BC SPARTINA TREATMENT PLAN

2022 UPDATE

B.C. SPARTINA Working Group

protecting our shorelines

Prepared by:

Richard Topp & Matt Christensen
Ducks Unlimited Canada

and

Becky Brown
Ministry of Forests

On Behalf Of

The British Columbia Spartina Working Group

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BACKGROUND

Spartina species (*anglica, alterniflora, densiflora, patens*) are invasive aquatic intertidal cord grasses on the Pacific Coast of Canada that modify natural tidal mudflats. Over a relatively short period of time (measured in years), these naturally sloping areas can be transformed into elevated Spartina meadows with a steep seaward edge. As a result, water circulation patterns change (increasing the risk of flooding), mudflats are converted into monotypic grass stands (resulting in loss of migratory bird and salmon habitat, as well as loss of economically important shellfish) and navigation channels may be altered. Since the 1980's, Spartina plants have expanded northward from the United States of California, Oregon and Washington. The BC Spartina Working Group (BC SWG) formed in 2004 to employ early detection and rapid response methods to eradicate Spartina. The BC SWG includes members of government and non-government organizations representing a diversity of responsibilities including environment, migratory birds, habitat restoration, and public use. The province's contributions in funding, technical expertise, and leadership are an integral part of the BC SWG and the accomplishments of the Spartina Early Detection and Rapid Response Program. Furthermore, the Province of BC has been instrumental in establishing the federal and provincial permits and registrations necessary for aquatic herbicide to be used as part of an integrated pest management approach. The team also liaises with San Francisco Estuary Spartina Project and the Washington State Department of Agriculture, which are two U.S. agencies involved in Spartina eradication along the Pacific Coast.

The B.C. Government has been a key annual funding source towards these efforts since 2005. Three out of four known Spartina species are present in BC, *Spartina anglica*, *Spartina densiflora*, and *Spartina patens*. The fourth species, *Spartina alterniflora*, is yet to be found in BC, but it remains a target species of the BC SWG in case it appears. To date, Spartina species cover approximately 50 ha spread over 663 ha. In BC, *S. anglica* is present in Boundary Bay and Robert's Bank extending to the Tsawwassen Ferry Terminal intercauseway.in the Lower Mainland. *S. anglica* poses significant threat to the intertidal zone due to its rapid growth rate and ability to establish lower in the intertidal zone, displacing important mudflat habitat. *S. patens* is found in both Burrard Inlet (east of second narrows bridge in the Maplewood Flats conservation area, Pacific Coast Terminals, and Old Mill Park in Port Moody) and in Baynes' Sound primarily around Courtenay/Comox harbour. *S. patens* is limited to the high salt marsh region of the intertidal zone, but still poses a significant threat due to its mat-like growth which can displace native vegetation in the high salt marsh. *S. densiflora* is found throughout Baynes' Sound from Courtenay/Comox Harbour to Ship's Point on Vancouver Island, on Sandy Island and the Seal Islets, and on Denman and Hornby Islands. *S. densiflora* is found in the high salt marsh and cobble beach areas of the foreshore.

From 2003 to 2012, Spartina control work in BC, led by the BC SWG, only used digging and excavation to control *S. anglica* and was unsuccessful in achieving containment of the species. In 2010 the BC Spartina Working Group formed a small sub-group, the herbicide technical committee to begin working with staff from provincial and federal Canadian agencies to determine the requirements and process to use herbicide as a means of control on Spartina in BC. The sub-group reviewed ecological impacts and best management information based on the success of using two herbicides to control Spartina in the United States (Washington, Oregon and California). Based on the Spartina control progress achieved by United States partners, the severity of the threat of Spartina and an inability to achieve containment after over a decade of digging, it was decided that herbicide treatment would be required as part of an integrated pest management approach to contain and eradicate Spartina from BC's shores. The subgroup determined that BC would require Emergency Use Registrations (EUR) of the herbicides with Health Canada's Pest Management Regulatory Agency (PMRA) as well as Pesticide Use Permits (PUP) from the BC Ministry of Environment (ENV). Since that time three Pesticide Use Permits (PUP) have been granted to control invasive Spartina species on BC's coast since 2013. Plant population levels, for *S. anglica*, peaked in 2016 with over

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23,000 plants spread over 970 hectares with an estimated leaf area of 1.6 hectares. Since then, the population has been reduced to approximately 3800 plants spread over 384 hectares with an estimated leaf area of 0.2 hectares as a result of integrating herbicide treatments.

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SPARTINA SPECIES OVERVIEW

Table 1 Spartina Species Ecology and Status in BC 2021

***Spartina* Species**	***S. anglica* (English cordgrass)**	***S. densiflora* (dense flowered cordgrass)**	***S. patens* (salt meadow cordgrass)**
Location in BC	Boundary Bay & Robert's Bank	Denman Island, Hornby Island, Sandy Island and the Seal Islets, East Coast of Vancouver Island (Baynes Sound)	Burrard Inlet, Denman Island, Hornby Island, Sandy Island and the Seal Islets, East Coast of Vancouver Island (Baynes Sound) Primarily Comox Estuary,
Tidal Range	High marsh zone to intertidal mudflat	High marsh to mid-intertidal;	High marsh zone
Growth Pattern	Seedlings expand via rhizomes to form circular clones	Grows in tufts and expand via rhizomes	Mat forming and expand via rhizomes
Leaf Area (ha)	0.21	0.01	4.91
Abundance (# of plants)	3844	1633	618
Impacted Area (ha)	384	153	162
Distribution	Several well - spaced patches or clumps of species, and several sporadically occurring individuals	Several well - spaced patches or clumps of species and several sporadically occurring individuals or clumps of species	Continuous dense occurrence of a species and A few patches or clumps of a species

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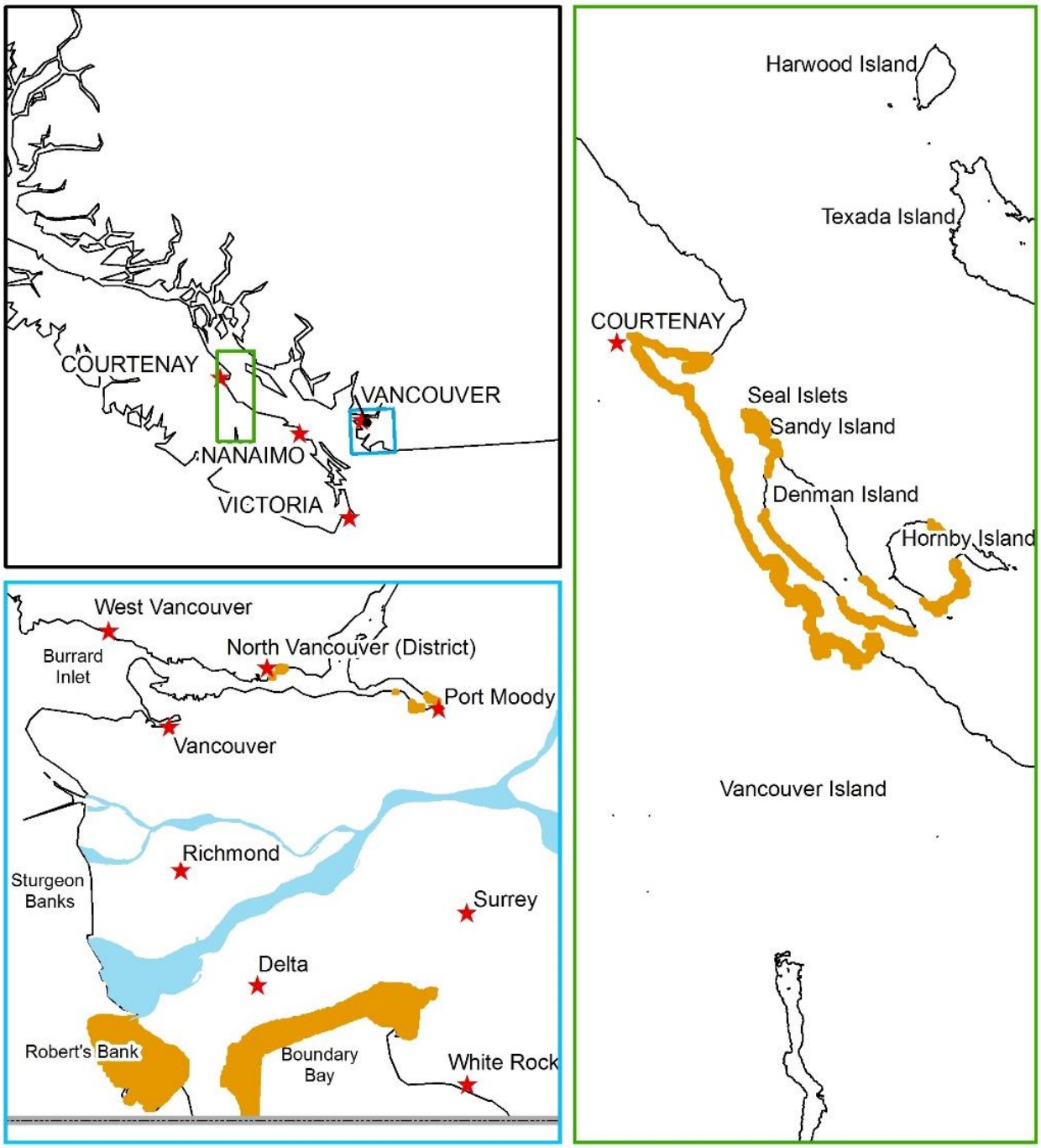

Figure 1 General location where Spartina is found throughout British Columbia. Blue represents the Lower Mainland and green represents Baynes' Sound. The approximate distribution of Spartina is shown in orange.

