

# Lower Duwamish Waterway Group

*Port of Seattle / City of Seattle / King County / The Boeing Company*

## **DATA REPORT:**

### **ARSENIC CONCENTRATIONS IN CLAM TISSUE SAMPLES AND CO-LOCATED SEDIMENT SAMPLES COLLECTED FROM BACKGROUND AREAS IN 2005**

## **FINAL**

Prepared for

**The US Environmental Protection Agency**

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## Appendix E. Chain-of-Custody Forms

## Acronyms

Acronym	Definition
COC	chain of custody
dw	dry weight
Ecology	Washington Department of Ecology
EPA	US Environmental Protection Agency
HGAAS	hydride generation atomic absorption spectrometry
ICP-MS	inductively coupled plasma-mass spectrometry
ID	identification
LDC	Laboratory Data Consultants
LDW	Lower Duwamish Waterway
LDWG	Lower Duwamish Waterway Group
MLLW	mean lower low water
NWR	National Wildlife Refuge
QAPP	quality assurance project plan
QA/QC	quality assurance and quality control
QC	quality control
SDG	sample delivery group
USFWS	US Fish and Wildlife Service
ww	wet weight

## 1.0 Introduction

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In 2004, the Lower Duwamish Waterway Group (LDWG) collected clams from the Lower Duwamish Waterway (LDW) and two background areas: Fay Bainbridge State Park and Seahurst Park (collectively referred to herein as the 2004 background areas). The clams were analyzed for both total and inorganic arsenic (Windward 2005a). The approach for evaluating arsenic background concentrations in fish and shellfish tissues is described in Appendix E of the *Quality Assurance Project Plan (QAPP): Fish and Crab Tissue Collection and Chemical Analysis* (Windward 2004b). The approach included obtaining information about background inorganic arsenic concentrations in fish and shellfish in areas of Puget Sound that were both within and outside areas influenced by aerial emissions from the former ASARCO smelter in Ruston, Washington (just northwest of Tacoma, and sometimes referred to as the “Tacoma Smelter”).

The locations for 2004 clam background sampling are discussed in the *Chemical Analyses of Benthic Invertebrate and Clam Tissue Samples and Co-located Sediment Samples Data Report* (Windward 2005a). Clams collected from Fay Bainbridge State Park on Bainbridge Island were intended to evaluate arsenic concentrations in clams in a background area that had not been influenced by the former ASARCO smelter plume. Clams collected from Seahurst Park along the western shore of central Puget Sound were intended to evaluate arsenic concentrations in clams from a background area that had been influenced by the former ASARCO smelter plume. The Washington Department of Ecology (Ecology) determined the soil arsenic concentrations to map the extent of the areas affected by the former ASARCO smelter plume. The soil arsenic concentrations in the Seahurst Park area were similar to those in the LDW vicinity. All the clams collected and analyzed for arsenic in the LDW were *Mya arenaria*. In contrast, none of the six clam species collected and analyzed for arsenic from the 2004 background areas (*Saxidomus giganteus*, *Clinocardium nuttallii*, *Macoma nasuta*, *Macoma secta*, *Tresus capax*, and *Protothaca staminea*) were *M. arenaria*.

The objective of this project was to determine differences in inorganic arsenic concentrations between LDW clam samples and those collected from background areas. In comments on the results of the 2004 sampling event, the US Environmental Protection Agency (EPA) stated their concern that tissue inorganic arsenic concentrations can vary widely among different shellfish species. EPA felt that this variation could confound a comparison of clam tissue inorganic arsenic concentrations at LDW and background conditions.

To address EPA’s concern, LDWG collected additional clam tissue samples in other background areas in August 2005, targeting *M. arenaria* only. This data report presents the results of this sampling and analysis. Sampling and analysis of these samples were

conducted in accordance with the benthic invertebrate QAPP (Windward 2004a) and the QAPP addendum on additional clam sampling in background areas (Windward 2005b).

This report is organized into five sections:

- ◆ Section 1.0 – Introduction
- ◆ Section 2.0 – Sample Collection and Processing
- ◆ Section 3.0 – Laboratory Methods
- ◆ Section 4.0 – Results of Chemical Analyses
- ◆ Section 5.0 -- References

The text is supported by the following appendices:

- ◆ Appendix A – Comparison to previous results
- ◆ Appendix B – Laboratory analytical results
- ◆ Appendix C – Data validation report
- ◆ Appendix D – Field forms, field notes, and protocol modification forms
- ◆ Appendix E – Chain-of-custody forms

## **2.0 Sample Collection and Processing**

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This section briefly describes the sample collection and processing methods used for the clam tissue and co-located sediment samples. The field procedures used to collect the clam samples are described in detail in the QAPP (Windward 2004a). Field deviations from the QAPP are also described in this section. Copies of field forms, field notes, and protocol modification forms are presented in Appendix D. Copies of completed chain-of-custody (COC) forms are presented in Appendix E.

### **2.1 SAMPLING LOCATION SELECTION**

New background sampling locations were chosen based on the potential spatial influence of the former ASARCO smelter's aerial plume, the presence of suitable *M. arenaria* clam habitat and clams, and the absence of any known local sources of arsenic contamination. The Nisqually Reach, Dungeness Spit (Dungeness River Area as identified by the Washington Department of Health), Pillar Point County Park, and East Dabob Bay were all identified as potential sampling locations in the QAPP addendum (Windward 2005b). The Nisqually Reach and Pillar Point County Park locations (Figure 2-1) were sampled on August 2 and 4, 2005, respectively, using the maximum level of effort specified in the QAPP addendum. The only *M. arenaria* found were several juvenile clams that did not meet the 2-cm width requirement specified in

the QAPP addendum (Windward 2005b). The Dungeness River Area was also sampled on August 4, 2005, with similar results. East Dabob Bay was deleted as a potential sampling location because of logistical considerations associated with accessing the site.

