

Appendix A

Temporal Benthic Macroinvertebrate Sampling Data



Corophium (mud shrimp: amphipod)



Marine Isopods



Hyperiid Amphipod

Table 10. Taxonomic list of macroinvertebrates collected from the Nooksack estuary.

Phylum Annelida

- Class Polychaeta
 - Order Capitellida
 - Family Capitellidae
 - Capitella* sp. (Fabricius, 1780)
 - Order Eunicida
 - Family Dorvilleidae
 - Order Opheliida
 - Family Opheliidae
 - Armandia brevis* (Moore, 1906)
 - Order Oweniida
 - Family Oweniidae
 - Owenia fusiformis* (Chiaje, 1841)
 - Order Phyllodocida
 - Family Goniadidae
 - Glycinde* sp.
 - Family Hesionidae
 - Family Nephtyidae
 - Nephtys cornuta* (Berkley and Berkley, 1945)
 - Family Nereidae
 - Platynereis bicanaliculata* (Baird, 1863)
 - Nereis* sp.
 - Family Phyllodocidae
 - Family Polynoidae
 - Harmothoe imbricate* (Linnaeus, 1766)
 - Order Sabellida
 - Family Sabellidae
 - Order Spionida
 - Family Spionidae
 - Order Terebellida
 - Family Ampharetidae
 - Hobsonia florida* (Hartman, 1951)
 - Family Terebellidae
- Class Oligochaeta
 - Oligochaetes (Unidentified)

Phylum Arthropoda

- Class Copepoda
 - Order Harpacticoida
 - Harpacticus* sp.
- Class Cirripedia
 - Order Thoracica
 - Balanus* sp.
- Class Malacostraca
 - Order Cumacea
 - Family Nannastacidae
 - Cumella* sp.
 - Order Tanaidacea
 - Family Paratanaidae
 - Leptochelia dubia* (Kröyer, 1842)

Phylum Arthropoda

Class Malacostraca

Order Isopoda

Suborder Asellota

Munna ubiquita (Menzies, 1952)

Suborder Flabellifera

Gnorimosphaeroma sp.

Suborder Valvifera

Iodeta sp.

Order Amphipoda

Superfamily Gammarioidea

Family Anisogammaridae

Eogammarus sp.

Superfamily Corophioidea

Family Corophiidae

Corophium sp.

Suborder Caprellidea

Caprellid (Unidentified)

Class Ostracoda

Suborder Podocopid

Ostracods (Unidentified)

Class Pycnogonida

Order Coleoptera

Family Elmidae

Order Decapoda

Infraorder Anomura

Family Paguridae

Pagurus sp.

Class Insecta

Order Diptera

Family Chironomidae

Phylum Mollusca

Class Gastropoda

Order Archaeogastropoda

Family Trochidae

Margarites marginatus (Dall, 1919)

Order Cephalaspidea

Family Atyidae

Haminaea vesicula (Gould, 1855)

Order Mesogastropoda

Family Cerithidae

Bittium sp.

Family Rissoidae

Alvania carpenteri (Weinkouff, 1885)

Order Neogastropoda

Family Columbellidae

Alia gausapata (Carpenter, 1864)

Family Nassariidae

Nassarius mendicus (Gould, 1849)

Order Patellogastropoda

Family Lottidae

Tectura persona (Rathke, 1833)

Order Pyramidellacea

Family Cyclosteremellidae

Cyclostremella Concordia (Bartsch, 1920)

Phylum Mollusca

Class Gastropoda

Order Pyramidellacea

Family Pyramidellidae

Odostomia sp.

Class Bivalvia

Order Veneroida

Family Cardiidae

Clinocardium nuttallii (Conrad, 1837)

Nemocardium centifilosum (Carpenter, 1864)

Family Lucinidae

Parvilucina tenisculpta (Carpenter, 1854)

Family Montacutidae

Rochefortia tumida (Carpenter, 1864)

Family Tellinidae

Macoma nasuta (Conrad, 1837)

Tellina bodegensis (Hinds, 1845)

Phylum Echinodermata

Class Ophiuroidea

Brittle Star (Unidentified)

Phylum Nematoda

Nematodes (Unidentified)

Phylum Sarcomastigophora

Subphylum Rhizopoda

Order Foraminiferida

Foraminiferans (Unidentified)

Table 11. Benthic macroinvertebrate sampling site descriptions.

