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ATTACHMENT

Electoral Area A
Geohazard Mapping Report

Phase 1: Geohazards Inventory and Methodology

EXECUTIVE SUMMARY

BGC Engineering Inc. (BGC) was retained by Metro Vancouver to complete a desktop inventory and characterization of geohazards (landslide, riverine and coastal inundation, and snow avalanches) with the potential to affect key parcels in Metro Vancouver's Electoral Area A. This is Phase 1 of a two-phase project to characterize geohazards and translate results into technical and policy maps for use in the review of building and land development permit applications. The current work is based on new landslide and snow avalanche mapping and existing geohazard information compiled from published reports and geoscience/engineering reports held by Metro Vancouver. The deliverables for this project are several pdf maps and the supporting spatial database (geographical information system – GIS). These deliverables provide a starting point and structure to update and refine results once further information becomes available through more detailed assessments.

BGC recommends that Metro Vancouver proceeds with their planned Phase 2 for this project which consists of developing a methodology to incorporate the findings of the geohazard mapping in Metro Vancouver's review process of building permit (primarily) and land development applications in Electoral Area A.

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LIMITATIONS

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1.0 INTRODUCTION

BGC Engineering Inc. (BGC) was retained by Metro Vancouver to map geohazards of select sections of the Electoral Area A (Figure 1-1, Areas of Interest, AOI). BGC understands that the geohazard mapping in Metro Vancouver's Electoral Area A forms Phase 1 of a two-phase project. This first phase synthesizes previous geohazard studies in a spatial database (geographical information system – GIS), supplemented by terrain analyses to confirm, refine, or add to previously developed geohazard inventories. The second phase of the project will develop a methodology to incorporate the findings of the geohazard mapping in Metro Vancouver's review process of building permit (primarily) and land development applications in Electoral Area A. The work was performed under Metro Vancouver's Consulting and Professional Services Agreement with the limit of liability and insurance coverage outlined in Document 49096723, RFSQ No 21-364, and approved on November 16, 2021.

1.1. Scope

The scope for this project is to map geohazards (landslide, riverine and coastal inundation, and snow avalanches) with the potential to affect key parcels[1] in Electoral Area A (Figure 1-1). The work plan to support this scope includes:

- Compiling geohazard information in published reports and contained in geoscience/engineering reports held by Metro Vancouver
- Mapping new landslide and snow avalanche hazards to fill gaps in current knowledge.

1.2. Limitations and Exclusions

BGC notes the following limitations and exclusions for the scope of this project:

- Magnitude-frequency (how large and how often) characterization of geohazards in the project area, nor their intensity (velocity, depth, erosion potential, impact forces).
- Mapping or modelling to characterize the potential impact area of a landslide or snow avalanche.
- Generating geohazard zonation maps (zone of high, medium, low hazard within a hazard extent).
- Landslide or snow avalanche susceptibility mapping.
- Geohazard risk assessment (i.e., inclusion of geohazard consequences).
- Characterization of hazards initiating within the project area and impacting infrastructure or people outside Electoral Area A.
- Existing geohazard mitigation strategies.
- Coastal inundation hazards related to tsunamis or wind and boat-generated waves.
- Detailed assessment of the potential effects of wildfire, insect infestations, or climate change on geohazards.

[1] Key parcels were identified by Metro Vancouver (email from Tom Pearce, personal communication October 2021).

Geohazards that are not part of this scope include ground shaking and liquefaction due to earthquakes and landslide-generated impulse waves. While they were considered out-of-scope for this study, they still represent credible geohazard scenarios with the potential for intense and widespread damage. Ground shaking during an earthquake can generate landslides as documented during the 2012 Haida Gwaii earthquake (Barth et al., 2020). Liquefaction can occur in saturated sandy soil during an earthquake. Sections of Electoral Area A may be susceptible to earthquake-triggered landslide and liquefaction. While landslide-generated impulse waves are infrequent occurrences, they have been documented in southwestern British Columbia (BC) (Evans, 1989; Roberts et al., 2012; Hughes et al., 2021) and their potential in Howe Sound has been discussed (Jackson et al., 2014).

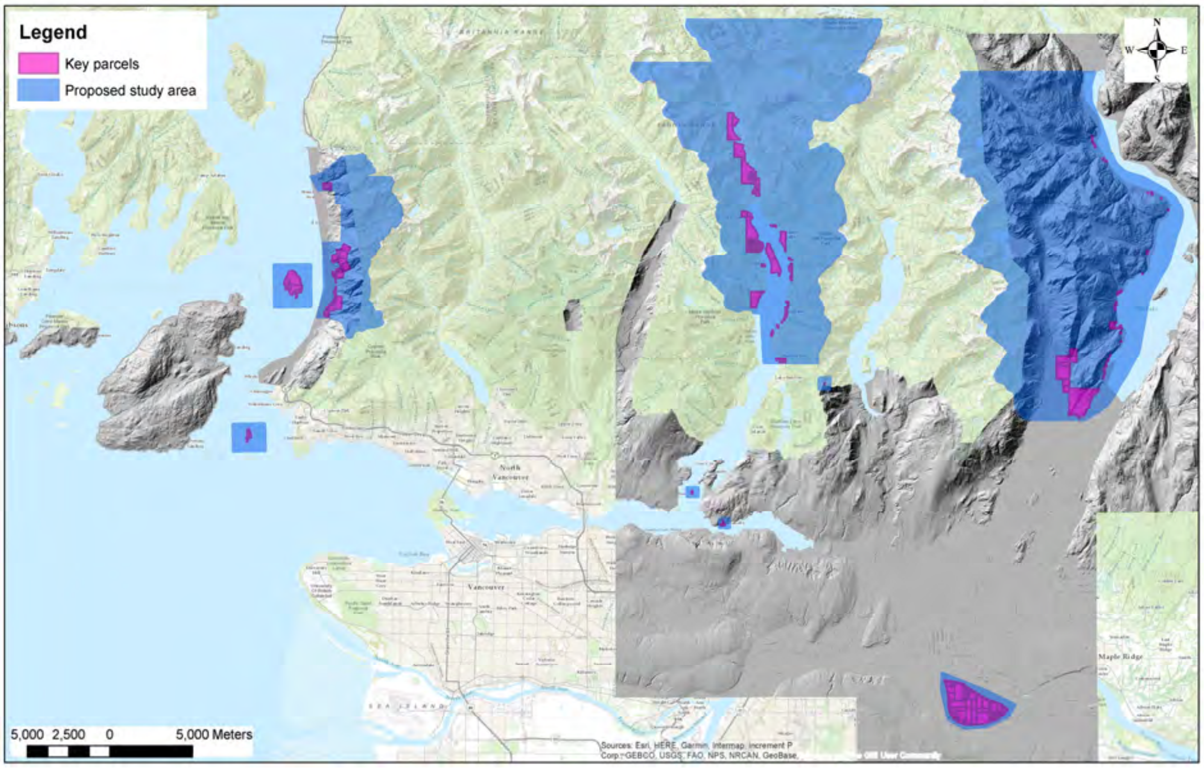

Figure 1-1. Project area showing the key parcels identified by Metro Vancouver and the extent of publicly available lidar.

As this project consists of a compilation of site-specific and regional-level geohazard assessments, one of its limitations is the variable mapping scale. That is, the entirety of the project area is not mapped at a set scale (e.g., 1:20,000). In the new mapping area, only landslides and snow avalanches of a size large enough to be observed on the consulted aerial photographs and imagery were recorded. As no fieldwork was conducted for this project, the geohazards were characterized based on the source material consulted during the desktop study. Based on the vintage of aerial photographs and imagery consulted, this represents a snapshot of 1953 to 1957 and 2018 to 2021. As additional past or present-day field observations become available these can be used to update the geohazard mapping and characterization. Empirical classification of steep creek geohazards (i.e., clear-water flood, debris-flood, or debris- flow hazards) was used in this study as it can be applied to large regions. However, classification reliability is lower than for detailed studies, which typically combine multiple lines of evidence such as statistical, remote-sensed, and field observation data. Assigning each fan with one of three likely steep creek process types also does not recognize that there is a continuum between clear-water floods and steep-creek processes that is not accounted for in morphometrics. Simlarly, many creeks are prone to a specific hazard up to a certain return period, above which another process dominates.

1.3. Project Area

The select sections of Electoral Area A that are part of the project include a range of physiographic regions from rugged steep mountains of the Coast Mountain Range, to rocky islands and a low-lying island of surficial material (Holland, 1976; Armstrong and Hickock, 1980; Blais-Stevens, 2008). While the climate of the low-lying area differs from the high elevation peak, they typically all received significant amounts of precipitation (rain or snow) in the winter (Figure 1-2). The project area is also within the zone of influence of the Cascadia Subduction zone which represents a high seismic hazard (Figure 1-3).

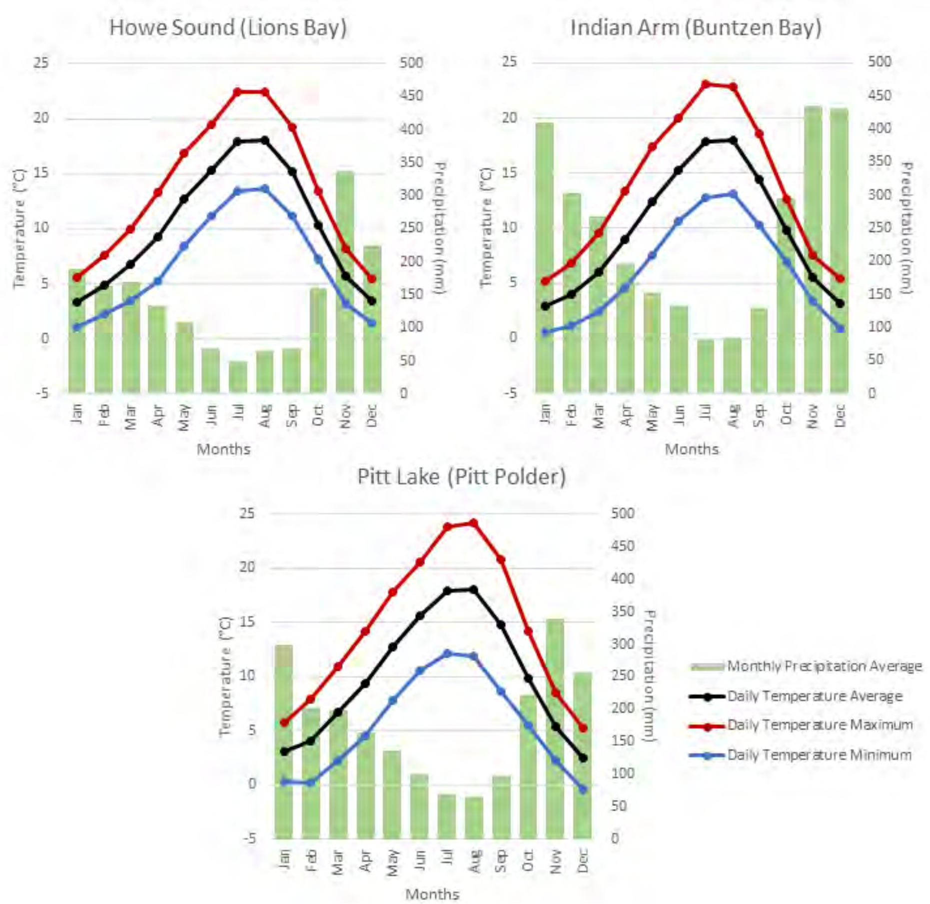

Figure 1-2. Climate Normals for three weather stations at or near sea level (data from PCIC, 2021).

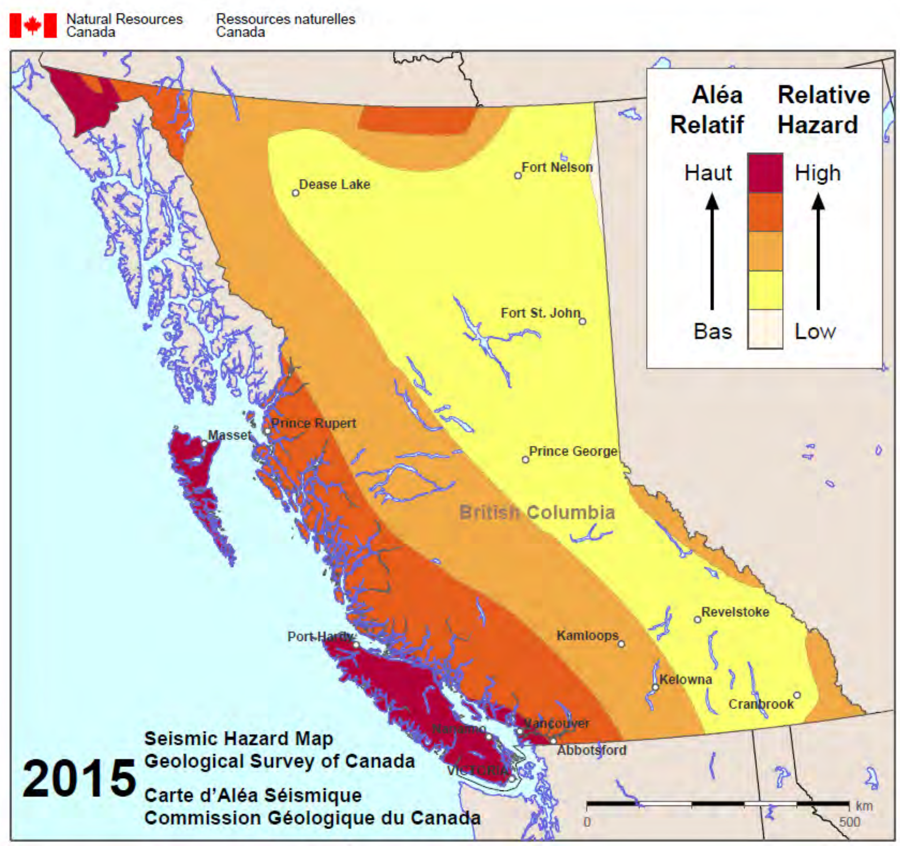

Figure 1-3. Simplified seismic hazard map for British Columbia (Natural Resources Canada, 2015).

2.0 METHODOLOGY

2.1. Landslide Mapping

In this geohazard compilation, landslide hazards were characterized using points, lines, and polygons (areas) depending on the spatial extent and uncertainty associated with the hazard. Points typically represent historical or potential hazards. Lines are predominantly used to represent the travel path of past landslides. Depending on context, areas can represent a potentially unstable section of the slope (e.g., block bounded by tension cracks) or the source and depositional areas (e.g., steep cliff and talus). The level of this project along with the inherent uncertainty associated with natural processes means that the absence of mapped feature does not represent an absence of hazard.

The landslide type classification by Hungr et al. (2014) was used in this report.

2.1.1. Previous Landslide Hazard Inventory

Landslide hazard information was extracted from geotechnical and geoscience reports provided by Metro Vancouver (See Table A1 in Appendix A for detailed list) and spatially compiled in a GIS environment. A spatial inventory of the parcels with previous geotechnical and geoscience assessments was generated by adding a point with details about report author and year in the centre of the associated parcel. Where landslide hazard specific to a landform was included in the previous reports, this information was represented as a point, line, or polygon (area) as appropriate. More details about the information recorded in the GIS layer is provided in Section 3.0 and Appendix B.

Of the different sections of the current project area, the Howe Sound corridor contains the most infrastructure (Highway 99 and CN Railway) and densely populated residential area. As such, it has been the subject of academic and governmental landslide hazard studies (e.g., Blais-Stevens, 2008; Blais-Stevens and Septer, 2008; Blais-Stevens et al., 2012). Landslide inventories complete for these studies were incorporated in the GIS compilation where applicable.

2.1.2. New Landslide Hazard Mapping

New screening-level landslide hazard mapping was completed by BGC using Google Earth imagery (all sections), 1952 to 1957 aerial photographs (all sections, see Table A2 in Appendix A for details), publicly available lidar (Howe Sound and Pitt Lake area, see Table A3 in Appendix A for details), and terrain mapping (Howe Sound and Indian Arm; Ryder et al. 1999 from BC Data Catalgue, 2010). The new landslide mapping is intended to supplement the information available in the geotechnical and geoscience reports held by Metro Vancouver. The new mapping focused on the area surrounding the parcels of interest but included some mapping of the upper reaches of the watershed reporting to the parcels of interest.

2.1.3. Fan Inventory

Fans are landforms created from the deposition of sediment by hydrogeomorphic processes (clear-water flood, debris flood or debris flow). While the presence of a fan indicates past geohazard occurrence, the lack of a fan on a steep creek does not necessarily rule out the potential for future geohazard occurrence. Also, some creeks discharge directly into the ocean, lakes or reservoirs. A fan likely exists but is submerged and thus not visible except in bathymetric information. As such, the fan inventory completed in this study should not be considered exhaustive. A fan inventory was compiled based on geomorphic mapping using the lidar and TRIM topographic map (GeoBC, 2016) along with review of previous geotechnical reports provided by Metro Vancouver. Each fan was assigned a process type based on empirical relationships between the Melton Ratio[2] and watershed length. These terrain factors are a useful screening-level indicator of the dominant hydrogeomorphic process (clear-water floods, debris floods, or debris flows) on a creek (Wilford et al., 2004; Holm et al., 2016). The morphometric values calculated by River Network Tool™ (RNT) were used alongside terrain interpretations (Table 2-1) to assign the dominant hydrogeomorphic process. They do not, however, acknowledge that processes on creeks may change depending on the chosen return period. For example, creeks subject to "floods" at higher return periods, become subject to debris floods, and, in some cases, at even higher return periods subject to debris flows (Jakob and Jordan, 2001). This implies that BGC's categorization should be understood as scoping level.

Table 2-1. Characteristics used to classify hydrogeomorphic process types on fans (after Lau, 2017).

	Debris flow	Debris flood	Flood
Air photo	Steep (>15°) average watershed channel gradient and typically small (< 3 km^2) watersheds with high relief Frequent sediment sources in upper watershed (rockfalls, debris avalanches, etc.) Inconsistent breaks in tree canopy on fan along stream channel.	Moderately steep (3-15°) average watershed channel gradient, medium to large watersheds with moderate to high relief Sediment sources in upper watershed (rockfalls, debris avalanches, etc.) Consistent break in tree canopy on fan along stream channel.	Low (<3°) average watershed channel gradient, medium to large watersheds with moderate to low relief. Wide channels Large gap in tree canopy along stream channel. Overbank deposits
Lidar	Fan gradient > 5° Levees along channel margin U-shaped channels (Boulder) lobes on fan surface Tongue-shaped boulder carpets Sharp deposit boundaries	Fan gradient 2-10° No levees along channel Potential lobes on fan surface Paired terraces	Fan gradient < 5° Wide channels Lack of lobes and levees along channel margin

[2] Melton ratio is watershed relief divided by the square root of watershed area (Melton, 1965).

2.2. Flooding and Coastal Inundation Mapping

2.2.1. Screening Level Flood Extents

Flood inundation extents and flood depths were approximated for each watercourse within the study area using a terrain-based mapping approach referred to as Height-Above-Nearest-Drainage (HAND) (Rennó et al., 2008). This mapping approach uses publicly available topographic and hydrometric data to approximate areas that could be inundated during a flood event as a practical alternative to hydraulic modelling over large spatial scales. The data required for HAND mapping includes a topographic model and a rules-based approach to classify the maximum predicted flood depth. This concept is illustrated in Figure 2-1 which shows that the HAND value for a given point represents the relative height between that point and the nearest stream that it drains to (Zheng et al., 2018). Therefore, any cell with a HAND value below a given threshold (a maximum predicted flood-depth) can be assumed to be within the inundation extents in the event of a flood reaching this level.

This terrain-based approach was used to estimate the approximate area that could be inundated in a 200-year return period flood event for all watercourses within the study area. The analyses were used to identify and prioritize areas subject to clear-water flooding and do not replace detailed floodplain mapping that includes bathymetric surveys and hydraulic modelling. The output of this process also serves as a basis for identifying locations where detailed floodplain mapping could be undertaken in the future.

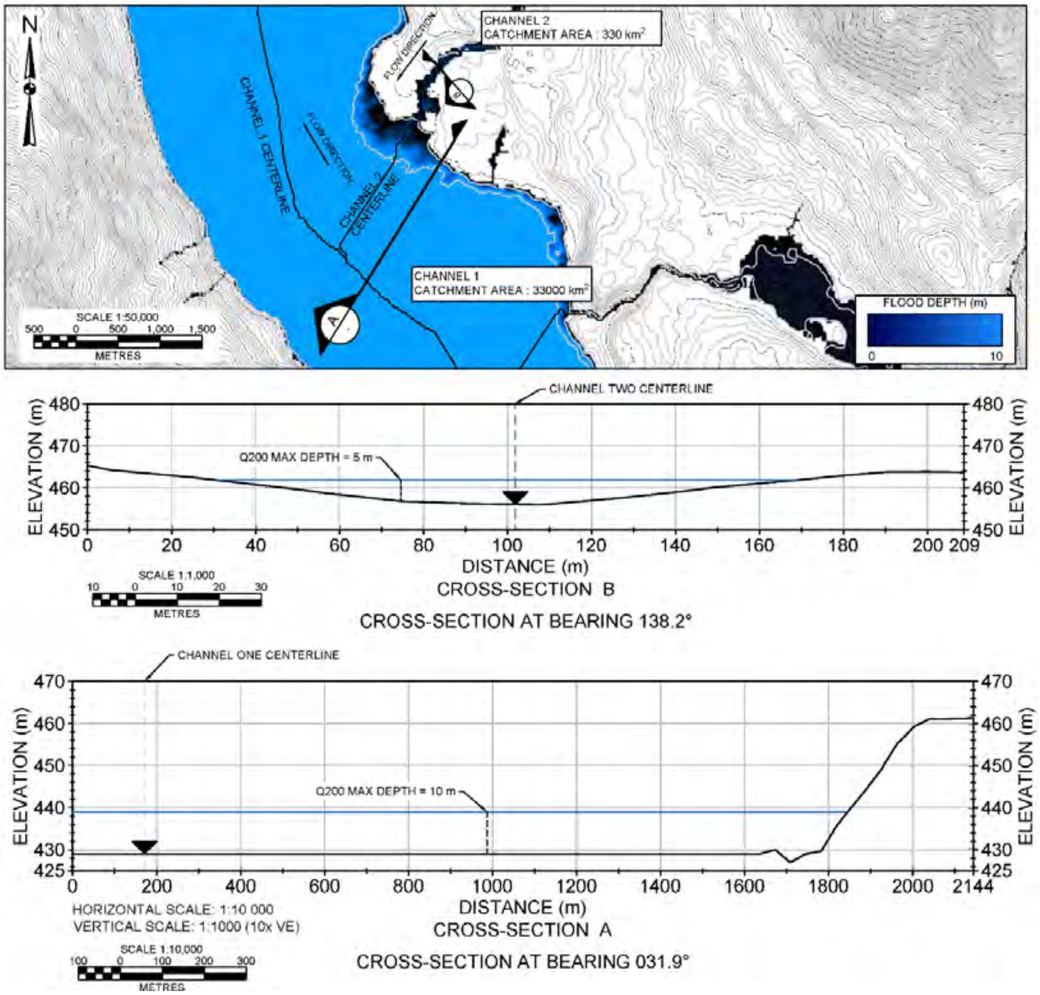

Figure 2-1. Illustration of the HAND concept (modified from Zheng et al., 2018).