Prior to the next low-tide cycle (when sampling could begin again), additional research was conducted on other suitable locations for *M. arenaria*. Dungeness National Wildlife Refuge (NWR), approximately 2 miles west of the previously sampled Dungeness River Area location, and Vashon Island were identified and approved by EPA and Ecology. These locations were sampled during low tides on August 19 and 23, 2005 (Table 2-1). The Dungeness NWR area consisted of a protected intertidal area with freshwater influence from the Dungeness River and soft, muddy substrate. The Vashon Island clam habitat consisted of medium to coarse sand and gravel with small amounts of mud. Additional details regarding the sampling efforts at these two locations, hereafter referred to collectively as the 2005 background areas, are provided below.

**Table 2-1. Tide information for 2005 background sampling events**

AREA	TIDE (ft MLLW)	TIME	DATE
Dungeness NWR	-2.2	0939	8/19/2005
Vashon Island	2.1	1411	8/23/2005

MLLW – mean lower low water

**2.1.1 Dungeness National Wildlife Refuge**

On August 19, 2005, the Dungeness NWR (Figure 2-1) was sampled for *M. arenaria* under a permit obtained from the US Fish and Wildlife Service (USFWS). Pam Sanguinetti, a USFWS biologist, assisted with the transport of the field crew and equipment. The Dungeness NWR is located to the west of the mouth of the Dungeness River and is a protected public beach with a soft, muddy substrate and an abundant *M. arenaria* population.

The Dungeness NWR is a suitable background clam sampling location because it provides estuarine habitat where *M. arenaria* have been collected by the Washington State Department of Fish and Wildlife. It is a natural area that is away from potential industrial sources and is outside the area influenced by the former ASARCO plume. EPA’s Environmental Monitoring and Assessment Program collected a surficial sediment sample at the base of Dungeness Spit in 1999. The total arsenic concentration for this sample was 4.17 mg/kg dry weight. In addition to this information, LDWG and EPA agreed that confirmation of the suitability of Dungeness NWR as a background sampling location would be provided by analysis of sediment samples that were co-located with clam samples. These sediment arsenic results suggest that sediments at the Dungeness NWR are not elevated by local arsenic sources (Table 4-4).

Therefore, the Dungeness NWR meets the study design requirements stated in the benthic invertebrate QAPP (Windward 2004a).

### 2.1.2 Vashon Island

A beach on Vashon Island private beachfront property was sampled on August 23, 2005. This location is on the northeastern side of the island (Figure 2-1) and is within the area potentially influenced by the former ASARCO smelter aerial plume. Because this location was not described in the QAPP addendum (Windward 2005b), a protocol modification form was completed in order to conduct sampling at this location and is included in Appendix D. This form was submitted to and approved by EPA prior to sampling at this location.

Vashon Island was selected as an additional clam sampling location because of the poor catch results for *M. arenaria* from the Nisqually Reach area, the originally proposed clam sampling location. Both the original Nisqually Reach area and the selected Vashon Island location are within the area downwind of the former ASARCO smelter plume and meet the study design requirements stated in the original benthic invertebrate QAPP (Windward 2004a). The northeastern portion of Vashon Island has soil arsenic concentrations similar to those within the LDW watershed, with the exception of two samples. These samples contained soil arsenic concentrations of 140 mg/kg dw and 120 mg/kg dw and are located approximately 0.5 to 1.5 miles, respectively, south of the clam sampling beach. In addition, four locations within the general vicinity of the Vashon Island clam sampling area have arsenic concentrations greater than 60 mg/kg dw in the soil, as displayed in Figure 2-2.

An additional consideration for selecting sampling locations that was discussed in the QAPP addendum was the presence of known or suspected arsenic sources as compiled in Ecology's Confirmed and Suspected Contaminated Site database. This database was consulted for the Vashon Island area. There were two upland sites listed, referred to as Maury Island Regional Park and Tacoma Smelter Plume Vashon Island (unknown location), with confirmed soil arsenic concentrations at both locations greater than 20 mg/kg that are located approximately 7 miles southeast of the Vashon Island clam sampling location. Two additional upland sites were listed with suspected soil arsenic concentrations greater than 20 mg/kg but their locations on Vashon Island were unknown and listed only as Tacoma Smelter Plume.

Table 2-2 summarizes the soil arsenic data collected as part of Ecology's ongoing investigation of the spatial extent of arsenic contamination attributable to the former ASARCO smelter plume. The average soil arsenic concentration located within 0.5 mile of the Vashon Island background clam sampling locations was 55 mg/kg dw compared to the average concentration of 31 mg/kg dw found in the general vicinity of the LDW (Figure 2-2).

As was noted for the Dungeness NWR, LDWG and EPA agreed that confirmation of the suitability of the Vashon Island sampling area for background characterization would be provided by analysis of sediment samples that were co-located with clam samples. These sediment arsenic results suggest that sediment arsenic concentrations at the Vashon Island sampling location were not elevated relative to sediment arsenic concentration at LDW clam sampling locations (see Table 4-4).

