Disposal Site History 1989 – 2021: Use, Monitoring And Issues

DMMP Status Paper

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for the Dredged Material Management Program

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TABLES

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ACRONYMS

AK	Anderson/Ketron
BB	Bellingham Bay
BCOC	Bioaccumulative Chemical of Concern
BT	Bioaccumulation Trigger
BSAF	Biota Sediment Accumulation Factor
COC	Chemicals of Concern
CSL	Cleanup screening value (upper limit, and used for site identification)
CTS	Chemical Tracking System
CY	Cubic yards
DDT	Dichlorodiphenyltrichloroethane
DM	Dredged Material
DMMP	Dredged Material Management Program
DNR	Washington Department of Natural Resources
DSMP	Disposal Site Monitoring Plan
DU	Decision Unit
EB	Elliott Bay
Ecology	Washington Department of Ecology
EPA	Environmental Protection Agency (Region 10)
ERDC	US Army Engineering Research and Development Center
HPAH	High molecular weight PAHs
M	million
ML	Maximum Level
MLLW	Mean Lower Low Water
PA	Port Angeles
PAH	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyls
PG	Port Gardner
PQL	Practical Quantitation Limit
PSDDA	Puget Sound Dredged Disposal Analysis
PT	Port Townsend
RB	Regional Background
RS	Rosario Strait
SCII	Site Condition II
SCO	Sediment Cleanup Objective (goal for state)
SCUM	Sediment Cleanup User Manual
SEF	Sediment Evaluation Framework
SEIS	Supplemental Environmental Impact Statement
SL	Screening Level
SMS	Sediment Management Standards
SQS	Sediment Quality Standard
SVOC	Semi-Volatile Organic Compound
TEQ	Toxicity Equivalents
TTL	Target Tissue Level
USACE	U.S. Army Corps of Engineers, Seattle District
VTS	Vessel Tracking System
WDFW	Washington Department of Fish and Wildlife
WES	US Army Waterways Experiment Station (former name for ERDC)

INTRODUCTION AND PURPOSE

This status paper has been prepared by the Dredged Material Management Program (DMMP) agencies to summarize the disposal site use and monitoring data from each Puget Sound disposal site since the start of the DMMP program (formerly known as the Puget Sound Dredged Disposal Analysis Program, or PSDDA) (Figure 1). PSDDA was a comprehensive, multi-year public process in the late 1980s that culminated in an interagency program to oversee dredged material management in Washington State, including establishment and monitoring of disposal sites (PSDDA 1987, 1988a, 1988b, 1988c, 1988d, 1989a, 1989b, 1989c).

One driver for development of a new monitoring framework is to incorporate enough flexibility to adapt to site-specific issues. Monitoring over the past three decades has revealed that each site and monitoring event can pose unique implementation and interpretation challenges. The DMMP's monitoring framework must provide enough flexibility to adapt to site- and event-specific issues to help ensure the monitoring program remains both effective and efficient.

The purpose of this paper is to inform future site monitoring and management decisions, and to support the adoption of a revised monitoring framework. Emphasis in this paper is on the non-dispersive sites in Puget Sound, though use of DMMP dispersive sites is also documented.

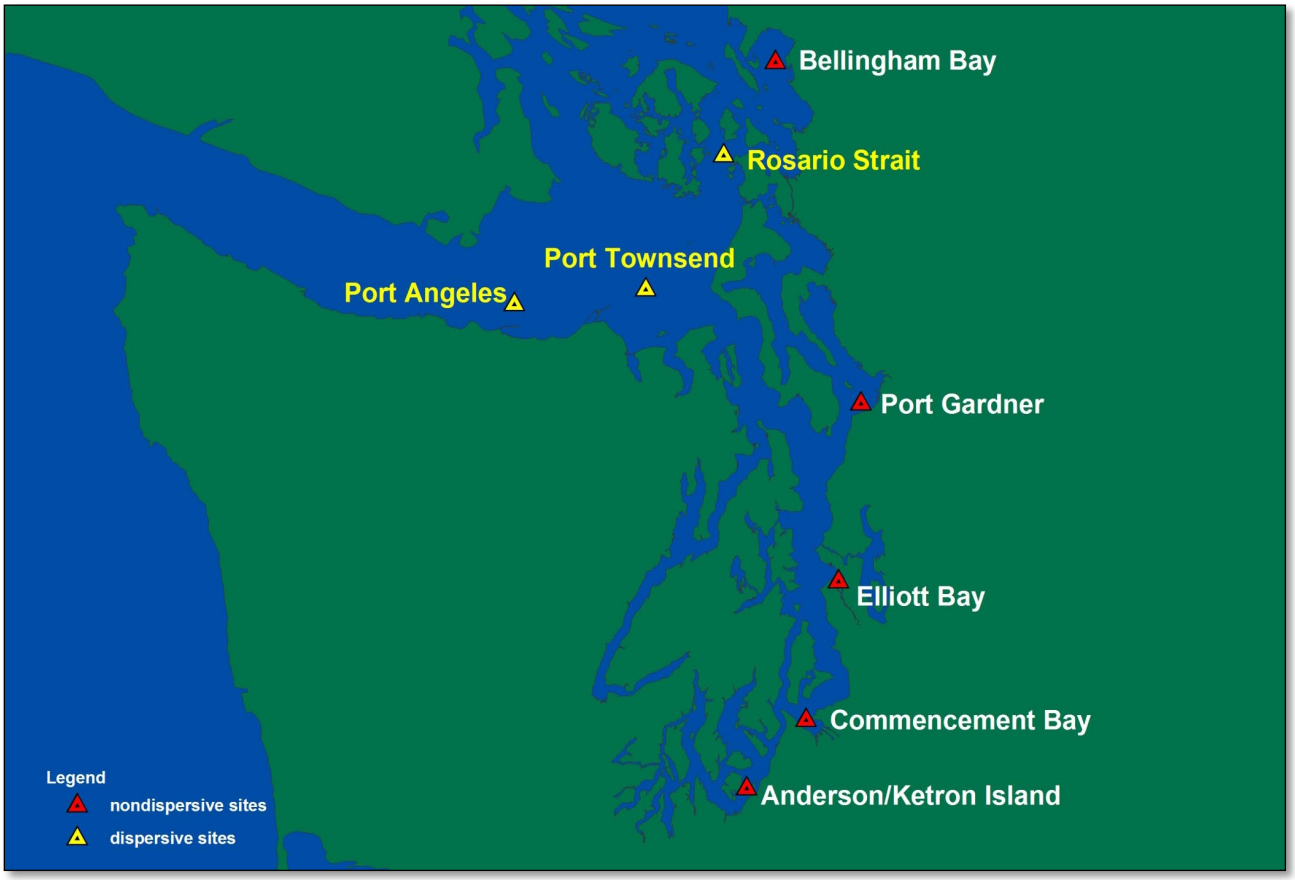

Figure 1. Puget Sound Area Disposal Sites

BACKGROUND

There are eight multi-user open water dredged material disposal sites in the greater Puget Sound area (three dispersive and five non-dispersive; see Table 1). There have also been two dispersive estuarine sites each in the coastal estuaries of Grays Harbor and Willapa Bay--though Willapa Bay sites are no longer under programmatic coverage. The DMMP agencies collectively evaluate the suitability of dredged material (DM) for disposal at these identified sites. As owner of the state's aquatic lands, DNR manages disposal site use and is responsible for environmental chemical and biological monitoring of all non-dispersive disposal sites.

Dredged material placed at **non-dispersive sites** remains onsite and is the subject of long-term monitoring, which provides a feedback loop with project testing to 1) keep project testing costs low, and 2) ensure no unacceptable adverse effects due to dredged material occur at the disposal sites.

Dredged material placed at **dispersive sites** - located in areas with strong currents – moves off site quickly and disperses widely. No adverse effects are allowed at dispersive sites, so dredged material must meet more stringent evaluation guidelines to be eligible for disposal at these sites.

Table 1. Puget Sound Area DMMP Disposal Sites Cumulative Volume 1989 - 2021

Site Name	Site Type	Cumulative Disposal Volume (cubic yards)
Anderson/Ketron (AK)	Non-dispersive	157,215
Bellingham Bay (BB)	Non-dispersive	78,883
Commencement Bay (CB)	Non-dispersive	8,694,544
Elliott Bay (EB)	Non-dispersive	3,245,240
Port Angeles (PA)	Dispersive	22,344
Port Gardner (PG)	Non-dispersive	3,886,794
Port Townsend (PT)	Dispersive	54,777
Rosario Strait (RS)	Dispersive	2,653,252

PUGET SOUND SITE NETWORK

One of the primary objectives of the original PSDDA study was establishment of a network of regional sites to provide cost-effective disposal options for dredging projects throughout the greater Puget Sound area, including the San Juan Islands and Strait of Juan de Fuca. Disposal sites were established where dredging needs were greatest: near the largest ports and centers of maritime commerce. A secondary objective of a network of sites was to minimize the interbay/geographic transfer of dredged material. Uniform suitability requirements were intentionally established for all non-dispersive sites to help preclude interbay transfers.

Port Gardner, Elliott Bay, and Commencement Bay sites are proximal to channels and port facilities of the densely populated central Puget Sound Region. Deep basins at these sites, as well as at the Anderson/Ketron site (South Sound) and Bellingham Bay (North Sound) are suitable for containment of deposited material that can be managed and monitored. Other inland marine areas within Washington state, particularly in the San Juan Islands and Strait of Juan de Fuca, are not conducive to non-dispersive

disposal. To serve these areas, dispersive sites were chosen in places where material could enter sediment transport streams and remain at depth while being widely dispersed.

Frequency of use and volume of material placed have varied widely between disposal sites (Figure 2) and between years. The Central Puget Sound sites have been used most frequently, as expected (PSDDA 1988a) due to their proximity to centers of population and maritime commerce. Monitoring history has generally mirrored site use, so those sites have also been studied more frequently.

ORIGINAL DISPOSAL SITE MONITORING FRAMEWORK

Objectives

Part of the original PSDDA study was development of a monitoring framework to assess the physical, chemical, and biological effects of dredged material disposal at Puget Sound non-dispersive aquatic disposal sites and their surrounding environments. The effects due to dredged material disposal are evaluated differently within site boundaries ("on-site") than in the surrounding area ("off-site").

The selected management goal for sediment quality on-site is called Site Condition II (SCII) and is broadly defined as "minor adverse effects." This means that there is no significant acute toxicity and no bioaccumulation levels exceeding human heath tissue guideline values. For on-site material, the original monitoring emphasis was on using benthic toxicity as an indicator of compliance with Site Condition II.

The original monitoring framework also needed to make sure that acceptable on-site effects did not adversely affect off-site resources. At the start of the PSDDA program there was little experience with dredged material placement or feedback from monitoring--but avoiding off-site adverse effects was a high priority. To evaluate off-site material in areas surrounding the disposal site, the emphasis was on using benthic community structure and invertebrate tissue analyses for comparison to background samples taken outside the influence of any dredged material placement.

Questions and Hypotheses

Three main questions were formulated to test whether material placed at the sites behaved as hypothesized:

1. **Does the dredged material stay on site?**
2. **Has dredged material disposal caused the biological effects conditions for site management to be exceeded at the site?**
3. **Are unacceptable adverse effects due to dredged material disposal occurring to biological resources off site?**

Six hypotheses were devised to answer these questions and to measure compliance with program guidelines and are detailed in Table 2.

For this paper, the results of monitoring studies over the years have been tabulated into site-specific "Monitoring Summary" tables that address each of the three questions and six hypotheses from the original monitoring framework. The hypotheses as abbreviated in these tables, along with notes, are as follows:

1) **DM Stay on Site?** (addresses Question 1)
   - Compliance was defined as no accumulation of dredged material (DM) > 3 cm at the site perimeter. "Site perimeter" is a line 0.125 nautical mile outside the site boundary. There have been excursions of material off site that triggered further studies, as detailed in the "special studies" tables for each site.
2) **Off-site Chemistry > SQS due to DM?** (addresses Questions 1 and 3)
   - At the start of the program, very little was known about how use of the disposal sites might impact off-site areas, either directly or indirectly. Even if DM could not be identified in Sediment Profile Imaging (SPI) surveys, it was not known whether there would be a detectable effect on habitat and resources outside the site.
   - Since monitoring began, there have been no detected elevations of sediment chemistry off-site attributable to DM placement at any site.
3) **On-site Chemistry < DMMP MLs?** (addresses Question 2).
   - Anything under the Maximum Level (ML) was considered acceptable under SCII if on-site benthic toxicity tests passed. Biological test results have always superseded chemical results in PSDDA/DMMP guidelines.
   - The only exceedances of MLs ever found at the disposal sites were in the baseline surveys prior to any DM placement. Since site use began, there have been no exceedances of sediment MLs in DM at any time or any site.
4) **On-site Toxicity Pass SCII?** (addresses Question 2).
   - At the start of PSDDA, benthic toxicity tests were considered an important check on sediment chemistry results and were always performed.
   - No on-site benthic toxicity tests have failed at any time or on any site.
5) **Tissue Chemistry Pass SCII?** (addresses Question 3).
   - Tissue chemistry data were used to test whether the chemical body burden of benthic infauna species collected at transect stations increased due to DM disposal.
   - In "Tiered" monitoring events, these samples were collected but not always analyzed, depending on other site-specific findings.
   - No elevated tissue chemistry levels have been documented in off-site benthic infauna species due to DM disposal.
6) **Benthic Infauna Abundance Pass SCII?** (addresses Question 3).
   - Benthic infaunal samples were taken at transect and benchmark stations to evaluate whether there was a significant decrease in the abundance of dominant benthic infauna species down-current of the disposal site due to DM disposal. Benchmark station samples were archived pending results of transect stations.
   - In "Tiered" monitoring events, these samples were collected and archived but not always analyzed, depending on other site-specific findings.
   - Apparent decreases in the abundance of dominant benthic infauna species have occurred at Anderson/Ketron, Port Gardner and Elliott Bay, resulting in further study. Those findings were found to be part of bay-wide changes and not the result of DM disposal.