CONTROL PROGRAM ACCOMPLISHMENTS

We have seen several successes in the treatment of Spartina species within BC since the implementation of herbicide within the integrated pest management approach. The abundance of all species of Spartina has dropped from over 30,000 plant individuals to approximately 6100 between 2016 and 2021. Total impacted area by Spartina species has been reduced from approximately 1400 ha to just under 700 ha in the same time period.

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The abundance of *S. anglica* infestations have reduced by approximately 80% since peak levels in 2016. Likewise, the extent of the *S. anglica* population has dropped from over 970 ha at its peak to under 350 ha presently. The estimated leaf area of *S. anglica* was calculated as 1.64 ha at its highest levels which has now dropped to just 0.21 ha at present.

S. densiflora has responded well to repeated manual and mechanical removal with abundance dropping by approximately 88% since 2015. The extent of the S. densiflora population has been cut in half from its peak of around 300 ha to 150 ha at present.

Non-herbicide control methods on *S. patens* have had very limited effectiveness and full treatment of the known *S. patens* population in BC has yet to be achieved. However, the treatments that have occurred on parts of the *S. patens* population have been successful. Jáji7em and Kw'ulh Marine Park (a.k.a. Sandy Island Marine Park) was treated in 2019 and saw an 80% reduction in estimated leaf area. Similar results were seen after two successive years of treatment at the Maplewood Flats conservation area in 2019 and 2020 where leaf area dropped by 85%. Treatment of the *S. patens* in 2021 focused on limiting the extent of the population, specifically in the Baynes' Sound region on Vancouver Island. Hornby Island was treated for the first time in the projects history and Sandy Island received its second year of treatment as treatment was missed in the 2020 season. The remaining *S. patens* population on the mainland of Vancouver Island South of Royston Wrecks was treated with the goal of limiting the population extent to the Courtenay/Comox harbour where the majority of *S. patens* remains.

TREATMENT HISTORY

Between 2003 and 2013, the BC *Spartina* Working Group (BC SWG) focused on the use of mechanical means to control *Spartina*. Building on previous work from Washington State, BC partners have used and/or evaluated the following non-herbicide control techniques: digging by hand, digging by excavator, seed head clipping, and covering (with geotextile, plastic sheeting and combinations of both). Due to high costs, the inability to achieve containment, and consideration for unintended impacts of non-herbicide methods, in 2010 the BC SWG began pursuing herbicide treatments to control Spartina in BC. In 2013, the BC SWG introduced chemical treatment as part of an integrated pest management plan.

While herbicide treatments were successfully being used to gain a foothold on containing and reducing *S. anglica* populations, non-herbicide methods continued to be explored for controlling *S. patens* and *S. densiflora* until 2019. *S. densiflora* has responded well to repeated removals by hand and excavator. For *S. patens*, these efforts have included several iterations of shade trials and digging, both by hand and with an excavator with limited success (see Figure 2). The results were low efficacy in *S. patens* control or significantly altered shoreline habitat or both. Herbicide treatments in Burrard Inlet have been extremely successful in reducing *S. patens* with native vegetation returning to previous *S. patens* locations within 1-2 years. Therefore, the BC SWG will use herbicide as the primary removal method into 2022 and beyond.

Table 2. Management Tool Cost, Timing and Location

Management Tool	Target Species	Estimated Cost per Hectare[1]	Timing	Location
Digging – by hand	*S. densiflora*	$123,000–$247,000/ha	Year Round Primary emphasis on Fall (September – November) & Winter removals (January – March)	East Coast Vancouver Island, Sandy Island and Seal Islets, Denman Island, Hornby Island
Herbicide – backpack sprayer or hand pump sprayer	*S. anglica* *S. patens*	$11,000 / ha	May – November Annually	Lower Mainland, East Coast of Vancouver Island, Sandy Island & the Seal Islets, Denman Island and Hornby Island

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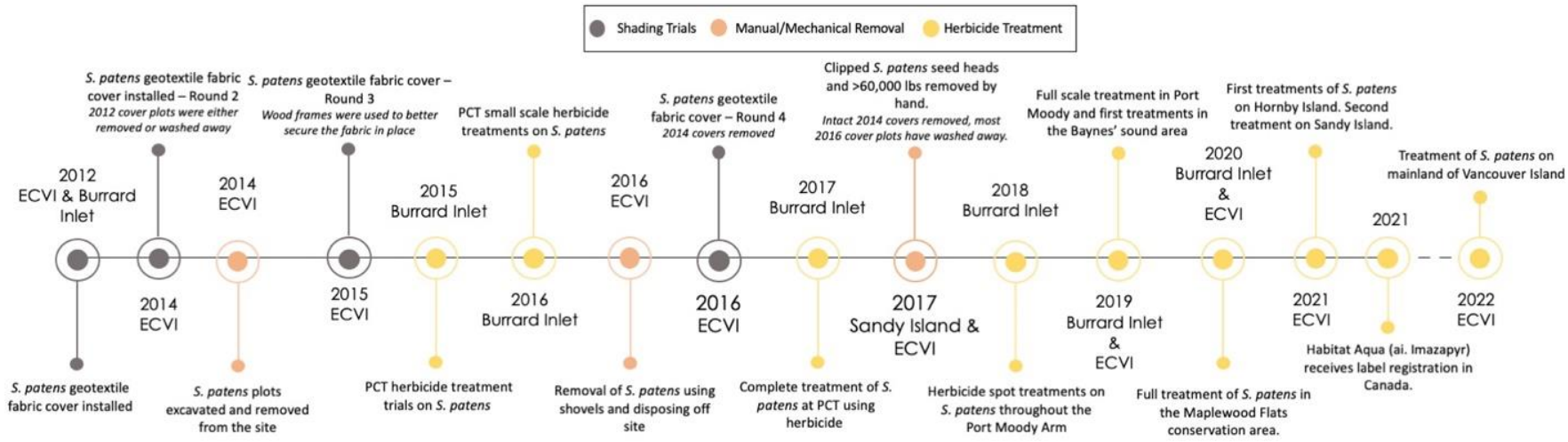

Figure 2 *S. patens* control since 2012. Grey represents shading trials, orange represents manual/mechanical removals and yellow represents herbicide treatments.

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TREATMENT METHODS AND TIMING

The BC SWG will continue to use an integrated approach of both manual and herbicide techniques based on the successes of each treatment methods for each species.

METHODS

MANUAL/EXCAVATOR REMOVALS

Manual techniques (e.g. digging) on *S. anglica* will occur on individual seedlings in areas where a minimum of 4 hour drying time cannot be obtained. Annual mapping has shown a decrease in recruitment of smaller size classes likely as result of both large plants being treated with herbicide thereby limiting seed production and manual removal of seedlings that are produced.

S. densiflora mapping and control activities noted a sizeable increase in abundance up to 2012-2013. However, since implementing dedicated manual/mechanical control measures populations have been significantly reduced in size. All plants that are detected are removed every year in late summer/early fall.

S. patens removal should only be undertaken in areas where a minimum of 4 hour drying time cannot be obtained. *S. patens* is predominantly found in the high salt marsh surrounded by native plants making it hard to determine the edge and if the entire plant has been removed. Small plants can be hard to distinguish among other salt marsh grasses; herbicide will minimize the disturbance area and foster faster re-introduction of native plants into treated areas.

Given the success in reducing plant size and population abundance of *S. densiflora* in recent years removals will continue to be managed by hand digging. *S. patens* removal by hand or excavator is not recommended due to concerns for altering shoreline topography and virtually no success in eradicating the plant.

HERBICIDE CONTROL

Herbicide control will be used as the primary means of control for *S. anglica* and *S. patens*. *S. anglica* is most commonly found in the lower intertidal region where native vegetation is scarce making it easy to spot and target. *S. patens* is predominantly found in the upper intertidal among native vegetation. Herbicide treatment is more precise than digging and the salt marsh begins returning to native plants faster than after shading or digging control methods. Herbicide treatment on *S. densiflora* is recommended as a secondary treatment option if manual control becomes ineffective at controlling the current population.

HERBICIDE SELECTION

A review of the herbicides used to eradicate *Spartina* in the US Pacific Coast jurisdictions revealed that the combined application of active ingredients imazapyr and glyphosate maximized efficacy in controlling *Spartina*. The BC SWG has elected to use only imazapyr to minimize the quantity and volume of pesticide being used while still achieving control and population reduction. This decision was further supported by the results of Spartina herbicide treatment efficacy trials between 2013 and 2015. The BC SWG found that glyphosate did not achieve significant control at the study site to justify including it in the tank mix for Spartina herbicide treatments. To date in BC, we have only used imazapyr in an operational capacity with application rates matching those used in Washington State and San Francisco (Table 3). Habitat P.C.P. # 30841 was the herbicide product used in association

with the annual Emergency Use Registration granted to the Province of B.C. by the Health Canada's Pest Management Regulatory Agency (PMRA) for the purposes of Spartina control from 2016 to 2021. Aquatic herbicide Habitat Aqua P.C.P. # 32374 received full registration in Canada in winter 2021 and is now the herbicide used to control invasive Spartina species in B.C.

Table 3 Herbicide Formulation Used in Washington and California (Leson and Associates, 2005)

	Spray Volume	Formulation	Active Ingredient	Surfactant	Colorant
Imazapyr P.C.P. # 30841	934 L/ha	0.52-0.75% solution (.56 - .75 L/100L)	1.12 - 1.68 kg a.e./ha	0.5% v/v Ag Surf II (0.5 L/ 100 L)	8.2 L/378 L

SURFACTANT SELECTION

Similar to the protocol used in Washington State and California, a surfactant will be added to improve the ability of the herbicide to bind to *Spartina*. The Integrated *Spartina* Program in San Francisco completed an environmental assessment of the impact of imazapyr on the water quality, biological resources, and human health and safety (Leson & Associates, 2005). A review of potential surfactants considered in the United States indicates Agridex has the least impact on fish and other biological resources. However, in Canada this and related surfactants are not registered. The PMRA Environmental Review Panel conducted an ecotoxicology review of suitable surfactants resulting in the recommendation of Ag-Surf II by IPCO as the most appropriate surfactant to use in combination with Habitat Aqua for Spartina herbicide treatments. Ag-Surf II P.C.P. # 30071 is the product used in association with herbicide Habitat Aqua for the Spartina control program.