HAND mapping was performed using a 30 m digital elevation model (DEM) for the study area acquired from the Shuttle RADAR Topography Mission (SRTM) (Farr et al., 2007). The analysis was performed using the Terrain Analysis Using Digital Elevation Models (TauDEM) GIS tool suite (Tarboton, 2016). TauDEM is a set of GIS-based tools designed for large-scale hydrological analysis of topographic data. The “Vertical Drop” function within this suite allows for the calculation of HAND using a stream network and flow accumulation model as inputs.

In order to identify appropriate HAND values to associate with flood depths, the relationship between catchment area and flood depth during a 200-yr return period flood was assessed. Hydrometric data from 205 Water Survey of Canada (WSC) (Environment and Climate Change Canada [ECCC], July 16, 2018) gauging stations with over 10 years of records located in southern BC were analyzed to provide a relationship between catchment area and flood depths. For each gauge, a stage-discharge curve was built using readings collected between June and July. These two months were selected as the rating curves are seasonally adjusted by the WSC so a stable period to generate the rating curves was required.

The HAND mapping exercise was carried out for all water bodies existing within the drainage network generated through TauDEM, these included rivers as well as lakes and reservoirs. The methodology for calculating the maximum 200-year flood depth did not differ based on the type of water body (i.e., lakes, rivers, and reservoirs were all treated the same way).

2.2.2. Coastal Inundation Mapping

Coastal inundation hazards result from a combination of processes including tides, storm surge, and wave action. These hazards and their contributing factors have been discussed in a series of provincial-level guidance documents (Ausenco Sandwell, 2011; Kerr Wood Leidal, 2011; BC FLNRORD, 2017; EGBC, 2017). As the scope for this project did not include a detailed site-specific assessment of the coastal inundation hazard, publicly available studies for the nearby Squamish (Kerr Wood Leidal, 2017), Egmont/Pender Harbour (Kerr Wood Leidal, 2015), Lions Bay (Cordilleran Geoscience, 2018), Vancouver (NHC, 2014), Lower Fraser Valley (Fraser Basin Council and NHC, 2017), and Victoria/Saanich Peninsula regions (Associated Engineering, 2021) were reviewed and their findings applied to the project area.

Based on the available studies (e.g., Ausenco Sandwell, 2011; NHC, 2014; KWL, 2015, 2017), the potential coastal flood area was estimated to a value of 4.35 m above the mean sea level. This value incorporates:

- Higher High Tide: 2.05 m Canadian Geodetic Vertical Datum 1928 (CGVD28)
- 500-year Storm Surge in the Salish Sea: 1.3 m CGVD28
- Global Sea Level Rise to 2100: 1.0 m above mean sea level.

KWL (2015) and Cordilleran Geoscience (2018) in an example application for the Sunshine Coast (British Columbia) and for the Village of Lions Bay studies respectively, also included the following general consideration for wave action, freeboard, and global sea level rise to 2200.

- Wave action of 1.2 m
- Freeboard of 1.0 m
- Global sea level rise from 2100 to 2200: 1.0 m above mean sea level.

Both studies rounded their total estimate of coastal inundation to 8 m.

In the Howe Sound section of the project area, the 8 m value was added to the 0 m above mean sea level value for extents covered by the 2016 lidar DEM[3]. For Indian Arm, which lies outside the available lidar extent, that value was applied to the 0 m CGVD28 from the SRTM DEM. The same data were also used for the HAND mapping described in Section 2.2.1. Because the SRTM DEM has a lower resolution and vertical accuracy than the available lidar, a 10 m buffer was applied on the extent of coastal inundation derived from the SRTM DEM. The 8 m line above the mean sea level represents a screening level coastal inundation estimate and it does not constitute a flood construction level (FCL) as site-specific modelling would be required to fully characterize

[3] The contributions of subsidence and uplift to coastal inundation were neglected in this study as the values reported in Ausenco Sandwell (2011) would, over a period of 100 to 200 years, be on the order of the uncertainty from the other factors considered.

the wave runup and freeboard allowance required for an FCL. Site-specific assessment by a qualified professional (QP) will supersede the estimated 8 m value from this study.

A coastal inundation level was not estimated for the Pitt Lake section of the study area as additional work will be required to assess the impact of sea level change, storm surge, or wave action for a narrow tidal lake in southern British Columbia (Ashley, 1977) and determine a representative inundation level.

2.3. Snow Avalanche Mapping

Sections of the land parcels that may be exposed to snow avalanche hazard were identified as part of this project. Recommendations for occupied structures outlined in Technical Aspects of Snow Avalanche Risk Management (TASARM), prepared by the Canadian Avalanche Association (CAA, 2016), indicate that snow avalanches up to a return period of 300 years should be identified.

Locator-level mapping as described by CAA (2016) was completed for this assessment, which identifies potential avalanche paths that could intersect with land parcels. This type of mapping provides baseline information on potential avalanche hazard areas but does not provide lateral extent or runout extents. The path lines originate at the top of a starting zone and extend into the runout zone. Other starting zones that runout in the same general area may exist adjacent to the starting zone identified with the line. The mapping was completed based on a snow supply assessment, identifying terrain steep enough to form snow avalanches, and sufficiently clear of vegetation to allow for avalanches to flow.

Snow depth was estimated for relevant elevations within the study area by computing linear regressions on freely available snowpack data obtained from nearby snow data sites operated by BC Ministry of Transportation and Infrastructure (BCMoTI), Metro Vancouver, and historical stations. The sites are summarized in Table 2-2. Extreme value statistical methods were used to estimate snow depths for each station for given return periods beyond the length of the data record (Figure 2-2). The estimated 100-year snow depth is 193 cm for an elevation of 300 m and 838 cm for an elevation of 1200 m. Figure 2-2 suggests that avalanche hazard may exist on sufficiently steep slopes above an elevation of approximately 200 m.

Climate change is anticipated to affect snowpack and avalanche conditions (IPCC, 2019). Since the study area is at relatively low elevation, future warming trends will likely result in a thinner average snowpack. However, avalanche events are common during the accumulation of snowfall amounts over a period of days, which is dependent on short-term winter weather. It is anticipated that such short-term weather fluctuations will continue even with a warming climate. More wet avalanches may result with climate change, which are likely the design events for the avalanche paths in the study area.

Table 2-2. Relevant snow data used for the snow supply assessment.

Station Name	Owner	Approximate Elevation (m)	Latitude (°)	Longitude (°)	Data Range (From-To)
Lions Bay Brunswick Pit	BCMoTI	130	49.371	-123.269	1983 to 1994
Eagle Ridge	BCMoTI	140	49.471	-123.237	2009 to 2021
Tantalus	BCMoTI	320	49.843	-123.143	2009 to 2021
Burwell Lake	Historical	880	49.536	-123.051	1945 to 1976
Palisade Lake	Metro Vancouver	880	49.400	-123.183	1946 to 2020
Loch Lomond	Historical	900	49.383	-123.077	1946 to 1982
Mount Seymour	Historical	1070	49.372	-122.962	1960 to 1989
Dog Mountain	Metro Vancouver	1080	49.366	-122.950	1945 to 2020
Grouse Mountain	Metro Vancouver	1100	49.466	-123.000	1936 to 2021
Hollyburn	Historical	1100	49.583	-123.083	1945 to 1987
Orchid Lake	Metro Vancouver	1190	49.454	-123.032	1972 to 2021

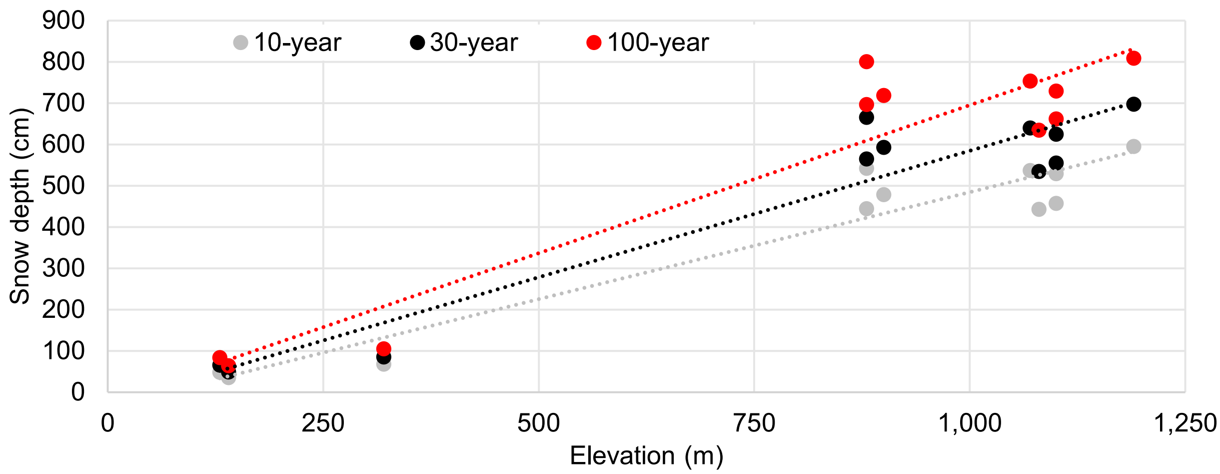

Figure 2-2. Estimated maximum snow depth assuming a linear relationship with respect to elevation for the study area.

2.3.1. Terrain and Vegetation

Slope angle was evaluated using the SRTM DEM (same as for HAND mapping in Section 2.2.1 and coastal inundation in Section 2.2.2). Vegetation cover was estimated using satellite imagery available on Google Earth, which was dated between 2019 to 2021. Terrain steeper than approximately 27° (Jamieson, 2018) with vegetation areas clear enough to form snow avalanches and the potential of travelling into land parcels was identified.

3.0 GIS COMPILATION

The geohazard mapping has been provided as Esri shapefiles representing the hazard as point, line, and polygon features (Table 3-1). The shapefiles use the NAD83 UTM Zone 10N projection. The geohazard mapping was completed in GIS software and Google Earth and was based on Appendix A and subject to the exclusions and limitations outlined in Section 1.2. The attributes compiled for each shapefile are described in Appendix B.

Table 3-1. Summary of geohazard mapping files provided with this report.

File name (data type)	Description
Landslide_mapping_points.shp (point)	Represents where previous geotechnical or geohazard assessment identified specific landslide occurrence or potential source of landslides
Previous_parcel_assessment_shp (point)	Inventories the parcels where previous geotechnical or geohazard assessment has been completed and filed with Metro Vancouver. Some parcels may have multiple reports associated with them.
Landslide_mapping_lines_shp (polyline)	Represents approximate travel path of actual landslide events as observed in the aerial photograph or imagery consulted. It may be an underestimate of the actual travel path as some of the distal debris might not be visible due to the resolution of the aerial photograph/imagery or vegetation cover.
Lineament_mapping.shp (polyline)	Represents a wide range of feature types such as potential tension cracks, scarps, trenches, or adversely oriented geological structures. Lineament type was not assigned to the features as part of this project. Lineaments were only recorded when noted above the parcels of interest.
Snow_avalanche_mapping_lines.shp (polyline)	Represent potential snow avalanche travel path as observed in the aerial photograph or imagery consulted. It may underestimate the actual travel of large events.
Landslide_mapping_polygons.shp (polygon)	Represents potential landslide source and runout zones of landslide activity. Polygon typically includes terrain (e.g., cliffs) and landforms (e.g., talus) associated with landslide activity. These polygons do not capture all the landscapes capable of producing landslides but only those with high potential as mapped at a regional scale.
Landslide_mapping_fans.shp (polygon)	Outlines the extent of fans based on lidar or TRIM dataset. Assigns a main hydrogeomorphic process to each fan based on empirical relationships.
SRTM_derived_coastal_inundation.shp (polygon)	Represents potential coastal inundation extent for area where only the SRTM elevation model was available.
lidar_derived_coastal_inundation.shp (polygon)	Represents potential coastal inundation extent for area where lidar elevation model was available.
Riverine_flooding.shp (polygon)	Represent potential river flowing extent based on the Height-Above-Nearest-Drainage approach.

4.0 DISCUSSION

This project provides the first compilation of geohazards for a select region of Metro Vancouver's Electoral Area A. While this work improves our understanding of geohazards at a screening level over a regional scale; landslide, inundation, and snow avalanche geohazards are complex phenomena that result from the interaction of site-specific conditions (e.g., topography, river profile, material type) and external forcing factors (e.g., precipitation, temperature, earthquake). The hazard level associated with these geohazards varies over time. The temporal scale can vary from seconds for an earthquake; hours and days for a rainstorm, weeks for the evolution of snow properties, months for the accumulation and melting of snowpack, or centuries to millennia in the case of progressive failure of rock slopes. As such the mapping presented in this work should be updated when additional and more detailed site-specific information becomes available. Table 4-1 discusses addtional factors that could influence geohazards in the study area.

The spatial scale of Drawings L01 to L14 and I01 to I17 summarizing the geohazard mapping from this project has been displayed at 1:25,000. As discussed in Section 1.2, information from various scales of mapping was compiled in preparing these drawings and 1:25,000 is representative of the overall scale at which it is intended to be used. This avoids overrepresenting the accuracy of the mapping by acknowledging that while detailed lidar was used for some of the analyses other relied on the coarser-resolution SRTM model. BGC anticipates that the geohazard mapping files provided with this report may be displayed digitally (e.g., via web application). Digital layer display is cautioned where scale can be adjusted by the user; BGC would be happy to discuss this issue further.

4.1. Landslide Hazard Mapping

Maps representing the potential hazard from landslides can take different form. As landslides occur more frequently on steep terrain, a slope map can be used approximate where landslide might occur. Slope maps tend to be conservative, do not account for material type, and do not identify fans (which have a gentle slope) as areas with a potential high landslide hazard. Slope maps were Metro Vancouver's main tool of characterizing landslide geohazards in Electoral Area A before this project. Geohazard inventory maps are the main deliverable of this project. They compile the known geohazard occurrence (recorded or observed) and can apply empirical relationships to provide a first estimate of where they might occur in the future.

While both slope and inventory maps are useful, the input from a QP is still often required for their interpretation. Development permit area (DPA) integrates information from slope map, inventory map, and regional knowledge to define map areas where development can occur without, with some, or with detailed geotechnical investigation. Composite hazard maps can further divide DPAs by considering the occurrence and intensity of multiple geohazards at a site thereby providing a more comprehensive characterization of the geohazards. The DPA and composite hazard maps require more effort to generate than slope or inventory maps. They are provided in format that can be interpreted by planners and approving officers.

Table 4-1. Summary of further considerations that were not incorporated in this work but could impact or improve our understanding of geohazard in Electoral Area A.

Parameter	Geohazard Affected	Description	Implication	Additional Work that could be Completed
Material type	Landslide	Material type refers to texture (e.g., clay, silt, sand, gravel) and the deposition mechanism (e.g., glacier, river, anthropogenic/construction). Glaciolacustrine and glaciomarine deposits are known to be susceptible to landslide activity and have been recognised in parts of the study area (Blais-Stevens, 2008; Cordilleran Geoscience, 2015). Anthropogenic ground can be suitable for a wide range of use when built for a specific purpose (e.g., mechanically stabilized earth landslide protection) or it can problematic if not specifically engineered or engineered for a different purpose (e.g., construction spoil).	A more detailed understanding of the texture, geotechnical properties, and spatial distribution of surficial and anthropogenic material would help understanding the variation of landslide susceptibility and erosion potential in the study area.	Desktop and field-based surficial geology mapping.
Old (legacy) logging roads	Landslide	Resource road upslope of parcel of interest were constructed at various times, using a range of techniques, based on different guidelines are currently under a range of utilization, maintenance efforts, and state of deactivation.	Old (legacy) logging roads can disrupt the natural drainage and redirect water onto sections of the slope that are not used to it, potentially triggering landslides. The fill from old logging roads can also be a source of landslides as the trees and logs lose their strength in decay. Unstable logging road sections have been documented in different parts of the study area (Cordilleran Geoscience 2017, 2020).	Compile inventory of location of old logging road based on lidar review and historical maps. Conditions of the road would need to be assessed on the ground. Landslide runout from such failures could be numerically modelled.
Magnitude and frequency	All geohazard	All geohazards have a magnitude-frequency distribution. While the exact relationship depends on the hazard type and terrain, the general trend is that small events happen more frequently compared to the rare large ones. The current work focuses on the geohazard potential and did not characterize their magnitude-frequency.	Uncertainty regarding the frequency of the hazard that could result in loss of life.	Preliminary qualitative or semi-quantitative risk assessment could be used to estimate which geohazard would benefit from a detailed site-specific investigation to define the magnitude-frequency of a hazard.
Change in vegetation	All geohazards	Changes in vegetation cover due to wildfire, insect infestation, disease, other geohazards, or anthropogenic activities.	Period of increased geohazard likelihood of occurrence and magnitude until the vegetation re-establish itself	Post-event mapping of the intensity of the disturbance could inform which areas could experience larger and more frequent, landslides, floods, and snow avalanches.
Climate change	All geohazards	Climate change refers to the change of temperature (extreme and average) and precipitation (yearly average, timing, intensity, type) observed globally since early 1900s and expected based the climate model. Climate change will affect the geohazard occurrence in the project area in different ways.	Climate change was considered in this study for the coastal inundation as it was straightforward to incorporate a first-order impact of sea-level rise. Climate change will also affect the other geohazards. Jakob and Owen (2021) historical data and climate model output and suggested that landslide frequency and size are likely to increase in the future. EGBC (2018) discusses potential implications for flood assessment.	Incorporating the latest output from the climate model for the Metro Vancouver area in the landslide and snow avalanche hazard models. Periodically update all geohazard models when significant new and/or higher resolution climate model become available.
Evolution of river profile	Riverine flooding and landslide	The evolution of the river profile due to channel migration, channel erosion, short- (months) to moderate- (years) term sediment storage.	Influences the local extent and depth of flooding. Bank erosion can also be a contributing factor to landslide occurrence.	Periodically evaluate the change in river profile for progressive change. Evaluate the change in river profile after significant flooding event. Use bank erosion models to predict bank erosion over time.
Coastal erosion	Coastal inundation and landslide	Coastal erosion is the progressive retreat of the coastline. The rate of change depends on the material type along the coast, sediment flux associated with longshore drift and is affected by the sea-level rise.	Coastal erosion can affect the area affected by coastal inundation and it can also generate landslide.	Periodically evaluate the change in coastline location and topographic profile. Evaluate the change in coastline after significant storm event. The 1-m sea level rise prescribed for BGC is also a mean (conservative) estimate. The tail end of the distribution could be evaluated (lower probability events with higher than expected sea levels.
Detection scale	Landslide	The size of geohazard mapped depends on the resolution of the imagery and DEM consulted.	A study by Brardinoni et al. 2003 of the Capilano Watershed demonstrated that remotely sensed inventory could miss up to 85% of landslide occurrences and up to 30% of the mass movement volumes when compared with results from field-based inventory.	Update geohazard inventory when more detailed imagery and DEM become available and supplement with field surveys.

5.0 SUMMARY AND RECOMMENDATIONS

The landslide mapping and snow avalanche locator-level mapping are summarized in Drawings L01 to L14. Landslide events or landslide potential have been mapped above the parcels of interest suggesting that they may be exposed to landslide hazards in the future. Land parcels with a locator-level line suggest that they may be exposed to snow avalanche hazards.

Parcels or parts of parcels were identified in Drawings I01 to I17 as within the preliminary riverine and coastal inundation areas and may be exposed to flooding hazards in the future.

5.1. Recommendations

While the geohazard inventory prepared in this project is a fundamental building block for understanding geohazards, additional steps will be needed to prepare maps and criteria for decision making. BGC recommends that Metro Vancouver proceeds with Phase 2, including the development of a framework to incorporate the results of this work into Electoral Area A decision processes, such as planning, policy, and regulation (building and development permits).

Next steps could include the following, which would be structured for potential incorporation into updated building and land development regulation within Electoral Area A:

- **Maps and supporting information (basis for decision making).** These may include thematic maps (e.g., slope gradient thresholds and defined setbacks at slope crest or base), interpreted maps of terrain stability or hazard susceptibility, avalanche, landslide, or flood hazard scenario maps, and related policy maps where available knowledge supports their preparation. BGC also recommends Metro Vancouver distinguish between maps intended for use by decision makers (policy maps) and hazard maps intended for use by practitioners in support of site assessments. A wide range of effort can be associated with hazard map development. As such it is important to align mapping objectives (and associated cost) with their intended use. BGC can provide further details on mapping approaches on request, with reference to the forthcoming update to the EGBC landslide guidelines.
- **Decision making framework**. These may include hazard or risk-based decision protocols for decision makers, for the application of spatial information (maps) and supporting information in the permitting process. These materials would reflect hazard types present within Electoral Area A, and would be structured for potential inclusion in bylaws, such as Official Community Plans (OCPs). For example, prior to the development of a land parcel that may be exposed to snow avalanche hazard, a detailed zoning-level hazard assessment (CAA, 2016) should be completed by a QP and avalanche professional, or one person that meets both qualifications by virtue of education and experience. BGC can provide further details on request, with reference to the forthcoming update to the EGBC landslide guidelines.

6.0 CLOSURE

We trust the above satisfies your requirements at this time. Should you have any questions or comments, please do not hesitate to contact us.

