APPENDIX M
ECOLOGY MEMORANDUM
ICS Uplands Ecological Risk Analysis
October 9, 2017

REMEDIAL INVESTIGATION REPORT
ICS/NWC RI/FS
SEATTLE, WASHINGTON
October 2025

Dalton, Olmsted & Fuglevand, Inc.

This page left intentionally blank

ICS Uplands Ecological Risk Analysis

Memorandum

To:	Victoria Sutton, Site Manager Toxics Cleanup Program Northwest Regional Office
From:	Arthur Buchan, Toxicologist Information & Policy Section Toxics Cleanup Program
Date:	October 09, 2017

This memorandum represents a Department of Ecology analysis and recommendation regarding the Terrestrial Ecological Evaluation section (Terrestrial Ecologic Contact – Section V (a) (1)) of the document: *Remedial Investigation Report: Industrial Container Services, WA, LLC [Former NW Cooperage Site] Seattle, Washington. Agency Review Draft: September 2016* (DOF, 2016) (Facility Site ID No. 2154).

Determination:

Consultant recommendations appear to be consistent with the requirements of the Model Toxics Control Act (MTCA), Terrestrial Ecological Evaluation (TEE), WAC 173-340-7490 through 7494 (Ecology, 2007) under the conditions described below (please see exclusionary criteria, 2a.).

For Questions regarding this Memorandum, please contact:

Arthur Buchan
Phone: (360) 407-7146
Email: abuc461@ecy.wa.gov

Comments/Recommendations

Exclusionary Criteria

No further evaluation of the TEE is required if any of the below exclusionary criteria are met at the site:

1. **Contamination below the point of compliance (340-7491(1) (a)).** This exclusion should not apply. It appears contamination is located at a shallower depth than 15 ft bgs.
2. **Incomplete exposure pathway (340-7491(1) (b)).** Section V (a) (1) of the Remedial Investigation Report details that *"The Upland Area portion of the Site is zoned industrial and is covered by buildings and paving and satisfies the exclusion criterion in WAC 173-340-7491(1) (b)."* However, it is unclear if this exclusion would apply. It appears there is an undeveloped upland area within the site boundaries. Please see Appendix A (*ICS Site – Exposure Pathways*) and verify that in the lower right hand section of the map (within the site boundaries) there are no hazardous substances detected.
   a. Recommendation: Please verify that there are no hazardous substances detected in the undeveloped area (circled) in Appendix A. If there are hazardous substances detected, the exclusion would not apply and a simplified TEE would be necessary.
3. **Area of contiguous undeveloped land (340-7491(1) (c)).** This exclusion should not apply. It appears that there is greater than 0.25 acres of contiguous undeveloped land on or within 500 ft of the site, and it also appears hazardous bioaccumulatives are present (i.e. pentachlorophenol, PCB mixtures, etc.). Please see Appendix B (*ICS Site with 500 ft. Buffer* - left hand side of the map – West of 509 freeway).

Discussion: Please clarify Exclusionary Criteria bullet 2a (above). The site would be excluded from the TEE requirements if the conditions of bullet 2a are met and an institutional control is implemented under WAC 173-340-440. If there are hazardous substances detected in the undeveloped area, a simplified TEE would be necessary.

Simplified or Site-Specific Criteria:

If the site cannot be excluded as discussed above, then a simplified or site-specific TEE is required. A site-specific TEE is required if any of the below criteria apply:

1. **Management or land use plans maintain or restore native vegetation (340-7491(2) (a) (i)).** It does not appear that this criterion would apply.
2. **Use by threatened or endangered species (340-7491(2) (a) (ii)).** It does not appear that this criterion would apply.
3. **Amount of native vegetation located on the property within 500 ft. of the site (340-7491(2) (a) (iii)).** It does not appear that this criterion would apply. Although there appears to be greater than 10 acres of native vegetation within 500 ft of the site, it is across from the freeway and not located within the property boundaries. Please see Appendix B (*ICS Site with 500 ft. Buffer* - left hand side of the map – West of 509 freeway).

4. **Department determination (340-7491(2) (a) (iv)).** This criterion should not apply. The department has not determined that the site may present a risk to significant wildlife populations.

Discussion: It does not appear that a Site-Specific TEE would be necessary.

Summary: If any of the exclusionary criteria have been met, the site should be excluded from the requirements of the TEE. However, if there is undeveloped land with hazardous substances detected on the site, then a Simplified TEE would be necessary.

Simplified TEE Requirements[1]:

The simplified TEE evaluation may be ended if any of the following criteria apply:

1. **Exposure analysis (total area of soil contamination) (340-7492(2) (a) (i)).** This criterion should not apply. It appears the total area of soil contamination > 350 square feet.
2. **Exposure analysis (substantial wildlife exposure) (340-7492(2) (a) (ii)).** This criterion should not apply. Appendix F (Table 749-1) has not been completed. However, I would recommend that the land west of the freeway and across from 4 should be considered. The interpretation of not considering land outside of the property boundary does not apply under this scenario (Appendix B – circled area). Based on the acreage (> 4 acres), the point total assigned should then be 12 pts. This point total would then be compared to the points added for boxes 2-5 (which is 8). Under this scenario, the simplified process should not be ended Please see Appendix C (Table 749-1).
3. **Pathways analysis (340-7492(2) (b)).** If the unpaved area within the site is contaminated, then it should be cleaned up. If the unpaved area within the site is not contaminated, the simplified evaluation may be ended with the implementation of a restrictive covenant maintaining the barriers. Please note that only exposure pathways for priority chemicals of ecological concern listed in Table 749-2 at or above the concentrations provided must be considered.
   a. Recommendation: Please clarify if the unpaved area within the site is contaminated with hazardous substances.
4. **Contaminants analysis (340-7492(2) (c)).** This criterion should not apply. There appears to be contaminants sampled and analyzed for that are above the values listed in Table 749-2 (either unrestricted or industrial/commercial columns).

Discussion: Please clarify Simplified TEE Requirements bullet 3a above. If this condition has been met, the simplified TEE process may be ended.

[1] Please note that for industrial or commercial properties, current or future potential for exposure need only be evaluated for terrestrial wildlife protection. Within the site, plants and soil biota need only be considered for species protected under the endangered species act, or for vegetation that must be maintained to comply with local land use regulations.

<u>What if the Simplified TEE cannot be ended?</u>

The hazardous substances and values listed in Table 749-2 are used as indicator substances and screening levels respectively for the purposes of conducting a contaminants analysis under WAC 173-340-7492(2) (c) to end a simplified terrestrial ecological evaluation.

Note that if none of the hazardous substances at the site are listed in Table 749-2 or exist at the site at the applicable points of compliance in concentrations that exceed the Table 749-2 values, then no further evaluation is required. However, at the discretion of the person conducting the evaluation, the values specified in Table 749-2 may be used as cleanup levels as another method of ending a simplified terrestrial ecological evaluation.

Draft contaminant list for the site (under an assumed simplified evaluation) has been included in Appendix D (Table 749-2).

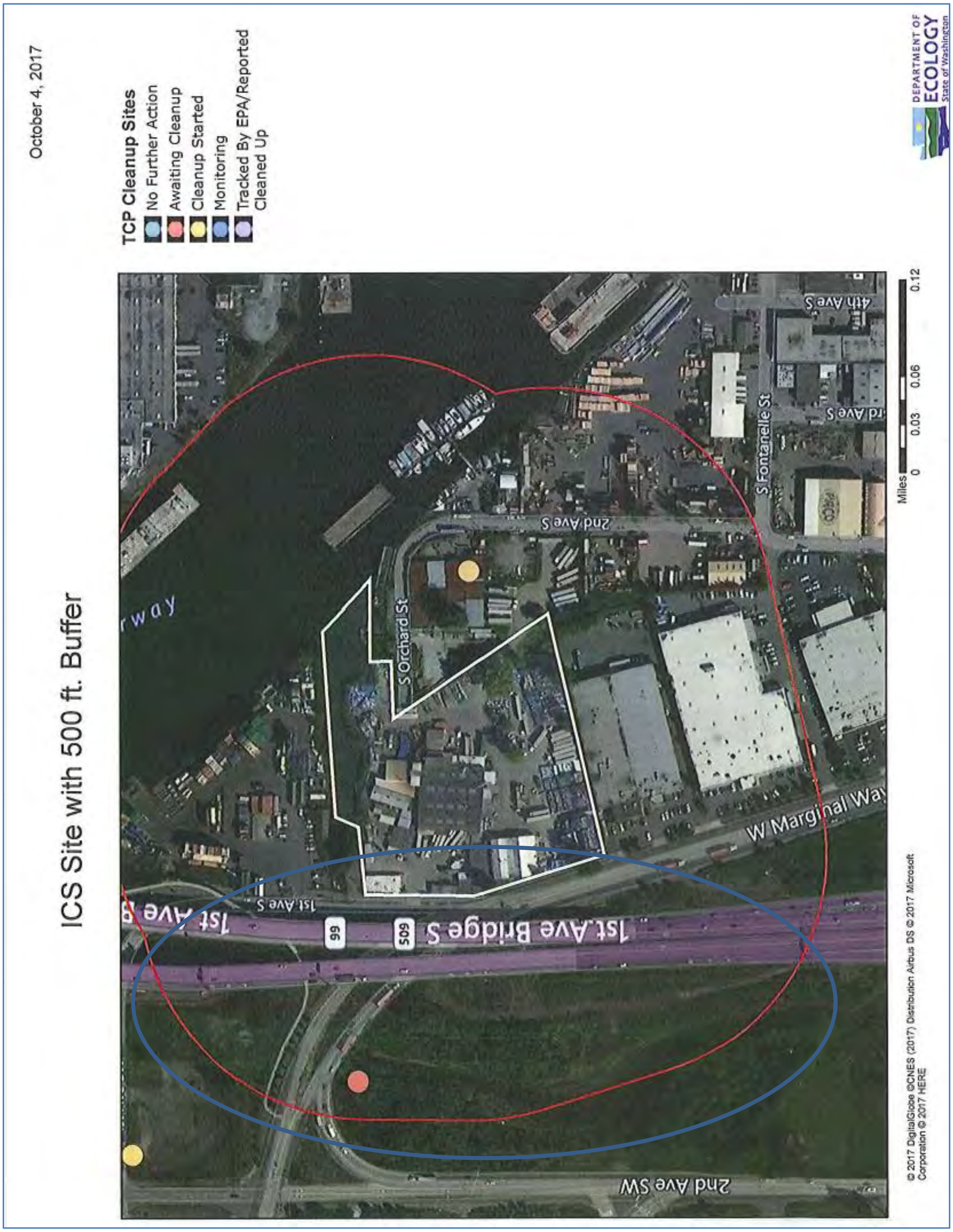
References Cited

DOF. (2016). *Remedial Investigation Report. Industrial Container Services, WA, LLC [Former NW Cooperage Site]. Seattle, Washington. Agency Review Draft.* Dalton Olmstead Fuglevand, 2016.

Ecology. (2007). *Model Toxics Control Act statute and regulation, Chapter 173-340 WAC.* (Ecology Publication No. 94-06). Lacey, WA: Washington State Department of Ecology, Toxics Cleanup Program.

Appendix A: ICS Site - Exposure Pathways

Appendix B: ICS Site with 500 ft. Buffer



Appendix C: Table 749-1, Exposure Analysis

Table 749-1
Simplified Terrestrial Ecological Evaluation – Exposure Analysis Procedure under WAC 173-340-7492(2)(a)(ii).[a]

Estimate the area of contiguous (connected) undeveloped land on the site or within 500 feet of any area of the site to the nearest 1/2 acre (1/4 acre if the area is less than 0.5 acre). "Undeveloped land" means land that is not covered by existing buildings, roads, paved areas or other barriers that will prevent wildlife from feeding on plants, earthworms, insects or other food in or on the soil.	
1) From the table below, find the number of points corresponding to the area and enter this number in the box to the right.	12
Area (acres) / Points: 0.25 or less — 4 0.5 — 5 1.0 — 6 1.5 — 7 2.0 — 8 2.5 — 9 3.0 — 10 3.5 — 11 4.0 or more — 12	
2) Is this an industrial or commercial property? See WAC 173-340-7490(3)(c). If yes, enter a score of 3 in the box to the right. If no, enter a score of 1.	3
3) Enter a score in the box to the right for the habitat quality of the site, using the rating system shown below[b]. (High = 1, Intermediate = 2, Low = 3)	3
4) Is the undeveloped land likely to attract wildlife? If yes, enter a score of 1 in the box to the right. If no, enter a score of 2. See footnote c.	1
5) Are there any of the following soil contaminants present: Chlorinated dioxins/furans, PCB mixtures, DDT, DDE, DDD, aldrin, chlordane, dieldrin, endosulfan, endrin, heptachlor, benzene hexachloride, toxaphene, hexachlorobenzene, pentachlorophenol, pentachlorobenzene? If yes, enter a score of 1 in the box to the right. If no, enter a score of 4.	1
6) Add the numbers in the boxes on lines 2 through 5 and enter this number in the box to the right. If this number is larger than the number in the box on line 1, the simplified terrestrial ecological evaluation may be ended under WAC 173-340-7492 (2)(a)(ii).	8

Footnotes:

a It is expected that this habitat evaluation will be undertaken by an experienced field biologist. If this is not the case, enter a conservative score (1) for questions 3 and 4.

b **Habitat rating system.** Rate the quality of the habitat as high, intermediate or low based on your professional judgment as a field biologist. The following are suggested factors to consider in making this evaluation:
Low: Early successional vegetative stands; vegetation predominantly noxious, nonnative, exotic plant species or weeds. Areas severely disturbed by human activity, including intensively cultivated croplands. Areas isolated from other habitat used by wildlife.
High: Area is ecologically significant for one or more of the following reasons: Late-successional native plant communities present; relatively high species diversity; used by an uncommon or rare species; priority habitat (as defined by the Washington Department of Fish and Wildlife); part of a larger area of habitat where size or fragmentation may be important for the retention of some species.
Intermediate: Area does not rate as either high or low.

c Indicate "yes" if the area attracts wildlife or is likely to do so. Examples: Birds frequently visit the area to feed; evidence of high use by mammals (tracks, scat, etc.); habitat "island" in an industrial area; unusual features of an area that make it important for feeding animals; heavy use during seasonal migrations.

