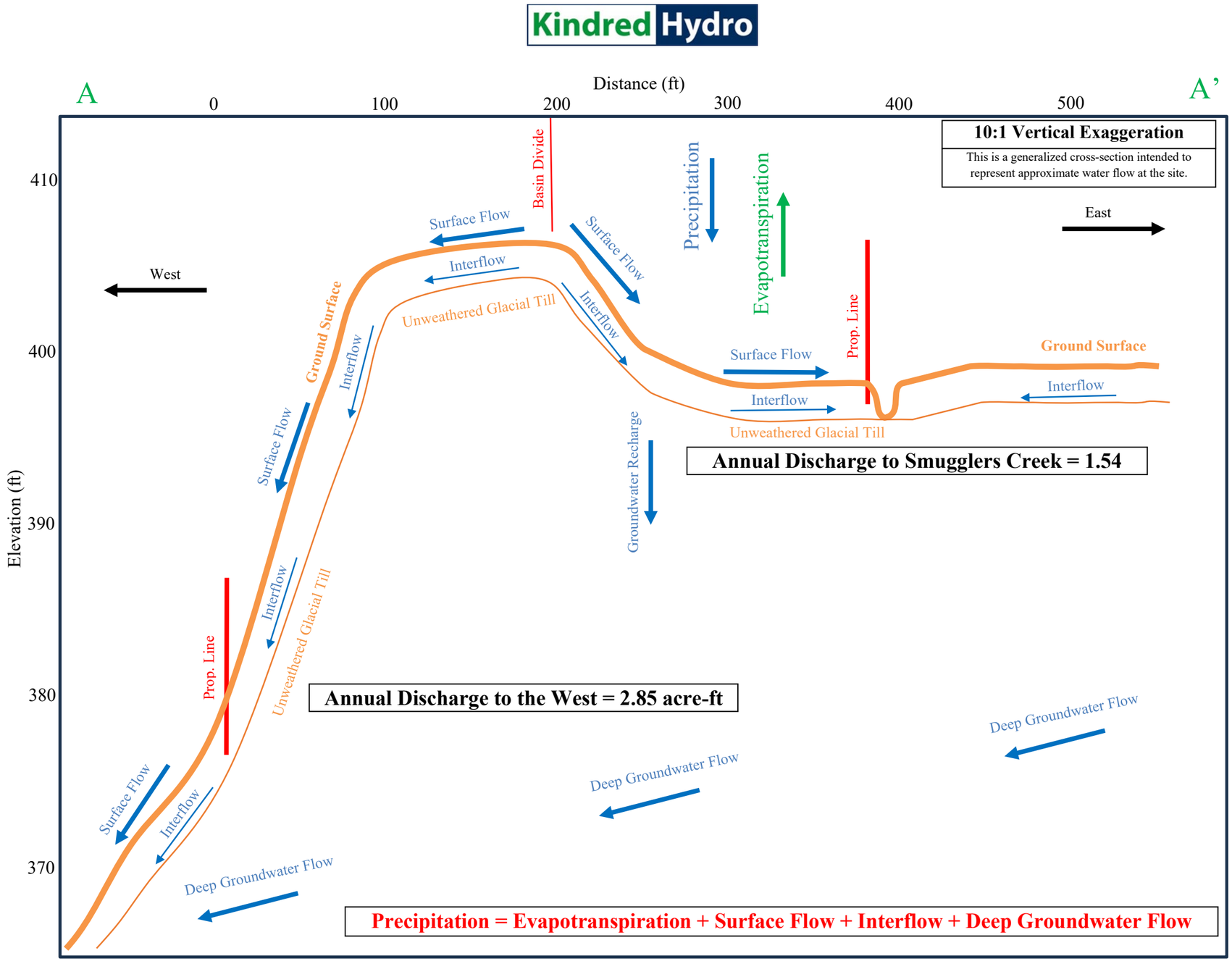


Figure 4: Generalized Cross-Section Showing Water Flow Under Existing Conditions

