MEMORANDUM

DATE: December 12, 2001

TO: Jim Thomson, HNTB

FROM: Michael Kenrick & Reese Hastings, Hart Crowser Inc.

RE: **Hydrologic Conditions and Wetland Hydrology**
Borrow Area 1
4978-62

INTRODUCTION

This memorandum provides an analysis of pre-construction and post-construction surface water and groundwater conditions at Borrow Area 1, which is one of the three proposed on-site borrow areas that are part of the Port of Seattle's Master Plan Update for Sea-Tac International Airport (STIA). The analysis includes evaluations of changes to local surface water and groundwater conditions, and measures planned by the Port to avoid potential hydrologic impacts to Des Moines Creek and wetland resources.

The Final Environmental Impact Statement (FEIS) prepared for STIA's Proposed Master Plan Update development actions (FAA 1996) discussed development of construction fill material borrow areas from eight identified sources within property controlled by the Port. Further study by the Port has focused on the Borrow Areas designated 1, 3, and 4, which are proposed to provide a combined total of 6.7 million cubic yards of fill material for embankment construction. Drawing 1 - Site and Exploration Plan shows the layout of Borrow Area 1. Development of materials from Borrow Areas 3 and 4 and the mitigation of potential hydrologic impacts to wetlands has been addressed in separate memoranda, including Sea-Tac Third Runway Borrow Area 3 Preservation of Wetlands (Hart Crowser 2000) and the conceptual development and reclamation plan (Hart Crowser 2001).

SUMMARY

Development of Borrow Area 1 has been planned to avoid disturbing wetlands to the maximum practical extent, and to avoid negative impacts to site hydrology associated with

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runoff and infiltration. The analysis of hydrologic impacts to wetlands discussed herein is consistent with results of the previous hydrologic study commissioned by the Washington State Department of Ecology (PGG 2000).

The proposed excavation plan for Borrow Area 1 preserves the upgradient surface drainage features that currently provide water to off-site wetlands, and promotes additional surface drainage that will continue to sustain these wetlands. Wetlands internal to the site (1.08 acres) will be unavoidably impacted by the borrow excavation. However, the excavation will remove mostly glacial till soils, which currently promote runoff and interflow that follow a relatively direct path to Des Moines Creek.

The completed excavation will expose an area of advance outwash soil below the glacial till. Since the outwash soils have greater permeability compared to the glacial till, precipitation and runoff from the post-mining topography will infiltrate into the exposed outwash and increase recharge to the underlying water table. This process will increase overall flow path duration, groundwater storage, and result in increased base flow to Des Moines Creek.

EXISTING CONDITIONS

Borrow Area 1 is located less than a mile south of the STIA's 34R runway. It consists of approximately 116 acres situated northwest of South 216th Street and 24th Avenue South. The area is bounded by these streets to the south and east, respectively, and on the north and west sides by the Des Moines Creek Park and the proposed Washington State Department of Transportation (WSDOT) SR-509 extension right of way. Borrow Area 1 straddles the boundary between the City of Des Moines and City of SeaTac.

Site Geology

Investigations of site geology at Borrow Area 1 have consisted of a review of prior field work in the area and six exploratory borings drilled by Hart Crowser in 1999, as shown on Drawing 1. The surficial geology in Borrow Area 1 previously identified as consisting of glacial till, preglacial, and recessional outwash materials (AGI 1995 and 1996) has been modified somewhat by more recent boring information. Hart Crowser's work determined that the glacial till forms a moderately thick continuous layer, with surface expression in the southern, central, and eastern portions of the site, while recessional outwash covers the lower elevations in the northern part of the site.

Drawings 2 and 3 show the principal soil units (recessional outwash, glacial till, and advance outwash), which are relatively continuous across the site. For clarity, several minor soil units that are not continuously present at the site are discussed below, but are not shown on the drawings.

Shallow Soils

Topsoil. Typically, this soil consists of a loose mixture of silt and sand with roots and other organic material. Topsoil is generally 1/2 to 1 foot thick where encountered. Many of the surficial soils at the site appear to be glacial soils at different stages of weathering.

Fill Soils. Fill soils were encountered in both the north and west of the site, typically associated with access roads, paved streets, or other grading activities associated with prior site use. Fill soils are generally loose to medium dense, comprising a variable mixture of silt, clay, sand, and gravel, and appear to be derived from the local glacial soils. The density and granular nature of the fill materials resemble the recessional outwash deposits, and the fill is sometimes difficult to distinguish from the outwash.

Alluvial Deposits. These soils occur in the low-lying areas and generally consist of soft or loose, moist to wet, interlayered silt, sand, and peat. While limited occurrences of these soils have been observed in the field, none were noted in our exploration borings.

Recessional Outwash. This material is generally slightly silty to silty, slightly gravelly to gravelly sand. Recessional outwash overlies the glacial till, and overlies the advance outwash where the glacial till has been eroded. Localized areas in the northern portions of Borrow Area 1 have deposits of recessional outwash measuring 20 feet or more in thickness.

Deeper Soils

Glacial Till. The till forms the predominant glacially overridden unit underlying the surficial materials described above. This material is generally comprised of a dense, slightly gravelly to gravelly, silty to very silty sand with local areas of gravelly clay. The particle size gradation of the till varies both vertically and laterally, as is common in the Puget Lowland.

In general, glacial till differs from the overlying recessional layers by having a higher silt content and much higher density. The top of the glacial till soils is generally within 5 feet of the ground surface except in the northern portions of Borrow Area 1. Some weathering has been noted near the surface of the glacial till in explorations of the borrow area.

Advance Outwash. This material is generally dense to very dense, slightly silty, slightly gravelly to gravelly sand. Most fines were washed away as this material was laid down by melt water from advancing glaciers, so the advance outwash can generally be distinguished from the glacial till by lower silt content. However, some areas of advance outwash may be silty or contain lenses of lacustrine silt and clay. The advance outwash occurs beneath the glacial till in the borrow area.

Surface Topography and Runoff

The site of Borrow Area 1 forms part of an elevated bluff rising above the southeast bank of Des Moines Creek where it crosses the boundary between the City of SeaTac and the City of Des Moines. Surface soils within Borrow Area 1 have been disturbed by prior site use, as noted by Parametrix (2001a). This area was a well-established residential development prior to acquisition by the Port of Seattle in the 1970s. The dominant topography and surface conditions at the site therefore include remnant features of site development prior to the Noise Abatement buyout and subsequent demolition of housing in the area.

Site development and abandonment has left a network of paved streets and old housing plots, which still carry features such as surface and roadside drains, buried pipes, and abandoned culverts. Previous grading has modified the land surface in the form of site leveling, driveways, landscaping, etc. Depressions filled with impermeable soils contribute to local ponding of water. These features tend to control drainage from the eastern and mid-sections of Borrow Area 1, affecting the concentration of runoff in a number of instances which have a direct bearing on the occurrence of wetlands, as described below.

Generally, the presence of the underlying glacial till layer promotes surface runoff and interflow, with less infiltration and deep percolation compared to outwash soils. Consequently, the overall hydrology of the existing site currently provides significant quantities of runoff, either directly or as short-term interflow, which has a relatively rapid flowpath to Des Moines Creek.

Groundwater Conditions

Hart Crowser has monitored the groundwater levels in eight monitoring wells within Borrow Area 1 from the spring of 1999 to the spring of 2001. The water level monitoring data for the two-year period are presented in Table 1 and displayed on Drawing 4. The highest recorded groundwater levels (Spring 1999) are shown on Drawing 4, along with interpolated water level contours for groundwater in the advance outwash beneath Borrow Area 1. Seasonal variation in groundwater levels has ranged from 2.9 to 5.0 feet.

Groundwater elevations shown on Drawing 4 indicate flow is generally toward the northwest, consistent with recharge entering the Shallow Regional Aquifer beneath a broad area of higher ground southeast of Borrow Area 1. The water table in the advance outwash generally mimics the local topography manifesting a hydraulic gradient from Borrow Area 1 down to Des Moines Creek. The water table slopes consistently toward Des Moines Creek, implying tnat groundwater discharge from the shallow aquifer contributes to Des Moines Creek baseflow (Hart Crowser 1999a). The Shallow Regional Aquifer also recharges deeper aquifers beneath the Des Moines upland and discharges via underflow into Puget Sound and the Green River valley (AGI 1996).

