

DRAFT

Report

Phase I – Reconnaissance Evaluation

Carlyon Beach/Hunter Point Landslide

Thurston County, Washington

March 18, 1999

For

Thurston County Development Services

DRAFT

March 18, 1999

Thurston County Development Services
Building 1, Second Floor
2000 Lakeridge Drive SW
Olympia, Washington 98502

Attention: Don Krupp, Director

We are pleased to submit our "Report, Phase I - Reconnaissance Evaluation, Carlyon Beach/Hunter Point Landslide, Thurston County, Washington".

Our services were requested on March 1, 1999 by Don Krupp, Director of Thurston County Development Services following submittal of our qualifications. The scope of our services is included as "Attachment A" to our contract with Thurston County dated March 15, 1999. The scope of services was developed during discussions with Thurston County. The contract was authorized on March 16, 1999.

We appreciate this opportunity to be of service to Thurston County on this project. Please call us if you have questions regarding this report, or if you require additional information.

Yours very truly,

GeoEngineers, Inc.

Jon W. Koloski
Principal

WEH:JWK:vc

Document ID: 7318001TR.DOC

File No: 7318-001-00

DRAFT**TABLE OF CONTENTS**

	<u>Page No.</u>
INTRODUCTION	1
BACKGROUND	2
SCOPE OF SERVICES	3
SITE DESCRIPTION	4
GENERAL	4
SURFACE CONDITIONS	4
Topography	4
Vegetation	5
Surface Water Features	5
SUBSURFACE CONDITIONS	5
CONCLUSIONS	7
RECOMMENDATIONS	7
LIMITATIONS	9
BIBLIOGRAPHY	10
 FIGURES	 <u>Figure No.</u>
Vicinity Map	1
Site Plan	2

DRAFT

REPORT
PHASE I – RECONNAISSANCE EVALUATION
CARLYON BEACH/HUNTER POINT LANDSLIDE
THURSTON COUNTY, WASHINGTON
FOR
THURSTON COUNTY DEVELOPMENT SERVICES

INTRODUCTION

This report summarizes our Phase I evaluation of the Carlyon Beach/Hunter Point landslide in northwestern Thurston County, Washington. The landslide is located along the northern end of the Steamboat Island Peninsula and includes a portion of the private community of Carlyon Beach as well as a number of rural residential dwellings along Northwest Hunter Point Road. The area of the landslide slopes down to shoreline and the marine waters of Squaxin Passage as shown in the Vicinity Map, Figure 1.

The purpose of our Phase I Evaluation is to provide a reconnaissance-level evaluation of the landslide area. Our goals include development of an estimate of the rate of movement, evaluate potential areas of headward propagation and develop a scope for a detailed Phase II geotechnical study of the slide. Our services for this phase of work were conducted under contract to Thurston County Development Services Department and were authorized by Mr. Don Krupp.

Movement of the landslide manifested as cracks and settlement in streets and driveways beginning around February 6, 1999. Previous movement had also occurred in some areas in recent years. At the time of this report the landslide encompasses portions of Mariner Drive, Crestridge Drive, Bowline Court and Jibstay Court within Carlyon Beach, as well as several properties located north of Northwest Hunter Point Road in unincorporated Thurston County.

Recent ground movement within the limits of an ancient landslide feature has affected a total of 37 residences within Carlyon Beach Estates and six residences outside the private community. Ground movement has resulted in severe distress of some building foundations and supports in the form of subsidence and lateral offset rendering the homes unsuitable for occupation. Numerous homes have experienced differential settlement resulting in racking of doorways and windows. Lateral as well as rotational offset was observed in shoreline bulkheads in the Carlyon Beach and Hunter Point area. The landslide has damaged numerous streets in Carlyon Beach, along with subsurface utilities and overhead power lines. In several instances, utilities have had to be disconnected to reduce the potential for additional damage to property and hazard to life. The domestic water supply well for the Fisher property located at 9743 Hunter Point Road has sheared at depth and is no longer useable. It does not appear that any of the water supply wells at Carlyon Beach are threatened at this time.

The headscarp of the slide currently threatens the integrity of the eastern end of Hunter Point Road and access to several residences in the Hunter Point Community. The current known limit of the landslide mass based on surface features is shown relative to surrounding physical features on the Site Plan, Figure 2.

DRAFT

BACKGROUND

Carlyon Beach Country Club was first platted as a summer resort and camping area in 1959. By the late 1960s permanent residences were being constructed on lots within the development. At that time, residences were served by individual, on-site septic systems. In 1972 a wastewater treatment plant was constructed to replace failing septic drainfields and reduce nitrate pollution into Squaxin Passage. Residents maintain enclosed septic holding tanks that are pumped on a regular basis. Effluent from the tanks is hauled by truck to the wastewater treatment plant for processing and discharge. Potable water is provided to the community by a series of community wells and reservoirs. New construction within the development ceased in the early 1990s when a moratorium was placed on new residences due to the limited capacity of the wastewater treatment plant and water system.

Several houses located on Hunter Point Road are apparent in the 1953 aerial photographs we reviewed as a part of this study indicating early development of this area.