Site ID	Habitat Type	Channel Type
L0	Agricultural Floodplain	Tributary
L1	Agricultural Floodplain	Intermittent Distributary
L2	Agricultural Floodplain	Tributary
L3	Agricultural Floodplain	Tributary
L4	Agricultural Floodplain	Relict Tidal
L5	Mud Flat	Offshore
L6	Sand Flat	Tributary
L7	Nearshore	Offshore
L8	Sand Flat	Subtidal Interface
L10	Sand Flat	Offshore
P1	Sand Flat	Offshore
P2	Mud Flat/Eelgrass	Offshore
P3	Nearshore/Mixed Coarse	Offshore
N1	Agricultural Floodplain	Mainstem
N2	Scrub-Shrub	Distributary
N3	Scrub-Shrub	Tributary
N4	Forested Floodplain	Distributary
N5	Forested Floodplain	Tributary
N6	Scrub-Shrub	Mainstem
N7	Forested Floodplain	Distributary Confluence
N8	Salt Marsh	Blind
N9	Salt Marsh	Distributary
N10	Sand Flat	Offshore E. Delta
N11	Sand Flat	Offshore W. Delta

Table 12. Benthic organisms sampled in Lummi Delta and nearshore sites in 2004.

Site ID	Phase I species abundance	Phase II species abundance	Phase III species abundance
L0	2 Chironomidae 1 <i>Hobsonia florida</i>	23 <i>Hobsonia florida</i> 5 Oligochaeta 5 Chironomidae 1 <i>Odostomia</i> sp. 1 <i>Parvilucina tenuisculpta</i>	313 Chironomidae 75 Ostracoda 57 <i>Hobsonia florida</i> 2 Oligochaeta 2 <i>Eogammarus</i> sp. 1 <i>Cyclostremella concordia</i>
L1	5 Arthropoda, unid. 1 Chironomidae	12 <i>Odostomia</i> sp. 10 Unidentified 6 Oligochaeta	21 Chironomidae 2 Unidentified
L2	48 Oligochaeta 2 <i>Eogammarus</i> sp. 1 <i>Hobsonia florida</i> 1 <i>Platynereis bicanaliculata</i> 1 Caprellidea 1 Chironomidae 1 <i>Cumella</i> sp.	n/a Samples Lost	356 Chironomidae 15 <i>Hobsonia florida</i> 2 <i>Capitella</i> sp. 1 <i>Corophium</i> sp. 1 <i>Gnorimosphaeroma</i> sp.
L3	278 <i>Caprellidea</i> 28 <i>Hobsonia florida</i> 2 <i>Sabellidae</i> 1 <i>Corophium</i> sp. 1 <i>Leptochelia dubia</i>	n/a Samples Lost	356 Chironomidae 15 <i>Hobsonia florida</i> 2 <i>Capitella</i> sp. 1 <i>Corophium</i> sp. 1 <i>Gnorimosphaeroma</i> sp.
L4	750 <i>Corophium</i> sp. 127 <i>Hobsonia florida</i> 98 Chironomidae 48 <i>Gnorimosphaeroma</i> sp. 39 <i>Leptochelia dubia</i> 13 Oligochaeta 3 Ostracoda 2 <i>Cumella</i> sp. 2 <i>Eogammarus</i> sp. 1 <i>Rocheffortia tumida</i>	n/a Samples Lost	359 Chironomidae 16 <i>Hobsonia florida</i> 7 Ostracoda 6 Oligochaeta 6 <i>Eogammarus</i> sp. 3 <i>Corophium</i> sp. 2 Nematoda 1 <i>Elmidae</i> 1 <i>Gnorimosphaeroma</i> sp. 1 <i>Munna ubiquita</i> 1 Unidentified

Table 12, continued.