HERBICIDE APPLICATION

Herbicide will be applied through ground-based direct application using pressurized hand pump backpack sprayers. Application will be conducted by applicators with certificates in the Industrial Vegetation and Noxious Weed category. Drift will be minimized by shrouding and using low drift nozzle and pressure configurations. Herbicide will not be applied without wind shrouds when winds are in excess of 8 km/h and will not be applied at all when winds are in excess of 20 km/h or when inversion conditions exist, or when wind could carry spray drift into inhabited areas and sensitive areas. All equipment will be properly calibrated prior to use. Application will occur on a low or receding tide when practical and will allow for a minimum 4-hour post treatment drying window from tides and rain. Following initial herbicide treatment, treatment areas will be re-visited to identify and flag missed plants that were not treated. Missed plants will include plants not yet emerged, plants too small for adequate herbicide uptake (e.g. less than 12" high) or overlooked due to human error.

TRAINING

The BC Spartina Working Group will prepare a training program for herbicide treatment. The training will be provided by the hired contractor principle and/or crew supervisor. A field season planning meeting will occur in May/June to complete the detailed coordination of herbicide treatment crews, follow up crews, and monitoring with regards to herbicide application. The Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD) Invasive Plant Program will coordinate with Ducks Unlimited Canada to directly contract and oversee the herbicide treatment crews.

APPLICATION RATES AND QUANTITIES

Assuming herbicide is required on all Spartina sites in 2022, the maximum annual herbicide requirement will be 350 litres of Habitat Aqua. See Table 4 for the break down by PUP. Habitat Aqua herbicide will be calibrated to

between 0.52% - 0.75% concentration in the spray mixture. Ag-Surf II will be calibrated to a 0.5% concentration in the spray mixture

Table 4 Proposed Herbicide Requirement to treat all Spartina in all Locations

	Trade Name	Active Ingredient (a.i.)	Product P.C.P. #.	Hectares (ha)	Application Rate (litres of product/ ha)	Maximum Total Amount Herbicide to be used per year (L)
Lower Mainland	Habitat Aqua	Imazapyr	32374	10	4.67-7.0	47-70
	IPCO Ag-Surf II	Alcohol ethoxylate	30071	10	4.67	47
Baynes' Sound	Habitat Aqua	Imazapyr	32374	40	4.67-7.0	187-280
	IPCO Ag-Surf II	Alcohol ethoxylate	30071	40	4.67	187

TREATMENT LOCATIONS

The specific location of Spartina treatment sites will not be known until the mapping is completed at the end of June 2022, however the mapping in previous years provides a good indication of sites for *S. anglica, S. patens, and S. densiflora* treatment in 2022 (see Appendix 1) which will focus mainly on the intertidal areas within approximately 1200m of the dike in the Boundary Bay and Roberts Bank area. For the Lower Mainland, *S. patens* treatment will be focused on any remaining patches in Port Moody Arm and treatment at the Maplewood Flats Conservation Area. In Baynes' Sound, *S. patens* herbicide treatment will target satellite populations first, such as those on Sandy Island and Hornby Island, to ensure the containment boundary is maintained before moving into the Comox estuary where the majority of *S. patens* on Vancouver Island is found. Final specific locations and timing will be dependent on input from local stakeholders including: local governments, First Nations, local stewardship groups, landowners and the aquaculture industry.

TIMING

Specific timing of the application will be dependent on weather, low tides, location of plant in tidal zone, applicator availability and plant development as outlined in (Table 5).

Table 5 Timing of Herbicide Treatments for Spartina Plants (adapted from Patten and Milne 2009)

Plant type/site	May – August	September - November
Spartina likely to go to seed	These should be a spray priority; at least two search and spray events should be done at sites that went to seed in previous year	
Spartina low in the mudflat	Best window during lowest tides	
Spartina high in the salt marsh	First to spray since it will be the tallest first	Last to spray since most visible and maybe only plants with good canopy left
All *Spartina*	Plants should ideally be at least 12 to 20” high before treatment	

To achieve a high control of Spartina, the following procedures based on Patten and Milne 2009 will be undertaken:

1. Treatment areas will be clearly marked so treatment crews do not need to search and identify Spartina and can focus on systematic treatment of the clones. In areas where Spartina density is extremely high, treatment lanes ranging 1 to 3 meters wide will be delineated with flags to guide applicators and ensure systematic treatment of an area.
2. Treatment crews will be certified and follow a training period that will include training session provided by the hired contractor principle and/or crew supervisor.
3. Treatment crews make multiple passes throughout the treatment season (June to November) to treat new or missed plants.
4. Individual members of the treatment crew will be rotated among areas to avoid habituation to each area and alternate the direction of travel
5. A separate follow up team will follow the treatment crew to provide feedback to individual members of the treatment crew on Spartina plants missed. The follow up team will flag any *Spartina* plant that lacked spray dye or had poor coverage of dye over the entire canopy. This can be done after the tide is no longer suitable for spraying, yet still low enough to find *Spartina*.
6. Each site needs to be visited three or more-times per season. A site no longer-has to be visited that year if no untreated plants are found during each of three consecutive searches. For any site in which untreated plants are found, the search sequence must be reset to zero and three more visits should be employed.

HERBICIDE HANDLING, SPILL PREVENTION AND SPILL RESPONSE

HERBICIDE USE

- All herbicides shall be applied by or under the direct supervision of trained, certified or licensed applicators and in accordance with the product label and pesticide use permit associated with the project
- On-site mixing and filling operations shall be confined to areas appropriately bermed or otherwise protected to minimize and contain spread or dispersion of spilled herbicide or surfactant into surface waters

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HERBICIDE STORAGE

Proper herbicide storage is one of the keys to using herbicides safely. Always wear rubber gloves when handling herbicides in storage, and review product labels for specific storage instructions.

General rules for herbicide storage include:

- Keep all herbicides in their original containers.
- Store herbicides in a locked shelter away from children and animals.
- Store herbicides in a dry cool and well- ventilated area.
- DO NOT subject herbicides to freezing or extremely high temperatures.
- Store herbicides separately from seed, fertilizer, insecticides and food.
- Make periodic inspections of storage facilities and storage containers. Check for possible leaks, spills and other similar problems.
- Keep appropriate absorbent material in the storage area at all times as well as a plastic container for storing damaged material.
- Reject any broken or leaking containers when herbicides are delivered.
- Do not store herbicides in office or break areas where employees congregate.

CONTAINER DISPOSAL

Empty herbicide containers must be disposed of according to government regulations or returned to the manufacturer for disposal. Empty containers not returned to the manufacturer can be handled according to the procedures below, as long as local, provincial and federal laws are followed:

- Triple rinse containers with water. Always pour the rinse-water into an appropriate receptacle.
- Rinsed containers should be disposed of in a landfill approved for pesticide disposal or in accordance with applicable government procedures. Check with your supervisor to find out if and when herbicide containers may be handled in this manner.

SPILL RESPONSE

Under all circumstances, it is the responsibility of the applicator to assure that all precautions are taken prior to initiating work to assure protection of water quality and the environment. The applicator is also responsible for the provision of a Spill Response Kit that is appropriate for the work being undertaken.

The following procedures should be followed in the case of a non-petroleum chemical spill:

- Put on protective gloves, eyewear, a long-sleeved shirt and pants before cleanup
- If a container is leaking, immediately transfer the remaining herbicide to another appropriate container to prevent further spillage
- If the herbicide was spilled on a person, remove the contaminated clothing and rinse the product from the body. If necessary, perform appropriate first aid.
- Cover the spill area with an absorbent material to soak up the herbicide. Common cat litter, sawdust, soil or sand can all be used for this purpose. Consult the manufacturer for more specific clean up recommendations.
- Remove any contaminated items from the spill area to prevent further contamination
- Remove the absorbent material with a broom and or shovel after the spill has been absorbed. Make sure all contaminated soil is removed from the spill area as well.
- Place the contaminated soil and absorbent material into a suitable container, and dispose of the container in an approved landfill area
- ***Do not wash down the area with water*** using a high-pressure hose. You may spread the spill and make the herbicide more difficult to contain and clean up.
- When a spill occurs on a site or is large enough that you need help to contain of clean it up, contact a supervisor immediately. In case of a major spill, call the manufacturer or Emergency Management BC 1-800-663-3456.

SPILL RESPONSE KIT

A Spill Response Kit should be provided at the work site and be immediately accessible to all personnel. Some or all of the following items may be included in a Spill Response Kit.

Consider site-specific conditions and the chemicals to be used to determine which of the following items are appropriate**.**

- PVC Gloves or equivalent (to mid forearm)
- Half-face respirator equipped with approved pesticide cartridge
- PVC boots or equivalent
- Chemical resistant splash goggles

PETROLEUM FUEL SPILL PREVENTION AND RESPONSE

Spills of gasoline or other petroleum products, required for operation of motorized equipment, into or near open water could degrade water quality, with potential for toxicity of contaminant bioaccumulation. Several types of equipment used for treatment of

Spartina may present opportunities for petroleum spills. Equipment used in *Spartina* control activities include:

- Air boats and outboard motor boats
- Offroad Vehicles (ATV, Side-by-Side, Amphibious Vehicles)

FUELING

Fueling of land-based excavators should be done offsite at fueling stations or suitable staging areas. A suitable staging area shall be equipped with sufficient protection to prohibit a petroleum spill from migrating beyond the immediate fueling area (e.g., an impermeable plastic tarp set between raised berms, a catch basin or similar portable device).