Box 1 > Box 6:
Simplified TEE should not be ended under Exposure Analysis

Appendix D: Table 749-2, Contaminants for the Simplified TEE

173-340-900 **MTCA Cleanup Regulation**

Table 749-2
Priority Contaminants of Ecological Concern for Sites that Qualify for the Simplified Terrestrial Ecological Evaluation Procedure.[a]

Priority contaminant	Soil concentration (mg/kg)	
	Unrestricted land use[b]	Industrial or commercial site
METALS:[c]		
Antimony	See note d	See note d
Arsenic III	20 mg/kg	20 mg/kg
Arsenic V	95 mg/kg	260 mg/kg
Barium	1,250 mg/kg	1,320 mg/kg
Beryllium	25 mg/kg	See note d
Cadmium	25 mg/kg	36 mg/kg
Chromium (total)	42 mg/kg	135 mg/kg
Cobalt	See note d	See note d
Copper	100 mg/kg	550 mg/kg
Lead	220 mg/kg	220 mg/kg
Magnesium	See note d	See note d
Manganese	See note d	23,500 mg/kg
Mercury, inorganic	9 mg/kg	9 mg/kg
Mercury, organic	0.7 mg/kg	0.7 mg/kg
Molybdenum	See note d	71 mg/kg
Nickel	100 mg/kg	1,850 mg/kg
Selenium	0.8 mg/kg	0.8 mg/kg
Silver	See note d	See note d
Tin	275 mg/kg	See note d
Vanadium	26 mg/kg	See note d
Zinc	270 mg/kg	570 mg/kg
PESTICIDES:		
Aldicarb/aldicarb sulfone (total)	See note d	See note d
Aldrin	0.17 mg/kg	0.17 mg/kg
Benzene hexachloride (including lindane)	10 mg/kg	10 mg/kg
Carbofuran	See note d	See note d
Chlordane	1 mg/kg	7 mg/kg
Chlorpyrifos/chlorpyrifos-methyl (total)	See note d	See note d
DDT/DDD/DDE (total)	1 mg/kg	1 mg/kg
Dieldrin	0.17 mg/kg	0.17 mg/kg
Endosulfan	See note d	See note d
Endrin	0.4 mg/kg	0.4 mg/kg
Heptachlor/heptachlor epoxide (total)	0.6 mg/kg	0.6 mg/kg
Hexachlorobenzene	31 mg/kg	31 mg/kg
Parathion/methyl parathion (total)	See note d	See note d
Pentachlorophenol	11 mg/kg	11 mg/kg
Toxaphene	See note d	See note d

OTHER CHLORINATED ORGANICS:		
Chlorinated dibenzofurans (total)	3E-06 mg/kg	3E-06 mg/kg
Chlorinated dibenzo-p-dioxins (total)	5E-06 mg/kg	5E-06 mg/kg
Hexachlorophene	See note d	See note d
PCB mixtures (total)	2 mg/kg	2 mg/kg
Pentachlorobenzene	168 mg/kg	See note d
OTHER NONCHLORINATED ORGANICS:		
Acenaphthene	See note d	See note d
Benzo(a)pyrene	30 mg/kg	300 mg/kg
Bis (2-ethylhexyl) phthalate	See note d	See note d
Di-n-butyl phthalate	200 mg/kg	See note d
PETROLEUM:		
Gasoline Range Organics	200 mg/kg	12,000 mg/kg except that the concentration shall not exceed residual saturation at the soil surface.
Diesel Range Organics	460 mg/kg	15,000 mg/kg except that the concentration shall not exceed residual saturation at the soil surface.

Footnotes:

a Caution on misusing these chemical concentration numbers. These values have been developed for use at sites where a site-specific terrestrial ecological evaluation is not required. They are not intended to be protective of terrestrial ecological receptors at every site. Exceedances of the values in this table do not necessarily trigger requirements for cleanup action under this chapter. The table is not intended for purposes such as evaluating sludges or wastes.
This list does not imply that sampling must be conducted for each of these chemicals at every site. Sampling should be conducted for those chemicals that might be present based on available information, such as current and past uses of chemicals at the site.

b Applies to any site that does not meet the definition of industrial or commercial.

c For arsenic, use the valence state most likely to be appropriate for site conditions, unless laboratory information is available. Where soil conditions alternate between saturated, anaerobic and unsaturated, aerobic states, resulting in the alternating presence of arsenic III and arsenic V, the arsenic III concentrations shall apply.

d Safe concentration has not yet been established. See WAC 173-340-7492(2)(c).

APPENDIX N
DMD GEOCHEMICAL ASSESSMENT OF PCBS
TECHNICAL MEMORANDUM - JANUARY 15, 2018

REMEDIAL INVESTIGATION REPORT
ICS/NWC RI/FS
SEATTLE, WASHINGTON
October 2025

This page left intentionally blank

D.M.D., Inc.
Environmental & Toxicological Services
13706 SW Caster Road, Vashon, WA 98070-7428 (206) 463-6223 email: dmdinc111@gmail.com

MEMORANDUM

TO: Matt Dalton (DOF)

FROM: Raleigh Farlow

DATE: January 15, 2018

SUBJECT: Geochemical Assessment of PCB's at the ICS/[former] Northwest Cooperage Site, Seattle, WA

This assessment supports the Remedial Investigation and Feasibility Study (RI/FS) for the Industrial Container Services, WA, LLC site, formerly known as Northwest Cooperage, Inc., (ICS/NWC) located on a small tributary embayment to the Lower Duwamish Waterway. The site consists of an upland area (6.3 acres) and adjacent embayment (~1 acre). The Remedial Investigation identifies a number of Chemicals of Potential Concern (COPC's) impacting upland soils, site groundwater, and estuarine sediments. PCB's were identified as the COPC's of greatest concern due to greatest frequency of exceedance of the screening levels (SL's) and the geographic extent of contamination.

This evaluation provides a geochemical perspective of the site-specific characteristics for PCB's contamination in environmental media at the ICS/NWC site to provide an understanding of the chemical characteristics, distributions, fates, and migration mechanisms/pathways as the basis for development of an effective remedial management strategy. The remedial objectives in the upland area include mitigation of contaminant hotspots/sources as they affect sensitive receptors and associated releases to surface waters and sediments via groundwater and storm water discharges. Remedial objectives in the estuarine portion of the site include cleanup of embayment sediments, prevention of sediment recontamination consequent to storm and ground water discharges, and prevention of surface water contamination.

<u>Summary of PCB's Contamination at the ICS/NWC Site</u>

This evaluation is based on the available site-specific data presented in the ICS/NWC draft Remedial Investigation (RI) report. PCB concentrations and distributions by site media are presented in the ICS/NWC draft RI report in the following figures:

- Figure 5-4a PCBs in Surface Sediment
- Figure 5-5a PCBs in Subsurface Sediment
- Figure 5-26a Total PCB Concentrations, Water Table Zone Above Aquitard
- Figure 5-26b Total PCB Concentrations (in groundwater), Upper Zone
- Figure 5-26c Total PCB Concentrations (in groundwater), Deeper Zone
- Figure 5-27a Extent of PCBs in Soil, (Less Than 15' Deep)
- Figure 5-27b Extent of PCBs in Soil, (Greater Than 15' Deep)

- Figure 5-30a PCBs (in subsurface soil) Along Section A-A’
- Figure 5-30b PCBs (in subsurface soil) Along Section B-B’
- Figure 5-30c PCBs (in subsurface soil) Along Section C-C’
- Figure 5-30d PCBs (in subsurface soil) Along Section D-D’
- Figure 5-30e PCBs (in subsurface soil) Along Section E-E’
- Figure 5-30f PCBs (in subsurface soil) Along Section F-F’
- Figure 5-30g PCBs (in subsurface soil) Along Section G-G’

A summary of site [total] PCB concentrations (measured and reported as Aroclors) by media is as follows:

	Freq. of Detection	Range	Arithmetic Mean	Coefficient of Variation (CV)
Surface Sed. (µg/kg)	100 %	42 – 1,600,000	56,947	4.75
Subsurface Sed. (µg/kg)	62.5 %	3.7 U – 44,100	4413 (U=0) 4414 (U=DL)	2.26 (U=0) 2.26 (U=DL)
Groundwater (µg/L)	46.6 %	0.004 – 6.91 (U[DL]=0.01)	0.212 (U=0) 0.218 (U=DL)	3.64 (U=0) 3.52 (U=DL)
Soil (µg/kg)	61.1 %	5 U – 119,000	10,000 (U=0) 10,000 (U=DL)	2.60 (U=0) 2.59 (U=DL)
LNAPL [SA-MW1] (µg/kg)	—	—	1,670,000 (0.167 %)	—

U – not detected. DL – reported detection limit. CV = (standard deviation [sd])/(arithmetic mean)

Areas exhibiting elevated concentrations of PCB’s and PCB ‘hotspots” are found in surficial and subsurface embayment sediments (Figures 5-4a and 5-5a), upland soils along the shoreline to the embayment, and soils (generally at less than 15’ depth) along a former [filled] drainage ditch to the embayment located on the eastern boundary of the property (Figure 5-27a). PCB’s in groundwater were generally detected (> 0.01 µg/L) in the immediate vicinity of soils exhibiting PCB’s contamination (Figures 5-30a – 5-30g). PCB’s contamination in soils and groundwater are relatively localized, in both depth and spatially. PCB’s in estuarine sediments are found at sediment depths averaging 5 feet and, generally, throughout the embayment (Figures 5-4a and 5-5a). Greatest concentrations in sediments are found in surface sediments along the southwestern shoreline of the embayment, up to 0.16% (Figure 5-4a). PCB’s-contaminated low density non-aqueous phase liquid (LNAPL) collected from SA-MW1 exhibited chromatographic characteristics/profile consistent with that of mineral oils employed in dielectric applications.

Properties and Characteristics of PCB’s

PCB’s and PCB mixtures (Aroclors) are chlorinated aromatic hydrocarbons that are chemically and physically recalcitrant, which has made them useful in a variety of applications, including dielectric fluids in electrical equipment, heat transfer fluids and lubricants. PCB’s and their mixtures are extremely hydrophobic and their aqueous solubilities (S) are relatively low compared to most other environmental contaminants. PCB’s in the environment have a strong affinity for soils, especially those with high organic carbon content, and are not readily solubilized into surface and groundwaters. Adsorption of PCB’s by soils is highly correlated to the level of organic carbon content (TOC in soils) and is quantified by a soil sorption constant or partition coefficient (K_{oc} or $\log(K_{oc})$). The degree of adsorption by soils, expressed in terms of the K_{oc} (soil-water partition coefficient), is directly related to the level of TOC in soils. The behavior of PCB’s and PCB mixtures in the environment is also related to and quantified by their octanol-water partition coefficient (K_{ow} or log(K_{ow})), which is related to a site-specific and determined K_{oc}. For comparison, Aroclor physicochemical coefficients and constants are similar to and within the range of those for tetracyclic and greater high molecular weight polycyclic aromatic hydrocarbons (HPAH (e.g. chrysene, benzopyrenes, indeno(1,2,3-cd)pyrene, benzo(g,h,i)perylene, etc.)). A summary of pertinent constants for PCB mixtures reported at the ICS/NWC site (as Aroclors; taken from a CRC treatise [PCBs and the Environment, Waid et al., 1986] and an ATSDR/CDC publication [PCBs Toxicological Profile, Chapt. 4, 2000]) is as follows:

	S (µg/L)	K_{oc}	K_{ow}
Aroclor 1242	240-340 (2.46)	12,400 (4.09)	196,500 (5.29)
Aroclor 1248	54 (1.73)	54,626 (4.74)	562,000 (5.75)
Aroclor 1254	12-57 (1.54)	63,914 (4.81)	1,288,000 (6.11)
Aroclor 1260	2.7 (0.43)	349,462 (5.54)	4,073,800 (6.61)

Values in parentheses are log transformations of the associated constants. K_{oc} values are published example values and dependent on site-specific media and associated TOC contents.

Because PCB's are hydrophobic chemicals with no polar or active functional chemical groups, their behaviors can be simply described and understood by the application of the above physicochemical parameters and constants. These physicochemical parameters are critical for understanding and controlling the fates and distributions of PCB's and PCB mixtures in the environment. In simple terms, PCB's in a mixed aqueous-soils/sediments environment will preferentially associate with, or partition to, solid surfaces and hydrocarbon/oil phases. The physicochemical values presented above are generally applicable to fresh and laboratory reagent-grade waters and do not account for site-specific factors that affect both solubility and phase partition mechanisms. Site-specific modifiers for S and K_{oc} values include [total] dissolved solids (TDS and salinity), soils TOC content, and [co]dissolved organic constituents, such as dissolved organic carbon (DOC), humic materials, and petroleum hydrocarbons (Environ. Sci. Technol., 2012, 46(3), pp. 1496-1503; Geochimica et Cosmochimica Acta, 1976, 40(5), pp. 555-561; DNAPL Site Evaluation by R.M. Cohen, J.W. Mercer & J. Matthews, C.K. Smoley Publishers, 1993, pp. 4-26 – 4-28). Estuarine-impacted waters with elevated TDS exhibit decreased hydrophobic organic compound solubilities due to the “salting-out effect” associated with increased solution ionic strengths. Similarly, K_{oc} values are increased with increasing TDS, resulting in decreased solution concentrations and increased mass adsorption (phase partitioning) of organic chemicals to solid/soil surfaces. Co-solvency or presence of organic co-solutes can affect these apparent values and increase hydrophobic chemical carrying capacity of ground and surface water systems. The above values for these partition coefficients also indicate, for example, a preferential aqueous solubility and partitioning of Aroclor 1242 compared to Aroclor 1260 of 20-100x in the same environment where all controlling variables are equivalent. This is due to greater hydrophobicity of Aroclor 1260 associated with increased chlorine content and substitution in the biphenyl molecule (Aroclor 1242 contains 42% chlorine whereas Aroclor 1260 contains 60% chlorine by weight). The fates and distributions of PCB's at the ICS/NWC site are easily understood and dependent on these critical physicochemical parameters.