On an average annual basis, precipitation on the glacial till (and surficial soils underlain by shallow glacial till) can be divided as shown below, based on hydrologic modeling performed for the Port (Parametrix 2000b) that simulates basin-wide conditions for Des Moines Creek:

Hydrologic Component	Forested Till	Grassed Till
Evapotranspiration	40.5%	33.8%
Direct Surface Runoff	0.2%	1.1%
Interflow (Basin Runoff)	8.5%	26.8%
Shallow Recharge (Baseflow)	19.2%	15.3%
Deep Recharge	31.6%	23.0%

The glacial till has low to moderate permeability, allowing on average between 38 and 51 percent of precipitation to percolate down to the underlying advance outwash (i.e., the combination of shallow recharge and deep recharge). The advance outwash is typically more permeable than the glacial till. By contrast, deep percolation through outwash that becomes groundwater recharge is therefore somewhat greater (between 60 and 68 percent of annual precipitation), where the till is not present, as the following figures show:

Hydrologic Component	Forested Outwash	Grassed Outwash
Evapotranspiration	40.1%	32.2%
Direct Surface Runoff	0.1%	0.3%
Interflow (Basin Runoff)	0.0%	0.0%
Shallow Recharge (Baseflow)	22.2%	26.3%
Deep Recharge	37.6%	41.2%

The glacial till forms a semi-perching layer with winter precipitation typically saturating the near-surface soils and generating significant quantities of interflow. A local perched water-

bearing zone is commonly observed in the topsoil and upper portion of the till, especially where shallow porosity and permeability of the glacial till have been increased by weathering processes. These perched or interflow zones occur principally above the unweathered glacial till layer (which is mostly unsaturated), and well above the much deeper groundwater level in the advance outwash.

Deep percolation through the till occurs as unsaturated flow that is controlled primarily by the moisture and permeability characteristics of the till. The maximum percolation rate occurs under conditions that are likely close to saturation during the winter months. This rate is around 10 inches per month, based on the above HSPF data, and corresponds to a saturated permeability for the till of 1×10^{-5} cm/sec (0.028 ft/day).

Since the till exhibits low to moderate permeability, it does store and transmit some water; however, it is not normally considered to be an "aquifer" because the rates and amounts of water transmitted are small in comparison to more permeable deposits such as the outwash materials, which are largely composed of sands and gravels. Horizontal flow within the till is therefore not generally considered to be significant; however, vertical flow, especially over large areas, can form a small to moderate portion of the overall water balance for some groundwater systems.

Although the potential deep percolation rate through the outwash is significantly higher than that for the till due to its much higher permeability, actual rates are controlled by the amount of water available from the surficial soil zone due to precipitation, after evapotranspiration demands have been met. In the Des Moines Creek basin, maximum monthly percolation rates through the outwash are therefore limited to approximately 25percent higher than those for the till, based on the HSPF data cited above.

Wetland Hydrology

Development of Borrow Area 1 will eliminate all or portions of three wetlands (designated B11, B14, and part of B12) totaling 1.03 acres as shown by comparison of Drawing 1 and Drawing 5. However, the remaining acres of wetlands within or adjacent to the proposed excavation will be protected by designing the borrow site to avoid impacting their surface catchment areas, and this will help to avoid or mitigate temporary impacts to off-site wetlands along with the imposition of protective buffers to limit adjacent disturbance (Parametrix 2000a and 2001b).

Wetland hydrology for those wetlands designated for avoidance of permanent impacts is addressed below.

Wetland B-1 (on the east side of Borrow Area 1) is connected to the neighborhood storm drain system to the east via a ditch and is surrounded by upland forest. It occupies a shallow depression located on till soils. Precipitation and stormwater runoff conveyed to the wetland from the ditch to the east appears to maintain seasonally wet soils in the wetland.

Wetland B-4 (on the west side of the site) is located at the base of a steep ravine where surface water, interflow, and shallow groundwater seep into a seasonal drainage. The base of the ravine contains a failed stormwater discharge system, and the ravine is littered with disconnected sections of a 12-inch culvert. The culvert originally conveyed stormwater from 208th Street to Des Moines Creek, but over time stormwater runoff has eroded the pipeline foundation, sections have separated, and flows have eroded the ravine. Ongoing erosion has prevented the establishment of dense natural vegetation. Groundwater also seeps onto the ravine slopes, and stormwater runoff enters the area from the east.

Wetland B12 (on the west side of the site) is located along a ravine that drains runoff from the west of the perimeter of Borrow Area 1 to Des Moines Creek. The water entering the ravine from upslope areas supports wetland conditions. Much of the water appears to originate from the existing stormwater drainage system still in place along 20th Avenue South.

Wetland B15 (a/b) and Wetland 48 are located along the southwest boundary of Area 1 and occur on a gentle slope (Wetland 15) or a shallow depression (Wetland 48). Portions of both wetlands pond 1 to 2 inches of surface water during rainy periods. Portions of the wetlands contain disturbed soils and fill material, and they were recently (pre-1970s) pastureland. Wetland hydrology appears to be sustained by direct precipitation falling on relatively flat terrain underlain by low-permeability soils.

The wetlands are located above a relatively thick (>20 feet) layer of dense low-permeability glacial till soils that likely encourages the shallow ponding and storage of water within the wetland. Field observations indicate the wetlands' source of water appears to be supplemented by overland flow and possibly shallow interflow from the gentle slopes that form a small catchment area to the southeast. The eastern extent of the potential catchment area is limited by 20th Avenue South, which is elevated relative to the surrounding land and contains a stormwater drainage system. The street crown is sloped to the east, and directs runoff toward a series of drainage ditches, storm drains, and catch basins along its eastern margin. There appears to be little if any existing surface flow or runoff from areas located on east side of 20th Avenue South to land west of the street, because the drainage system intercepts this water and directs it to Wetland B12.

Wetland B13 occurs downslope and west of the excavation area, and is in a ravine where stormwater drainage pipes outfall. The hydrology of the wetland is similar to Wetlands B12 and B1, in that it is largely maintained by stormwater runoff generated from the paved surfaces of abandoned streets (South 210th Street and 20th Avenue South).

Wetland 32 (located on the south side of the borrow area) is located on the northwest corner of South 216th Street and 20th Avenue South. The wetland is situated in a small depression that receives runoff from the stormwater ditch servicing the northern side of South 216th Street. The wetland's catchment includes a small depression, which is slightly larger than the wetland.

Wetland 51 (located to the northwest of the northern part of Borrow Area 1) occupies a broad low-lying riparian area adjacent to Des Moines Creek. The area appears to be underlain by outwash materials, with till that forms the next downstream reach of Des Moines Creek to the south, possibly forming a buried shelf or dam that helps to impound surface waters. The main portion of this wetland is situated generally at an elevation of around 230 feet, which is similar to or lower than water levels measured in monitoring wells at the northernmost end of Borrow Area 1 (see Drawing 4). These observations indicate that this wetland is likely maintained by the water table present in the advance outwash aquifer that extends beneath the site. A small portion of Wetland 51 occurs upslope of the riparian area and is in a roadside drainage ditch north of Borrow Area 1. This area is outside the Borrow Area Development Boundary and the runoff areas that contribute to the wetland will not be affected by borrow area excavations.

SITE DEVELOPMENT

This section describes the basic approach of the Port plans to use to obtain borrow materials from Borrow Area 1. Mine planning activities to date have focused on confirming initial observations about site geology, hydrogeology, and revising the resource estimate by applying a set of project limitations to a basic material extraction scenario. The site will be developed to avoid or mitigate potential impacts to wetland resources delineated within and adjacent to Borrow Area 1. As soil excavation occurs, appropriate measures will be taken to ensure that erosion, sedimentation, and stormwater runoff are managed in accordance with the Port's standards and state and local permit requirements. The effects of site development activities on post-excavation surface water and groundwater features are also presented below.

Mine Plan

Planning for the excavation of Borrow Area 1 has focused on avoidance of wetland impacts to develop a conceptual mine plan. Sequence of excavation and other details are not yet as complete as those for Borrow Areas 3 and 4, which will be developed prior to Borrow Area 1. Mine planning activities for Borrow Area 1 are based on a resource estimate derived from field explorations that supports basic mine planning assumptions and material haul options. The resource estimate, development concepts, and haul options are described in the following paragraphs.

Resource Estimate

Engineering estimates conducted in 1994 (AGI 1995, HNTB 1995) to support the FEIS indicated that 6.6 million bank cubic yards (BCY - volume unit of soil in place, prior to excavation) of material were available from Borrow Area 1. Changes in site development conditions and the adoption of wider buffers around the site perimeter and adjacent to Des Moines Creek resulted in this figure being adjusted in 1998 to approximately 4.8 million BCY of borrow material.

Additional exploration borings (Hart Crowser 1999b) generally confirmed earlier engineering estimates. While bedding thickness varies between sites, the slightly silty to silty sands and gravels in Borrow Area 1 materials closely resemble those observed in Borrow Areas 3 and 4. After adjusting the conceptual mine plan to avoid all unnecessary wetland impacts, recent estimates indicate that Borrow Area 1 could produce approximately 4.2 million BCY of borrow material. The post-excavation contours and geologic composition of the remaining pre-reclamation materials are depicted on Drawings 5 and 6.

Conceptual Mine Plan, Assumptions and Constraints

Mine planning for Borrow Area 1 is intended to follow an approach similar to that taken in developing Borrow Areas 3 and 4, described in the Conceptual Development and Reclamation Plan for Borrow Areas 3 and 4 (Hart Crowser 2001). Equipment utilization, site pre-development, seasonal operations, and reclamation would likely follow the similar steps taken to develop the other borrow areas.