**Table 2-2. Summary of arsenic soil concentrations collected in the general vicinity of the LDW and Vashon Island clam sampling locations**

LDW (mg/kg dw)	VASHON ISLAND (mg/kg dw)
86	32
30	27
20	37
17	25
28	64
23	140
13	62
<b>31 (average)</b>	55 (average)
<b>25 (standard deviation)</b>	41 (standard deviation)

dw = dry weight

## 2.2 SAMPLE IDENTIFICATION

Four sampling locations were identified at the Dungeness NWR, and six sampling locations were identified at Vashon Island. Each sampling location was assigned a unique alphanumeric identification (ID) number. Samples from the background areas were designated either “DU” (for Dungeness NWR) or “VI” (for Vashon Island), followed by a “C” (for clam) to indicate the target matrix and an associated numeral representing the sampling location, and the suffix T for composite clam tissue sample or S for co-located composite sediment sample. Thus, for example, a composite clam tissue sample collected from the first sampling location at the Dungeness NWR was labeled DU-C1-T, whereas the co-located composite sediment sample from the same location was labeled DU-C1-S.

## 2.3 SAMPLING METHODS AND PROCEDURES

Clam tissue and co-located sediment samples were collected at intertidal locations at the two background areas in accordance with the original QAPP (Windward 2004a) and the QAPP addendum (Windward 2005b).

Six composite clam tissue samples were collected at each of the two sampling areas (Figure 2-1). The coordinates of the sampling locations are presented in Table 2-2. Clams at these beaches had very fragile, brittle shells that resulted in many broken shells; and an intensive sampling effort was required to collect a sufficient number of



clams with unbroken shells. Table 2-3 presents the dates and times of sampling and the number of clams represented in each composite tissue sample from the two background areas.

**Table 2-2. 2005 background area sampling location coordinates**

SAMPLING LOCATION ID	COORDINATES <sup>a</sup>			
	LATITUDE	LONGITUDE	X	Y
DU-C1	48 08.883	123 11.063	1066572	427542
DU-C2	48 08.900	123 11.058	1066596	427644
DU-C3	48 08.867	123 11.067	1066553	427445
DU-C4	48 08.917	123 11.033	1066701	427744
VI-C1	47 27.217	122 26.617	1242046	169634
VI-C2	47 27.225	122 26.613	1242064	169683
VI-C3	47 27.228	122 26.613	1242064	169701
VI-C4	47 27.229	122 26.617	1242046	169707
VI-C5	47 27.232	122 26.617	1242046	169725
VI-C6	47 27.236	122 26.617	1242046	169750

<sup>a</sup> Geographic and state plane coordinates (WA State Plane N, US survey feet) based on NAD 83 horizontal datum

**Table 2-3. Collection information for 2005 background area samples**

COMPOSITE CLAM TISSUE SAMPLE ID	CO-LOCATED COMPOSITE SEDIMENT SAMPLE ID	COLLECTION DATE	COLLECTION TIME	NO. OF CLAMS PER COMPOSITE TISSUE SAMPLE	NO. OF 50-ML SEDIMENT SUBSAMPLES PER COMPOSITE SEDIMENT SAMPLE
DU-C1-T	DU-C1-S	8/19/05	0800-1415	12	20
DU-C2-T	DU-C2-S	8/19/05	0800-1415	12	20
DU-C3-T	DU-C3-S	8/19/05	0800-1415	12	20
DU-C4-T	DU-C4-S	8/19/05	0800-1415	10	10
DU-C123-T1 <sup>a</sup>	-- <sup>b</sup>	8/19/05	0800-1415	12	--
DU-C123-T2 <sup>a</sup>	-- <sup>b</sup>	8/19/05	0800-1415	12	--
VI-C1-T	VI-C1-S	8/23/05	1130-1320	20	20
VI-C2-T	VI-C2-S	8/23/05	1130-1320	20	20
VI-C3-T	VI-C3-S	8/23/05	1130-1320	20	20
VI-C4-T	VI-C4-S	8/23/05	1130-1320	20	20
VI-C5-T	VI-C5-S	8/23/05	1130-1320	20	20
VI-C6-T	VI-C6-S	8/23/05	1130-1320	19	19

<sup>a</sup> This composite clam tissue sample consisted of 12 randomly selected clams from locations DU-C1, DU-C2, and DU-C3.

<sup>b</sup> A separate co-located composite sediment sample was not associated with this composite clam tissue sample.

Each composite clam tissue sample consisted of 10 to 20 individual *M. arenaria*. The total target number of 120 clams (i.e., 20 clams per composite tissue sample) could not be collected at the Dungeness NWR area within the allotted maximum level of effort. The 70 clams collected at this area were collected from four different sampling locations (DU-C1, DU-C2, DU-C3, and DU-C4). Twenty clams each were collected at DU-C1, DU-C2, and DU-C3; ten clams were collected at DU-C4. In consultation with EPA, it was decided to form one composite tissue sample consisting of 12 clams from each of the first three locations, one composite tissue sample consisting of the 10 clams from the fourth location, and to create two additional composite tissue samples (DU-C123-T1 and DU-C123-T2) by randomly selecting a total of 24 clams from the 60 clams collected at locations DU-C1, DU-C2, and DU-C3 and dividing them into two additional composite samples of 12 clams each (Table 2-3). The Dungeness locations were very close to one another; therefore, compositing tissue samples from the multiple sample locations (i.e., DU-C123-T1 and DU-C123-T2) would not be an issue with regards to violation of independent samples for computation of a 95% upper confidence limit on the mean. Six composite samples were desirable to match the site-wide study design assumptions for calculating a 95% upper confidence limit on the mean for risk assessment purposes. Five composite clam tissue samples from Vashon Island consisted of 20 clams, and one composite clam tissue sample (VI-C6-T) consisted of 19 clams.

