Northwest Geological Society

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Society Field Trips in Pacific Northwest Geology

Quaternary Geology of the Tacoma Area

June 26 - 27 1999

Kathy G. Troost
Derek B. Booth
Patrick Pringle

*Note- Some images in this guide have been slightly reduced in size to fit format requirements

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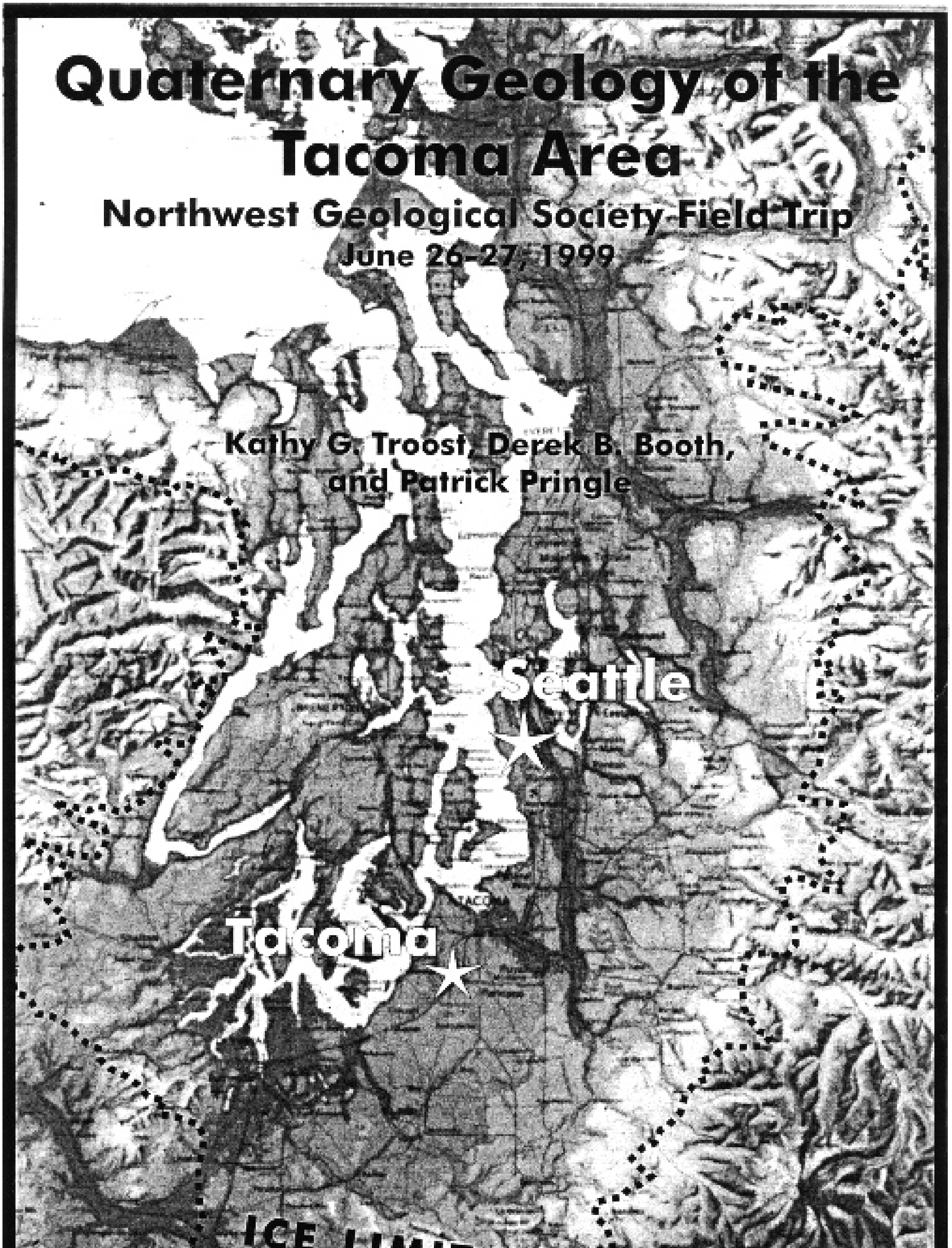

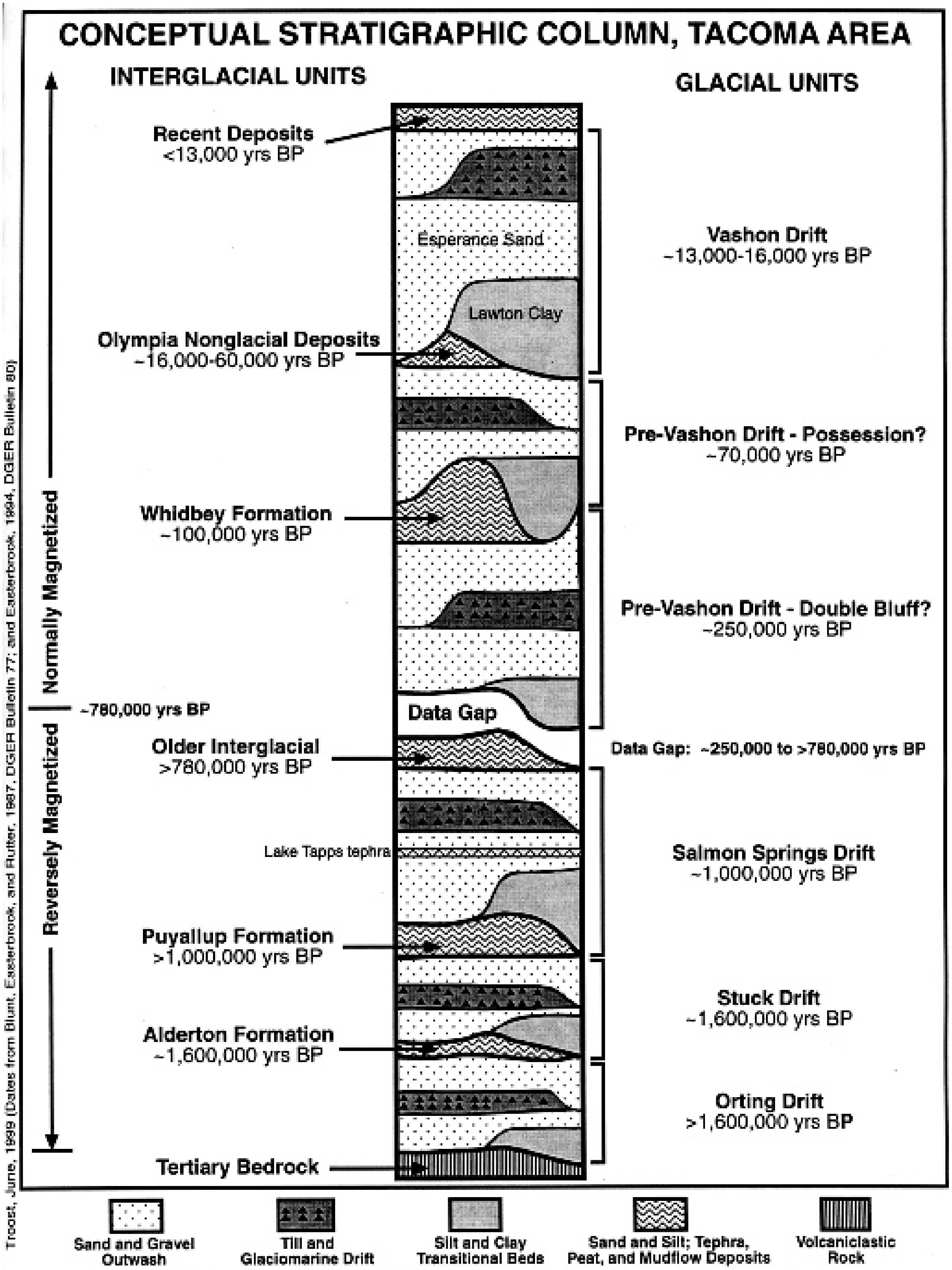
CONCEPTUAL STRATIGRAPHIC COLUMN, TACOMA AREA
INTERGLACIAL UNITS
GLACIAL UNITS
Recent Deposits
<13,000 yrs BP
Esperance Sand
Lawton Clay
Olympia Nonglacial Deposits
~16,000-60,000 yrs BP
Vashon Drift
~13,000-16,000 yrs BP
Pre-Vashon Drift - Possession?
~70,000 yrs BP
Whidbey Formation
~100,000 yrs BP
Pre-Vashon Drift - Double Bluff?
~250,000 yrs BP
Normally Magnetized
~780,000 yrs BP
Data Gap
Reversely Magnetized
Older Interglacial
>780,000 yrs BP
Data Gap: ~250,000 to >780,000 yrs BP
Lake Tapps tephra
Salmon Springs Drift
~1,000,000 yrs BP
Puyallup Formation
>1,000,000 yrs BP
Stuck Drift
~1,600,000 yrs BP
Alderton Formation
~1,600,000 yrs BP
Orting Drift
>1,600,000 yrs BP
Tertiary Bedrock
Troost, June, 1999 (Dates from Blunt, Easterbrook, and Rutter, 1987, DGER Bulletin 77; and Easterbrook, 1994, DGER Bulletin 80)
Sand and Gravel Outwash
Till and Glaciomarine Drift
Silt and Clay Transitional Beds
Sand and Silt; Tephra, Peat, and Mudflow Deposits
Volcaniclastic Rock

Quaternary Stratigraphy of the Tacoma Area

Correlation and chronology of Quaternary deposits in the Tacoma area has long been a source of frustration for those working in the area. Much field and laboratory research, utilizing radiocarbon dating, paleomagnetic studies, tephrochronology, bulk geochemistry, thermoluminescence dating, fission track dating, and pollen and diatom analyses, is underway to establish the chronology and distribution of these and other critical Quaternary deposits. In addition, efforts are underway to confirm correlation of units here with the well-developed stratigraphy of southeast and northern Puget Sound (see strati graphic column). Most of the chronologic work on Quaternary stratigraphy has been accomplished by Easterbrook (1994) and his co-researchers. He compiled the following stratigraphic section for the Puget Lowland. Note that there is no “named” Olympia-age deposit on this section:

The field trip will visit newly measured sections that span the Steilacoom Gravel of the Vashon Drift through deposits tentatively correlated with the Puyallup Formation. Emphasis will be on stratigraphic relationships and Quaternary history, evidence (or lack) of tectonic deformation, variability within individual strata, and impacts to local and regional groundwater patterns.
Regional Geologic Setting

The southern Puget Lowland has been glaciated at least six times during the Pleistocene Epoch (Easterbrook, 1994). The most recent, during the Vashon Stade of the Fraser Glaciation, was marked by the advance and retreat of the Puget Lobe of the Cordilleran Ice Sheet in western Washington. The glacier reached the central Puget Sound region about 15,000 14C years BP and retreated past this area by 13,650 14C years BP. Nonglacial deposits, where present, separate deposits of one glacier advance from another. Because the coastal mountains of British Columbia were the source area for each of the ice sheet advances, macroscopic lithology cannot be used to identify or differentiate the deposits of one glacial period from another glacial period. Because the Cascade volcanoes were primary sediment source areas during each nonglacial period in the Tacoma area, sediment lithology is probably not useful as a basis for differentiating the deposits of one nonglacial interval from those of another.

Field Identification of Nonglacial Deposits
Field recognition of nonglacial deposits depends heavily on the ability to differentiate glacial from nonglacial deposits. Because of the mixing that results from reworking of underlying deposits during a glacier advance and erosional/sedimentation cycles, differentiation of glacial from nonglacial deposits is unavoidably ambiguous. For end-member cases, however, several distinguishing characteristics are as follows. The following table (Troost and others, 1998) summarizes the criteria for differentiating glacial from nonglacial deposits. Note that some of the criteria only work in the south part of the Lowland.

During glacial periods the apparent source of sediments is displaced to the north relative to nonglacial periods. In the Tacoma area, nonglacial sediments are predominantly derived from Mount Rainier and proto-Mount Rainier to the southeast (see Table 3 below from Noble and Wallace, 1966). Glacial sediments, however, are dominated by lithologies with sources from the central and north Cascades more than 30 miles north. Similarly, nonglacial sediments that are exposed along Hood Canal on the western margin of the lowland are predominantly composed of lithologies from the Olympic Mountains, but glacial sediments are predominantly derived from the North Cascades (Borden, 1998). In the Seattle area during nonglacial times, rivers carry sediments from both the Mt. Rainier area and the central Cascades. These relationships are probably valid for glacial and nonglacial sediments throughout the lowland, although it may be locally complicated by the reworking of older glacial sediments during interglacial periods. Furthermore, the percentage of land area receiving deposition is small during nonglacial periods rela-

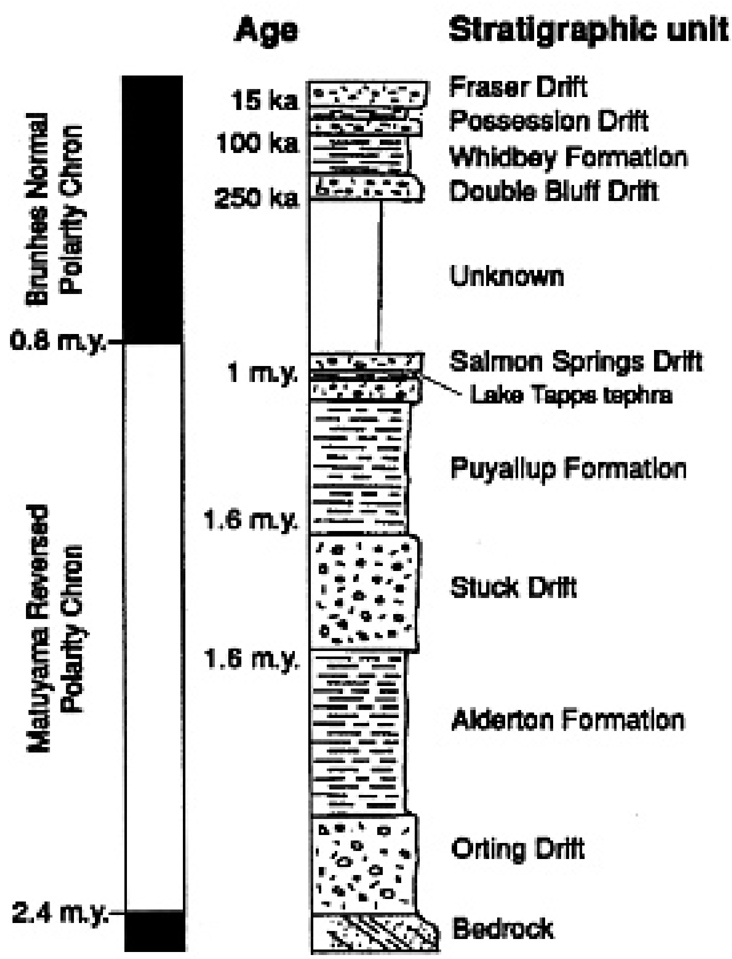

Figure 2. Composite stratigraphic section and ages of sediments in the Puget Lowland.