Site ID	Phase I species abundance	Phase II species abundance	Phase III species abundance
L5	76 <i>Corophium</i> sp. 58 Oligochaeta 27 Cirratulidae 11 <i>Gnorimosphaeroma</i> sp. 10 <i>Bittium</i> sp. 8 <i>Owenia fusiformis</i> 5 <i>Glycinde</i> sp. 3 <i>Spionidae</i> 3 Unidentified Polychaetes 2 <i>Cumella</i> sp. 1 <i>Eogammarus</i> sp. 1 <i>Harpacticus</i> sp. 1 <i>Nassarius mendicus</i> 1 <i>Pagurus</i> sp.	20 <i>Spionidae</i> 15 Unidentified Polychaetes 14 Nematoda 11 <i>Bittium</i> sp. 8 <i>Alvania carpenteri</i> 6 <i>Leptochelia dubia</i> 5 <i>Armandia brevis</i> 4 Cirratulidae 3 <i>Gnorimosphaeroma</i> sp. 2 <i>Glycinde</i> sp. 2 Oligochaeta 2 Unidentified 1 <i>Lumbrineridae</i> 1 <i>Nephtys cornuta</i> 1 <i>Eogammarus</i> sp. 1 <i>Margarites marginatus</i>	9 <i>Leptochelia dubia</i> 6 Nematoda 5 <i>Capitella</i> sp. 5 <i>Glycinde</i> sp. 3 <i>Eogammarus</i> sp. 3 <i>Alvania carpenteri</i> 3 <i>Odostomia</i> sp. 3 <i>Rochefortia tumida</i> 2 <i>Owenia fusiformis</i> 2 <i>Platynereis bicanaliculata</i> 2 <i>Spionidae</i> 2 Unidentified Polychaetes 1 <i>Harmothoe imbridata</i> 1 <i>Nephtys cornuta</i> 1 Cirratulidae 1 <i>Cumella</i> sp. 1 <i>Iodeta</i> sp.
L6	627 Cirratulidae 49 <i>Bittium</i> sp. 20 Oligochaeta 13 <i>Pagurus</i> sp. 8 <i>Nassarius mendicus</i> 7 Unidentified 6 <i>Glycinde</i> sp. 6 <i>Spionidae</i> 5 <i>Eogammarus</i> sp. 2 <i>Corophium</i> sp. 2 <i>Rochefortia tumida</i> 1 <i>Haminoea vesicula</i>	84 <i>Corophium</i> sp. 63 Nematoda 21 <i>Capitella</i> sp. 20 Unidentified Polychaetes 9 <i>Cumella</i> sp. 7 <i>Gnorimosphaeroma</i> sp. 5 <i>Glycinde</i> sp. 4 <i>Eogammarus</i> sp. 4 <i>Bittium</i> sp. 4 Unidentified 3 <i>Nassarius mendicus</i> 3 <i>Foraminiferans</i> 2 Cirratulidae 2 <i>Rochefortia tumida</i> 1 <i>Hobsonia florida</i> 1 <i>Spionidae</i> 1 <i>Alvania carpenteri</i> 1 <i>Macoma nastua</i> 1 <i>Pagurus</i> sp.	19 <i>Capitella</i> sp. 16 <i>Bittium</i> sp. 13 Nematoda 6 Oligochaeta 5 <i>Terebellidae</i> 4 <i>Glycinde</i> sp. 4 <i>Nassarius mendicus</i> 2 Cirratulidae 1 <i>Dorvilleidae</i> 1 <i>Nephtys cornuta</i> 1 <i>Spionidae</i> 1 Chironomidae 1 <i>Odostomia</i> sp.

Table 12, continued.