Site-specific Observations and Characteristics Affecting PCB Fates and Distributions

Soils and Sediments

The ICS/NWC draft RI report identifies an association of PCB's with petroleum hydrocarbon oils (expressed as the sum of diesel oil-range and lube (motor) oil-range hydrocarbons, or TPH) and is evaluated for upland site soils in Figure 5-29, PCBs *vs.* TPH in Soil. This relationship indicates that 30% of the variability in soil PCB's levels is strictly controlled by TPH with the remaining (70%) variability due to variation in concentrations of PCB's in source materials and co-releases of other petroleum hydrocarbon mixtures (not containing PCB's). The slope of the line in the figure indicates the mean concentration of total PCB's in site non-aqueous phase liquids or oils is 9.9×10^{-4} or ~0.1% (~ 1 part per thousand (ppth) or 1000 ppm). The mean PCB concentration in oil for soil samples is 1.6 gm/kg (ppth) [1.6×10^{-3}] with a range of 2.1×10^{-5} to 6.6×10^{-3} and a coefficient of variation (CV) of 1.1. Available data indicate that PCB's contamination at the ICS/NWC site is principally associated with the release of petroleum-derived dielectric fluids based on TPH chromatographic analyses exhibiting mineral oil-type profiles. Other PCB-containing fluids, such as heat transfer fluids, hydraulic oils, and turbine coolants/lubricants, may also be present. Much of the variability in PCB concentrations in oil is expected to be related to the variability in primary source materials handled at and released from the facility (varying PCB formulations in oil), and presence/release of other contaminant hydrocarbons independent of PCB formulations (i.e. other hydrocarbon oils mixing with PCB-containing oils). PCB's are associated with TPH in site embayment (surficial and subsurface) sediments; with the following statistics for PCB's in oil associated with site estuarine sediments: mean concentration of PCB's in oil = 4.6×10^{-3} (4.6 ppth), range = $2.1 \times 10^{-5} – 2.7 \times 10^{-2}$ (2.7%), CV = 1.2. The greatest concentrations of PCB's in oil are found in nearshore surficial sediments in the southwestern portion of the embayment (5.3% at SED1 (SAIC 2007) and 2.7% at DSS-10 (DOF 2012)). *PCB's in site soils and sediments are clearly associated with non-aqueous phase petroleum fluids and oils.*

Groundwater

The spatial distributions of PCB's in groundwater for both upper and deeper zones presented in Figures 5-26b and 5-26c reflect the distributions of PCB's in upland soils presented in Figures 5-27a and 5-27b. This observation suggests that:

> **a**) PCB's in groundwater is a result of groundwater contact with PCB-contaminated soils and oils, and
>
> **b**) PCB-contaminated groundwater migration is either relatively slow and/or site conditions provide relatively high attenuation for the migration of PCB's in groundwater.

PCB's in groundwater are generally associated with TPH in groundwater. An evaluation of PCB's *vs.* TPH in site groundwater indicates that approximately 20% of the variability in PCB concentrations is strictly dependent on the level of TPH in groundwater. This variability is similar to that observed for site soils (30%). (As indicated above, the factors controlling the remaining variability in PCB concentrations (in TPH or oil) include the variability in source-material PCB formulations and the amount of other contaminant hydrocarbon mixtures released that do not contain PCB's). The slope or mean concentration of PCB's in TPH for groundwaters is 6.7×10^{-4} or 0.67 ppth (670 ppm in oil). This concentration is comparable to the slope determined for PCB's in oil (TPH) for upland soils (9.9×10^{-4}). The range of concentrations for PCB's in oil/TPH for groundwaters is also comparable to that observed for upland soils – $(1.9 \times 10^{-5} – 9.0 \times 10^{-3})_{groundwater}$ *vs.* $(2.1 \times 10^{-5} – 6.6 \times 10^{-3})_{soils}$.

Further analysis of PCB's associated with TPH in site media (groundwater and soils) was performed on collocated soil, LNAPL and groundwater samples. The location selected for this analysis due to available data (multiple media contact in the same location) is at SA-MW1 for groundwater (tPCB's = 4.21 µg/L), LNAPL (tPCB's = 1670 mg/kg) and soil (same as P29; tPCB's = 77 mg/kg). Specific Aroclors are presented as the percentage or proportion of the total PCB's found to evaluate any selective partitioning between media for Aroclors. (Note that any phase partitioning of PCB's between media, if occurring, is expected to show up to an 8x difference for Aroclor 1242/48 *vs.* Aroclor 1260 due to the differences in partition coefficients/factors, K_{oc}'s and K_{ow}'s. Aroclor 1242/48 would show a significant and proportional increase over Aroclor 1260 in groundwater relative to soils and LNAPL if/when partitioning is an important mechanism for release of PCB's from soils/LNAPL to groundwater.) The screening interval for the well is 4-24' and the sampling interval for the soil (SA-1-5 (P29))was 5-6.5' below ground surface (bgs). The groundwater (GW) data represents a mean for three samples taken at different periods (11/15, 3/16 & 9/16).

	Aroclor percentage (%) of total PCB's			
	Aroclor 1242/48	Aroclor 1254	Aroclor 1260	total PCB's in oil (ppth)
SA-MW1 GW	65	24	11	2.9
SA-MW1 LNAPL	60	28	12	1.7
SA-MW1 (P29) soil	66	23	11	1.2

The above data indicate the relative proportions of Aroclors in groundwater, LNAPL and soil are essentially the same, suggesting that a phase partition mechanism for transfer of PCB's to water from soil/oil in source areas is negligible. If a phase partition mechanism was active, then the proportion of Aroclor 1242/48 to the total PCB's would be greater than the proportion exhibited in soil/oil. (This is due to the differences in the partition coefficients, K_{oc} and K_{ow} [critical physicochemical constants discussed above], showing preferential partitioning or migration of Aroclor 1242/48 compared to Aroclor 1260 from soil/oil to water.) The above data indicate that PCB's in groundwater in the vicinity of source areas and materials is likely a result of simple solubilization of the oil and associated PCB constituents. Another interesting observation is the near doubling of the PCB concentration in the oil (TPH) associated with the aqueous or groundwater phase compared to the LNAPL and oil in soil. This difference in PCB concentrations associated with oils in water and soils is not consistent with the means (slopes) determined for PCB's in site-wide media, where the values were near equivalent (see previous discussion). Potential causes for the difference in PCB concentrations in TPH/oil observed at SA-MW1 could include – the concentration of PCB's associated with oil in soil and LNAPL are not entirely representative of the media contributing to the groundwater contamination, and/or some preferential degradation of petroleum hydrocarbons *vs.* PCB's is occurring in groundwater. The later mechanism is entirely possible as PCB's are significantly more recalcitrant and stable to chemical and microbiological degradation than petroleum hydrocarbons. In summary, available ICS/NWC *site-specific data indicates that PCB's groundwater contamination in source areas is primarily a result of the mixing and solubilization of contaminated oils found in soils. Selective phase partitioning across media in source areas is <u>not</u> evident.*

Migration or spread of PCB-contaminated groundwater at the site is relatively limited, and groundwater contamination appears to be mostly confined to identifiable source areas containing contaminated oil and soils. Figures 5-26a, 5-26b and 5-26c showing the distribution of PCB's in groundwater identify a [relatively contiguous] contaminated area in the upper and deeper groundwater zones that is in direct contact with contaminated soils. This area comprises a northerly nearshore section of land (southern shoreline to the embayment) and former ditch/lagoon flanked by areas with groundwater exhibiting nondetectable (< 0.01 µg/L) PCB's contamination. A separate and less-contaminated area (regarding groundwater contamination) is identified in the water table zone above the primary aquitard (Figure 5-26a). PCB-contaminated groundwater that likely impacts the estuarine environment (sediments and surface water) due to direct connectivity to estuarine waters is at HC-B1, MW-Eu, SA-MW2, and possibly SA-MW1.

Groundwater PCB's Attenuation

A comparison of groundwater PCB concentrations in source areas (SA) to downstream or downgradient (DG) (relative to groundwater flow direction) areas shows a steep reduction in groundwater PCB levels. The following analysis estimates groundwater PCB attenuation rates in the vicinity of the pipeline and former ditch located on the eastern boundary of the property. A groundwater mixing zone lies between the former ditch, which is a source area for PCB-contaminated groundwater, and the estuarine Duwamish Waterway. Groundwater migration and net flow in this zone is expected to be relatively low due to tidally influenced flow reversals. Groundwater station locations were selected in both the upper and deeper zones, and in line with the estimated groundwater flow paths. Percentage estuarine influence is found in and taken from Figures 4-22a and 4-22b of the draft RI report.

Upper Zone (10-17' depth)		
Source area – DOF-MW1	49% estuarine	0.646 µg/L tPCB's
Downgradient – P26	87% estuarine	0.020 µg/L tPCB's
	tPCB's attenuation = 32	
	~ 60' distance between locations	
Deeper Zone (19-35' depth)		
Source area (SA) – P18-A	10% estuarine	0.59 µg/L tPCB's
SA – P21-A	< 5% estuarine	0.85 µg/L tPCB's
SA – P33-A	< 5% estuarine	0.30 µg/L tPCB's
Mean SA	5% estuarine	0.58 µg/L tPCB's
Downgradient (DG) – MW-IL	37% estuarine	0.006 µg/L tPCB's
DG – MW-FL	20% estuarine	< 0.01 µg/L tPCB's
DG – MW-GL	51% estuarine	< 0.01 µg/L tPCB's
Mean DG	36% estuarine	0.006 µg/L tPCB's
	tPCB's attenuation ≃ 100	
	60-120' distance between locations	

The estuarine influence in both upper zone samples is likely the result of leakage from the drainage pipe (10.5' bgs) of estuarine water accumulated due to tidal backflow originating at the pipe discharge to the 2nd Ave. storm drain outlet in the embayment. Significant [lateral or horizontal] mixing of PCB-contaminated groundwater in the deeper zone beneath the former ditch and pipeline is not apparent, based on the large differences in groundwater TDS (salinity and estuarine contributions) and PCB concentrations between the source area (the former ditch) and nearby downgradient wells (as demonstrated above). Estuarine water contribution in the deeper zone in the area of the former ditch is low, averaging less than 5%, whereas estuarine water contributions to downgradient wells (at the same depth) are significantly greater; averaging 36%.

Significant attenuation of PCB's contamination in site groundwater is observed in both upper and deeper zones between contaminant source areas and downgradient wells. Groundwater PCB "apparent" attenuation factor rates from the pipeline and former ditch average 5-17x per 10 feet (0.5-1.7x/ft) in the downgradient flow direction. Possible mechanisms that control the observed attenuation in downgradient areas are low or restricted groundwater flow from source areas, groundwater advection/dispersion in downgradient mixing zones, and soil adsorption from the dissolved phase (application of K_{oc}) between source and downgradient areas. Either one or both of the first two mechanisms are important as demonstrated in the differences in percentage estuarine influence as an indicator of groundwater mixing. The third mechanism, soil adsorption and sequestration of PCB's from groundwater, is also likely significant, especially if soil organic carbon contents are elevated. Soil partition coefficients (K_{oc}) can be as great as 350,000, in the case of Aroclor 1260, and can provide the mechanism for adsorption and soil sequestering of hydrophobic contaminants. This mechanism is the basis for commercial application of contaminated groundwater cleanup strategies employing injectable activated carbon suspensions (PlumeStop® by Regenesis). An evaluation of site TOC (total organic carbon) data for nonimpacted sediments (no measurable TPH and PCB's) indicates the range of site [fill] soil TOC to likely be in the range of 0.3-4.2%, with a mean of 2% and a CV of 0.51. Adsorption of hydrophobic chemicals, such as PCB's, to TOC-containing soils is an important mechanism for the extraction and sequestration of chemicals from groundwater. This process is facilitated and enhanced by an increase in TDS in the mixing zone. The ICS/NWC site possesses characteristics that are demonstrated to "naturally" and effectively attenuate groundwater PCB's for the protection of estuarine surface water and sediments.

<u>Summary</u>

An evaluation of the fates and distributions of PCB's in contaminated media at the ICS/NWC site demonstrates that PCB's behavior is consistent with current published technical literature descriptions and understanding of extremely hydrophobic chemicals' contamination of environmental media. The ICS/NWC site exhibits site-specific characteristics that have minimized the wide-spread contamination of environmental media with PCB's from groundwater flow. PCB's-contaminated environmental media are relatively localized and, in conjunction with other factors, have been contained by fill soils exhibiting moderate levels of organic carbon (TOC) content. Groundwater migration of PCB's from highly contaminated source materials in some areas of the site has been relatively low as demonstrated by PCB groundwater attenuation rates on the order of 0.5-1.7x/ft.