CRITERIA	Glacial	Nonglacial
Source Area	Northern and Central Cascades	Mount Rainier area
Lithology	granites and metamorphic rocks	andesites
Mineralogy	garnets, epidotes, abundant quartz	hypersthene
Mode of Deposition	glacial ice, meltwater, lacustrine	fluvial, subaerial, lacustrine
Organics	detrital	peats, paleosols
Volcanic Deposits	detrital, rare tephras	lahars, tephras, pumice clasts
Silt/Sand Color	"salt and pepper", gray, brown	lavender, pink, red, white, gray, dark brown

tive to glacial periods, as shown on the figure on the following page from Borden and Troost (1999).

Table 3.- Source areas of the unconsolidated deposits of the southern Puget Sound lowland

(Provenance of heavy minerals contributed by D. R. Mullineaux, U. S. Geological Survey.)

Source area	General color of unweathered deposits	Indicator stones	Indicator minerals
Northern Cascades (north of Stevens Pass)	In Thurston County rocks from these areas are mixed. Much light gray, black, some pink, green. No reds.	Granites Metamorphic rocks	Garnet Epidote
Central Cascades (Stevens Pass south to Mount Rainier)		Granodiorites, Keechelus and Northcraft lavas which are light green to black. Very dense, may have feldspar phenocrysts.	Hypersthene Hornblende Epidote
Mount Rainier	Much light gray with few whites, reds, greens.	Pink, red, gray, purple, and black lava with many small voids. May have coarse phenocrysts of hypersthene and hornblende.	Hypersthene

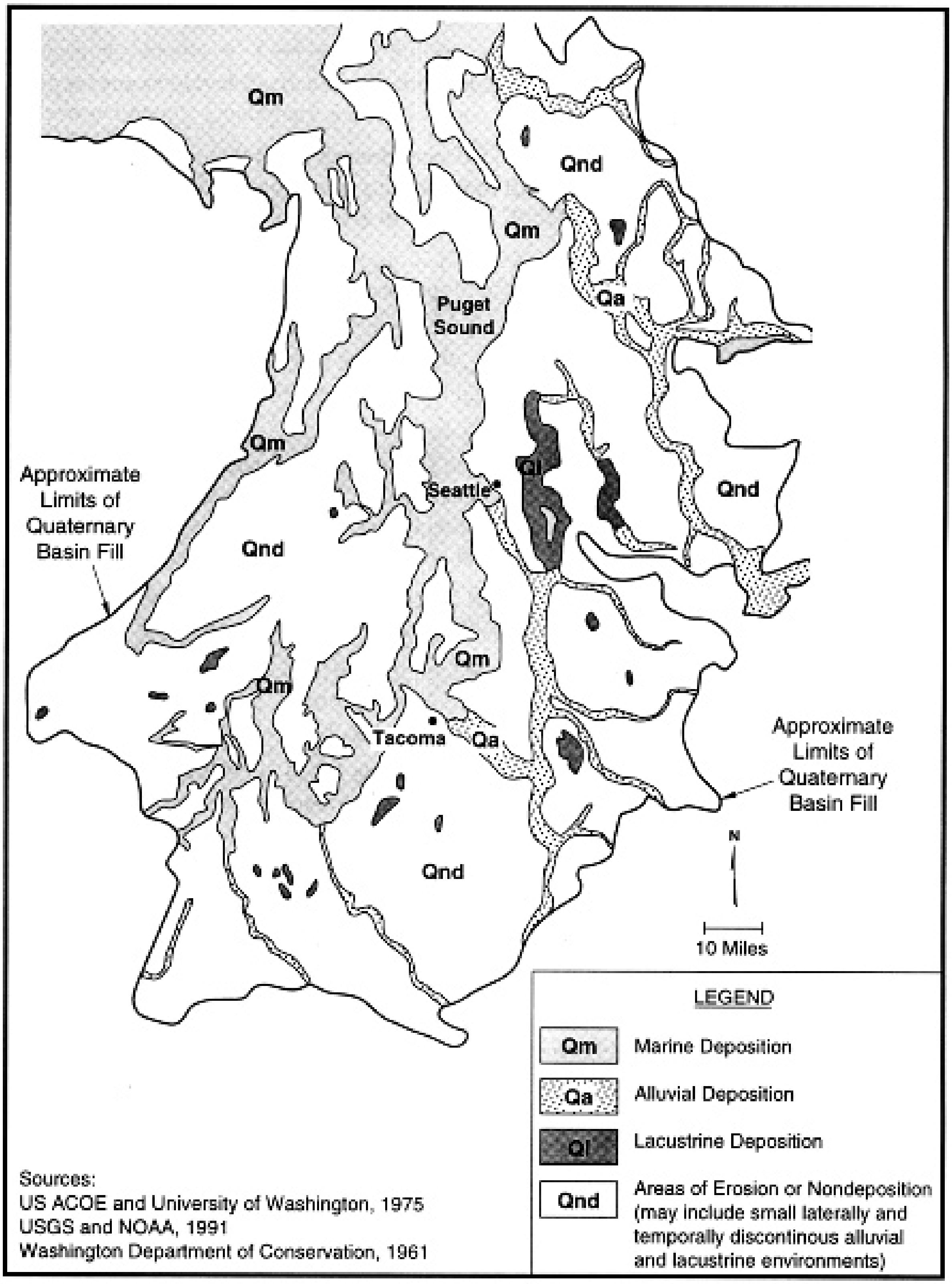

Figure 2-1 Modern Puget Lowland Depositional Environments

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NEW GEOLOGIC MAPS OF THE TACOMA AREA IN PRESS, REVIEW, OR PREPARATION:

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Summary of Field Trip Sites

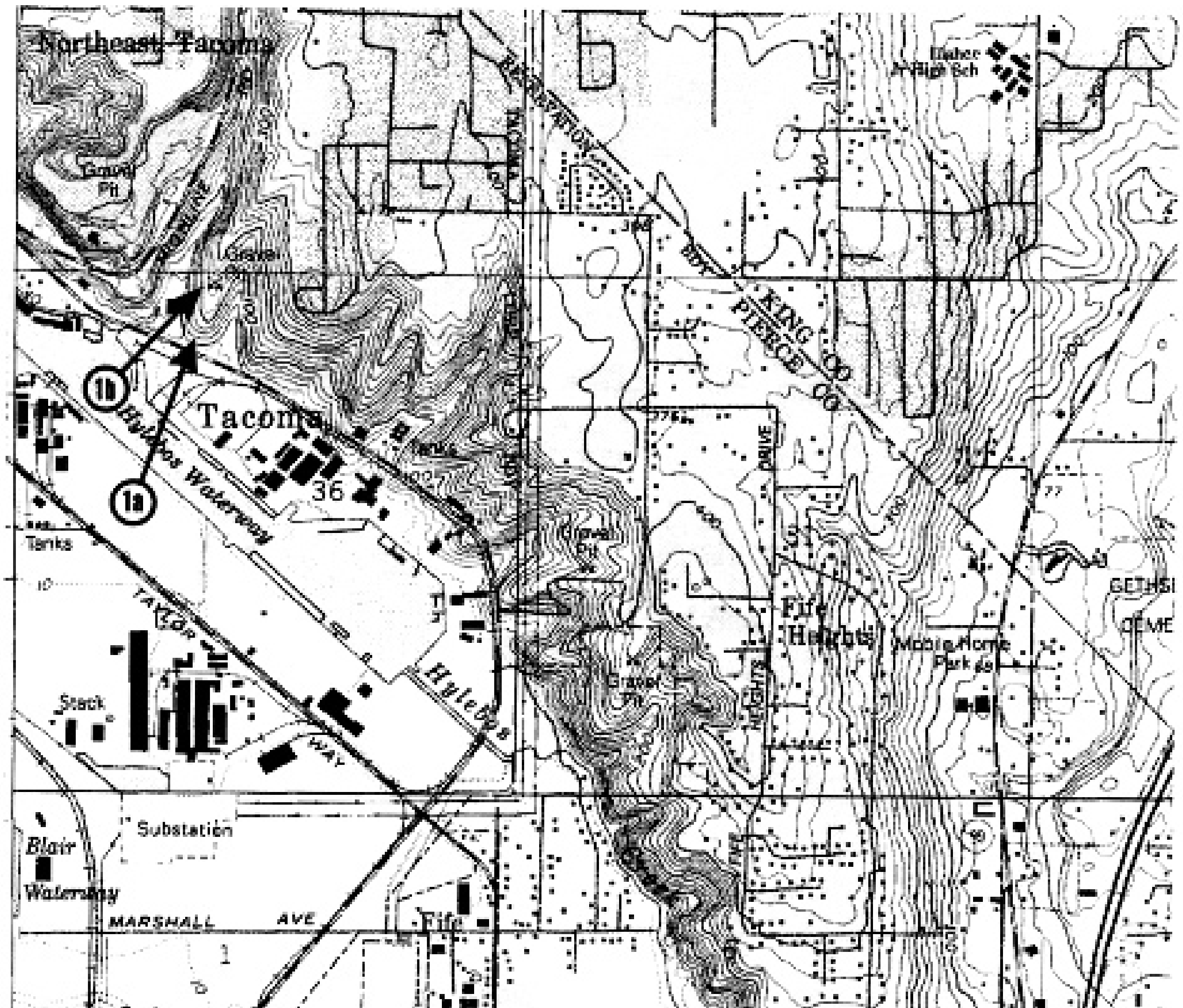
Stop #	Name	Start	End	Activity	Notes
Saturday 6/26/99		7:00	8:00	Depart in van from University of Washington	
		7:30		Depart in van from SR 16 Park-and-Ride	
1	Woodworth Quarry and Jones East	8:00	9:00	View road-level exposure (a); Walk up to abandoned quarry (b)	(a) Good exposure of reversely magnetized nonglacial deposits with multiple tephra layers; andesite-rich sand. Fission-track dated at 1.1 my (Stewart, pers.comm., 1999) (b) Contact between unoxidized Vashon outwash and older, somewhat oxidized outwash Vashon and Olympia-age deposits are now covered by the residential development at Pointe Woodworth at top of slope and to the northwest. There is at least one major unconformity present in this section, on top of the pre-Olympia glacial drift (Stop 1b) and/or between the pre-Olympia glacial deposits and 1.1 MY old nonglacial deposits at bottom of slope. The older oxidized outwash has been mapped as Salmon Springs. There is no evidence to make this correlation. The 1.1 MY nonglacial deposits may correlate with the Puyallup Fm based on age. While driving along Marine View Drive, observe the white layer at the break in slope or bench at about 100 ft in elevation. This layer can be correlated along the bluff line with the dated Olympia deposits at Pointe Woodworth. Peats bracketing this white layer (reworked volcanic ash) at many of these quarries confirm the Olympia age (Borden and Troost, 1999).
		9:00	9:30	Travel to Stop 2	
2	Garfield Park	9:30	10:30	View exposures under vegetation	Nonglacial deposits well exposed here—tephra is reworked and altered, peat is compact and altered (reduced

Stop #	Name	Start	End	Activity	Notes
					environment). This section of nonglacial deposits is fairly continuous along Schuster Parkway to the southeast for about 1 mile, where a thick glaciolacustrine deposit occupies the same elevation. The nature of the contact is unknown.
		10:30	11:00	Travel to Stop 3	
3	Owen Beach	11:00	2:00	Lunch @ beach, walk toward lighthouse and exposures	Note structure (folds and faults) in glaciolacustrine deposits in base of bluff and on beach; contact between Vashon outwash and older outwash based on presence of discontinuous Olympia nonglacial deposits, weathering horizon, and change in oxidation; good exposures of landslides. This beach segment is interpreted to have at least two nonglacial deposits and at least 3 glacial drifts. The lowest of the nonglacial deposits is best exposed at the lighthouse, but it serves as a continuous marker bed for the length of the outcrop. Evidence for progressive deformation includes unconformities within the "Defiance silt" and less folding in progressively younger units.
		2:00	2:30	Travel to Stop 4	
4	Tacoma Public Utilities	2:30	3:30	Examine Vashon till and outwash at gravel pit	Note heterogeneity in till and variability in primary and secondary hydraulic conductivity. Current landscape is predominantly the result of last glaciation; view large recessional outwash channel below (Nalley Valley). The Vashon till in the Tacoma area is generally thinner and contains more sand lenses than in the Seattle area. During drive in Ft. Lewis area, note the flat surface of the Steilacoom outwash plain.
		3:30	4:00	Travel to Stop 5	
5	Sequalitchew delta	4:00	5:00	View planar surface of late-recessional outwash delta and internal sedimentary structure	Note range of sedimentary structures, texture, and clast lithologies. The Sequalitchew delta, like the Steilacoom delta just north, resulted when outwash from glacial Lake Puyallup entered a water body occupying Puget Sound. The Steilacoom plain is marked by kettles indicating

Stop #	Name	Start	End	Activity	Notes
					stagnant ice blocks, possibly carried by torrential meltwater.
		5:00	6:00+	Travel to SR 16 Park-and-Ride, Tides Tavern (Gig Harbor), motel, and campground	
Sunday 6/27/99		8:30	8:45	Depart campground for Stop 6	
6	South Maplewood Driveway	8:45	9:45	View exposure of glacial and nonglacial deposits along (private) driveway	Peat near top of exposure ^{14}C dated at 38,790 ±790 yr B.P.; layer just below is >44,000 yr B.P. Note also sand sill and cross-cutting dike in lower gray nonglacial silt. This is a good exposure to view the heterogeneity within a glacial till and drift package. Till layers grade laterally into dirty outwash and then back into till. The deformation in the beds beneath one of the till layers may have resulted from subglacial processes. Note numerous exposures of Vashon till and underlying advance sand between Gig Harbor and Stop 7.
		9:45	10:15	Travel to Stop 7	
7	Fox Island	10:15	11:30	Walk along beach from Toy Point to Fox Point to observe structures and landslides	Just to south of Toy Point beach access route, two tills (??) are exposed. Walk north towards Fox Point and note broad folding, clastic dikes, and small offsets in low bank below "the castle," high-angle faults in landsliding in high bluff just beyond, and high-angle reverse faults cutting glaciofluvial sediments at Fox Point. The age of the oxidized outwash is unknown (other than pre-Vashon).
		11:30	12:00	Travel to Stop 8	
8	Point Evans	12:00	2:30	Descend to beach for lunch and view of multiple glacial drifts	This section is interpreted to have at least 3 glacial drifts, all normally magnetized. The intervening nonglacial deposits are discontinuous and thin. This is also a good beach section for viewing the lateral variability in iron-oxide staining within the same outwash. The oldest glacial drift contains a deformed till bed.
		2:30	3:15	Travel to Stop 9	

Stop #	Name	Start	End	Activity	Notes
9	East Valley Highway near Sumner	3:15	4:15	View possible lahars and fluvial volcanic sediment within mapped Puyallup Formation	(a) Exposure of nonglacial fluvial deposits and possible lahar in channel. Abundant pumice clasts with hypersthene and hornblende. (b) Exposure of same nonglacial sand overlain by oxidized glacial outwash (mapped as Puyallup and Salmon Springs formations, respectively) by Crandell (1963). At this locality the Puyallup sand also contains multiple ash layers (devitrified airfall).