Site ID	Phase I species abundance	Phase II species abundance	Phase III species abundance
L7	28 <i>Rochefortia tumida</i> 28 <i>Tellina bodegensis</i> 8 <i>Alvania carpenteri</i> 6 <i>Corophium</i> sp. 6 <i>Eogammarus</i> sp. 4 <i>Capitella</i> sp. 4 <i>Owenia fusiformis</i> 2 <i>Glycinde</i> sp. 2 <i>Nereis</i> sp. 2 <i>Clinocardium nuttallii</i> 1 <i>Armandia brevis</i> 1 <i>Platynereis bicanaliculata</i> 1 Unidentified Polychaetes 1 <i>Cumella</i> sp. 1 <i>Leptocheilia dubia</i>	991 <i>Capitella</i> sp. 13 Nematoda 10 <i>Nemocardium centifilosum</i> 9 Unidentified Polychaetes 8 <i>Glycinde</i> sp. 2 <i>Nephtys cornuta</i> 2 <i>Spionidae</i> 2 <i>Tellina bodegensis</i> 1 <i>Owenia fusiformis</i> 1 <i>Phyllodocidae</i>	104 <i>Capitella</i> sp. 23 <i>Owenia fusiformis</i> 7 <i>Rochefortia tumida</i> 4 <i>Glycinde</i> sp. 1 <i>Nephtys cornuta</i> 1 Unidentified Polychaetes 1 <i>Cumella</i> sp. 1 <i>Tellina bodegensis</i>
L8	52 <i>Leptocheilia dubia</i> 31 Unidentified Polychaetes 16 <i>Alvania carpenteri</i> 14 <i>Oligochaeta</i> 8 <i>Armandia brevis</i> 5 <i>Eogammarus</i> sp. 5 <i>Nuttallia obscurata</i> 4 <i>Nereis</i> sp. 3 <i>Iodeta</i> sp. 3 Unidentified 3 Ostracoda 2 <i>Glycinde</i> sp. 1 <i>Corophium</i> sp. 1 <i>Haminoea vesicula</i> 1 <i>Odostomia</i> sp.	41 <i>Leptocheilia dubia</i> 25 <i>Alvania carpenteri</i> 15 Unidentified Polychaetes 11 <i>Nereis</i> sp. 10 <i>Odostomia</i> sp. 8 <i>Platynereis bicanaliculata</i> 6 <i>Armandia brevis</i> 5 <i>Eogammarus</i> sp. 3 <i>Rochefortia tumida</i> 2 <i>Terebellidae</i>	36 <i>Capitella</i> sp. 30 <i>Bittium</i> sp. 8 Cirratulidae 8 <i>Balanus</i> sp. 4 Nematoda 3 <i>Rochefortia tumida</i> 3 Unidentified 2 <i>Nemocardium centifilosum</i> 1 <i>Owenia fusiformis</i> 1 <i>Spionidae</i> 1 Unidentified Polychaetes 1 Chironomidae 1 <i>Cumella</i> sp. 1 <i>Macoma nasuta</i> 1 <i>Tellina bodegensis</i>
L10	224 <i>Owenia fusiformis</i> 140 Cirratulidae 30 Unidentified Polychaetes 25 Nematoda 19 <i>Corophium</i> sp. 18 <i>Spionidae</i> 6 <i>Harpacticus</i> sp. 5 <i>Tellina bodegensis</i> 4 <i>Rochefortia tumida</i> 3 <i>Nemocardium centifilosum</i> 2 <i>Nassarius mendicus</i> 1 <i>Glycinde</i> Sp. 1 <i>Margarites marginatus</i>	16 <i>Eogammarus</i> sp. 12 <i>Owenia fusiformis</i> 7 <i>Glycinde</i> sp. 5 <i>Terebellidae</i> 4 <i>Spionidae</i> 4 <i>Nassarius mendicus</i> 3 <i>Macoma nastua</i> 2 <i>Capitella</i> sp. 2 <i>Harmothoe imbridata</i> 1 <i>Bittium</i> sp.	4 <i>Owenia fusiformis</i> 2 <i>Balanus</i> sp. 2 <i>Corophium</i> sp. 2 <i>Iodeta</i> sp. 1 <i>Phyllodocidae</i> 1 <i>Cumella</i> sp. 1 <i>Leptocheilia dubia</i> 1 <i>Rochefortia tumida</i>

Table 13. Benthic organisms sampled in Bellingham Bay delta and nearshore sites in 2004.