Yours sincerely,

BGC ENGINEERING INC.
per:

Marc-André Brideau, Ph.D., P.Geo.
Senior Engineering Geologist

Elisa Scordo, M.Sc., P.Ag., P.Geo.
Senior Hydrologist

Reviewed by:

Kris Holm, M.Sc., P.Geo.
Principal Geoscientist

MAB/KH/mj/syt

EGBC Permit to Practice 1000944

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APPENDIX A
MATERIAL CONSULTED

Table A1: List of reports consulted (provided by Metro Vancouver)

Report No.	Title	Author	Year	Notes
1	Debris training wall Lot 2 Montezambert Creek*	N.A. Skermer	1989	One page summary that the hazard category for debris torrents on Montizambert Creek is moderate and there is no known history of debris torrents in that creek
2	Shoreline Sales Program Hazard Study Indian Arm, Lillooet Lake and Harrison Lake	Northwest Hydraulic Consultants Ltd.	1990	Hazard assessment Indian Arm. Includes debris torrent potential in creeks along Indian Arm.
3	Lot 2 Montizambert Creek, Wynd	Thurber Engineering Ltd.	1990	Review of previous report by Skermer regarding the hazard assessment of debris torrents potential on Montizambert Creek.
4	Lot 2 Montizambert Creek, Wynd	N.A. Skermer	1990	Follow up after Thurber Engineering Ltd.'s report with design recommendations for a training wall.
5	Montizambert Creek	N.A. Skermer	1995	One page memo summarizing that fill placement on debris flow protection structure.
6	Assessment of Debris Flow Potential Newman Creek, Howe Sound	Vandine Geological Engineering Ltd.	1998	Outlines landslide event on Newman Creek in January 1998
7	Proposed Cabin, South 1/2, Block 1, District Lot 1027, North Vancouver, BC - Natural hazards assessment	Horizon Engineering Inc.	1998	No evidence of natural hazards were observed on the aerial photographs. Mentions that lack of trees suggests previous debris flows, and a crack of concern is located at the south end of the rock wedge
8	Montizambert Creek	BC Ministry of Environment	2000	e-mail chain notifying GVRD of failures in the upper reaches of M Creek and Newman Creek
9	Sunset Highlands housing development, Sunset Beach	Cordilleran Geoscience	2001	Excavation for highway found burried logs by a rock slide/rock avalanche.
10	Geotech assessment for Unit 1, Ocean Point Drive	Horizon Engineering Inc.	2002	Full geotech report for a property on Newman Creek Fan. Includes documented chronology of known events on the creek up to 2002
11	Supplement to geotechnical engineering review for existing Pitt Lake recreational cabin	Trow Consulting Engineers Ltd	2003	Recommendations on lakeshore and excavation slope remedial requirements
12	Geotechnical report proposed gatehouse, lot 1-16 Strachan Point Road, West Vancouver, B.C.	Davies Geotechnical Inc.	2003	Provides recommendations regarding slope stability, site preparation and foundation design for a proposed gatehouse structure.
13	Crown Lease Lots on Pitt and Harrison Lakes, BC Reconnaissance Level Geological Slope Hazard Assessment	Thurber Engineering Ltd.	2004	Rates the slope hazards on selected Crown lease lots
14	Main residence, Strachan Point, Howe Sound - Geotechnical Report	Tony Dell and Associates	2004	Geotech review of a proposed house
15	Slope hazard assessment Indian Arm property on the Lighthall Creek fan	Baumann Engineering	2004	Debris flow and flooding hazard assessment
16	Hazard, risk, and vulnerability analysis - Electoral Area A Greater Vancouver Regional District	EmergeX Planning Inc	2005	Provides an analysis of the hazards that may present risks to Electoral Area A of GVRD. Outlines geological hazards along Highway 99 including documenting past events
17	Harrison and Pitt Lakes shoreline hazards. Hydrogeomorphic hazard assessment	Northwest Hydraulic Consultants Ltd.	2005	Assesses waterfront properties on Harrison Lake and Pitt Lake that the province intends to sell. Overview-level hydrogeomorphic hazard assessment of 28 properties at Pitt Lake
18	Slope Hazard Assessment at 24 Johnson Bay, Indian Arm Provincial Park	Horizon Engineering Inc.	2005	Reviews slope hazards for existing house on subject property. This property is on the Lighthall Creek Fan, and comments on the frequency of debris flows
19	Geotechnical hazard assessment - Proposed subdivision, Montizambert properties	Golder Associates	2006	Table outlining air photos reviewed and if landslides were observed above subdivision. Specific description of the terrain above each plot, and the hazards that potentially exist
20	Charles Creek erosion during November 2006 event. Geotechnical and hydraulics study	Thurber Engineering Ltd.	2007	Study of erosion on Charles Creek (8 km north of horseshoe bay) after a November 2006 event.
21	Slope hazard assessment at Lot 7006 Block E Johnson Bay, Indian Arm Provincial Park - Updated report	Horizon Engineering Inc.	2007	Reviews slope hazards for existing house on subject property. This property is on the Carter Creek Fan, and comments on the frequency of debris flows.
22	Proposed residential development, Block E, District Lot 824, Group 1, Indian Arm BC. Geotechnical Report - Slope hazard assessment	Horizon Engineering Inc.	2008	Site located on Clementine Creek. Mentions rockfall potential and colluvium as evidence of previous rock fall

Report No.	Title	Author	Year	Notes
23	"M" Creek residential site - Block 7, Plan 4485, DL 2935, N.W. Group 1 Land District, site protection works	Geopacific Consultants Ltd.	2009	Provide recommendations for protecting a specific lot from Howe Sound waters and debris flows from "M creek".
24	Geotechnical engineering review and assessment. 10 Ocean Point Drive West Vancouver, B.C.	Jecth Consultants Inc.	2009	Recommendations for foundation design and construction of proposed development.
25	Geotechnical and hydrotechnical assessment. Block B, District Lot 7006, Group 1, New Westminster District	AJIA Canadian Building Systems Inc.	2009	Debris flow hazard assessment.
26	Geotechnical and Geohazards assessment, 7094 West Grant Channel, Pitt lake. District Lot 7094, Group 1, New Westminster District	Valley Geotechnical Engineering Services Ltd.	2010	Assess conditions of a site where an old cabin was demolished and a new one was proposed.
27	Block D DL 6955, Group 1, New Westminster District, Owner: Eagle Ridge Mechanical - Garth Moore, Geotechnical assessment (amended 18 December 2009 report)	Lasca Group Technical Services	2010	Reviews hazards on Isherwood Creek.
28	Report on Debris Slide Protection Works Completed July 2010 - "M" Creek Residential Site - Block7	Geopacific Consultants Ltd.	2011	Comments on construction of block wall and debris flow wall for M Creek
29	Geotechnical and Hydrotechnical Assessment for Lot 29 Johnson Bay, Indian Arm, BC	AJIA Canadian Building Systems Inc.	2011	Evaluate slope hazard potential.
30	Engineer/Inspector's Daily Report. RVYC/Generator Building/Wigwam.	Golder Associates	2011	Record of observing fill placement at Wigwam Inn
31	Lot B, DL 7233 on Pitt Lake, BC. Geotechnical assessment	Thurber Engineering Ltd.	2011	Summarizes previous reports on the lot.
32	Terrain Hazard Assessment for DL 7008A	BC Ministry of Forests, Lands and Natural Resource Operations	2012	Landslide hazard assessments for 27 lots in Indian Arm.
33	Terrain Hazard Assessment for DL 7008C	BC Ministry of Forests, Lands and Natural Resource Operations	2012	Landslide hazard assessments for 27 lots in Indian Arm.
34	Terrain Hazard Assessment for DL 7008D	BC Ministry of Forests, Lands and Natural Resource Operations	2012	Landslide hazard assessments for 27 lots in Indian Arm.
35	Terrain Hazard Assessment for DL 7019	BC Ministry of Forests, Lands and Natural Resource Operations	2012	Landslide hazard assessments for 27 lots in Indian Arm.
36	Terrain Hazard Assessment for DL 7026A	BC Ministry of Forests, Lands and Natural Resource Operations	2012	Landslide hazard assessments for 27 lots in Indian Arm.
37	Terrain Hazard Assessment for DL 7026B	BC Ministry of Forests, Lands and Natural Resource Operations	2012	Landslide hazard assessments for 27 lots in Indian Arm.
38	Terrain Hazard Assessment for DL 7058B	BC Ministry of Forests, Lands and Natural Resource Operations	2012	Landslide hazard assessments for 27 lots in Indian Arm.
39	Terrain Hazard Assessment for DL 7058C	BC Ministry of Forests, Lands and Natural Resource Operations	2012	Landslide hazard assessments for 27 lots in Indian Arm.
40	Terrain Hazard assessment for DL 824F	BC Ministry of Forests, Lands and Natural Resource Operations	2012	Landslide hazard assessments for 27 lots in Indian Arm.
41	Terrain Hazard assessment for DL 3150	BC Ministry of Forests, Lands and Natural Resource Operations	2012	Landslide hazard assessments for 27 lots in Indian Arm.
42	Terrain Hazard assessment for DL 3152A	BC Ministry of Forests, Lands and Natural Resource Operations	2012	Landslide hazard assessments for 27 lots in Indian Arm.
43	Terrain Hazard assessment for DL 3152B	BC Ministry of Forests, Lands and Natural Resource Operations	2012	Landslide hazard assessments for 27 lots in Indian Arm.
44	Terrain Hazard assessment for DL 4217B	BC Ministry of Forests, Lands and Natural Resource Operations	2012	Landslide hazard assessments for 27 lots in Indian Arm.
45	Terrain Hazard assessment for DL 6858	BC Ministry of Forests, Lands and Natural Resource Operations	2012	Landslide hazard assessments for 27 lots in Indian Arm.
46	Terrain Hazard assessment for DL 6955E	BC Ministry of Forests, Lands and Natural Resource Operations	2012	Landslide hazard assessments for 27 lots in Indian Arm.
47	Terrain Hazard assessment for DL 6955A	BC Ministry of Forests, Lands and Natural Resource Operations	2012	Landslide hazard assessments for 27 lots in Indian Arm.
48	Terrain Hazard assessment for DL 6955B	BC Ministry of Forests, Lands and Natural Resource Operations	2012	Landslide hazard assessments for 27 lots in Indian Arm.
49	Terrain Hazard assessment for DL 6955C	BC Ministry of Forests, Lands and Natural Resource Operations	2012	Landslide hazard assessments for 27 lots in Indian Arm.
50	Terrain Hazard assessment for DL 6981	BC Ministry of Forests, Lands and Natural Resource Operations	2012	Landslide hazard assessments for 27 lots in Indian Arm.
51	Terrain Hazard assessment for DL 6984A	BC Ministry of Forests, Lands and Natural Resource Operations	2012	Landslide hazard assessments for 27 lots in Indian Arm.
52	Terrain Hazard assessment for DL 6984C	BC Ministry of Forests, Lands and Natural Resource Operations	2012	Landslide hazard assessments for 27 lots in Indian Arm.
53	Terrain Hazard assessment for DL 7006A	BC Ministry of Forests, Lands and Natural Resource Operations	2012	Landslide hazard assessments for 27 lots in Indian Arm.
54	Terrain Hazard assessment for DL 7006C	BC Ministry of Forests, Lands and Natural Resource Operations	2012	Landslide hazard assessments for 27 lots in Indian Arm.
55	Terrain Hazard assessment for DL 7006D	BC Ministry of Forests, Lands and Natural Resource Operations	2012	Landslide hazard assessments for 27 lots in Indian Arm.
56	Terrain Hazard assessment for DL 7006E	BC Ministry of Forests, Lands and Natural Resource Operations	2012	Landslide hazard assessments for 27 lots in Indian Arm.
57	Terrain Hazard assessment for DL 7006F	BC Ministry of Forests, Lands and Natural Resource Operations	2012	Landslide hazard assessments for 27 lots in Indian Arm.

Report No.	Title	Author	Year	Notes
58	Terrain Hazard assessment for DL 7006H	BC Ministry of Forests, Lands and Natural Resource Operations	2012	Landslide hazard assessments for 27 lots in Indian Arm.
59	Terrain Hazard assessment for DL 7007B	BC Ministry of Forests, Lands and Natural Resource Operations	2012	Landslide hazard assessments for 27 lots in Indian Arm.
60	Proposed renovation of home and slope stability concerns - 4 Montizambert Wynd, West Vancouver, BC	Geotek Designs	2012	Reviews of the foundation excavations for the funicular proposed for the area adjacent to the north property line of the lot. Property that crosses Sclufield Creek, within "Montizambert Wynd", looking to do renovations.
61	Geotechnical Assessment proposed funicular foundations for Block 3 Montizambert Wynd	Islay Engineering Services Inc	2014	Reviews of the foundation excavations for the funicular proposed for the area adjacent to the north property line of the lot
62	Geotechnical hazard assessment, Private cabin on Pitt Lake, Blk 1, District Lot 3022, Group 1, NWD - North of Cozen Point - Pitt Lake	Braun Geotechnical Ltd.	2014	Assess and evaluate terrain hazard conditions with potential to impact the existing partially constructed residential cabin at the site
63	Geomorphology for the Indian River watershed: observations bearing on archeological site visibility.	Cordilleran Geoscience	2015	Discusses the deglacial and early post-glacial period deposits along with present day activity of the fans as it relates to the archeological potential of sites in the Indian River area.
64	Reservoir fill slope sign off	Cordilleran Geoscience	2015	Battani Creek reservoir (Howe Sound) fill slope required pullback to reduce the risk to downslope resources. Cordilleran Geoscience reviewed the work done on the reservoir fill slope pullback.
65	Geotechnical investigation report - Proposed residential development on lot 3 Ocean Point Drive	Geopacific Consultants Ltd.	2015	Geotech review and provides recommendations for design and construction of the proposed development. Includes slope stability analysis results
66	Application preventative maintenance dredging between Mile 20 bridge on CN's Squamish Subdivision and the Highway 99 Bridge over M (Yahoo) Creek	Canadian National Railway	2016	Application for maintenance dredging between CN and Ministry of Transportation and Infrastructure bridges
67	Geotechnical report to support recently constructed domestic water catchment and distribution system, Montizambert Creek, West Vancouver, BC	Cordilleran Geoscience	2016	Reviewed the water system for Montizambert Wynd subdivision from intake to termination making observations of terrain conditions at the site.
68	Revised geotechnical engineering report for proposed new single family residence at lot 12, Strachan Point Road, West Vancouver, BC	Phillips Engineering Ltd.	2016	Engineering recommendations on building.
69	Georisk assessment, 16 East Crocker Point, Indian Arm, near Vancouver, BC.	Cordilleran Geoscience	2017	Quantitative geohazard risk assessment for district lot 6921 F.
70	Geotechnical review - Natural hazards statement for new residential structure on #7 Montizambert Wynd, West Vancouver, B.C.	Terrane Geotechnical Group	2019	Determined whether the site is subject to natural hazards that would preclude "safe" development and prepare a natural hazard statement.
71	Landslide risk assessment, Moonshine Bay, Pitt Lake	Cordilleran Geoscience	2020	Notes on slide that hit Moonshine Bay in 1990
72	Gazebo building permit application. 17 Strachan Point Road, Metro Vancouver, BC. Geotechnical slope hazard assessment report	Horizon Engineering Inc.	2020	Describes some potential rockfall hazard to the gazebo
73	Study to determine the appropriate flood construction level at Barnston Island	Associated Engineering	2021	Provides guidance on the establishment of a flood construction level for Barnston island and potential additional flood mitigation recommendations
74	Geotechnical assessment for proposed new residence and detached garage/carriage house located at 6 Strachan Point Road, West Vancouver, B.C.	Phillips and Associates Engineering Consultants Ltd.	2021	Provides subsoil information and recommendations for site prep, foundation design etc. Discusses that lot is on the debris flow deposits of Charles Creek
75	Slope Stability Assessment for Proposed Residence Located at 6 Strachan Point Road, West Vancouver, B.C.	Phillips and Associates Engineering Consultants Ltd.	2021	Rock slope hazard assessment
76	Geotechnical Summary Report. Proposed renovation. Lot 49, Passage Island, BC	Horizon Engineering Inc.	2021	No mention of any landslide hazards

Notes: * Spelling used in the original report

Table A2: Aerial photograph consulted

Year	Flight line	Photograph	Project area
1952	BC 1632	26 to 35	Indian Arm
1952	BC 1632	47 to 55	Indian Arm
1952	BC 1632	102 and 103	Indian Arm
1952	BC 1633	40 to 43	Indian Arm
1952	BC 1634	59 to 64	Howe Sound
1953	BC 1806	68 to 78	Pitt Lake
1953	BC 1806	107 to 109	Pitt Lake
1953	BC 1807	1 and 2	Pitt Lake
1953	BC 1816	102 to 106	Pitt Lake
1957	BC 2326	69 to 74	Pitt Lake
1957	BC 2326	108 to 114	Pitt Lake
1957	BC 2327	1 to 5	Pitt Lake
1957	BC 2327	35 to 49	Pitt Lake
1957	BC 2336	79 to 98	Pitt Lake
1957	BC 2337	17 to 37	Pitt Lake
1957	BC 2337	103 to 108	Pitt Lake
1957	BC 2338	1 to 7	Pitt Lake
1957	BC 2338	63 to 65	Indian Arm
1957	BC 2339	75 to 89	Indian Arm
1957	BC 2340	30 to 48	Indian Arm
1957	BC 2341	45 to 47	Indian Arm
1957	BC 2341	63 to 81	Indian Arm
1957	BC 2345	93 to 107	Indian Arm
1957	BC 2346	61 to 75	Indian Arm
1957	BC 2347	20 to 27	Indian Arm
1957	BC 2347	80 to 82	Indian Arm
1957	BC 2348	75 to 84	Howe Sound
1957	BC 2349	18 to 29	Howe Sound
1957	BC 2349	49 to 53	Howe Sound
1992	BCB92018	136 and 137	Indian Arm
1992	BCB92018	45	Belcarra
1984	BC84016	77 and 78	Belcarra

Table A-3: Publicly available lidar consulting for this project

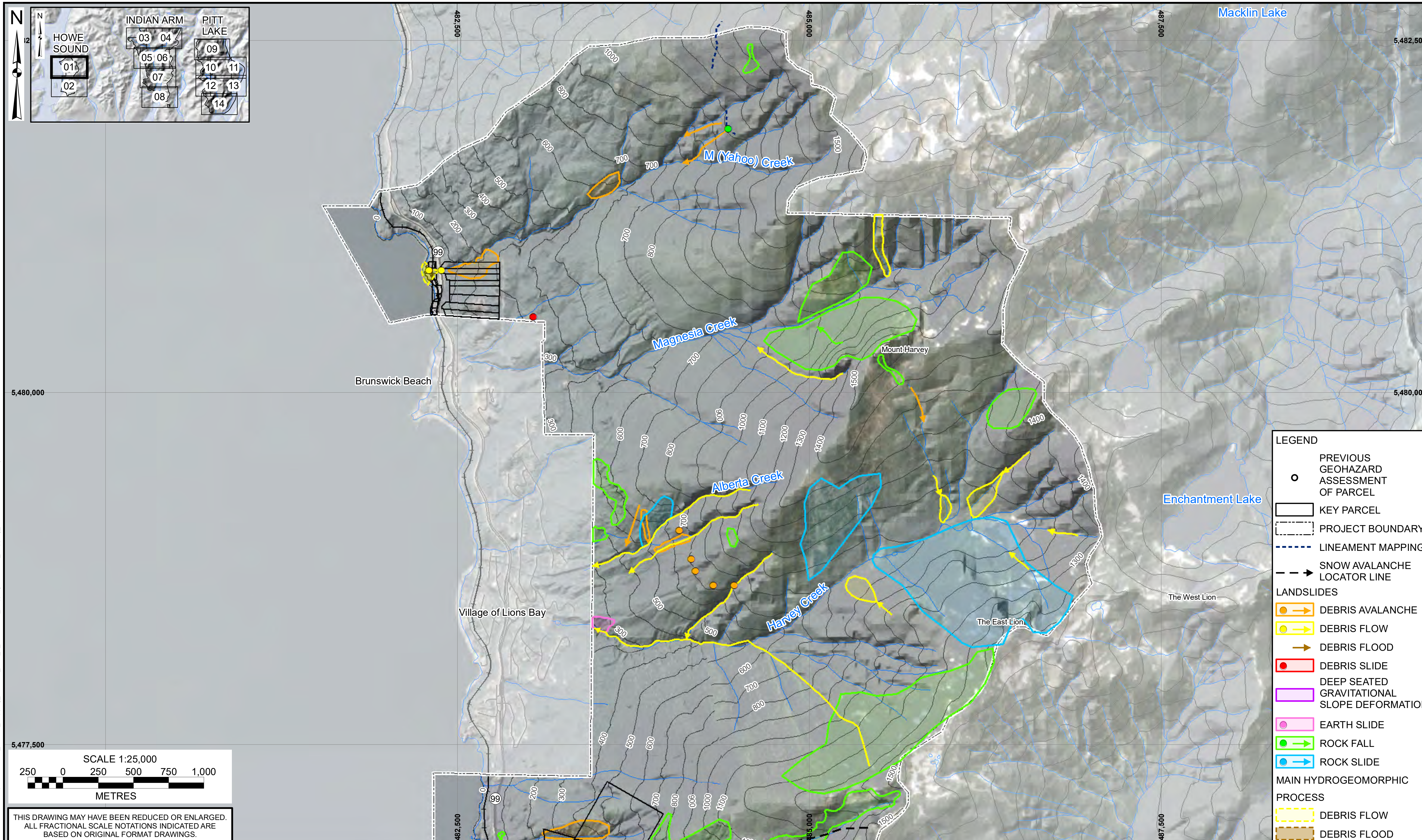
Tile	Source	Year	Resolution
bc_092g017_xl1m_utm10_170714	BC Government	2016	1 m
bc_092g026_xl1m_utm10_170713	BC Government	2016	1 m
bc_092g027_xl1m_utm10_170713	BC Government	2016	1 m
bc_092g034_xl1m_utm10_2019	BC Government	2019	1 m
bc_092g036_xl1m_utm10_170713	BC Government	2016	1 m
bc_092g044_xl1m_utm10_2019	BC Government	2019	1 m
bc_092g045_xl1m_utm10_170713	BC Government	2016	1 m
bc_092g046_xl1m_utm10_170713	BC Government	2016	1 m
dtm_1m_utm10_e_1_146	Natural Resource Canada	2016	1m
dtm_1m_utm10_e_2_146	Natural Resource Canada	2019	1m
dtm_1m_utm10_e_2_147	Natural Resource Canada	2019	1m
dtm_1m_utm10_e_2_147	Natural Resource Canada	2020	1m
dtm_1m_utm10_e_2_148	Natural Resource Canada	2019	1m
dtm_1m_utm10_e_2_148	Natural Resource Canada	2020	1m
dtm_1m_utm10_e_3_146	Natural Resource Canada	2019	1m
dtm_1m_utm10_e_3_147	Natural Resource Canada	2019	1m
dtm_1m_utm10_e_3_148	Natural Resource Canada	2019	1m