<u>Remedial Management Strategy</u>

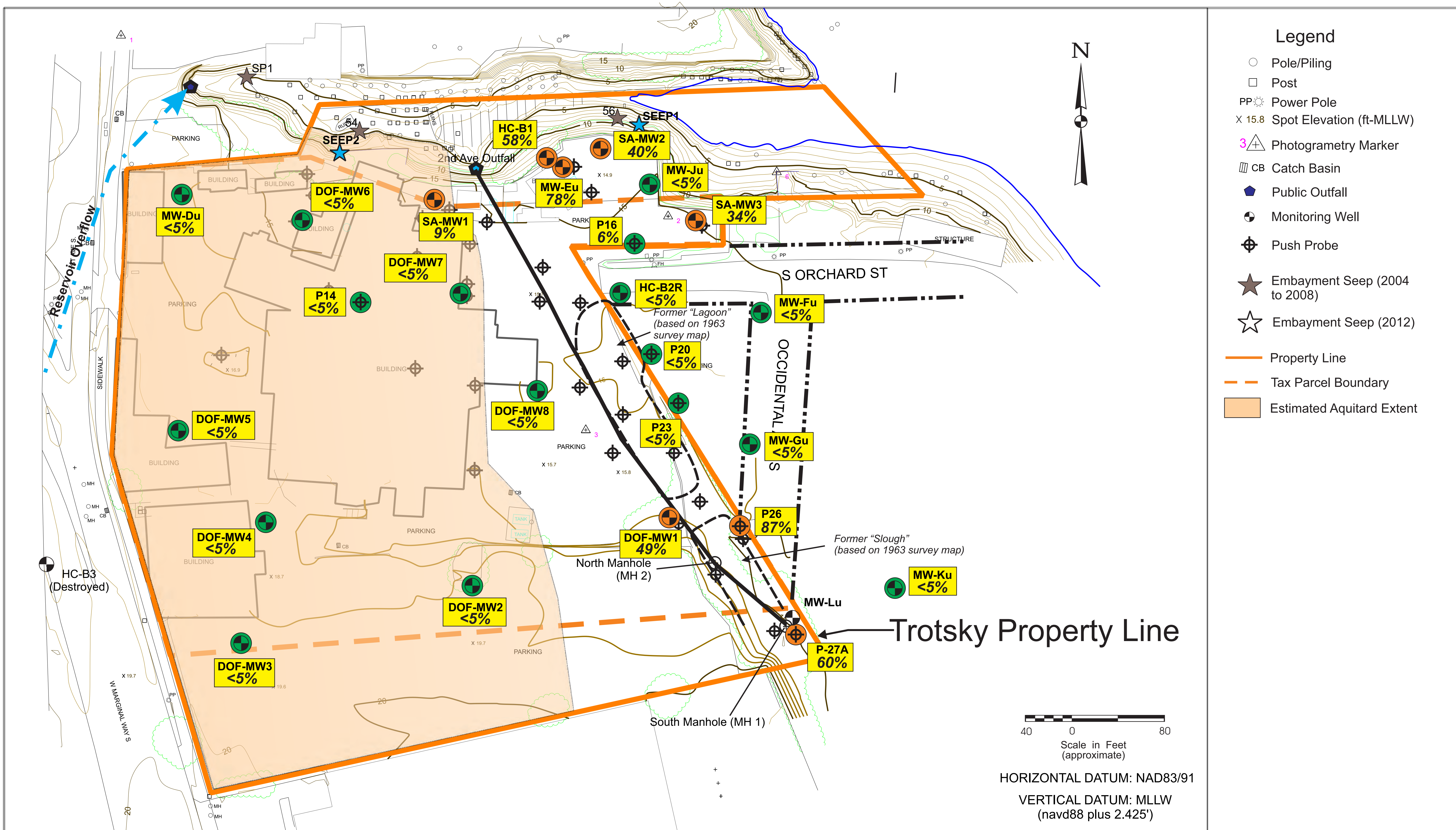
Based on the above findings, elements of an effective remedial strategy for the ICS/NWC site may include the following activities:

- Removal of contaminated embayment sediments, as practical, and consider placement of an appropriate cap (augmented with organic carbon) to reduce migration of contaminated groundwater to surface waters and remediated sediments.
- Removal of contaminated source materials/soils from the nearshore area, as practical, to prevent estuarine contamination from groundwater seeps and soils erosion. If removal is

impractical due to engineering constraints, the placement of an appropriate barrier may be necessary.

- Removal of contaminated source material/soils from along the pipeline and former ditch, as practical.
- Ensure that groundwater flowpaths from any residual contaminated source materials are sufficiently long to enhance attenuation by prolonging contact time with relatively noncontaminated and nonleachable soils (or amended soils) to extract/sequester contaminants from groundwater prior to discharge to surface waters. This may include redirection of groundwater flowpaths to enhance advection/dispersion and increase efficiencies of contaminant sequestration prior to discharge to surface waters.
- Ensure conditions are optimal for sequestration of contaminants from groundwater, such as sufficient levels of TOC in soils or amended soils. Injection of activated carbon suspensions into soils and groundwater could be employed as a contingency measure to enhance sequestration by adsorption and prevent PCB's migration via groundwater.

Appropriate engineering solutions can be designed and applied during site remediation in order to address the site-specific issues identified above. An effective remedial strategy should be within the range of established remedial construction practices.



Notes:

1) Property Survey by Continental Survey Co. (12-15-09)
2) Topography by David C. Smith Associates (flown 3-18-10 @ 1412 PDT)

Ref: Mixing Ratios

Estuarine Water Content Less Than 5%

Estuarine Water Content Equal to or Greater Than 5%

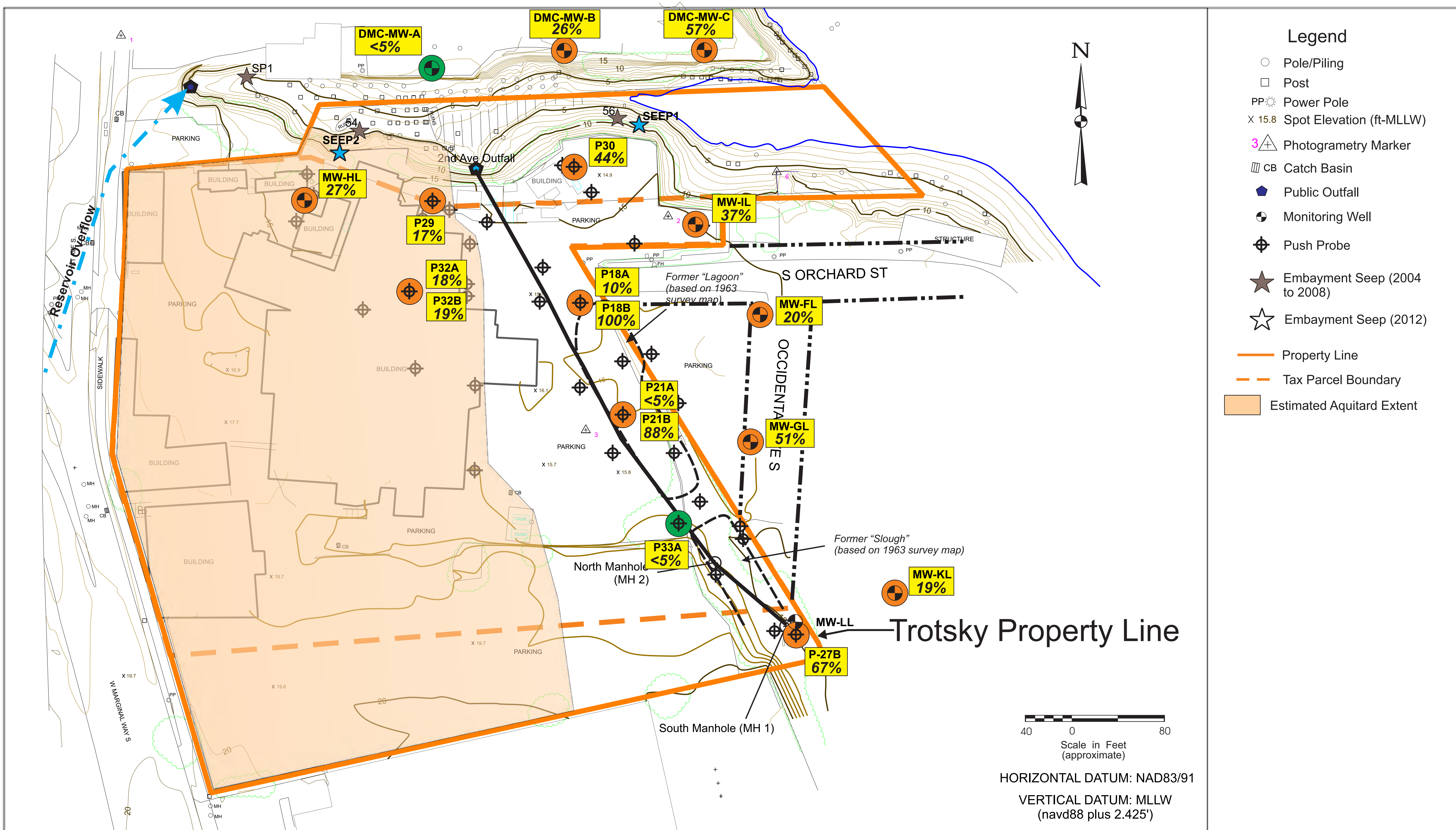
ICS/NW Cooperage Site

Estuarine Water Contents Upper Zone Groundwater

SUM-008-00 (ICS) *Sept. 2016*

Dalton, Olmsted & Fuglevand, Inc.

FIGURE 4-22a



Notes:

1) Property Survey by Continental Survey Co. (12-15-09)
2) Topography by David C. Smith Associates (flown 3-18-10 @ 1412 PDT)

Estuarine Water Content Less Than 5%

Estuarine Water Content Equal to or Greater Than 5%

Ref: Mixing Ratios.cdr

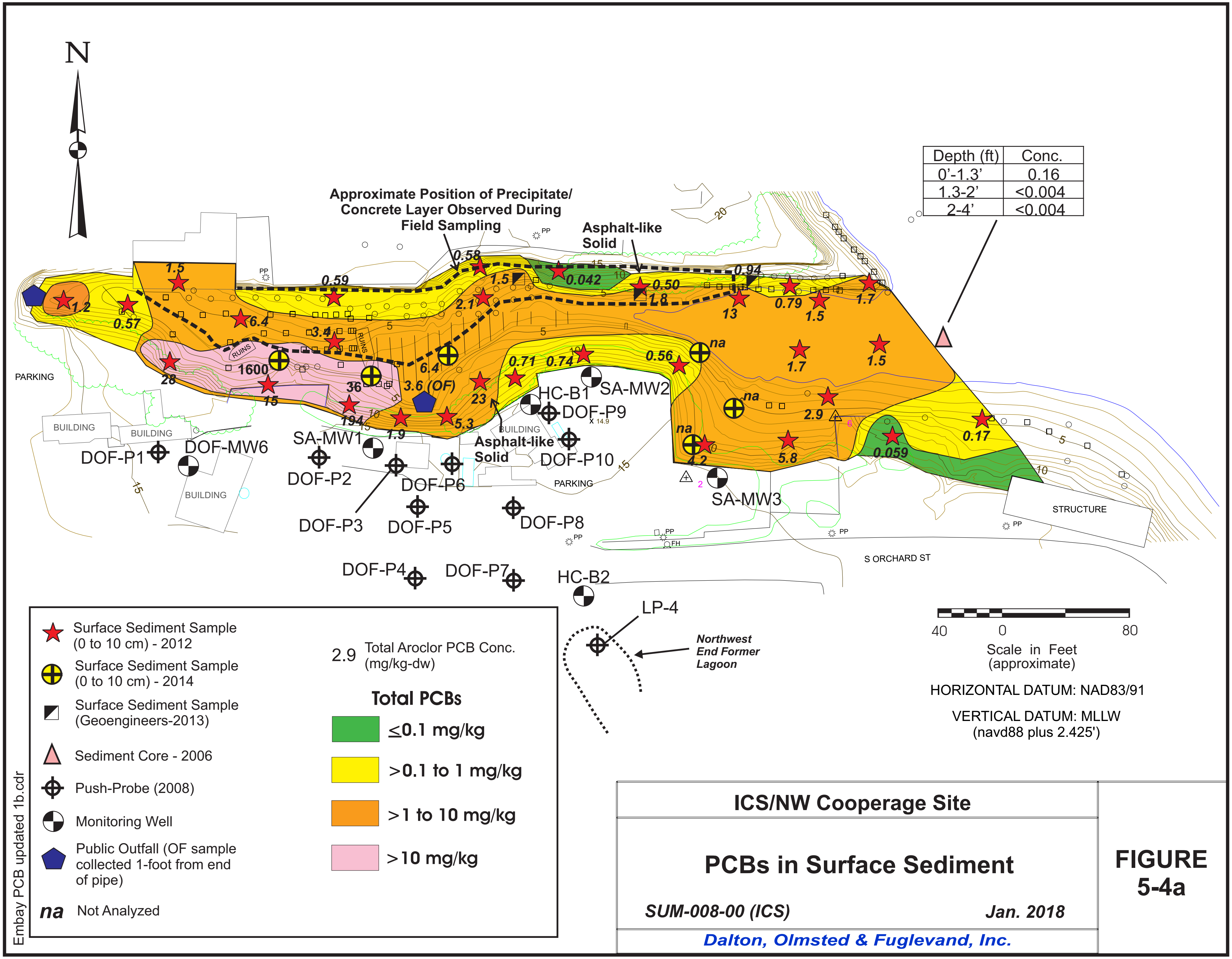
ICS/NW Cooperage Site

Estuarine Water Contents Deeper Zone Groundwater

SUM-008-00 (ICS) *Sept. 2016*

Dalton, Olmsted & Fuglevand, Inc.