Drawing 5 illustrates how the current development plan will avoid several perimeter wetlands, and how it will typically maintain a 200-foot setback to protect the Des Moines Creek riparian area. The Borrow Area 1 development plan is based on the following constraints and assumptions:

- The perimeter of the proposed excavation limits is inside a 50-foot reclamation setback from the Area 1 property boundary;

- Wetland buffers of 50 feet separate mining-related surface disturbances from protected wetlands, and a 200-foot setback to avoid impacts to the Des Moines Creek drainage system;

- Temporary excavation and sediment controls (TESC) will be implemented prior to any site disturbance. The TESC will include provision to infiltrate detained stormwater to the maximum practical extent;

- A 10-foot minimum separation will be maintained between excavation floor and underlying water table;

- Final reclaimed slopes within the site will be 2H:1V or flatter, with the central part of the site regraded to a minimum 2 percent drainage slope toward Des Moines Creek;

- Reclamation, including replacement of stockpiled topsoil, revegetation, and permanent erosion and sediment controls, will be accomplished annually to protect the areas already mined; and

- The Port will monitor the hydrologic, soil, and vegetation conditions in wetlands located near the borrow areas according to conditions D5, D6, and D7 of the *Water Quality Certification #1996-4-02325 (Amended-1)* issued by the Washington State Department of Ecology on September 21, 2001.

Further refinements to this conceptual plan and the extraction schedule may be made as the decisions to utilize these borrow materials progress.

Site Preparation, Stormwater Management, and Reclamation Activities

The Port would use a similar approach to site development, stormwater management, and site reclamation as it has put forward for developing materials from Borrow Areas 3 and 4 (Hart Crowser 2001, Parametrix 2001a). All Temporary Erosion and Sedimentation Control (TESC) and permanent, post-reclamation stormwater measures will be consistent with the NPDES Sand and Gravel General Permit, applicable portions of the King County Surface Water Design Manual (King County 1998), and other applicable permits and approvals.

Stormwater management and TESC facilities would be installed prior to site development. Site clearing preparations would consist of vegetation stripping and topsoil removal. Prior to vegetation stripping and topsoil removal, merchantable timber will be harvested and removed from the site in accordance with a Forest Practices Permit. All remaining vegetation would be removed and managed by composting or land filling as needed.

During the site clearing and pre-production stage, native topsoils would be stockpiled adjacent to areas utilized for excavation and outside of wetland protection areas. The stockpiled soils would then be utilized in reclaiming each area.

Collection ditches would be used to direct site runoff to infiltration ponds, drainage swales, or other diversion systems appropriate for site-specific stormwater drainage. These facilities would be sized to accommodate a 100-year storm event while providing filtration for lesser flows. Drawing 7 depicts general site drainage features of the post-excavation topography.

Depending on other Third Runway project constraints, utilization of Borrow Area 1 may extend over 1, 2, or 3 years. Near the end of each work season, disturbed areas will be stabilized, and reclamation efforts will be implemented to control wet season-related surface erosion, slope stability, and stormwater runoff. As each portion of the borrow site is permanently reclaimed, additional temporary or permanent erosion, slope stability, and stormwater management measures will be implemented as necessary. As shown on Drawing 7, post-extraction topography would be contoured to drain naturally toward the creek, with increased infiltration occurring where outwash soils are exposed in the floor of the excavated borrow area.

Post-extraction topography would drain toward the creek through approved erosion, infiltration, and sediment control structures constructed along the western margins of the excavation. During excavation and site development, these would include drainage ditches and swales, stormwater detention ponds, and any stormwater BMPs required for treatment of surface water runoff.

Impacts on Site Hydrology

Excavation of fill materials from Borrow Area 1 will change surface contours and exposed surface soils, which will affect hydrologic process such as runoff, infiltration, interflow, deep percolation, and groundwater recharge. Drawing 6 illustrates the post-excavation limits and resulting surficial geology.

Runoff

Approximately 71 percent of the existing ground surface at Area 1 consists of glacial till, residual soils (topsoil, fill) derived from the glacial till, and/or other shallow soils underlain by glacial till. This condition generates moderate to high rates of direct surface runoff and interflow that currently flows overland or through the surficial soils to enter Des Moines Creek with little or no time delay. In addition, the site includes approximately 4.2 percent impervious area composed of abandoned streets, old driveways, and concrete building foundations. The remaining area (23 percent) is underlain by recessional outwash that is relatively permeable and generates very little runoff. Approximately 1.9 percent of the site is occupied by wetlands.

After excavation, the amount of exposed till surfaces is estimated to be reduced to 53 percent, with much of the surficial recessional outwash being removed along with a substantial portion of the till. Exposed till slopes around the perimeter of the excavated area would be expected to produce a temporary increase in runoff (which would be mitigated by constructed stormwater management facilities) until they are reclaimed with topsoil and planted. Lower runoff rates will occur on the relatively flat portion of the glacial till soils (average slope about 2 percent) left in the main excavated area. Impervious surfaces will be reduced to 1.4 percent, reducing the amount of runoff compared to existing conditions.

Infiltration

Infiltration into the till areas will be changed by the removal of vegetation and the excavation that will create new surfaces, which will form the final grade within Borrow Area 1. After reclamation, the infiltration in the exposed till slopes around the excavation will be less than occurs to current till soil areas, due to the increased average surface slope, loss of forest cover, and lack of a surficial weathered till zone.

Existing infiltration into the surficial recessional outwash soils will be replaced by infiltration into the increased area of exposed advance outwash beneath the till, which will occupy approximately 45 percent of the site as shown on Drawing 6. Overall, rates of infiltration to the site will increase due to the compensating effects of these changes in subsoil exposure. Increased infiltration to the water table will have beneficial results of reducing peak flows to Des Moines Creek, increasing groundwater recharge, and extending higher base flows from the aquifer for longer periods into the late summer.

Interflow

Interflow currently provides a relatively rapid pathway for a portion of the stored water perched on the till to flow downslope and into Des Moines Creek. This flowpath (estimated for HSPF simulations for the Third Runway project to be typically 3 to 7 days in duration) will be interrupted by development of the Borrow Area 1. In the developed condition, interflow is expected to occur as runoff from the exposed till slopes around the excavation perimeter, which then will flow across the main, relatively flat area of glacial till soils left after mining, where additional infiltration is anticipated, or will infiltrate as relatively rapid groundwater recharge via the exposed advance outwash (see Drawing 6). Both these flowpaths are expected to be longer than the existing interflow, with the beneficial result of reducing peak flows to Des Moines Creek, increasing groundwater recharge, and extending higher base flows from the aquifer for a longer period into the late summer.

Deep Percolation

Changes in the quantity and timing of deep percolation through the till will be one of the more significant hydrologic effects of developing Borrow Area 1. Based on modeling work for the Third Runway embankment, storage effects and slow percolation through the existing till layer are estimated to delay downward flow by around 1 to 2 months. However, because infiltration into and percolation through the glacial till is limited by the lower permeability of the till compared to the advance outwash soils exposed by mining, the amount of water involved in this process is less than the amount of deep percolation that will occur through the same area of exposed outwash. In the developed site, this small portion of delayed deep percolation through the till will be replaced by a larger quantity of direct infiltration into the increased surface area of the exposed outwash soils. This flow will reach the water table more rapidly, and the greater volume of water will serve to increase groundwater storage and thus extend the baseflow discharge period compared to existing conditions. (Release of this water during low-flow periods has not been evaluated.)

Groundwater Recharge

The amount of groundwater recharge occurring post-excavation is expected to increase slightly over current conditions, because the exposed outwash area is increased and the area of impervious surfaces is reduced. Based on the change in areas of exposed soils as a result of the excavation, an increase in shallow groundwater recharge equivalent to around 0.03 cfs is estimated. This is comparable to the value estimated by Pacific Groundwater Group (2000) in their report *Runway Fill Hydrologic Studies* (p 73). This will provide increased baseflow to Des Moines Creek.

Wetland Protection

Original development plans anticipated impacts to 1.40 of the 1.83 acres of wetlands in Borrow Area 1. Current plans for the extraction of borrow materials from Borrow Area 1 would minimize these impacts to 1.03 acres as depicted by Drawing 7.

- The proposed site development approach would facilitate on-site infiltration and controlled drainage of surface runoff into Des Moines Creek and the adjoining wetlands located on the parcel adjacent to and west of Wetlands 15a and 48.

- Excavation in two wetlands (B-1 and B-4) will be avoided by configuring the borrow site boundary and mined slopes to avoid disturbing land inside a 50-foot buffer around the wetland margins.

- Potential impacts to Wetlands B-15a/b, 32, and 48 would be completely avoided by avoiding any material extraction activities west of 20th Avenue South.

The following text explains how the wetland hydrology will be preserved, as depicted by Drawings 5 and 7.

Wetland B-1. The water source for wetland B-1 is a storm drain system associated with development east of Borrow Area 1. The ditch, and hence the seasonal water supply to Wetland B-1, will not be affected by development of Borrow Area 1. Wetland B-1 will therefore continue to receive current water flows with no impacts to wetland hydrology. The shallow subsoils in the depression sustaining the wetland will not be disturbed, and the 50-foot wetland setback will leave in place the natural low-permeability soils that form the closed depression As a result, excess drainage out of the wetland will be avoided.