APPENDIX B
GEOHAZARD MAPPING ATTRIBUTES

Table B1: List of attributes for each GIS file

File name	Attribute	Possible values	Additional information
Landslide_mapping_points.shp	Slide_YN	Yes or no	Occurrence of a landslide
	Hazard_Typ	Debris flood, debris flow, debris avalanche, earth slide, rock fall, rock slide, rock avalanche	Landslide type according to Hungr et al. 2014 classification
	Reference	Site assessment report from which information was extracted	
Previous_parcel_assessment.shp	Parcel	First jurisdiction - roll number	
	Reference	Site assessment report from which information was extracted	
Landslide_mapping_lines.shp	Haz_type	Landslide type according to Hungr et al. 2014 classification	
	Reference	Source from which information was extracted	New mapping is referenced as BGC 2022
	Comment	Freeform field for additional details on the hazard	
	Hazard	Event or potential	
Lineament_mapping.shp	Reference	Source from which information was extracted	New mapping is referenced as BGC 2022
	Comment	lidar review or date of imagery	
	Hazard	Potential	All lineaments are considered potential hazard
Snow_avalanche_mapping_lines.shp	Source	Google Earth or aerial photograph	
	Process	Snow avalanche	
Landslide_mapping_polygons.shp	Haz_type	Landslide type according to Hungr et al. 2014 classification	
	Reference	Source from which information was extracted	New mapping is referenced as BGC 2022
	Comment	Freeform field for additional details on the hazard	
	Hazard	Event or potential	
Landslide_mapping_fans.shp	Reference	Source from which information was extracted	New mapping is referenced as BGC 2022
	MainProcess	Flood, debris flood, debris flow	
SRTM_derived_coastal_inundation.shp	Reference	BGC, 2022	New analysis performed for this project
lidar_derived_coastal_inundation.shp	Reference	BGC, 2022	New analysis performed for this project
Riverine_flooding.shp	Source	CDED	Dataset used for the analysis
	Reference	BGC, 2022	New analysis performed for this project

DRAWINGS



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CLIENT: metro vancouver

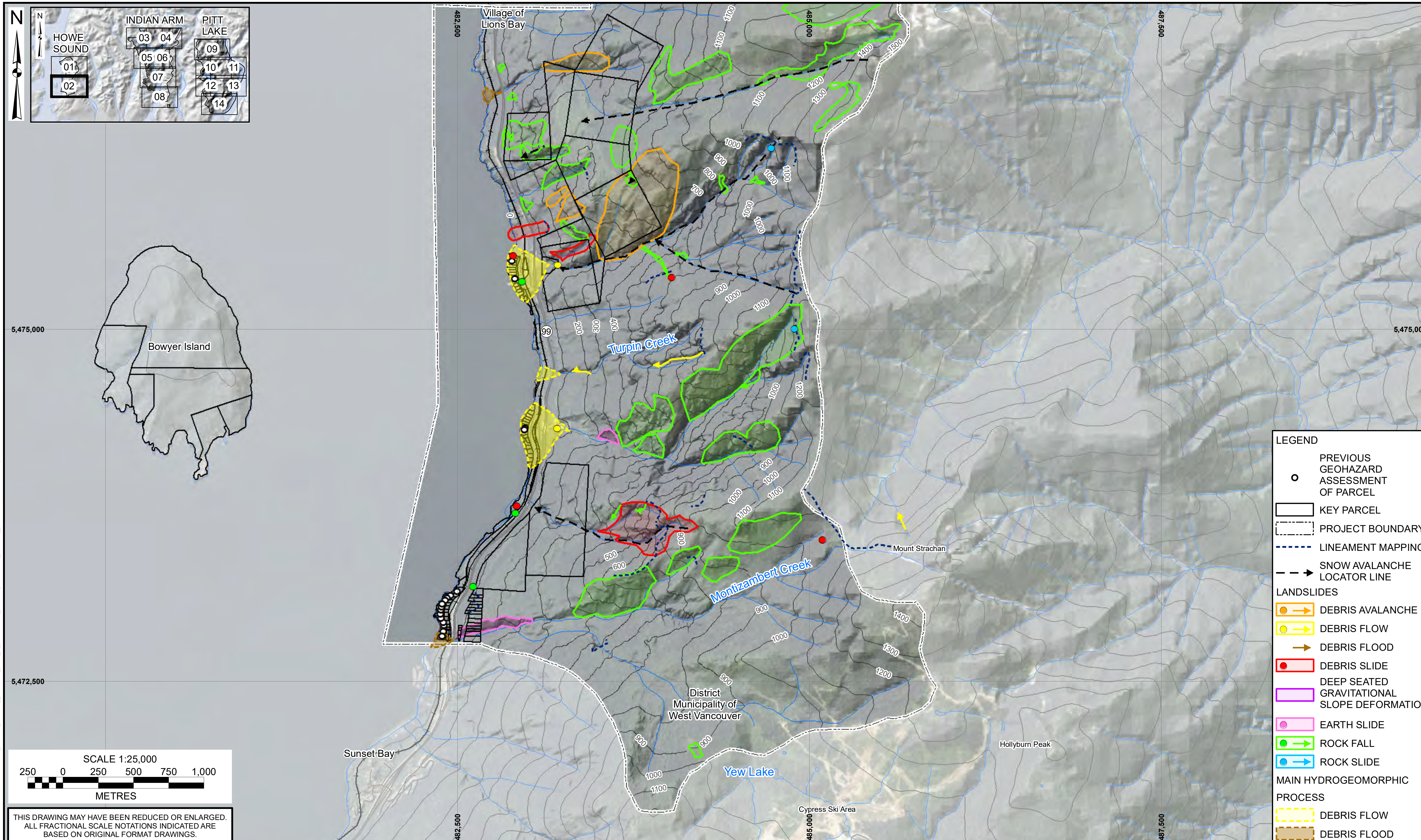
BGC

PROJECT: ELECTORAL AREA A - GEOHAZARD MAPPING

TITLE: LANDSLIDE MAPPING HOWE SOUND

PROJECT No.: 0431031

DWG No: L 01



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BGC

PROJECT: ELECTORAL AREA A - GEOHAZARD MAPPING

TITLE: LANDSLIDE MAPPING HOWE SOUND

PROJECT No.: 0431031

DWG No: L 02

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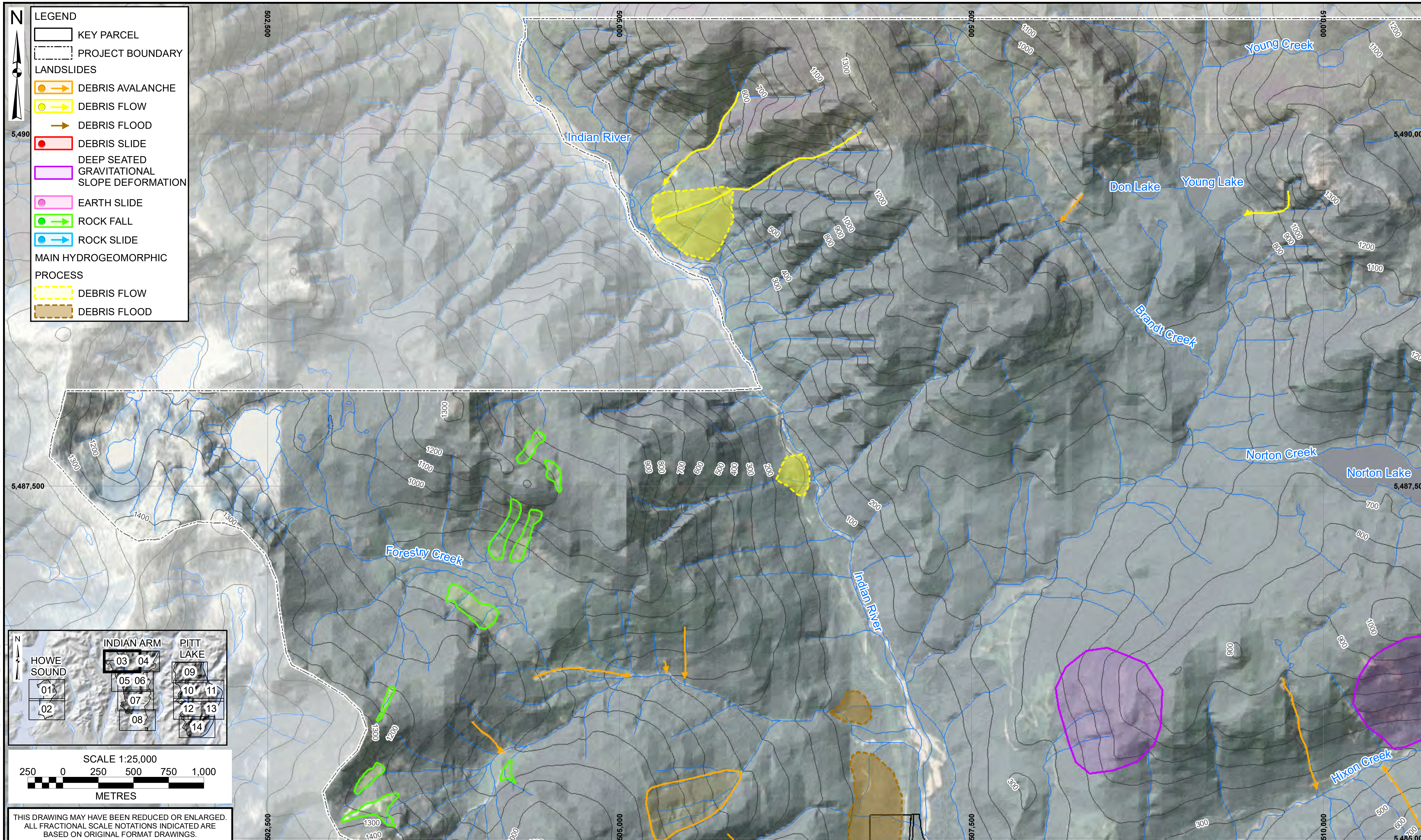

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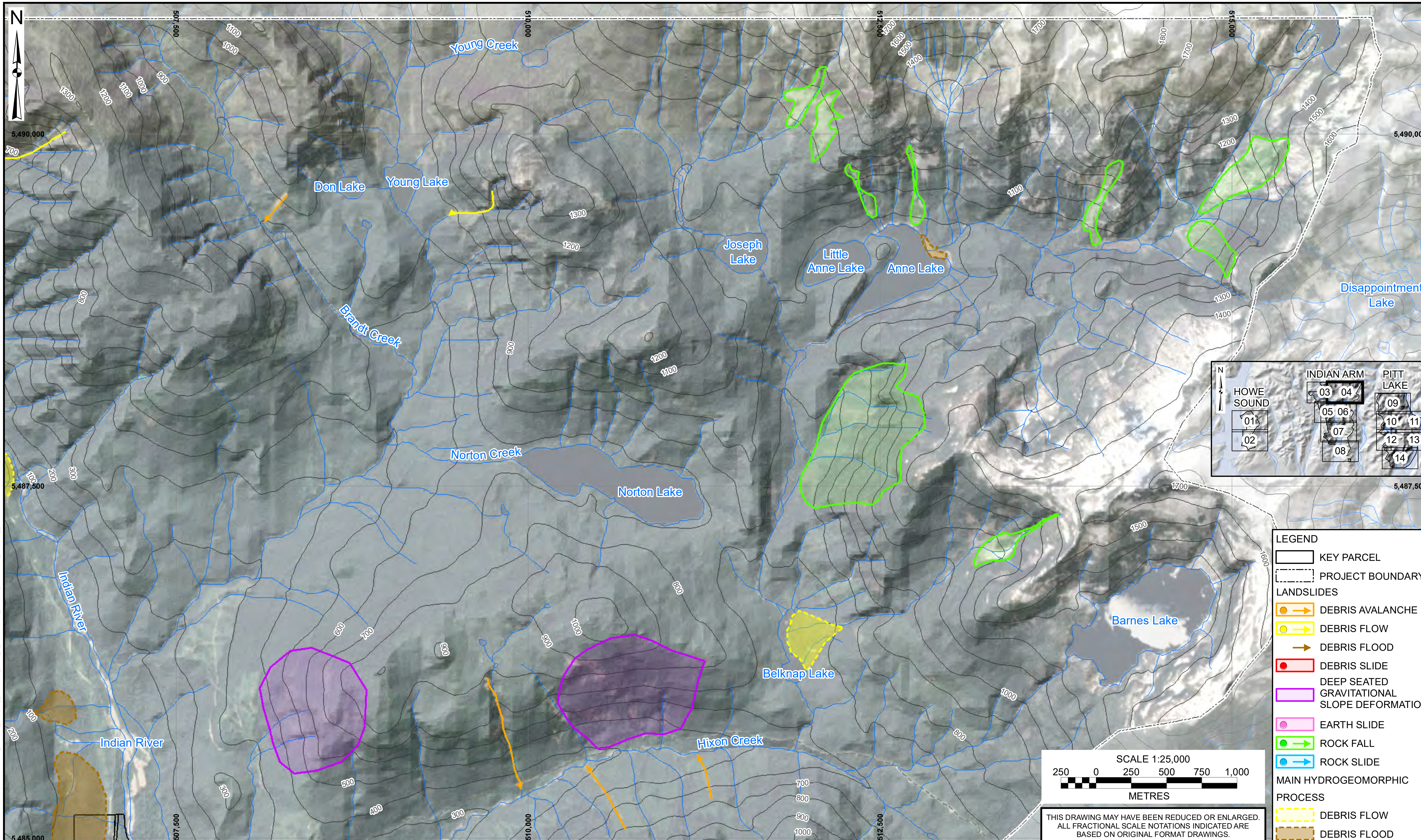
BGC

PROJECT: ELECTORAL AREA A - GEOHAZARD MAPPING

TITLE: LANDSLIDE MAPPING INDIAN ARM

PROJECT No.:	DWG No:
0431031	L 03



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PROJECT: ELECTORAL AREA A - GEOHAZARD MAPPING

TITLE: LANDSLIDE MAPPING INDIAN ARM

PROJECT No.:	DWG No:
0431031	L 04

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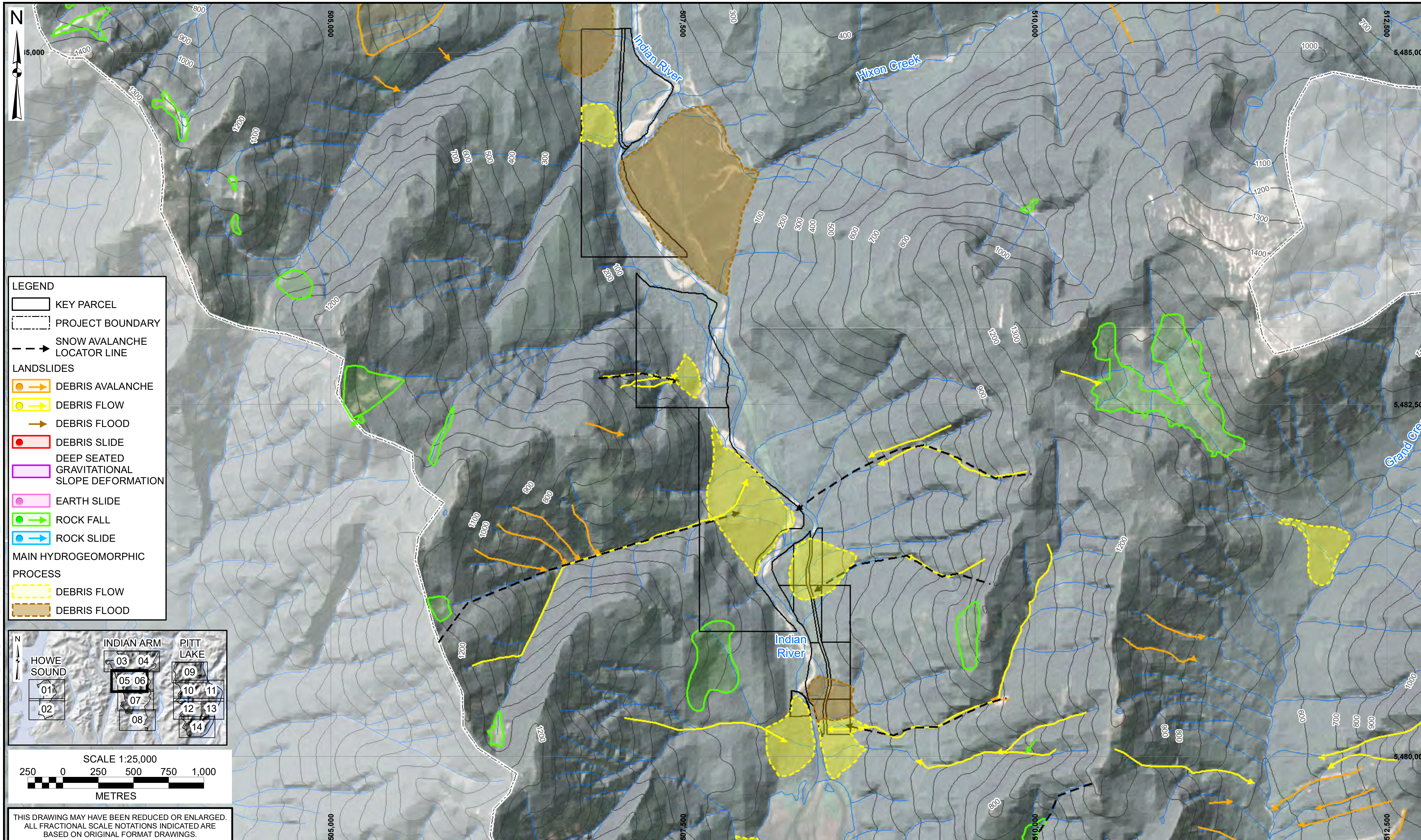

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PROJECT: ELECTORAL AREA A - GEOHAZARD MAPPING

TITLE: LANDSLIDE MAPPING INDIAN ARM

PROJECT No.: 0431031

DWG No: L 05

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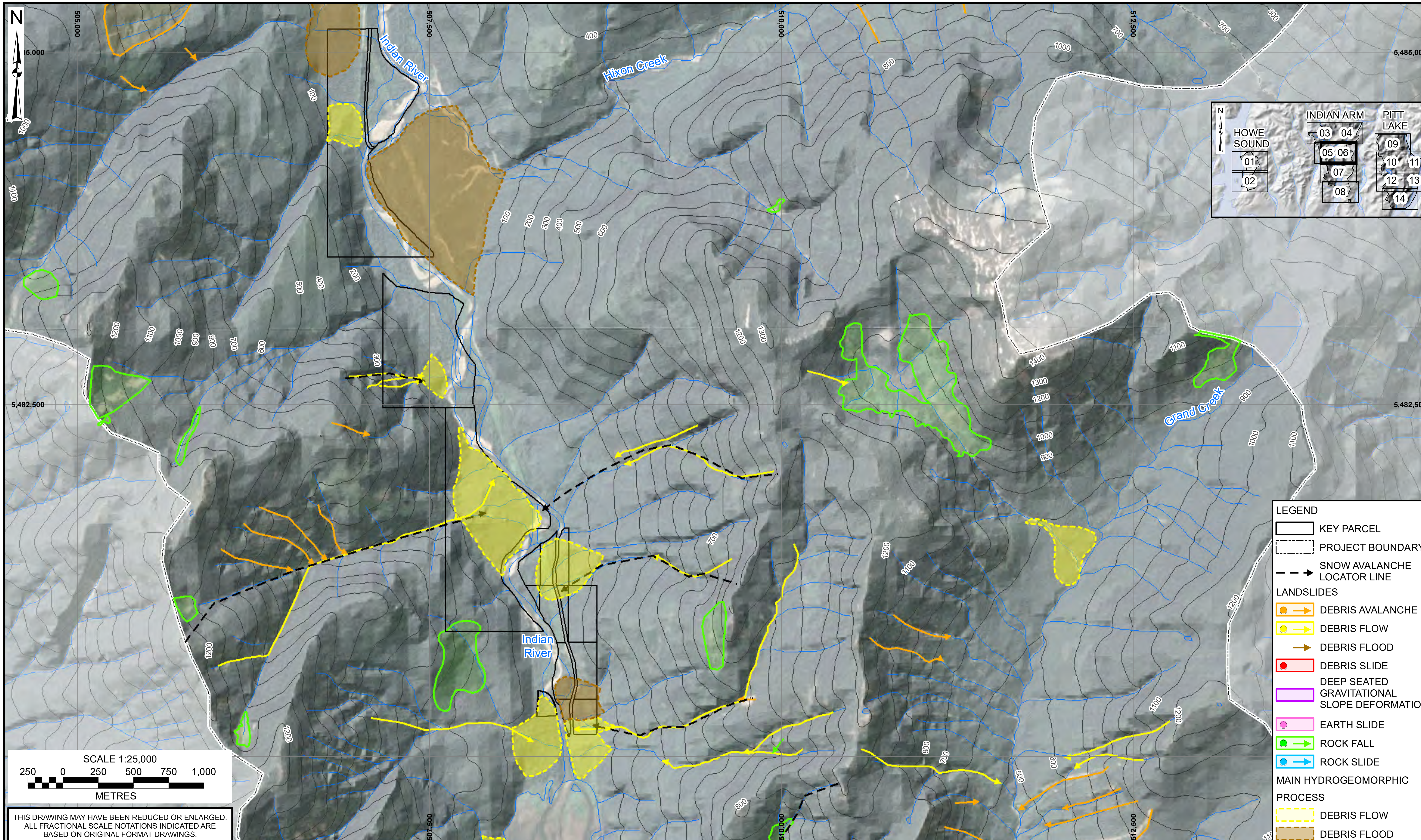