Site ID	Phase I species abundance	Phase II species abundance	Phase III species abundance
N1	29 <i>Nematodes</i>	9 Chironomidae 1 Oligochaeta 1 Nematoda	9 Unidentified Polychaetes 4 Chironomidae 1 <i>Iodeta</i> sp.
N2	0 Organisms	3 Chironomidae 1 <i>Harmothoe imbridata</i>	19 Chironomidae 1 Oligochaeta
N3	7 <i>Capitella</i> sp. 2 Chironomidae 1 <i>Carratulidae</i>	13 Oligochaeta 7 Chironomidae 1 <i>Rochefortia tumida</i>	9 Unidentified Polychaetes 4 Chironomidae 1 <i>Iodeta</i> sp.
N4	1 Chironomidae 1 <i>Cumella</i> sp.	6 Chironomidae 1 <i>Corophium</i> sp. 1 <i>Nematodes</i>	15 Chironomidae 8 <i>Corophium</i> sp.
N5	1 Oligochaeta	9 Chironomidae	17 Chironomidae 3 Oligochaeta 1 Nematoda
N6	15 Chironomidae 4 Unidentified Polychaetes	1 Chironomidae	25 Chironomidae 1 <i>Capitella</i> sp. 1 <i>Glycinde</i> sp.
N7	2 Chironomidae 2 <i>Corophium</i> sp.	3 <i>Corophium</i> sp.	0 Organisms
N8	138 Chironomidae 91 Oligochaeta 46 <i>Corophium</i> sp. 12 <i>Hobsonia florida</i> 9 <i>Eogammarus</i> sp. 1 <i>Cumella</i> sp. 1 Nematoda	44 <i>Corophium</i> sp. 20 <i>Hobsonia florida</i> 3 <i>Eogammarus</i> sp. 1 <i>Gnorimosphaeroma</i> sp.	32 <i>Corophium</i> sp. 14 <i>Hobsonia florida</i> 5 Chironomidae 2 Oligochaeta
N9	0 Organisms	0 Organisms	17 <i>Corophium</i> sp. 1 Chironomidae
N10	99 <i>Harpacticus</i> sp. 33 Oligochaeta 27 <i>Corophium</i> sp. 8 Nematoda 7 Unidentified Polychaetes	8 <i>Corophium</i> sp.	70 <i>Eogammarus</i> sp. 26 <i>Corophium</i> sp. 2 <i>Platynereis bicanaliculata</i> 1 <i>Gnorimosphaeroma</i> sp.
N11	350 Nematoda 98 <i>Harpacticus</i> sp. 23 <i>Owenia fusiformis</i> 5 <i>Foraminiferans</i> 3 <i>Tellina bodegensis</i> 2 <i>Glycinde</i> sp. 2 Ostracoda 1 <i>Cumella</i> sp. 1 <i>Parvilucina tenuisculpta</i>	5 <i>Hesionidae</i> 4 Unidentified Polychaetes 2 Nematoda	4 Nematoda 3 <i>Owenia fusiformis</i> 2 <i>Cumella</i> sp. 1 <i>Armandia brevis</i> 1 Cirratulidae 1 Unidentified Polychaetes 1 <i>Corophium</i> sp. 1 <i>Rochefortia tumida</i> 1 <i>Foraminiferans</i>

Table 14. Benthic organisms sampled in Portage Bay sites in 2004.