Water-based excavators, airboats and outboard motor boats shall be fueled offsite at commercial fueling stations or designated locations such as equipment maintenance yards. When fueling is done on or adjacent to treatment sites, a spill prevention and response plan must be prepared and implemented.

Gas powered, hand held machinery *(e.g., brushcutters)* shall be refueled on a non-absorbent tarp or mat placed under machinery to catch any spills. In addition to spills during refueling operations, small amounts of oil or fuel may leak from improperly maintained equipment. Before using any equipment in the marsh, check to make sure that it is in good working order with no signs of leakage or corrosion that might indicate the potential for inadvertent spills on the work site. Transport vessels and vehicles, and other equipment (e.g., mower, pumps, etc.) shall not be serviced or fueled in the field except under emergency conditions.

Under all circumstances, it is the responsibility of the applicator to assure that all precautions are taken prior to initiating work to assure protection of water quality and the environment. The applicator is also responsible for the provision of a Spill Response Kit that is appropriate for the work being undertaken.

- Vice grip pliers
- Phillips head screwdriver (2)
- Shovels
- Brooms, dustpan
- Clay granules or a sawdust
- Activated charcoal or other appropriate absorbent material
- Tyvek coveralls (2 pair) or neoprene coveralls
- First aid kit
- Recovery drums
- DOT triangular reflector kit
- Source of clean water and soap
- In the case of refueling or mixing activities planned on open mudflats the spill response kit should include a portable wet vacuum or other pumping equipment

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PREVENTING SPILLS

The following procedures will help to minimize the risk of spills occurring:

- Keep bags and cardboard containers dry at all times
- Prevent or correct leaks in herbicide containers and application equipment
- Properly dispose of all empty pesticide containers
- Tie down or otherwise secure containers when transporting pesticides to prevent them from falling from a vehicle
- Store herbicides only in their original containers or properly labeled service containers
- Stay alert and attentive when handling or using herbicides where on-site or in-field transfer of liquid chemicals (herbicide mixtures, fueling operations) are planned.

SPARTINA CONTROL IN SENSITIVE AREAS

Spartina control activity areas include sensitive wildlife habitat and species, First Nations use, aquaculture activities and public recreation areas. Descriptions and proposed mitigation strategies for each of these sensitive components include:

SENSITIVE WILDLIFE HABITAT AND SPECIES

All of Boundary Bay, Roberts Bank and Sturgeon Bank are part of a RAMSAR wetland designation, Western Shorebird Reserve Network designation, and Wildlife Management Area thereby demonstrating the critical value of these areas to wildlife. The manager of these sites (FLNRORD) recognizes the importance of removing *Spartina* from the area to ensure these areas continue to provide the critical habitat for migratory birds. Sites of rare and endangered wildlife species and habitats are detailed in Appendix 3. Within 500 m four different red and blue listed ecological communities can be found, one species of invertebrate, two vascular plants and two vertebrate animals. All the rare ecological community occurrences within 500 m of Spartina are within a provincial and regional parks, prior to Spartina control activities the park staff will be engaged. Sand-verbena Moth and Yellow Sand-verbena are both associated with rare ecological communities protected by provincial and regional parks. The BC SWG will work with parks staff and ecosystems efforts to minimize disturbance to these species and habitats should Spartina occur there. Currently the closest spartina plant location is > 200 m. Green Heron have an occurrence within 50 m of Spartina. Crews will watch for any birds, especially if endangered and rare, that are nesting, feeding or migrating and will adjust the work plan accordingly.

Core Strategies to mitigate the impact on these species include:

1. No herbicide application at the sites when these species are present. At lowest tide, the bird species (green heron, double crested cormorant, great blue heron (Fannini subspecies), Brant) have limited use of the sites.
2. For herbicide treatments of nearby Spartina, low drift nozzles and pressure techniques in addition to wind shrouding will minimize any potential drift to sensitive plants and habitats.
3. For herbicide treatments, digging, and mapping, crews will, within reasonable means, avoid walking through these sensitive habitats. If necessary crews may walk the perimeter of these habitats.
4. Spartina digging should also minimize disturbance to any wildlife and plants.
5. Apply herbicide at the label rate which has a low toxicity to vertebrate bird species (green heron, double crested cormorant, great blue heron (Fannini subspecies), Brant) and invertebrate species (Audouin's Nightstalking Beetle).

6. Henderson's checker mallow occurs higher in the tidal zone than Spartina, and more than 150m from the nearest Spartina plant. Washington Springbeauty, Roell's Brotherella, Needle-leaved Navarretia, Black Knotweed, Vancouver Island Beggarticks, Yellow Sand-verbena,and Chaffweed also occur more than 150m from the nearest Spartina plant. Therefore, herbicide application for Spartina can occur without any impact on this species. However, should Spartina be next to any of these existing plants, no herbicide application will occur.

FIRST NATIONS CULTURAL SIGNIFICANCE AREAS

The intertidal foreshore was and continues to be an important area for First Nations food, social and ceremonial purposes. During the consultation process for the provincial Pesticide Use Permit (PUP), First Nations are consulted to document concerns and recommendations for the Spartina control program. The BC SWG continues meaningful engagement throughout the PUP duration and delivery of Spartina control activities for capacity building of both First Nations communities and the eradication program. First Nations community members have local knowledge and expertise that can improve Spartina detection and response. Spartina control activities such as mapping, mechanical and chemical treatments involve First Nations in the planning and implementation to ensure activities do not negatively impact First Nation's rights and interests in areas where Spartina occurs.

AQUACULTURE ACTIVITIES

There are 122 tenures of cultivated and wild aquatic species (shellfish and plants) in intertidal areas within or near the proposed pesticide use permit boundary (Appendix 4a). One of these registered harvests includes harvesting of Salicornia in Boundary Bay.

The majority of *S. patens* infestations are nearby but not within existing tenures. Forty-seven tenures are within 1000 m of *S. patens* in the Baynes Sound and Comox Estuary; three tenures are located within 100 m of *S. patens* in the Comox estuary and only one aquaculture tenure has *S. patens* within the tenure boundary. Six of the seven tenures within 1000 m of *S. patens* are located within "Area 14 - Pacific Region Sanitary Closures - Closure 14.1"[2] which has had an annual closure since February 2014 (Appendix 4b). However, some shellfish harvesters have obtained exemptions to the closure via DFO granted depuration permits (permits that require additional shellfish sanitation pre-consumption). Imazapyr has a low bioaccumulation factor (BAF) of 3, suggesting low potential for bioconcentration in aquatic organisms (Leson & Associates 2005). The US Environmental Protection Agency (EPA) considers compounds with a BAF less than 100 to have a low bioaccumulation potential. Proposed Spartina herbicide treatments present a low risk of impact to aquaculture due to the low herbicide application rate, preventing imazapyr from bioaccumulating in shellfish tissue, the low number of tenures within a 100 m proximity of an aquaculture tenure, and the additional steps for sanitation required by DFO for harvest in the Comox Estuary Closure. The Spartina Program will engage with registered, active aquaculture and plant harvesters within or immediately adjacent to Spartina sites proposed for herbicide treatment to ensure the impact of Spartina treatments to aquaculture and food collection are minimized.

There is one license issued for the collection of Salicornia plants in Boundary Bay. The BC SWG, led by FLNRORD and Ducks Unlimited Canada, completed an inventory and spatial analysis to identify the sites and total

area where Salicornia occurs within one metre of Spartina. Based on this analysis, there are 231.6 ha of Salicornia in Boundary Bay, 1.1 ha of which is intermixed with Spartina. The Spartina Program is working in partnership with provincial permitting agencies to engage with the harvester each year to plan when herbicide treatments will occur minimizing the impact Spartina herbicide treatments have on the Salicornia harvest while still effectively controlling *S. anglica* populations in Boundary Bay.

There is one license issued for the collection of Salicornia plants in Baynes' Sound. Again the BC SWG works with provincial permitting agencies and the harvester to minimize the impact Spartina treatments have on Salicornia harvest while still effectively controlling and reducing Spartina populations.

PUBLIC RECREATION AREAS

The proposed herbicide application has potential to overlap areas used by birders, cyclists, joggers, pedestrians, and users of beaches and parks (Appendix 5a, Appendix 5b). To minimize risks to the public, mitigation measures for herbicide treatment methods will be implemented in treatment activities. Such measures include, but are not limited to, the following:

1. Post signs indicating date and location of treatment areas.. At least one week prior to application, post signs informing the public of impending herbicide treatment at prominent locations where the public may access the tidal areas such as where the streets and paths intersect with the dikes. Not all access points are documented in this treatment plan and some areas of shoreline have unlimited accessibility; signage will be posted and visible markers will clearly mark an area before treatment.
2. Clearly mark treatment areas by visibly identifiable means.
3. Minimize drift. Manage herbicide application to minimize potential for herbicide drift. Herbicide must not be applied when winds are in excess of 20 km per hour or when inversion conditions exist, or when wind could carry spray drift into inhabited areas.
4. Post signs at access points within 24 hours prior to treatment. The signs should inform the public that the area is to be sprayed with Habitat Aqua herbicide for weed control, and that the spray can be harmful if inhaled. The signs should advise "no entry" for humans and animals for 48 hours after treatment, and the treatment date and time should be stated. A 24-hour contact number may be provided. Signs will be removed 30 days after treatment of an area.
5. Avoid high use areas such as beaches. As well, avoid application in other non-beach areas within 24 hours of high use periods, such as weekends or certain holidays.