Stop 1: Jones East (1a) and Woodworth Quarry (1b)



From USGS Poverty Bay 7.5-minute topographic map

Stops 1a and 1b Woodworth Quarry and Jones East

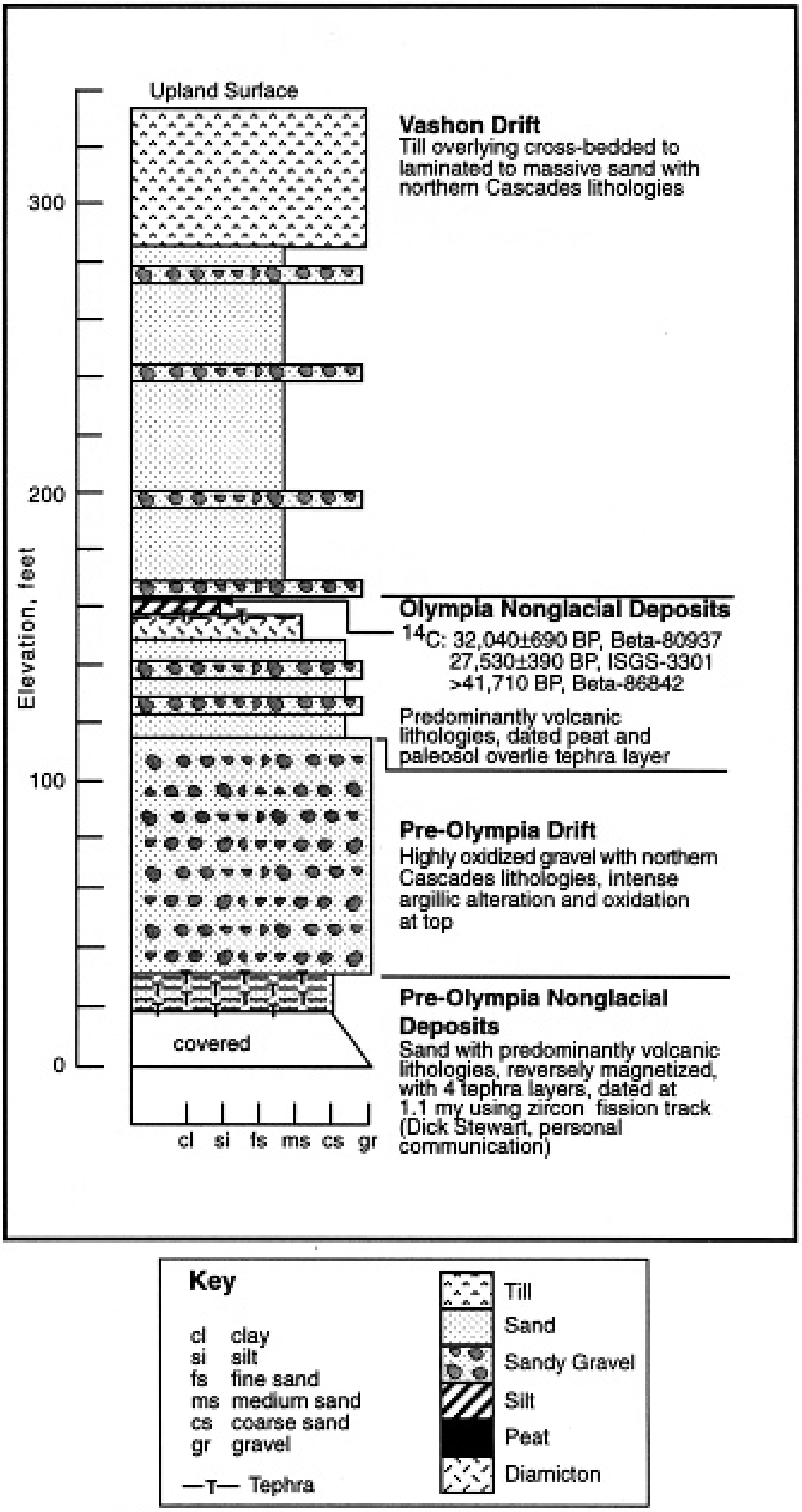
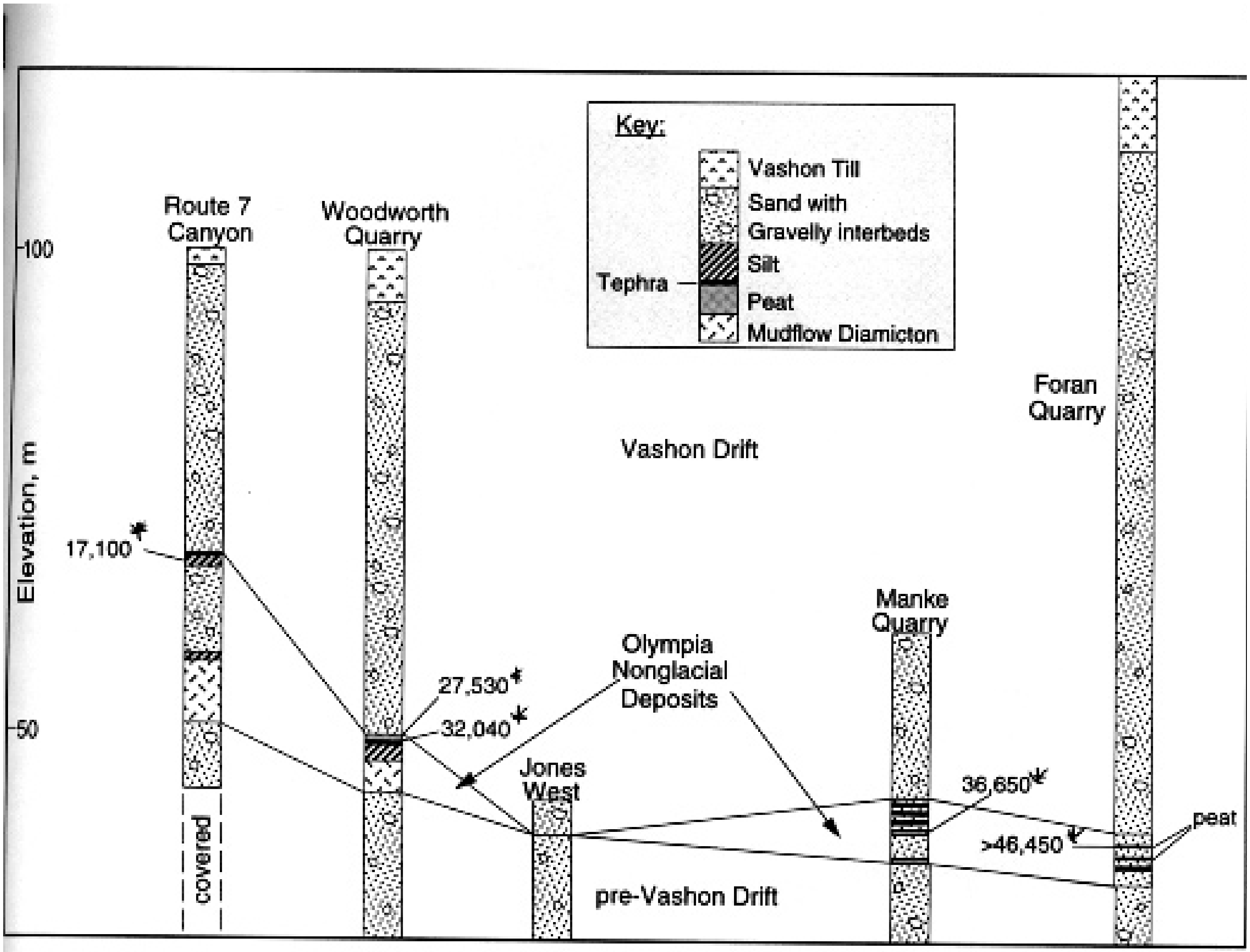
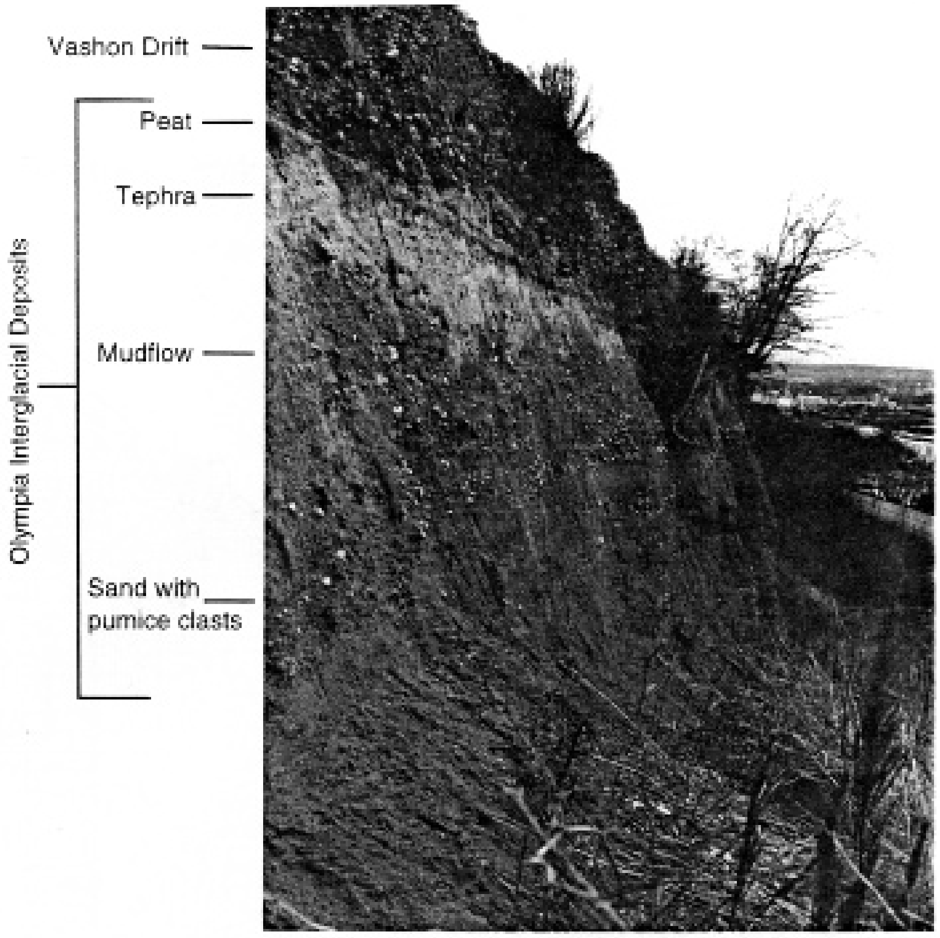


Figure B-1 Woodworth Quarry Measured Section
(Borden and Troost, WDNR OFR, 1999, in review)



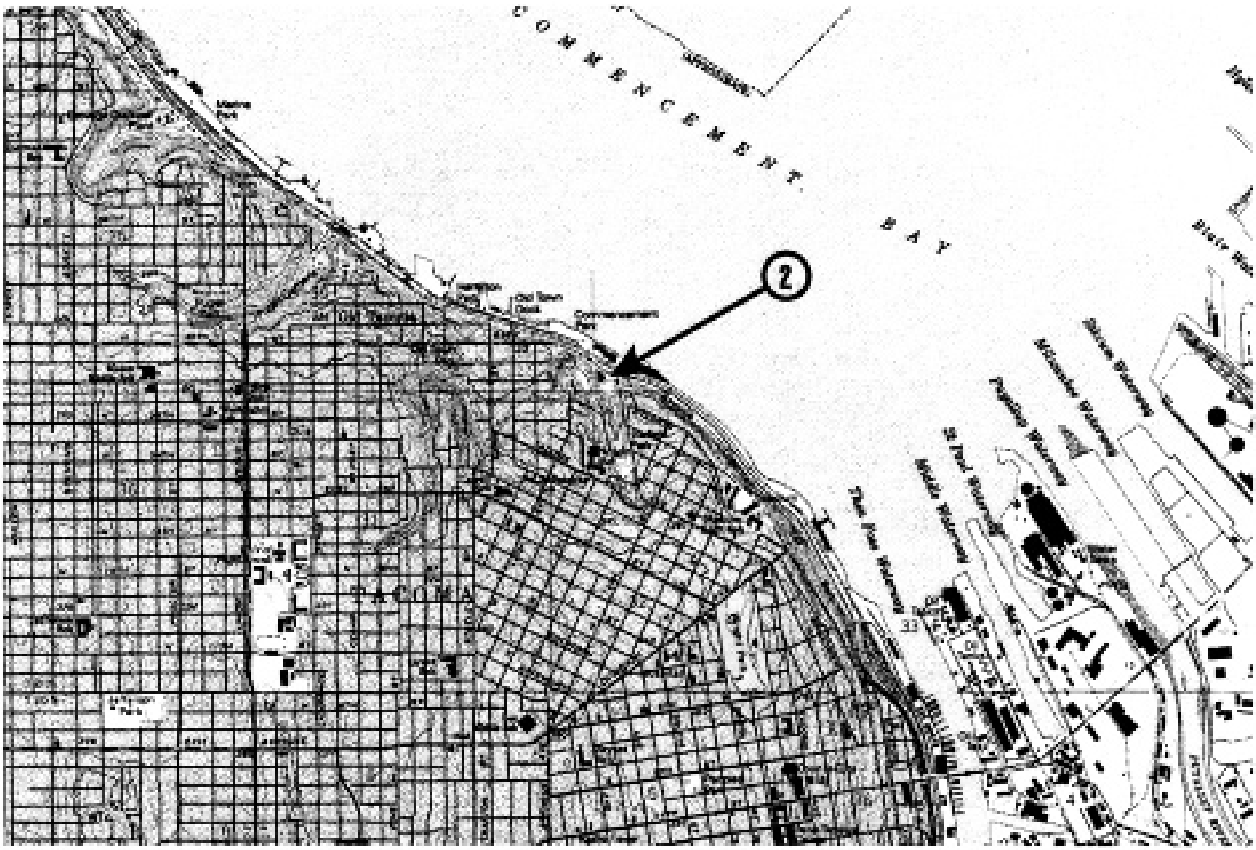
Correlation of Olympia nonglacial deposits along the Hylebos waterway and on Route 7.