To retrieve clams, holes were dug to a depth ranging from 15 to 60 cm. At each clam collection location, 50 mL of sediment from the first shovelful of sediment was collected for chemical analysis. The volume of the sediment was estimated using a 200 mL beaker. Shovels were used to initiate the hole, but in many cases, hand digging was required to retrieve clams without breaking the shells. When an unbroken clam was collected, the 50 mL of sediment previously collected from that location was retained and placed in a large stainless steel bowl; clams with broken shells were discarded. A minimum of twenty 50-mL sediment subsamples were composited into each 1-L sediment sample per location (except for the sediment samples DU-C4-S, where 10 subsamples were collected, and VI-C6-S, where 19 subsamples were collected). Only four co-located composite sediment samples were collected at the Dungeness NWR area because clams were collected from only four locations.

The co-located 50-mL sediment subsamples from each location were homogenized to form a single composite sediment sample for that location, which was then placed into an appropriately sized glass jar, labeled, transported on ice, and stored in a refrigerator at the Windward Environmental LLC (Windward) laboratory until delivery to the Brooks Rand LLC laboratory.

Clams from each location were rinsed in site water, placed into 1-gallon zip-lock plastic bags, placed in coolers on ice, and transported to the Windward laboratory, where the shell lengths at the longest point were measured and recorded. The average

clam lengths for 2005 background area samples are presented in Table 2-4. After confirmation of clam identification and measurement of lengths, clams were returned to the plastic bags, stored in a freezer at the Windward laboratory, and hand delivered to Brooks Rand for chemical analysis on September 2, 2005.

**Table 2-4. Average clam lengths for 2005 background area samples**

SAMPLE	AVERAGE LENGTH (cm)	STANDARD DEVIATION (cm)	NUMBER OF CLAMS
DU-C1-T	6.9	1.1	12
DU-C2-T	6.0	1.0	12
DU-C3-T	5.8	0.94	12
DU-C4-T	6.4	0.92	10
DU-C123-T1	6.3	1.1	12
DU-C123-T2	6.3	1.1	12
VI-C1-T	5.9	0.69	20
VI-C2-T	6.6	0.80	20
VI-C3-T	6.4	0.79	20
VI-C4-T	6.4	0.84	20
VI-C5-T	6.5	0.74	20
VI-C6-T	6.9	0.91	19

## 2.4 FIELD DEVIATIONS FROM THE QAPP

Field deviations from the QAPP (Windward 2004a) included modifications to collection methods, dates, and locations. These field deviations did not affect the data quality. EPA was consulted on deviations that had a significant effect on study design. The deviations are listed below:

- ◆ The maximum level of effort was exceeded at the Dungeness NWR location to collect a sufficient number of clams and co-located sediment. Seventy clams and 3.5 L of co-located sediment were collected after sampling for 6.25 hours, exceeding the 3-hour-maximum level of effort specified in the QAPP addendum (Windward 2005b).
- ◆ Vashon Island was selected as an alternative background area after an insufficient number of clams was collected at the Nisqually Reach area.
- ◆ Only 19 clams were collected at location VI-C6, even though the target number was 20. However, sufficient tissue mass was collected for chemical analysis at this location.
- ◆ The sample collection areas at the Vashon Island location overlapped slightly because the field crew was restricted to working within a relatively small intertidal area on the private waterfront property. In addition, the collection areas

at Dungeness NWR slightly overlapped because the greatest abundance of clams was found in a relatively small part of the intertidal area.

- ◆ The field schedule was modified to increase the sampling effort from 4 days to 6 days (at low tide) so that sufficient *M. arenaria* could be collected for to meet the objectives and design of the QAPP addendum (Windward 2005b). Accordingly, the Dungeness NWR and the northeastern end of Vashon Island were sampled on August 19, and August 23, 2005, respectively.

### 3.0 Laboratory Methods

The methods and procedures used to chemically analyze the tissue and sediment samples are described briefly in this section and in detail in the QAPP (Windward 2004a).

#### 3.1 TISSUE AND SEDIMENT ANALYTICAL METHODS

Brooks Rand shucked, homogenized, and analyzed each composite clam tissue sample for total and inorganic arsenic (Table 3-1). Brooks Rand also analyzed the co-located sediment samples for total arsenic to demonstrate that the background areas did not contain abnormally high arsenic concentrations that would confound the interpretation of the clam tissue results. Analytical testing adhered to the laboratory's standard operating procedures and current EPA quality assurance and quality control (QA/QC) guidelines and analysis protocols (EPA 2002a; PSEP 1997). All methods selected represent standard methods used for the analysis of the identified analytes in tissue and sediment.

**Table 3-1. Analytical methods**

SAMPLE TYPE	ANALYTE	UNIT	METHOD	REFERENCE
Clam tissue	arsenic (total)	mg/kg ww	ICP-MS	EPA 1638 modified
	arsenic (inorganic)	mg/kg ww	HGAAS	EPA 1632
Co-located sediment	arsenic (total)	mg/kg dw	ICP-MS	EPA 1638 modified

dw – dry weight

ww – wet weight

HGAAS – hydride generation atomic absorption spectrometry

ICP-MS – inductively coupled plasma-mass spectrometry

#### 3.2 LABORATORY DEVIATIONS FROM THE QAPP

There were no laboratory deviations. The laboratory followed the methods and procedures described in the QAPP (Windward 2004a) and the QAPP addendum (Windward 2005b).