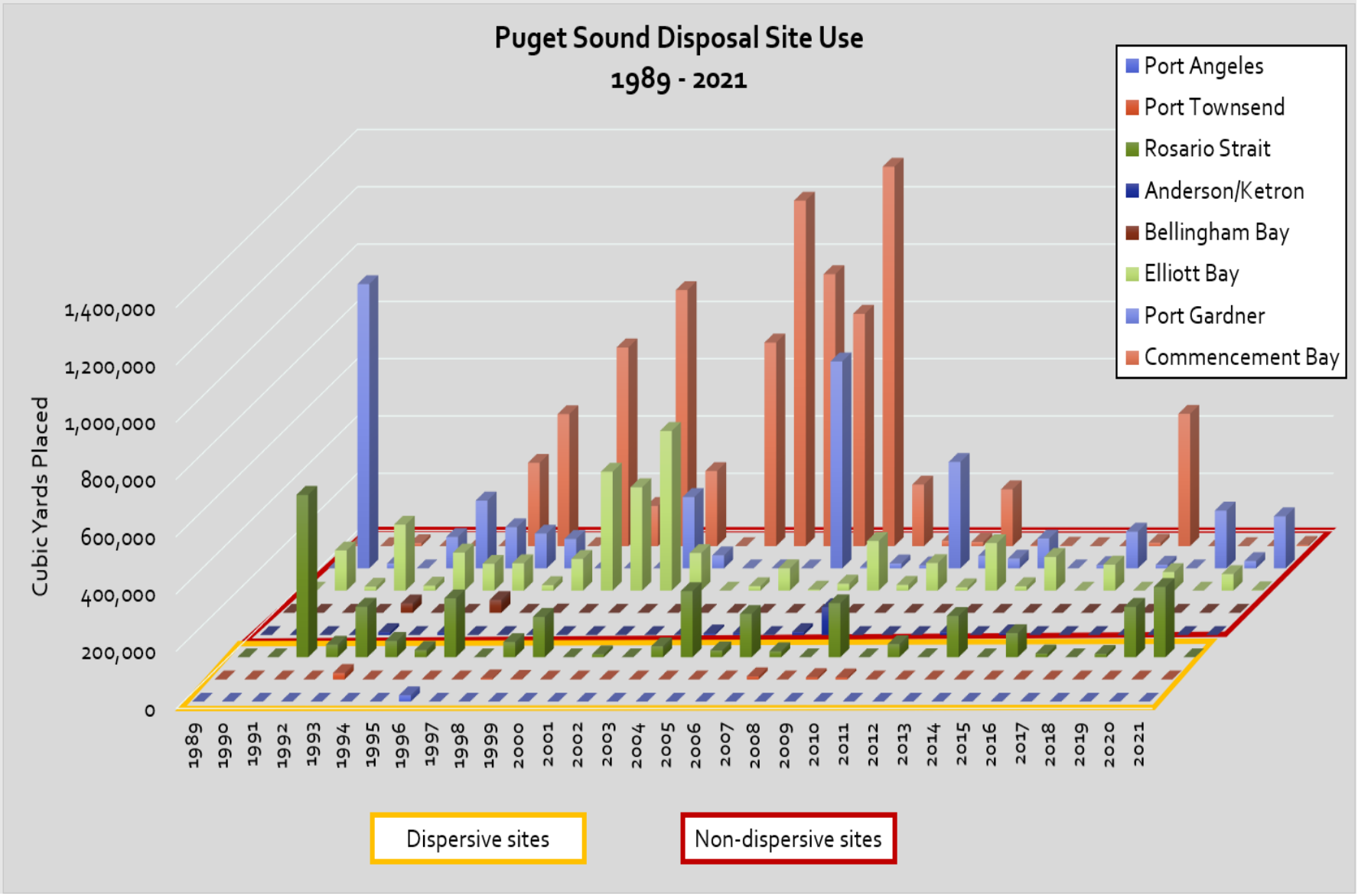

Figure 2. Puget Sound Disposal Site Use 1989 – 2021

Table 2. Original PSDDA/DMMP Monitoring Framework

Question	Hypothesis	Monitored Variable	Interpretive Guideline	Action Item (When exceedances noted)[1]
1. Does the deposited dredged material stay on site?	1. Dredged material remains within the site boundary	Sediment Vertical Profiling System (SVPS) Onsite and Offsite	Dredged material layer is greater than 3 cm at the perimeter stations.	Further assessment is required to determine full extent of dredged material deposit.
	2. Chemical concentrations do not measurably increase over time due to dredged material disposal at offsite stations.	Sediment Chemistry Offsite	Washington State Sediment Quality Standards and Temporal analysis	Post-disposal benchmark station chemistry is analyzed and compared with appropriate baseline benchmark station data.
2. Are the biological effects conditions for site management [PSDDA-defined Site Condition II] exceeded at the site due to dredged material disposal? (PSDDA 1988b)	3. Sediment chemical concentrations at the onsite monitoring stations do not exceed the chemical concentrations associated with PSDDA Site Condition II guidelines due to dredged material disposal.	Sediment Chemistry Onsite	Onsite chemical concentrations are compared to DMMP maximum levels.	PSDDA agencies may seek adjustments of disposal guidelines and compare post-disposal benchmark chemistry with appropriate baseline benchmark station data.
	4. Sediment toxicity at the onsite stations does not exceed the PSDDA Site Condition II biological response guidelines due to dredged material disposal.	Sediment Bioassays Onsite	DMMP Bioassay Guidelines (Section 401 Water Quality Certification)	Benchmark station bioassays are performed (if archived after monitoring) and compared with baseline benchmark bioassay data.
3. Are unacceptable adverse effects due to dredged material disposal occurring to biological resources off site?	5. No significant increase due to dredged material disposal has occurred in the chemical body burden of benthic infauna species collected down current of the disposal site.	Tissue Chemistry Transect	Guideline values: Metals: 3x the baseline concentrations Organics: 5x the baseline concentrations	Compare post-disposal benchmark tissue chemistry with baseline benchmark tissue chemistry data.
	6. No significant decrease due to dredged material disposal has occurred in the abundance of dominant benthic infaunal species collected down current of the disposal site.	Infaunal Community Structure Transect	Guideline values: Abundance of major taxa < ½ baseline macrobenthic infauna abundances.	Compare post-disposal benchmark benthic data with baseline benchmark data.

[1] To determine if observed changes in chemical conditions or infaunal benthos are due to dredged material disposal, data from the benchmark stations are considered. All decisions are subject to DMMP agency review and best professional judgment.

NON-DISPERSIVE SITES

Three main considerations factored into selection of non-dispersive sites: 1) the sites had to be located in low-energy areas so that dredged material remained on site; 2) it was important to minimize the impact to biological resources, and 3) the sites needed to be located in areas with significant dredging needs. Goals for selection of non-dispersive sites in the Puget Sound area included:

- Areas with peak 1% bottom current speeds less than 25 cm/second
- In-water depths between 120 and 600 feet (though the BB site is shallower than -120 ft MLLW)
- Greater than 2,500 feet from biological resources
- Greater than 2,500 feet from shoreline

Anderson/Ketron

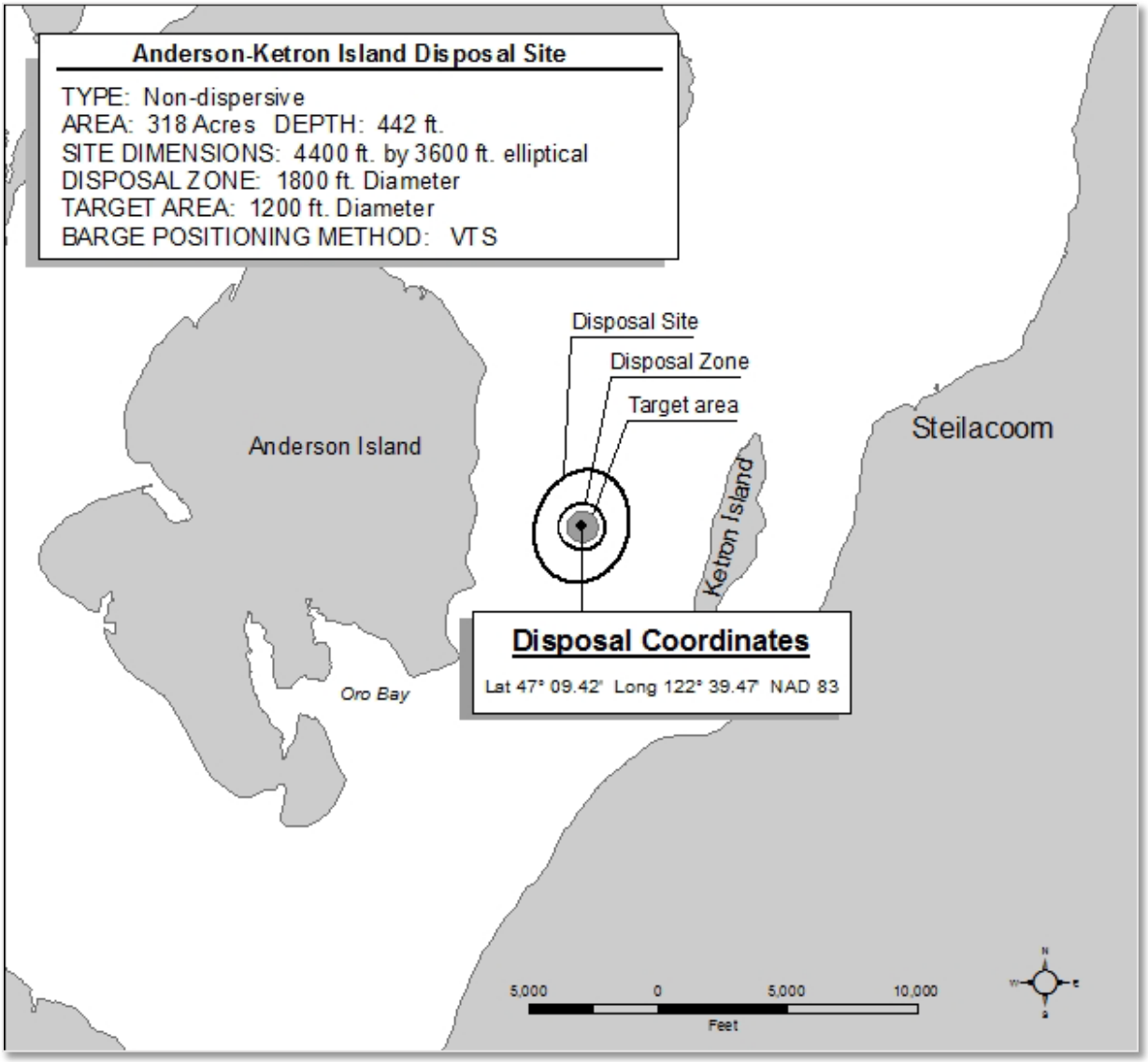

Figure 3. Anderson/Ketron Disposal Site

Anderson/Ketron Summary. This site in South Puget Sound (Figure 3) has not been heavily used. In 2011 the Nisqually Reach Aquatic Reserve was established in the region, extending north from the Nisqually River Delta and around Anderson and Ketron Islands. The AK site is now entirely within the boundaries of the reserve. The management plan for the Nisqually Reach Aquatic Reserve includes dredged material disposal at the Anderson/Ketron Island site as an approved use, contingent on scientific and management oversight of the DMMP (DNR, 2011). Site capacity is 9,000,000 cubic yards (cy).

Anderson/Ketron Site Use 1989-2021. Located south of the Tacoma Narrows, the AK site was intended to serve south sound dredging projects. To date, the site has been used for a few relatively small projects (Figure 4). Though the Port of Olympia and its associated federally maintained navigation channel are potential large users of the site, most of the material tested from those locations to date has not been suitable for open-water disposal.

In 2007, one barge load of suitable dredged material from the Olympia Harbor Navigation Project was inadvertently placed outside the disposal site boundary. One sample from the site of the accidental dump was taken as part of a Puget Sound-wide dioxin survey; dioxin TEQ was consistent with results from benchmark stations and no additional follow-up was required.

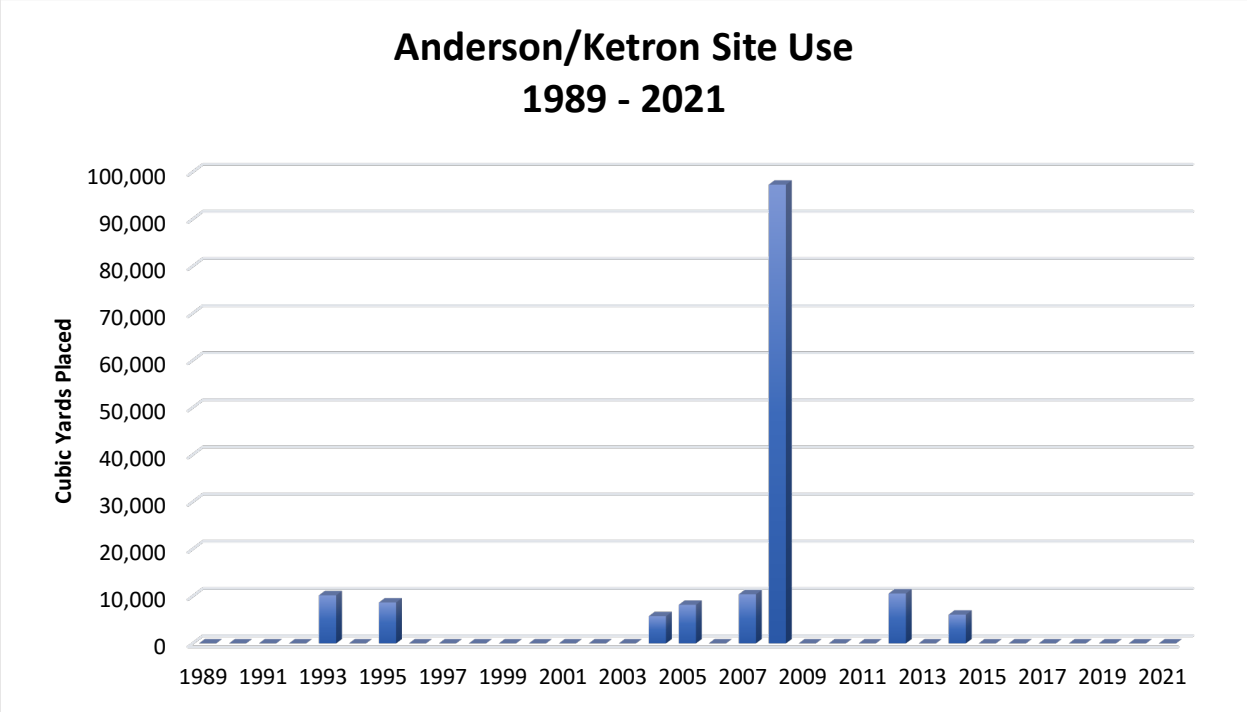

Figure 4. Anderson/Ketron Site Use 1989 - 2021

AK Monitoring History. Due to low site use, there has only been one routine post-disposal monitoring event at the AK site (Table 3 and Table 4). Several special studies have been done at the site—due primarily to the establishment of the Nisqually Reach Aquatic Reserve and not due to any monitoring findings (Table 5). During August 2008, a limited special study was conducted by the DMMP agencies at the Anderson/Ketron site to assess the impact from the 2007 disposal of material dredged from the Olympia Harbor Federal/Port of Olympia Navigation Project, as well the inadvertent off-site disposal

from the same project. This assessment was conducted as part of the EPA Ocean Survey Vessel (OSV) Bold's Puget Sound dioxin/furan survey.

Table 3. Anderson/Ketron Monitoring Summary

Survey	Cumulative Volume (cy)	DM Stay On Site?	Off-site Chemistry > SQS due to DM?	On-site Chemistry < DMMP MLs?	On-site Toxicity Pass SCII?	Tissue Chemistry Pass SCII?	Benthic Infauna Abundance Pass SCII?
1989 Baseline Survey	0	--	No	Yes	Yes	Yes	Yes
2005 Full Monitoring	32,826	Yes	No	Yes	Yes	Yes	No[1]

[1] Attributed to regional fluctuations in benthic macroinvertebrates

Table 4. Anderson/Ketron Monitoring History

Year	Type of Survey	Findings
1989	Initial Baseline Survey	Only 1 on-site sediment sample, no SL exceedances (PTI 1989).
2005	Full Monitoring (new baseline)	Recent DM did not exceed 3 cm at the perimeter stations. No SQS exceedances or temporal trends off site, no exceedances of ML on site, all on-site bioassays passed, in-situ tissue chemistry less than guideline values. Abundance of major taxa less than ½ of baseline benthic macroinvertebrate abundances. Comparison of benchmark benthic macroinvertebrate abundances with baseline found statistically significant decreases in arthropods and increases in Mollusca, Annelida and miscellaneous, likely reflecting regional changes to benthic macroinvertebrate distribution and abundance (SAIC, 2005a; SAIC, 2006a).

Table 5. Anderson/Ketron Special Studies

Year	Type of Study	Findings
2006	Dioxin Evaluation	Eight archived sediment samples and three archived tissue samples from the 2005 full monitoring event were analyzed for dioxins/furans. Dioxin sediment concentrations ranged from 2.0 to 7.3 pptr TEQ at onsite and perimeter stations. Benchmark and transect stations ranged from 1.8 to 3.2 pptr TEQ. Tissue concentrations ranged from 0.05 to 0.53 pptr TEQ wet wt. (SAIC, 2006b).
2007	Dioxin Baseline Survey	In-situ tissue from 2 species were also collected by trawl and analyzed. Whole body English sole dioxin concentration averaged 0.29 pptr TEQ (SAIC, 2008b).
2008	Dioxin/Furan Post-Disposal Special Survey & Off-Site Disposal Evaluation	Special evaluation after Olympia Harbor Navigation Project disposal and accidental off-site dump, as part of OSV Bold Survey. Dioxin sediment concentrations ranged from 2.0 to 3.1 pptr TEQ at onsite and perimeter stations. Benchmark and transect stations ranged from 1.5 to 1.8 pptr TEQ. Off-site disposal location sample 2.9 pptr TEQ (DMMP *et al*, 2009).
2014	Fate & Transport Study	Model results confirmed assumptions used during PSDDA site selection. Results indicated that 97-98% of material disposed settles out of suspension within the disposal site boundary. The remaining 2-3% of material disposed at AK could settle outside of the disposal site boundary,

Year	Type of Study	Findings
		but likely would remain within the basin at water depths greater than 100 meters (USACE, 2014).
2014	Multibeam Bathymetric Survey	Confirmed disposal site depths of 390-510 feet (USACE, 2014).
2014/15	Benthic Trawl Survey	Compared demersal biota in the vicinity of the disposal site between 2014-2015, and 1987 site selection study. Dungeness crab densities increased compared to 1987 but remain far below the threshold for a recreational or commercial crab fishery. Combined density of harvestable crabs was less than 20% of the viability thresholds in all seasons. Debris observed on site which serves as habitat *for C. gracilis* reinforced need for debris management of material going to DMMP sites. No change in viability of pandalid shrimp fishery (not viable). Pink shrimp densities have increased, but not sufficient to support a commercial fishery. Overall, trawl study results demonstrated that the demersal resources in the area are low and have not changed substantially since the 1987 site selection study (Herrera and NewFields, 2016).