* ^{14}C years BP



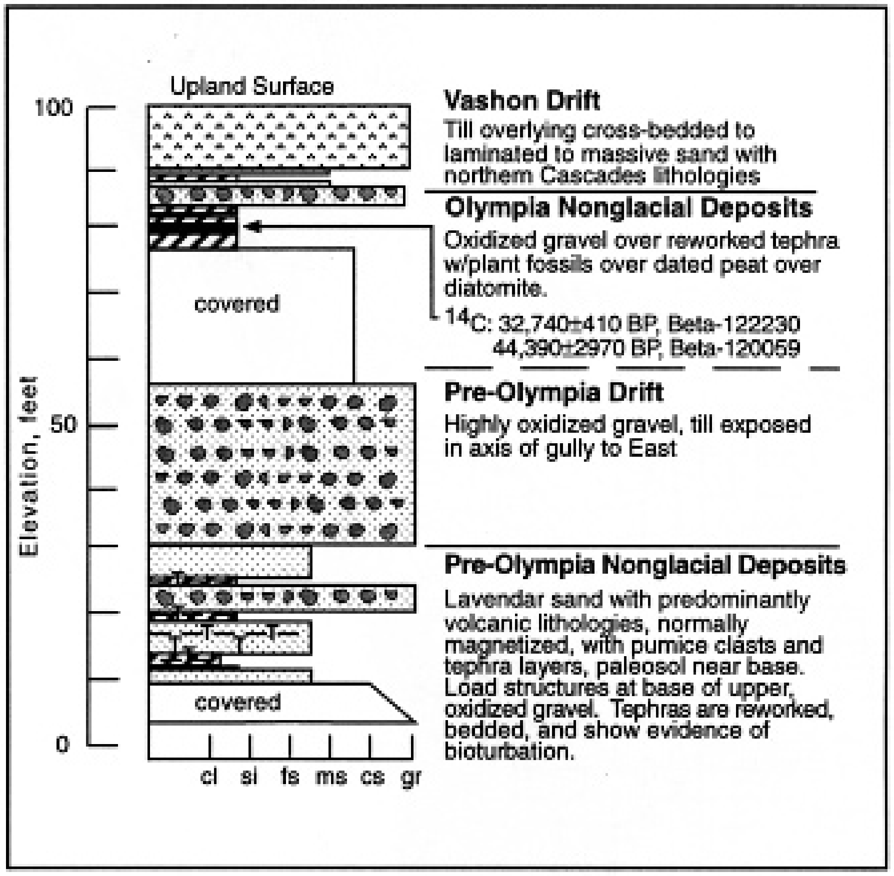
Former exposure of Olympia nonglacial deposits @ Woodworth Quarry. Outcrop has been graded for residential development.

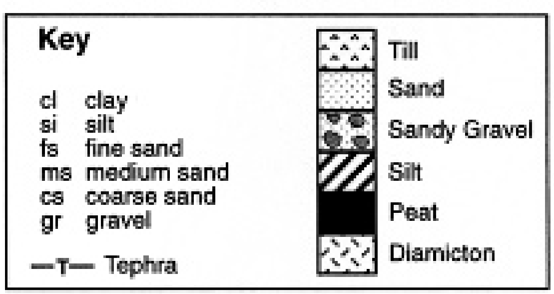
Stop 2: Garfield Park Nonglacial Units



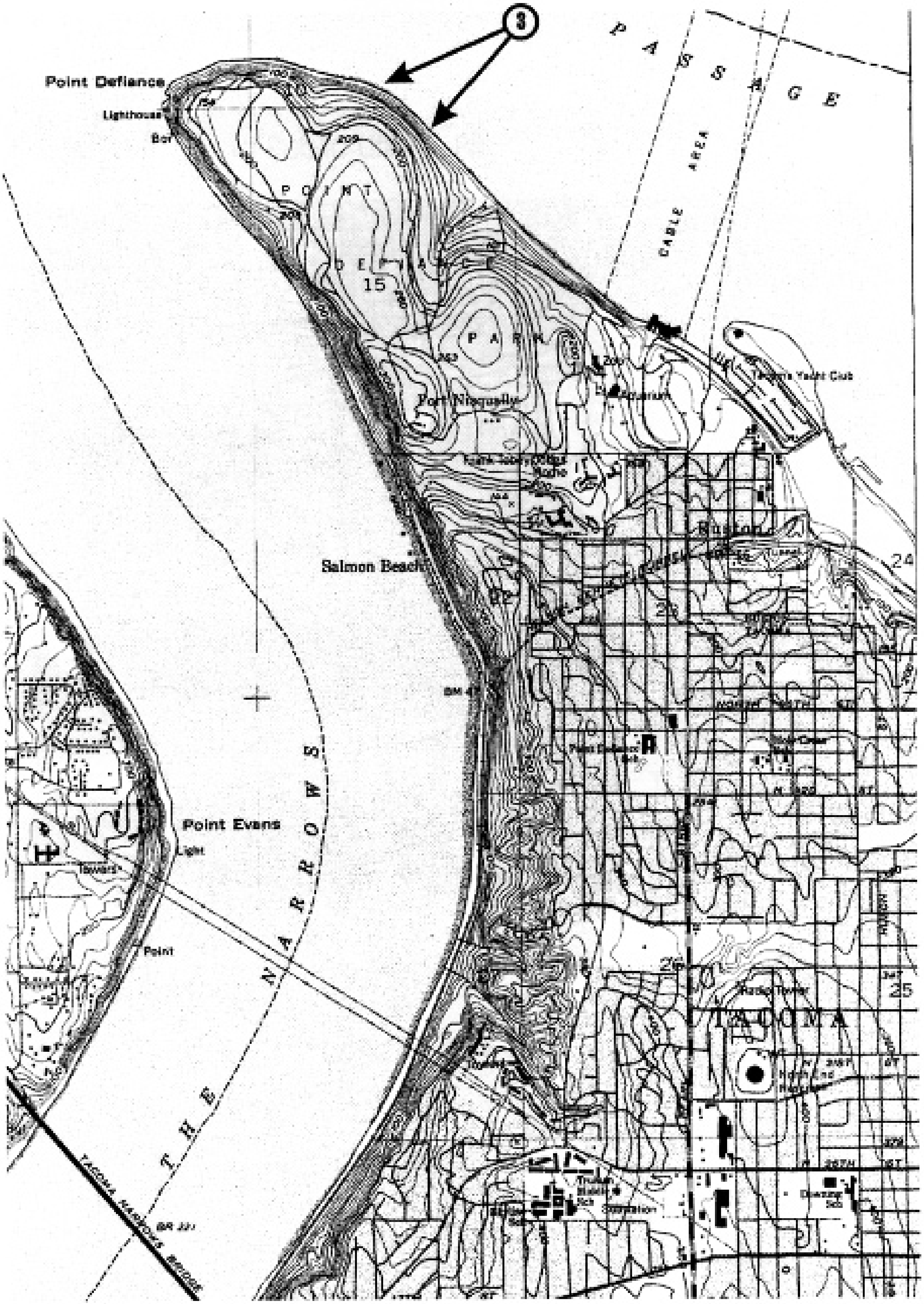
From USGS Tacoma N 7.5-minute topographic map

Stop 2 Garfield Park Composite Section
Northwest side



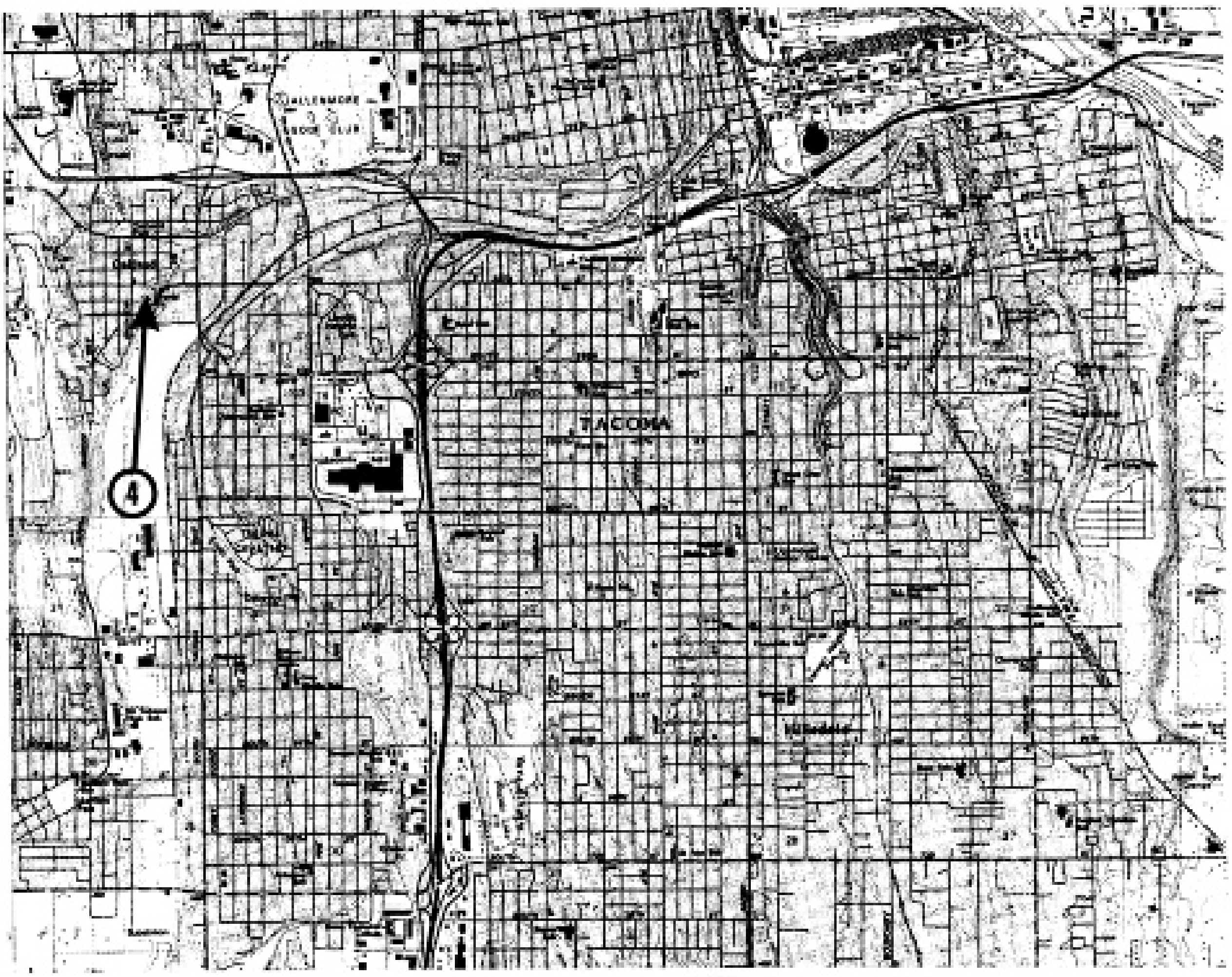


Stop 3: Owen Beach Structure and Stratigraphy



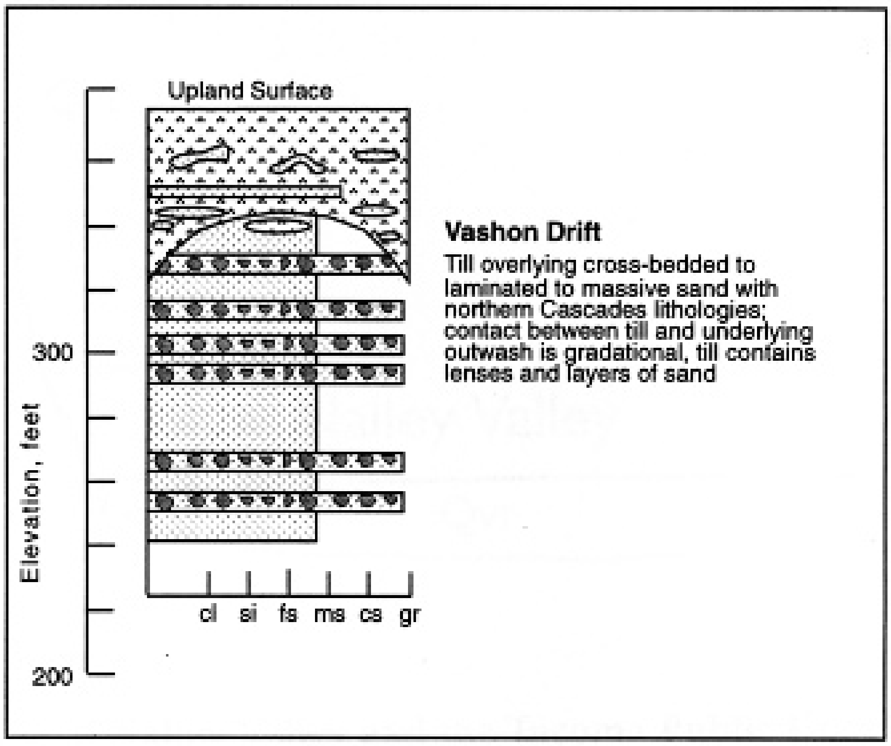
From USGS Gig Harbor 7.5-minute topographic map