Bradley-Noble Geotechnical Services (Bradley-Noble) was retained in 1996 by Mr. John Arata, owner of the property located at 10127 Mariner Drive NW in Carlyon Beach, to evaluate ground movement in the area between 10103 and 10137 Mariner Drive. Bradley-Noble drilled three borings ranging between 19 and 24 feet below ground surface to evaluate subsurface conditions and found generally loose silt over firm silt. In their July 16, 1996 report, Bradley-Noble surmised that the soil failure appeared to be the result of a loss of soil from the beach area thereby reducing resisting forces along a sloping failure plane. Bradley-Noble suggested that the installation of a cutoff drain along Mariner Drive might be useful to divert subsurface water that could be contributing to the soil failure. It is our understanding that this drain was not installed.

During the winter of 1996-97 ground cracking was again observed within the asphalt of Mariner and Crestridge Drives as well as in several homes in Carlyon Beach. JW Morrisette and Associates, Inc. (Morrisette) of Olympia was retained by the Carlyon Beach Homeowners' Association to evaluate the cause of ground failure in the area. In their January 1997 report, Morrisette describes the failure as being attributable to loose, poorly compacted fill soil generated during site grading overlying relatively stiff, glacially consolidated silts in conjunction with a shallow ground water table. At that time failure appeared to be in the area of an apparent buried drainage.

Morrisette was again retained by the Homeowners' Association in February 1999 to evaluate ground failure in the same area as observed in 1997 along with new failure features observed upslope in the area of Bowline Court NW. In their report dated February 16, 1999, Morrisette concluded that the landslide was multi-block failure of a colluvial terrace driven by high soil-water pressures resulting from above average rainfall. Morrisette recommended the installation of several geotechnical borings and piezometers along Mariner and Crestridge Drive to evaluate subsurface conditions. It is our understanding that these investigations have not yet been performed.

DRAFT

Bradley-Noble also conducted a geotechnical evaluation of the Dillon property located at 9710 Hunter Point Drive to assess ground cracking and movement in December 1997. Their report also refers to a previous investigation of soil movement the western portion of the Dillon property. Bradley-Noble installed three ground water piezometers ranging in depth between 19 and 29 feet below ground surface. The causes of ground movement at the Dillon property were attributed to increased precipitation and a resulting rise in the ground water table, removal of fine-grained soil from the subsurface due to ground water piping and lowering of the beach due to erosion from longshore currents.

SCOPE OF SERVICES

The purpose of this phase of investigation is to provide a reconnaissance-level survey of landslide extent and morphology in order to allow Thurston County to make decisions regarding homeowner safety and the need for additional investigation. The specific tasks conducted for Phase I include:

1. Conduct an initial site visit and physical evaluation of the affected landslide area and potentially affected areas by a field geology team to assess and establish baseline conditions, with consideration of before-slide topography.
2. Review readily available, relevant geologic maps, aerial photographs, geotechnical reports, permitting information, and other data compiled by the County or immediately accessible through other means. These materials are referenced in the bibliography of this report.
3. Conduct a follow-up site visit by the field geology team to compare and contrast physical changes from identified baseline conditions established in Task #1, above, in order to estimate the scope, scale and rate of ground movement.
4. Attend as many as three public community meetings, staff briefings as requested to discuss the scope of work and share interim results, and one meeting to present the final report of the Phase I investigation.
5. Prepare a draft report for submittal to the County that includes:
 - a general description of the geology and morphology of the landslide, including selected reconnaissance-level cross sections,
 - an evaluation of the immediate threat to homes and infrastructure within the affected and potentially affected areas,
 - a description of possible interim or immediate remedial actions that might be implemented to reduce the scope, scale and rate of the landslide, or that may assist property owners in protecting or preventing damage to improvements on their property and,
 - a detailed scope of work and estimated budget for subsurface explorations that would be included during a Phase II investigation.

DRAFT

SITE DESCRIPTION

GENERAL

The Carlyon Beach/Hunter Point landslide is located approximately 10 miles north-northwest of Olympia at the north end of the Steamboat Island peninsula in south Puget Sound, Washington as shown in Figure 1.

The landslide extends for about 2,800 feet along the shoreline of Squaxin Passage and is roughly oval in plan view, with the long axis oriented slightly north of west. The eastern limit is near Hunter Point. The western limit is near a large ravine that bisects the Carlyon Beach community. The slide area extends from seaward of the existing shoreline to the upland of the peninsula ranging between 700 and 900 feet in width.

The active landslide area encompasses portions of Mariner and Crestridge Drives Northwest, Broadview Court and Hunter Point Road. Additionally, the landslide encompasses all of Jibstay and Bowline Courts. The southern limit of the landslide approaches Broadview and Seahurst Courts and Lookout Drive. The landslide includes both developed and undeveloped residential properties, together with associated roadway and utility systems. A smaller active landslide is located on the east edge of Hunter Point.

SURFACE CONDITIONS

Topography

The Carlyon Beach/Hunter Point landslide is located on a north-facing slope overlooking Squaxin Passage in south Puget Sound as shown in Figures 1 and 2. The upland area to the south of the landslide is broad and nearly level. The landslide headscarp intersects the upland at about Elevation 165 feet mean sea level (MSL). The toe of the landslide appears to be at, or near sea level.