## 4.0 Results of Chemical Analyses

Results of chemical analyses of the tissue and sediment samples are summarized in this section. Summary data tables and raw laboratory data are presented in Section 4.1 and Appendix B, respectively. The number of significant figures shown for each concentration in the summary tables in this section was specified by the analytical laboratory in the electronic data deliverable. Significant figures are based on the method detection limit of the test method. There was no additional manipulation of significant figures.

Quality assurance review of the chemistry data was conducted in accordance with the QA/QC requirements and technical specifications of the methods, the laboratory's standard operating procedures, and the national functional guidelines for inorganic data review (EPA 2002b). Laboratory Data Consultants (LDC) conducted independent data validation. The results of the data validation are discussed in Section 4.3 and presented in full in Appendix C.

### 4.1 CLAM TISSUE RESULTS

Table 4-1 presents a summary of the total and inorganic arsenic concentrations in composite clam tissue samples from the two background areas sampled in 2005, including the detection frequency and the range of detected concentrations. Sample-specific results for total arsenic and inorganic arsenic are presented in Table 4-2.

**Table 4-1. Summary of total and inorganic arsenic concentrations in composite clam tissue samples**

SAMPLING AREA	ANALYTE	DETECTION FREQUENCY	MINIMUM DETECTED CONCENTRATION (mg/kg ww)	MAXIMUM DETECTED CONCENTRATION (mg/kg ww)
Dungeness NWR	arsenic (total)	6/6	0.63	0.82
	arsenic (inorganic)	6/6	0.047	0.112
Vashon Island	arsenic (total)	6/6	0.92	1.52
	arsenic (inorganic)	6/6	0.093	0.211

ww – wet weight

**Table 4-2. Total and inorganic arsenic concentrations in composite clam tissue samples**

ANALYTE	CONCENTRATION (mg/kg ww)											
	DU-C1-T	DU-C2-T	DU-C3-T	DU-C4-T	DU-C123-T1	DU-C123-T2	VI-C1-T	VI-C2-T	VI-C3-T	VI-C4-T	VI-C5-T	VI-C6-T
Arsenic (total)	0.73	0.81	0.74	0.63	0.82	0.72	0.92	1.03	1.42	1.52	1.20	1.45
Arsenic (inorganic)	0.047	0.060	0.053	0.048	0.112	0.062	0.148	0.125	0.159	0.123	0.211	0.093

Total and inorganic arsenic were detected in all composite clam tissue samples from the background areas. Total arsenic concentrations for Dungeness NWR and Vashon Island samples ranged from 0.630 to 1.520 mg/kg wet weight (ww). The inorganic arsenic concentrations ranged from 0.047 to 0.211 mg/kg ww. The mean values for the total arsenic concentration for Dungeness NWR and Vashon Island are 0.742 and 1.26 mg/kg ww, respectively. The mean values for the inorganic arsenic concentration for Dungeness NWR and Vashon Island are 0.064 and 0.143 mg/kg ww, respectively. Maximum concentrations were slightly higher at Vashon Island as compared to those at the Dungeness NWR.

#### 4.2 CO-LOCATED SEDIMENT RESULTS

Table 4-3 presents a summary of the total arsenic concentrations in the Dungeness NWR and Vashon Island co-located composite sediment samples, including the detection frequency and the range of detected concentrations. Sample-specific results are presented in Table 4-4.

**Table 4-3. Summary of total arsenic concentrations in co-located composite sediment samples**

SAMPLING AREA	ANALYTE	DETECTION FREQUENCY	MINIMUM DETECTED CONCENTRATION (mg/kg dw)	MAXIMUM DETECTED CONCENTRATION (mg/kg dw)
Dungeness NWR	arsenic (total)	4/4	2.43 J	3.34 J
Vashon Island	arsenic (total)	6/6	1.73 J	3.05 J

dw – dry weight

J – estimated concentration

**Table 4-4. Total arsenic concentrations in co-located composite sediment samples**

ANALYTE	CONCENTRATION (mg/kg dw)									
	DU-C1-S	DU-C2-S	DU-C3-S	DU-C4-S	VI-C1-S	VI-C2-S	VI-C3-S	VI-C4-S	VI-C5-S	VI-C6-S
Arsenic (total)	2.58 J	2.55 J	3.34 J	2.43 J	2.66 J	3.05 J	2.34 J	1.87 J	2.17 J	1.73 J

J – estimated concentration

Total arsenic was detected in all composite sediment samples co-located with the composite clam tissue samples. Total arsenic concentrations in the Dungeness NWR and Vashon Island sediment samples ranged from 1.73 J to 3.34 J mg/kg dw. Concentrations were very similar in the two areas.

### **4.3 DATA VALIDATION RESULTS**

Independent data validation was conducted by LDC. The complete data validation report is provided in Appendix C. The following subsections present a summary of the data validation results.

#### **4.3.1 Overall data quality**

All of the tissue and sediment samples were analyzed by Brooks Rand in one sample delivery group (SDG). LDC conducted a full validation on all of the results in this SDG (WIN002). Based on the information reviewed, the overall data quality was considered acceptable as qualified.

#### **4.3.2 Sample transport and holding times**

All samples were analyzed within the maximum holding times. The chain-of-custody forms were reviewed for documentation of cooler temperatures, and all cooler temperatures were within validation criteria.

#### **4.3.3 Analytical quality control parameters**

##### ***Calibration***

Initial calibrations were performed for each method and matrix. The frequency and analysis criteria of the initial calibration verifications and continuing calibration verifications were met.