AK Future Site Use & Monitoring Considerations. Currently, the AK disposal site monitoring volume trigger is 150,000 cy (DMMP 2021a). Should proposed regional projects increase future site use, monitoring frequency and timing may be reassessed. Any such changes would undergo public coordination and review.

The Capitol Lake – Deschutes Estuary Long-Term Management Project is in the Environmental Impact Statement phase. The selected preferred alternative is the Estuary Option, which includes removal of the dam separating Capitol Lake from the lower reaches of Budd Inlet (Enterprise Services, 2021). Sediments removed from the estuary are not suitable for open water disposal due to the presence of invasive aquatic species and would not be placed at the AK site. However, dam removal will likely result in higher sedimentation rates in adjacent marinas and Port of Olympia berths, which would require more frequent dredging of newly deposited sediment.

Another project that could impact AK disposal volumes is the Budd Inlet Sediment Cleanup Site. Pending the outcome of this Ecology-led cleanup, dredging of cleaner material deemed suitable for open-water disposal could occur in portions of Budd Inlet East Bay and West Bay.

Ecology has not established Regional Background concentrations for the Anderson/Ketron Island area. A South Puget Sound/Budd Inlet regional background has been established, but it does not cover the area of the disposal site (Ecology, 2018). Future monitoring at Anderson/Ketron will use the Environs Decision Unit (DU) to approximate background concentrations.

DMMP agencies have agreed to coordinate with the Nisqually Aquatic Reserve management group for future dredged material disposal events and the AK site.

Bellingham Bay

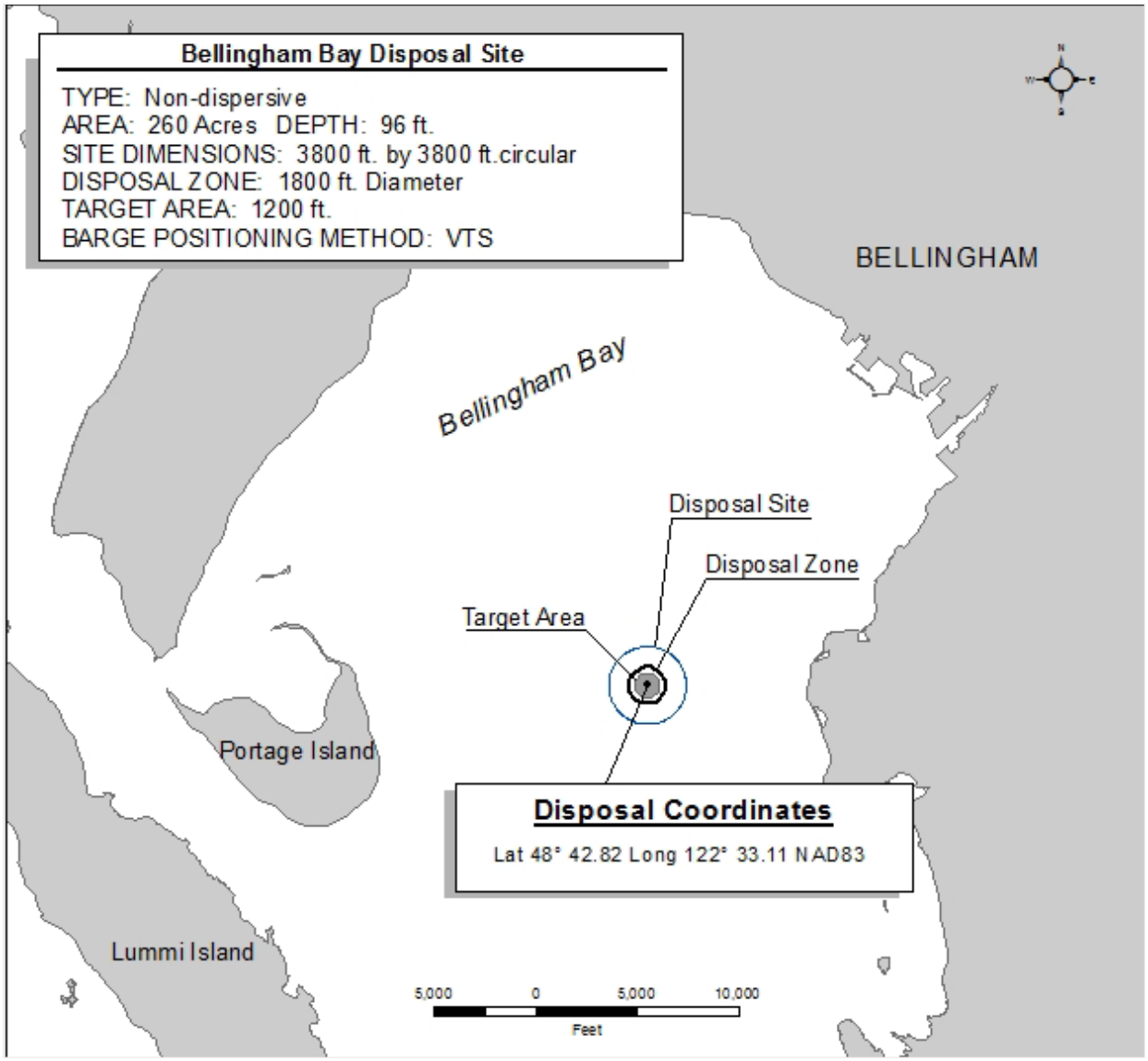

Figure 5. Bellingham Bay Disposal Site

BB Summary. The Bellingham Bay site (Figure 5) is the shallowest of the DMMP disposal sites, at less than -100 ft mean lower low water (MLLW) – shallower than original siting goals targeted. Other potential disposal areas were studied prior to site selection but all were shallower than 120 feet. This site was chosen because it minimized possible unacceptable adverse effects on fish and shellfish resources at least partially due to restricted work windows for disposal defined by the Washington Department of Fish and Wildlife (WDFW) (PSDDA 1989c). The Lummi Nation reported impacts to the tribal Dungeness crab (*Cancer magister*) fishery in the early 1990s. This and other potential resource impacts have limited use of the BB site, which has not been used since 1998. Site capacity is 9,000,000 cy.

BB Site Use 1989 - 2021. The Bellingham Bay disposal site has been used only three times since its establishment, most recently in 1998, with a total of 78,883 cy of dredged material placed there

between 1992 and 1998 (Figure 6). Only material from maintenance of the USACE Squalicum Creek Waterway and Port of Bellingham Cold Storage was ever placed at the site.

In 2009, the Port of Bellingham entered into an intergovernmental framework agreement with the Lummi Nation regarding fifteen specific clean-up, habitat restoration and commercial development projects, many of which included dredging (Chmelik Sitkin & Davis 2009). For those projects with potential open-water disposal, the Port of Bellingham agreed not to use the DMMP disposal site in Bellingham Bay. USACE has also used alternative disposal sites since 1996 for dredged material from Bellingham Bay.

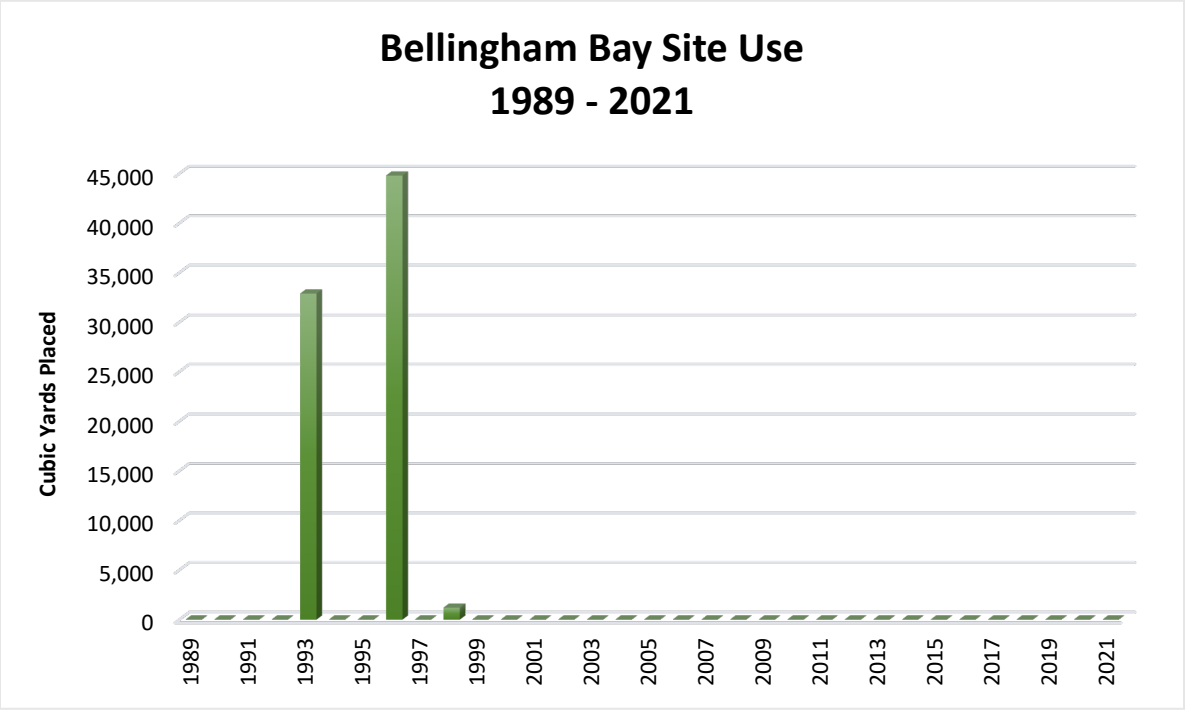

Figure 6. Bellingham Bay Site Use 1989 - 2021

BB Monitoring History. Due to relatively low disposal volumes, the Bellingham Bay disposal site has only been monitored once, in 1993 (Table 6 and Table 7). Special studies have concentrated on potential chemical and physical effects to Dungeness crab.

Table 6. Bellingham Bay Monitoring Summary

Year	Cumulative Volume (cy)	Type of Survey	Findings
1989	0	Initial Baseline Survey	Predominantly silt & clay; Pre-disposal exceedances of mercury at several stations; 1 station had phenol > ML (PTI 1989)
1993	32,883	Partial Monitoring	Recent DM did not exceed 3 cm at the perimeter stations. SCII met on site; arsenic found at perimeter stations not due to DM (SAIC 1993a and 1993b).

Table 7. Bellingham Bay Special Studies

Year	Type of Study	Findings
1990	Dungeness Crab Density Study	Most crabs found were in water depths <20 m. Female crabs more likely than males to be found in deeper water, often buried during winter months (SAIC 1991a).
1991	Dungeness Crab Bioaccumulation Survey	Baseline tissue and hepatopancreas tissue analyses for lipids, metals and pesticides (SAIC 1991b).
1991	Special Study: Crab Tissue Chemistry Protocol	Recommends approaches for determining whether DM disposal contributes to crab body burdens (SAIC 1991d).
2007	Dioxin Baseline Survey	Average dioxin concentration in sediments: 8.2 pptr TEQ, with concentrations decreasing with distance from shore. In-situ tissue from 8 species were also collected and analyzed. Whole body English sole dioxin concentration averaged 0.29 pptr TEQ (SAIC, 2008b).

BB Future Site Use & Monitoring Considerations. The Bellingham Bay monitoring volume trigger is 150,000 cy (DMMP 2021). Currently there is little demand for use of the Bellingham Bay site due to the Port of Bellingham's intergovernmental framework agreement with the Lummi Nation. Most material from nearby federal navigation channels (I&J and Squalicum Creek Waterways) is either suitable for disposal at the Rosario Strait dispersive site or is not suitable for any kind of open-water disposal or placement.

Although not used in many years, and future use is not currently anticipated, the DMMP has not permanently removed the Bellingham Bay site from the disposal site network. If there is a demonstrated need for the Bellingham Bay site to support future disposal, then discussions with the Lummi Nation, governmental agencies, and stakeholders would be pursued. Further special studies may be required before use of the Bellingham Bay site could be resumed.

Regional Background concentrations for Bellingham Bay were established by Ecology in 2015 and will be used as a resource for any future monitoring of the BB site (Ecology, 2015).

Commencement Bay

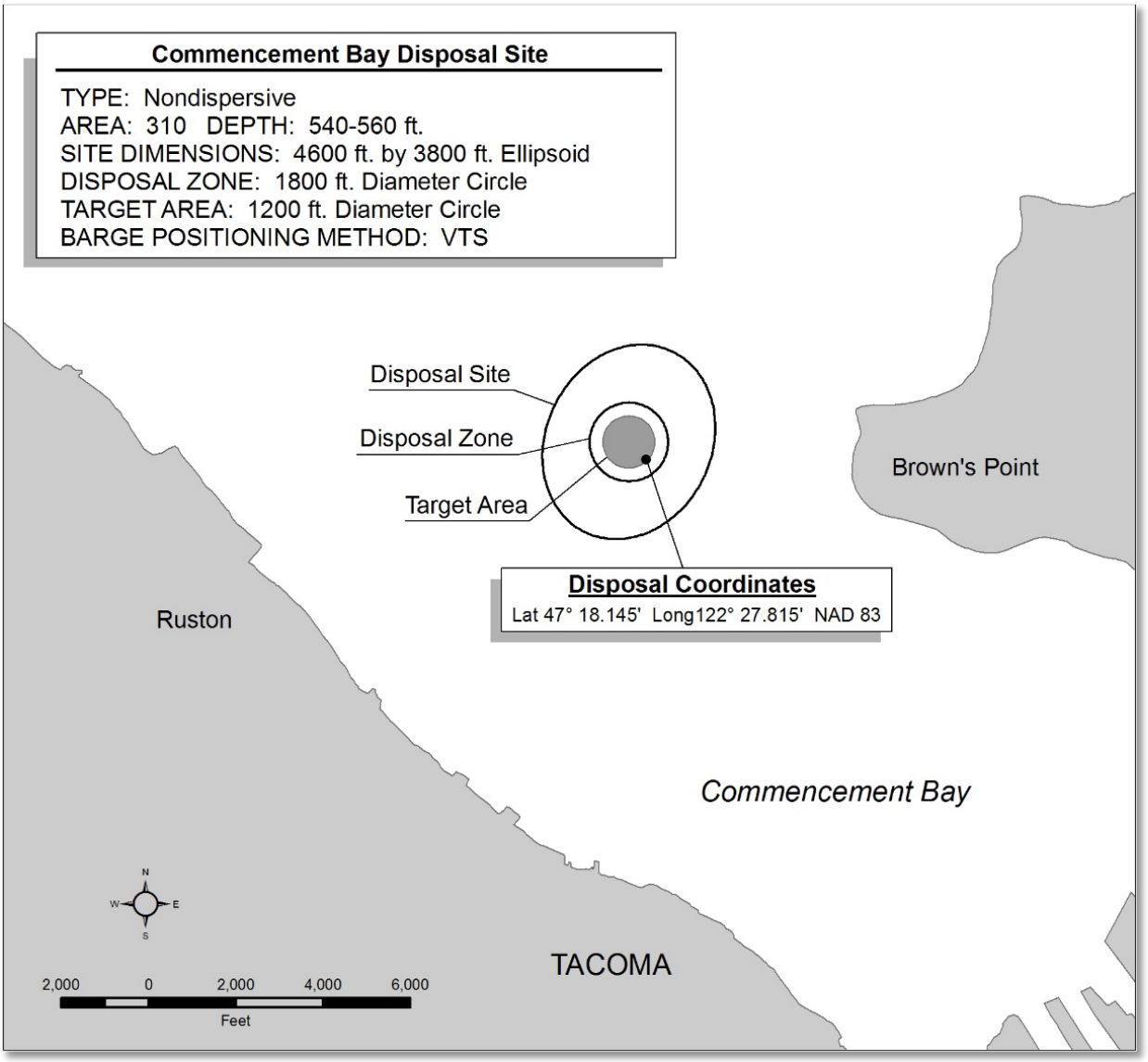

Figure 7. Commencement Bay Disposal Site

CB Summary. Historically, Commencement Bay (Figure 7) has been the most heavily used site, with multiple navigation channel deepening and large Port of Tacoma cut-back projects resulting in millions of cy disposed. Large disposal volumes in the early 2000's caused problems with off-site drift that have not been observed at other disposal sites. Due to heavy use, the site was re-authorized in 2009 to increase the site capacity from 9 million cy to 23 million cy (SAIC, 2009).