BC Spartina Treatment Plan

MONITORING

Annual mapping will occur prior to treatment and the following year after treatment to evaluate efficacy and ensure treatment applications are containing and reducing Spartina populations. The results will appear in annual reporting provided by the BC SWG.

Mapped Spartina plants represented as points

Hectare Grid Cell showing the total number of plants in each cell representing total abundance

Site Summary (site boundary shown in red)

Figure 3 Spartina invasion tracking and evaluation analyses

To effectively track and convey the status of the Spartina invasion a few different metrics are used (See Appendix II for a more detailed overview):

1. the number of plants detected;
2. the size of those plants (single seedling, clone <0.3m, clone 0.3m - 1.0m, clone > 1.0m in diameter, or 5m area of single plants);
3. the estimated leaf area (size x number of plants = ~ how many square meters a dispersed population would occupy if all Spartina plants were grouped together);
4. how much shoreline is impacted (a measure of how many 1-hectare (Ha) grid cells had one or more Spartina occurrence points); and
5. Site level reporting (a roll up of metrics 1 - 4 at the site level; see Figure 2)

The area impacted might go down while the number of plants increases, which might indicate that the containment boundary is getting smaller and there is likely a seedbank or seed source generating many new small plants. These numbers are evaluated at the species level across the province and by region and the site level. Tracking and reporting across all these metrics gives a better indication of the species invasion status/control progress provincially while lending insights to site specific nuances. Additionally, after herbicide treatment crews walk through and flag any plants that were missed for follow up treatment. Throughout the season a site is returned to two or three times to check for new plants and observe signs of herbicide efficacy.

CONTROL EFFICACY TO DATE

ANGLICA

The number of *S. anglica* plants has reduced by approximately 85% from peak abundance in 2016, as a result of herbicide treatment efforts. The total area impacted by *S.anglica* has declined from its peak of 973 ha in 2016 to 348 ha presently and the calculated leaf area has dropped from 1.64 ha of plant matter to 0.21 ha. We are seeing fewer plants in each size category (Figure 4) and we have seen a 95% reduction in the amount of seedlings found since 2016. Due to scheduling issues in 2020 surrounding the global Covid-19 pandemic, we have seen a slight increase in some of the bigger size classes, but full coverage was achieved in 2021.

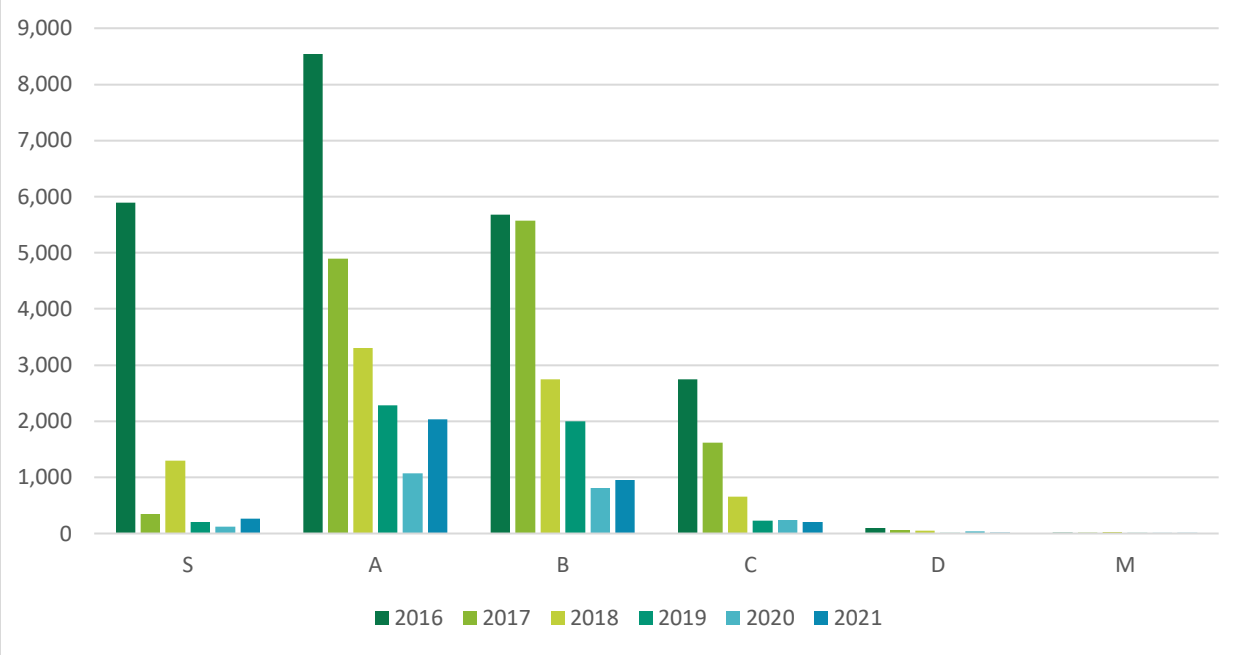

Figure 4. S. anglica plants found each year by size class.

PATENS

The number of *S. patens* plants continues to increase, particularly in Baynes' Sound, following very limited success with non-herbicide control methods. *S. patens* continues to decrease in the Burrard Inlet following operational scale herbicide treatment. Specifically, *S. patens* on Sandy Island saw a decrease of 80% estimated leaf area after a single pass of chemical treatment conducted in 2019. Unfortunately, Sandy Island missed treatment in 2020, but in 2021 another full pass was conducted on the present *patens* population which was still 60% smaller than the population found in 2019. Additionally, treatments of *S. patens* at the Maplewood Flats Conservation Area over two consecutive years reduced the *S. patens* population by 85%

DENSIFLORA

S. densiflora has responded well to repeated manual and mechanical removal, with the number of plants dropping by 90% since 2015. The extent of the *S. densiflora* population has been cut in half since 2015 and the estimated leaf area has been reduced by 97% indicating that mechanical methods are effective at controlling the population.

These results are indicative of progress being made in the Spartina control program as a result of an integrated pest management approach.

COMMUNICATION

A sandwich board sign is placed at work sites and along paths while mapping, digging or spraying spartina with information on what spartina is, how we are treating it and how to get more info.

A notice of the permit issued is published in at least one community newspaper circulated within each treatment area. The notice details the permit number, method of application, treatment area maps, pesticide being used, dates for commencement and completion of the work and information on how the public can contact the permit holder to obtain any related pesticide information.

Pesticide treatment areas boundaries are clearly marked with flags and accompanied by signs that explain what the flags mean.

The PUP and treatment maps are posted at the BC Ministry of Environment – Ecosystems Protection and Sustainability Branch in Victoria, the Forests, Lands and Natural Resource Operations (FLNRO) office in Surrey, and the FLNRO Invasive Plant Program website[3]. The permits remain posted until at least one week after all pesticide use activities have ceased.

At least 24 hours prior to any pesticide use signs are posted at main access points to the treatment area advising of impending pesticide use. The signs remain in place for a period of one month after pesticide application, including information on timing, locations, precautions and contact information.

Detailed information on proposed, current and past pesticide use is held readily available to any First Nations, licence holders and members of the general public that may wish to use the area. This information is hosted in a spatial database. The BC Spartina Working Group will continue to respond to requests for information and oversee the general Spartina control program, which includes mapping, treatment (herbicide, mechanical) and monitoring.

An annual progress report is written and published online at Spartina.ca.

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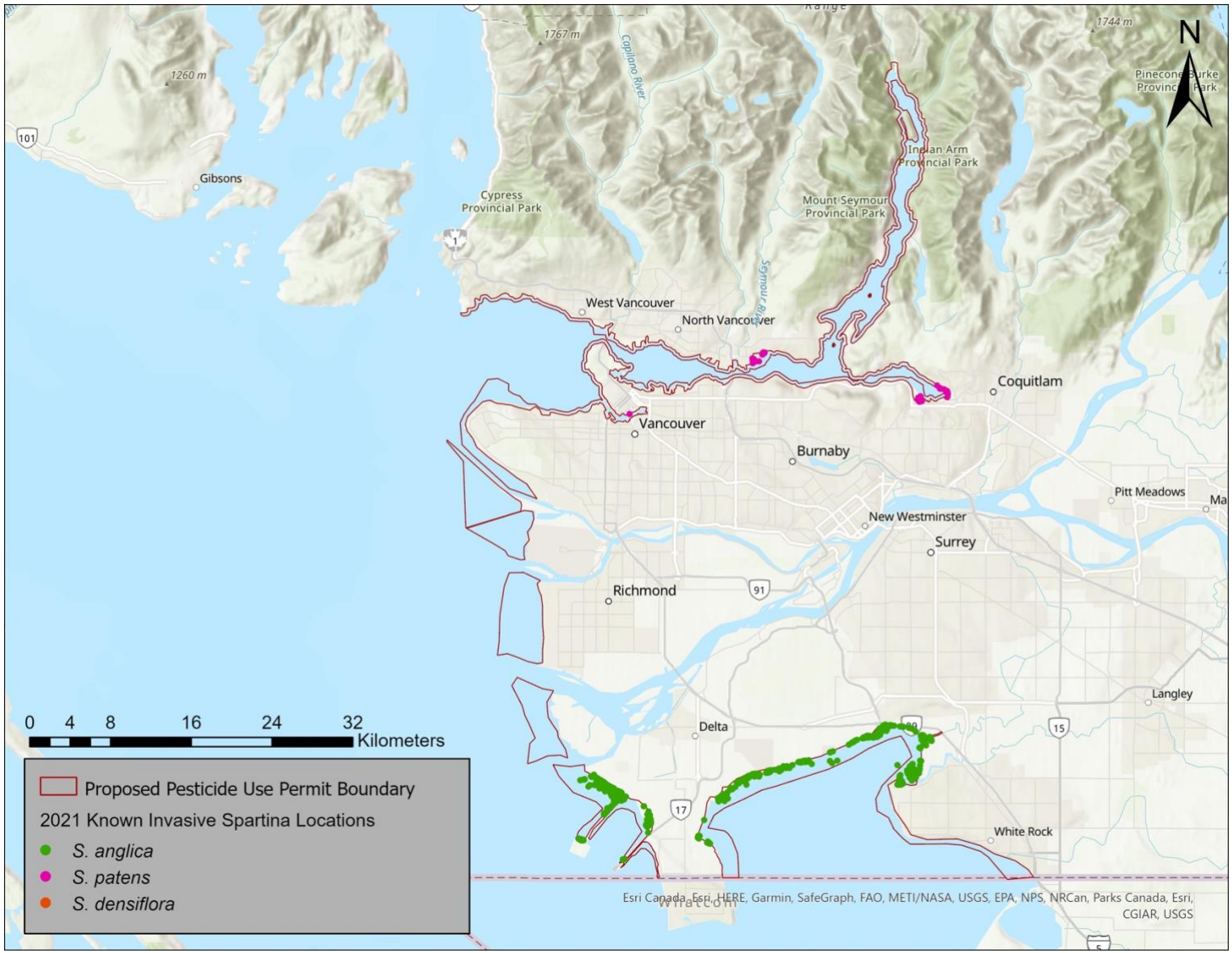
BC Spartina Treatment Plan