FIGURE 4-22b



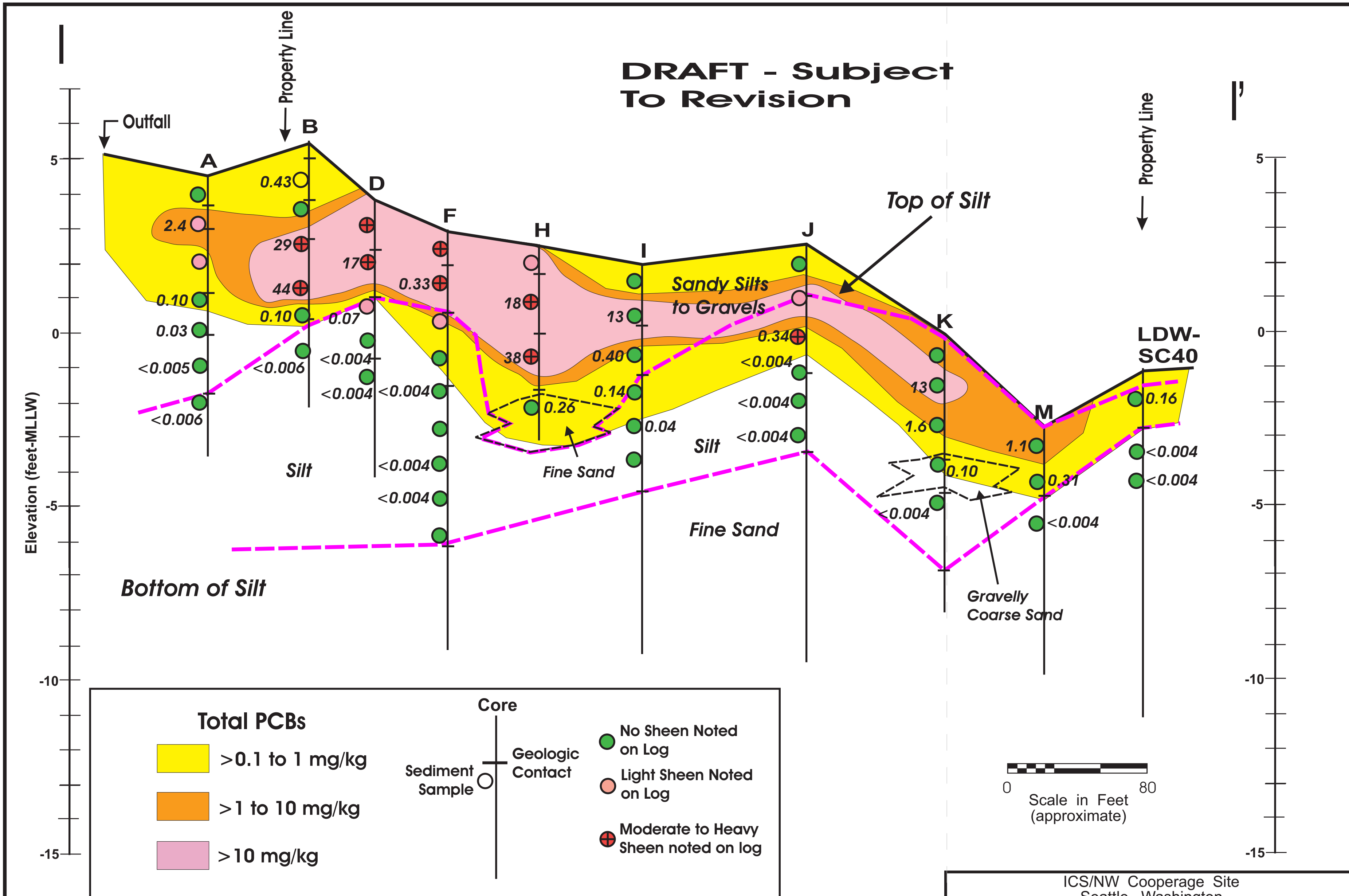
ICS/NW Cooperage Site

PCBs in Surface Sediment

FIGURE 5-4a

SUM-008-00 (ICS) *Jan. 2018*

Dalton, Olmsted & Fuglevand, Inc.



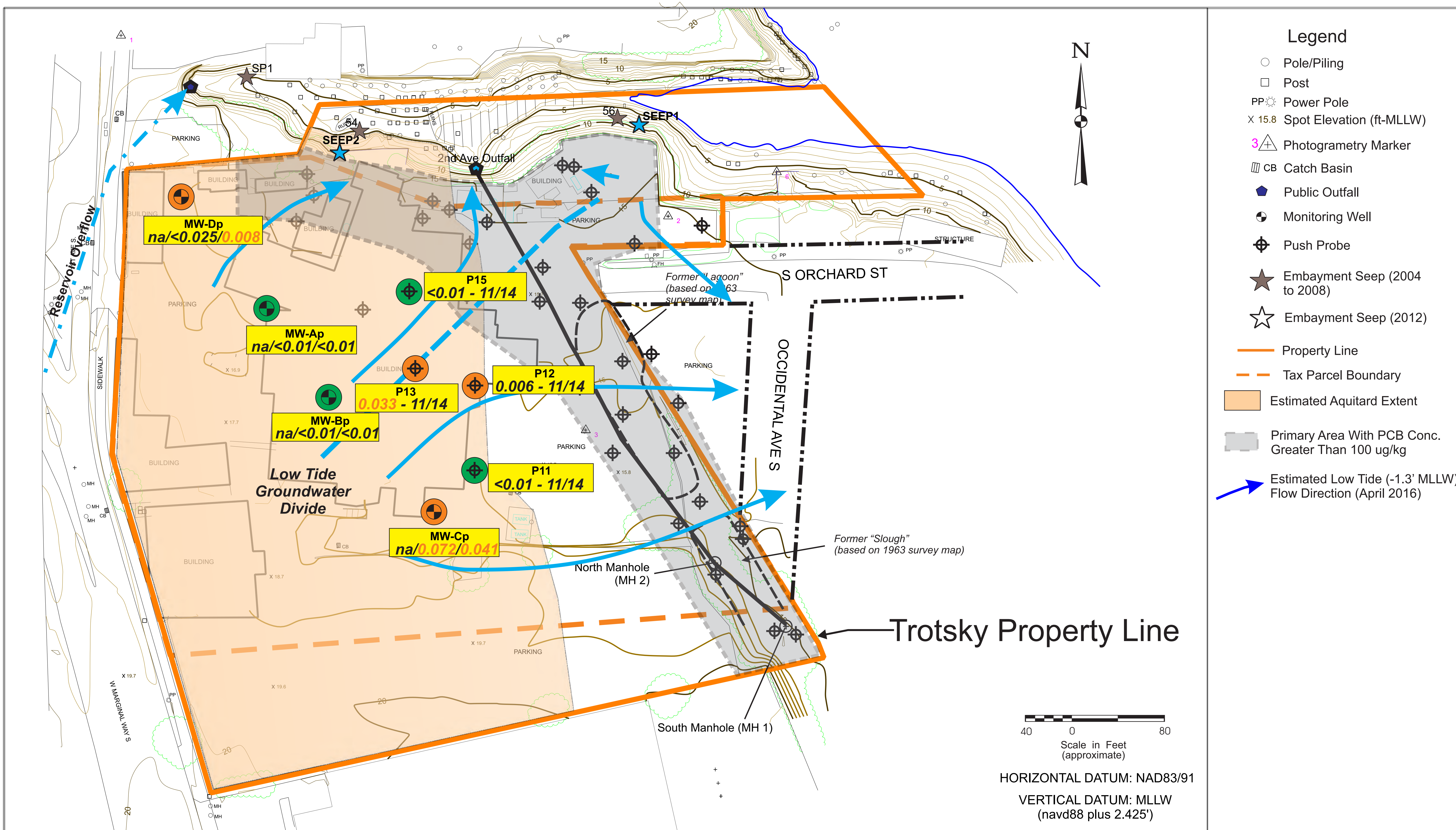
ICS/NW Cooperage Site
Seattle, Washington

PCBs in Subsurface Sediment

POT-001-00 **FIGURE 5-5a Rev.** July 2016

Dalton, Olmsted & Fuglevand, Inc.

Ref: Section I-I' PCBs rev rpt.cdr



Notes:
1) Property Survey by Continental Survey Co. (12-15-09)
2) Topography by David C. Smith Associates (flown 3-18-10 @ 1412 PDT)

Ref: TPCBs GW Plot R1-R2.cdr

Concentration ≤ Screening Level (SL= 0.01* ug/l)
Concentration > Screening Level (SL= 0.01* ug/l)
2.0/5.3/6.0 Concentration - ug/l (11-2012/11-2015/3-2016)
na - Not Available; * SL Based on PQL

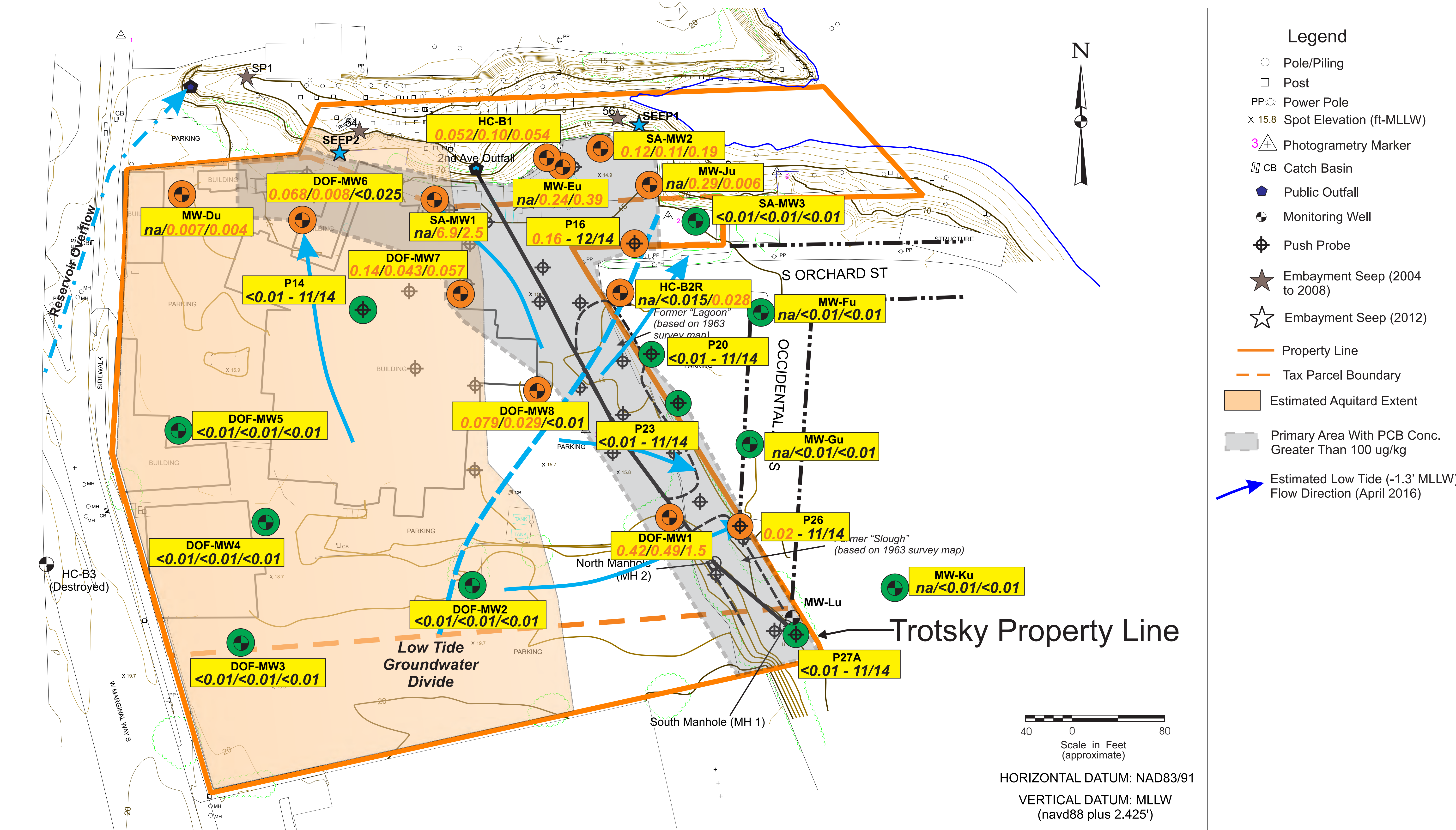
ICS/NW Cooperage Site

Total PCB Concentrations
Water Table Zone Above Aquitard

SUM-008-00 (ICS) ***June 2016***

Dalton, Olmsted & Fuglevand, Inc.

FIGURE 5-26a



Notes:
1) Property Survey by Continental Survey Co. (12-15-09)
2) Topography by David C. Smith Associates (flown 3-18-10 @ 1412 PDT)

Ref: TPCBs GW Plot R1-R2.cdr

Concentration ≤ Screening Level (SL= 0.01* ug/l)

Concentration > Screening Level (SL= 0.01* ug/l)

2.0/5.3/6.0 Concentration - ug/l (11-2012/11-2015/3-2016)

na - Not Available; * SL Based on PQL

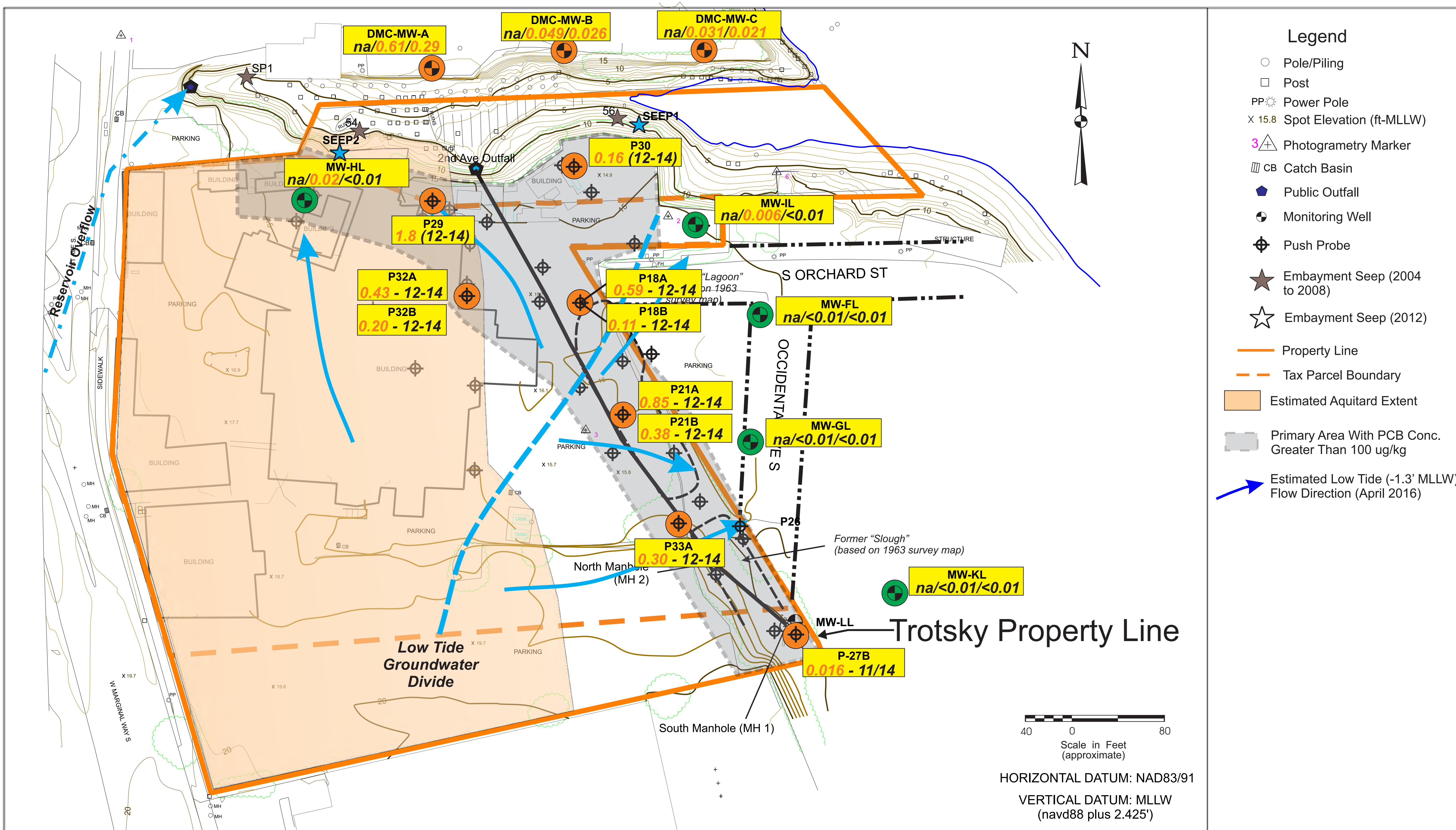
ICS/NW Cooperage Site

Total PCB Concentrations Upper Zone

SUM-008-00 (ICS) ***June 2016***

Dalton, Olmsted & Fuglevand, Inc.