CB Site Use 1989-2021. The main user of the Commencement Bay site is the Port of Tacoma, with a few other users from the Tacoma industrial area. Use of the site has been sporadic, with a period of about 10 years (1997 – 2007) when large expansion projects in the Port of Tacoma's Blair Waterway drove heavy use of the site (Figure 8). As the cumulative site volume rose rapidly towards the 9,000,000-cy capacity originally anticipated in the PSDDA study, the DMMP undertook a process for expanding site capacity up to 23,000,000 cy by shifting disposal coordinates at predetermined intervals to reduce

mound height while keeping dredged material on-site. To justify the increased site capacity, a Supplemental Environmental Impact Statement (SEIS) was prepared, supported by monitoring data as well as by information from other special studies.

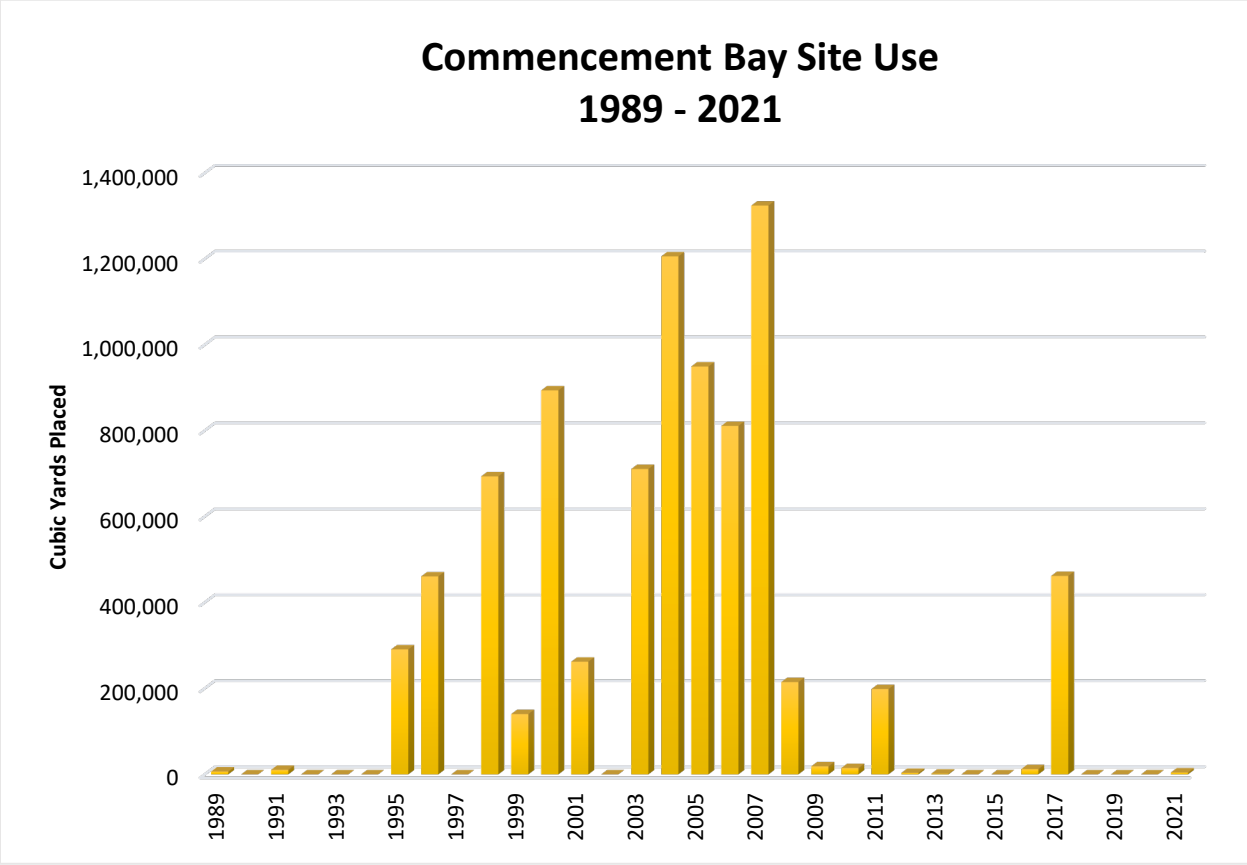

Figure 8. Commencement Bay Site Use 1989 - 2021

CB Monitoring History. The Commencement Bay monitoring volume trigger is 500,000 cy (DMMP 2021a). SPI surveys through the years have indicated the presence of a thin layer of dredged material accumulation extending beyond the site perimeter, some of which exceeded the guideline parameter of 3 cm at the site perimeter. Off-site dredged material accumulation was observed in 1998, 2001, 2003, 2004, and 2005 (Table 8). Though the amount of dredged material measured outside the boundaries of the site has been relatively small, with over 95 percent of the DM located within the site boundary (Nelson 2006; Michelson 2008), the off-site material catalyzed several investigations into its causes and effects. The CB site was closed to disposal during dredging year 2002 (June 16, 2001 – June 15, 2002) while the DMMP agencies evaluated the effects of off-site material. Based on site monitoring in 2001, the DMMP agencies determined that off-site sediments were below all chemical guidelines of concern (SQS), exhibited no toxicity, and showed no impacts to benthic communities or elevated tissue chemistry that could be attributed to dredged material disposal (SAIC, 2009). Table 9 and Table 10 summarize findings from regular monitoring and special studies since site establishment.

Periodic bathymetric surveys conducted at the site have confirmed that the dredged material mound is centered over the site target coordinates, although between 1998-2005 off-site material was found northwest of the site boundary. The footprints and heights of the dredged material mound measured

by the bathymetric surveys were consistent with SPI survey results. Depth-averaged tidal currents modeled in Commencement Bay were not found to be at a sufficient velocity to initiate bed load transport, indicating that bottom currents are not strong enough to move dredged material off-site. However, disposal data also showed that 80 percent of disposal barges/scows were traveling in a northwest direction during disposal. This bias in vessel course could have been a contributing factor to the northwest deposition of dredged material, as observed during the 2001 survey (Michelson 2008). Moving the disposal target coordinates 565 feet to the southeast, effective June 16, 2007, has reduced the rate of growth of the mound height and minimized the deposition of dredged material to the northwest (Wasson *et al*., 2007). Monitoring in 2007 and 2017 found no off-site DM.

A review of the qualitative parameters measured from SPI images has shown that dredged material accumulation has not caused long-term adverse impacts to benthic habitat quality. The benthic community appears to be resilient and adaptable to the disposal of dredged material. This conclusion is supported by the wide distribution of Stage III infaunal communities within the disposal site during post-disposal surveys.

Table 8. Commencement Bay Monitoring Summary

Survey	Cumulative Volume (cy)	DM Stay On Site?	Off-site Chemistry > SQS due to DM?	On-site Chemistry < DMMP MLs?	On-site Toxicity Pass SCII?	Tissue Chemistry Pass SCII?	Benthic Infauna Abundance Pass SCII?
1988 Baseline Survey	0	--	No	Yes	No[1]	--	--
1995 Full Monitoring	308,405	Yes	No	Yes	Yes	Yes	Yes
1996 Partial Monitoring	769,089	Yes	No	Yes	Yes	--	--
1998 Physical Monitoring	1,462,629	No	--	--	--	--	--
2001 Full Monitoring	2,762,591	No	No	Yes	Yes	Yes	Yes
2003 Tiered-Full Monitoring	3,473,266	No	Yes[2]	Yes	Yes	Yes	Yes
2004 Partial Monitoring	4,679,259	No	No	Yes	Yes	--	--
2005 Physical Monitoring	5,628,658	No	No[3]	--	--	--	--
2007 Full Monitoring	7,763,912	Yes	No	Yes	Yes	Yes	Yes
2013 Physical Monitoring	8,216,022	Yes	--	--	--	--	--
2017 Tiered-Full Monitoring	8,686,120	Yes	No	Yes	Yes	--	--

[1]The 1988 baseline amphipod test did not pass the DMMP interpretive guideline for one of two reference sediment evaluations.
[2]SQS was exceeded for 1,2,4-trichlorobenzene, butyl benzyl phthalate, bis(2-ethylhexyl) phthalate, and phenol
[3]Only phenol and 4-methylphenol were analyzed as part of a special study
-- = not applicable

Table 9. Commencement Bay Monitoring Findings

Year	Type of Survey	Findings
1988	Initial Baseline Survey	SL exceedances of PAHs at southern perimeter stations; SL exceedances of mercury, nickel, and antimony at perimeter stations; and SL exceedances of mercury, nickel, phenol, 4-methylphenol, and hexachlorobutadiene at on-site stations (PTI 1988).[1]
1995	Tiered-Full (new baseline)	Recent DM did not exceed 3 cm at the perimeter stations. Chemistry & bioassay results all met SCII. Some evidence of increase in fines and metal concentrations over initial baseline at south perimeter station. No apparent benthic community impacts or accumulations of COCs in *Molpadia* tissues from transect stations (SAIC, 1995a).
1996	Partial Monitoring	Recent DM did not exceed 3 cm at the perimeter stations. Chemistry & bioassay results all met SCII (SAIC, 1996).
1998	SPI Survey	Thin, small band (<5 cm) of DM off site to the northwest (SEA, 1998).
2001	Full Monitoring	Large accumulations (trace to 15.2 cm) of DM off site to the northwest. Chemistry, bioassay, benthic infaunal abundance and tissue results all met SCII (SEA, 2001; SEA, 2002).
2003	Tiered-Full Monitoring, including List 1 & 2 BCOCs	Thin, small band (2.7–4.5 cm) of DM off site to the northwest. Chemistry, bioassay and benthic infaunal abundance results met SCII. Cadmium concentrations in transect station tissues were a concern, but not enough to reject Hypothesis 5. Benthic infaunal and tissue sample analyses were conducted on transect samples but not required for benchmark samples (SAIC, 2003).
2004	Partial & Bathymetric Survey	Thin, small band (0.4–3.8 cm) of DM off site to the northwest. Chemistry & bioassay results all met SCII (SAIC, 2004).
2005	SPI Survey	Thin (trace to 6.0 cm) but extensive accumulation of off-site DM to the northwest (SAIC, 2005b).
2007	Full Monitoring & Multibeam Bathymetric Survey	Recent DM did not exceed 3 cm at the perimeter stations. Chemistry, bioassay, benthic infaunal abundance and tissue results all met SCII (SAIC, 2008c).
2013	SPI Survey + Multibeam Bathymetric Survey	Recent DM did not exceed 3 cm at the perimeter stations, though trace of DM extended beyond site perimeter to the north (NewFields, 2013).
2017	Tiered-Full Monitoring & Multibeam Bathymetric Survey	Recent DM did not exceed 3 cm at the perimeter stations. Chemistry and bioassay results all met SCII. No analysis of collected benthic community or *Molpadia* tissue samples required. PBDEs measured (NewFields, 2018).

[1] Exceedances of 1988 SLs

Table 10. Commencement Bay Special Studies

Year	Type of Study	Findings
2005	Special Phenol Study	Low phenol concentrations were found in perimeter and benchmark stations, confirming the short-lived and variable nature of phenols in sediments. No concentrations exceeded SLs (SAIC, 2005b).
2007	Dioxin Baseline Survey	13 on-site and off-site sediment samples were analyzed. Average sediment dioxin concentration was 3.12 +/- 3.61 pptr TEQ. Highest concentrations found at CBZ01 (SAIC, 2008b). In-situ tissue from 5 species were also collected and analyzed. Whole body English sole dioxin concentration averaged 0.66 pptr TEQ (SAIC, 2008b).

CB Future Site Use & Monitoring Considerations. The Commencement Bay monitoring volume trigger is 500,000 cy (DMMP 2021a). Future site use is expected to remain similar to use over the past decade, with one possible significant exception. Deepening and widening of the navigation channel in the Blair Waterway is currently being investigated by USACE as part of the Tacoma Harbor Navigation Improvement Study. If this project moves forward, between 500,000 and 2.3 million cy of dredged material could be disposed at the CB site over two to three dredging seasons.

Based on the 2009 SEIS for Commencement Bay, the disposal target coordinates must be shifted once the cumulative disposal volume reaches 13 million cy to minimize the disposal site mound height. The site management objective for Commencement Bay is to keep the mound height below 250 feet above the floor of Puget Sound. The current cumulative disposal volume is 8.69 million cy. At the current average rate of disposal (271,000 cy/year), the 13 million cy trigger to shift disposal coordinates would be reached in approximately 15 years. However, this is highly dependent on sporadic new work dredging projects. Maintenance dredging accounts for a small fraction of the total dredging that occurs in Commencement Bay.

Ecology has not established Regional Background concentrations for Commencement Bay. Future monitoring at Commencement Bay will use the Environs DU to approximate background concentrations.

Elliott Bay

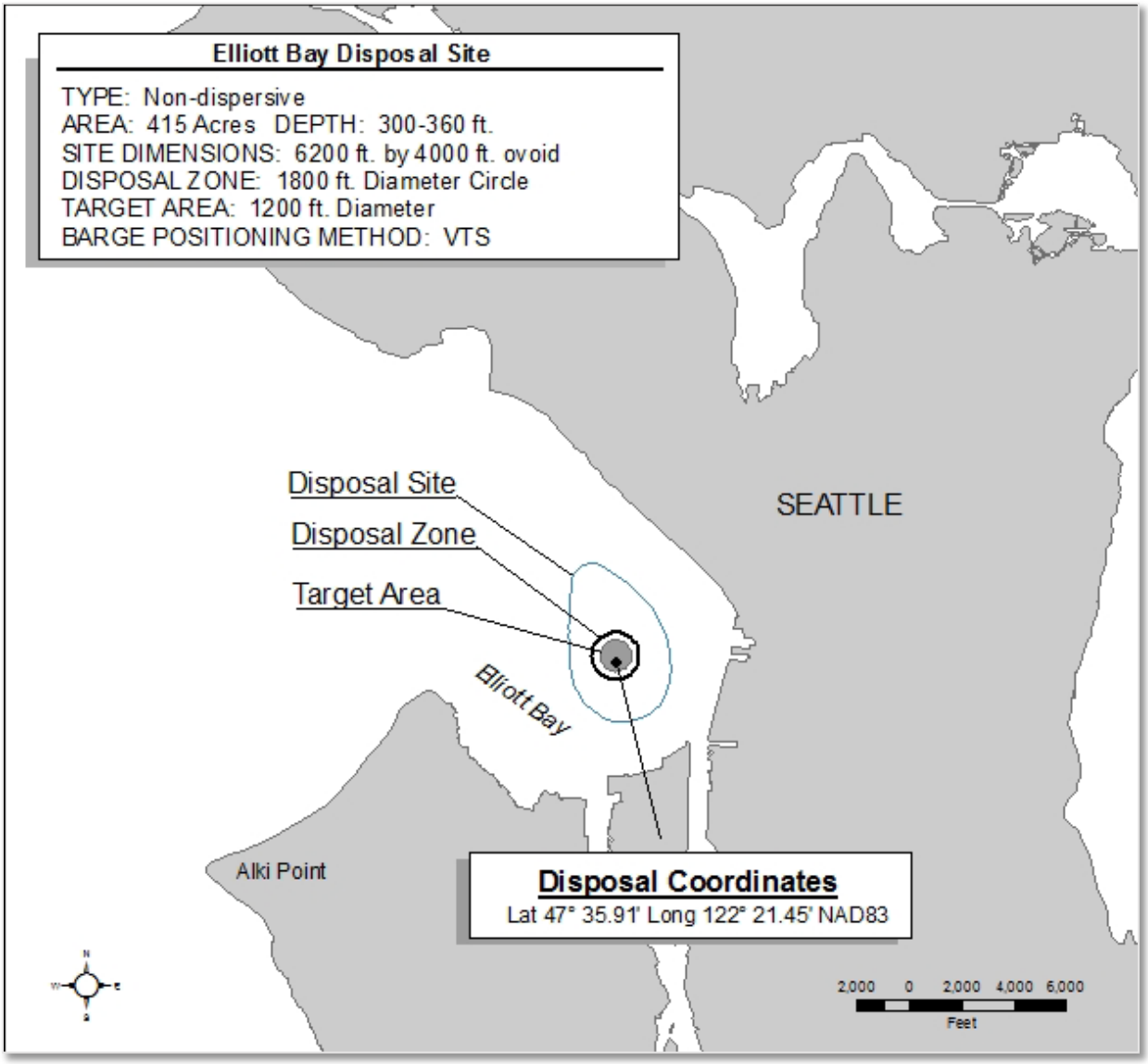

Figure 9. Elliott Bay Disposal Site

EB Summary. The Elliott Bay site (Figure 9) lies directly west of downtown Seattle and is an area of historical sediment contamination. The mouth of the Duwamish River to the south, along with port and industrial facilities on Harbor Island, the East and West Waterways and the Seattle waterfront have been the site of multiple cleanup projects. Monitoring over time has shown decreasing levels of metals, PAHs and PCBs within the site boundary since identification of the site during the PSDDA study. Site capacity is 9,000,000 cy.