Wetland B4. No excavation will occur within this wetland, and the primary impact of borrow area development will be to remove the stormwater drainage that reaches the wetland from the abandoned streets (South 208th Street and 22nd Avenue South). Removal of these stormwater sources would reduce peak flows in the wetland and likely promote increased vegetation cover in the eroded ravine that forms the wetland. Groundwater, precipitation, and interflow sources of water to the wetland will remain following excavation.

Wetland B12. Precipitation, groundwater, and interflow sources of water that support Wetland B12 will remain following excavation. The current source of seasonal runoff generated by 20th Avenue South will also be maintained.

Wetland B13. The current sources of precipitation and groundwater flow that help maintain wetland conditions will remain. Seasonal stormwater runoff generated from South 210th Street and 20th Avenue South drainage systems will be removed. Since the wetland is at elevations lower than much of the floor of the borrow area, a surface drainage path to the wetland will be established to provide runoff as shown on Drawing 7.

Wetland B15 and Wetland 48. The catchment area for these wetlands (located west of 20th Avenue South) will be avoided by preventing surface disturbance within this area. As a result, the existing precipitation and runoff sources of water to the wetlands will remain undisturbed after Borrow Area 1 has been developed.

Wetland 32. Development of Borrow Area 1 will not affect the off-site source of flow to this wetland. The stormwater ditch feeding runoff from South 216th Street to Wetland 32 will not be altered as it is located outside the area disturbed by borrow are a excavation activities. A 50-foot buffer around the wetland will prevent impacts to the margins of the wetland and its slightly larger catchment area.

Wetland 51. The hydrology of this riparian wetland is associated with Des Moines Creek and regional groundwater discharge from the advance outwash aquifer. These hydrologic conditions will not be affected by development of Borrow Area 1, except by a possible increase in groundwater levels. Borrow area excavation is not anticipated to have any significant effect on the rate or amount of seepage from the water table that reaches this wetland.

The Port has considered alternatives to the proposed development plan and determined that it would not be practicable to avoid impacts to the remaining wetlands B14, B11, and part of B12 within Borrow Area 1, because: 1) preservation of the wetlands would render the resource impracticable to mine; and 2) excavation of the resource would completely remove the upgradient source of water flow sustaining these wetlands. Mitigation for these wetlands is described in the Natural Resource Mitigation Plan (Parametrix, Inc. 2001b).

Attachments:
References
Table 1 - Borrow Area 1 Water Level Data
Drawing 1 - Site and Exploration Plan
Drawing 2 - Pre-Excavation Topography and Surficial Geology
Drawing 3 - Geologic Cross Section A-A'
Drawing 4 - Groundwater Elevation Contour Map
Drawing 5 - Conceptual Post-Excavation Elevation Contour Map

Drawing 6 - Post-Excavation Limits and Surficial Geology
Drawing 7 - Post-Excavation Site Drainage

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Table 1 - Borrow Area 1 Water Level Data

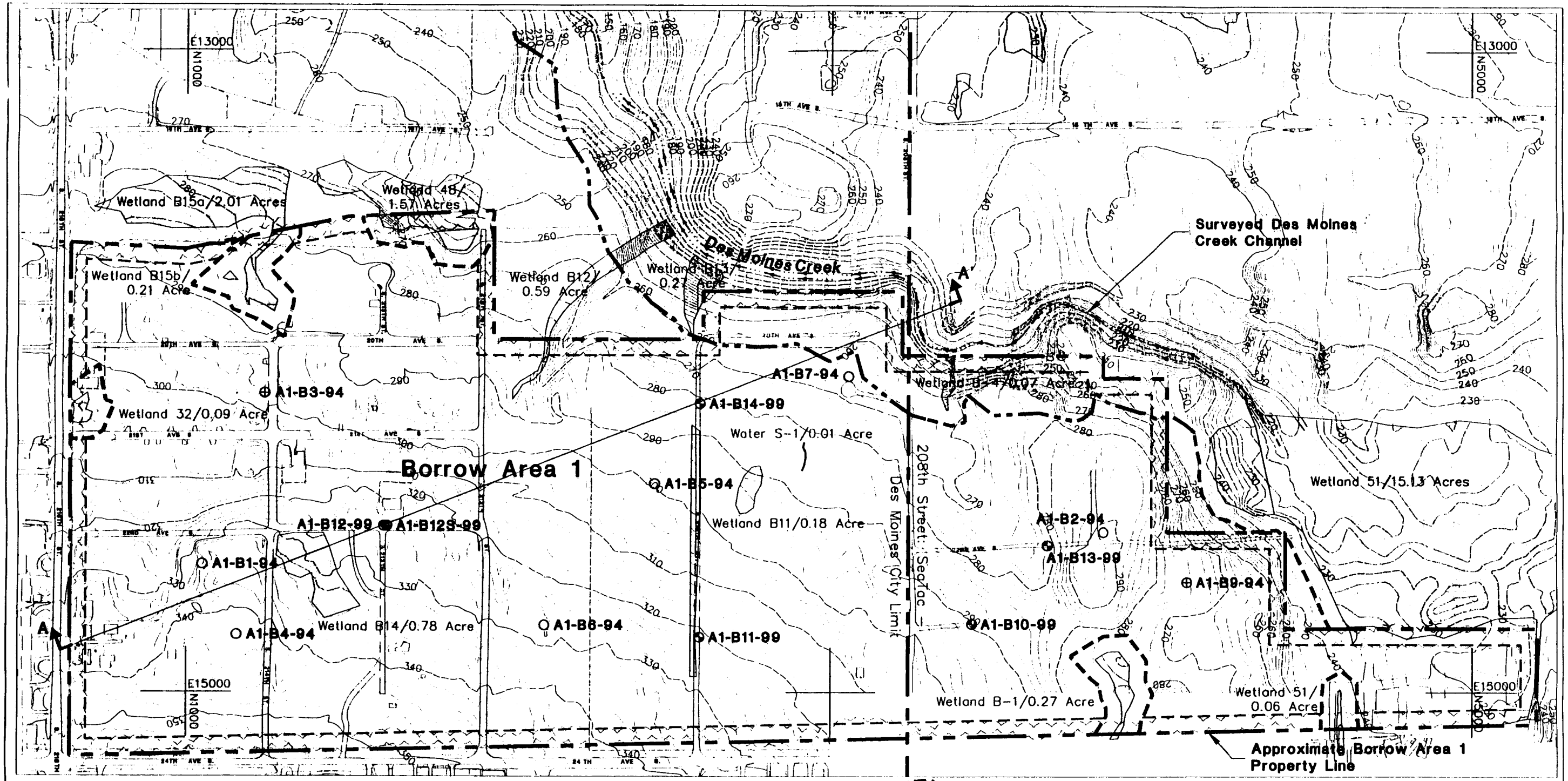
		AGI Borings				Hart Crowser Borings					
		A1-B3-94		A1-B9-94		A1-B10-99		A1-B11-99		A1-B12-99	
		Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet
Top of Monument	(Monument)	*-0.25*	304.67	*-0.25*	279.29	-0.68	273.30	-0.35	322.41	-0.25	324.78
Measuring Point	(Top of Casing)	0.00	*304.42*	0.00	*279.04*	0.00	272.90	0.00	322.06	0.00	324.53
Ground Level	(Stick-Up)	*1.90*	*302.5*	*1.52*	*277.5*						
Top of Screen	(below GS)	*43.0*	*259.5*	*53.0*	*224.5*	59.0	213.9	55.0	267.1	79.0	245.5
Bottom of Well	(below GS)	*53.5*	*249.0*	*63.0*	*214.5*	69.0	203.9	65.0	257.1	89.0	235.5
Water Levels	12/28/1994	30.5	272.02	49.9	227.62						
	1/26/1995	29.5	273.02	48.7	228.82						
	(ATD)					52.7	220.20	41.0	281.06	62.0	262.53
	2/16/1999					52.8	220.10	41.25	280.81	61.1	263.43
	2/19/1999	28.57	275.85	47.34	231.70	53.10	219.80	41.08	280.98	61.55	262.98
	5/5/1999	28.94	275.48	46.71	232.33	53.87	219.03	40.84	281.22	60.56	263.97
	6/14/1999	29.22	275.20	47.60	231.44	53.65	219.25	40.84	281.22	59.90	264.63
	7/15/1999	29.65	274.77	48.24	230.80	54.20	218.70	41.23	280.83	60.04	264.49
	8/13/1999	30.00	274.42	48.71	230.33	54.70	218.20	41.52	280.54	60.24	264.29
	9/14/1999	30.21	274.21	49.20	229.84	54.99	217.91	41.79	280.27	60.33	264.20
	10/13/1999	30.52	273.90	49.52	229.52	55.50	217.40	42.19	279.87	60.71	263.82
	11/11/1999	30.85	273.57	49.36	229.68	55.62	217.28	42.60	279.46	61.60	262.93
	12/10/1999	30.16	274.26	49.00	230.04	55.16	217.74	41.97	280.09	61.30	263.23
	1/12/2000	29.10	275.32	48.65	230.39	54.31	218.59	41.26	280.80	60.96	263.57
	2/15/2000	28.84	275.58	48.40	230.64	53.85	219.05	41.23	280.83	61.32	263.21
	3/10/2000	28.45	275.97	47.99	231.05	53.34	219.56	40.92	281.14	61.09	263.44
	4/12/2000	28.52	275.90	48.08	230.96	53.40	219.50	40.76	281.30	60.58	263.95
	5/10/2000	28.79	275.63	48.30	230.74	53.83	219.07	40.64	281.42	60.05	264.48
	6/21/2000	29.56	274.86	49.12	229.92	54.71	218.19	41.28	280.78	60.25	264.28
	7/11/2000	29.78	274.64	49.52	229.52	55.09	217.81	41.49	280.57	60.30	264.23
	10/13/2000	30.89	273.53	50.94	228.10	56.79	216.11	42.79	279.27	61.16	263.37
	1/23/2001	30.94	273.48	51.00	228.04	56.95	215.95	42.58	279.48	61.72	262.81
	5/3/2001	32.12	272.30	50.88	228.16	56.22	216.68	43.02	279.04	64.90	259.63

Notes:

1) AGI Borings have stick-up monuments
2) Hart Crowser borings are completed with flush monuments
3) Water levels are measured as depths below the Measuring Point
4) Measuring Point is top of PVC casing
5) - Indicates data not available.