FIGURE 5-26b



Notes:

1) Property Survey by Continental Survey Co. (12-15-09)
2) Topography by David C. Smith Associates (flown 3-18-10 @ 1412 PDT)

Concentration ≤ Screening Level (SL= 0.01* ug/l)

Concentration > Screening Level (SL= 0.01* ug/l)

2.0/5.3/6.0 Concentration - ug/l (11-2012/11-2015/3-2016)

na - Not Available; * SL Based on PQL

Ref: TPCBs GW Plot R1-R2.cdr

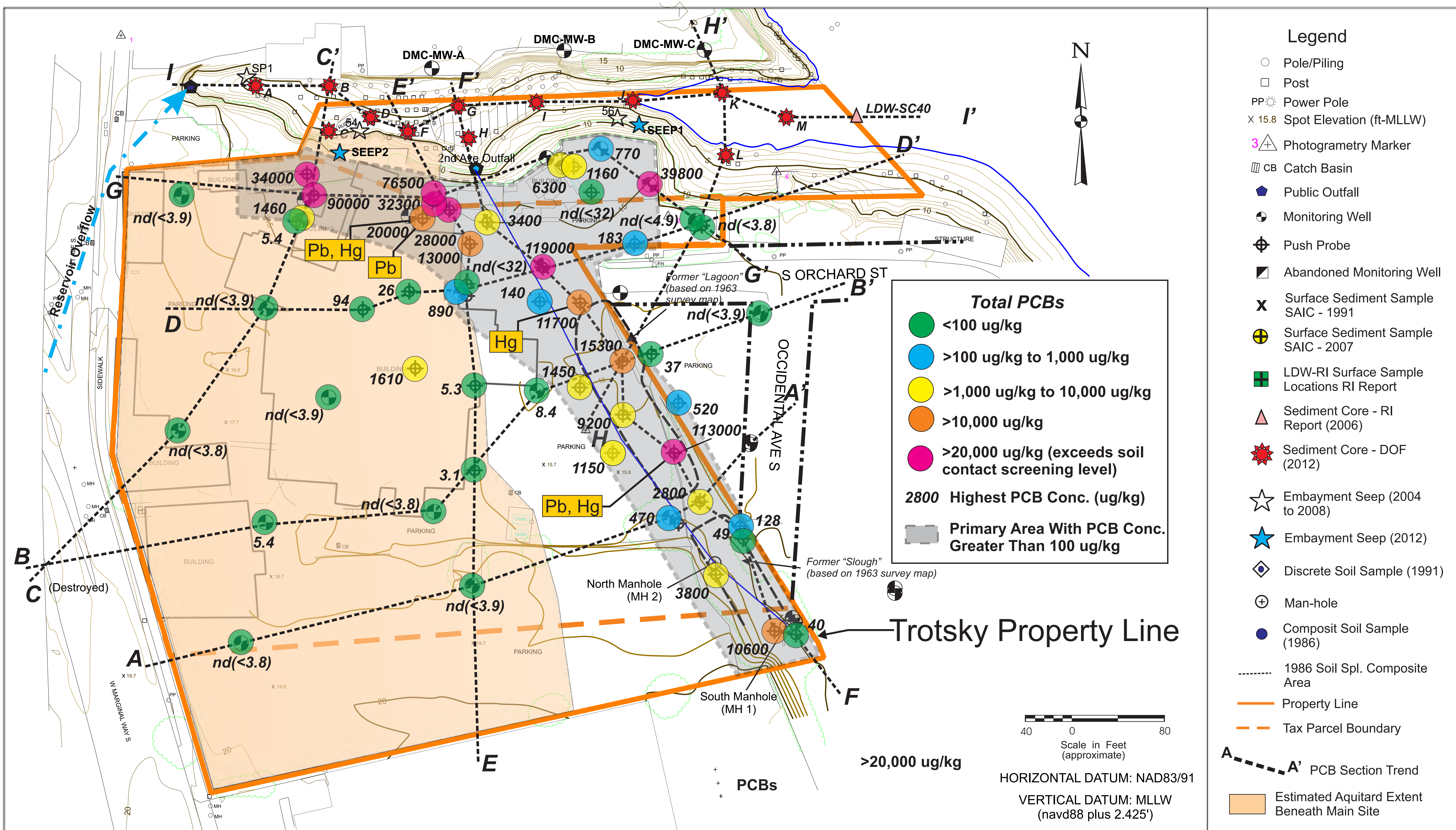
ICS/NW Cooperage Site

Total PCB Concentrations
Deeper Zone

SUM-008-00 (ICS) ***June 2016***

Dalton, Olmsted & Fuglevand, Inc.

FIGURE 5-26c



Notes:
1) Property Survey by Continental Survey Co. (12-15-09)
2) Topography by David C. Smith Associates (flown 3-18-10 @ 1412 PDT)

Ref: Upland Phase 2a PCBs 100 ug_kg rev.cdr

PCBs

Pb and/or Hg

Locations That Exceed Soil Contact Screening Levels

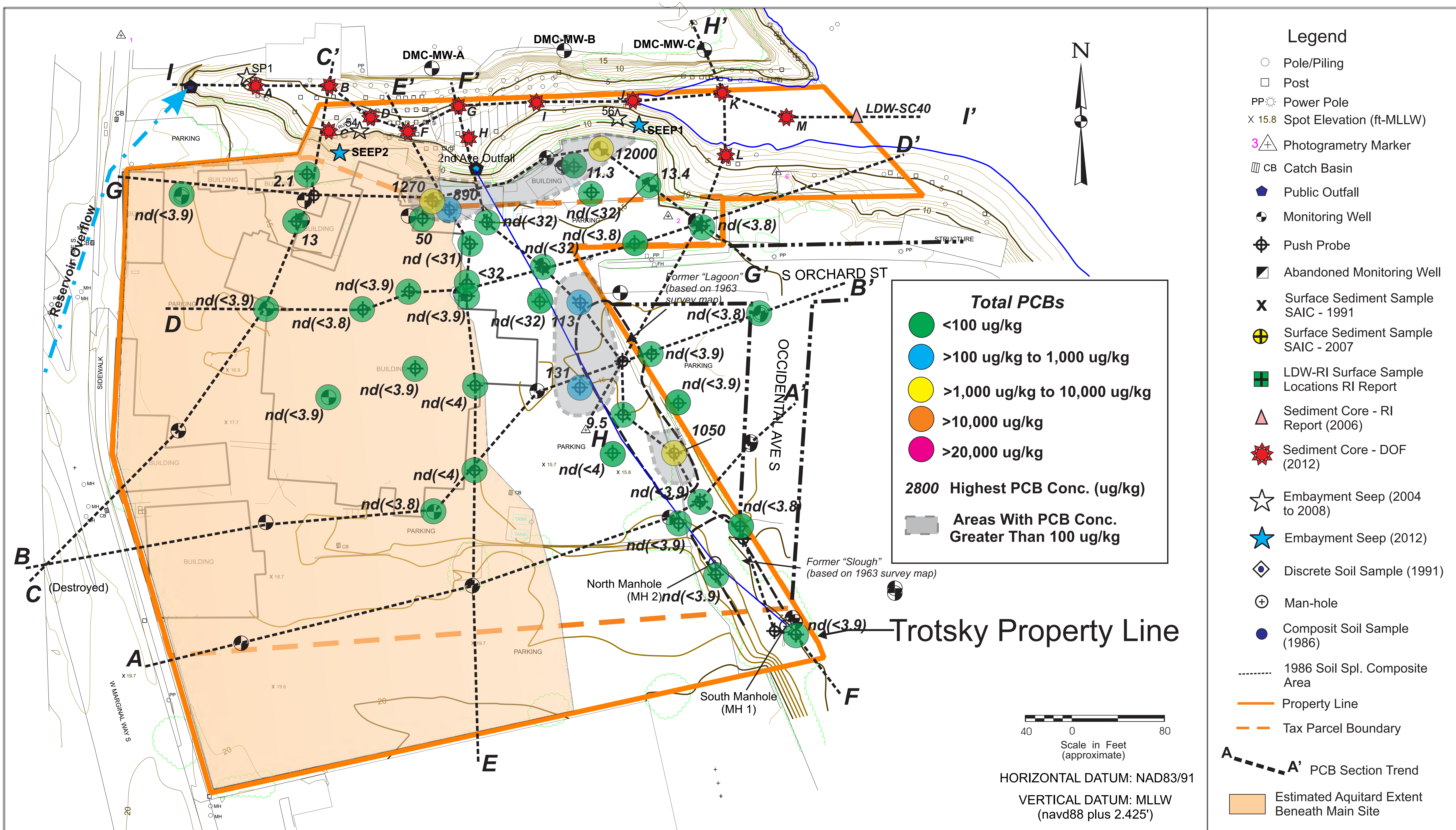
ICS/NW Cooperage Site

Extent of PCBs in Soil (Less Than 15' Deep)

SUM-008-00 (ICS) *July 2016*

Dalton, Olmsted & Fuglevand, Inc.

FIGURE 5-27a



Notes:

1) Property Survey by Continental Survey Co. (12-15-09)
2) Topography by David C. Smith Associates (flown 3-18-10 @ 1412 PDT)

Ref: Upland Phase 2a PCBs 100 ug_kg rev.cdr

ICS/NW Cooperage Site

Extent of PCBs in Soil (Greater Than 15' Deep)

SUM-008-00 (ICS) *July 2016*

Dalton, Olmsted & Fuglevand, Inc.

FIGURE 5-27b

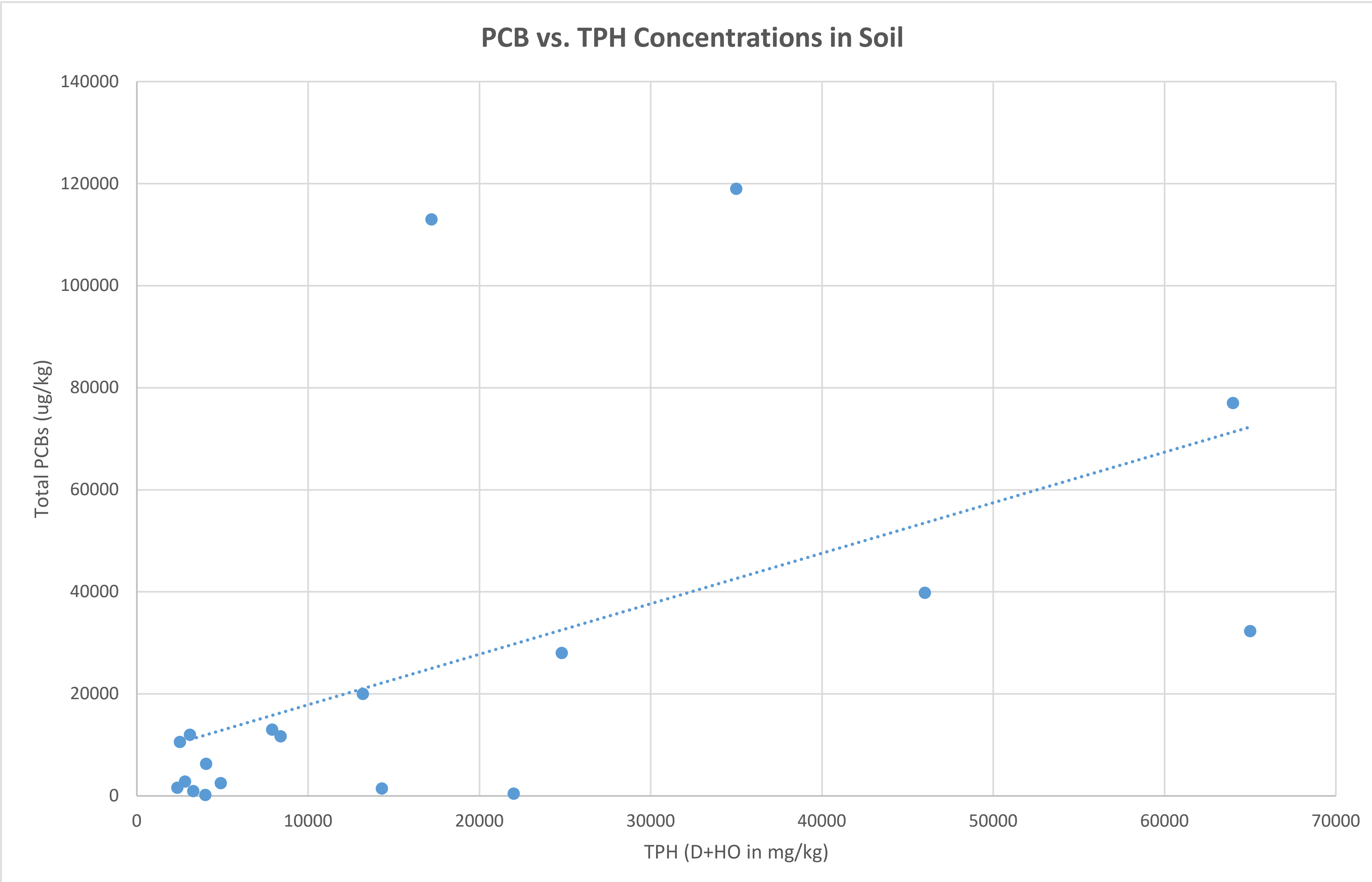
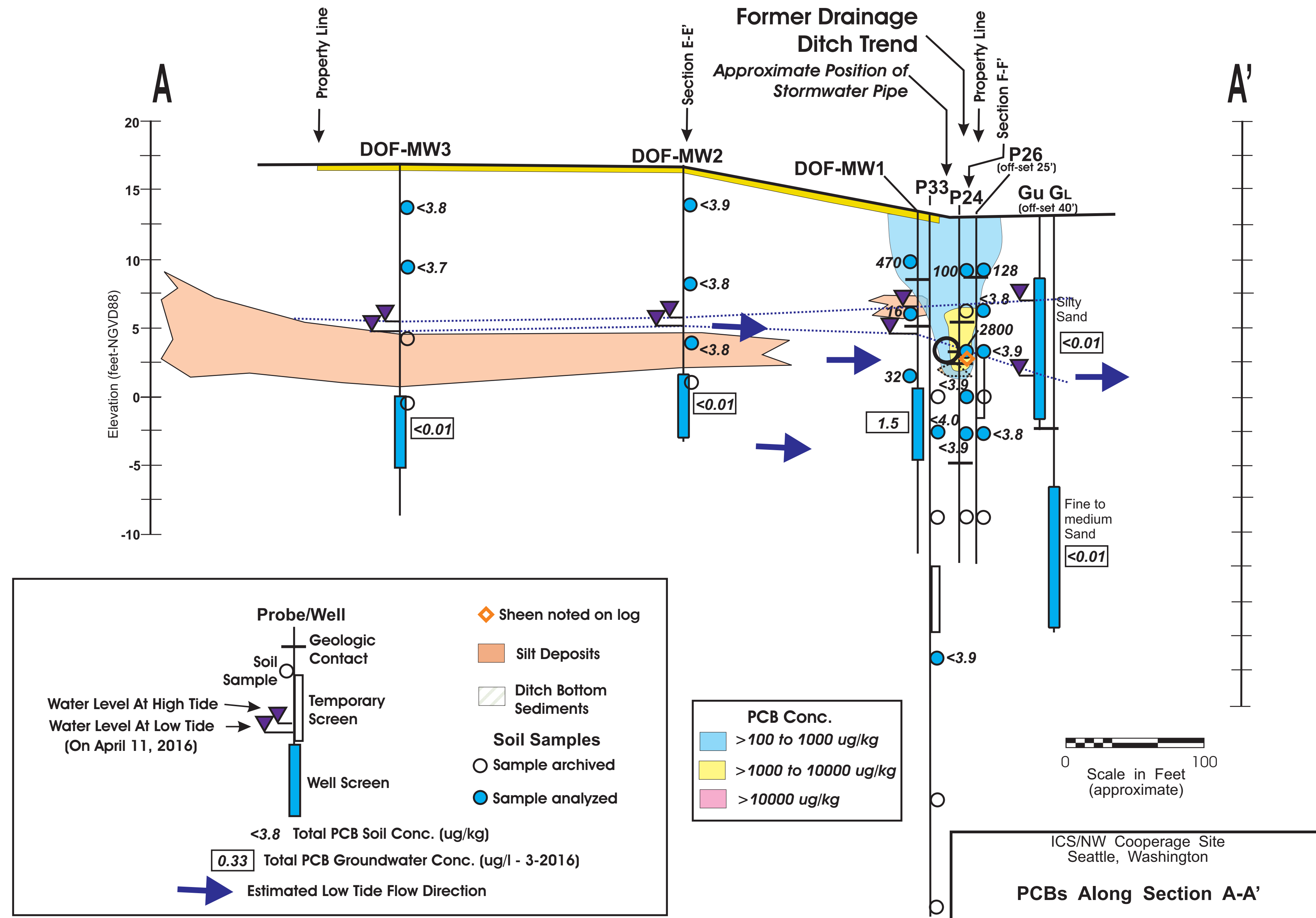