EB Site Use 1989 - 2021. The Port of Seattle and USACE have been the main users of the site, as well as many small businesses and marinas along the Duwamish River and throughout Elliott Bay and central Puget Sound. Freshwater sediments from Lake Washington and the Lake Washington Ship Canal have also been placed at the Elliott Bay site. Volume of site us is summarized in Figure 10.

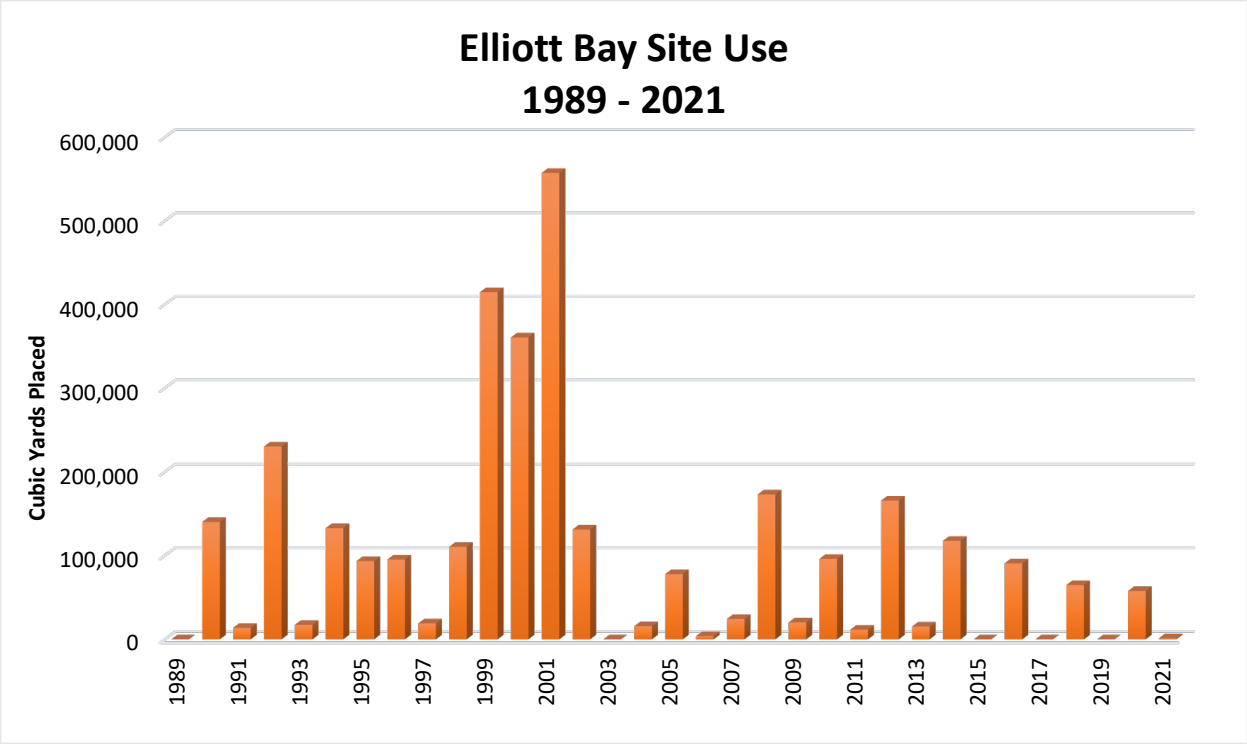

Figure 10. Elliott Bay Site Use 1989 - 2021

EB Monitoring History. The Elliott Bay monitoring volume trigger is 500,000 cy (DMMP 2021a). Baseline environmental conditions in and near the Elliott Bay site reflected an urban environment with multiple sources of chemical contaminants and environmental disturbance. Several DMMP chemicals of concern exceeded DMMP SLs prior to use of the newly established site, and two samples had an ML exceedance for mercury. In general, the highest chemical concentrations were measured at stations nearest the Seattle waterfront and adjacent to the north end of Harbor Island. Over time, concentrations of chemicals of concern in surface sediments within the site boundaries have decreased as cleaner material is placed (Table 11, Table 12 and Table 13).

Table 11. Elliott Bay Monitoring Summary

Survey	Cumulative Volume (cy)	DM Stay On Site?	Off-site Chemistry > SQS due to DM?	On-site Chemistry < DMMP MLs?	On-site Toxicity Pass SCII?	Tissue Chemistry Pass SCII?	Benthic Infauna Abundance Pass SCII?
1988 Baseline Survey	0	--	--	No[1]	Yes	--	--
1990 Partial Monitoring	140,150	Yes	No	Yes	Yes	--	--
1992 Full Monitoring	384,055	Yes	No	Yes	Yes	--	Yes
2000 Full Monitoring	1,627,639	Yes	No	Yes	Yes	Yes	Yes
2002 Tiered-Full Monitoring	2,316,131	Yes	No	Yes	Yes	Yes	Yes
2013 Partial Monitoring	2,919,252	Yes	No	Yes[2]	Yes	--	--

[1]Mercury was only chemical exceeding DMMP ML
[2]Average on-site Dioxin/Furan concentration was 6.9 pptr TEQ. See Table 12 for details.
-- = not applicable

Table 12. Elliott Bay Monitoring Findings

Year	Type of Survey	Findings
1988	Initial Baseline Survey (pre-disposal conditions)	SL exceedances of several metals, Hg, PAHs & PCBs. Levels of contaminants increased with proximity to Seattle/Harbor Island shorelines (PTI 1988).
1990	Partial Monitoring	Recent DM did not exceed 3 cm at the perimeter stations. Reduction over baseline for Hg, PCB, and HPAH values in on-site stations. One benchmark (off-site) station failed bioassays; all on-site & perimeter stations passed (SAIC 1991c).
1992	Full Monitoring	Recent DM did not exceed 3 cm at the perimeter stations. Cu, Pb, Ag and Hg exceeded SLs at multiple stations but at concentrations lower than baseline. PAHs, DDT and PCBs also exceeded SLs at some stations, but all on-site stations passed bioassays. No on-site COCs exceeded MLs. No statistical differences in species or abundance of infaunal species relative to baseline. Not sufficient tissue collected on site to evaluate tissue burdens (SAIC 1992).
2000	Full Monitoring	Recent DM did not exceed 3 cm at the perimeter stations, except for a small southwest lobe purposely placed to cover historic PCB contamination. No on-site COCs exceeded MLs. Bioassays passed, though no acceptable larval test was run so results were based on two bioassays. The total abundance of major taxa observed increased with distance from the site, as observed in 1988 and 1992 (SAIC 2000).
2002	Tiered-Full Monitoring	Recent DM did not exceed 3 cm at the perimeter stations. COC concentrations at perimeter stations were below SQS. No measurable increase in chemical concentrations over time attributable to DM disposal. No on-site COCs exceeded MLs. All on-site bioassays passed (on-site station Z01 had a minor hit in the larval bioassay). *Molpadia* tissue concentrations were less than guidelines established in 2000. Two of three transect stations had significant decreases in molluscan abundances of *Axinopsida serricata*, a species known to have wide shifts in abundance attributable to causes other than DM (SEA 2002a).
2013	Partial Monitoring & Multibeam Bathymetric Survey (MBS)	Recent DM did not exceed 3 cm at the perimeter stations. Multi-beam survey showed a well-shaped mound with apex near the disposal site center coordinates. All on-site COCs were less than SLs and MLs. All bioassays from on-site station Z01 passed with no hits. Average dioxin in 10 on-site stations was 6.90 pptr TEQ, above the 4 pptr TEQ site management objective. Presence of older DM in the samples collected may have contributed to the elevated result. Average concentration of five stations within recent DM footprint was 3.31 pptr TEQ (Integral 2014).

Table 13. Elliott Bay Special Studies

Year	Type of Study	Findings
1995	Side-Scan Sonar Survey (debris evaluation)	Evidence of large woody debris and small amounts of riprap within the site boundary. No appreciable impacts due to *de minimus* riprap disposal.
2000	45-day bioaccumulation, PCB Congener and WES Cell-Line Assay	45-day bioaccumulation results showed elevated tissue concentrations for metals and TBT compared to reference (Carr Inlet), but nothing exceeded guidelines for human health. The PCB cell-line assay study was inconclusive due to low PCB concentrations in tested sediment and tissues (SAIC, 2000).
2002	BCOC Special Study (Lists 1 & 2)	Study initiated to determine whether analytical methods (EPA methods 8260 and 8270) were sensitive enough to achieve low-level detection limits for List 1 and List 2 BCOC analytes. Results also provided baseline documentation of presence/ absence of target compounds adjacent to and within the disposal area. Methods were successful; some detections of BCOCs but not at known levels of concern (SEA, 2003).
2005	Special On-site Chemistry Study	Three on-site stations (Z1, S2, S4) were analyzed; only S4 lacked recent DM. At Z1 there were no exceedances of SLs and dioxins measured 0.72 pptr TEQ. Station S2 had SL exceedances of PCBs in 0-10 cm and 0-2 cm samples, and dioxins at 6.7 pptr TEQ. Station S4 exceeded PCB SL in 0-10 cm, and dioxins at 1.5 pptr TEQ (SAIC, 2005c).
2007	Dioxin Baseline Survey	Mean dioxin concentration of three on-site stations was 9.7 pptr TEQ; mean concentration of 11 off-site stations was 8.7 pptr TEQ. In-situ tissue from 5 species were also collected and analyzed. Whole body English sole dioxin concentration averaged 0.69 pptr TEQ (SAIC, 2008b).
2014	ROV Inspection	Debris matching that documented in disposal records was found on site in approx. 210-230 ft of water, including PVC pipe, a tire, concrete debris, and small diameter steel cable.

EB Future Site Use & Monitoring Considerations. The Elliott Bay monitoring volume trigger is 500,000 cy (DMMP 2021a). Future site use is not expected to change substantially, though large development projects may contribute one-time substantial amounts of material. For example, the Seattle Harbor Navigation Improvement Project could place approximately 750,000 cy of material at the Elliott Bay site if this federal deepening project is constructed.

Ecology has not established Regional Background concentrations for Elliott Bay. Because there are elevated concentrations of several contaminants bay-wide, it is anticipated that the concentrations found in the Environs DU composite (off site) will be higher than the Disposal Site DU composite concentrations (on site). When Ecology establishes regional background concentrations in Elliott Bay, it will aid in the interpretation of EB site monitoring.

Port Gardner

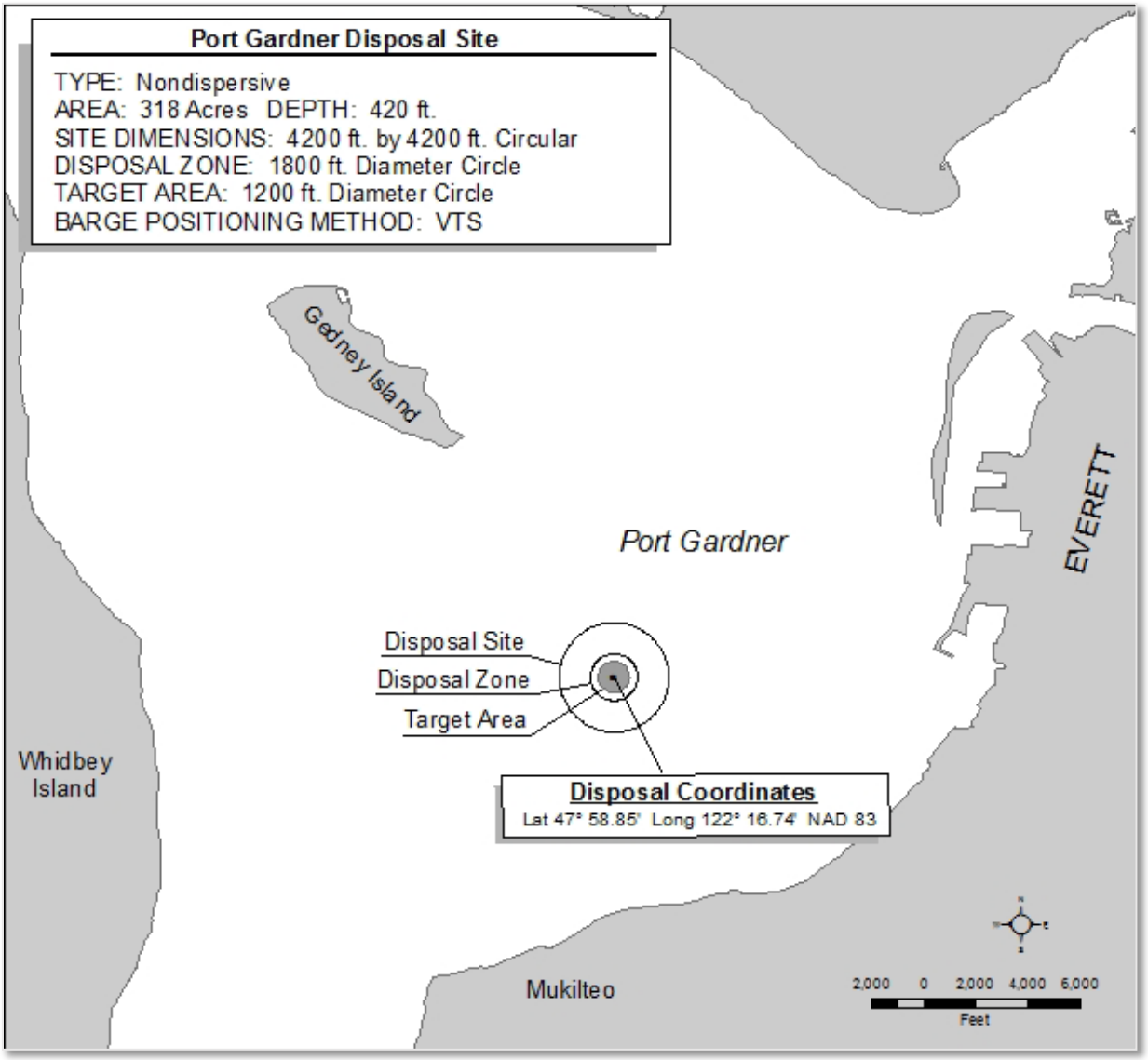

Figure 11. Port Gardner Disposal Site

PG Summary. Port Gardner lies in Possession Sound east of Everett, Washington (Figure 11). The Snohomish River empties into the sound northeast of the site and is the source of much of the material placed at this site. Site capacity is 9,000,000 cy.

PG Site Use 1989 - 2021. The US Navy, Port of Everett, and US Army Corps of Engineers (USACE) have been the main users of the Port Gardner site (Figure 12). The US Navy Homeport project disposed over a million cubic yards of material at Port Gardner, with 992,074 placed at the site in 1990. Following that early project, dredged material accumulated off the Port Gardner site – apparently due to use of several different target areas over the course of the project, which were used on the assumption that depositing material over different portions of the site would spread the material more evenly. That practice was abandoned after that early off-site excursion, and deposited material has stayed within the site boundary since then.