APPENDIX 1 – PROPOSED 2022 SPARTINA TREATMENT AREAS IN THE LOWER MAINLAND



BC Spartina Treatment Plan

APPENDIX 2-PROPOSED 2022 SPARTINA TREATMENT AREAS IN BAYNES' SOUND

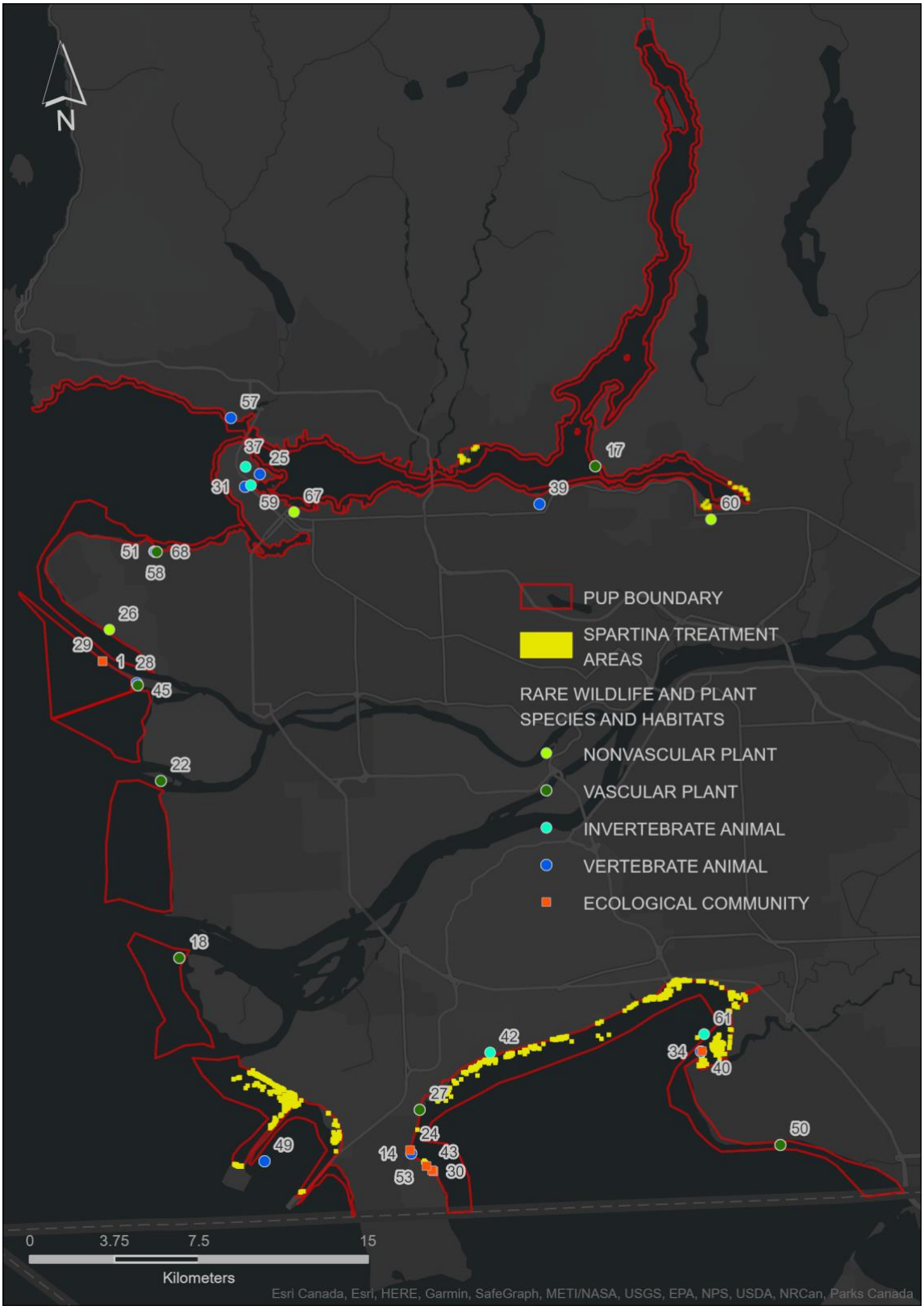
BC Spartina Treatment Plan

APPENDIX 3A – RECORDED INCIDENCES OF RARE AND ENDANDEGERED SPECIES AND HABITATS IN PROXIMITY TO *SPARTINA SPP.*

		Baynes' Sound		Lower Mainland	
ENGLISH NAME	**SCIENTIFIC NAME**	**# of CDC Occurences**	**Minimum Distance to Nearest Spartina Plant (m)**	**# of CDC Occurences**	**Minimum Distance to Nearest Spartina Plant (m)**
Ecological Community					
Douglas-fir / Alaska Oniongrass	*Artemisia campestris - Festuca rubra / Racomitrium canescens*	1	5426		
Dune Wildrye - Beach Pea	*Carex macrocephala Herbaceous Vegetation*			2	33
Garry oak / California brome	*Leymus mollis ssp. mollis - Lathyrus japonicus*	2	4138		
Large-headed Sedge Herbaceous Vegetation	*Populus tremuloides / Malus fusca / Carex obnupta*			2	127
Northern Wormwood - Red Fescue / Grey Rock-moss	*Pseudotsuga menziesii / Melica subulata*	1	37	1	348
Trembling Aspen / Pacific Crab Apple / Slough Sedge	*Quercus garryana / Bromus carinatus*	2	5275		
Vertebrate Animal					
Brant	*Ardea herodias fannini*	1	655		
Double-crested Cormorant	*Branta bernicla*			1	1032
Great Blue Heron, Fannini Subspecies	*Butorides virescens*	3	1033	2	3661
Green Heron	*Megascops kennicottii kennicottii*			2	10
Painted Turtle	*Chrysemys picta*			1	9624
Western Screech-owl, Kennicottii Subspecies	*Phalacrocorax auritus*	1	5151		
Invertebrate Animals					
Audouin's Night-stalking Tiger Beetle	*Callophrys johnsoni*			2	292
Blue Dasher	*Erynnis propertius*			1	9506
Common Woodnymph	*Cercyonis pegala incana*	1	2769		
Dun Skipper	*Euphydryas editha taylori*	1	5514		
Edith's Checkerspot, Taylori Subspecies	*Euphyes vestris*	2	5276		
Johnson's Hairstreak	*Nearctula sp. 1*			1	9355
Propertius Duskywing	*Omus audouini*	2	4890		
Sand-verbena Moth	*Pachydiplax longipennis*	2	142		
Threaded Vertigo	*Sympetrum vicinum*	1	1288		
Nonvascular Plants					
Banded Cord-moss	*Brotherella roellii*	1	5212		
Roell's Brotherella	*Entosthodon fascicularis*			2	519
Vascular Plants					
Black Knotweed	*Abronia latifolia*	1	153		
Chamisso's Montia	*Montia chamissoi*	1	581		
Coast Microseris	*Bidens amplissima*	1	5432		
Coastal Wood Fern	*Claytonia washingtoniana*	3	3817		
Fragrant Popcornflower	*Dryopteris arguta*	1	4460		
Henderson's Checker-mallow	*Erigeron philadelphicus var. glaber*	2	143		
Macoun's Meadow-foam	*Isoetes nuttallii*	1	4819		
Nuttall's Quillwort	*Microseris bigelovii*	2	4466		
Salt Marsh Philadelphia Daisy	*Navarretia intertexta*			1	4665
Vancouver Island Beggarticks	*Plagiobothrys figuratus ssp. figuratus*	1	299	2	877
Washington Springbeauty	*Polygonum paronychia*			1	5077
White-top Aster	*Sericocarpus rigidus*	1	5276		
Yellow Montane Violet	*Sidalcea hendersonii*	1	3753		
Yellow Sand-verbena	*Viola praemorsa var. praemorsa*	2	133		

BC Spartina Treatment Plan

APPENDIX 3B – RECORDED INCIDENCES OF RARE AND ENDANGERED SPECIES IN THE LOWER MAINLAND (C.D.C)