FIGURE 5-29 - PCBs vs. TPH in Soil



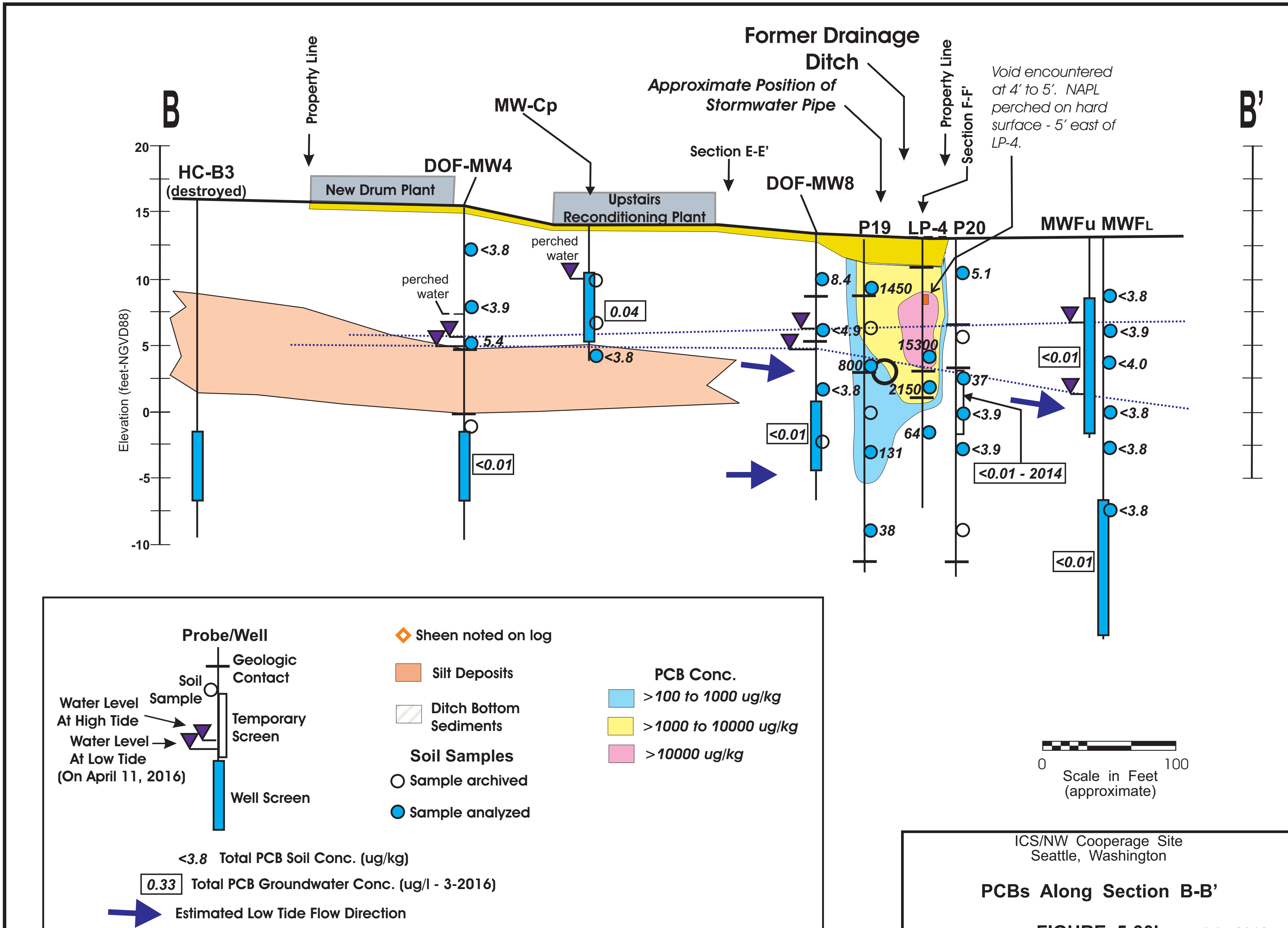
ICS/NW Cooperage Site
Seattle, Washington

PCBs Along Section A-A'

POT-001-00 **FIGURE 5-30a** July 2016

Dalton, Olmsted & Fuglevand, Inc.

Ref: Section A-A' PCB 7-2016.cdr



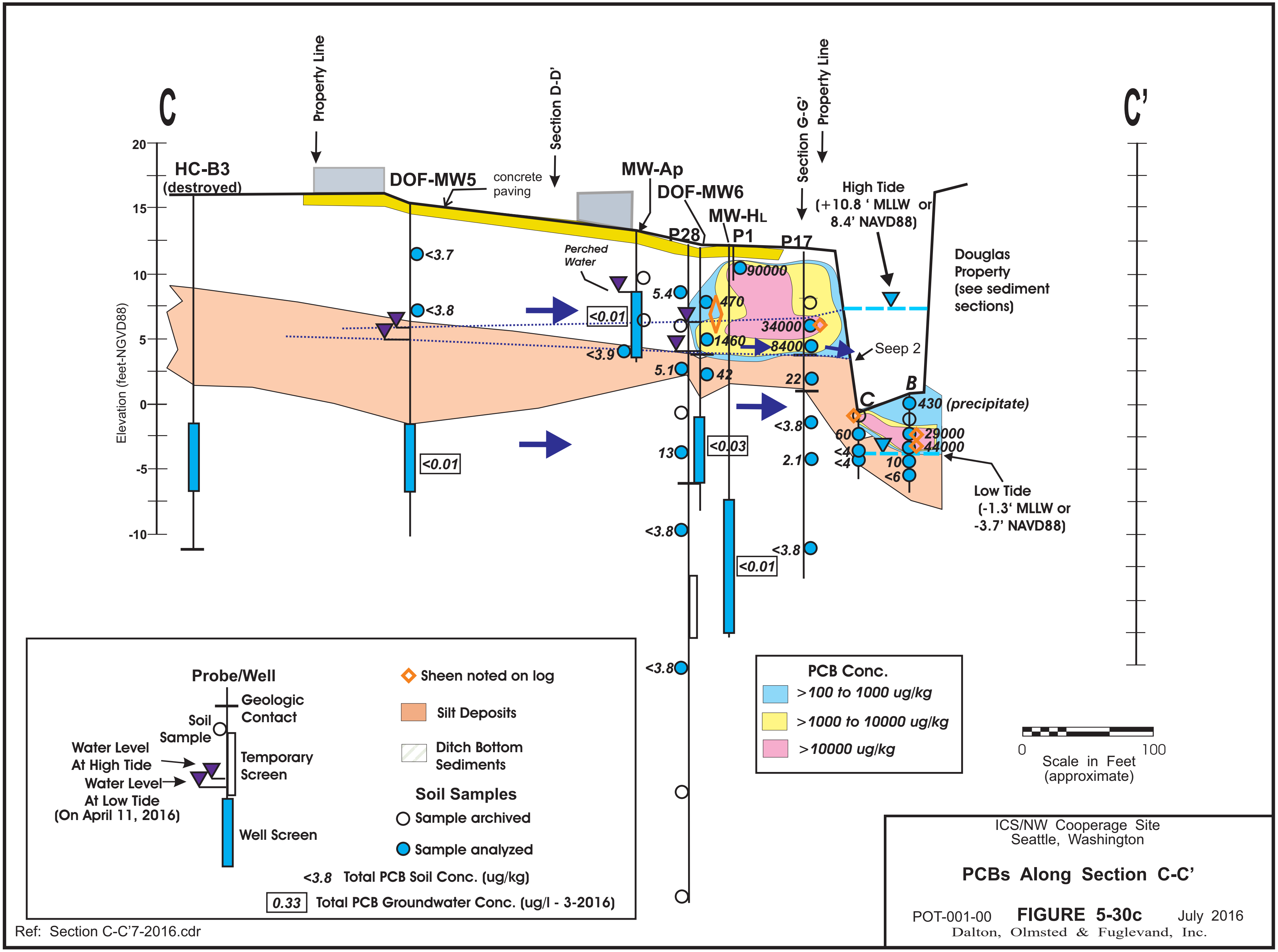
ICS/NW Cooperage Site
Seattle, Washington

PCBs Along Section B-B'

POT-001-00 **FIGURE 5-30b** July 2016

Dalton, Olmsted & Fuglevand, Inc.

Ref: Section B-B'7-2016.cdr

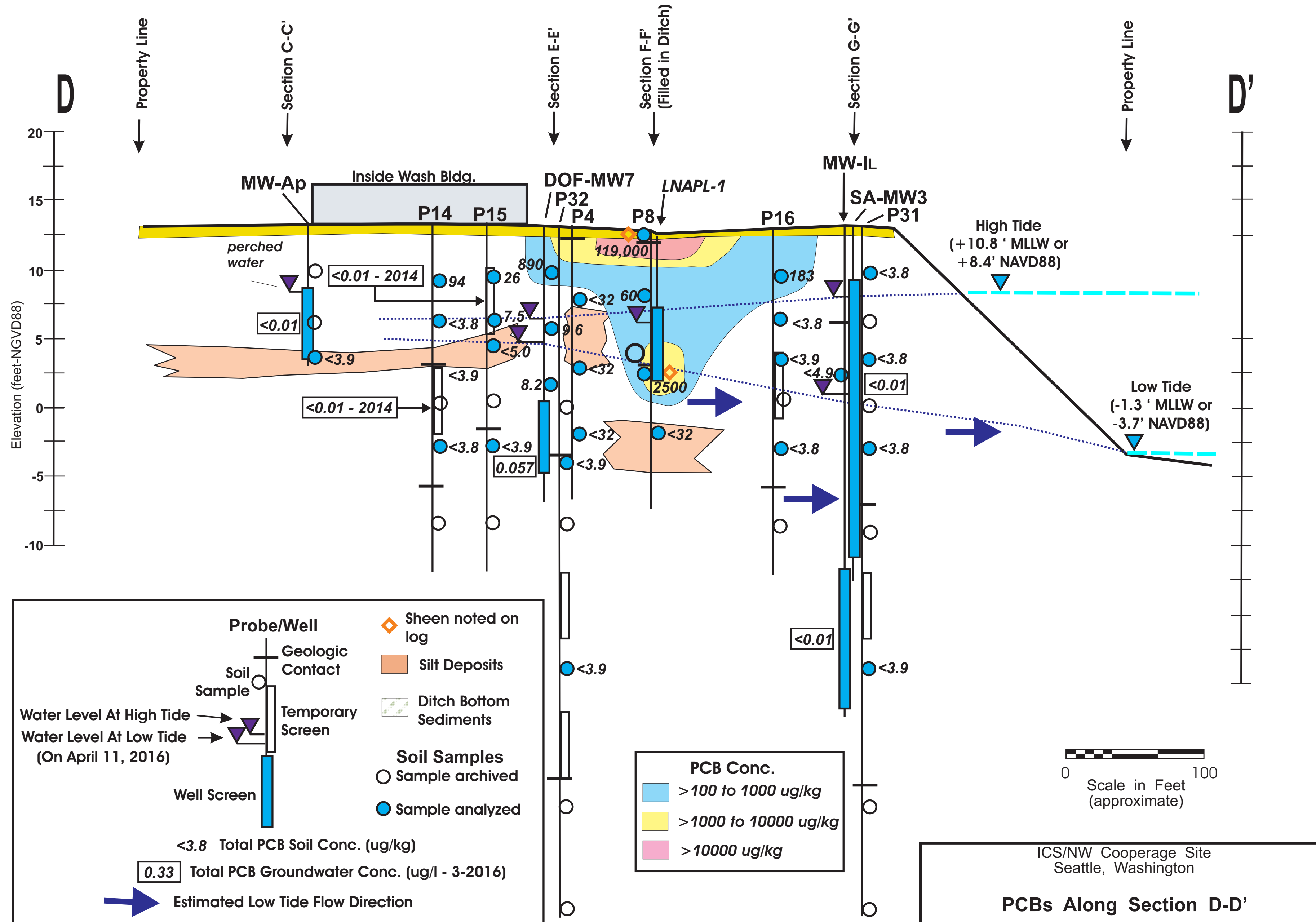


ICS/NW Cooperage Site
Seattle, Washington

PCBs Along Section C-C'

POT-001-00 **FIGURE 5-30c** July 2016

Dalton, Olmsted & Fuglevand, Inc.