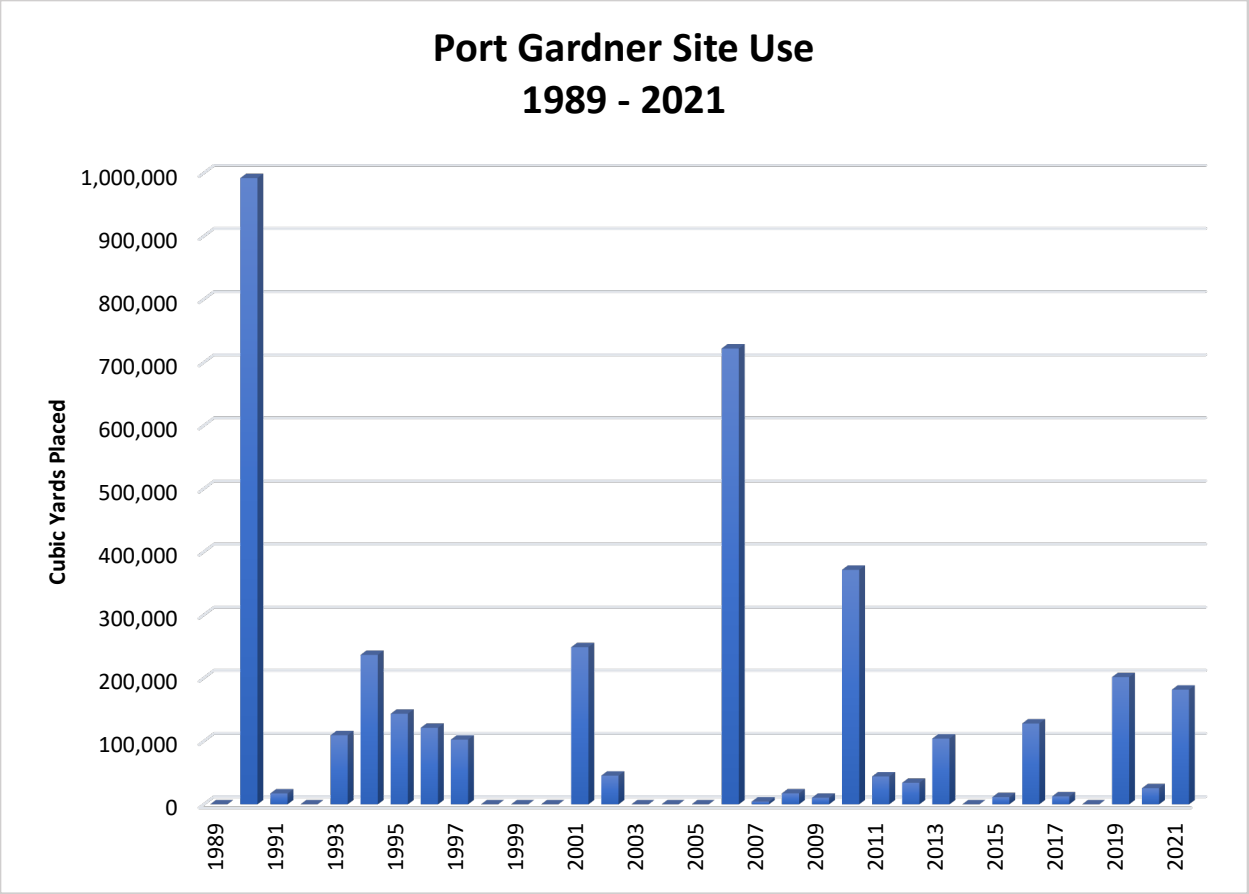

Figure 12. Port Gardner Site Use 1990 - 2021

PG Monitoring History. Monitoring has shown that the Port Gardner site has few site-specific issues that led to off-site material, or difficulties distinguishing between area-wide changes and those caused by disposal of dredged material (Table 14, Table 15 and Table 16).

Table 14. Port Gardner Monitoring Summary

Survey	Cumulative Volume (cy)	DM Stay On Site?	Off-site Chemistry > SQS due to DM?	On-site Chemistry < DMMP MLs?	On-site Toxicity Pass SCII?	Tissue Chemistry Pass SCII?	Benthic Infauna Abundance Pass SCII?
1988 Baseline Survey	0	--	--	Yes	No[1]	--	--
1990 Full Monitoring	992,074	No	No	Yes	Yes	Yes	Yes
1994 Tiered-Full Monitoring	1,355,584	Yes	No[2]	Yes	Yes	--	--
2006 Full Monitoring	2,739,421	Yes	No	Yes	Yes	Yes	Yes
2010 Tiered-Full Monitoring	3,143,161	Yes	No	Yes	Yes	--	--

[1]Amphipod bioassay failed at two stations: PGZ01 (on-site) and PGB02 (off-site)
[2]Phenol exceedances of SL at one on-site and two perimeter stations triggered analysis of phenol at benchmark stations (n=6) which were all also elevated above SL (part of bay-wide trend not affiliated with DM disposal)
-- = not applicable

Table 15. Port Gardner Monitoring Findings

Year	Type of Survey	Notes
1988	Initial Baseline Survey (pre-disposal conditions)	SL exceedance of nickel at all stations; no other SL exceedances (PTI 1988).
1990	Full Monitoring	>3 cm of DM at and beyond the perimeter line, particularly to North and West of site. Chemistry, bioassay and benthic infaunal abundance and tissue results met SCII on-site. Several perimeter chemistry values exceeded guideline values, but were not associated with recent dredged material, therefore no benchmark chemistry analysis was conducted. One benchmark (off-site) station failed bioassays. Evidence of area-wide decreases in abundances of dominant benthic infauna not due to DM disposal (SAIC, 1991c).
1994	Tiered-Full Monitoring	Recent DM did not exceed 3 cm at the perimeter stations. Phenol exceedances on site and at perimeter stations determined to be part of bay-wide trend due to consistent benchmark (off-site) station results. Chemistry and bioassay results met SCII. No benthic community or tissue analyses (SAIC, 1995b).
2006	Full Monitoring; included analysis for List 1 & 2 BCOCs	Recent DM did not exceed 3 cm at the perimeter stations. Chemistry, bioassay and benthic infaunal abundance met SCII. *Molpadia* tissues from perimeter & transect stations showed low or no detections of all BCOCs (SAIC, 2006c).
2010	Tiered-Full Monitoring; included analysis for List 1 & 2 BCOCs	Triggered due to unsanctioned disposal event from flat-top barge. No increase in chemical concentrations at perimeter stations. Recent DM did not exceed 3 cm at the perimeter stations. Chemistry and bioassays met SCII. No analysis of collected benthic community or *Molpadia* tissue samples required. Onsite dioxin concentrations less than 4 pptr TEQ (SAIC, 2010).
2020	Pilot Study – New Framework	Recent DM did not exceed 3 cm at the perimeter stations nor 10 cm at the site boundary. Five on-site stations analyzed individually for DMMP benthic COCs, all results < SL, no bioassays triggered. Lab bioaccumulation tests of Site DU and Environs DU showed low or no bioaccumulative risk, per revised framework (NewFields, 2021).

Table 16. Port Gardner Special Studies

Year	Type of Study	Notes
1990	Bioaccumulation study: comparison of tissues from *Macoma nasuta* laboratory exposures between on-site sediment and control	No evidence of bioaccumulation in tissues exposed to site sediments (SAIC 1991c).

Year	Type of Study	Notes
1991	New benchmark station	Original benchmark station showed unexplained toxicity; new benchmark chosen to better represent typical disposal site conditions with no DM influence (SAIC, 1991c)
2007	Dioxin Baseline Survey	Sediment samples collected from 4 on-site and 9 off-site stations. Benthic invertebrates collected from perimeter, transect & benchmark stations; fish & crab tissue collected via trawl sampling. On-site sediment dioxin ppt dry-wt TEQ average was 1.8; off-site average was 4.4 ppt TEQ (SAIC, 2008b). No tissue collected from on-site stations; In-situ tissue from 4 species were collected off-site and analyzed. Whole body English sole dioxin concentration averaged 0.44 pptr TEQ (SAIC, 2008b).

PG Future Site Use & Monitoring Considerations. The Port Gardner monitoring volume trigger is 500,000 cy (DMMP 2021a). It is anticipated that the PG site will continue to be used at a similar frequency as in the past, with most of the material deposited from the Snohomish River federal navigation channel. The Port of Everett continues to maintain its facilities with periodic dredging of marinas and berths. Material found unsuitable for open-water disposal has either not been dredged or has been removed from water and placed at an upland site.

The Port Gardner site was monitored in 2020 as part of a pilot project to test new conceptual monitoring guidelines to evaluate potential bioaccumulative adverse effects from dredged material disposal (NewFields, 2021). This site was chosen for the pilot study partially due to the existence of a Regional Background (RB) for bioaccumulatives in Port Gardner Bay (Ecology, 2014). Regional background includes chemical concentrations in sediment from diffuse sources that are not directly attributable to a specific source or release – such as the PG disposal site. This enabled the DMMP to determine whether material placed at the PG site contributes to offsite adverse effects, and to test the DMMP's concept of an Environs Decision Unit as a reasonable stand-in for background concentrations of bioaccumulatives.

DISPERSIVE SITES

Dredged material placed at these sites is not intended to remain on site, but to disperse widely. Because post-disposal monitoring is not possible at these sites, the evaluation guidelines for projects intending to use dispersive sites are more stringent than those used at the non-dispersive sites. Specific criteria for selection of non-dispersive sites in the Puget Sound area included:

- Areas with average current speed greater than 25 cm/second
- In-water depths greater than 180 feet
- Minimum of one nautical mile from shorelines and human use areas

Port Angeles

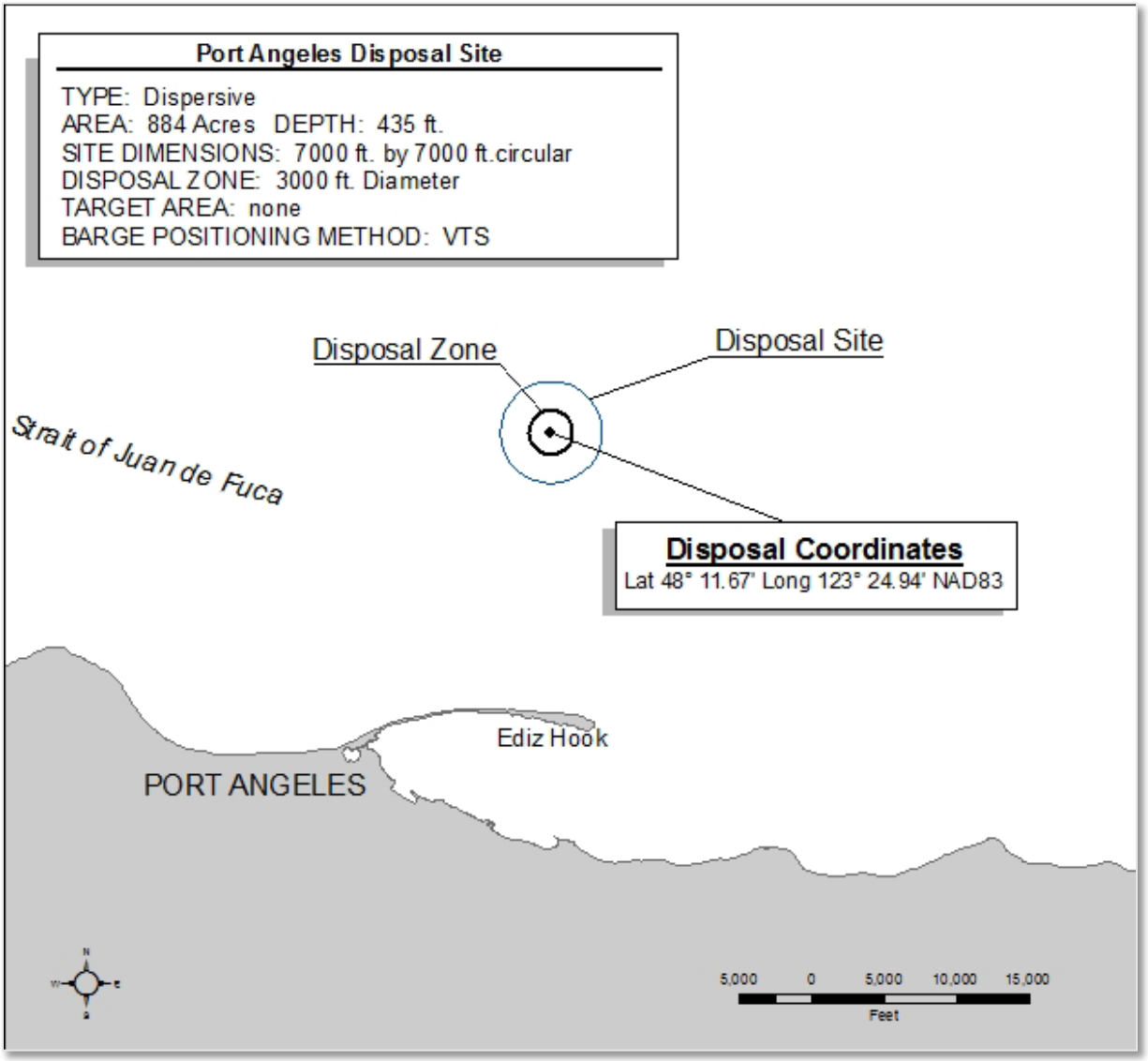

Figure 13. Port Angeles Disposal Site

PA Summary. The Port Angeles site is the western-most (Figure 13) and least used (Figure 14) site. Though Port Angeles Harbor has maritime commerce, there are large and complex cleanup projects (e.g., Western Port Angeles Harbor and Rayonier Mill) in the area that affect dredging and suitability.

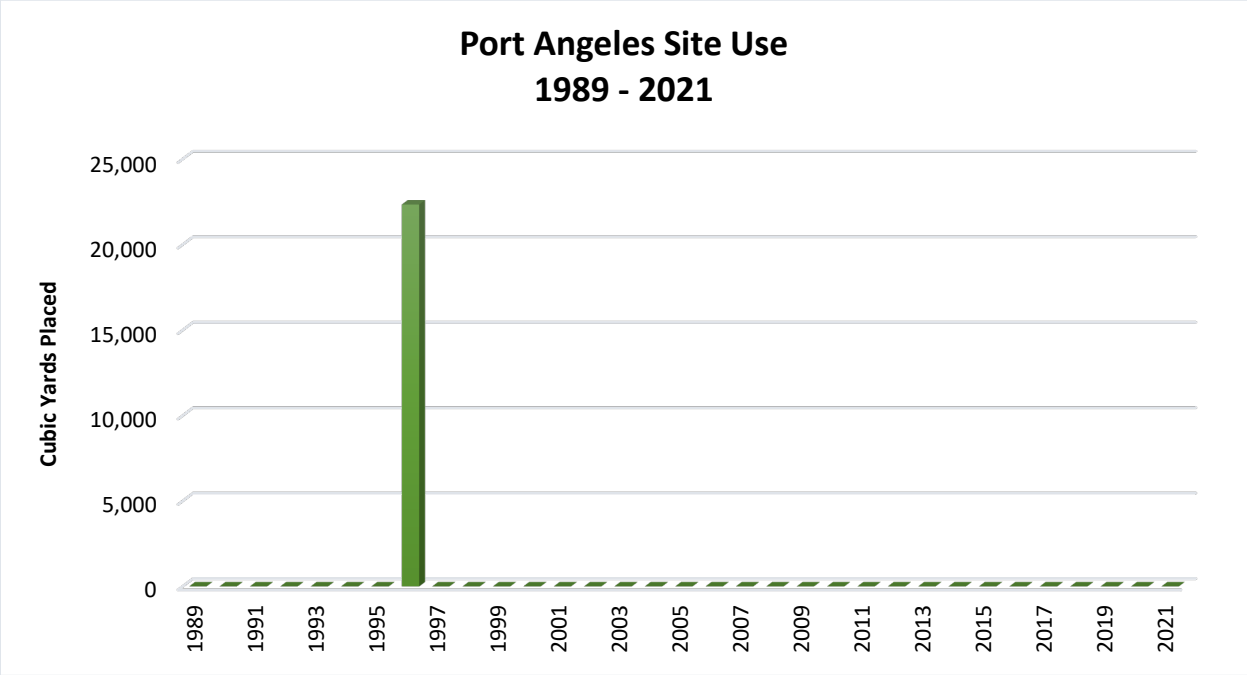

Figure 14. Port Angeles Site Use 1989 - 2021

PA Site Use 1989 - 2021. The Port Angeles Site has only been used for one project, in 1996. The site overlaps the International Maritime Organization (IMO) designated Traffic Separation Scheme (Coast Guard, 2013). Because the site is used infrequently, and because the area is covered by the Coast Guard Vessel Traffic Service (VTS), no use limitations are currently in place for the PA site.

PA Monitoring History. Monitoring of dispersive sites is typically limited to bathymetric surveys to ensure that material is not accumulating or mounding at the site. No bathymetric surveys have been needed at the PA site due to low site use.