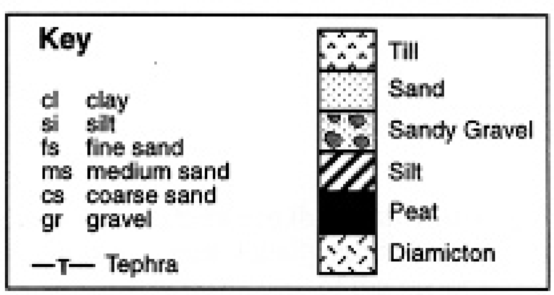
Stop 4: Tacoma Public Utilities Pit



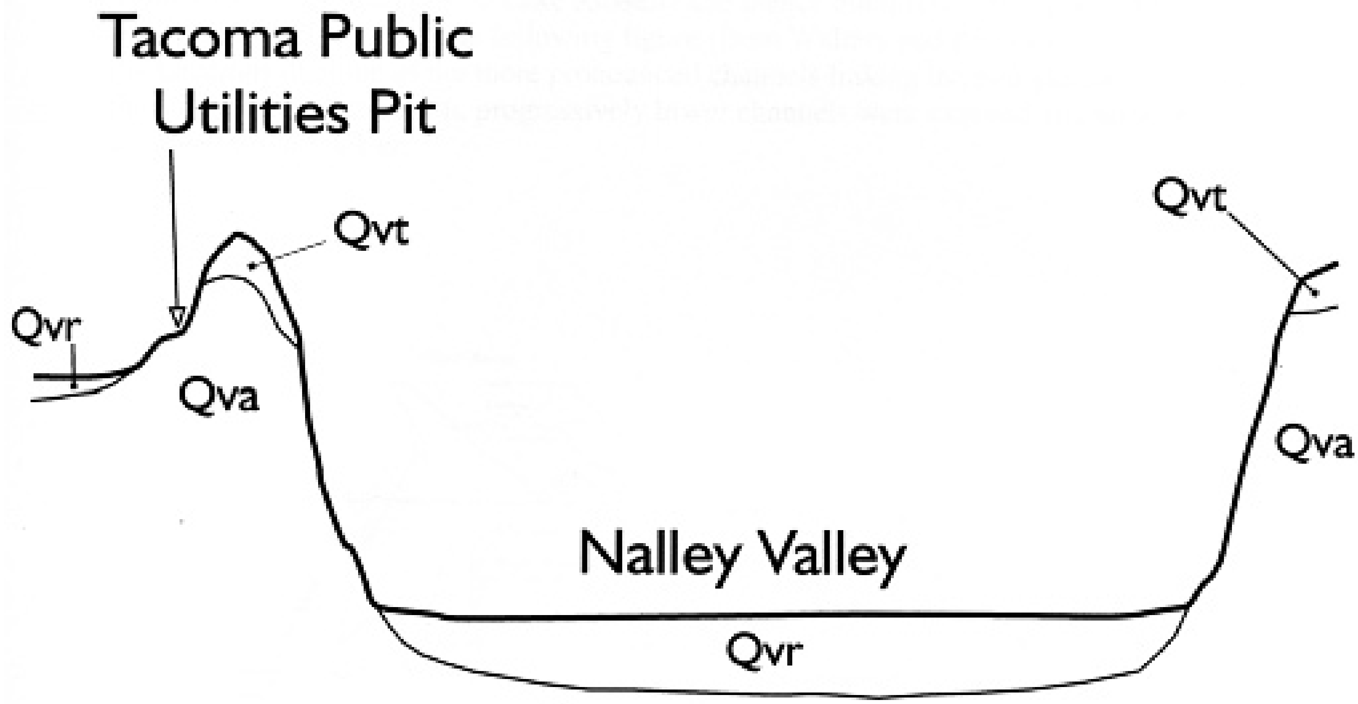
From USGS Tacoma S 7.5-minute topographic map

Stop 4 Tacoma Public Utilities Pit





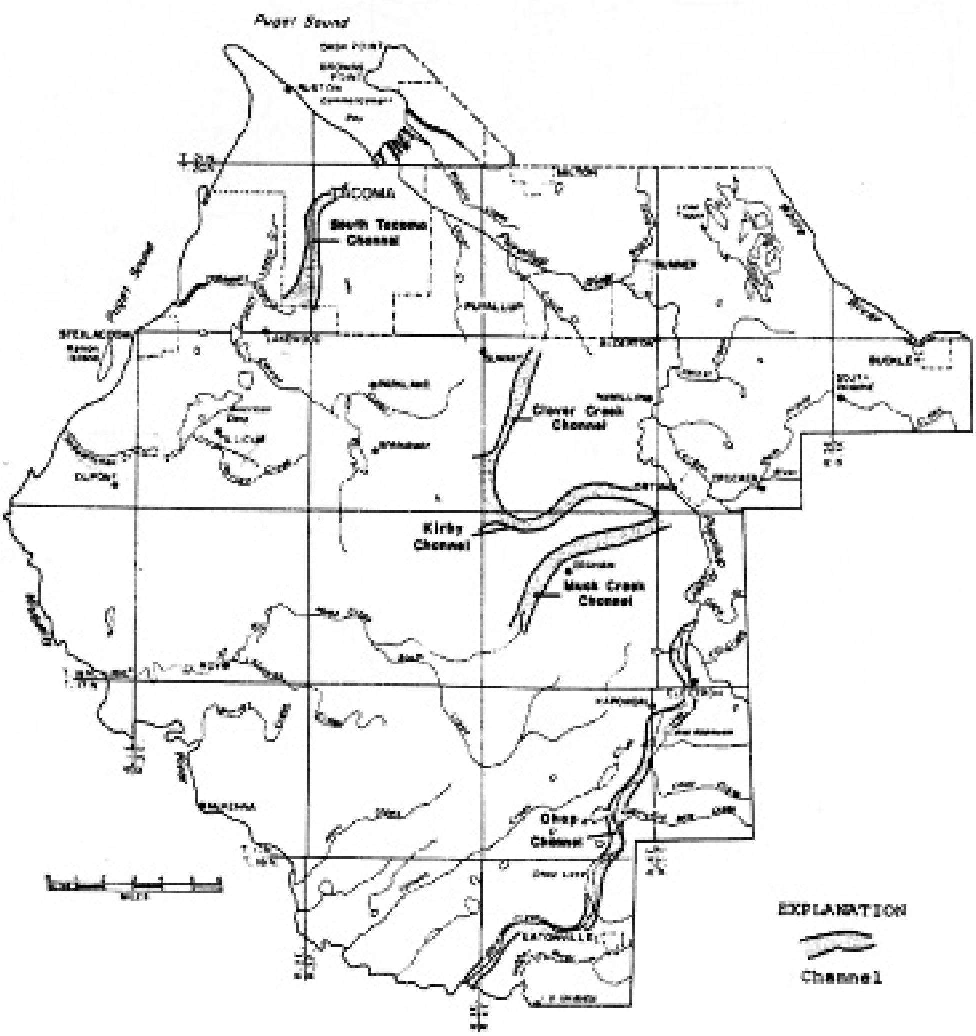
Stop 4:



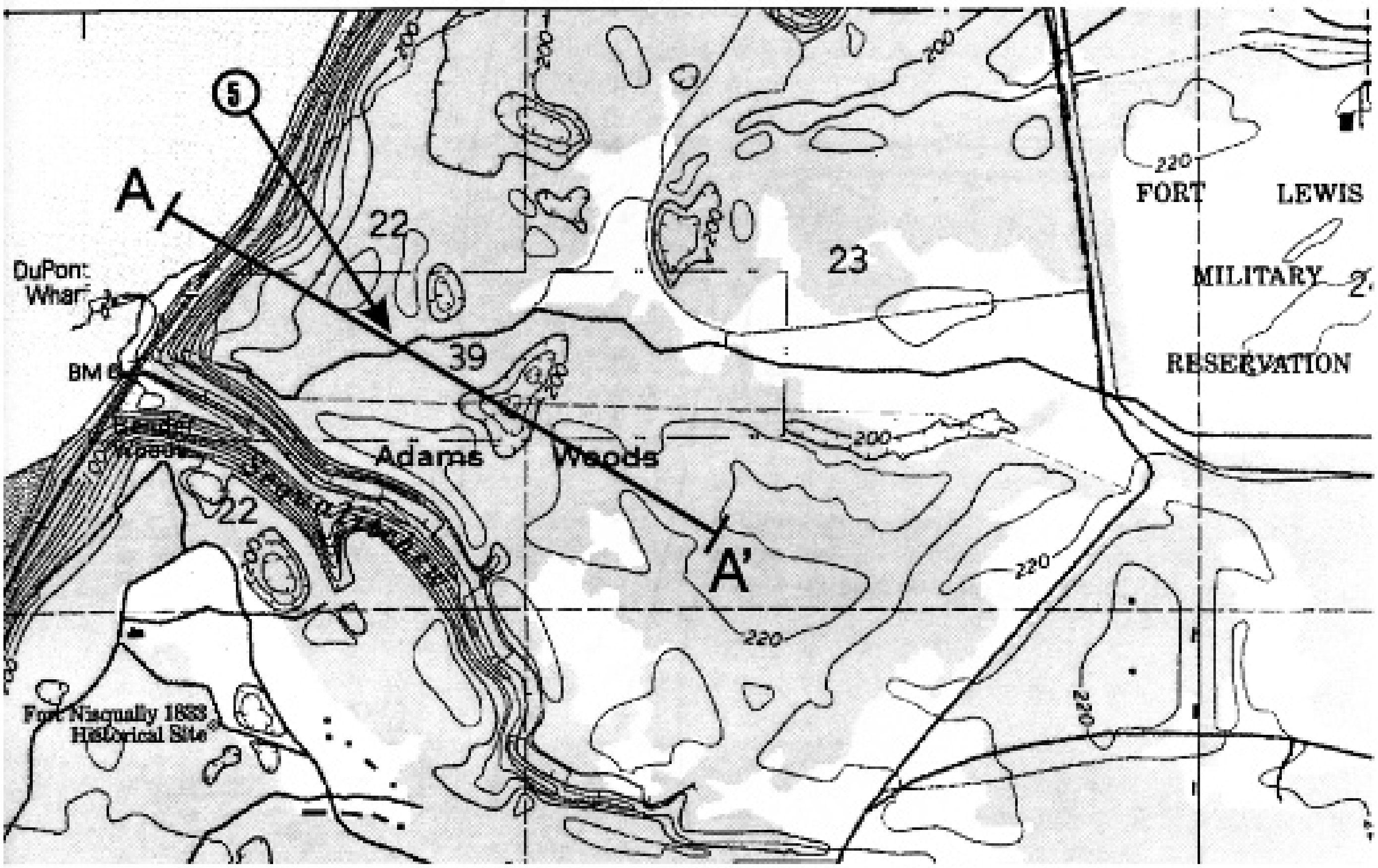
Cross section of Nalley Valley and the Tacoma Public Utilities Pit at Stop 4, looking north

This locality displays a classic relationship between the main Vashon glacial units. The Vashon till (Qvt) drapes the upland surface, but it has been locally eroded by the action of recessional meltwater (leaving deposit Qvr). Nalley Valley is one of the major channels that connected different arms of the proglacial recessional lake that drained through progressively lower spillways into Lake Russell, and from there south over the Black Hills into the Chehalis River. Beneath the recessional and till lies sand and gravel of the Vashon advance outwash (Qva), which constitues most of the topographic relief present in the modern landscape.

In the Tacoma area, multiple recessional channels served as “spillways,” allowing water to drain southwest from glacial Lake Puyallup into the main proglacial lake along the axis of the Puget Lowland (glacial Lake Russell) and thence out through the Black Hills and into the Chehalis River. The following figure (from Walters and Kimmel, 1968) shows the locations of some of the more pronounced channels linking the two glacial lakes. As the ice receded to the north, progressively lower channels were exposed and so were occupied by meltwater.

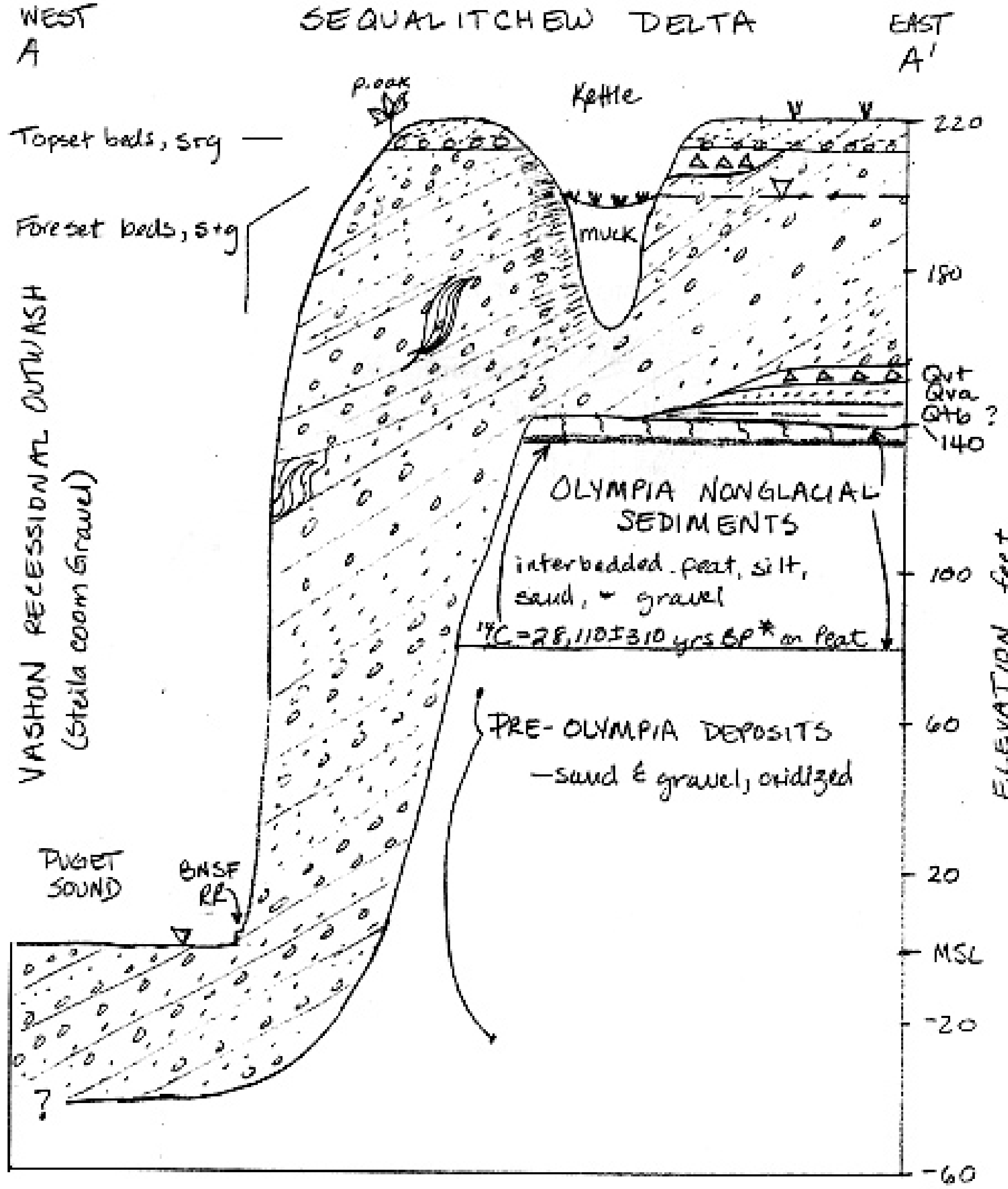


Stop 5: Sequlitchew delta gravel pit



From USGS Nisqually 7.5-minute topographic map

STOP 5
SEQUALITCHEW DELTA



Lone Star DuPont Gravel Pit – pre excavation subsurface data provided by Ron Summers and Dick Inwards, of Lone Star Northwest.