##### ***Blanks***

Method blanks and calibration blanks were reviewed. No arsenic was detected in any of the blank samples.

##### ***Matrix spikes***

Matrix spike and matrix spike duplicate samples were reviewed for each matrix. All percent recoveries and relative percent differences were within quality control (QC) limits.

##### ***Replicate sample analyses***

Laboratory sample replicate results were reviewed for each method and matrix. All relative percent differences were within QC limits, ranging from 1 - 20%.

##### ***Laboratory control samples***

The results of the laboratory control samples for each method were reviewed. All percent recoveries were within QC limits. Standard reference material was analyzed for total arsenic analysis, and results were within QC limits.

### ***Internal standards***

All internal standard recoveries were within QC limits for the tissue samples. The internal standard recoveries in the sediment samples were above QC limits, resulting in the J-qualification of all detected results in the sediment samples.

## **5.0 References**

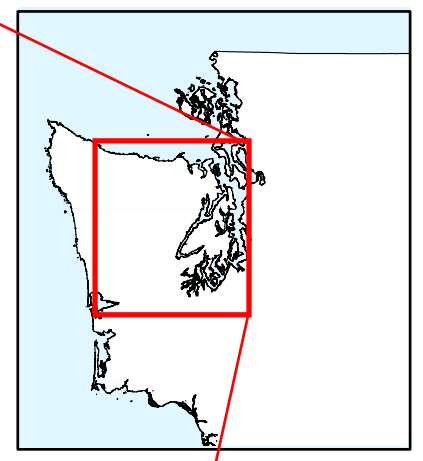
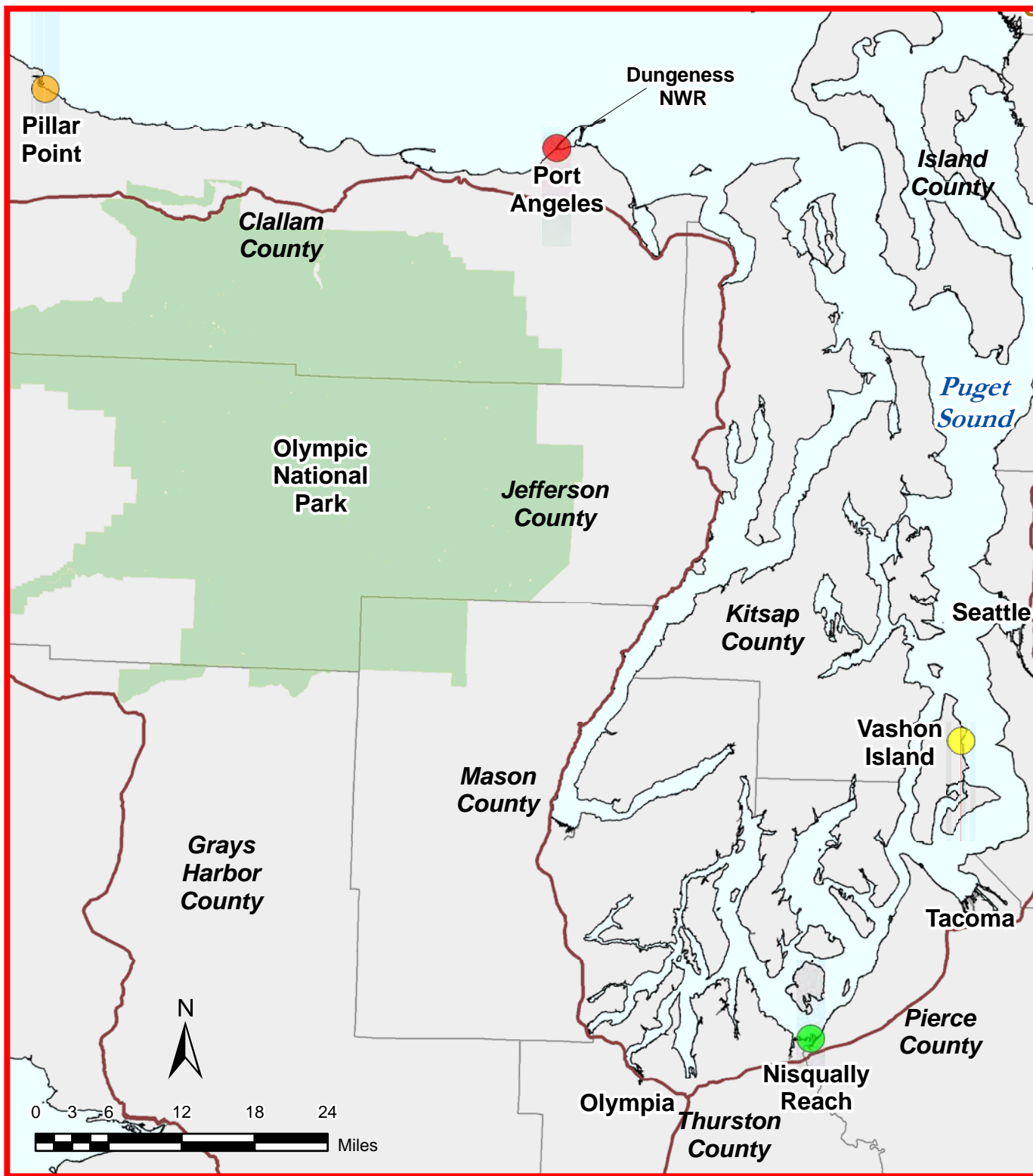
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**Figures**

