The WRIA 9 Marine Shoreline Monitoring and Compliance Pilot Project

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King County

Department of Natural Resources and Parks
Water and Land Resources Division
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The WRIA 9 Marine Shoreline Monitoring and Compliance Pilot Project

Prepared for:

Watershed Resource Inventory Area 9 Watershed Ecosystem Forum, Washington Department of Fish and Wildlife, and Washington Department of Natural Resources.

Submitted by:

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ABSTRACT

Natural shorelines, including beaches and bluffs with overhanging native trees and other vegetation, are important habitat for salmon and other wildlife in Puget Sound. As part of ~~the~~ salmon recovery efforts, several projects have been completed this past decade where shoreline armoring has been removed and natural shoreline conditions restored. For this grant-funded project, King County conducted surveys of 92 miles of shoreline from Seattle to Federal Way, and on Vashon-Maury Island, to assess the change in shoreline armoring and other shoreline infrastructure since a previous survey in 2005.

A major finding of the project is that more new shoreline armoring has been built since 2005 than has been removed through restoration. This means that even with the salmon recovery efforts undertaken so far, there is now more armored shoreline than there was in 2005. This project also found that the amount of shoreline trees has decreased since 2005, and that other construction activities are also occurring on the shorelines. A review of permits from the local jurisdictions shows that some shoreline activities appear to be properly permitted. However, there are examples in each jurisdiction where it appears that appropriate permits were not obtained. Staff from each jurisdiction have indicated that they will follow their internal procedures related to following up on the potentially unpermitted actions. Similar shoreline studies on Bainbridge Island and the San Juan Islands found comparable results.

EXECUTIVE SUMMARY

The Watershed Resource Inventory Area 9 (WRIA 9) includes portions of unincorporated King County (Vashon and Maury Islands), and the cities of Seattle, Burien, Normandy Park, Des Moines, and Federal Way. Like other WRIAs in Western Washington, jurisdictions within WRIA 9 have been implementing plans to recover salmon for many years. Among the primary goals of the WRIA 9 salmon habitat plan are reducing the amount of existing shoreline armoring (bulkheads, revetments, etc.) and limiting the amount of new shoreline armoring in these jurisdictions, given concerns that these modifications can negatively affect salmon habitat.

In 2012, the WRIA 9 Implementation Technical Committee completed a five year "Status and Trends Report" that included multiple analyses describing the changes in condition of various fresh water and saltwater habitats since the plan was adopted (changes occurring between 2005 and 2010). Given the difficulty in tracking the status of some salt water shoreline habitats via aerial photograph analysis, the 2012 Status and Trends Report recommended conducting annual boat-based monitoring surveys to evaluate if the WRIA 9 goals for reducing marine shoreline armoring are being met and specifically, if shoreline land use regulations are being followed.

Following these recommendations, WRIA 9 staff applied for and received funding from the Puget Sound Marine and Nearshore Protection and Restoration Grant Program to undertake boat-based marine shoreline monitoring surveys of WRIA 9. The intent of the grant was twofold. The first goal was to update the 2004 baseline data on shoreline conditions for the 92 miles of marine shoreline in WRIA 9 with field collected data. The second goal was to assess how well shoreline regulations were being followed to assist the WRIA meet its programmatic salmon recovery goal to, "Improve enforcement of existing land use and other regulations." To accomplish this, the grant project called for evaluating if permits were obtained for the observed changes in shoreline conditions and tracking enforcement responses to any unpermitted changes in condition.

The project work included undertaking boat-based surveys as close to shore as practical along the entire 92 miles of marine shoreline of WRIA 9 in 2012 and again in 2013. Two surveys were done to attempt to understand the rate of changes occurring. Jurisdictions with WRIA 9 shoreline include unincorporated King County, primarily Vashon and Maury Islands (56% of the shoreline), the cities of Seattle (24%), Burien (5%), Normandy Park (4%), Des Moines (6%), and Federal Way (5%). The rural unincorporated area makes up about 56% of the WRIA 9 shoreline. The surveys collected shoreline condition data to update and compare to baseline monitoring data sets (2004 and 2009) as well as document other changes in shoreline condition that were not original baseline data sets. These included buildings (mostly houses), retaining walls, and stairs along the shoreline that were in construction or obviously recently constructed at the time of the surveys. Based on information provided by the relevant jurisdictions, each identified change in shoreline

condition was then evaluated to determine whether or not it had received a permit for the change.