Table 1 - Borrow Area 1 Water Level Data

		Hart Crowser Borings					
		A1-B12S-99		A1-B13-99		A1-B14-99	
		Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet
Top of Monument	(Monument)	-0.40	324.64	-0.58	288.57	-0.45	283.25
Measuring Point	(Top of Casing)	0.00	324.24	0.00	287.99	0.00	282.80
Ground Level	(Stick-Up)						
Top of Screen	(below GS)	59.0	265.2	58.9	229.1	55.0	227.8
Bottom of Well	(below GS)	64.0	260.2	69.2	218.8	65.0	217.8
Water Levels	12/28/1994						
	1/26/1995						
	(ATD)	61.5	262.74	62.5	225.49	53.0	229.80
	2/16/1999	-	-	41.9	246.09	52.6	230.20
	2/19/1999	61.26	262.98	40.33	247.66	53.41	229.39
	5/5/1999	60.53	263.71	39.76	248.23	52.44	230.36
	6/14/1999	59.93	264.31	40.33	247.66	53.17	229.63
	7/15/1999	59.97	264.27	40.96	247.03	53.16	229.64
	8/13/1999	60.03	264.21	41.46	246.53	53.80	229.00
	9/14/1999	60.12	264.12	41.75	246.24	54.15	228.65
	10/13/1999	60.41	263.83	42.20	245.79	54.22	228.58
	11/11/1999	60.72	263.52	42.20	245.79	54.27	228.53
	12/10/1999	60.93	263.31	41.92	246.07	53.91	228.89
	1/12/2000	60.85	263.39	41.30	246.69	53.27	229.53
	2/15/2000	61.06	263.18	41.03	246.96	53.28	229.52
	3/10/2000	60.95	263.29	40.48	247.51	52.86	229.94
	4/12/2000	60.55	263.69	40.46	247.53	52.83	229.97
	5/10/2000	60.20	264.04	40.66	247.33	52.93	229.87
	6/21/2000	60.18	264.06	41.52	246.47	53.63	229.17
	7/11/2000	60.17	264.07	42.00	245.99	54.13	228.67
	10/13/2000	60.84	263.40	43.51	244.48	55.38	227.42
	1/23/2001	61.49	262.75	43.36	244.63	55.15	227.65
	5/3/2001	63.71	260.53	43.45	244.54	55.52	227.28



— — — —340— — — Existing Elevation Contour in Feet

Reclamation Setback

200-Foot Stream Buffer

Property Line

A1-B12S-99 Boring with Observation Well (by Hart Crowser)

A1-B9-94 Boring with Observation Well (by AGI)

A1-B6-94 Boring (by AGI)

Wetland B11/0.18 Acre

AA' Cross Section Location and Designation

Wetlands Delineated by Parametrix (06/01) with 50-Foot "No Disturbance" Wetland Buffer and Number/Area

N

0 300 600

Scale in Feet

Notes:
1) Base map prepared from drawing provided by HNTB entitled "Borrow Sites Areas 3 & 4 Grading Plan", dated April 13, 1998.
2) Wetland and stream channel survey data prepared from drawing provided by Parametrix entitled, "w_060601.dwg", dated June 6, 2001.

RC 12/7/01 1=1 (xref)see drawing file/charlie.pc2
49786902.dwg

Bench Mark:

Proj. Mgr.: M. J. BAILEY	Designed By: R. HASTINGS	Drawn By: R. CHAO
Checked By: C. T. BOTH	Approved By: M.B	Date: 12/05/01

No.	Date	By	Revision

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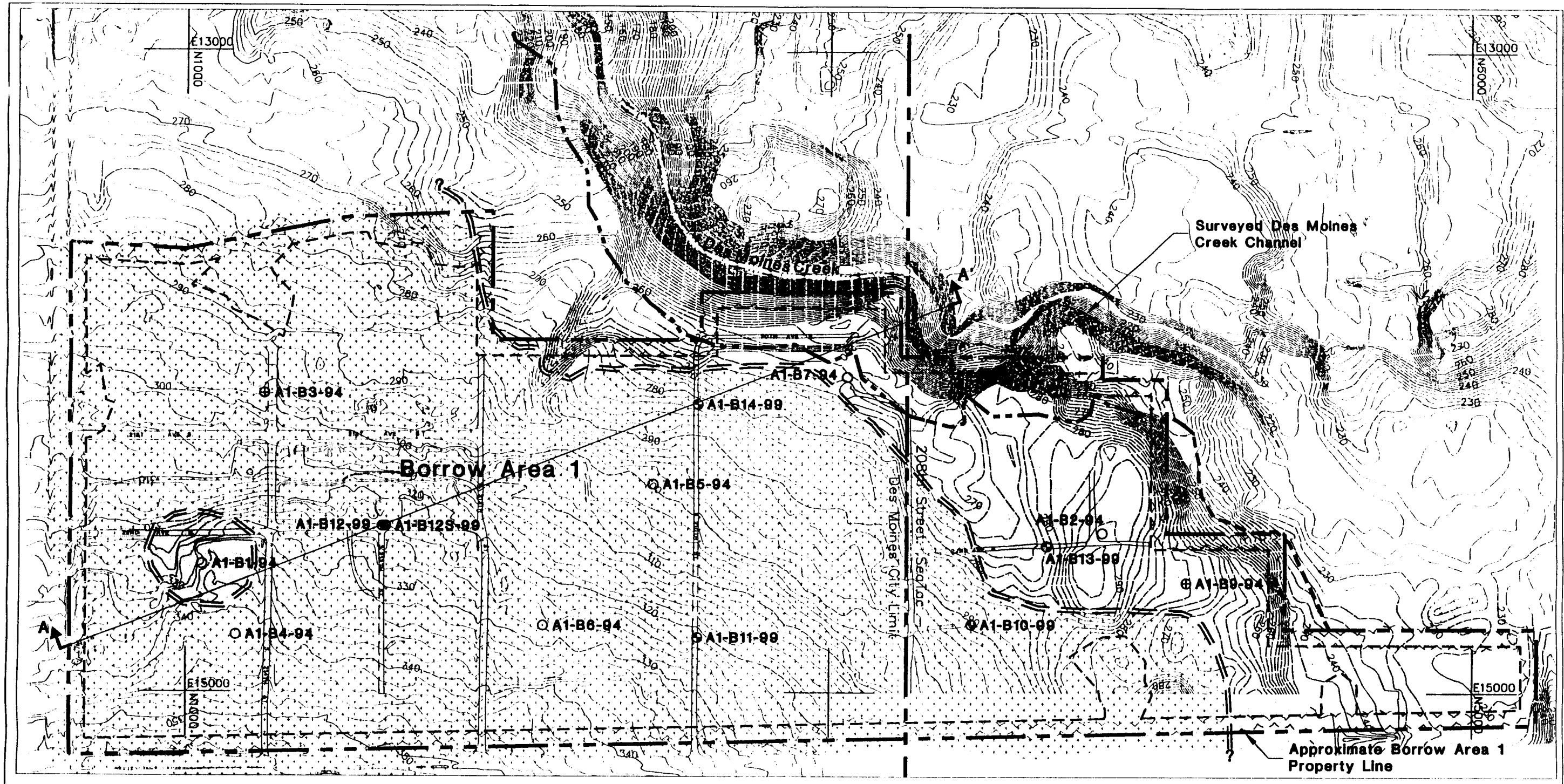
206.324.9530

SEA-TAC THIRD RUNWAY BORROW AREA 1

SITE AND EXPLORATION PLAN

Drawing Size: 11x17	Scale: AS SHOWN	Date Issued: 12/05/01	Drawing Type: DRAFT	Job No: 4978-69	SHEET: 1 of 7	Drawing No.: 1

AR 053215



340 Existing Elevation Contour in Feet

Reclamation Setback

200-Foot Stream Buffer

Property Line

A1-B12S-99 Boring with Observation Well (by Hart Crowser)

A1-B9-94 Boring with Observation Well (by AGI)

A1-B6-94 Boring (by AGI)

Glacial Till
Inferred Contact
Outwash (Recessional/Advanced)

AA' Cross Section Location and Designation

N

0 300 600

Scale in Feet

Notes:
1) Base map prepared from drawing provided by HNTB entitled "Borrow Sites Areas 3 & 4 Grading Plan", dated April 13, 1998.
2) Wetland and stream channel survey data prepared from drawing provided by Parametrix entitled, "w_060601.dwg", dated June 6, 2001.