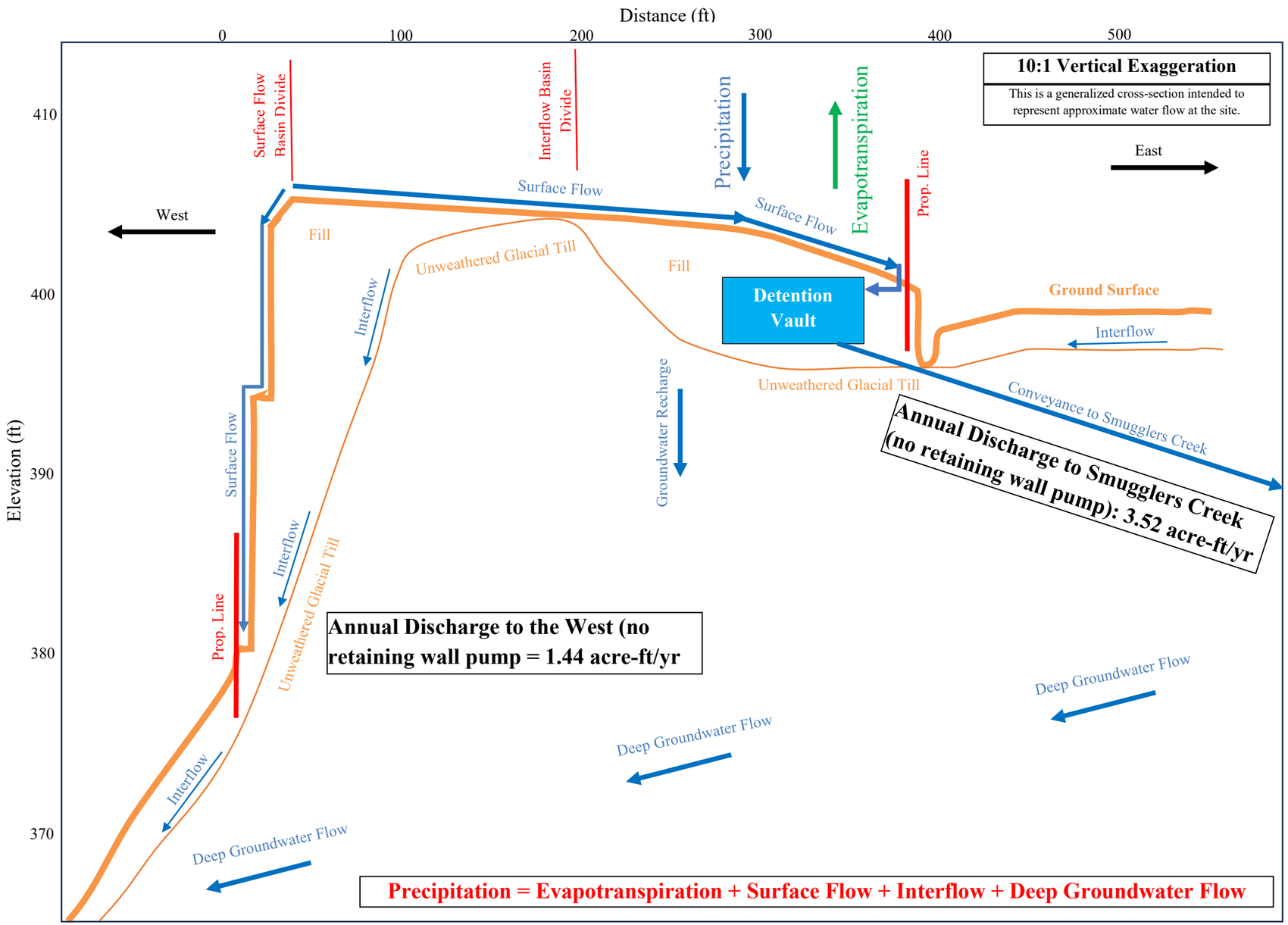


Figure 5: Generalized Cross-Section Showing Water Flow Under Developed Conditions