The 2012 survey found 85 distinct changes in WRIA 9 shoreline condition that had occurred between 2004 and 2012. The 2013 survey found 60 additional distinct changes in shoreline condition, most of which occurred between 2012 and 2013. Of the total 145 changes found by both surveys, changes associated with shoreline armoring accounted for 50% of the changes noted, with most changes consisting of repairs to existing shoreline armoring infrastructure. Changes associated with clearing of vegetation, docks and other overwater structures, and stairs each accounted for approximately 10% of the total, and changes associated with houses accounted for 7% of the changes. The rest of the changes were composed of a variety of alterations such as aquaculture facilities, decks, retaining walls and boat ramps.

As part of this project, each WRIA 9 jurisdiction with marine shoreline was contacted with a list of the changes that occurred in their jurisdiction and asked to verify if the changes identified in the surveys were permitted or not. Whether a change in condition was permitted or not was used to define the "non-field verified compliance rate." While it is known if a permit was given for the changes identified, in order to calculate a fully verified compliance rate, each jurisdiction needs to decide if the changes identified truly need a permit. It is important to note that actual compliance has not yet been field verified by each jurisdiction. It is possible that once staff from a jurisdiction visit the site they will decide the change may have not needed a permit, and thus actually be in compliance.

For the 85 changes identified in the 2012 survey, 19 (22%) were permitted prior to the work being done. The non-field verified compliance rate within each jurisdiction varied from 0 to 100%, with an average rate across all jurisdictions of 34%. There were no patterns seen when jurisdictions with smaller amounts of shoreline were compared to jurisdictions with larger amounts of shoreline. The non-field verified compliance rate was much higher in the urban area (50%) than the rural area (14%) for 2012. Compliance data for 2013 has not yet been provided by all jurisdictions. Based on 2013 data, 25(43%) of the changes observed were permitted prior to the work being done. The non-field verified compliance rate within each jurisdiction varied from 0 to 73%, with an average rate across all jurisdictions of 43%.

When evaluating compliance, it is important to note that properties that did not have any modifications during the study period were also in compliance with the existing rules and regulations. This is reflected in the rate of development activity that occurred between 2004 and 2013, as identified in the two surveys. By jurisdiction, the range of properties that had no development activity was 95 to 99 % of all shoreline properties in WRIA 9.

It is noteworthy that two similar studies have recently been done in other parts of Puget Sound that had compliance rates ranging from 50% to 80%. Along the 53 miles of the City of Bainbridge Island, Washington Department of Fish and Wildlife evaluated recent shoreline changes against their permit database of state Hydraulic Project Approvals (HPAs) in 2012. While that study did not evaluate if projects had local city permits, it found

that 80% of the changes had received an HPA for the work done. The San Juan Initiative undertook surveys of 34 miles of different sections of several islands within the San Juan archipelago. They evaluated a smaller subset of shoreline changes (shoreline armoring and docks) and found that 50% of the changes did not have a state or county permit. It is unclear why the other study areas had higher non-field verified compliance rates. One possibility is that the WRIA 9 study was more comprehensive and evaluated all changes in shoreline condition, while the other two studies focused on a subset of shoreline changes.

In addition to examining changes in shoreline condition, this project included a coarse evaluation of the ecological and physical effects of the changes identified in both surveys. In the 2012 survey, 34 (40%) of the changes encountered did not appear to have any obvious physical or ecological effects, and the changes to shoreline condition with no obvious effects were spread throughout the study area. In general, these were modifications of structures already in existence in the baseline year of 2004. In the 2013 survey, 23 (38%) of the changes encountered did not appear to have any physical or ecological effect. Of the remaining identified changes, approximately 60% were likely to have some observed or expected ecological or physical effect, though many of these changes were relatively small.

In aggregate, a comparison of 2004 baseline shoreline armoring conditions to existing conditions (ca. 2013), indicates that there has been relatively little change in the overall amount of shoreline armoring within WRIA 9. In part, this is because the vast majority of changes noted to shoreline armoring were repairs or rebuilds to existing structures rather than new structures. The other reason there has been little change to the overall amount of shoreline armoring is because the increase in new shoreline armoring was offset by shoreline restoration projects. The amount of new shoreline armoring found through the course of this study offset all of the gains from shoreline restoration projects over the past 8 years. Between 2004 and June of 2013, approximately 1,500 feet of shoreline armoring had been removed, but there has been a net increase in the amount of shoreline armoring in WRIA 9 by approximately 70 feet.

The WRIA 9 Status and Trends Report also indicated that there had been an overall loss of both densely treed shoreline as well as patchily treed shorelines throughout the WRIA from 2004 to 2009. As with the WRIA 9 Status and Trends Report, the majority of the clearing of treed shorelines noted over both years of this project was in unincorporated King County; most instances of clearing were unpermitted. The 2012 survey found that roughly 3 acres of vegetation along the WRIA 9 shoreline had been cleared (between 2009 and 2012), while the 2013 survey found an additional 2.5 acres had been cleared between 2012 and 2013. Most instances of clearing were near houses, suggesting that they may have been associated with efforts to create unobstructed views of the water, or as part of remodeling an existing house. As noted in the WRIA 9 Status and Trends Report, there have been very few marine riparian restoration projects undertaken by the WRIA or its partners that would offset these losses. The findings in this report indicate that there has been a continuing loss of treed shorelines on Vashon and Maury Islands between 2009 and June of 2013.