A steep slope is located along the south limit of the landslide. This slope is approximately 15 to 25 feet high and typically inclined at 30 to 40 degrees. Recent displacement near the top of this slope has created a near vertical headscarp ranging from 1 to 7 feet in height. This steep slope extends both east and west of the currently active landslide area as shown in Figure 2.

The west third of the landslide comprises residential properties of the Carlyon Beach community. Slopes within the developed area are generally inclined between 7 and 20 degrees. Terrain features within this area have been modified by development activities with the exception of the steep slope and headscarp located at the southern limit of the landslide. The headscarp is inclined at 20 to 45 degrees. Ground cracks with vertical and horizontal offsets of up to 1.3 and 0.8 feet, respectively, were observed as of March 11, 1999. These cracks are generally sub-parallel to the headscarp and affect most of the roads and many of the houses within the landslide area.

The region east of Carlyon Beach is sparsely developed. The slope in this area is composed of a series of topographic benches inclined at approximately 5 to 20 degrees to the south. These benches are separated by shallow depressions called grabens and by steep slopes inclined at 10 to 30 degrees. Recent ground cracks with vertical and horizontal offsets of up to 2.8 feet and 0.5 feet, respectively, were observed in this area as of March 11, 1999. Cracks were noted to

DRAFT

increase both vertically and horizontally in the week between our site visits. Access roads and residences within this area have been severely damaged by slope movement.

Vegetation

Vegetation within the developed areas of the Carlyon Beach community downslope of the headscarp consists of grass lawns and landscaped areas. Between these landscaped areas is a mixture of mature and sub-mature second-growth coniferous and deciduous trees and patches of blackberries. Vegetation in the sparsely developed area east of Carlyon Beach consists of a second-growth forest of coniferous and deciduous trees with an understory of sword fern, blackberry, and salmonberry.

Some of the mature coniferous trees within the landslide area are butt-bowed (concave upslope). Many trees are tilted both up and down slope at up to 20 degrees from vertical. The trunks of these trees are normally vertical and straight. Shallow slope movements, including creep, disturbs vertical tree growth, resulting in a bowed base. Deeper-seated slope movement results in tilting of otherwise vertical trees.

Seepage and standing water areas within the slide area are vegetated with hydric plants such as water tolerant grasses, rushes, and algae which indicate saturated soil conditions.

Surface Water Features

The primary surface water features within the landslide include small drainages, sag ponds, and seeps. The drainages originate from seepage areas and sag ponds within the landslide area and terminate in Squaxin Passage. Seepage and surface water are concentrated into a creek immediately east of the residence at 9700 Hunter Point Road with a discharge of approximately 10 gallons per minute (GPM) on March 11, 1999. Seepage and surface water near the east end of Mariner Drive and Jibstay Court collect into a small creek with a discharge of approximately 5 to 10 GPM on March 11, 1999. The flow in these drainages is variable and can significantly increase in volume during periods of intense precipitation. Some flow is also diverted and infiltrated into open fissures where the drainages cross these features.

Sag ponds and saturated ground are found within grabens located immediately north of Hunter Point Road in the sparsely developed area of the landslide. Seepage zones are present throughout the northern half of the landslide area.

Other surface water features include the residential storm drain system and ditches within Carlyon Beach. The residential storm drain system collects surface water from streets and residential downspouts, and discharges into Puget Sound. One section of the ditch on the western side of the intersection of Crestridge and Mariner Drives has been routed with a 12-inch corrugated metal half-pipe. This section of half-round pipe crosses directly over a major ground crack.

SUBSURFACE CONDITIONS

Subsurface soil conditions in the study area were evaluated by reviewing published geologic maps and references, nearby water well logs, previously completed geotechnical reports and by

DRAFT

conducting surficial geologic reconnaissance. Water well reports were reviewed for wells located at 2417 Crestridge Drive Northwest, 9634 Hunter Point Road, 9731 Hunter Point Road, and a location between the southern portion Lookout Drive and Hunter Point Road. Three interpretive logs from previously completed geotechnical borings near the east end of Mariner Road were reviewed along with three boring logs from 9710 Hunter Point Road, as shown on Figure 2.

Light brown fine sand was observed on the headscarp face within the undeveloped area east of the Carlyon Beach Community. Similar sandy near-surface soils were observed from immediately downslope of the headscarp to near the bottom of the slope. Surficial soils near the toe of the landslide are generally siltier than those observed upslope. Stiff, bluish-gray clayey silt is exposed in outcrops at the landslide toe and beneath a thin mantle of sand on the beach. Normally horizontal bedding within the silt in these areas dips toward the south at angles of up to 38 degrees from horizontal.

Logs of borings at the east end of Mariner Road indicate soils consist of soft to stiff silt and gravelly silt from the surface to a depth of 12 to 20 feet overlying stiff to hard silt to depths of 19 to 24 feet. Boring logs from two of the borings at 9710 Hunter Point road indicate soils consisting of very loose to loose fine sand from the surface to a depth of approximately 13 to 20 feet overlying hard silt to depths of 19 to 24 feet. Loose to stiff plastic silt was encountered from the surface to a depth of 29 feet in the third boring at 9710 Hunter Point Road. Our field measurements on March 4, 1999 indicate that two of the borings have been either infilled, or sheared off at, depths of approximately 17 and 19 feet below ground surface.