1000 feet

V.E. = 25 x

*Lepp & Koger, AESI, personal communication, 1999 – sample collected from Sequalitchew Creek valley wall, β - 5175

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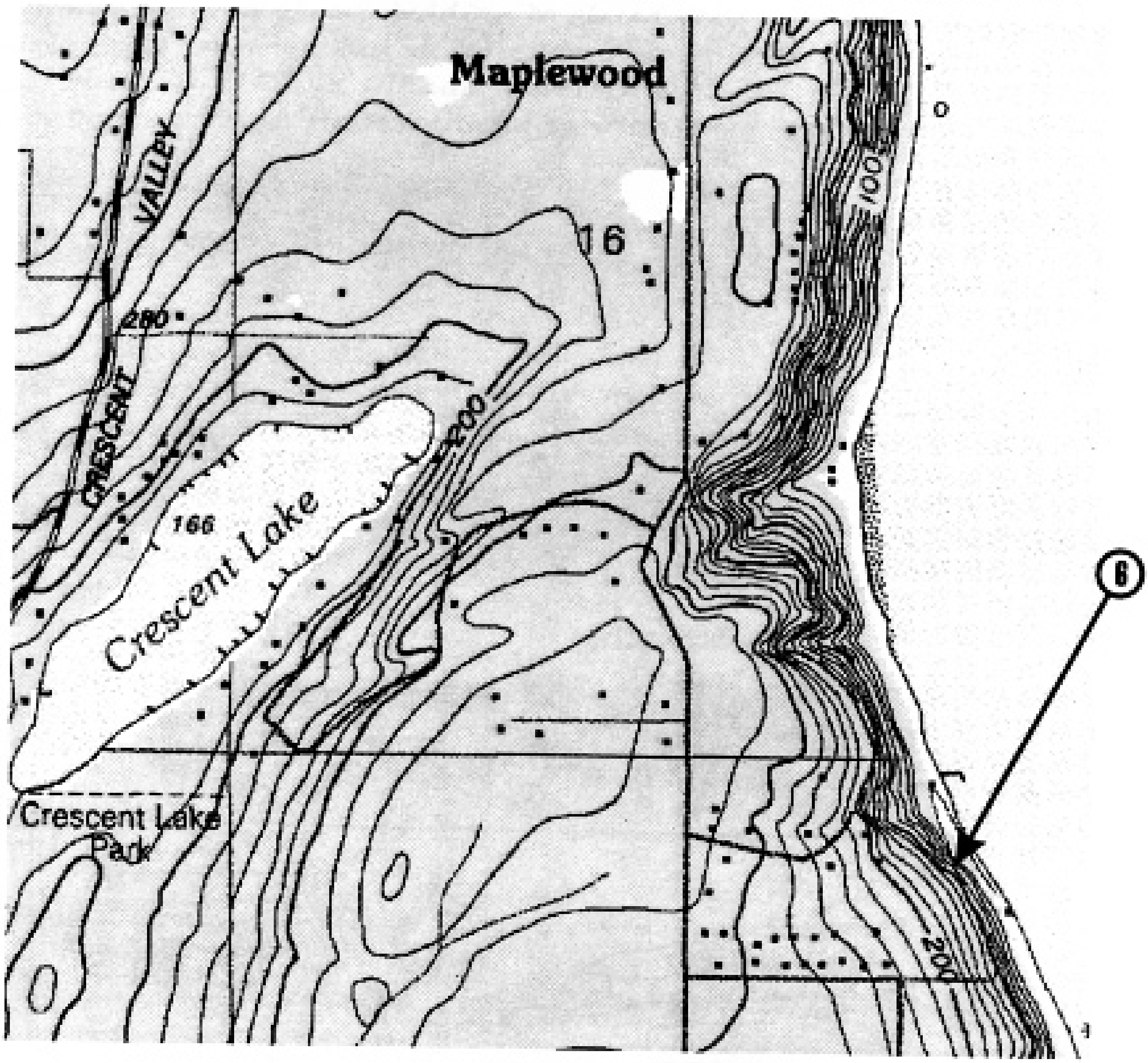
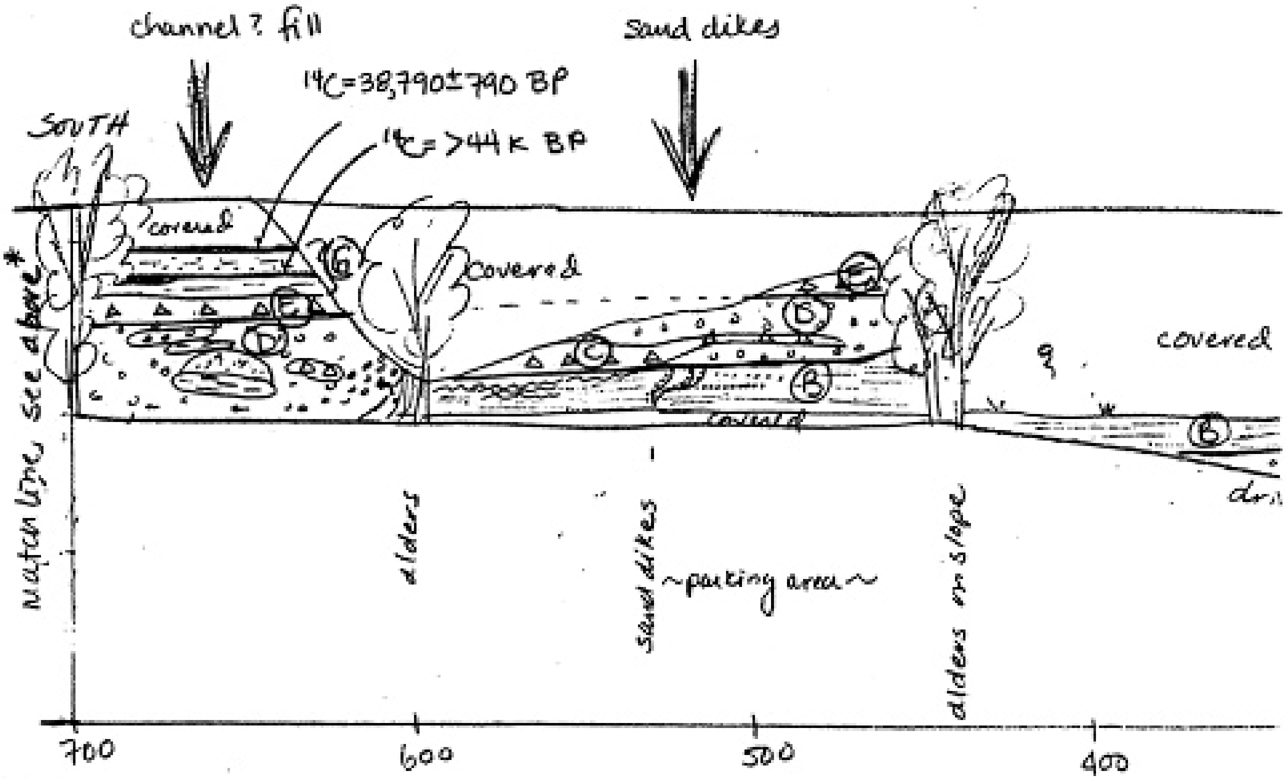
Stop 6: South Maplewood Driveway glaciotectonic features



From USGS Olalla 7.5-minute topographic map

SITE 6

I – oxidized silty GRAVEL; Vashon drift (Qv)
H – SAND over micaceous SILT; transitional beds?
G – SAND, PEAT, org SILT, PEAT, wavy bedding, purple silt (ash?); nonglacial – Olympia-age
F – lightly oxidized GRAVEL and SAND; outwash?
E – glacial diamict; subglacial till
E₁ – subglacial or lodgment facies?
E₂ – subglacial melt out facies? and subglacially sheared + folded SAND + SILT
D – oxidized SAND + GRAVEL w/ large clasts of SILT + GRAVEL; possible channel fill, subglacial or debris flow; oxidized
C – glacial diamicton, may be part of E or D
B – SILT, laminated @ top, wavy bedding in places, very micaceous, finely disseminated organics, sand partings and dikes; nonglacial fluvial deposit
A – oxidized sandy GRAVEL w/ silt and sand interbeds and lenses, glacial lithologies; older outwash, South flow indicated by imbricated gravels



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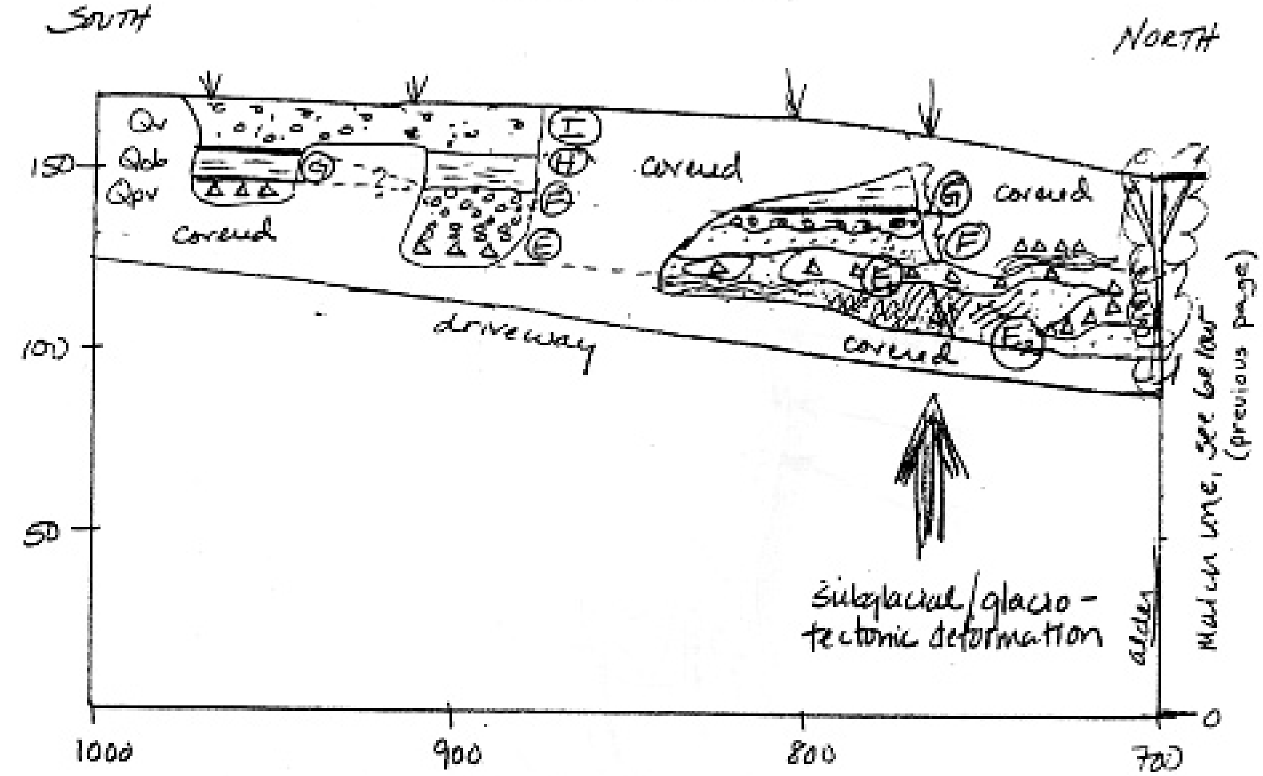
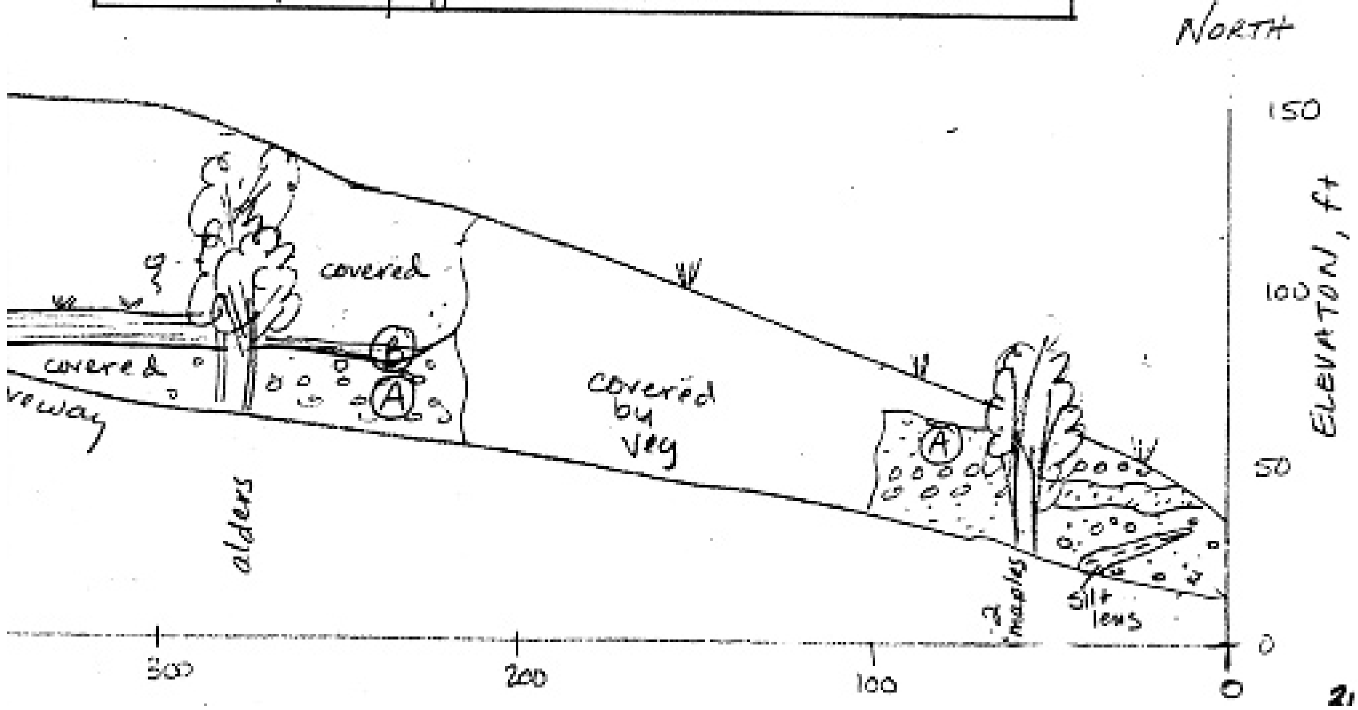
*section continues next page