Concerns expressed by tribes regarding potential impacts to tribal shellfish resources led to a fate and transport study for all three non-dispersive sites (DMMP, 2011). The modeling results indicated that impacts to commercial shellfish beds from dredged material disposed at the Port Angeles site is unlikely Table 17).

Table 17. Port Angeles Special Studies

Year	Cumulative Volume (cy)	Type of Survey	Findings
2010 to 2012	22,344	Fate & Transport Study	Principal current direction is E to W. Site is highly dispersive with sediment remaining suspended after 72 hours. At least 90% of fine-grained particles descend to depths greater than 20 meters after 72 hours, which is generally deeper than managed shellfish beds.

Port Townsend

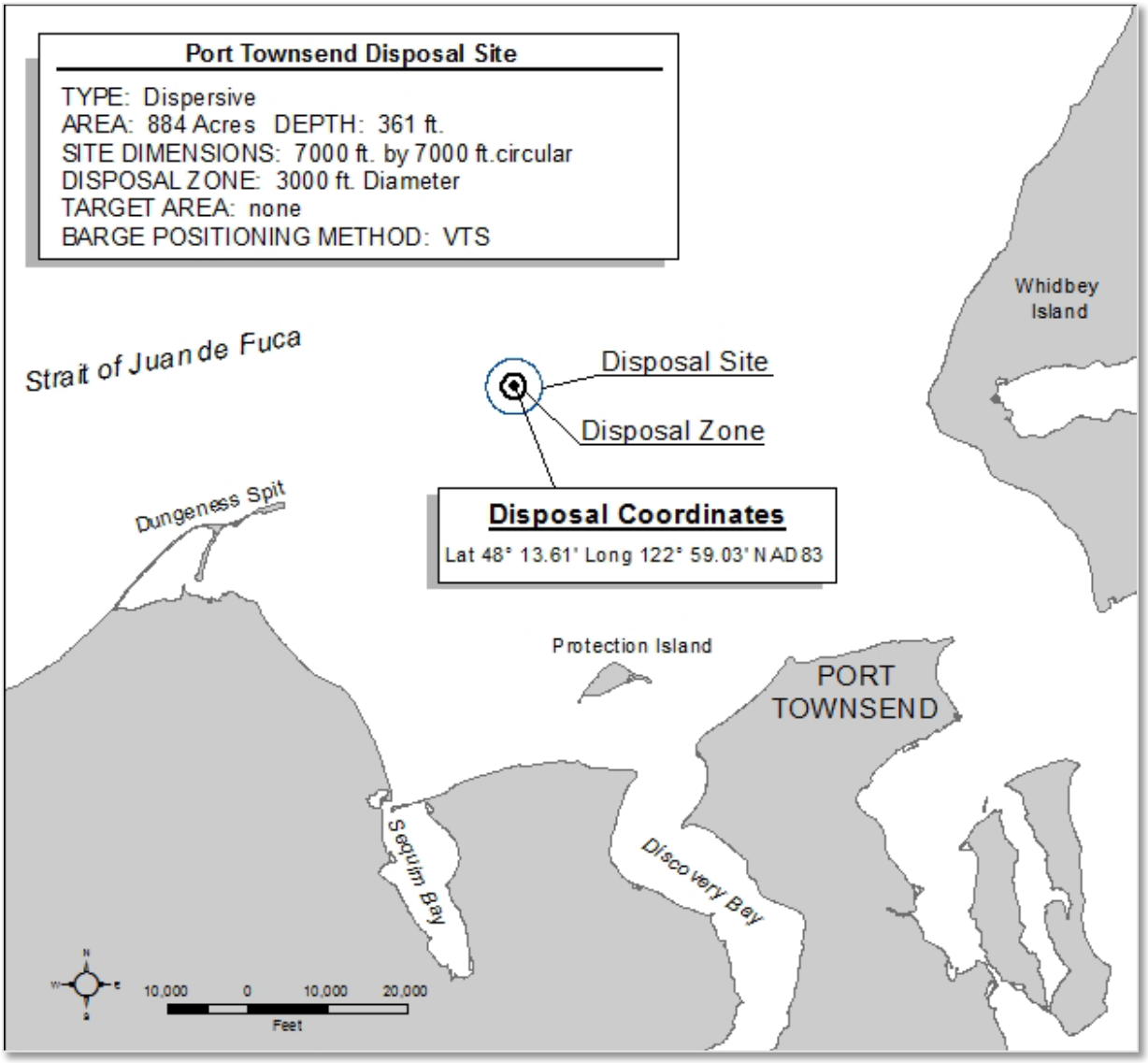

Figure 15. Port Townsend Disposal Site

PT Summary. This site is located about 10.5 nautical miles NW of Port Townsend in water about 360 feet deep (Figure 15). It is used sporadically (Figure 16).

PT Site Use History. The Port Townsend Site has been used by a few entities, primarily from the Port of Port Townsend's Pt. Hudson Marina. It has also been used by the communities of Driftwood Keys and Bridgehaven.

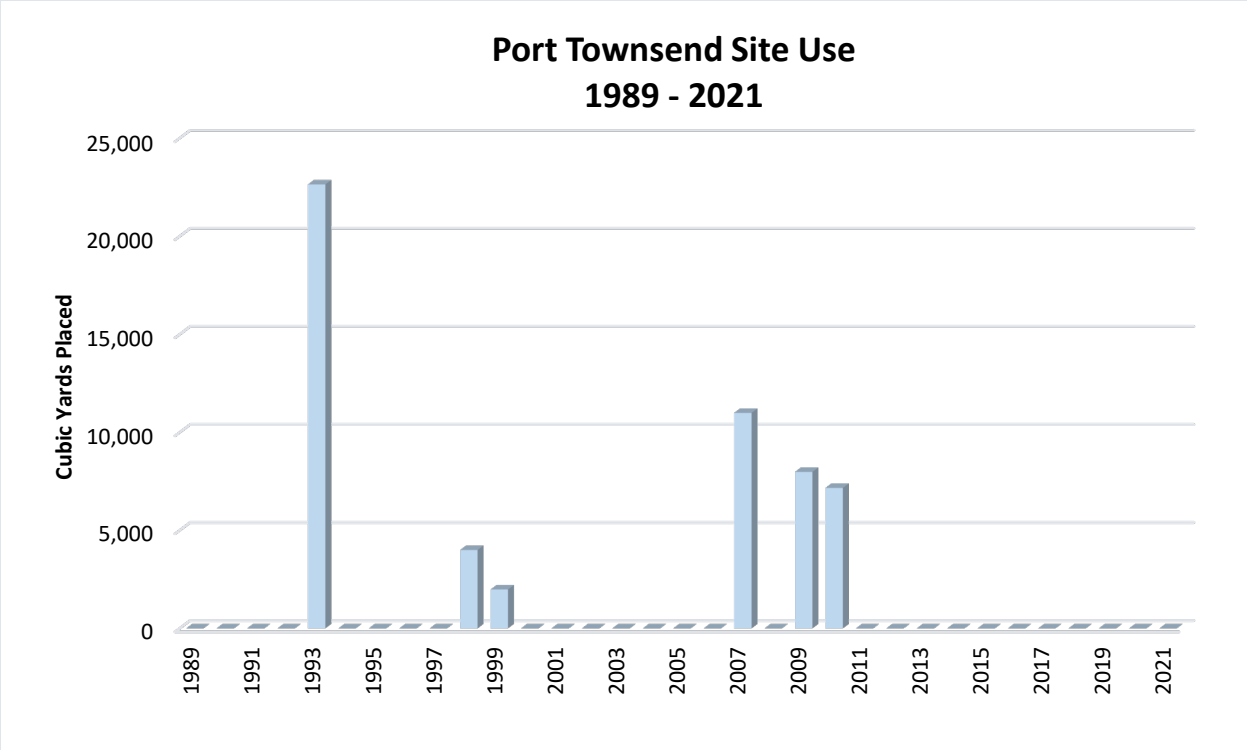

Figure 16. Port Townsend Site Use 1989 – 2021

PT Monitoring History. As a dispersive site, monitoring at Port Townsend is typically limited to bathymetric surveys as needed to ensure that material is not accumulating or mounding. No bathymetric surveys have been needed at the PA site due to low site use.

Concerns expressed by tribes regarding potential impacts to tribal shellfish resources led to a fate and transport study for all three non-dispersive sites (DMMP, 2011). The modeling results indicated that impacts to commercial shellfish beds from dredged material disposed at the DMMP dispersive sites is unlikely.

Table 18. Port Townsend Special Studies

Year	Cumulative Volume (cy)	Type of Study	Findings
2010 to 2012	54,777	Fate & Transport Study	Principal current direction is east-west. Majority of disposed material stays offshore. Bathymetric features limit dispersion and result in a significant reduction in active sediment mobility after 24 hrs. At least 90% of fine-grained particles descend to depths greater than 20 meters after 72 hours, which is generally deeper than managed shellfish beds.

Rosario Strait

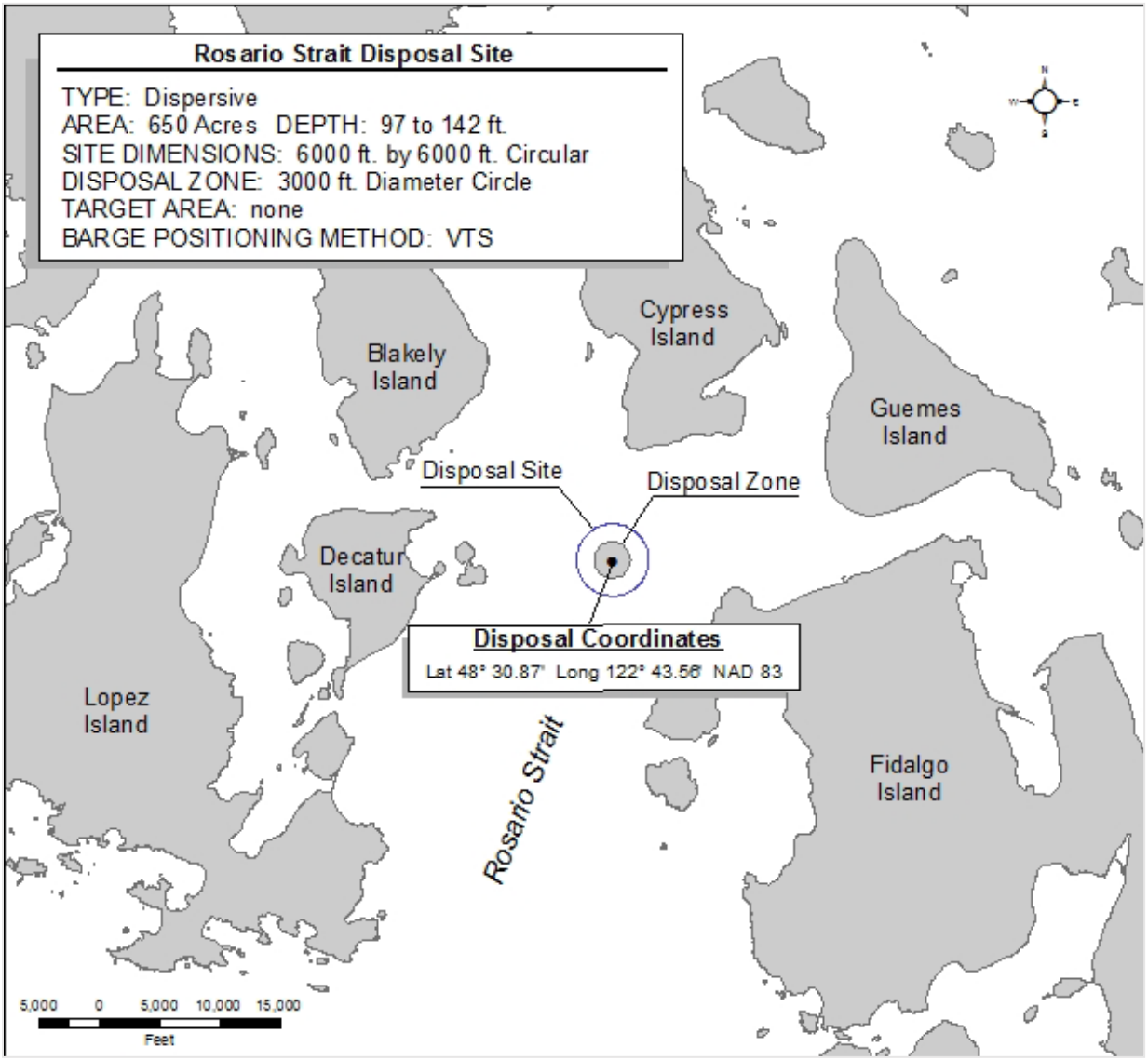

Figure 17. Rosario Strait Disposal Site

RS Summary. Located east of the San Juan Islands, northeast of Puget Sound, and between the Straits of Georgia and Juan de Fuca (Figure 17), the Rosario Strait site is the most heavily used of the greater Puget Sound dispersive sites (Figure 18). The Rosario Strait site has the highest current velocities of the three dispersive sites. Most dredged material suitable for open-water disposal in the Bellingham and Anacortes areas is disposed at the Rosario Strait site rather than at the Bellingham Bay site.

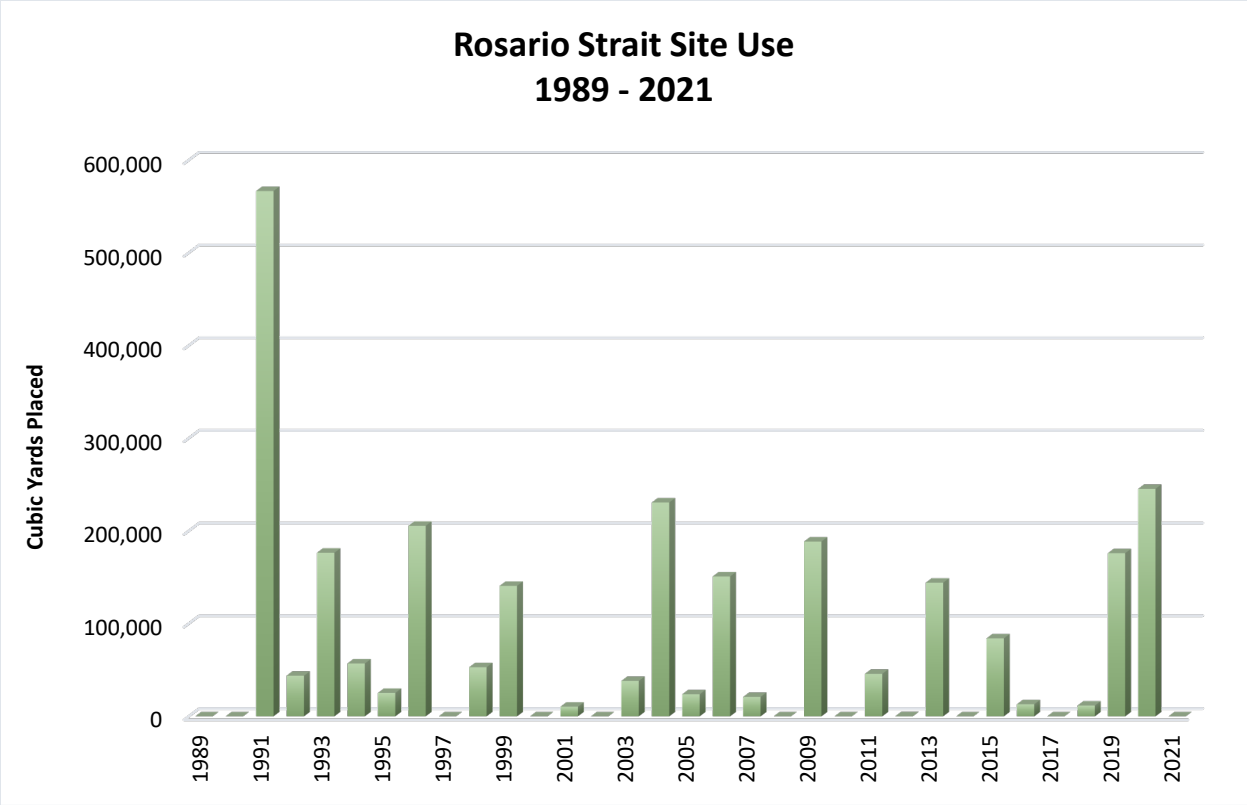

Figure 18. Rosario Strait Site Use 1989 – 2021

RS Monitoring History. Monitoring of dispersive sites is typically limited to bathymetric surveys as needed to ensure that material is not accumulating or mounding at the site. Bathymetric surveys have been conducted every few years to confirm that even high volumes of material do not accumulate or mound at the site.