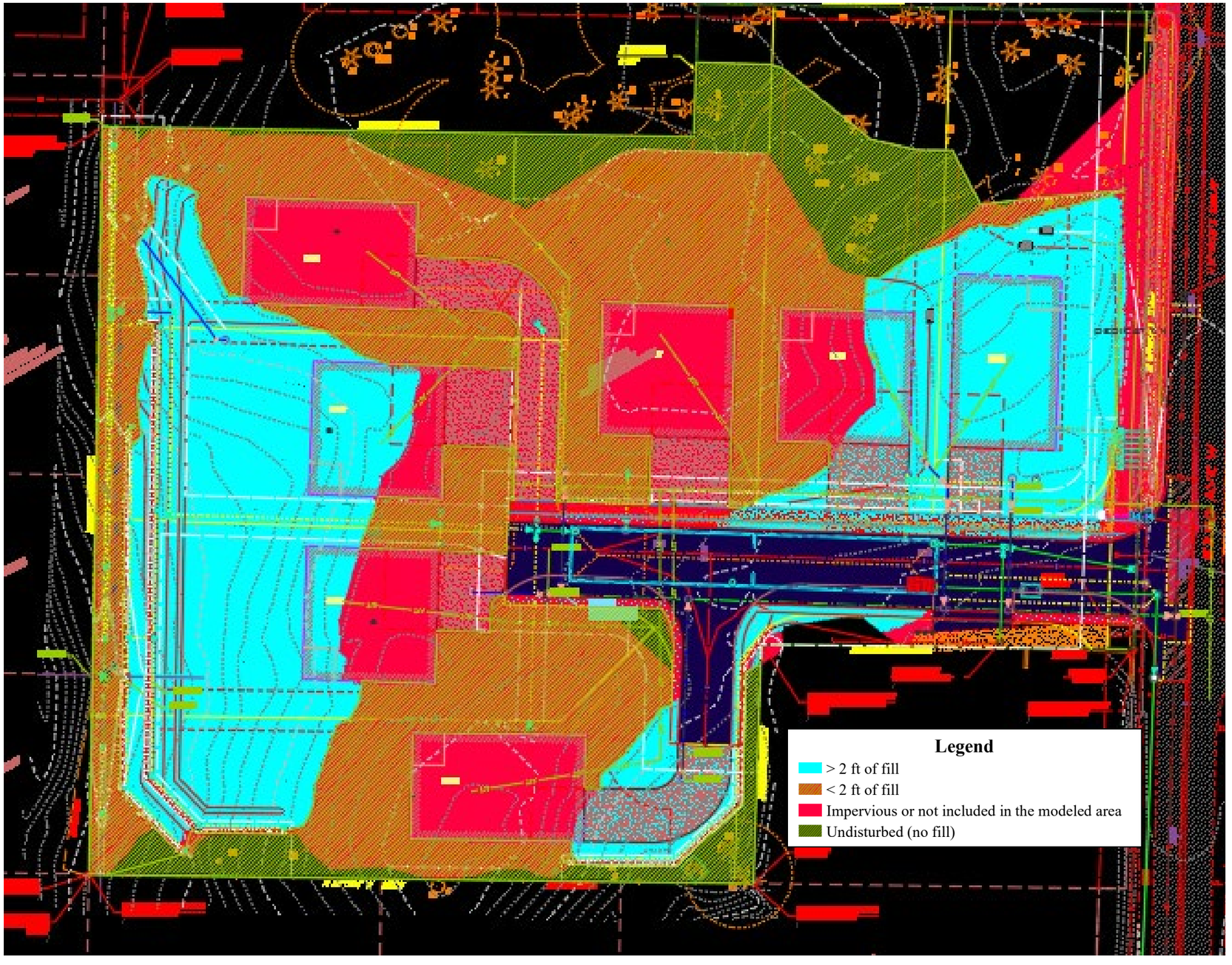


Figure 6: Areas with more and less than 2 feet of fill after grading

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Attachment A: WWHM Hydrologic Modeling of Existing Conditions

(Separate models were run for west and east basins.)

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Attachment B: WWHM Hydrologic Modeling of Developed Conditions

(Separate models were run for west, east, and retaining wall basins.)