Site ID	Phase I species abundance	Phase II species abundance	Phase III species abundance
P1	33 <i>Armandia brevis</i> 33 <i>Platynereis bicanaliculata</i> 18 <i>Capitella</i> sp. 9 Nematoda 3 <i>Parvilucina tenuisculpta</i> 3 <i>Foraminiferans</i> 2 <i>Phyllodocidae</i> 2 Oligochaeta 2 Ostracoda 1 <i>Glycinde</i> Sp.	13 <i>Platynereis bicanaliculata</i> 13 <i>Alvania carpenteri</i> 12 <i>Foraminiferans</i> 12 Nematoda 6 Unidentified Polychaetes 5 <i>Littorina scutulata</i> 5 <i>Odostomia</i> sp. 4 <i>Leptochelia dubia</i> 1 <i>Nephtys cornuta</i> 1 <i>Cirratulidae</i> 1 <i>Parvilucina tenuisculpta</i> 1 Ostracoda	164 Cirratulidae 90 Oligochaeta 36 <i>Dorvilleidae</i> 15 <i>Owenia fusiformis</i> 14 Unidentified Polychaetes 7 <i>Glycinde</i> sp. 5 <i>Rochefortia tumida</i> 4 <i>Capitella</i> sp. 4 <i>Nephtys cornuta</i> 3 <i>Harmothoe imbridata</i> 3 <i>Macoma nasuta</i> 3 Nematoda 2 <i>Platynereis bicanaliculata</i> 1 <i>Nereis</i> sp. 1 <i>Cumella</i> sp. 1 <i>Alvania carpenteri</i> 1 <i>Odostomia</i> sp. 1 <i>Tectura persona</i> 1 <i>Tellina bodegensis</i>
P2	187 <i>Foraminiferans</i> 40 <i>Rochefortia tumida</i> 35 Oligochaeta 35 Nematoda 31 Unidentified Polychaetes 29 <i>Margarites marginatus</i> 21 <i>Corophium</i> sp. 20 <i>Cirratulidae</i> 11 <i>Dorvilleidae</i> 10 Ostracoda 4 <i>Armandia brevis</i> 4 <i>Alvania carpenteri</i> 4 <i>Tectura persona</i> 3 <i>Eogammarus</i> sp. 3 Unidentified 2 <i>Harmothoe imbridata</i> 2 <i>Nuttallia obscurata</i> 1 Chironomidae 1 <i>Harpacticus</i> sp. 1 <i>Alia gausapata</i> 1 <i>Tellina bodegensis</i>	15 <i>Armandia brevis</i> 6 <i>Harmothoe imbridata</i> 5 <i>Alia gausapata</i> 3 Unidentified Polychaetes 2 <i>Dorvilleidae</i> 2 Oligochaeta 1 <i>Nereis</i> sp. 1 Chironomidae 1 <i>Cumella</i> sp. 1 <i>Leptochelia dubia</i> 1 <i>Margarites marginatus</i> 1 Unidentified	72 <i>Rochefortia tumida</i> 39 Cirratulidae 10 <i>Harmothoe imbridata</i> 10 <i>Alvania carpenteri</i> 9 Nematoda 8 Unidentified Polychaetes 5 <i>Parvilucina tenuisculpta</i> 4 <i>Hesionidae</i> 4 <i>Leptochelia dubia</i> 4 <i>Alia gausapata</i> 4 <i>Foraminiferans</i> 2 <i>Armandia brevis</i> 2 <i>Dorvilleidae</i> 2 <i>Spionidae</i> 2 <i>Corophium</i> sp. 2 <i>Odostomia</i> sp. 2 <i>Tellina bodegensis</i> 1 <i>Owenia fusiformis</i> 1 <i>Platynereis bicanaliculata</i> 1 <i>Cumella</i> sp. 1 <i>Harpacticus</i> sp. 1 <i>Iodeta</i> sp.

Table 14, continued.

Site ID	Phase I species abundance	Phase II species abundance	Phase III species abundance
P3	232 <i>Foraminiferans</i>	13 <i>Rochefortia tumida</i>	164 Cirratulidae
	75 <i>Rochefortia tumida</i>	7 Cirratulidae	90 Oligochaeta
	58 Unidentified Polychaetes	6 <i>Harmothoe imbridata</i>	36 <i>Dorvilleidae</i>
	28 <i>Oligochaeta</i>	6 Unidentified Polychaetes	15 <i>Owenia fusiformis</i>
	20 <i>Dorvilleidae</i>	2 <i>Dorvilleidae</i>	14 Unidentified Polychaetes
	17 <i>Hesionidae</i>	2 <i>Margarites marginatus</i>	7 <i>Glycinde</i> sp.
	16 <i>Cirratulidae</i>	1 Oligochaeta	5 <i>Rochefortia tumida</i>
	16 Nematoda	1 <i>Leptochelia dubia</i>	4 <i>Capitella</i> sp.
	13 Ostracoda	1 Ostracoda	4 <i>Nephtys cornuta</i>
	9 Unidentified		3 <i>Harmothoe imbridata</i>
	4 <i>Platynereis bicanaliculata</i>		3 <i>Macoma nasuta</i>
	4 <i>Nuttallia obscurata</i>		3 Nematoda
	3 <i>Harpacticus</i> sp.		2 <i>Platynereis bicanaliculata</i>
	3 <i>Alia gausapata</i>		1 <i>Nereis</i> sp.
	3 <i>Alvania carpenteri</i>		1 <i>Cumella</i> sp.
	2 <i>Leptochelia dubia</i>		1 <i>Alvania carpenteri</i>
	1 <i>Harmothoe imbridata</i>		1 <i>Odostomia</i> sp.
	1 <i>Nephtys cornuts</i>		1 <i>Tectura persona</i>
	1 <i>Cumella</i> sp.		1 <i>Tellina bodegensis</i>
	1 <i>Munna ubiquita</i>		