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PROJECT: ELECTORAL AREA A - GEOHAZARD MAPPING

TITLE: LANDSLIDE MAPPING INDIAN ARM

PROJECT No.: 0431031

DWG No: L 06

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PROJECT: ELECTORAL AREA A - GEOHAZARD MAPPING

TITLE: LANDSLIDE MAPPING INDIAN ARM

PROJECT No.: 0431031

DWG No: L 07

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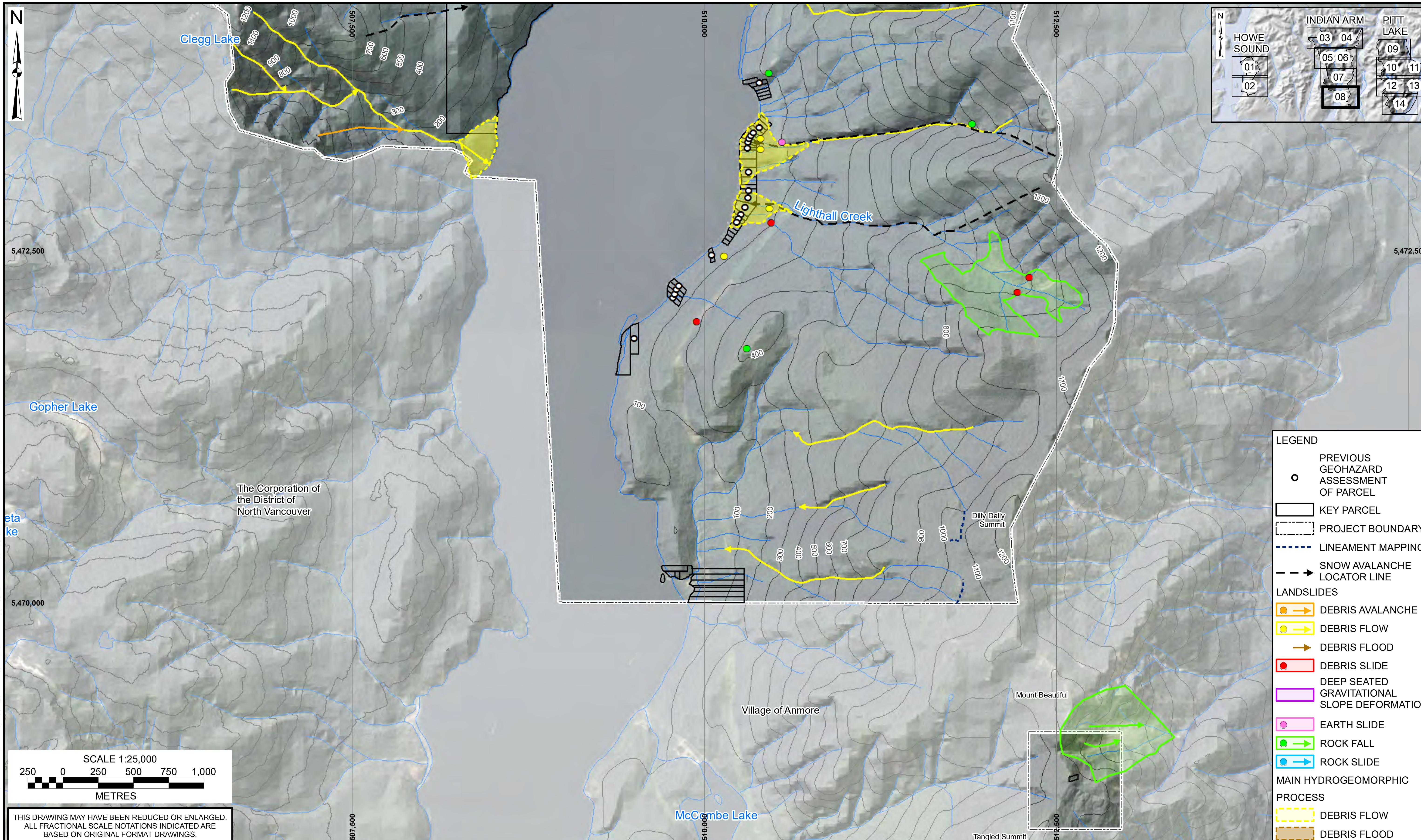

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BGC

PROJECT: ELECTORAL AREA A - GEOHAZARD MAPPING

TITLE: LANDSLIDE MAPPING INDIAN ARM

PROJECT No.:	DWG No:
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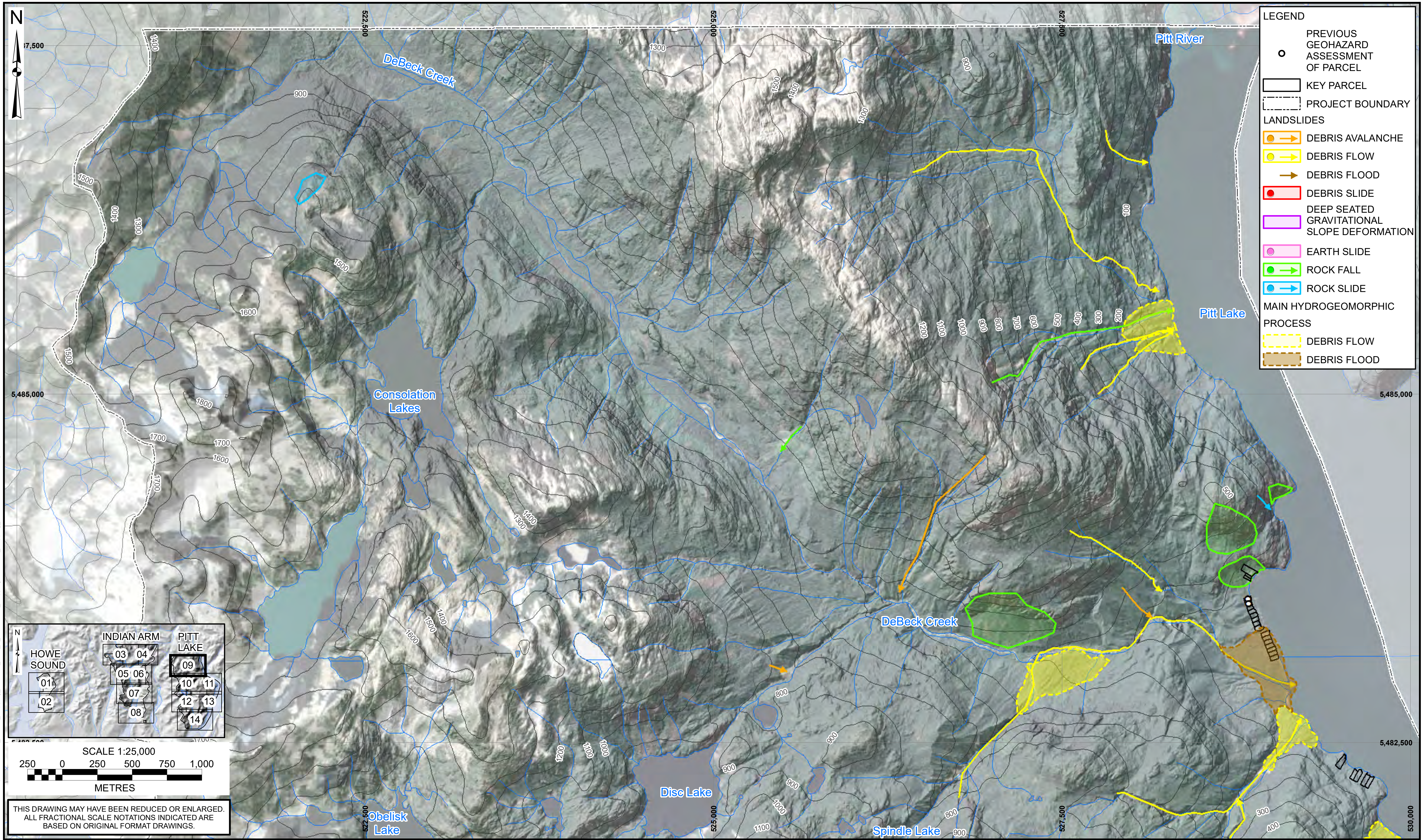

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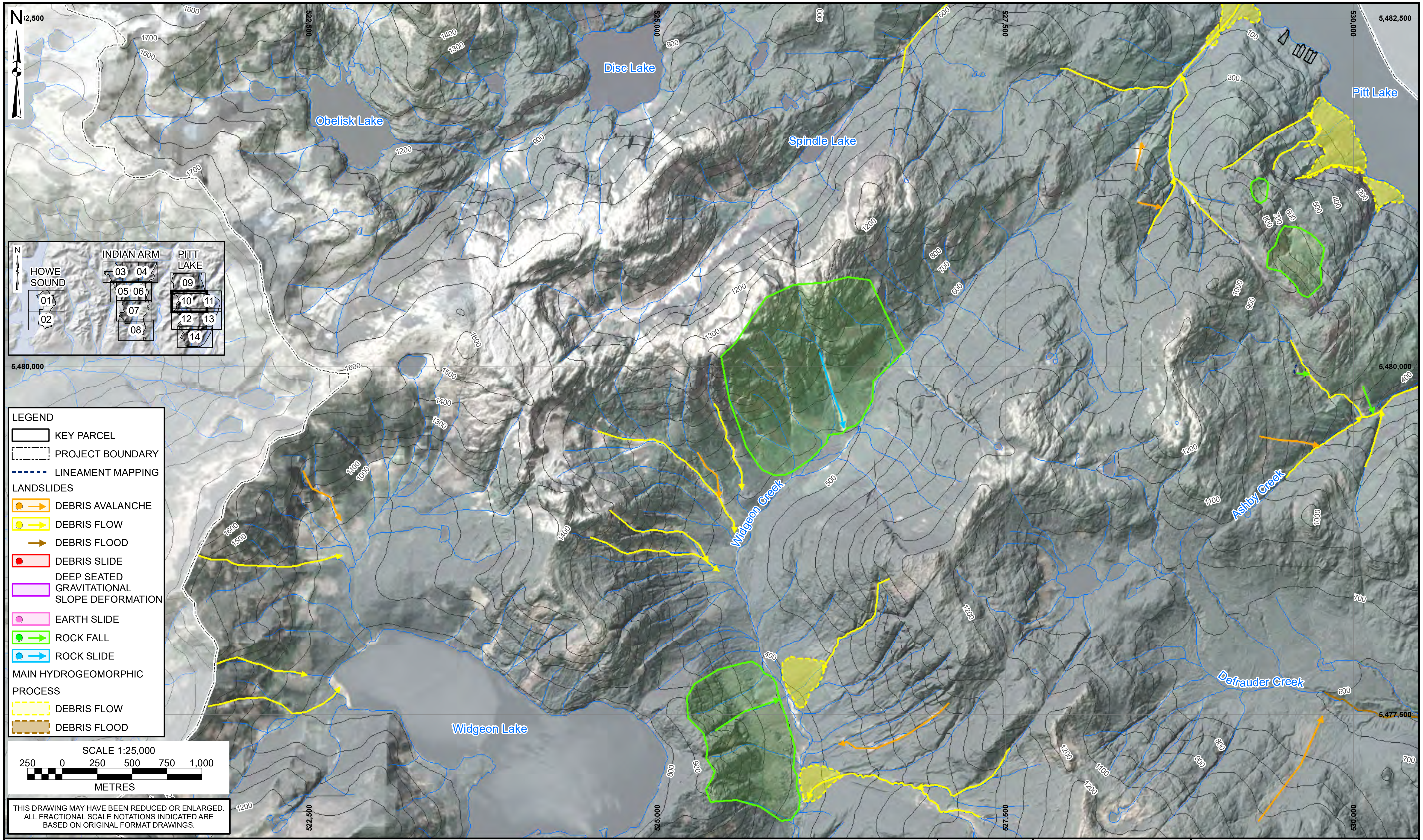
CLIENT: metro vancouver / BGC

PROJECT: ELECTORAL AREA A - GEOHAZARD MAPPING

TITLE: LANDSLIDE MAPPING PITT LAKE

PROJECT No.:	DWG No:
0431031	L 09



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CLIENT: metro vancouver

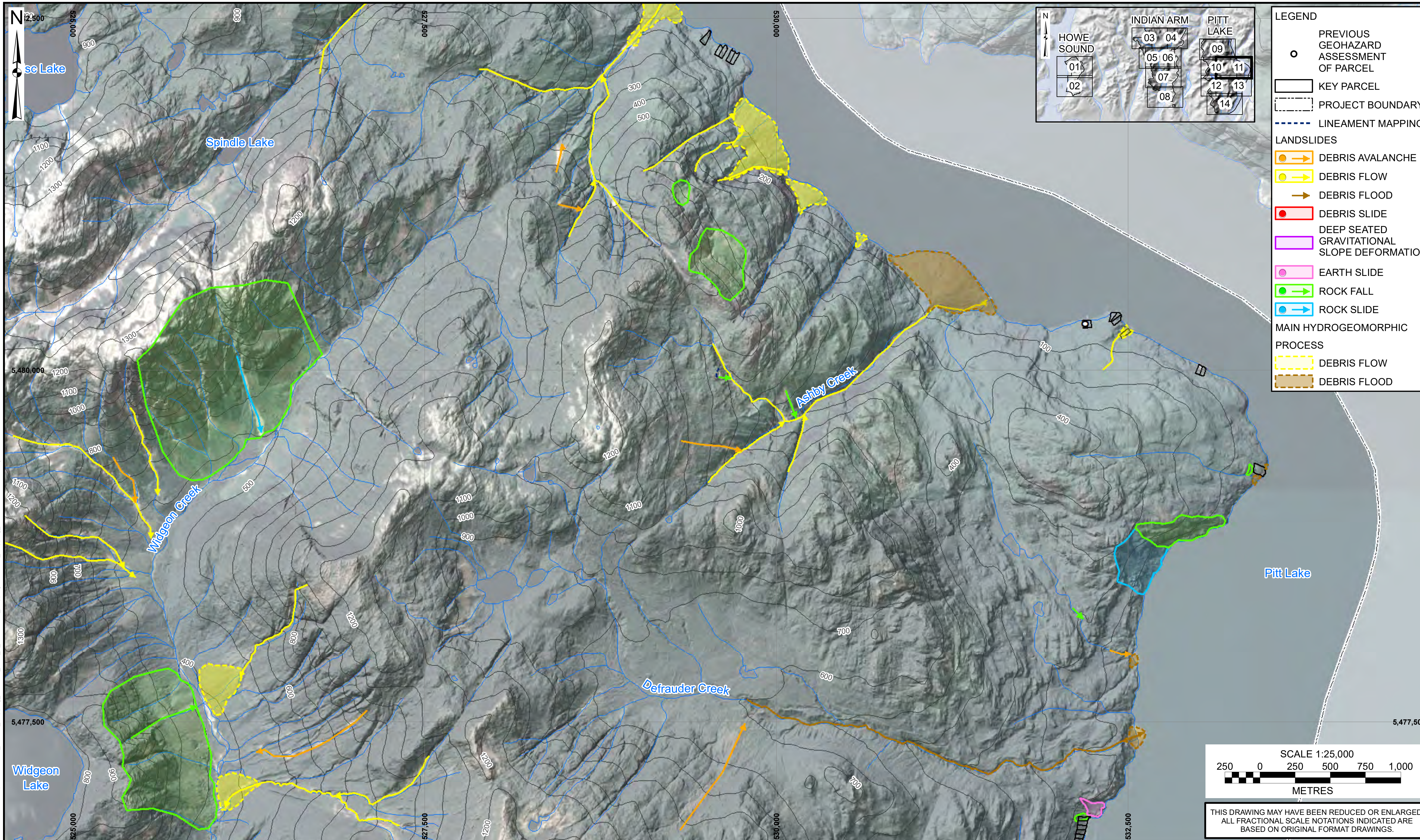
BGC

PROJECT: ELECTORAL AREA A - GEOHAZARD MAPPING

TITLE: LANDSLIDE MAPPING PITT LAKE

PROJECT No.: 0431031

DWG No: L 10



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DATE:	MAR 2022
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REVIEW:	KH
APPROVED:	MAB

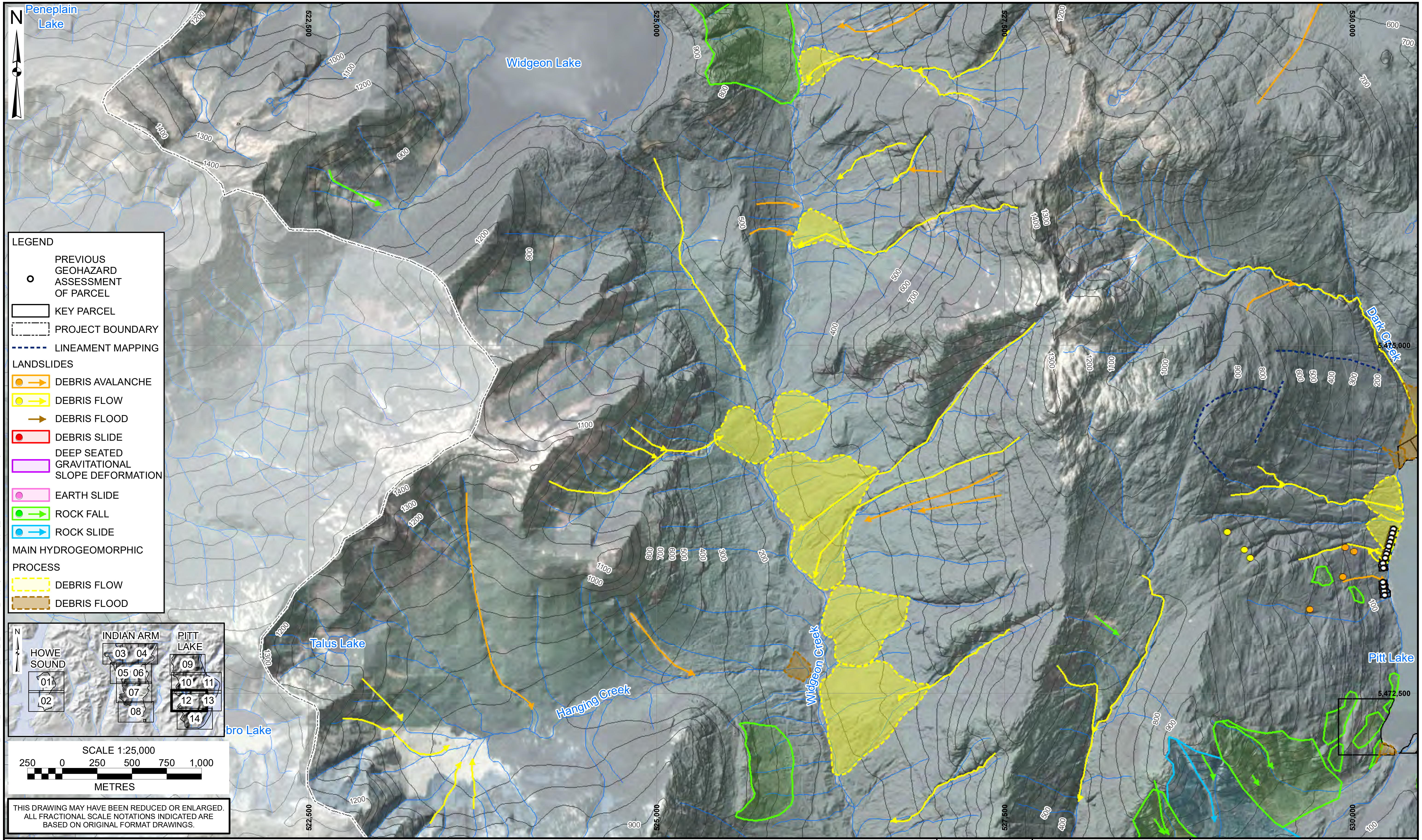
CLIENT: metro vancouver

BGC

PROJECT: ELECTORAL AREA A - GEOHAZARD MAPPING

TITLE: LANDSLIDE MAPPING PITT LAKE

PROJECT No.:	DWG No:
0431031	L 11



THIS DRAWING MAY HAVE BEEN REDUCED OR ENLARGED. ALL FRACTIONAL SCALE NOTATIONS INDICATED ARE BASED ON ORIGINAL FORMAT DRAWINGS.