RC 12/7/01 1=1 (xref)see drawing file/charlie.pc2
4978690.3.dwg

Bench Mark:					
Proj. Mgr.: M. J. BAILEY			Designed By: R. HASTINGS	Drawn By:	R. CHAO
Checked By: G. T. BOTH			Approved By: MJB	Date:	12/05/01
No.	Date	By	Revision		
1	12/05/01	RC/RPH	LOCAL GEOLOGY		

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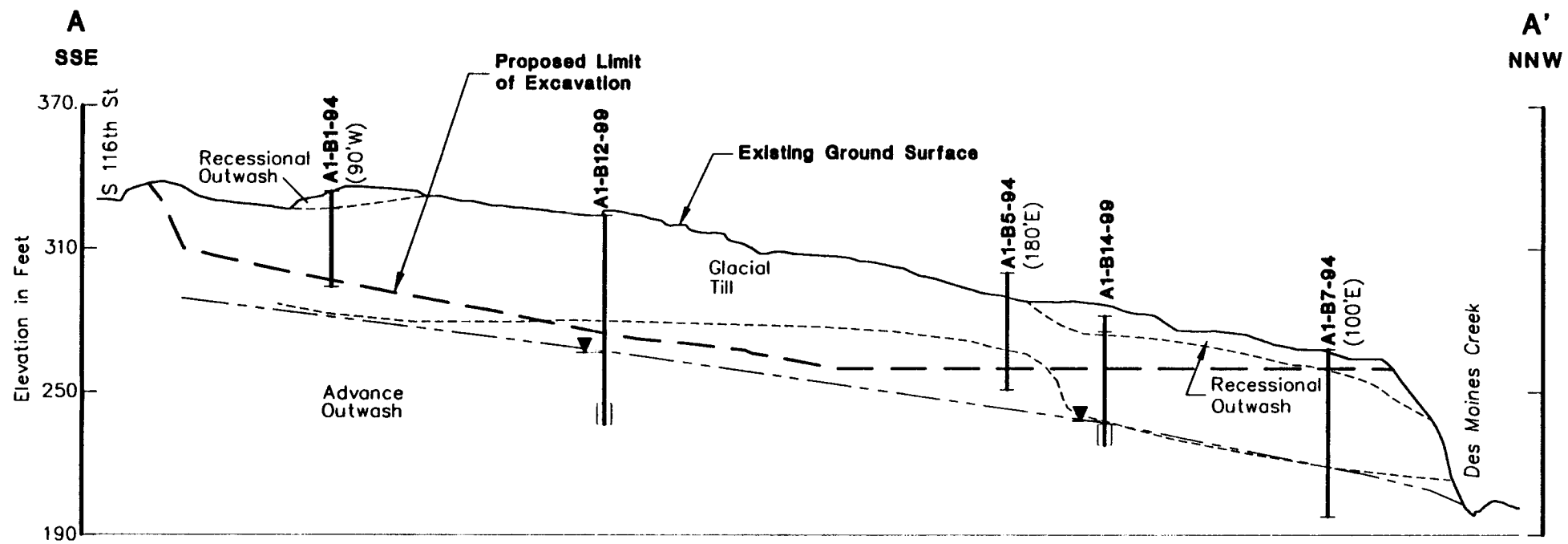
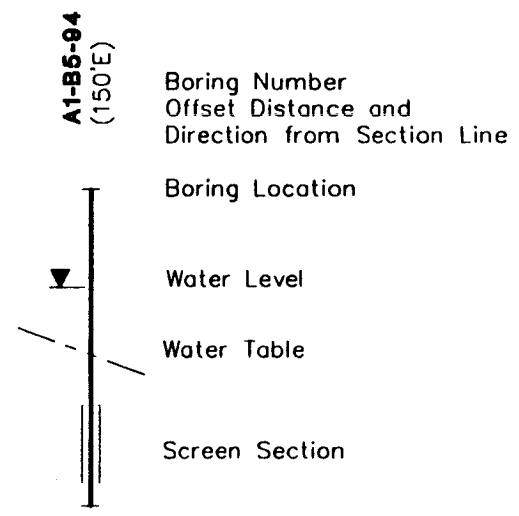
SEA-TAC THIRD RUNWAY BORROW AREA 1

PRE-EXCAVATION TOPOGRAPHY AND SURFICIAL GEOLOGY

Drawing Size:	Scale:	Date Issued:	Drawing Type:	Job No.:	SHEET:	Drawing No.:
11x17	AS SHOWN	12/05/01	DRAFT	4978-69	2 of 7	2

AR 053216





Notes: Contacts between soil units are based upon interpolation between borings and represent our interpretation of subsurface conditions based on currently available data.

Horizontal Scale in Feet
0 300 600
0 60 120
Vertical Scale in Feet
Vertical Exaggeration x 5

Bench Mark:

Proj Mgr.: M. J. BAILEY	Designed By: R. HASTINGS	Drawn By: R. CHAO
Checked By: G. T. BOTH	Approved By: MJB	Date: 12/05/01

No	Date	By	Revision
1	12/05/01	RC/RPH	GEOLOGIC CROSS SECTION

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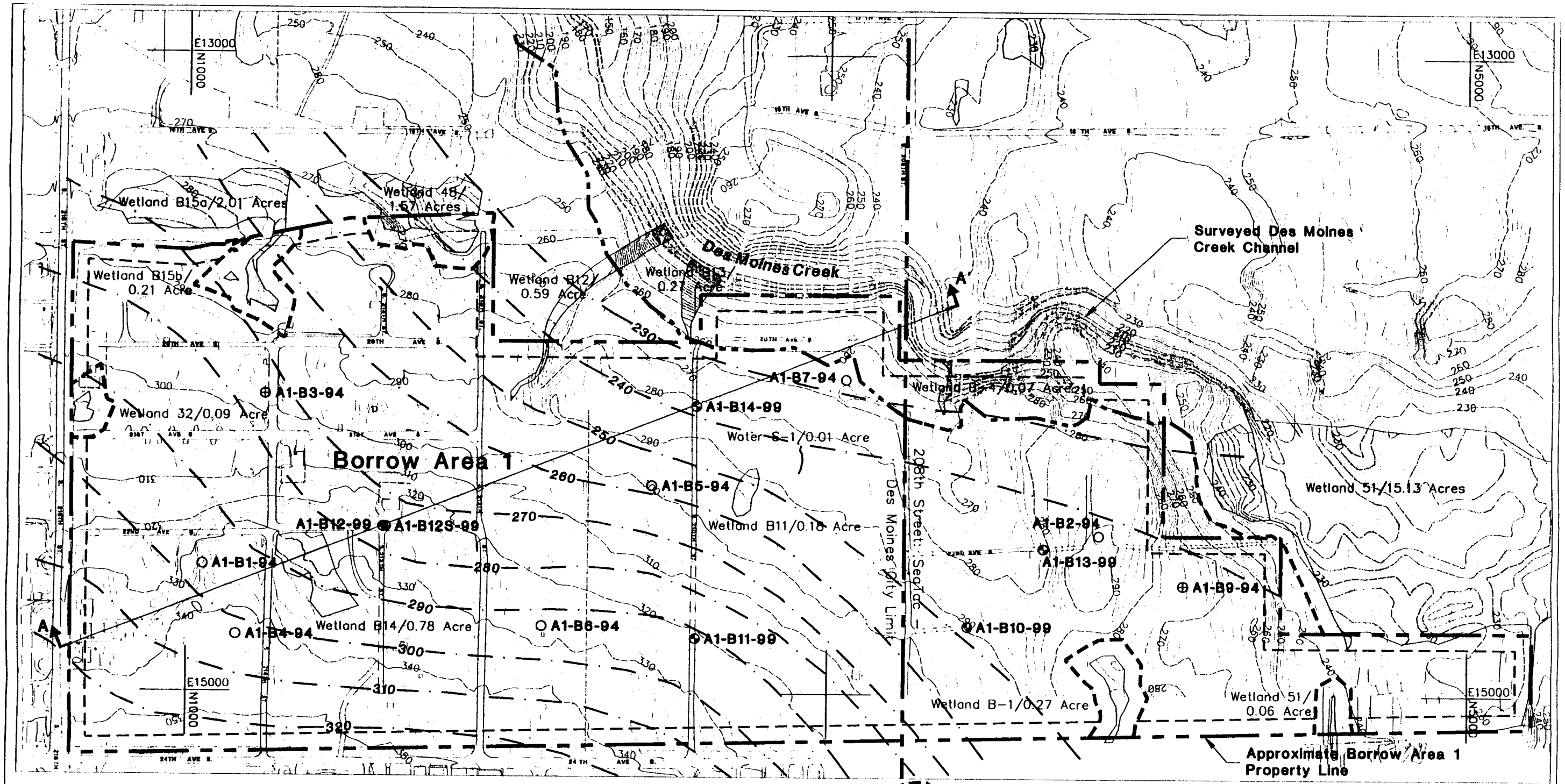
SEA-TAC THIRD RUNWAY BORROW AREA 1