The ground surface near the water well located at 2417 Crestridge Drive Northwest (Well #1) is at approximately Elevation 124 feet. This well is located approximately 1,200 feet southwest of the west end of the landslide. Soils encountered in this well were not logged from the surface to a depth of 116 feet. Sand, silty sand and gravel were encountered from depths of 116 feet to 334 feet. Gray clay, silt and silty sand were encountered from depths of 334 feet to 690 feet. These soil units overlie layers of gravel and compacted clay, which are present from depths of 690 feet to the bottom of the well at 765 feet below ground surface.

Water well #2 is at approximately Elevation 142 feet between the south portion of Lookout Drive and Hunter Point Road, approximately 800 feet south of the landslide headscarp. The soils encountered in this boring consist of blue or tan clay to a depth of 126 feet underlain by brown "hard pan" to a depth of 163 feet. Gray medium to coarse sand and gravel was encountered to a depth of 207 feet, overlying blue-gray clay the bottom of the boring at 209 feet.

The water well located at 9634 Hunter Point Road (Well #3) is at Elevation 168 feet, approximately 250 feet south of the landslide headscarp. The stratigraphy encountered in this well consisted of light brown sand to the full depth of the boring (40 feet).

The well at the address 9731 Hunter Point Road (Well #4) is approximately 50 feet south of the headscarp at Elevation 165 feet MSL. Soils encountered in this boring consist of sandy clay from 2 to 15 feet overlying gray clay to a depth of 34 feet. Sand was encountered from a depth of 34 to 52 feet and overlies clay to a depth of 183 feet. Sand and gravel was encountered from a depth of 183 feet to the bottom of the boring.

DRAFT

Well locations are shown in the Site Plan, Figure 2. Stratigraphy for selected wells is shown in Cross Sections A-A' and B-B', Figures 3 and 4, respectively.

CONCLUSIONS

In our opinion, the Carlyon Beach/Hunter Point Landslide appears to be the reactivation of a large ancient landslide feature. The direct cause of the current movement appears to be an increase in the amount of ground water recharge due to above-average rainfall for the area during the past several years and substantially above-average rainfall for the past two months. Increased ground water recharge increases the weight of the soil mass and thereby the driving force, while concurrently reducing internal friction, or resisting force, of the soil provided by grain-to-grain contact. It is unknown at this time whether the failure plane of the landslide is at the interface between the glacially consolidated silt and overlying sand or colluvium, or is represented by a deeper failure plane within the silt unit itself. In places the toe of the slope appears to be offshore of the existing shoreline bulkhead. Therefore, we believe the failure plane is deep within the silt unit.

Previous movement was noted by residents at the eastern and western limits of the slide in the Carlyon Beach community and near the Dillon residence during the winter of 1996-1997 as indicated by geotechnical reports prepared for those properties at that time. It is probable that previous movement had occurred but was not noticed. However, none of the previous investigations appear to have evaluated the landslide as a whole and have only investigated limited portions of the slide.

Landslides of this type move episodically and differentially. Decades or years may pass with little or no movement. The movement may be substantial in one portion or area and very minor in another, or the entire slide mass can move at once. Normally, this type of landslide moves slowly, often at a rate of inches per day or slower. Local movement can be as rapid as feet per day.

In our opinion, the landslide will continue to move until equilibrium conditions are restored either through natural processes or by the application of engineered mitigation efforts. Continued damage to houses and infrastructure can be expected to occur within the current mapped limits of the landslide. Houses, streets and utilities within the slide area that are not currently damaged will likely eventually experience damage as individual blocks within the slide fracture into smaller blocks. Headward progression of the main failure scarp should be expected to occur at some future date and should be monitored by visual observation as well as by instrumentation.

RECOMMENDATIONS

As stated above, continued movement of soil within the landslide is likely to damage houses and infrastructure. We recommend continued monitoring of structural integrity within the landslide area by Thurston County Development Services to evaluate safety to occupants. When buildings become damaged or unstable to the point they present a safety hazard to occupants they should be "yellow tagged" or "red tagged" in accordance with current County protocol.

DRAFT

At this time, the subsurface geometry of the landslide is not known. The application of predictive tools such as computer models, or design of engineered mitigation efforts requires evaluation of the failure plane as well as soil properties and ground water conditions within and adjacent to the landslide. We recommend that Thurston County implement the following at this time:

- Drill a series of geotechnical borings to evaluate subsurface soil and ground water conditions within and adjacent to the landslide area. Relatively undisturbed soil samples should be collected at regular intervals during drilling to evaluate geologic materials encountered and provide samples for laboratory testing.
- Install inclinometer casings in selected borings to conduct ongoing monitoring of slide movement and provide a potential for early warning should headward failure of the slide begin to occur. Several inclinometer casings should be installed landward of the current headscarp to evaluate the potential for propagation of the scarp to the south. Inclinometer measurements should be collected initially on a weekly basis for a period of six weeks to evaluate the rate of movement. Thereafter, the schedule may be adjusted as needed.
- Install piezometers in selected borings to evaluate ground water elevations and assess changes in ground water levels in response to precipitation events. Ongoing collection of published precipitation data also will be conducted.
- Install survey reference points in various locations of the slide mass to evaluate the direction and speed of slide movement. We recommend a series of survey reference points be established along existing roads at approximately 100-foot spacing. A series of reference points should also be established along the top of concrete bulkheads and along the beach areas to evaluate movement along the toe of the slide. All reference points located within the slide area should be tied to control points located well outside the zone of movement.
- Conduct physical laboratory tests on selected recovered soil samples to evaluate soil strength properties.
- Perform routine monitoring of inclinometer casings, ground water levels in piezometers and survey lines to evaluate the nature and rate of movement. At a minimum, monitoring will be conducted on a weekly basis for the first six weeks.
- Conduct an analysis of landslide movement and the potential for expansion of the landslide using appropriate computer models.
- Provide an interim status report to Thurston County by April 23, 1999 describing preliminary results and providing a description of additional recommended fieldwork. Additional activities may include installation of supplementary inclinometer casings or water extraction wells for testing and conduction of aquifer pumping tests.
- Provide a final report to Thurston County by May 21, 1999 describing activities conducted to date including monitoring data and findings from additional activities (if authorized). The report will also include a description and associated order-of-magnitude estimates of costs for various remedial options deemed appropriate for mitigation of slide movement.

DRAFT

The locations of proposed subsurface explorations are shown in Figure 5.

GeoEngineers is prepared to provide a detailed cost estimate and schedule for the scope of work described above at the request of Thurston County. If the County desires to proceed with Phase II activities, GeoEngineers is prepared to respond to the field immediately following verbal authorization. We will request assistance from the County in obtaining right-of-entry agreements with property owners for the proposed locations and permission to use public rights-of-way.

LIMITATIONS

We have prepared this report for use by Thurston County Development Services. The data and the report may be made available to other parties, as the County deems appropriate, but our report, conclusions and interpretations should not be construed as a warranty of the subsurface conditions.

This report is based on conditions present as of March 16, 1999. Data collection and field observations are continuing and additional information could result in modifications to our conclusions or recommendations.

Within the limitations of scope, schedule and budget outlined in our contract with Thurston County, our services have been performed in accordance with the standard of care and skill ordinarily exercised by other geotechnical professionals in the area at the time the report was prepared. No other warranty or conditions, express, or implied, should be understood.

————— ◆ —————

Thank you for the opportunity of working on this project. Please call if you have questions regarding this report or require additional information.

Very truly yours,

GeoEngineers, Inc.

William E. Halbert
Senior Hydrogeologist

Jon W. Koloski
Principal

WEH:JWK:vc

Document ID: 7318001R.DOC

Attachments

DRAFT

BIBLIOGRAPHY

- Bradley-Noble Geotechnical Services, 1996, Report to Mr. John Arata regarding a geotechnical evaluation of soil stability in the area of 10103 and 10137 Mariner Drive, in Carlyon Beach.
- Bradley-Noble Geotechnical Services, 1997, Report to Wes and Elaine Dillon regarding landslide investigation conducted at 9710 Northwest Hunter Point Road, Thurston County, Washington.
- Jerome W. Morrisette and Associates, Inc., 1997, Slope Failure Evaluation, Mariner/Crestridge Drive NW" for Carlyon Beach Homeowners' Association.
- Jerome W. Morrisette and Associates, Inc., 1999, "1999 Slope Failure Evaluation, Mariner/Crestridge Drive NW" for Carlyon Beach Homeowners' Association.
- Squier/HGI Associates, 1998, "Foundation Investigation, Proposed Community Water Storage Tank, Olympia, Washington", for Carlyon Beach Homeowners' Association.
- Thurston County Department of Roads and Transportation - Aerial Photographs of the Carlyon Beach/Hunter Point area dated 8/14/53.
- United States Department of the Interior Geological Survey, 1994, "Hydrology and Quality of Ground Water in Northern Thurston County, Washington", Water Resources Investigations Report 92-4109.
- United States Department of the Interior Geological Survey, 1968, "Squaxin Island, Washington Quadrangle 7.5 Minute Series (Topographic)".
- Walsh, T.J., Korosec, M.A., Phillips, W.M., Logan, R.L., and Schasse, H.W., 1987, "Geologic Map of Washington - Southwest Quadrant". Washington Division of Geology and Earth Resources Geologic Map GM-34.
- Washington State Department of Ecology, 1980, "Coastal Zone Atlas of Washington State, Thurston County".
- Washington State Department of Ecology, Southwest Region - Logs of various water wells for sections 33 and 34, Township 20 North, Range 2 West.
- Washington State Department of Natural Resources - Aerial Photographs of the Carlyon Beach/Hunter Point area dated 6/4/65, 5/19/78 and 5/19/95.