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- Initial 2005 clam sampling area
- Nisqually Reach
  - Pillar Point County Park
- Final 2005 clam sampling area
- Dungeness NWR
  - Vashon Island

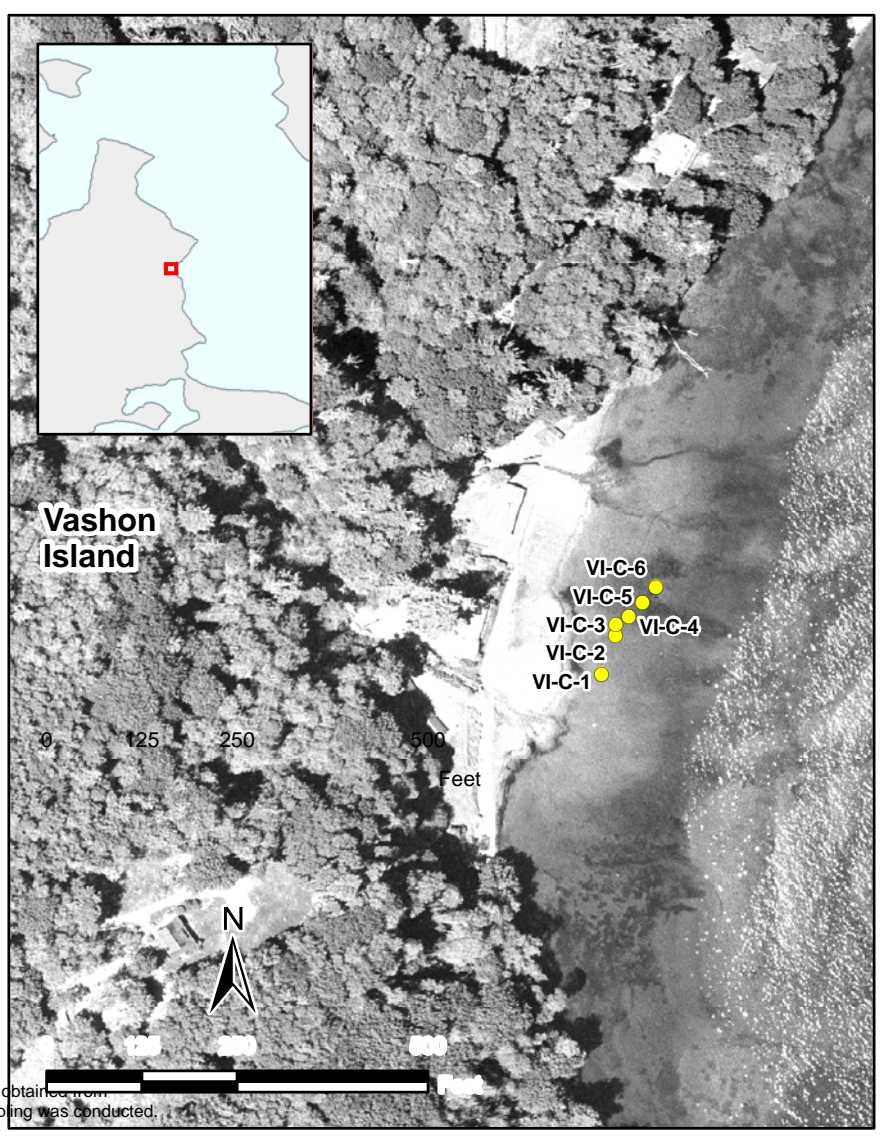
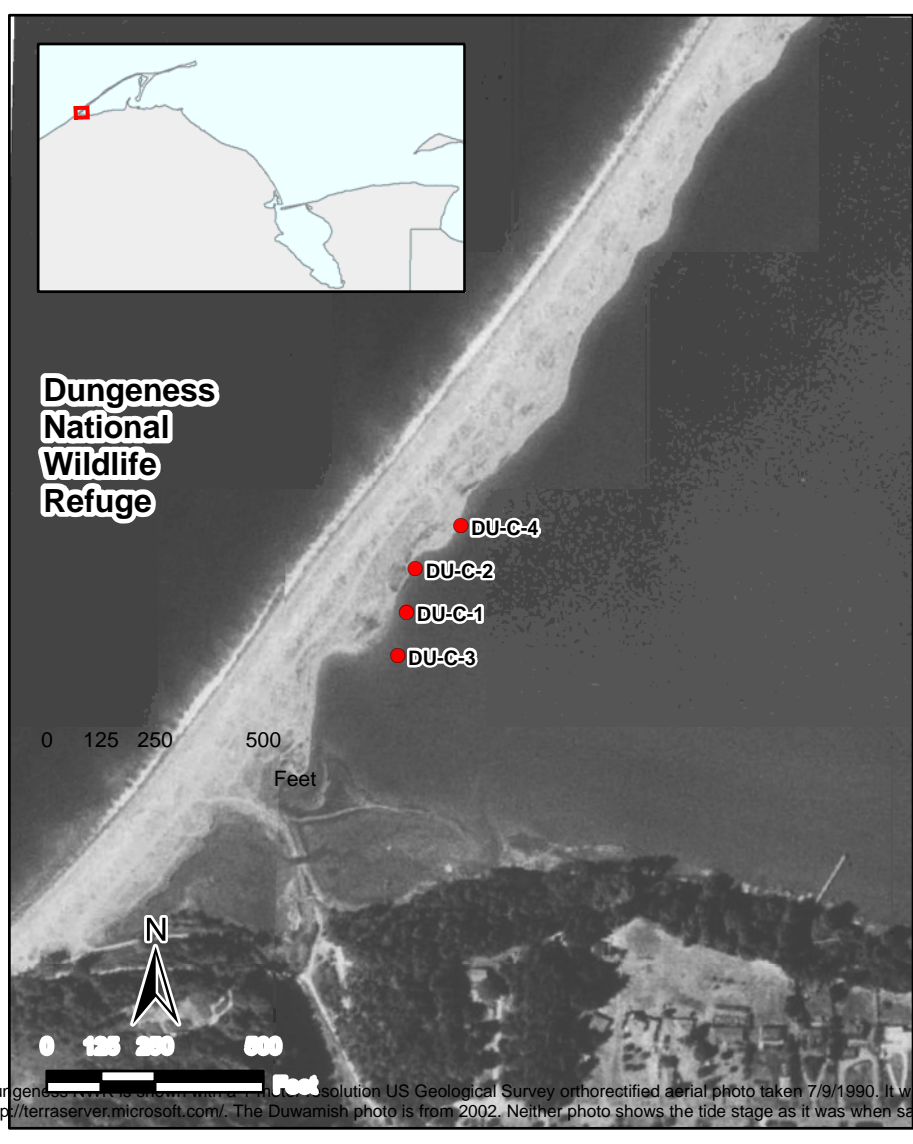