Concerns expressed by tribes regarding potential impacts to tribal shellfish resources led to a fate and transport study for all three non-dispersive sites (DMMP, 2011). The modeling results indicated that impacts to commercial shellfish beds from dredged material disposed at the DMMP dispersive sites is unlikely (Table 19).

Table 19. Rosario Strait Special Studies

Year	Cumulative Volume (cy)	Type of Study	Findings
2010	1,932,758	Fate & Transport Study	Principal current direction is SW-NE. Bathymetric features to the south restrict transport. Site is highly dispersive. Finer-grained material remained in the water column longer due to longer fall times (USACE, 2012)

REFERENCES

Chmelik Sitkin & Davis P.S., 2009. Intergovernmental Framework Agreement Between the Lummi Nation and the Port of Bellingham. Filed for Record on 8/05/2009.

Coast Guard, 2013. Email from Mark Ashley (USCG) to David Kendall (USACE) and Celia Barton (DNR). January 13, 2013.

DMMP *et al*, 2009. OSV Bold Summer 2008 Survey: Final Data Report. Prepared the Dredged Material Management Program, with the assistance of Science Applications International Corporation, Avocet Consulting, and TerraStat Consulting Group. June 25, 2009.

DMMP, 2011. Biennial Report: Dredging Years 2010/2011. Prepared for the Puget Sound dredging Disposal Analysis, Grays Harbor/Willapa Bay Evaluation Procedures, and NW Regioual Sediment Evaluation Framework (WA) by the DMMP agencies. 2011.

DMMP, 2021a. Updates to DMMP Disposal Site Monitoring Triggers in Puget Sound. Clarification Paper prepared by Shannon Soto (WDNR) for the Dredged Material Management Program, June 2021.

DNR, 2011. Nisqually Reach Aquatic Reserve Management Plan. Prepared by the Washington Department of Natural Resources, Aquatic Resources Division, September 2011.

Ecology, 2014. Port Gardner Bay Regional Background Sediment Characterization, Everett, WA. Final Data Evaluation and Summary Report. Publication No. 14-09-339. December 31, 2014.

Ecology, 2015. Bellingham Bay Regional Background Sediment Characterization: Final Data Evaluation and Summary Report. Publication No. 15-09-044. February 2015.

Ecology, 2018. South Puget Sound Regional Background: Final Data Evaluation and Summary Report. Publication no. 18-09-117. May 2018.

Ecology, 2021. Sediment Cleanup User's Manual (SCUM), Guidance for Implementing the Cleanup Provisions of the Sediment Management Standards, Chapter 173-204 WAC, Washington State Department of Ecology, Second Revision December 2021.

Enterprise Services, 2021. Draft Environmental Impact Statement, Capitol Lake – Deschutes Estuary, Long-Term Management Project. June 2021.

Herrera and NewFields, 2016. Dredged Disposal Site Biological Characterization: 2014-2015 Trawl Study at the Anderson/Ketron Island Disposal Site, Pierce County, WA. Prepared for the U.S. Army Corps of Engineers, Seattle District by Herrera Environmental Consultants, Seattle, WA and by NewFields, Edmonds, WA. April 2, 2016.

Integral 2011. Port Angeles, Port Townsend, and Rosario Strait PSDDA Disposal Site ADCP Survey. Data report prepared by Integral Consulting Inc. for the Washington State Department of Natural Resources. November 11, 2011.

Integral 2014. Partial Monitoring at the Elliott Bay Non-Dispersive Unconfined Open-Water Dredged Material Disposal Site. Draft prepared by Integral Consulting Inc. for the Washington State Department of Natural Resources, 2013. Finalized by the DMMP agencies, August 2014.

Michalsen, D.R. 2008. Commencement Bay PSDDA Disposal Site: Historic use, forecasted future mound configuration, and sediment transport potential near the site. U.S. Army Corps of Engineers, Seattle District. Final Memorandum to David Kendall. June 9, 2008.

Nelson, 2006. Evaluation of Future Disposal Mound Configuration for the Commencement Bay PSDDA disposal site. U.S. Army Corps of Engineers, Seattle District. Memorandum for the Record. CENWSEC-DB-CS. 17 February 2006.

NewFields, 2013. 2013 Sediment Profile Imaging Surveys. Commencement Bay and Elliott Bay DMMP Sites. October 21, 2013.

NewFields, 2018. 2017 Tiered-Full Monitoring at the Commencement Bay Non-Dispersive Unconfined Open-Water Dredged Material Disposal Site. Final Data Report. March 2018

NewFields, 2021. 2020 Pilot Study: DMMP Monitoring of the Port Gardner Non-Dispersive Unconfined Open-Water Dredged Material Disposal Site. Final Data Report. July 2021.

PSDDA 1987. Puget Sound sediment deposition analysis: Phase II, Prepared for Puget Sound Dredged Disposal Analysis., Evans Hamilton, Inc., Seattle, WA.

PSDDA 1988a. Final Environmental Impact Statement - Unconfined Open-Water Disposal Sites for Dredged Material, Phase I (Central Puget Sound). Puget Sound Dredged Disposal Analysis Reports Series. Cooperatively published by U.S. Army Corps of Engineers, Seattle, District; U.S. Environmental Protection Agency, Region 10; Washington State Department of Ecology; and Washington State Department of Natural Resources.

PSDDA 1988b. Evaluation Procedures Technical Appendix - Phase I (Central Puget Sound). Puget Sound Dredged Disposal Analysis reports series. Cooperatively published by U.S. Army Corps of Engineers, Seattle District; U.S. Environmental Protection Agency, Region 10; Washington State Department of Ecology; and Washington State Department of Natural Resources.

PSDDA 1988c. Management Plans Technical Appendix - Phase I (Central Puget Sound). Puget Sound Dredged Disposal Analysis reports series. Cooperatively published by U.S. Army Corps of Engineers, Seattle District; U.S. Environmental Protection Agency, Region 10; Washington State Department of Ecology; and Washington State Department of Natural Resources.

PSDDA 1988d. Disposal Site Selection Technical Appendix - Phase I (Central Puget Sound). Puget Sound Dredged Disposal Analysis reports series. Cooperatively published by U.S. Army Corps of Engineers, Seattle District; U.S. Environmental Protection Agency, Region 10; Washington State Department of Ecology; and Washington State Department of Natural Resources.

PSDDA 1989a. Final Environmental Impact Statement - Unconfined Open-water Disposal for Dredged Material, Phase II (North and South Puget Sound). Puget Sound Dredged Disposal Analysis Reports Series. Cooperatively published by U.S. Army Corps of Engineers, Seattle District; U.S. Environmental Protection Agency, Region 10; Washington State Department of Ecology; and Washington State Department of Natural Resources. September 1989.

PSDDA 1989b. Management Plan Report - Unconfined Open Water Disposal of Dredged Material, Phase II (North and South Puget Sound). Puget Sound Dredged Disposal Analysis Reports Series. Cooperatively published by U.S. Army Corps of Engineers, Seattle District; U.S. Environmental Protection Agency, Region 10; Washington State Department of Ecology; and Washington State Department of Natural Resources. September 1989.

PSDDA 1989c. Disposal Site Selection Technical Appendix - Phase II (North and South Puget Sound). Puget Sound Dredged Disposal Analysis reports series. Cooperatively published by U.S. Army Corps of Engineers, Seattle District; U.S. Environmental Protection Agency, Region 10;

Washington State Department of Ecology; and Washington State Department of Natural Resources. September 1989.

PTI 1988. Puget Sound Dredged Disposal Analysis: Baseline Survey of Phase I Disposal Sites. Final Report. Prepared for Washington Department of Ecology by PTI Environmental Services, Bellevue, WA. December 1988.

PTI 1989. Puget Sound Dredged Disposal Analysis: Baseline Survey of Phase II Disposal Sites. Final Report. Prepared for Washington Department of Ecology by PTI Environmental Services, Bellevue, WA. June 1989.

Puget Sound Harbor Safety Committee. 2017. Puget Sound Harbor Safety Plan. Updated and Republished June 2017 (minor links revision 3-1-21).

SAIC 1991a. PSDDA 1990: Crab Density Study in Bellingham Bay. Final Report. Prepared for the Washington State Department of Natural Resources, Olympia, WA, by Science Applications International Corporation, Bothell, WA. April 1991.

SAIC 1991b. PSDDA 1990: Crab Bioaccumulation Survey of Bellingham Bay. Final Report. Prepared for the Washington State Department of Natural Resources, Olympia, WA. Prepared by Science Applications International Corporation, Bothell, WA. April 1991.

SAIC 1991c. PSDDA 1990 Monitoring: Post-Disposal Surveys of Elliott Bay and Port Gardner. Final Report. Prepared for the Washington State Department of Natural Resources, Olympia, WA. Prepared by Science Applications International Corporation, Bothell, WA. August 1991.

SAIC 1991d. PSDDA 1990: Guidelines for the Evaluation of Crab Body Burden Data from Bellingham Bay. Final Report. Prepared for the Washington State Department of Natural Resources, Olympia, WA by Science Applications International Corporation, Bothell, WA. September 1991.

SAIC 1991e. PSDDA 1991 Monitoring Program: Port Gardner Benchmark Station Observations, Tissue Chemistry of Invertebrates from Port Gardner and Bellingham Bay, and Bioaccumulation Guidelines Assessment from Bellingham Bay. Draft Report. Prepared for the Washington State Department of Natural Resources, Olympia, WA. Prepared by Science Applications International Corporation, Bothell, WA. September 1991.

SAIC 1992. 1992 Full Monitoring in Elliott Bay. Draft Report. Prepared for the Washington State Department of Natural Resources, Olympia, WA by Science Applications International Corporation, Bothell, WA. 30 September 1992.

SAIC 1993a. Partial Monitoring in Bellingham Bay. Draft Report. Prepared for the Washington State Department of Natural Resources, Olympia, WA. Prepared by Science Applications International Corporation, Bothell, WA. July 19, 1993.

SAIC 1993b. Partial Monitoring in Bellingham Bay – Strong Acid Digest Analysis of Archived Samples. Prepared for the Washington State Department of Natural Resources, Olympia, WA. Prepared by Science Applications International Corporation, Bothell, WA. September 30, 1993.

SAIC, 1995a. Full Monitoring at the Commencement Bay PSDDA Disposal Site. Submitted to Washington State Department of Natural Resources, Olympia, WA. Submitted by Science Applications International Corporation, Bothell, WA, and Herrera Environmental Consultants, Seattle, WA. September 30, 1995.

SAIC, 1995b. Tiered-Full Monitoring at the Port Gardner PSDDA Disposal Site. Final Report. Submitted to the Washington State Department of Natural Resources, Olympia, WA by Science Applications International Corporation, Bothell, WA. March 29, 1995.

SAIC, 1996. 1996 Partial Monitoring at the Commencement Bay PSDDA Disposal Site. Prepared for the Washington State Department of Natural Resources, Olympia, WA by Science Applications International Corporation, Bothell, WA.

SAIC, 2000. 2000 Full Monitoring at the Elliott Bay PSDDA Disposal Site. Prepared for the Washington State Department of Natural Resources, Olympia, WA, by Science Applications International Corporation, Bothell, WA. December 15, 2000.

SAIC, 2003. 2003 Tiered-Full Monitoring at Commencement Bay, Tacoma, WA. Draft Data Report. Submitted to Washington State Department of Natural Resources, Olympia, WA. Submitted by Science Applications International Corporation, Bothell, WA. November 2003.

SAIC, 2004. 2004 Partial Monitoring at Commencement Bay, Tacoma, WA. Draft Report. Prepared for the Washington State Department of Natural Resources, Olympia, WA. Prepared by Science Applications International Corporation, Bothell, WA. October 22, 2004

SAIC, 2005. 2005 Full Monitoring at the Anderson/Ketron Islands PSDDA Disposal Site. Draft Data Report. Prepared for the Washington State Department of Natural Resources, Olympia, WA. Prepared by Science Applications International Corporation, Bothell, WA. December 29, 2005

SAIC, 2005b. Physical Monitoring and Phenol Study at the Commencement Bay PSDDA Site, Tacoma, Washington. Draft Data Report. Prepared for the Washington State Department of Natural Resources, Olympia, WA by Science Applications International Corporation, Bothell, WA. December 9, 2005

SAIC, 2005c. Contaminant Investigation at the Elliott Bay PSDDA Site, Seattle, Washington. Draft Data Report. Prepared for the Washington State Department of Natural Resources, Olympia, WA by Science Applications International Corporation, Bothell, WA. December 5, 2005.

SAIC, 2006a. 2005 Full Monitoring at the Anderson/Ketron Islands PSDDA Disposal Site. Analysis of Archived Benthic Samples Supplemental Data Report. Prepared for the Washington State Department of Natural Resources, Olympia, WA. Prepared by Science Applications International Corporation, Bothell, WA. August 28, 2006.

SAIC, 2006b. 2005 Full Monitoring at the Anderson/Ketron Islands PSDDA Disposal Site. Dioxin/Furan Analysis of Archived Sediment and Tissues Supplemental Data Report. Prepared for the Washington State Department of Natural Resources, Olympia, WA. Prepared by Science Applications International Corporation, Bothell, WA. September 15, 2006.

SAIC, 2006c. 2006 Full Monitoring at the Port Gardner Non-Dispersive Unconfined Open-Water Dredged Material Disposal Site. Data Report. Submitted to Washington State Department of Natural Resources, Olympia, WA. Submitted by Science Applications International Corporation, Bothell, WA. November 30, 2006.

SAIC 2008b. Dioxin/Furan Concentrations at the Non-Dispersive Open-Water Dredged Material Disposal Sites in Puget Sound. Prepared for the Washington State Department of Natural Resources, Olympia, WA. July 10, 2008.

SAIC, 2008c. 2007 Full Monitoring at the Commencement Bay Non-Dispersive Unconfined Open-Water Dredged Material Disposal Site. Data Report. Submitted to Washington State Department of Natural Resources, Olympia, WA. Submitted by Science Applications International Corporation, Bothell, WA. April 2, 2008.

SAIC, 2009. Reauthorization of Dredged Material Management Program Disposal Site Commencement Bay, Washington. Supplemental Environmental Impact Statement. Prepared for the DMMP agencies. Prepared by Science Applications International Corporation, Bothell, WA. August 2009.

SAIC, 2010. 2010 Tiered-full monitoring at the Port Gardner non-dispersive unconfined open-water dredged material disposal site. Final Data Report. Submitted to the Washington State Department of Natural Resources, Olympia, WA. Submitted by Science Applications International Corporation, Bothell, WA. December 1, 2010.

SEA, 1998. Physical Monitoring of the Commencement Bay PSDDA Dredged Material Disposal Site. December 1998 SVPS Survey. Prepared for the U.S. Army Corps of Engineers, Seattle District. Prepared by Striplin Environmental Associates, Olympia, WA. April 15, 1998.

SEA, 2001. 2001 Full Monitoring in Commencement Bay, Tacoma, WA. Final Data Report. Submitted to Washington State Department of Natural Resources, Olympia, WA by Striplin Environmental Associates, Olympia, WA. November 30, 2001.

SEA, 2002. 2001 Full Monitoring in Commencement Bay, Tacoma, WA. Supplemental Report, Analysis of Benchmark Station Data. Submitted to Washington State Department of Natural Resources, Olympia, WA. Submitted by Striplin Environmental Associates, Olympia, WA. April 26, 2002.

SEA, 2003. 2002 Elliott Bay Monitoring: Bioaccumulative Contaminants of Concern. Final Report. Submitted to Washington State Department of Natural Resources, Olympia, WA by Striplin Environmental Associates, Olympia, WA. July 18, 2003.

USACE, 2012. Dredged Material Management Program: Dispersive Disposal Site Fate and Transport Analysis for Puget Sound, Washington. Prepared by USACE for the Washington State Department of Natural Resources, Olympia, WA. September 2012.

USACE, 2014. Anderson/Ketron PSDDA Disposal Site Fate and Transport Modeling. Design Memorandum. Prepared by Seattle District, U.S. Army Corps of Engineers. September 2014.

Wasson et al., 2007. Management of the Commencement Bay Non-Dispersive Disposal Site. Prepared by Courtney Wasson (DNR), John Hansen (DNR), David Kendall, (Corps), David Fox (Corps), and Jonathan Freedman (EPA) for the DMMP agencies.