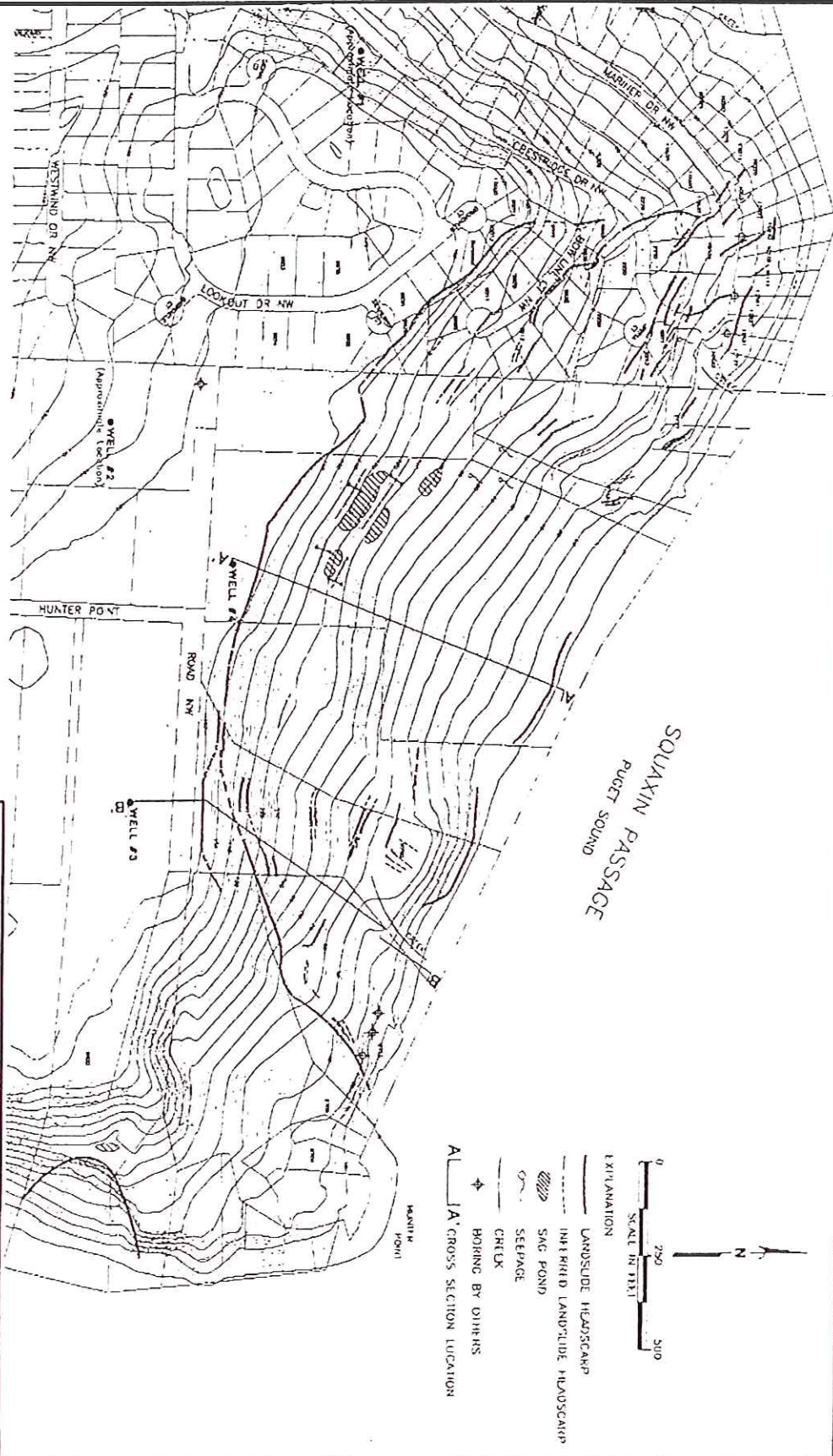
CRA:LA P:\7318001\CAD\7318001A.DWG

03/17/99

Note: The locations of oil features shown are approximate.
 Reference: Drawings provided by Thurston Geoplate Center, March 1999.