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APPROVED:	MAB

CLIENT: metro vancouver

BGC

PROJECT: ELECTORAL AREA A - GEOHAZARD MAPPING

TITLE: LANDSLIDE MAPPING PITT LAKE

PROJECT No.:	DWG No:
0431031	L 12

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NOTES:
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CLIENT: metro vancouver

BGC

PROJECT: ELECTORAL AREA A - GEOHAZARD MAPPING

TITLE: LANDSLIDE MAPPING PITT LAKE

PROJECT No.: 0431031

DWG No: L 13

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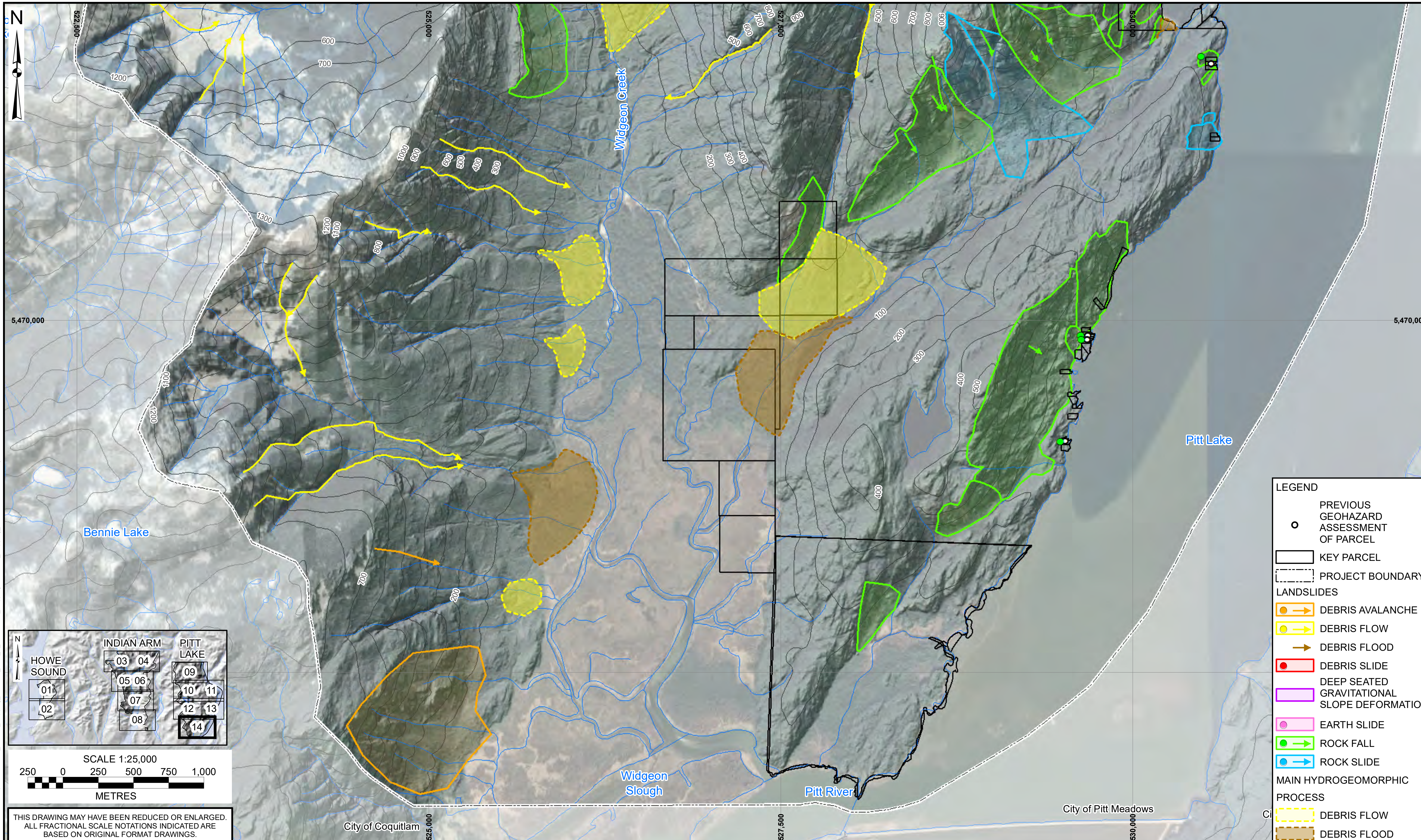

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REVIEW:	KH
APPROVED:	MAB

CLIENT: metro vancouver

BGC

PROJECT: ELECTORAL AREA A - GEOHAZARD MAPPING

TITLE: LANDSLIDE MAPPING PITT LAKE

PROJECT No.: 0431031

DWG No: L 14

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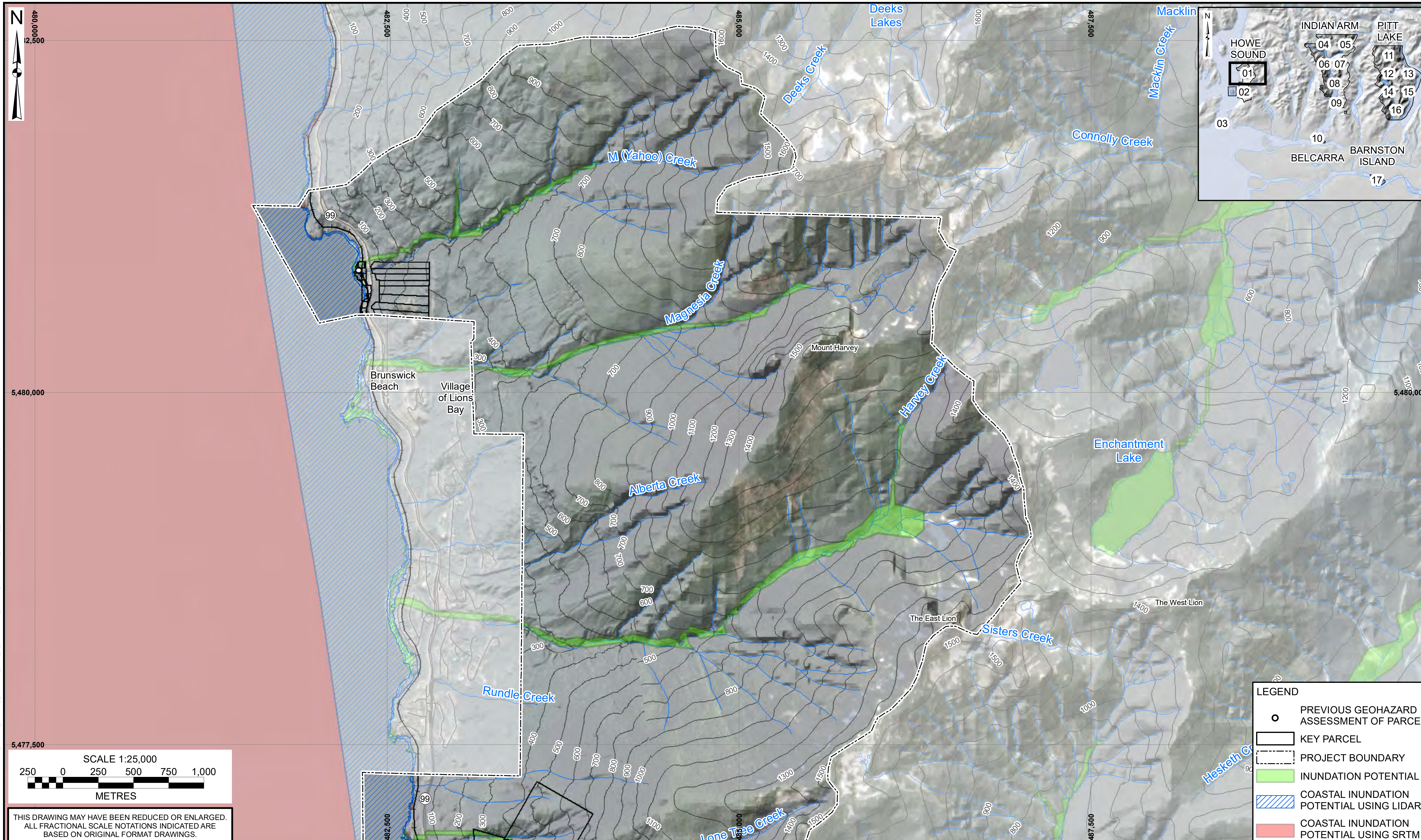

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CLIENT: metro vancouver

BGC

PROJECT: ELECTORAL AREA A - GEOHAZARD MAPPING

TITLE: INUNDATION MAPPING HOWE SOUND

PROJECT No.: 0431031

DWG No: I 01

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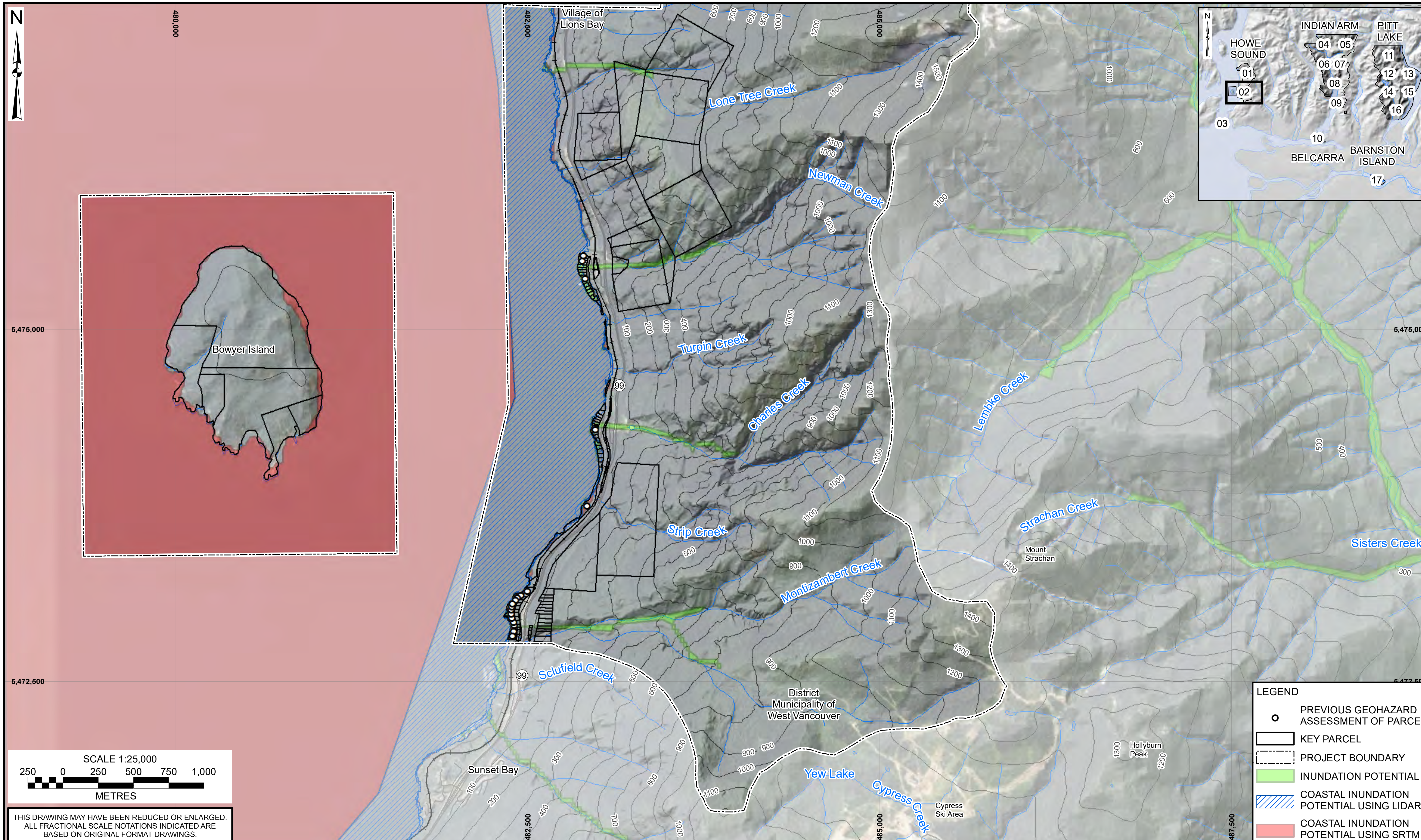

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CLIENT: metro vancouver

BGC

PROJECT: ELECTORAL AREA A - GEOHAZARD MAPPING

TITLE: INUNDATION MAPPING HOWE SOUND

PROJECT No.: 0431031

DWG No: I 02

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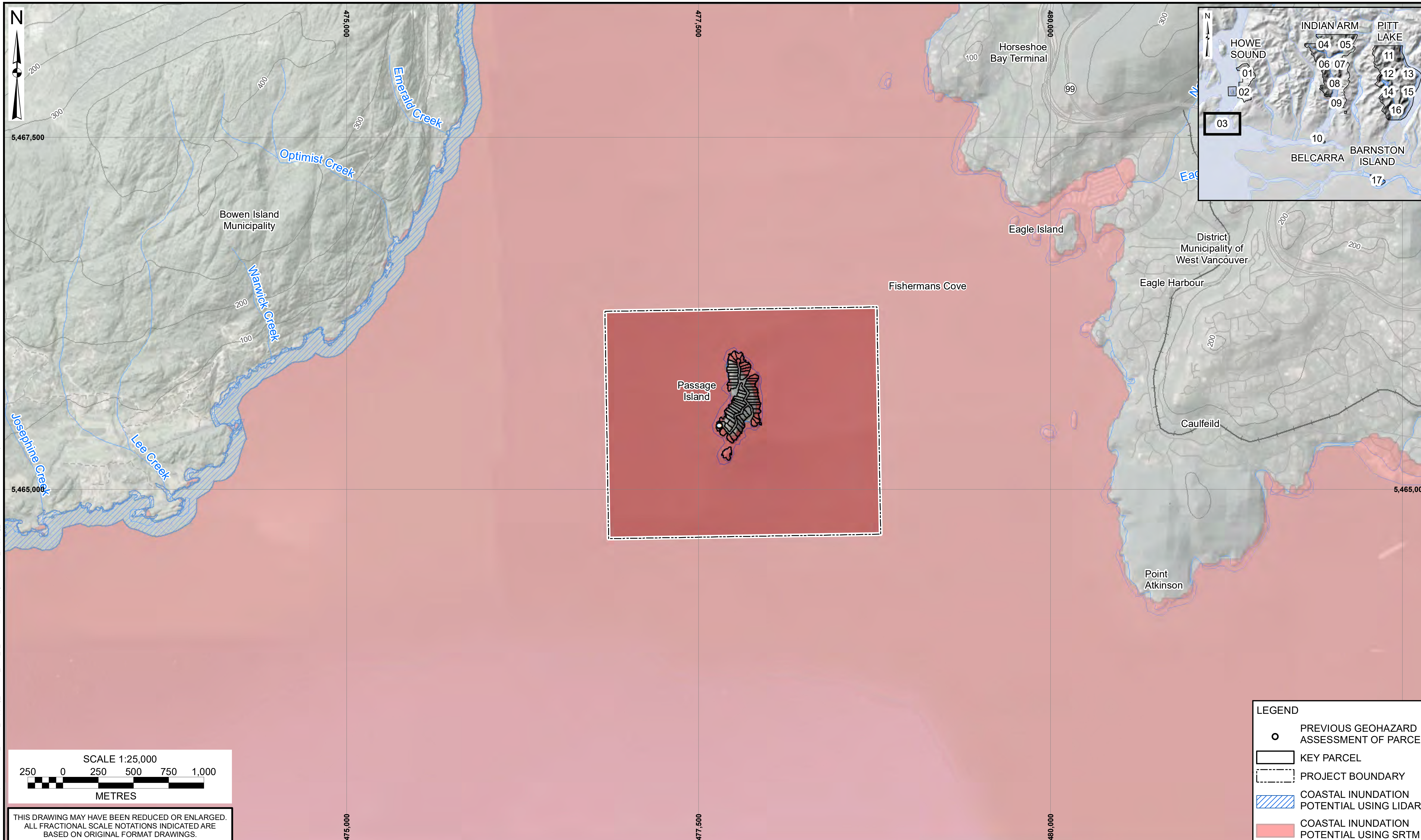

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CLIENT: metro vancouver

BGC

PROJECT: ELECTORAL AREA A - GEOHAZARD MAPPING

TITLE: INUNDATION MAPPING HOWE SOUND

PROJECT No.: 0431031

DWG No: I 03

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APPROVED:	MAB

CLIENT: metro vancouver

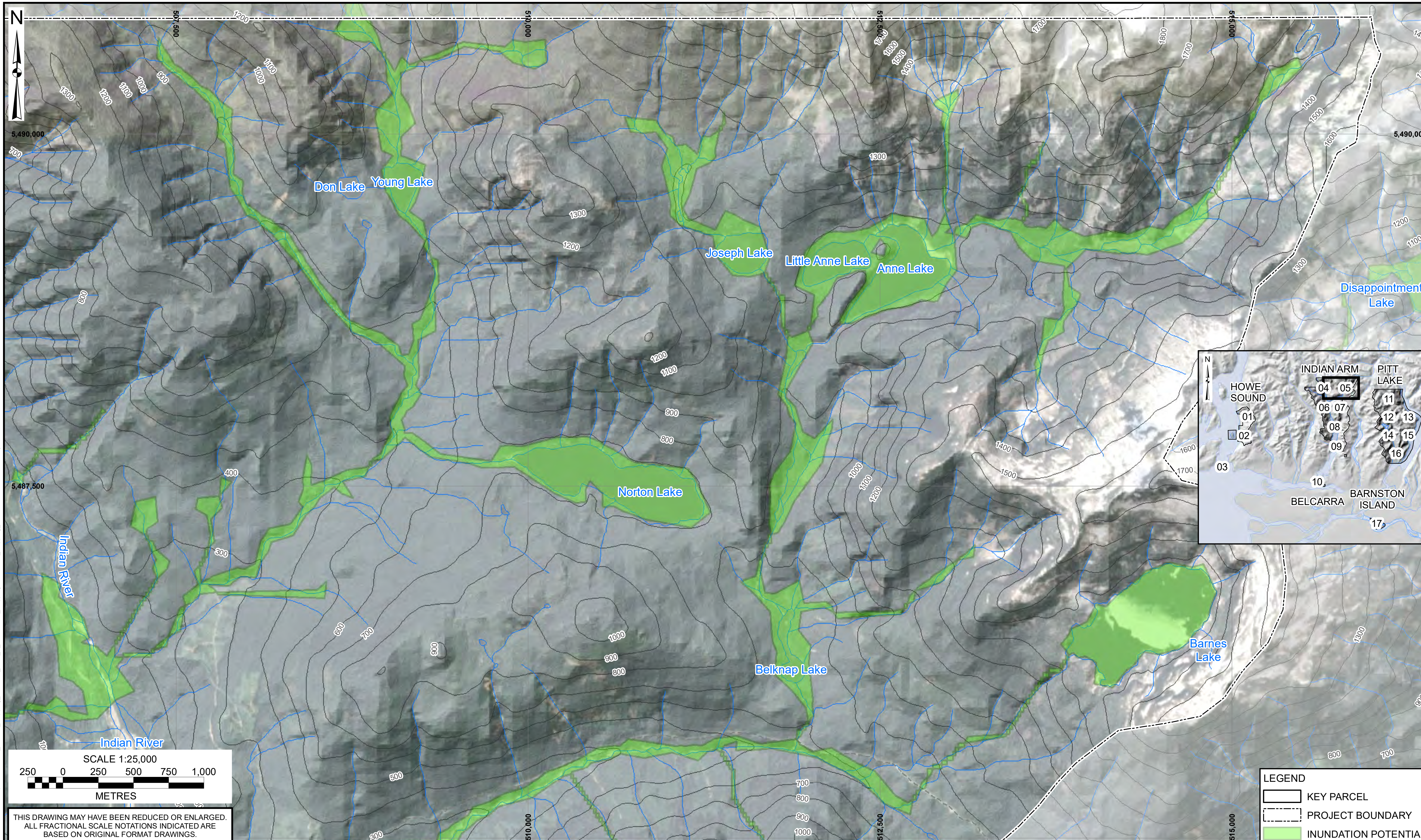
BGC

PROJECT: ELECTORAL AREA A - GEOHAZARD MAPPING

TITLE: INUNDATION MAPPING INDIAN ARM

PROJECT No.: 0431031

DWG No: I 04



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BGC

PROJECT: ELECTORAL AREA A - GEOHAZARD MAPPING

TITLE: INUNDATION MAPPING INDIAN ARM

PROJECT No.: 0431031

DWG No: I 05

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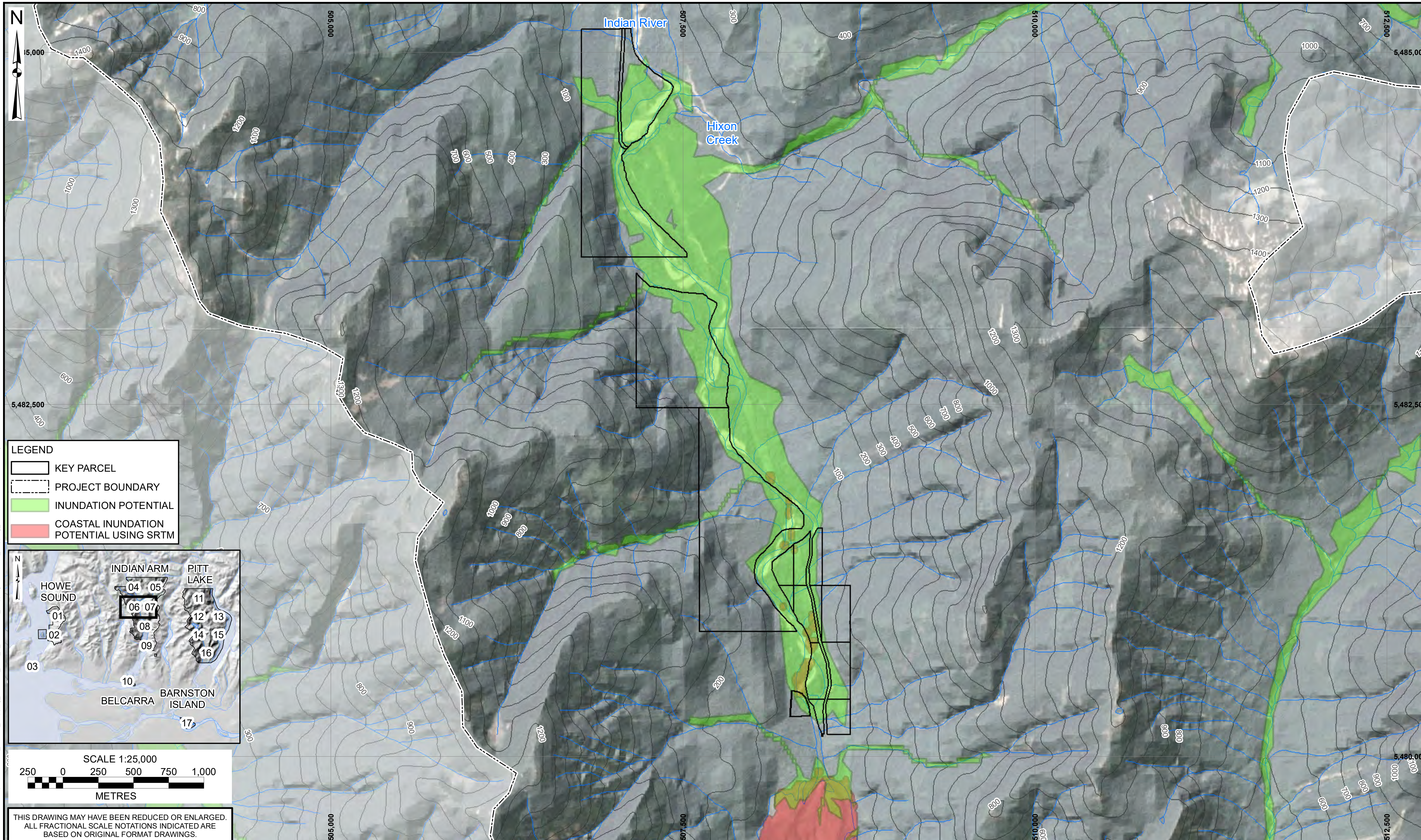