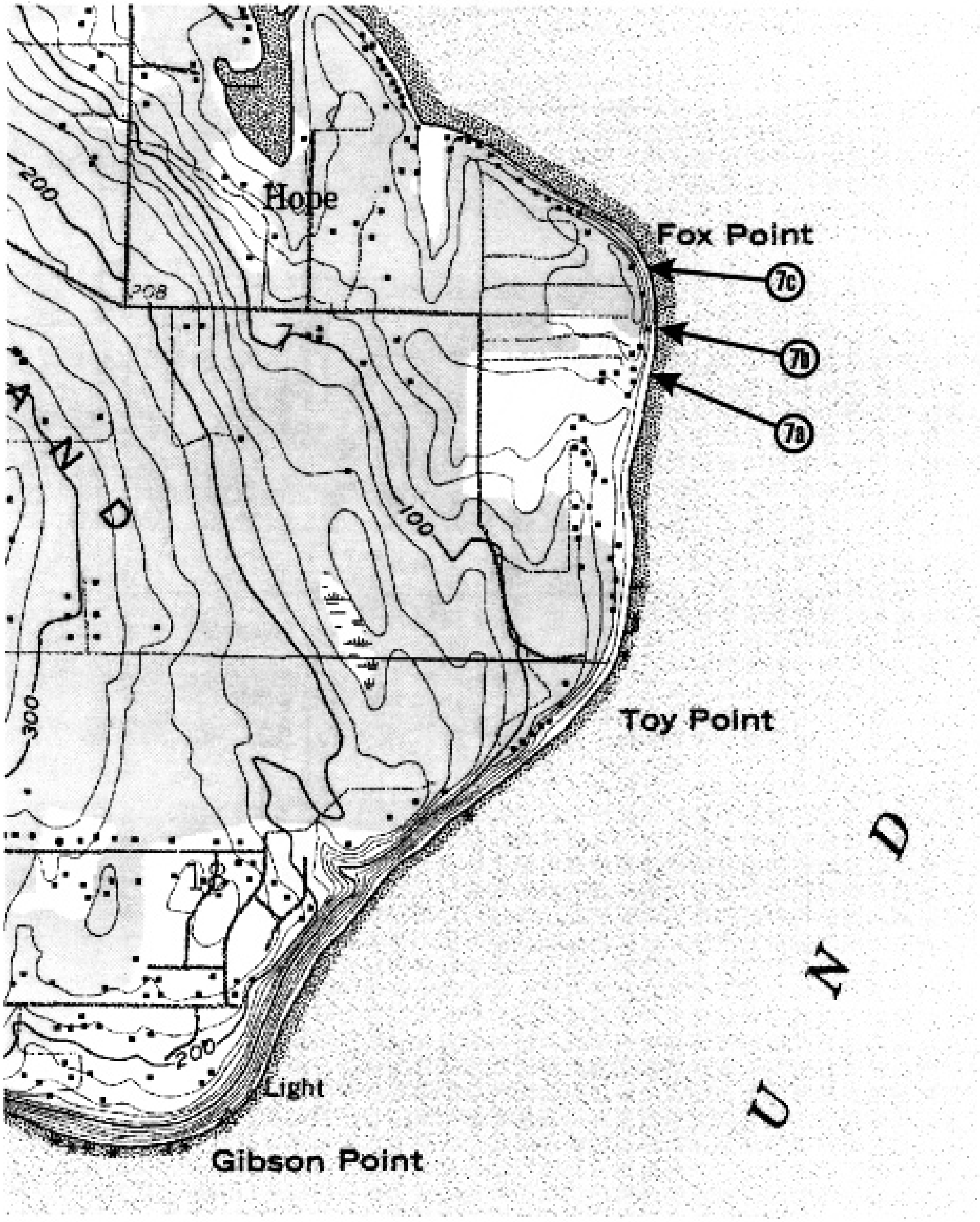
STOP 6 (cont.)
MAPLEWOOD SOUTH DRIVEWAY
COLVOS PASSAGE



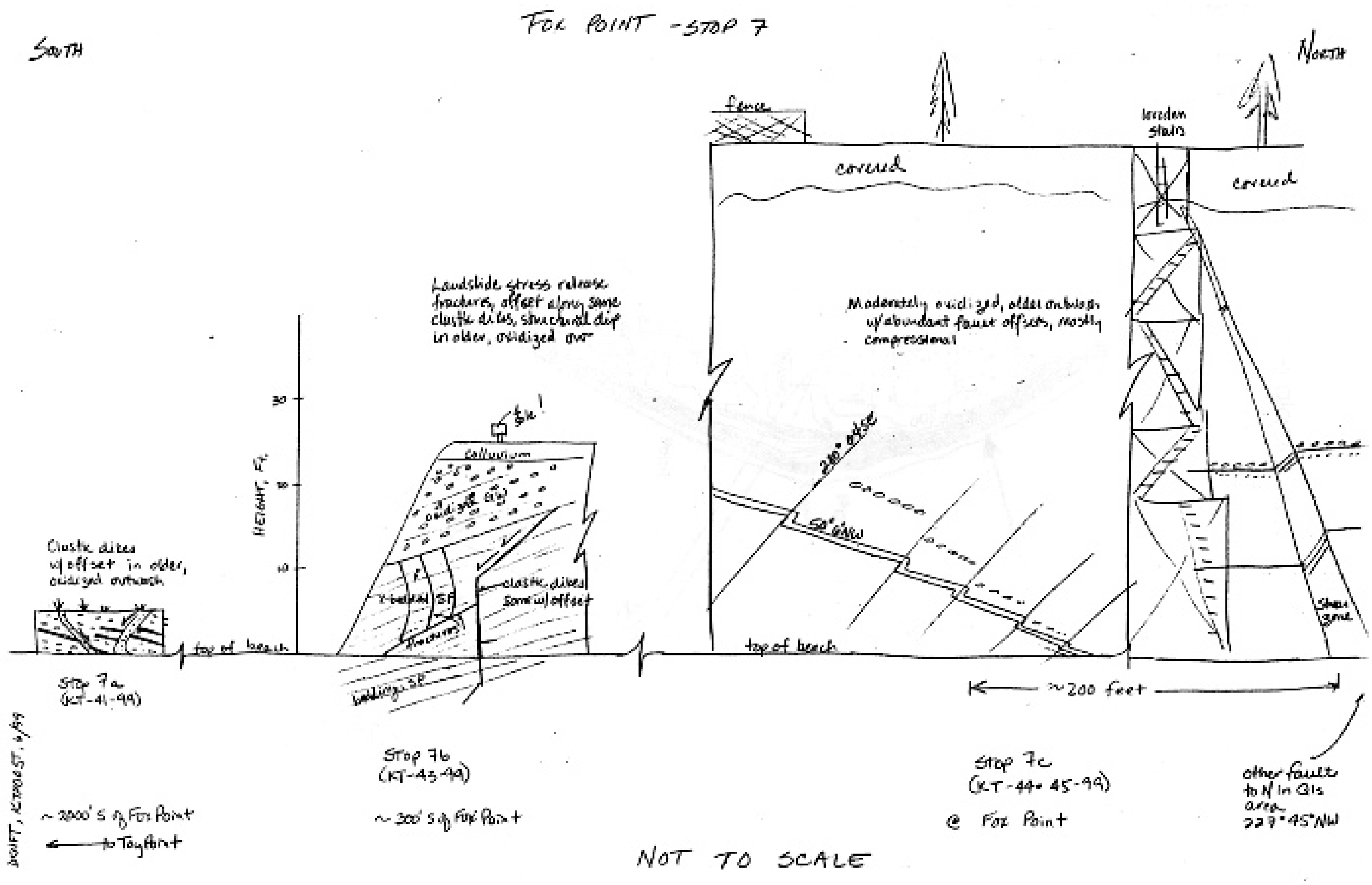
NOTE: Please respect this private driveway and the privacy of the owners.



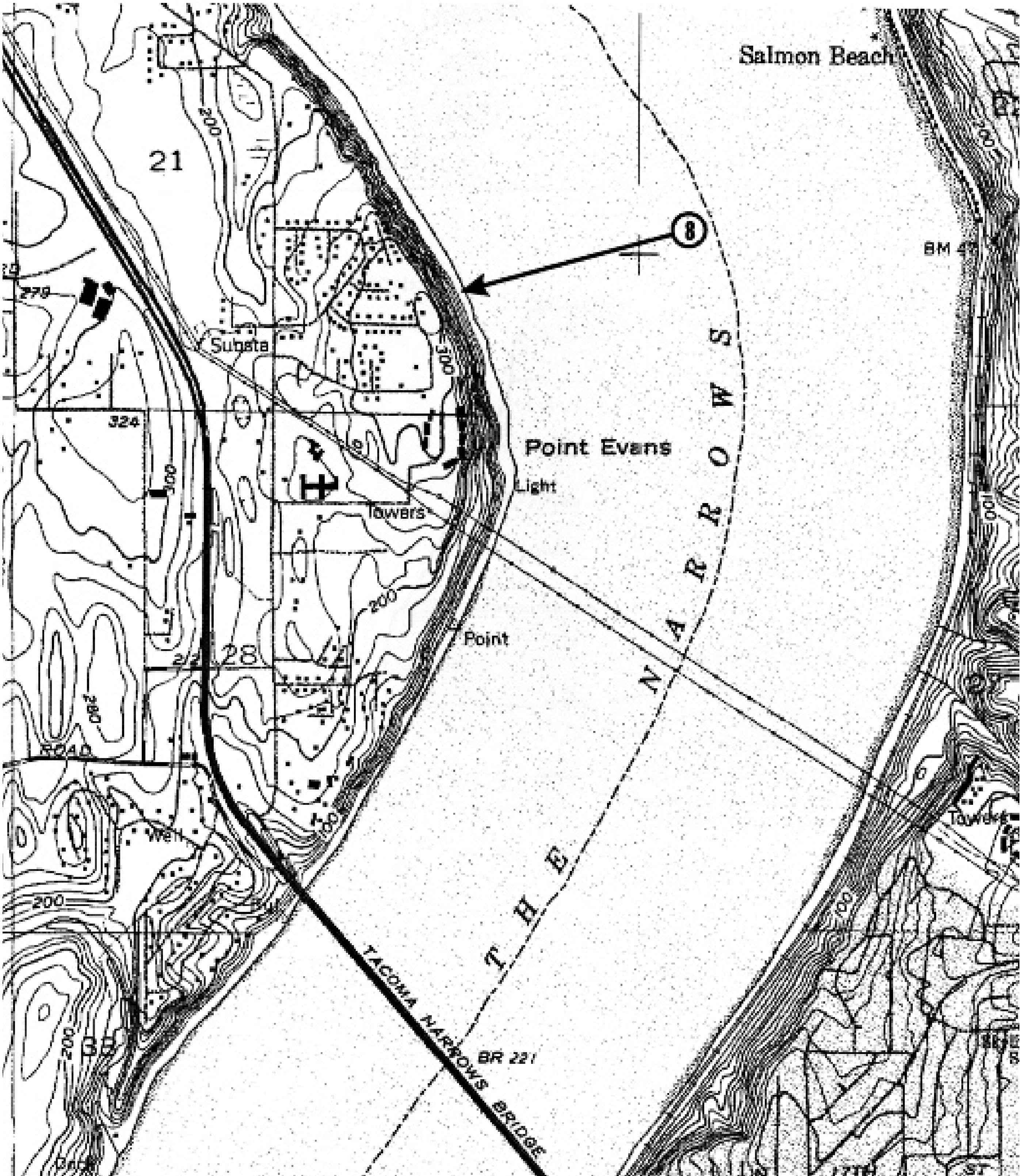
Stop 7: Fox Island structural deformation



From USGS Steilacoom 7.5-minute topographic map

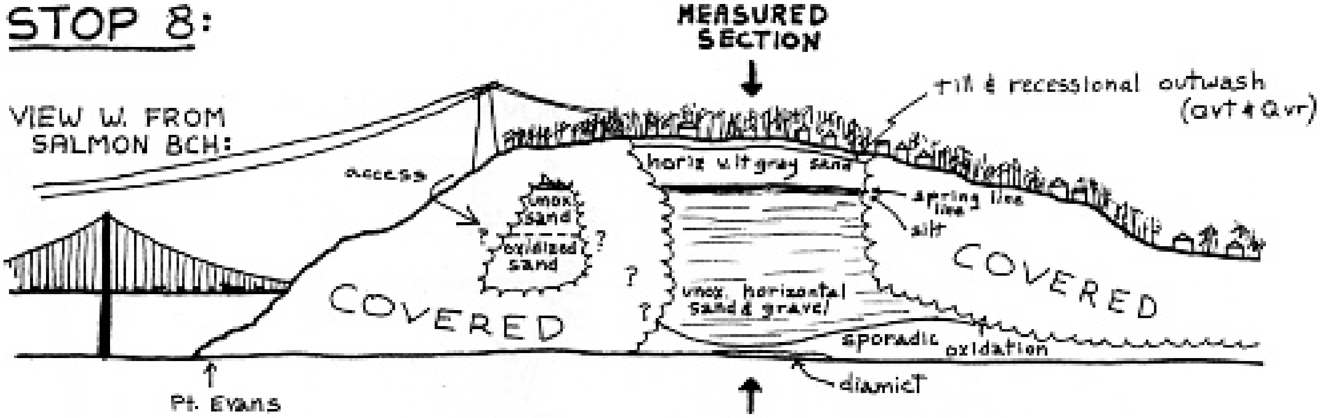

FOX POINT - STOP 7
SOUTH
NORTH
fence
covered
wooden stairs
covered
Landslide stress release fractures, offset along some clastic dikes, structural dip in older, oxidized out
Moderately oxidized, older outwash w/abundant fault offsets, mostly compressional
30
20
10
HEIGHT, ft.
colluvium
oxidized
Clastic dikes w/offset in older, oxidized outwash
clastic dikes some w/offset
fractures
bedding SE
top of beach
top of beach
280° 45SE
50°&NW
shear zone
~200 feet
Stop 7a (KT-41-99)
Stop 7b (KT-43-99)
Stop 7c (KT-44+45-99)
other faults to N in Qls area 227°45°NW
~2000' S of Fox Point to Toy Point
~300' S of Fox Point
@ Fox Point
NOT TO SCALE