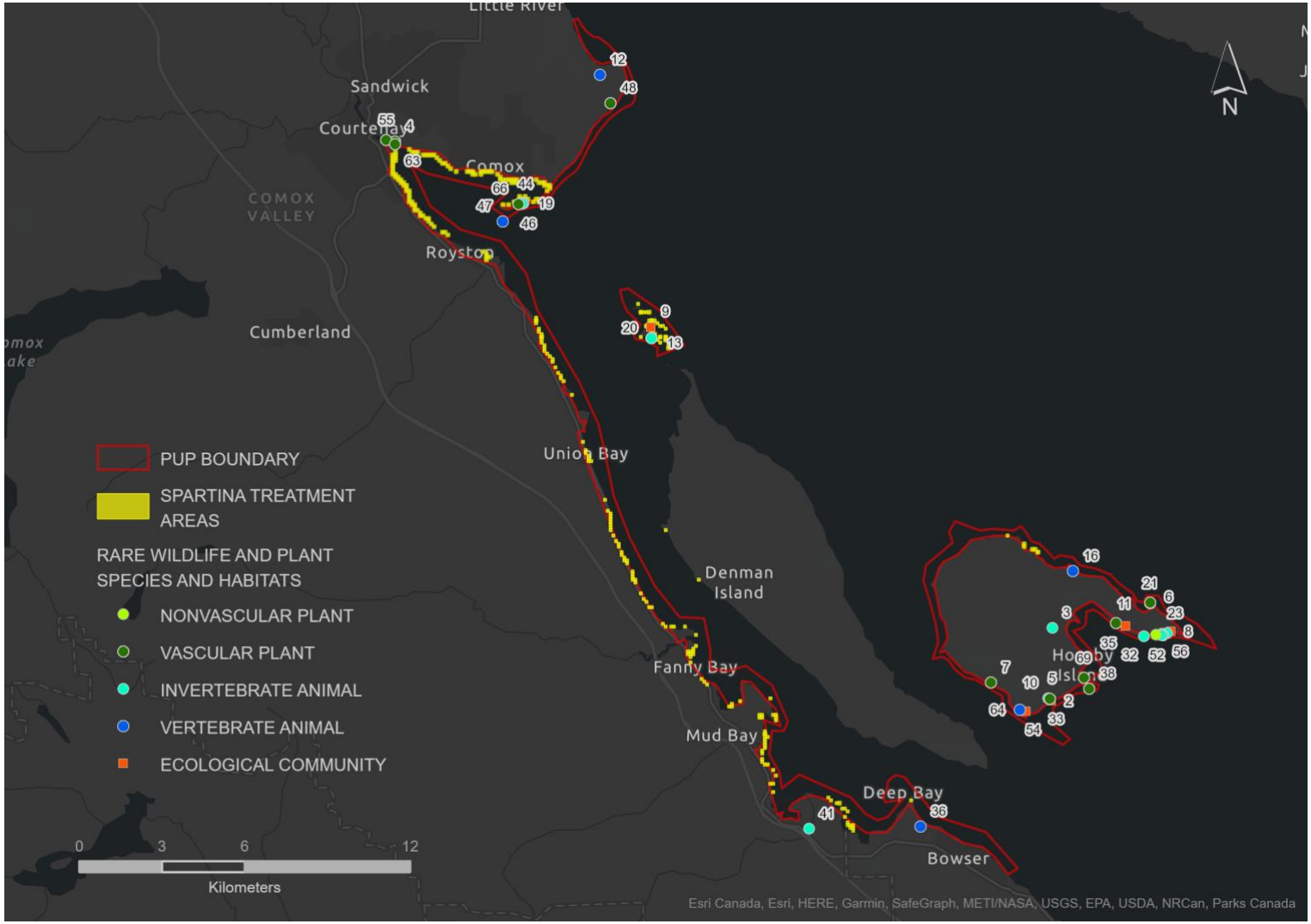


BC Spartina Treatment Plan

ID	NAME	TYPE
1	Large-headed Sedge Herbaceous Vegetation	Ecological Community
14	Green Heron	Vertebrate Animal
17	Washington Springbeauty	Vascular Plant
18	Vancouver Island Beggarticks	Vascular Plant
22	Vancouver Island Beggarticks	Vascular Plant
24	Large-headed Sedge Herbaceous Vegetation	Ecological Community
25	Great Blue Heron, Fannini Subspecies	Vertebrate Animal
26	Roell's Brotherella	Nonvascular Plant
27	Vancouver Island Beggarticks	Vascular Plant
28	Painted Turtle - Pacific Coast Population	Vertebrate Animal
29	Dune Wildrye - Beach Pea	Ecological Community
30	Large-headed Sedge Herbaceous Vegetation	Ecological Community
31	Painted Turtle - Pacific Coast Population	Vertebrate Animal
34	Green Heron	Vertebrate Animal
37	Blue Dasher	Invertebrate Animal
39	Great Blue Heron, Fannini Subspecies	Vertebrate Animal
40	Dune Wildrye - Beach Pea	Ecological Community
42	Audouin's Night-stalking Tiger Beetle	Invertebrate Animal
43	Northern Wormwood - Red Fescue / Grey Rock-moss	Ecological Community
45	Vancouver Island Beggarticks	Vascular Plant
49	Double-crested Cormorant	Vertebrate Animal
50	Near Navarretia	Vascular Plant
51	Autumn Meadowhawk	Invertebrate Animal
53	Dune Wildrye - Beach Pea	Ecological Community
57	Green Heron	Vertebrate Animal
58	Green Heron	Vertebrate Animal
59	Johnson's Hairstreak	Invertebrate Animal
60	Roell's Brotherella	Nonvascular Plant
61	Audouin's Night-stalking Tiger Beetle	Invertebrate Animal
67	Roell's Brotherella	Nonvascular Plant
68	Vancouver Island Beggarticks	Vascular Plant

BC Spartina Treatment Plan

APPENDIX 3B – RECORDED INCIDENCE OF RARE AND ENDANGERED SPECIES ON THE EAST COAST OF VANCOUVER ISLAND (C.D.C)