Figure 2-1. 2005 background clam sampling areas



Prepared by STS 11/15/05, modified by LSM 11/28/05, 12/01/05 Map 2075 (formerly Map 1852)

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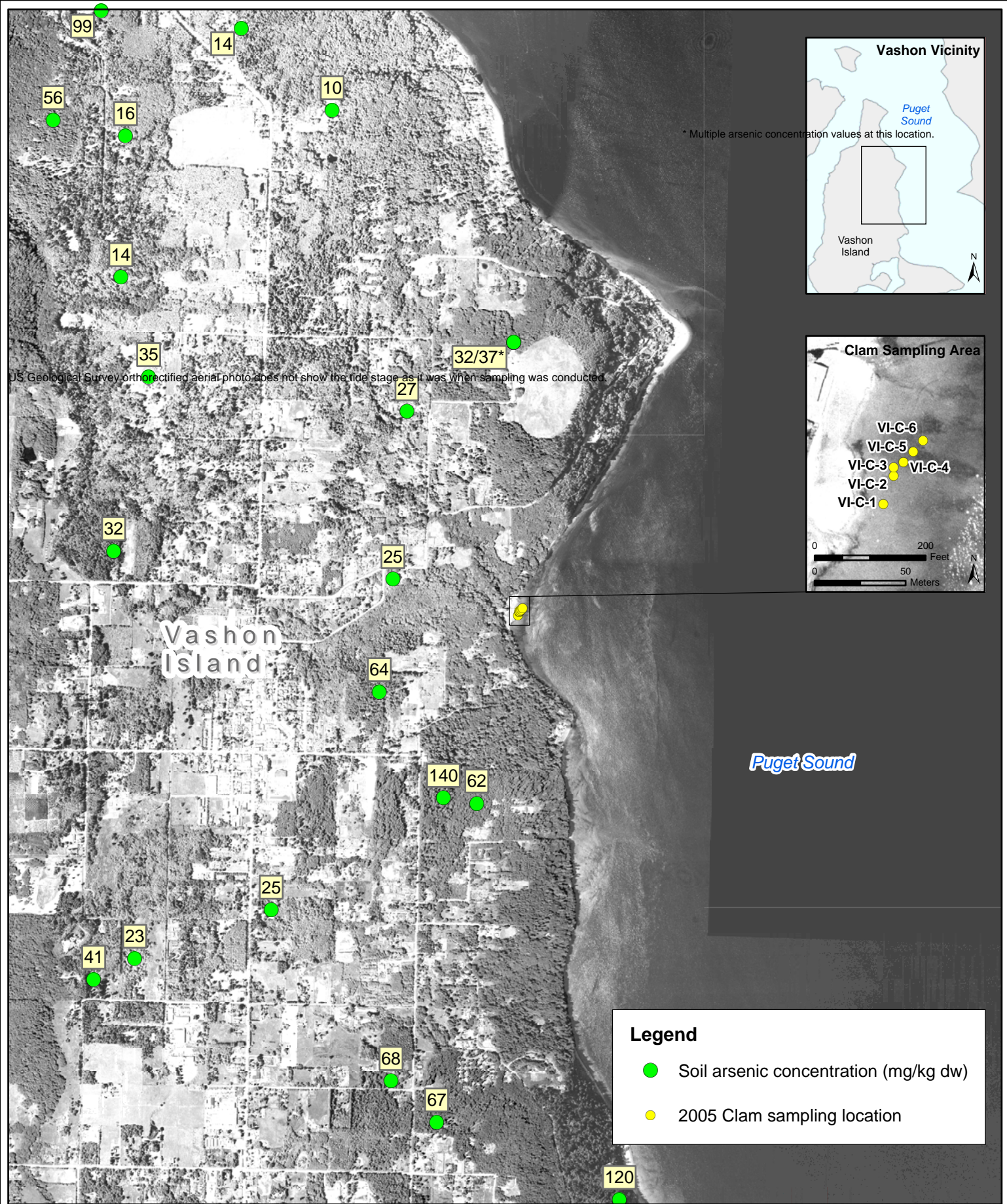


Figure 2-2. Vashon Island clam sampling locations and soil arsenic data