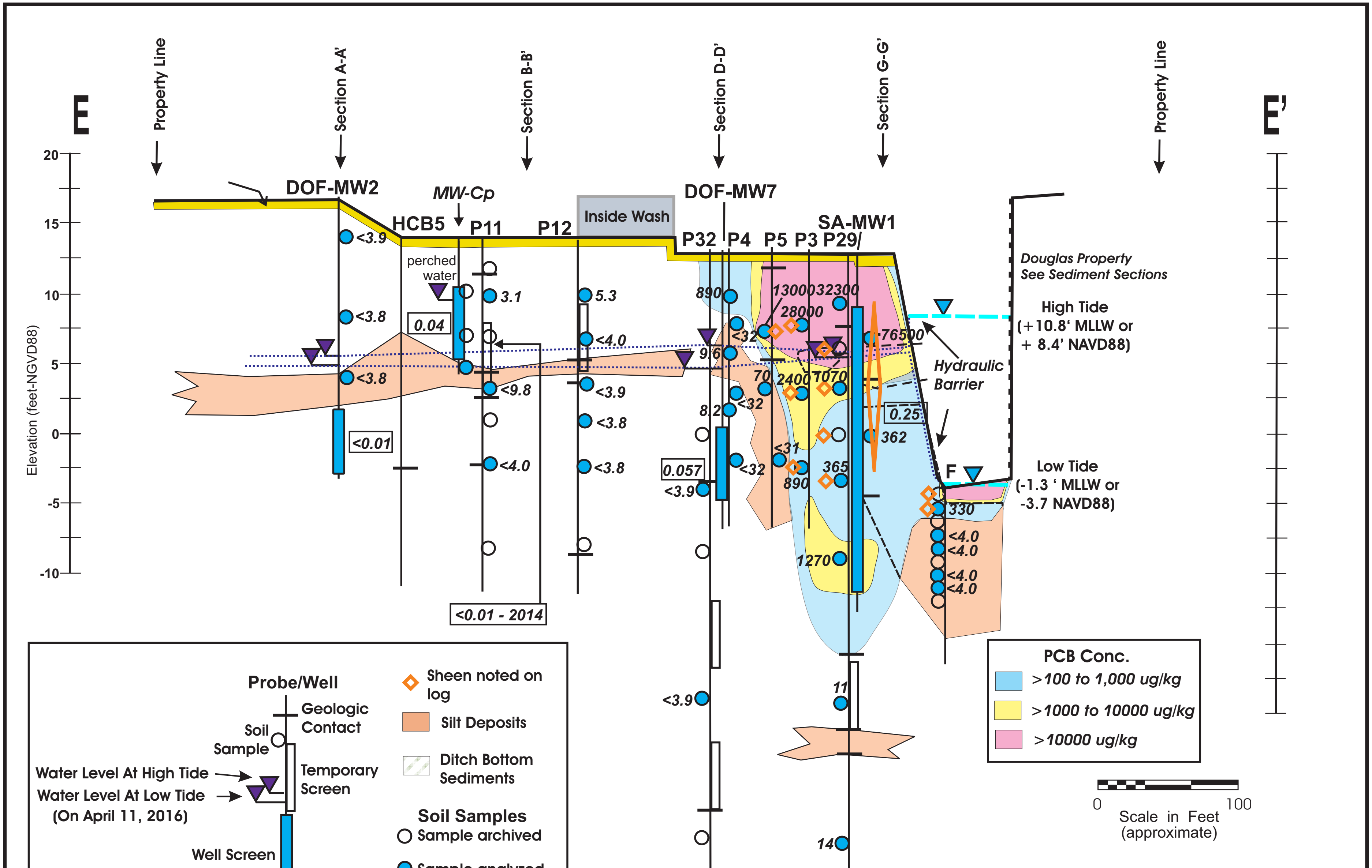
ICS/NW Cooperage Site
Seattle, Washington

PCBs Along Section D-D'

POT-001-00 **FIGURE 5-30d** July 2016

Dalton, Olmsted & Fuglevand, Inc.

Ref: Section D-D' PCB 7-2016.cdr



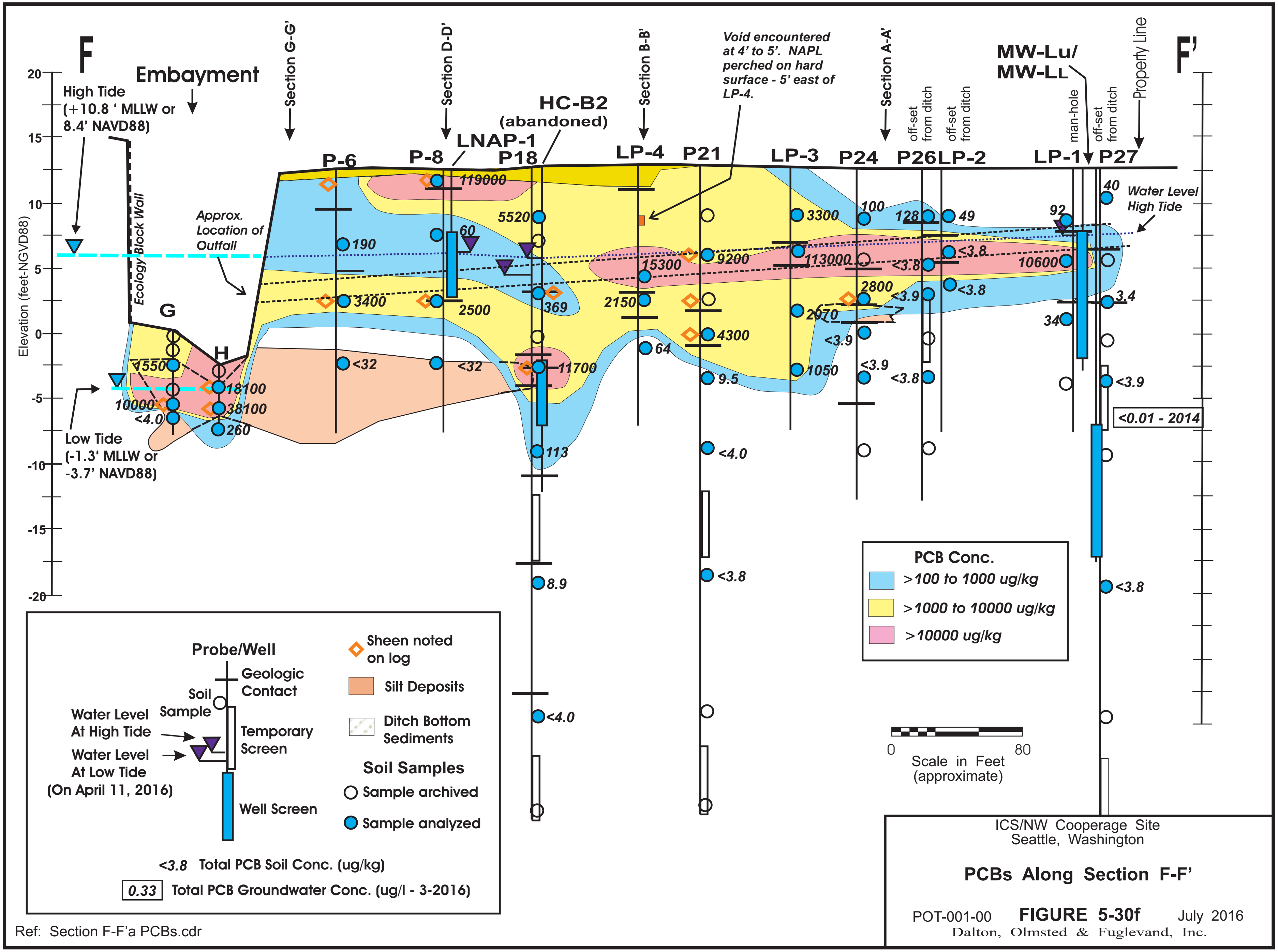
Ref: Section E-E' PCB7-2016.cdr

ICS/NW Cooperage Site
Seattle, Washington

PCBs Along Section E-E'

POT-001-00 **FIGURE 5-30e** July 2016

Dalton, Olmsted & Fuglevand, Inc.



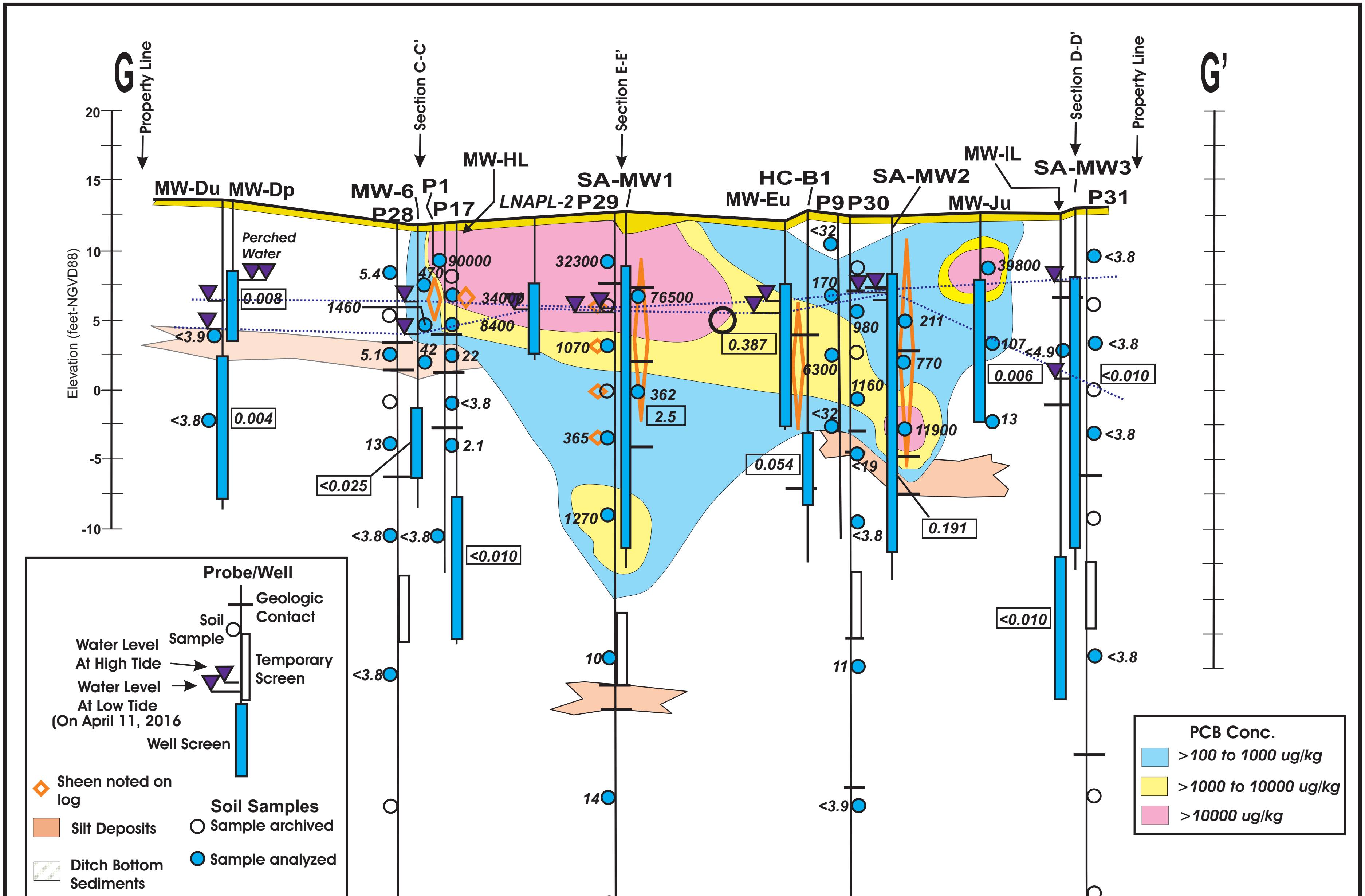
Ref: Section F-F'a PCBs.cdr

ICS/NW Cooperage Site
Seattle, Washington

PCBs Along Section F-F'

POT-001-00 **FIGURE 5-30f** July 2016

Dalton, Olmsted & Fuglevand, Inc.



ICS/NW Cooperage Site
Seattle, Washington

PCBs Along Section G-G'

POT-001-00 **FIGURE 5-30g** June 2016

Dalton, Olmsted & Fuglevand, Inc.