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BGC

PROJECT: ELECTORAL AREA A - GEOHAZARD MAPPING

TITLE: INUNDATION MAPPING INDIAN ARM

PROJECT No.:	DWG No:
0431031	I 06

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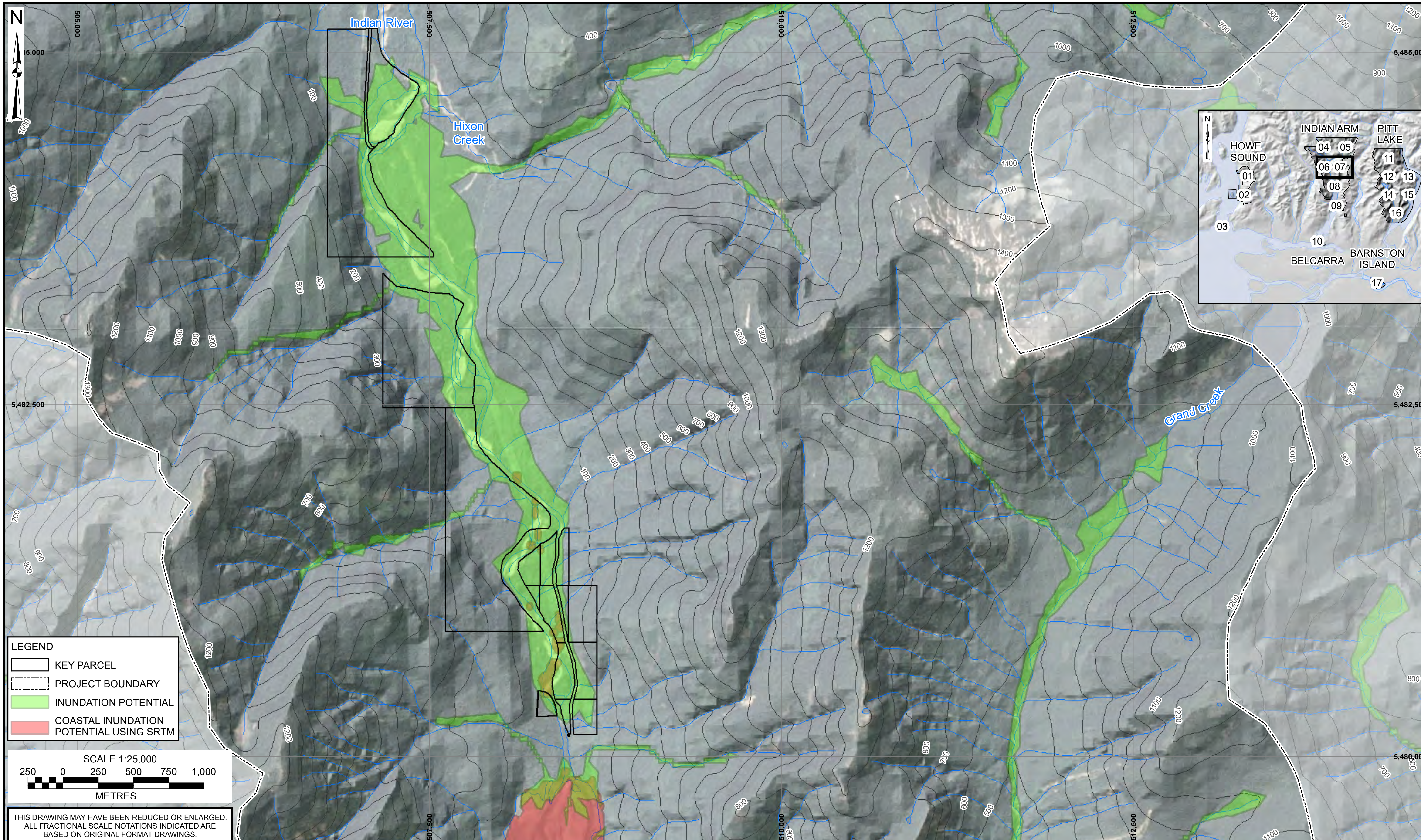

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CLIENT: metro vancouver

BGC

PROJECT: ELECTORAL AREA A - GEOHAZARD MAPPING

TITLE: INUNDATION MAPPING INDIAN ARM

PROJECT No.: 0431031

DWG No: I 07

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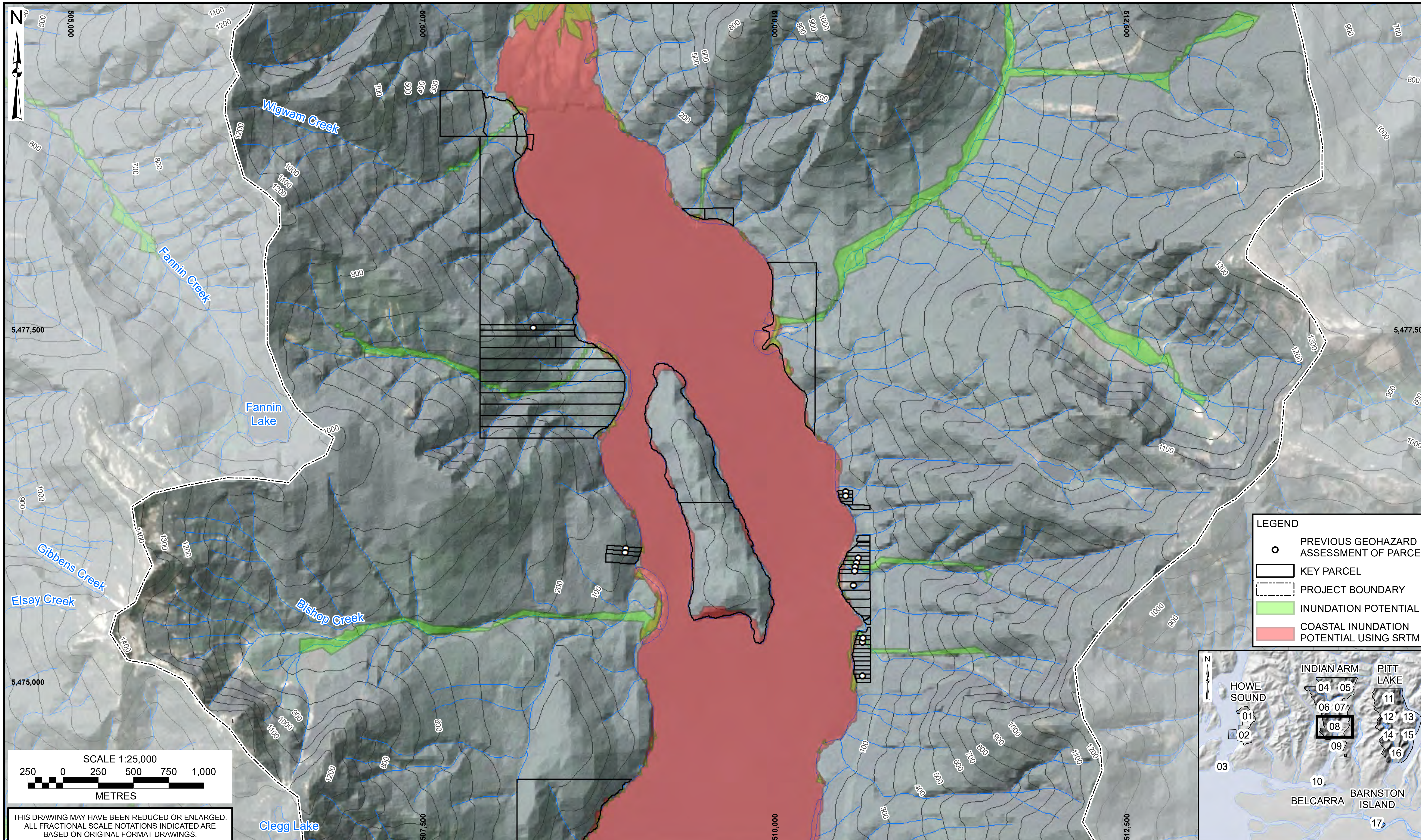

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CLIENT: metro vancouver

BGC

PROJECT: ELECTORAL AREA A - GEOHAZARD MAPPING

TITLE: INUNDATION MAPPING INDIAN ARM

PROJECT No.: 0431031

DWG No: I 08

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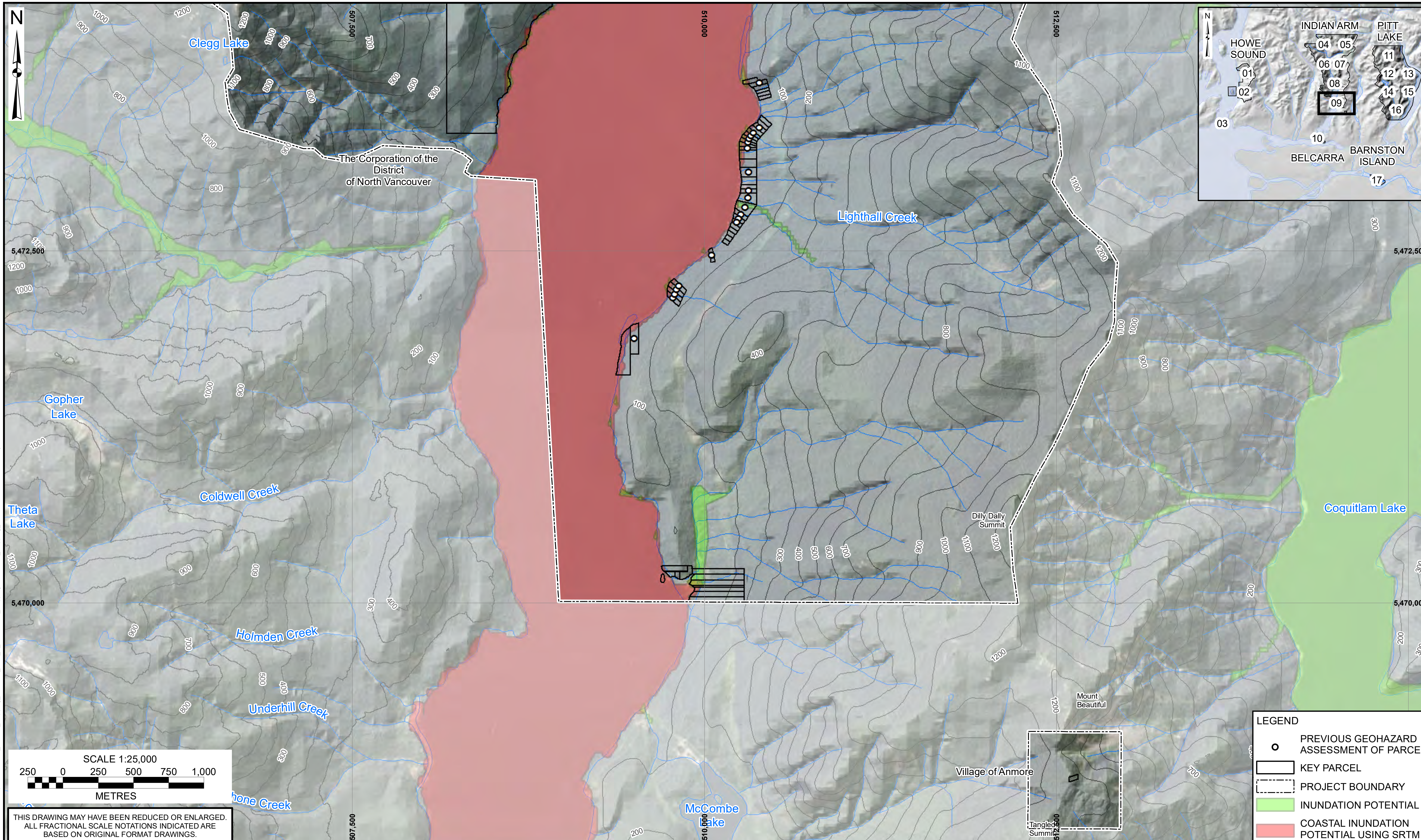

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CLIENT: metro vancouver

BGC

PROJECT: ELECTORAL AREA A - GEOHAZARD MAPPING

TITLE: INUNDATION MAPPING INDIAN ARM

PROJECT No.: 0431031

DWG No: I 09

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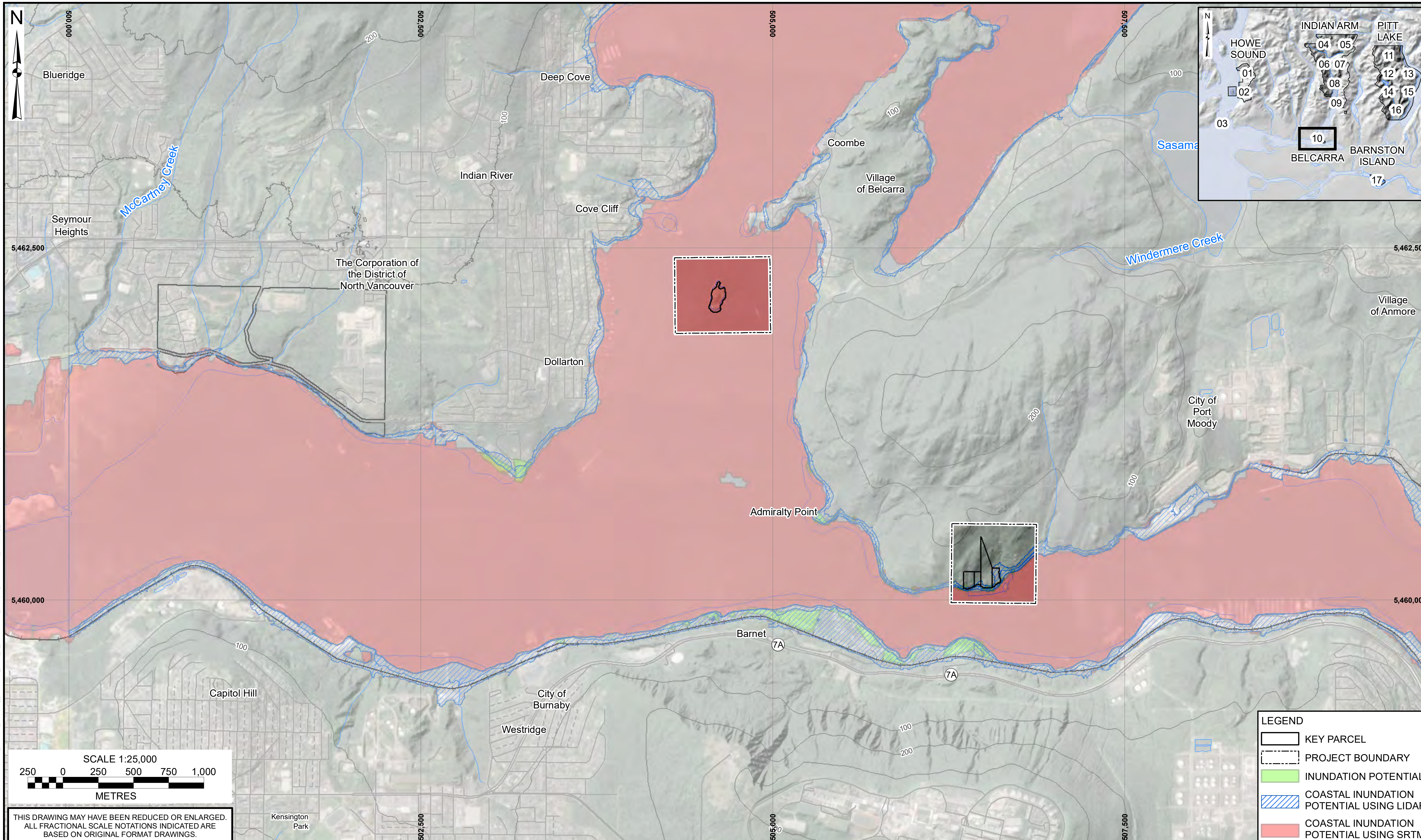

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APPROVED:	MAB

CLIENT: metro vancouver

BGC

PROJECT: ELECTORAL AREA A - GEOHAZARD MAPPING

TITLE: INUNDATION MAPPING BELCARRA

PROJECT No.: 0431031

DWG No: I 10

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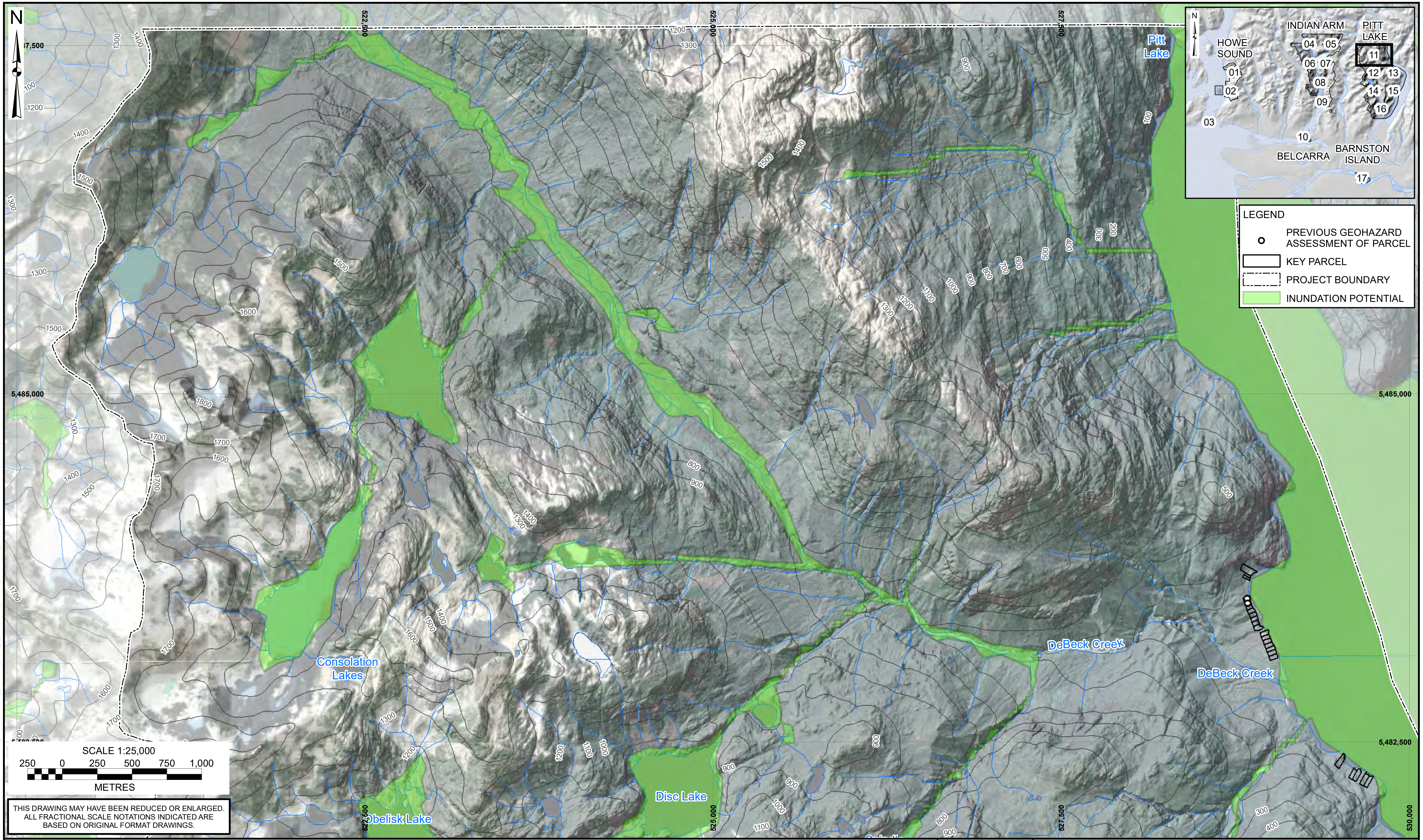

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NOTES:
1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE NOTED.
2. THIS DRAWING MUST BE READ IN CONJUNCTION WITH BGC'S REPORT TITLED "ELECTORAL AREA A - GEOHAZARD MAPPING", AND DATED MARCH 2022.
3. BASE TOPOGRAPHIC DATA BASED ON COMPILATION OF DIGITAL ELEVATION MODELS FROM BC GOVERNMENT AND NATURAL RESOURCES CANADA. SEE APPENDIX A FOR DETAILS. CONTOUR INTERVAL IS 100 m.
4. ALLUVIAL FANS ARE NOT MAPPED, COLLUVIAL FANS ARE SHOWN ON DRAWINGS L01 TO L14.
5. COORDINATE SYSTEM IS NAD 1983 UTM ZONE 10N. VERTICAL DATUM IS UNKNOWN.
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REVIEW:	KH
APPROVED:	MAB

CLIENT: metro vancouver

BGC

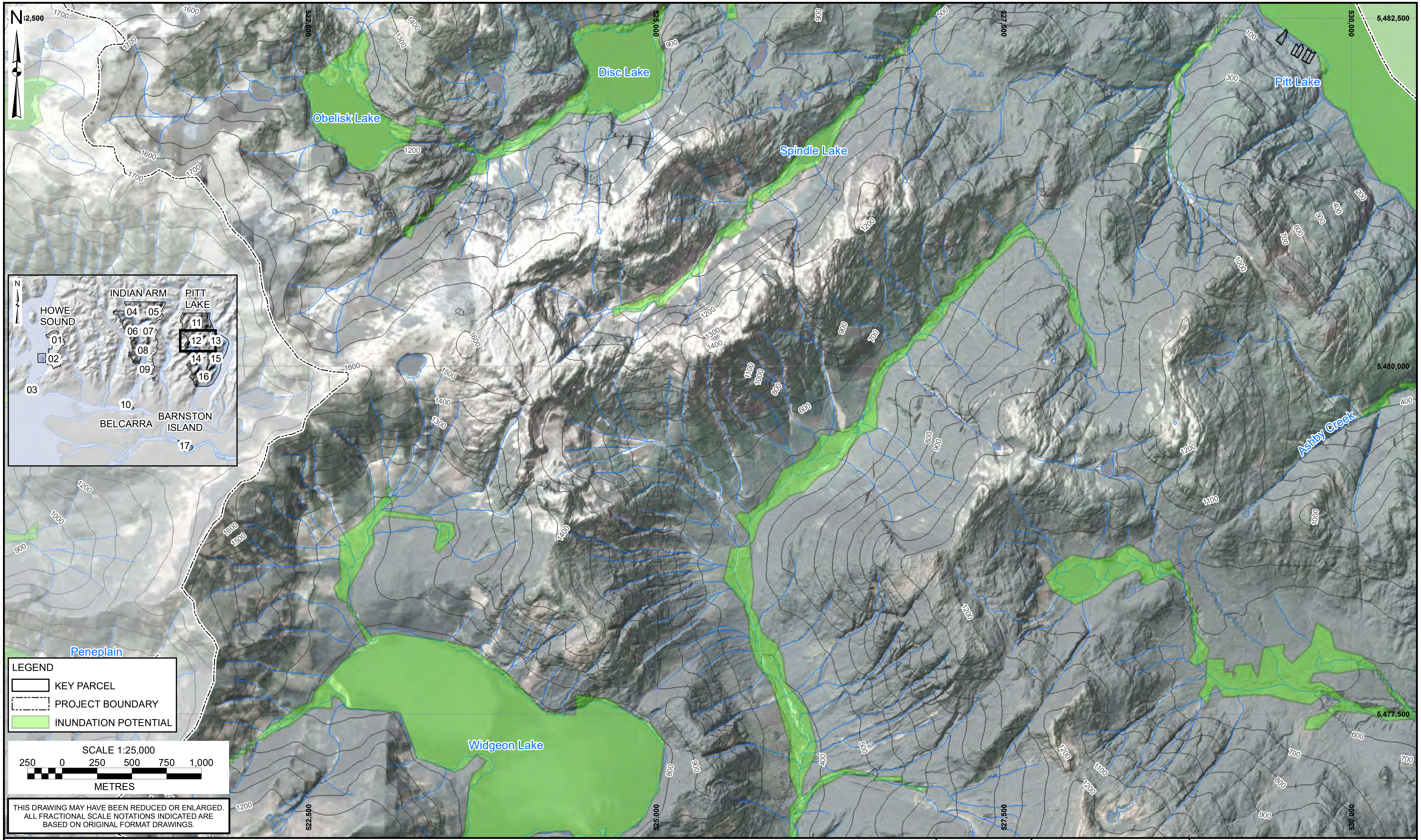
PROJECT: ELECTORAL AREA A - GEOHAZARD MAPPING