Appendix B

Lummi Delta Soil Salinity Assessment

The influence of salt water on delta landscapes may not be limited to direct contact with or inundation by brackish or salt water. Soil salinity may also be influenced through tidal prism percolation into groundwater. To assess potential presence of salt in the delta landscapes through groundwater mixing with, groundwater in the Lummi Delta was seasonally tested for temperature and salinity. Summer testing commenced when low tides on the delta were observed, between June and August 2003. Winter testing commenced during high tides on the Lummi Delta, December 2003 through January 2004. The objectives of measuring groundwater near the Lummi Delta were threefold: 1) to test for marine influence on existing groundwater quality, 2) to establish baseline data to assist planning restoration projects in the initial stages, and to 3) accommodate monitoring efforts post-restoration.

METHODS

Groundwater samples were obtained at sampling sites (Figure 91) by digging a 0.5-foot diameter pit using a post-hole digger until groundwater depth at the bottom of the hole was deep enough to submerge the measuring probe of a YSI-30 salinometer. Equipment limitations prevented sampling groundwater at depths below 6.5 feet. Pits were usually adjacent to irrigation and drainage ditches; at those sites near ditches holding water, the water quality of the ditches was also measured. After sampling water quality, pits were filled back in to prevent rainwater intrusion from skewing groundwater chemistry. Winter conditions were measured in pits that were dug adjacent to the summer pits. Both pit depth and water depth were recorded, for later groundwater depth comparisons. Salinity and temperature were recorded, in addition to tide information.

RESULTS

Summer sampling conditions were hot and dry, and coincided with seasonal low tides. Mean pit depth was 3.3 feet. The maximum depth to reach groundwater was 6.4 feet. Fourteen pit sites were dry 6.5 feet below the surface, and data were not recorded there. Summer water quality trends in the area describe low salinity and moderate temperatures in the groundwater, often six feet below the surface (Figure 92). However, there were outlier sites that measured more than 15 ppt salinity, located within parcels that were actively farmed in 2003 and 2004.

Each site was revisited and sampled during the following winter. Winter sampling conditions were cold and wet; daytime tides were high. At this time, sites were often inundated with standing surface water. The winter samples yielded results that were not comparable to summer data, due to surface water covering most test sites. Salinity recorded during winter conditions was highly variable, likely due to the influence freshwater rain had on the surface water samples. Standing water at sites precluded digging pits, as surface water would have filled the pits, diluting groundwater samples below the surface. Water quality data was collected from surface water standing at these sites.



Figure 91. Groundwater sampling sites in the Lummi Delta. The basemap is an aerial photo series flown in March, 2004.

CONCLUSIONS

In areas registering high salinity groundwater, it is possible that historic tidal inundation that flooded and evaporated left behind salts that compacted into soil layers as floodplain land use changed with development. The high salinity of the groundwater did not seem to adversely affect crops grown in the vicinity of these sites.

From the sites that were not affected by standing water, data collected describe conditions that were very low in salinity. One site had groundwater salinity above 5 ppt; the others that were measured had very low salinities, mostly below 1.0 ppt. Trends in the comparison of valid summer and winter data were random. Sites that were high in the summer were not necessarily high in the winter, and vice versa. The winter site with the highest concentration (6.5 ppt) had a summer concentration of 0.6 ppt; the summer site with the highest concentration (21.6 ppt) had a winter concentration of 0.3 ppt. Because those winter sites not inundated with standing water still registered low salinities, and several summer sites registered high salinities during negative tides, we conclude that surface hydrology has a greater effect on groundwater salinity than tidal hydrology. In addition, it is important to note that areas of Lummi Delta groundwater reflect high

salinities, under the influence of working tidegates meant to keep saline water out of the agricultural floodplain.