GEOLOGIC CROSS SECTION A-A'

Drawing Size: 11x17	Scale: AS SHOWN	Date Issued: 12/05/01	Drawing Type: DRAFT	Job No.: 4978-69	SHEET: 3 of 7	Drawing No.: 3

Dat 12/05/01 1 :1 (xref)see drawing file/charlie pc2
49786907.dwg

AR 053217



300 Groundwater Elevation Contour in Feet

340 Existing Elevation Contour in Feet

Reclamation Setback

200-Foot Stream Buffer

Property Line

A1-B12S-99 Boring with Observation Well (by Hart Crowser)

A1-B9-94 Boring with Observation Well (by AGI)

A1-B6-94 Boring (by AGI)

Wetland B11/0.18 Acre

AA' Cross Section Location and Designation

Wetlands Delineated by Parametrix (06/01) with 50-Foot "No Disturbance" Wetland Buffer and Number/Area

N

0 300 600

Scale in Feet

Notes:

1) Base map prepared from drawing provided by HNTB entitled "Borrow Sites Areas 3 & 4 Grading Plan", dated April 13, 1998.

2) Wetland and stream channel survey data prepared from drawing provided by Parametrix entitled, "w_060601.dwg", dated June 6, 2001.

RC 12/7/01 1-1 (xref)see drawing file/charlie.pc2 49786908.dwg

Bench Mark:

Proj. Mgr.: M. J. BAILEY	Designed By: R. HASTINGS	Drawn By: R. CHAO
Checked By: C. T. BOTH	Approved By: MJB	Date: 12/05/01

No.	Date	By	Revision

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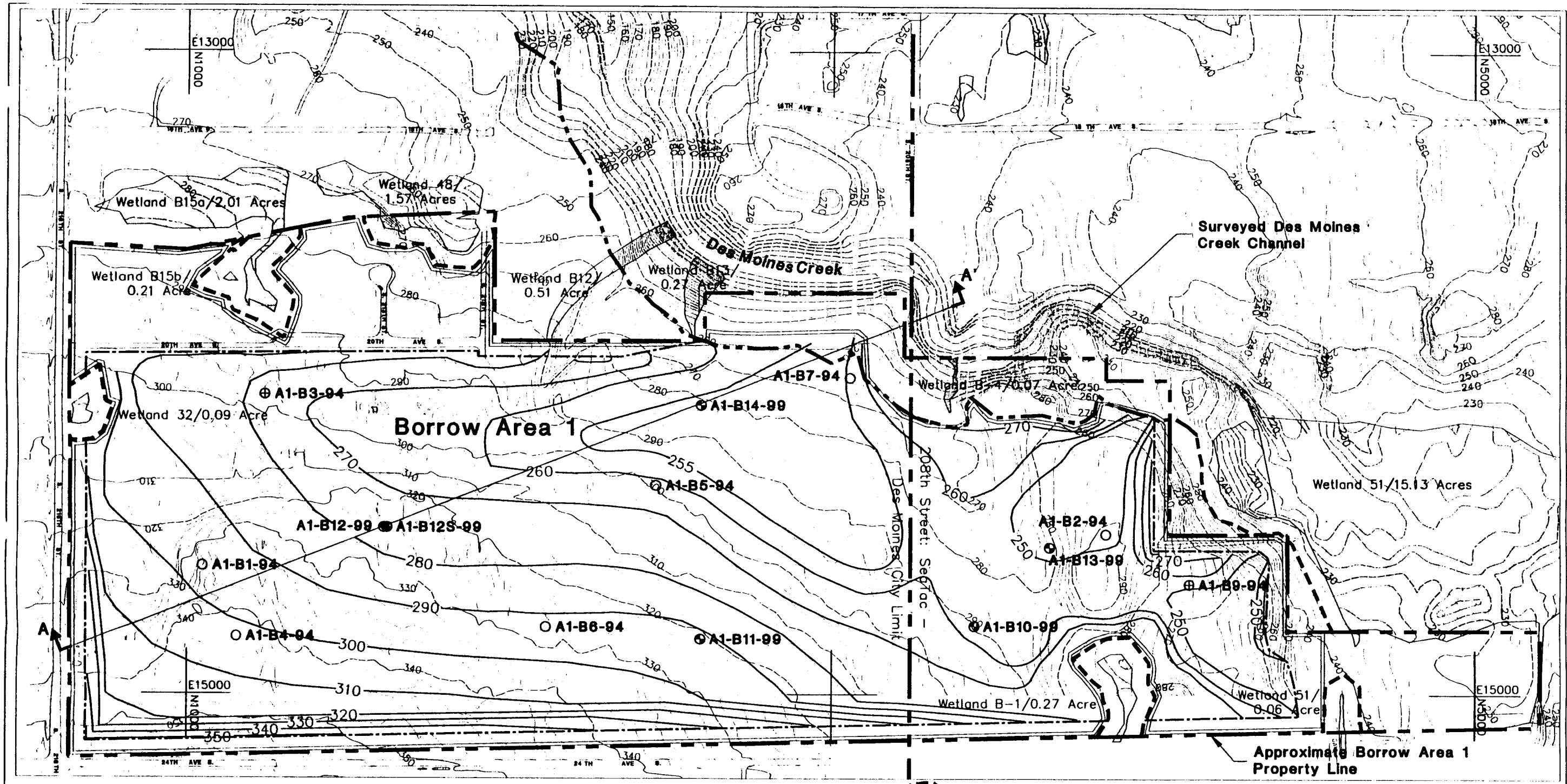
SEA-TAC THIRD RUNWAY BORROW AREA 1

GROUNDWATER ELEVATION CONTOUR MAP

Drawing Size: 11x17	Scale: AS SHOWN	Date Issued: 12/05/01	Drawing Type: DRAFT	Job No: 4978-69	SHEET 4 of 7	Drawing No. 4

AR 053218



340 Existing Elevation Contour in Feet

320 Post-Excavation Elevation Contour in Feet

Limit of Excavation

200-Foot Stream Buffer

Borrow Area Development Boundary

Property Line

A1-B12S-99 Boring with Observation Well (by Hart Crowser)

A1-B9-94 Boring with Observation Well (by AGI)

A1-B6-94 Boring (by AGI)

Wetland B11/0.18 Acre

AA' Cross Section Location and Designation

Wetlands Delineated by Parametrix (06/01) with 50-Foot "No Disturbance" Wetland Buffer and Number/Area

N

0 300 600

Scale in Feet

Notes:

1) Base map prepared from drawing provided by HNTB entitled "Borrow Sites Areas 3 & 4 Grading Plan", dated April 13, 1998.
2) Wetland and stream channel survey data prepared from drawing provided by Parametrix entitled, "w_060601.dwg", dated June 6, 2001.

RC 12/7/01 1:1 (xref)see drawing list/charlie.pc2 49786904.dwg

Bench Mark:

Proj. Mgr: M. J. BAILEY	Designed By: R. HASTINGS	Drawn By: R. CHAO
Checked By: C. T. BOTH	Approved By: MJB	Date: 12/05/01