TITLE: INUNDATION MAPPING PITT LAKE

PROJECT No.: 0431031

DWG No: I 11

X:\Projects\0431 MetroVancouver\031\Production\Report\20211117_Hazard_mapping_Electoral_Area_A_Geohazard_Mapping\Inundation_Mapping_DDP.mxd Date: Wednesday, March 30, 2022 Time: 10:02 AM



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APPROVED:	MAB

CLIENT: metro vancouver

BGC

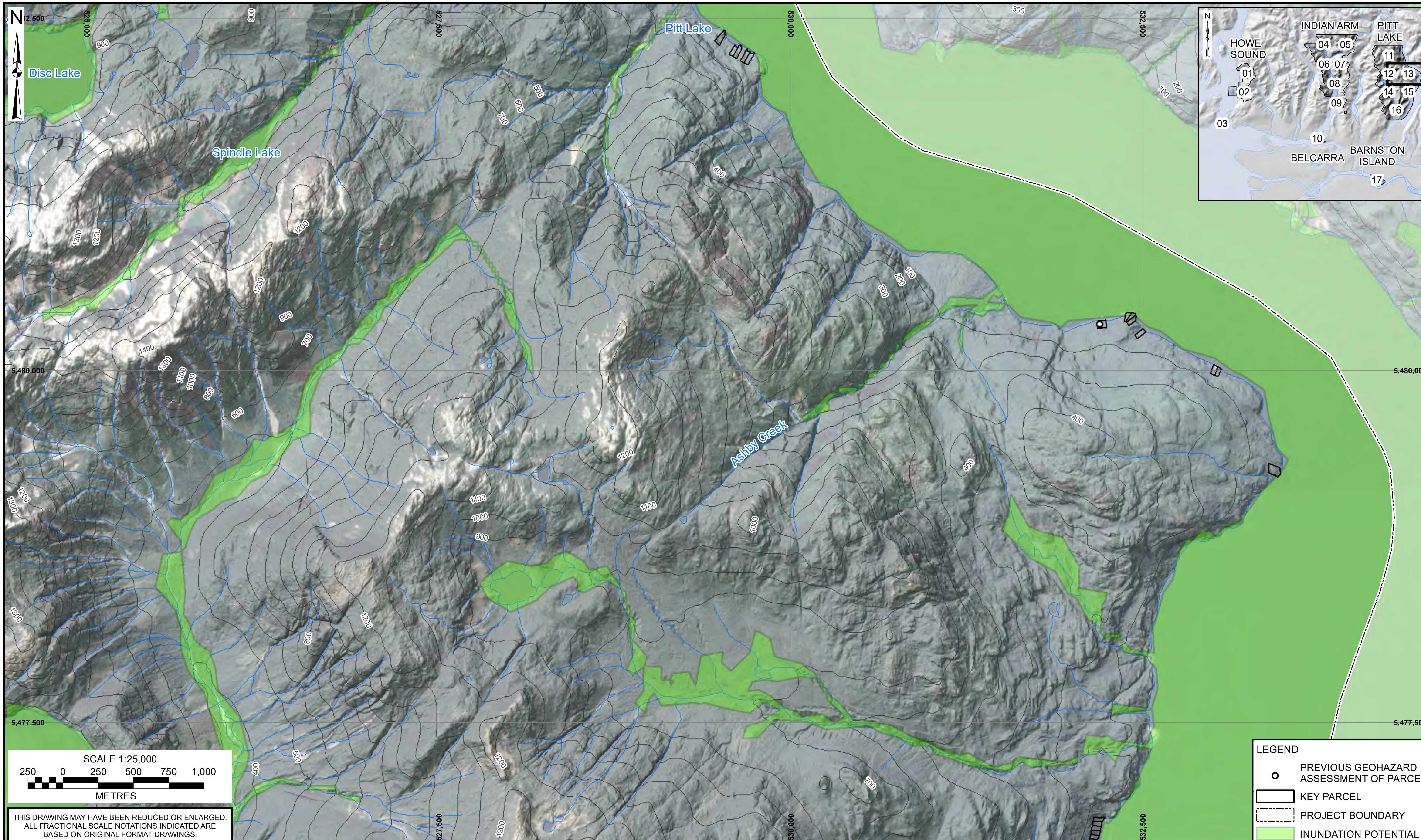
PROJECT: ELECTORAL AREA A - GEOHAZARD MAPPING

TITLE: INUNDATION MAPPING PITT LAKE

PROJECT No.: 0431031

DWG No: I 12

X:\Projects\0431 MetroVancouver\031\Production\Report\20211117_Hazard_mapping_Electoral_Area_A_Geohazard_Mapping\Inundation_Mapping_DDP.mxd Date: Wednesday, March 30, 2022 Time: 10:03 AM



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PROJECT: ELECTORAL AREA A - GEOHAZARD MAPPING

TITLE: INUNDATION MAPPING PITT LAKE

PROJECT No.: 0431031

DWG No: I 13

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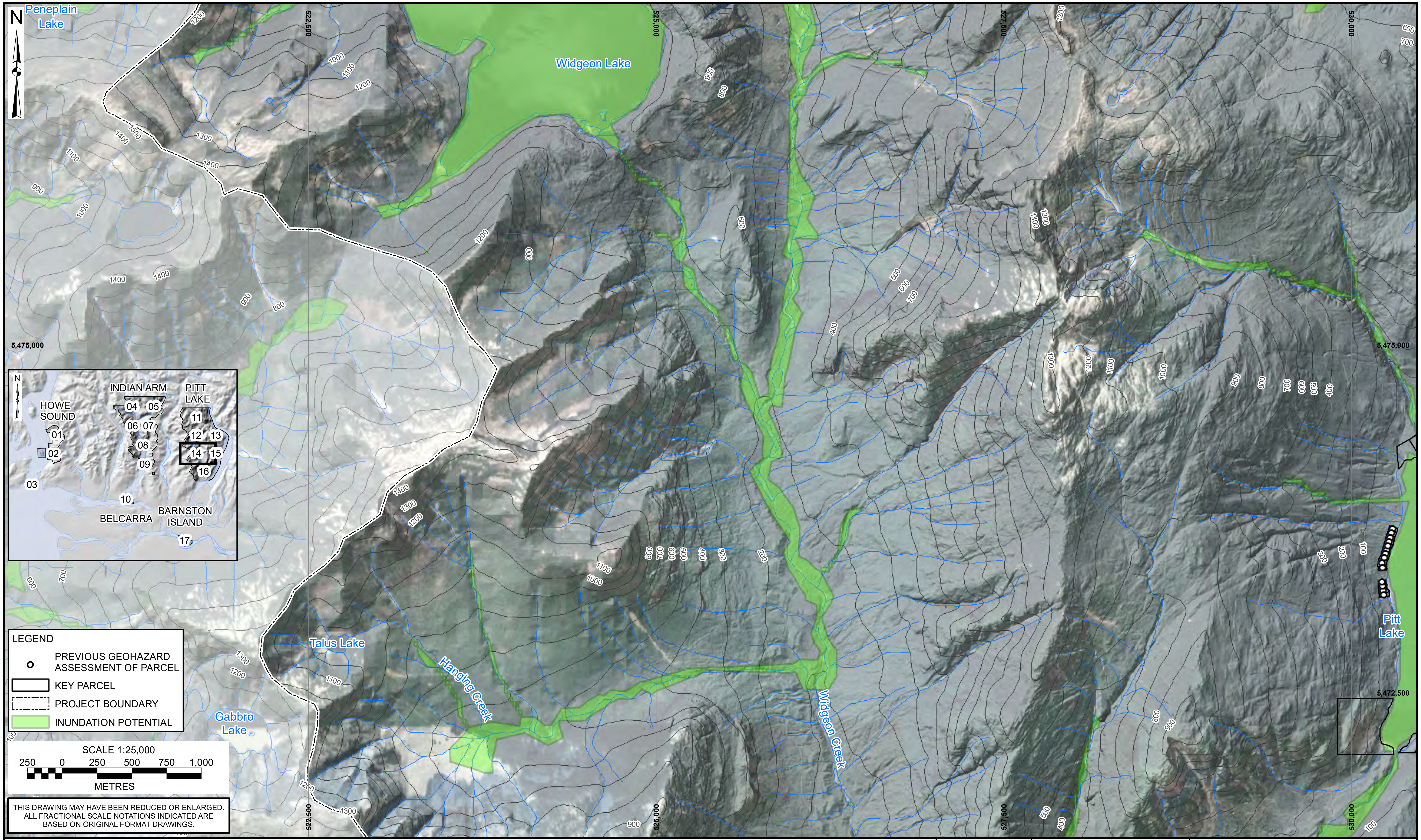

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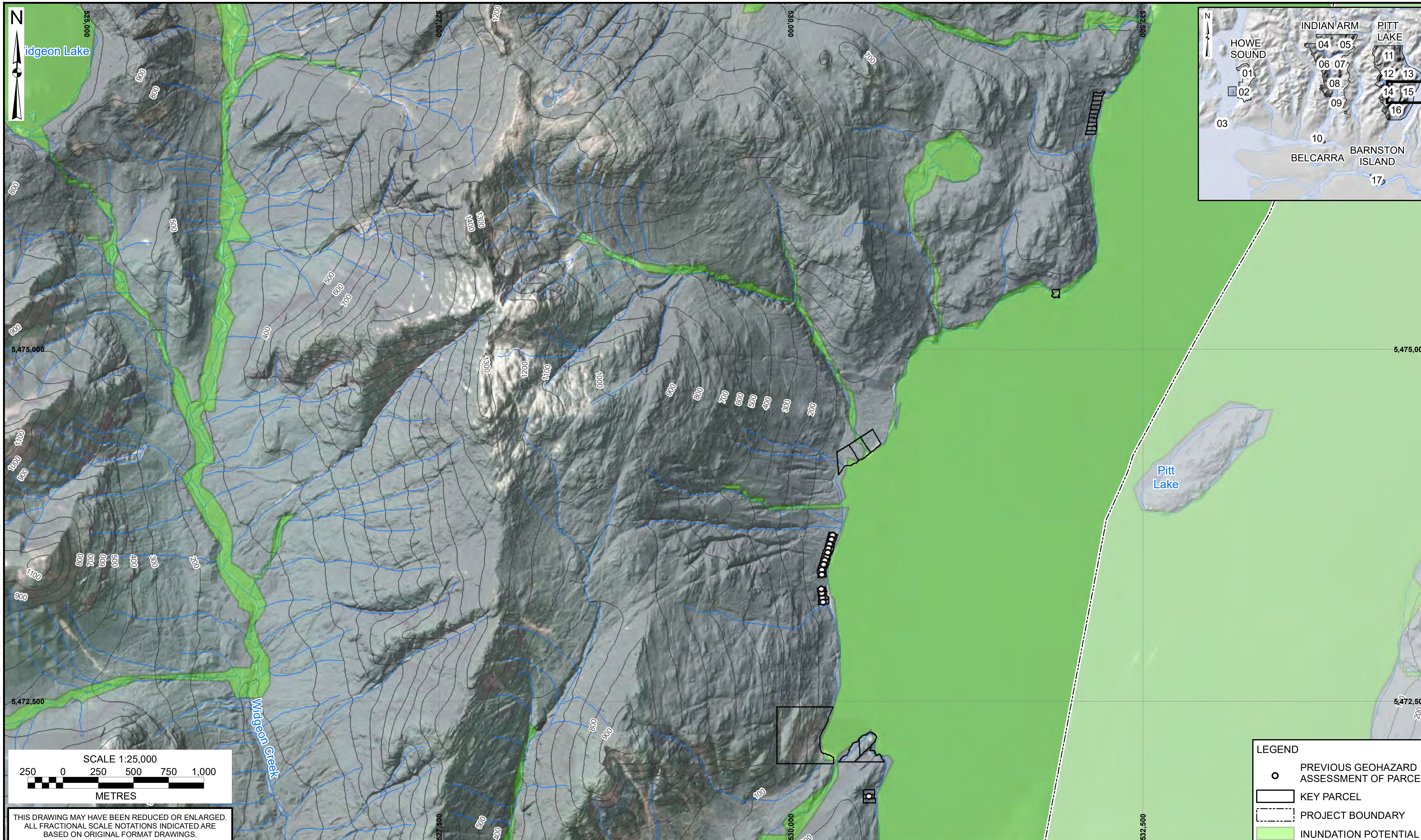
PROJECT: ELECTORAL AREA A - GEOHAZARD MAPPING

TITLE: INUNDATION MAPPING PITT LAKE

PROJECT No.: 0431031

DWG No: I 14



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PROJECT: ELECTORAL AREA A - GEOHAZARD MAPPING

TITLE: INUNDATION MAPPING PITT LAKE

PROJECT No.: 0431031

DWG No: I 15

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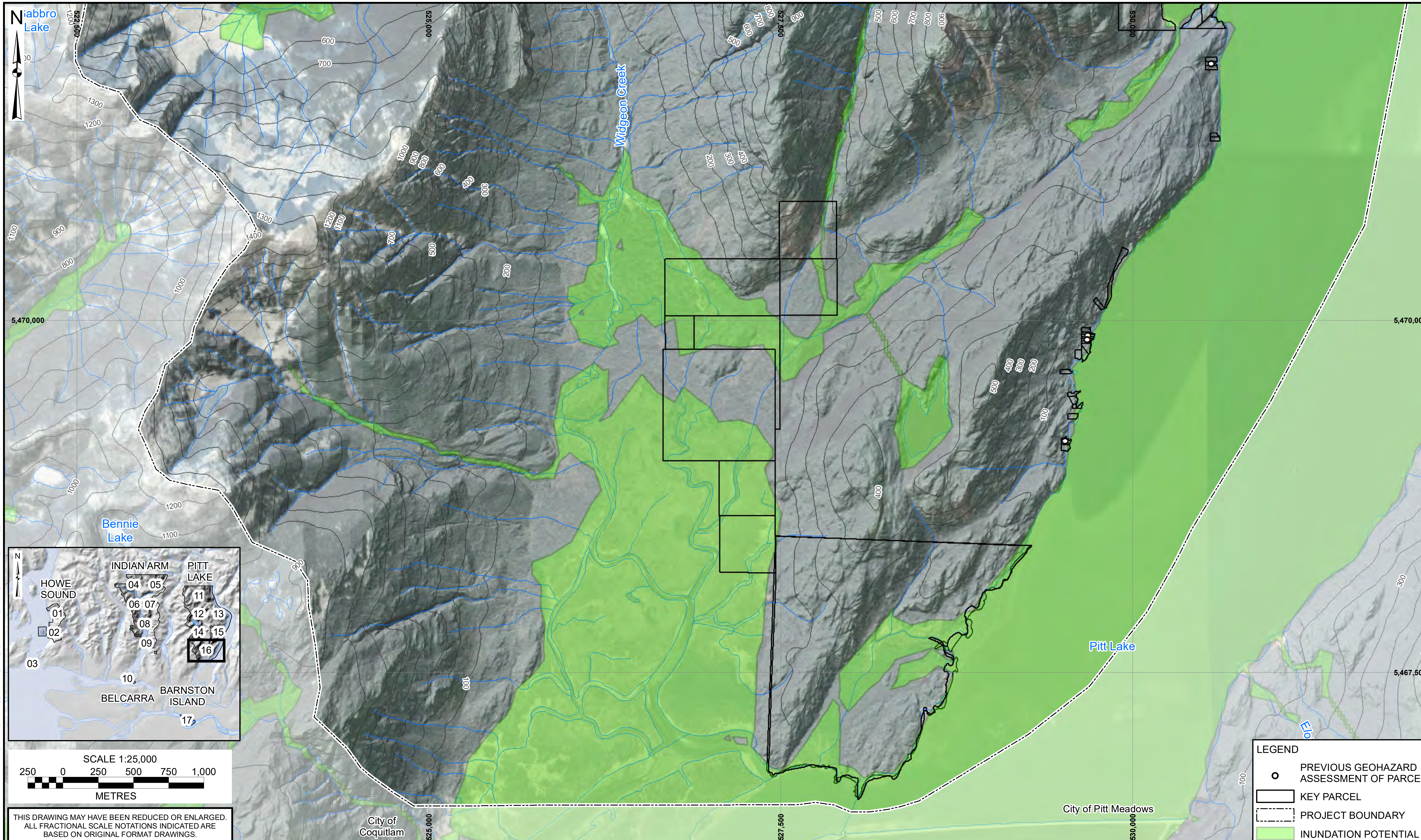

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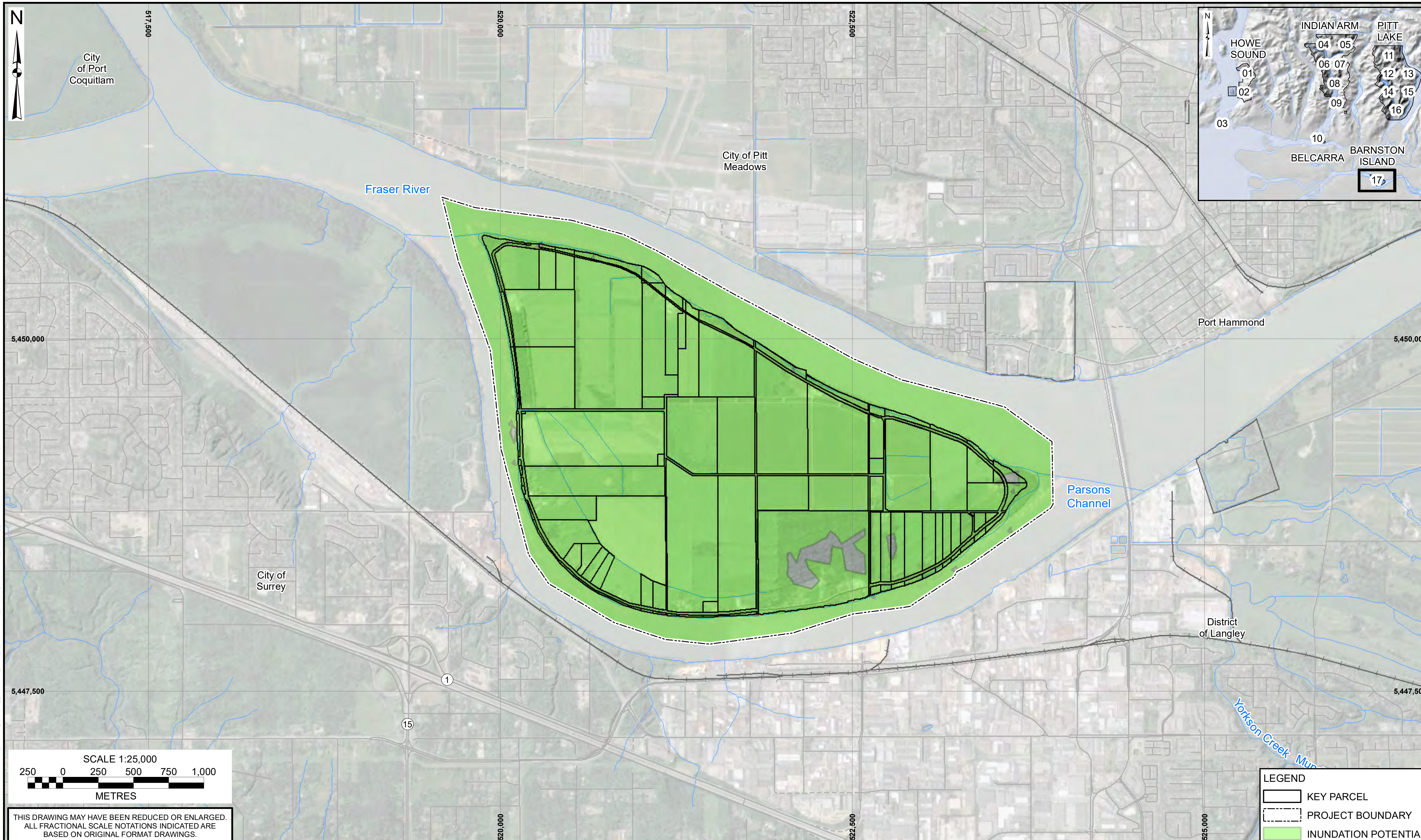
PROJECT: ELECTORAL AREA A - GEOHAZARD MAPPING

TITLE: INUNDATION MAPPING PITT LAKE

PROJECT No.: 0431031

DWG No: I 16



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PROJECT: ELECTORAL AREA A - GEOHAZARD MAPPING

TITLE: INUNDATION MAPPING BARNSTON ISLAND

PROJECT No.: 0431031

DWG No: I 17