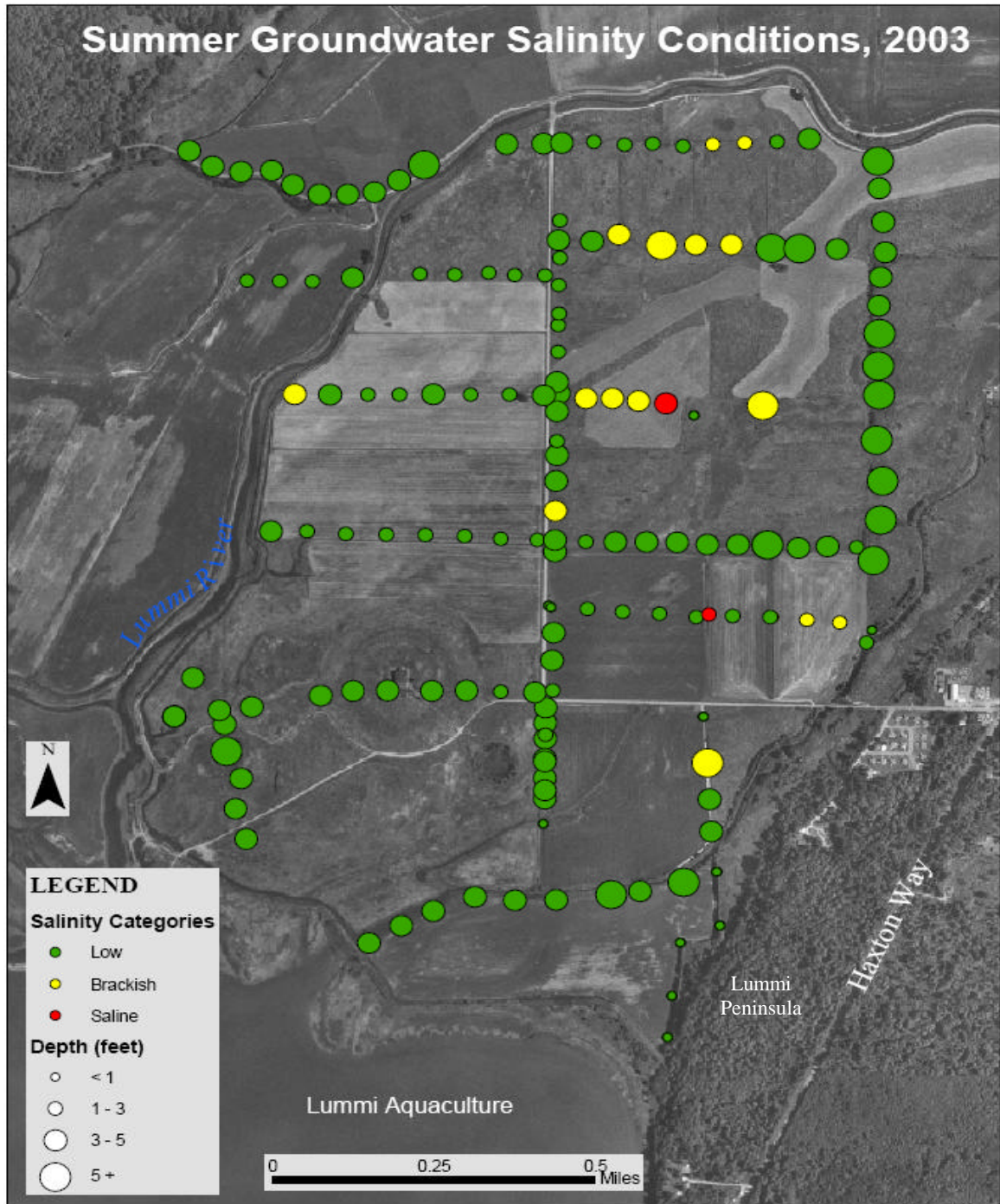


Figure 92. Groundwater salinity data by concentration and depth for sites sampled in 2003.