Geo  Engineers

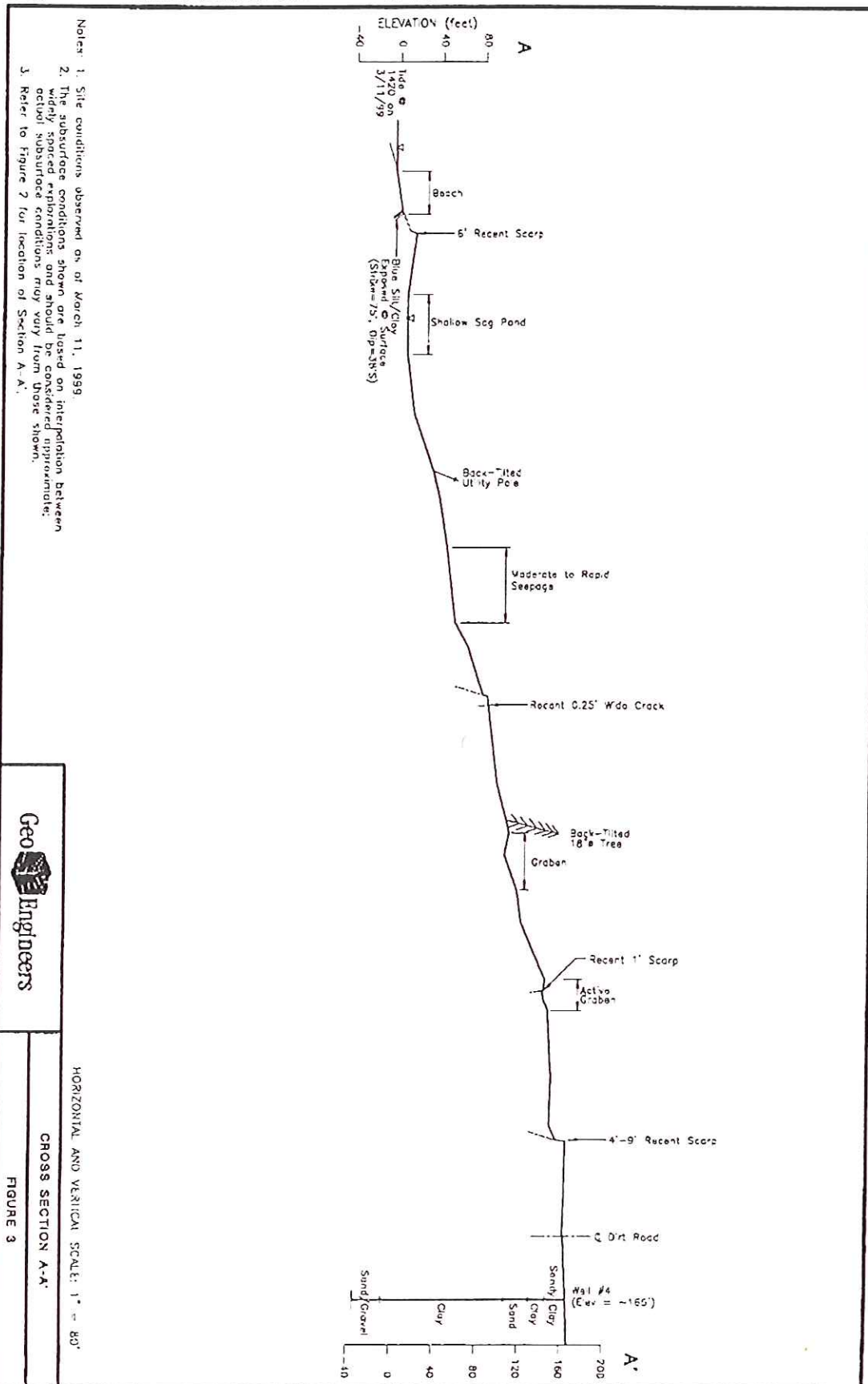
SITE PLAN
 FIGURE 2



07-838

P:\7318001\CAD\7318001B.DWG

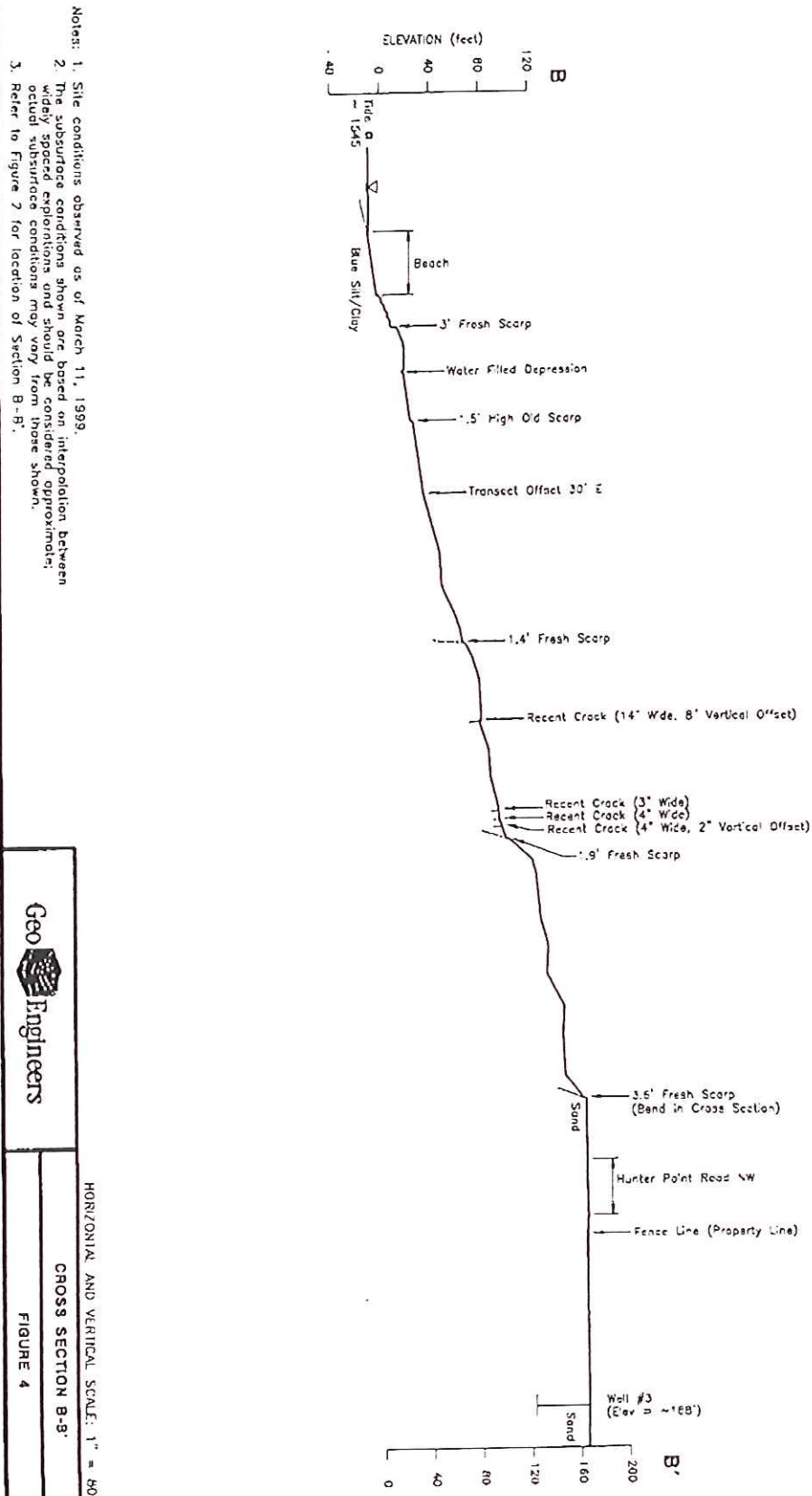
03/17/93

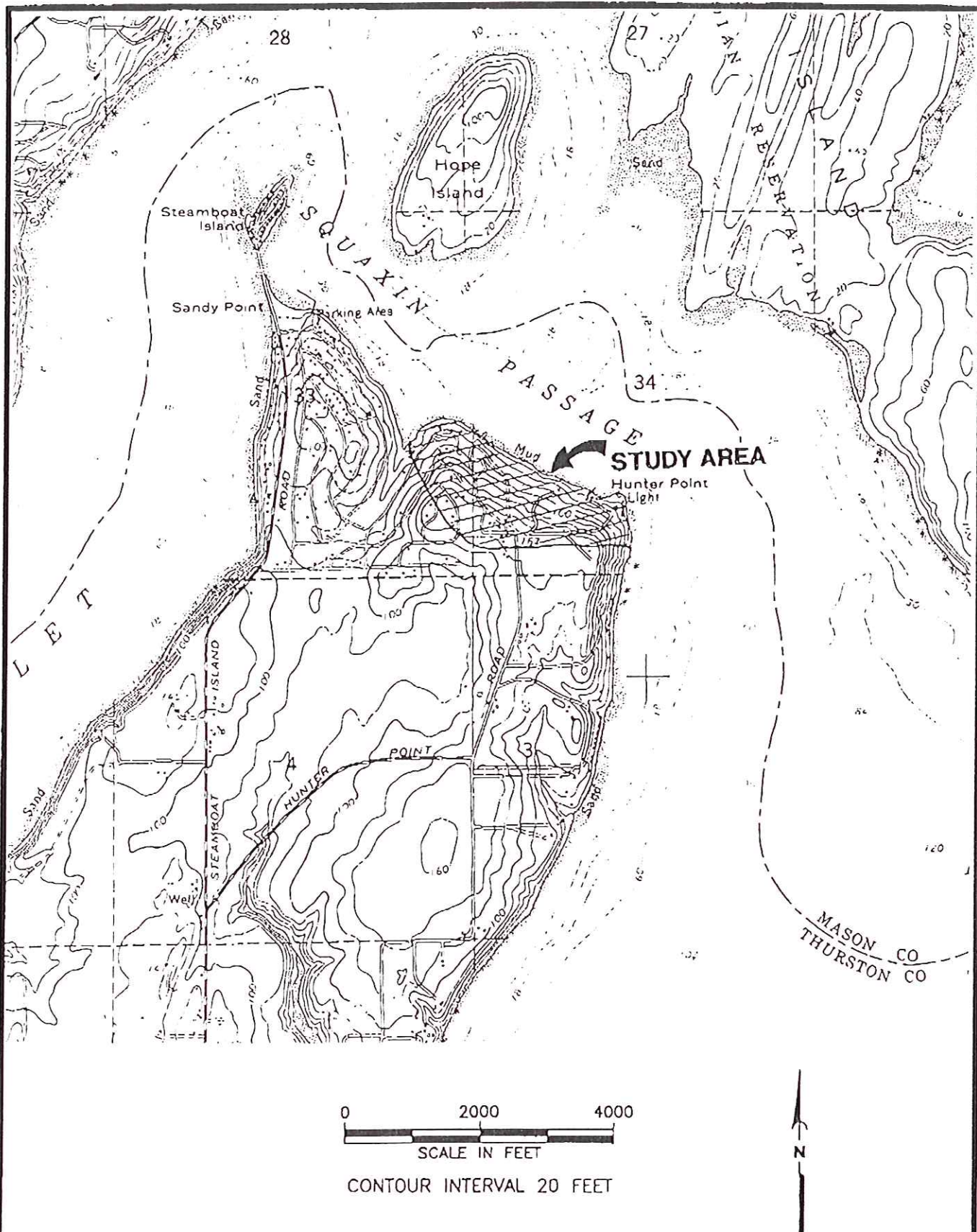


3EB:10

P:\7318001\CAD\73180010.DWG

03/18/99





Reference: USGS 7.5' topographic quadrangle map "Squaxin Island, Wash." photorevised 1968.

C:\7318001\CAD\73180010.DWG C3/17/95