Stop 8: Point Evans multiple glacial drifts

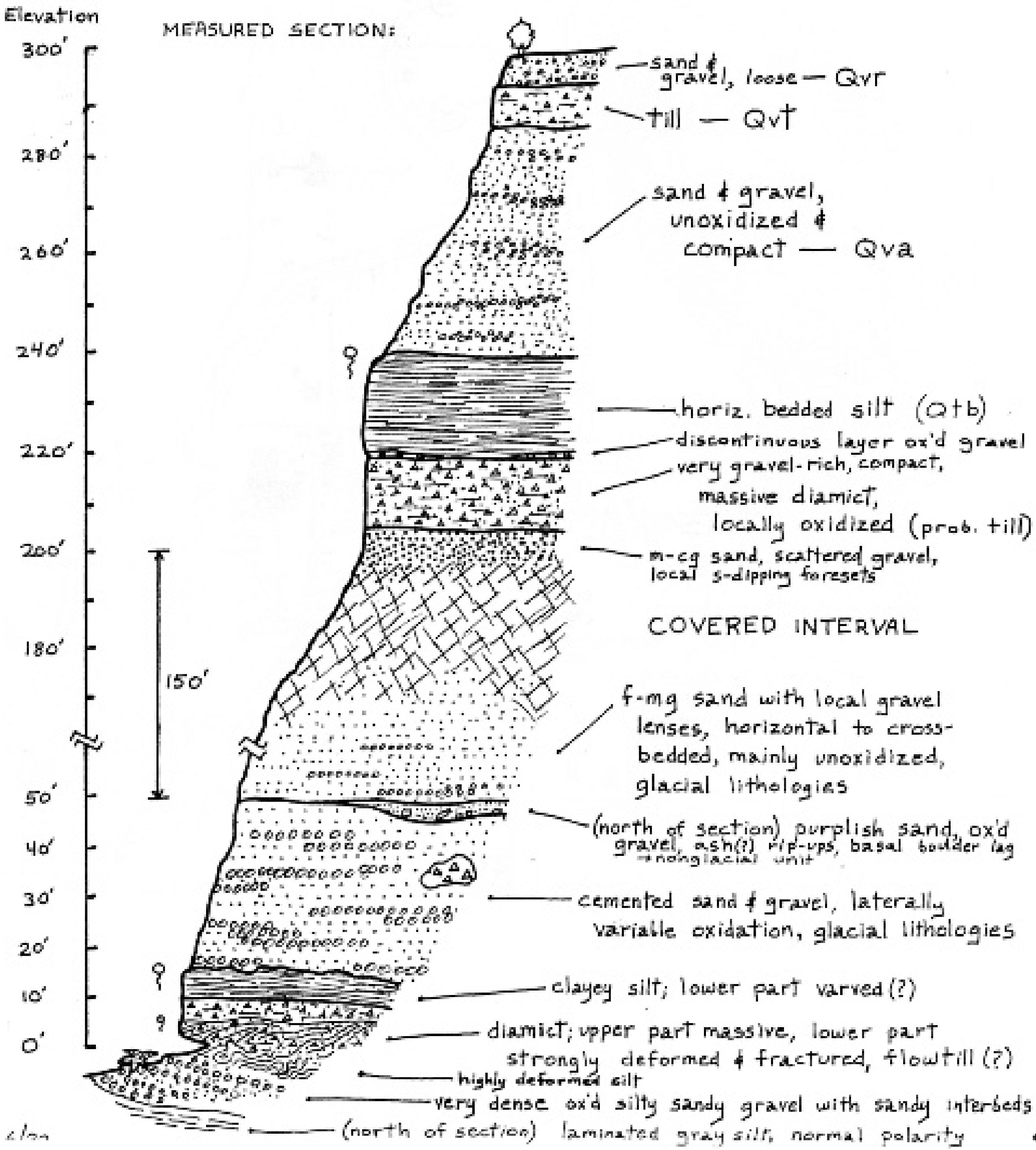


From USGS Gig Harbor 7.5-minute topographic n

STOP 8:

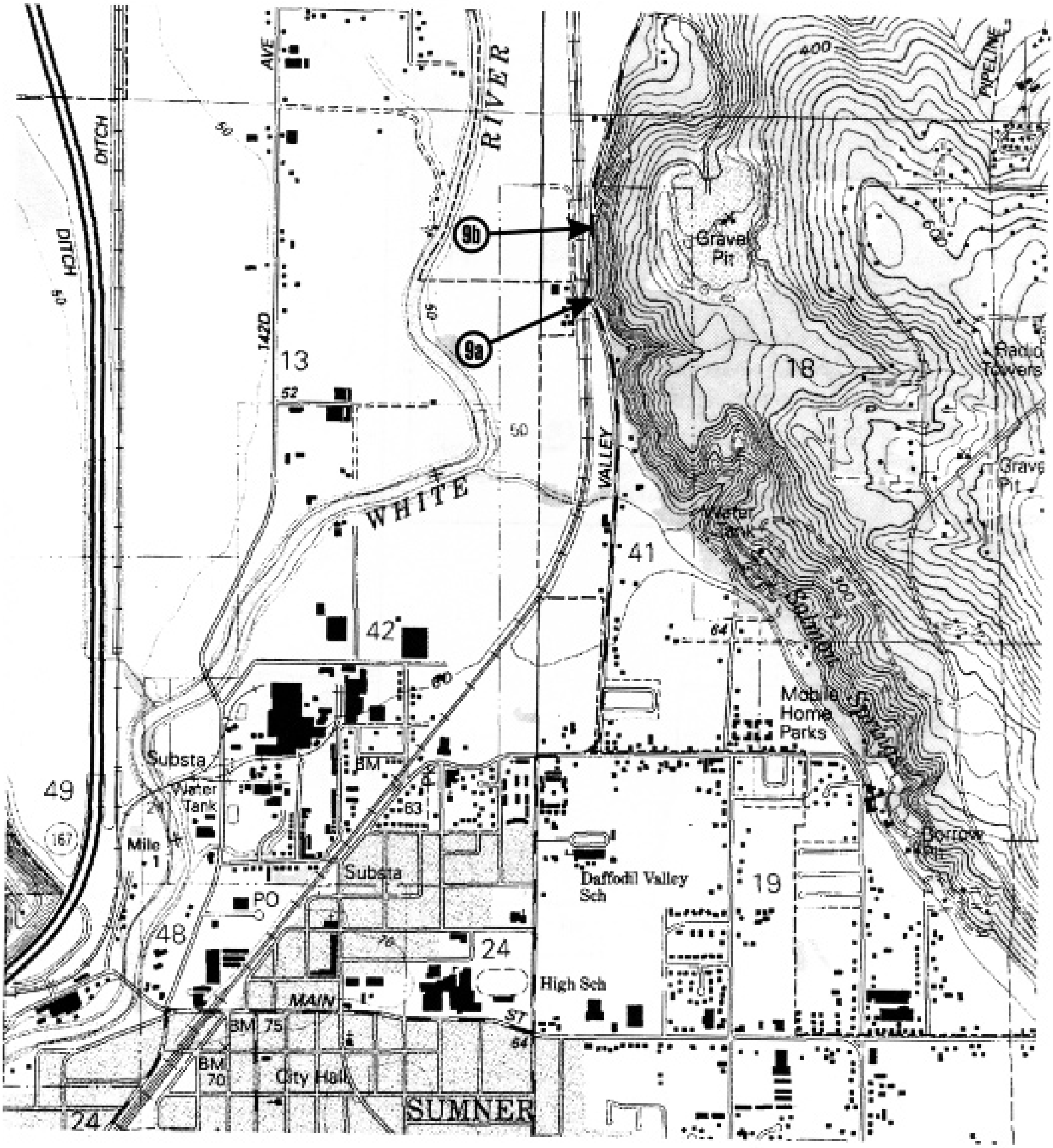


MEASURED SECTION
VIEW W. FROM SALMON BCH:
till & recessional outwash (Qvt & Qvr)
access
unox sand
oxidized sand
horiz. wlt gray sand
spring line
silt
COVERED
unox. horizontal sand & gravel
COVERED
sporadic oxidation
diamict
Pt. Evans



Elevation
MEASURED SECTION:
300'
280'
260'
240'
220'
200'
180'
150'
50'
40'
30'
20'
10'
0'
sand & gravel, loose — Qvr
till — Qvt
sand & gravel, unoxidized & compact — Qva
horiz. bedded silt (Qtb)
discontinuous layer ox'd gravel
very gravel-rich, compact, massive diamict, locally oxidized (prob. till)
m-cg sand, scattered gravel, local S-dipping foresets
COVERED INTERVAL
f-mg sand with local gravel lenses, horizontal to cross-bedded, mainly unoxidized, glacial lithologies
(north of section) purplish sand, ox'd gravel, ash(?) rip-ups, basal boulder lag — nonglacial unit
cemented sand & gravel, laterally variable oxidation, glacial lithologies
clayey silt; lower part varved (?)
diamict; upper part massive, lower part strongly deformed & fractured, flowtill (?)
highly deformed silt
very dense ox'd silty sandy gravel with sandy interbeds
(north of section) laminated gray silt, normal polarity

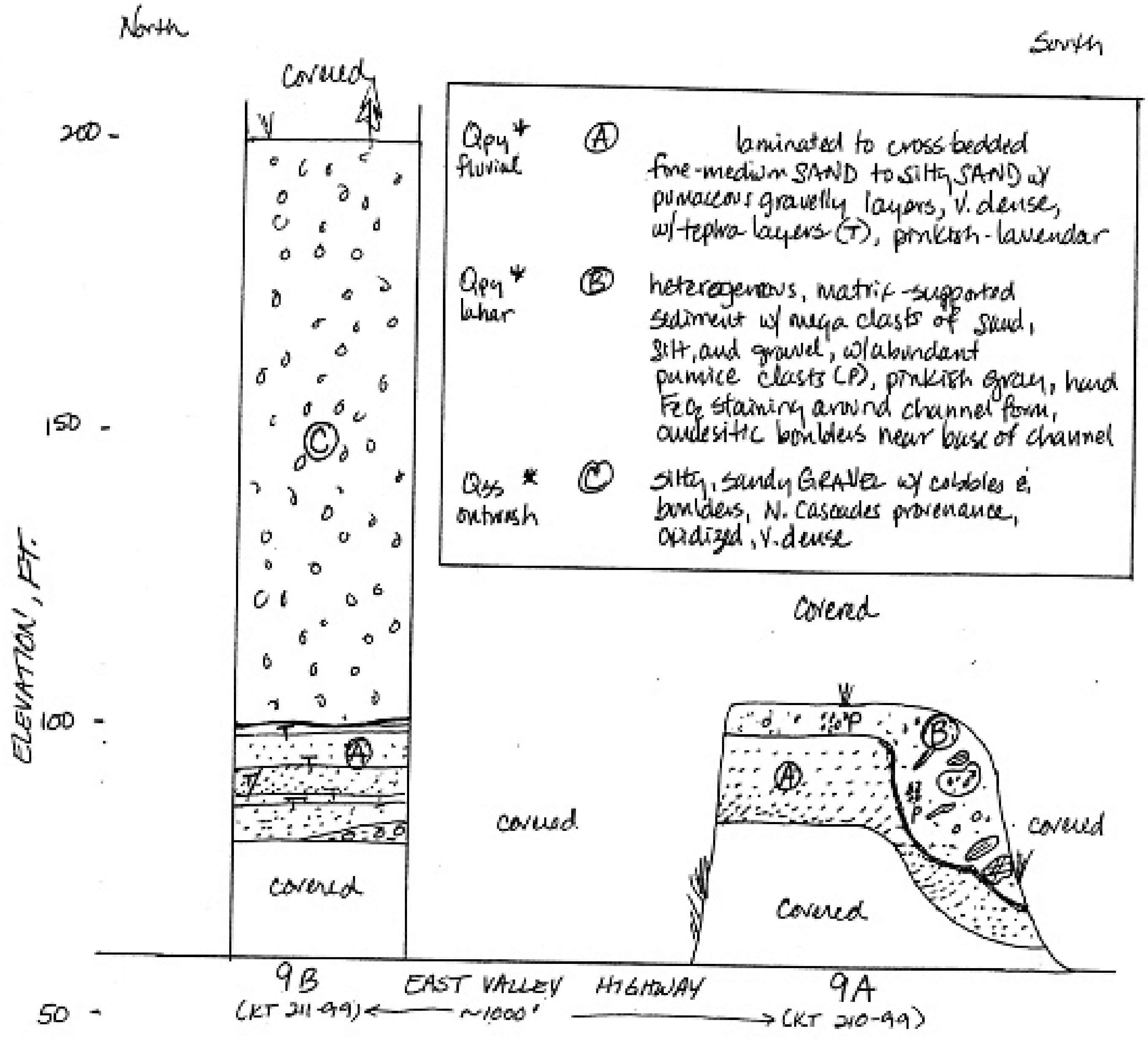
Stop 9: East Valley Highway volcanic sediments



From USGS Sumner 7.5-minute topographic map

STOP 9 A & B

EAST VALLEY HIGHWAY, N. of SUMNER



* Strat units based on Crandell, 1963 USGS Prof Paper 388-A, Lake Tapps Quad
Qpy = Puyallup formation
Qss = Salmon Springs Drift

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