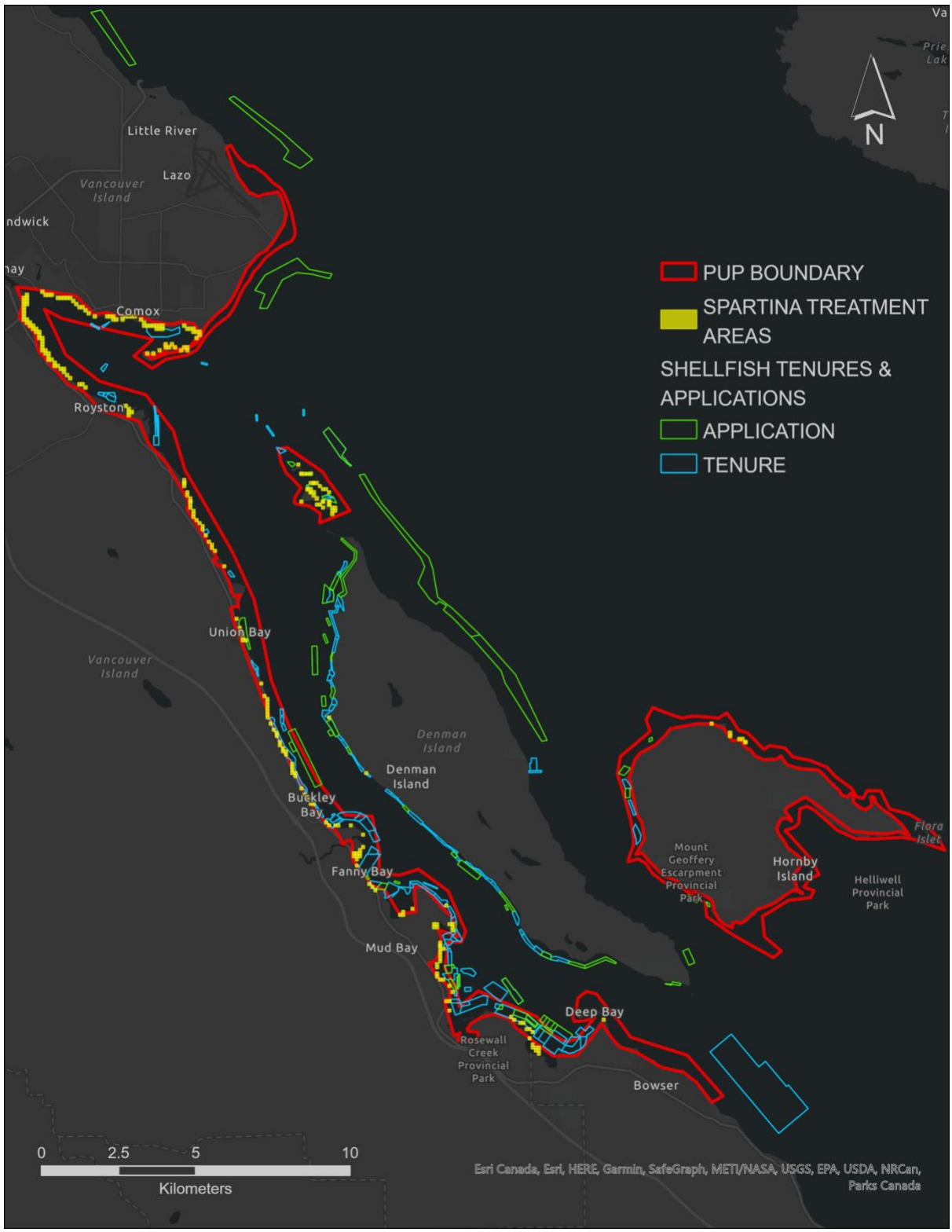


BC Spartina Treatment Plan

ID	NAME	TYPE
2	Garry oak / California brome	Ecological Community
3	Common Woodnymph, Incana Subspecies	Invertebrate Animal
4	Henderson's Checker-mallow	Vascular Plant
5	Edith's Checkerspot, Taylori Subspecies	Invertebrate Animal
6	Nuttall's Quillwort	Vascular Plant
7	Coastal Wood Fern	Vascular Plant
8	Trembling Aspen / Pacific Crab Apple / Slough Sedge	Ecological Community
9	Northern Wormwood - Red Fescue / Grey Rock-moss	Ecological Community
10	Propertius Duskywing	Invertebrate Animal
11	Coastal Wood Fern	Vascular Plant
12	Great Blue Heron, Fannini Subspecies	Vertebrate Animal
13	Yellow Sand-verbena	Vascular Plant
15	Douglas-fir / Alaska Oniongrass	Ecological Community
16	Great Blue Heron, Fannini Subspecies	Vertebrate Animal
19	Black Knotweed	Vascular Plant
20	Sand-verbena Moth	Invertebrate Animal
21	Fragrant Popcornflower	Vascular Plant
23	Dun Skipper	Invertebrate Animal
32	Propertius Duskywing	Invertebrate Animal
33	Coastal Wood Fern	Vascular Plant
35	Garry oak / California brome	Ecological Community
36	Great Blue Heron, Fannini Subspecies	Vertebrate Animal
38	White-top Aster	Vascular Plant
41	Threaded Vertigo	Invertebrate Animal
44	Yellow Sand-verbena	Vascular Plant
46	Sand-verbena Moth	Invertebrate Animal
47	Brant	Vertebrate Animal
48	Yellow Montane Violet	Vascular Plant
52	Nuttall's Quillwort	Vascular Plant
54	Trembling Aspen / Pacific Crab Apple / Slough Sedge	Ecological Community
55	Chamisso's Montia	Vascular Plant
56	Coast Microseris	Vascular Plant
62	Edith's Checkerspot, Taylori Subspecies	Invertebrate Animal
63	Vancouver Island Beggarticks	Vascular Plant
64	Western Screech-owl, Kennicottii Subspecies	Vertebrate Animal
65	Banded Cord-moss	Nonvascular Plant
66	Henderson's Checker-mallow	Vascular Plant
69	Macoun's Meadow-foam	Vascular Plant

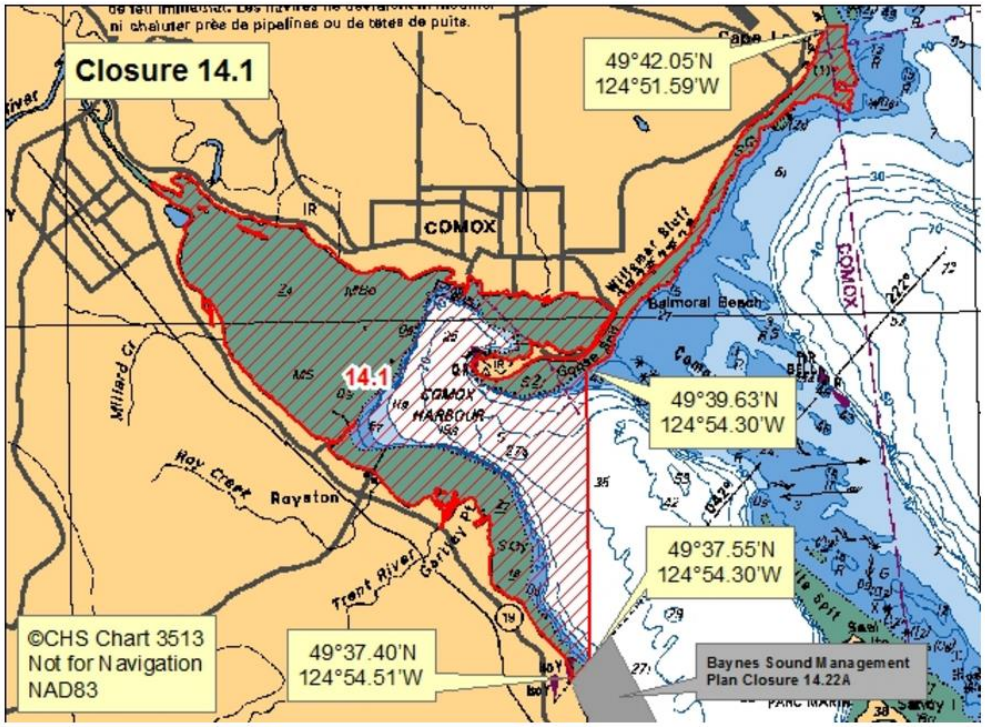
BC Spartina Treatment Plan

APPENDIX 4A – SHELLFISH HARVEST TENURES AND APPLICATION TENURES AROUND SPARTINA TREATMENT AREAS



APPENDIX 4B – SHELLFISH HARVEST SANITARY CLOSURES IN THE COMOX HARBOUR[3]

Area 14 - Pacific Region Sanitary Closures - Closure 14.1



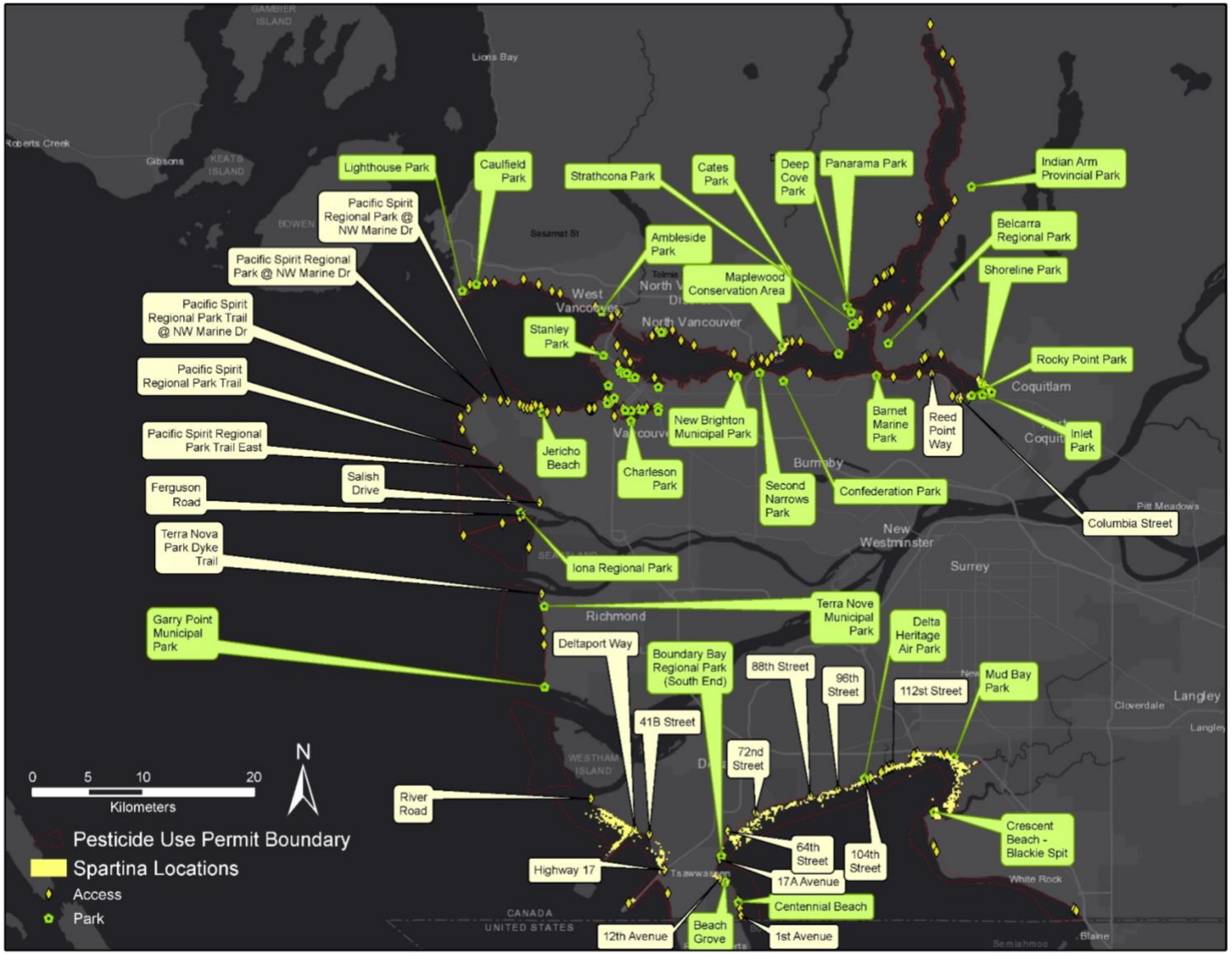
The waters and intertidal foreshore of Comox Harbour lying inside a line drawn from the point on land at the range markers at 49°37.40' north latitude and 124°54.51' west longitude, south of Gartley Point, thence seaward northeasterly to a point in water at 49°37.55' north latitude and 124°54.30' west longitude, thence due north towards the road entrance gate to HMCS Quadra on Goose Spit to a point in water at 49°39.63' north latitude and 124°54.30' west longitude, thence extending northeasterly along the low water mark to the first prominent point of land at the south end of Cape Lazo at 49°42.05' north latitude and 124°51.59' west longitude. [NAD 83]

Closed January 1 to December 31

[3] [Map retrieved from: http://www.pac.dfo-mpo.gc.ca/fm-gp/contamination/sani/area-secteur-14/14.1-eng.html]

BC Spartina Treatment Plan

APPENDIX 5A – PUBLIC ACCESS AND PARKS IN THE LOWER MAINLAND AROUND THE PROPOSED PUP BOUNDARY



APPENDIX 5B – PUBLIC ACCESS AND PARKS ON THE EAST COAST OF VANCOUVER ISLAND NEAR THE PUP BOUNDARY