No.	Date	By	Revision

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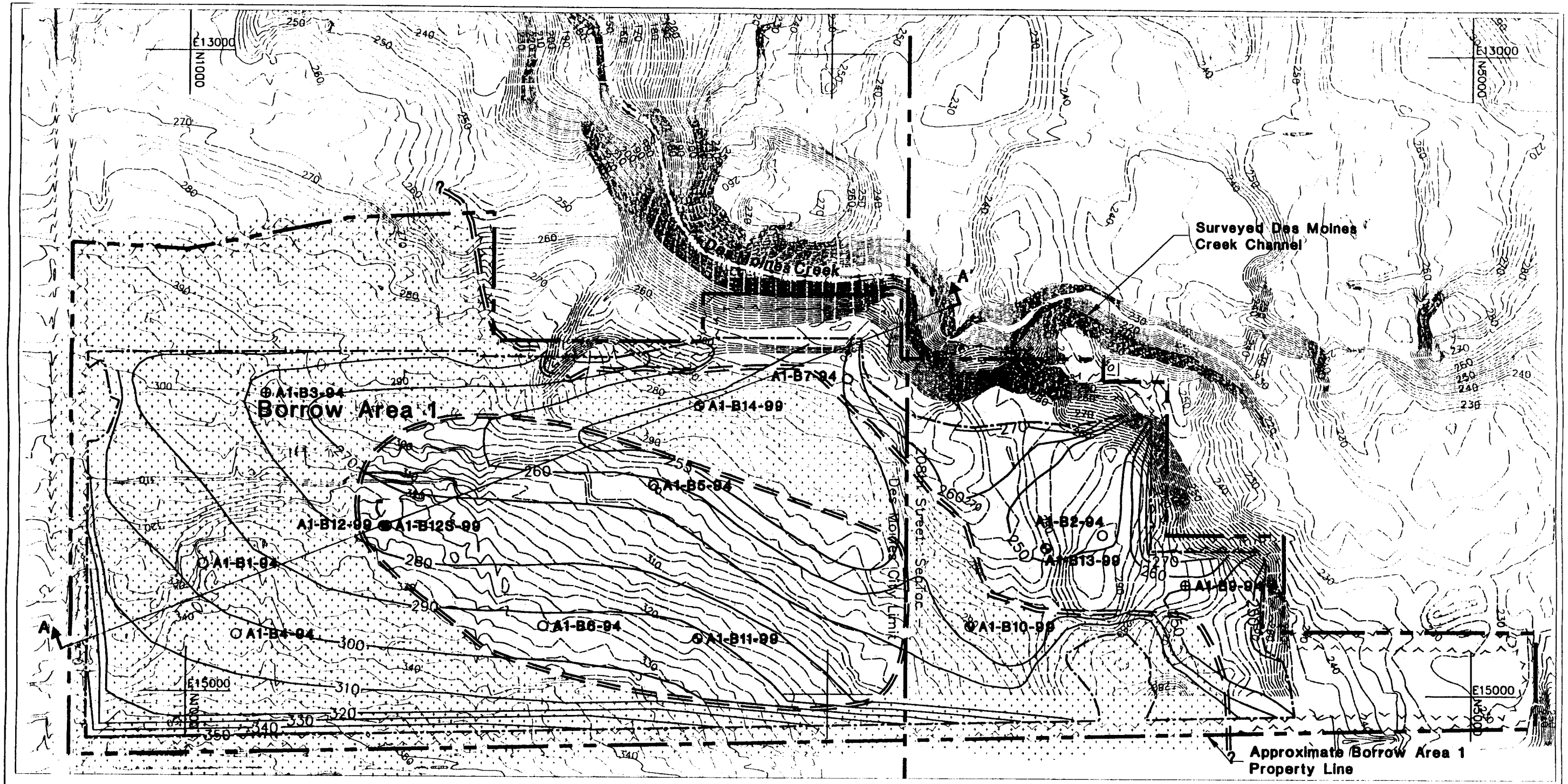
SEA-TAC THIRD RUNWAY BORROW AREA 1

CONCEPTURAL POST-EXCAVATION ELEVATION CONTOUR MAP

Drawing Size: 11x17	Scale: AS SHOWN	Date Issued: 12/05/01	Drawing Type: DRAFT	Job No.: 4978-69	SHEET 5 of 7	Drawing No.: 5

AR 053219



340 Existing Elevation Contour in Feet

320 Post-Excavation Elevation Contour in Feet

Limit of Excavation

Property Line

A1-B12S-99 Boring with Observation Well (by Hart Crowser)

A1-B9-94 Boring with Observation Well (by AGI)

A1-B6-94 Boring (by AGI)

Glacial Till
Inferred Contact
Outwash (Recessional/Advanced)

AA' Cross Section Location and Designation

N

0 300 600

Scale in Feet

Notes:
1) Base map prepared from drawing provided by HNTB entitled "Borrow Sites Areas 3 & 4 Grading Plan", dated April 13, 1998.
2) Wetland and stream channel survey data prepared from drawing provided by Parametrix entitled, "w_060601.dwg", dated June 6, 2001.

D.ai 12/05/01 1=1 (eret)see drawing file/charlie.pc2
49/86909.dwg

Bench Mark:

Proj. Mgr.: M. J. BAILEY	Designed By: R. HASTINGS	Drawn By: R. CHAO
Checked By: G. T. BOTH	Approved By: MJB	Date: 12/05/01

No.	Date	By	Revision
1	12/05/01	RC/RPH	POST-EXCAVATION GEOLOGY

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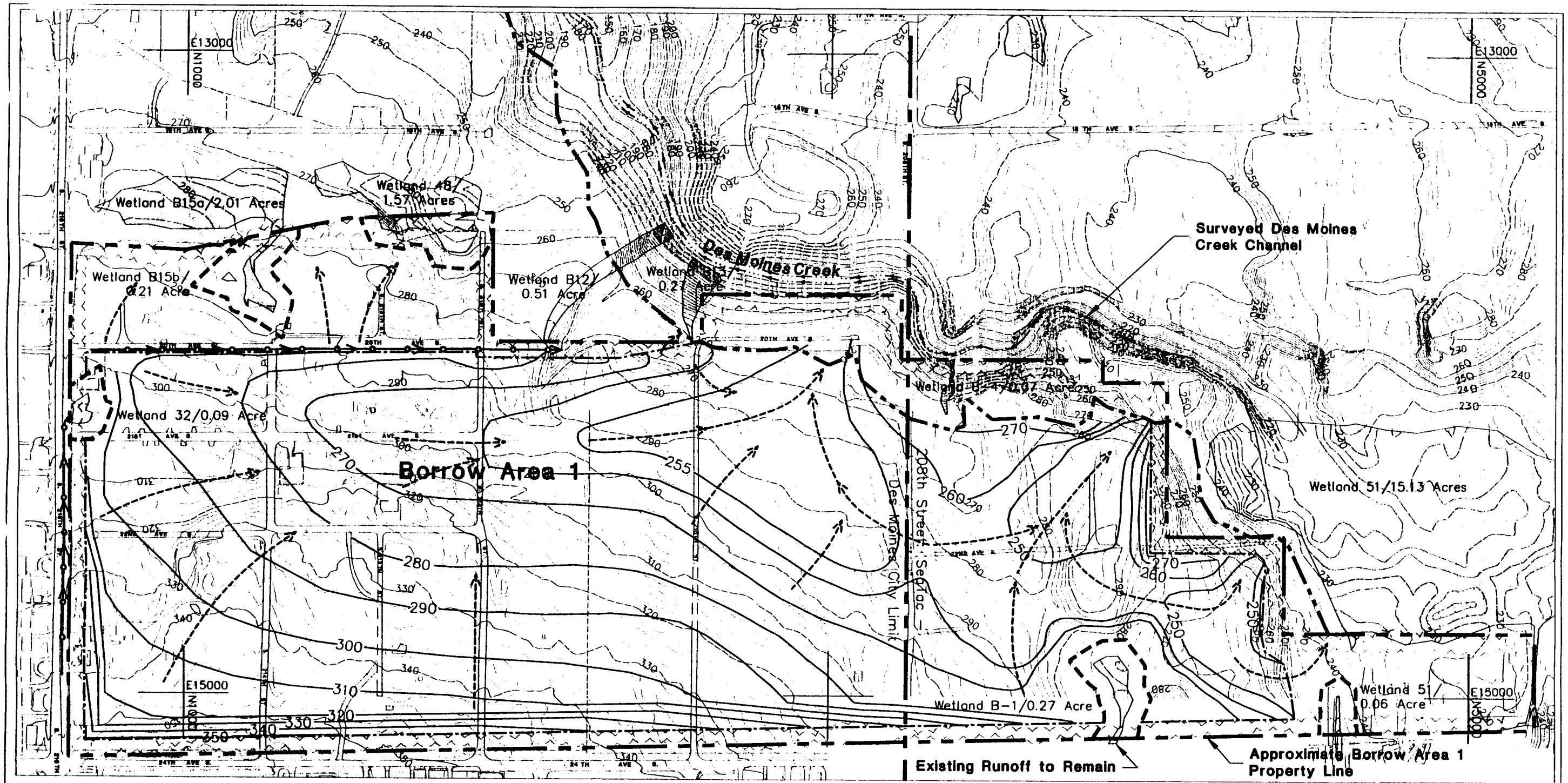
SEA-TAC THIRD RUNWAY BORROW AREA 1

POST-EXCAVATION LIMITS AND SURFICIAL GEOLOGY

Drawing Size: 11x17	Scale: AS SHOWN	Date Issued: 12/05/01	Drawing Type: DRAFT	Job No.: 4978-69	SHEET 6 of 7	Drawing No.: 6

AR 053220



Notes:
1) Base map prepared from drawing provided by HNTB entitled "Borrow Sites Areas 3 & 4 Grading Plan", dated April 13, 1998.
2) Wetland and stream channel survey data prepared from drawing provided by Parametrix entitled, "w_060601.dwg", dated June 6, 2001.

RC 12/7/01 1 1 (xref)see drawing file/charlie.pc2
49786905.dwg

Bench Mark:

Proj. Mgr.: M. J. BAILEY	Designed By: R. HASTINGS	Drawn By: R. CHAO
Checked By: C. T. BOTH	Approved By: MJB	Date: 12/05/01

No.	Date	By	Revision

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SEA-TAC THIRD RUNWAY BORROW AREA 1

POST-EXCAVATION SITE DRAINAGE

Drawing Size: 11x17	Scale: AS SHOWN	Date Issued: 12/05/01	Drawing Type: DRAI	Job No.: 4978-69	SHEET: 7 of 7	Drawing No.: 7

AR 053221

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