In sum, the study indicates that there have been modifications made to shorelines that have not been permitted. As indicated above, it is not clear that in all cases the changes would have needed a permit, and much of the work does not appear likely to have had a large ecological effect. However, to the extent that a permit was in fact needed, these instances represent missed opportunities to work with landowners as part of the permit process to ensure projects are undertaken in a manner most protective of shoreline resources. This includes a potential missed educational opportunity that can help lessen the impacts from construction techniques, as well a potential missed opportunity to work with the landowner to improve the existing baseline conditions and design or placement of the activity.

The findings in this report were provided to permitting jurisdictions, but the timeframe for the project did not allow for a thorough review of any follow-up and enforcement activity. A future study would be necessary to evaluate the jurisdictional responses to the unpermitted changes noted in this report.

Finally, it is important to note that this study did not identify why people are not getting permits or why there might be differences in compliance rates among different jurisdictions within the study area. It is suggested that a separate study be undertaken in the future to understand these questions. Understanding why permits were frequently not obtained would be very useful to help craft specific and culturally relevant approaches to improving compliance rates. This in turn would like help improve shoreline conditions in WRIA 9.

1.0. INTRODUCTION

The Watershed Resource Inventory Area 9 (WRIA 9) salmon habitat recovery plan (Green/Duwamish and Central Puget Sound Watershed Resource Inventory Area 9 Steering Committee 2005) has stated that reducing the amount of existing shoreline armoring (bulkheads, revetments, etc.) and limiting the amount of new shoreline armoring are high priority goals.

In 2004, the WRIA undertook an assessment of shoreline condition for the entire marine shoreline of WRIA 9 (Anchor Environmental). That assessment included collecting data on: marine shoreline armoring, vegetation condition within a 200 foot zone from the ordinary high water line, boat ramps, docks and other overwater structures, breakwaters, and groins.

In 2012, the WRIA 9 Implementation Technical Committee compiled a 5 year Status and Trends Report describing the changes in condition of various habitats since the plan was adopted in 2005 (WRIA 9 Implementation Technical Committee, 2012). Much of this effort involved evaluating aerial photographs from 2005, 2007 and 2009 to identify visible changes in shoreline conditions. It also included requesting the previous 5 years of shoreline permit information from the various WRIA 9 jurisdictions. This worked well for an initial screening of what activities were permitted versus what were not. However, it was clear that this approach of combining aerial photograph analysis and existing permits had limits for identifying changes in shoreline armoring due to the vertical nature of most shoreline armoring infrastructure.

While finalizing the Status and Trends Report, a one day boat survey was undertaken along Vashon and Maury Islands in June of 2011 as a quality control/quality assurance of the analysis for marine shoreline armoring. The survey found several new anthropogenic features including 2 docks, and 3 bulkheads that were not captured by the aerial photograph analysis. The survey also noted a large number of repairs to shoreline infrastructure and instances of vegetation clearing that were not previously observed. Given the previous review of permits related to the shoreline it was known that the majority of the features noted in the survey were unpermitted. Given the results of the quality control/quality assurance survey the WRIA 9 Status and Trends Monitoring Report (2012) included a recommendation to undertake an annual boat-based monitoring survey to evaluate if WRIA 9 is meeting its salmon recovery goals for shoreline armoring and if land use regulations are being enforced. During the same time period, the Puget Sound Chinook Recovery Implementation Technical Team reviewed WRIA 9's three-year work plan and provided feedback that more work needed to occur related to programmatic actions, including "supporting regulations that benefit salmon."

Following these recommendations, in 2012, WRIA 9 staff applied for and received funding from the Puget Sound Marine and Nearshore Protection and Restoration Grant Program to undertake a project to undertake boat-based surveys of the marine shoreline of WRIA 9 (Figure 1). The intent of the grant was twofold. The first goal was to update the 2004

baseline data on shoreline conditions for the 92 miles of marine shoreline in WRIA 9. The second goal was to help the WRIA meet some of its programmatic salmon recovery goals, including the watershed wide program # 12, "Improve enforcement of existing land use and other regulations" by evaluating if the changes in shoreline conditions were permitted or not and tracking the enforcement response to any unpermitted changes in condition.

This report summarizes the results of the grant funded project. The report is broken into five sections (introduction, methods, results, discussion, and appendices). The results are described in four major topic areas (changes by year of survey, compliance rates by year and jurisdiction, ecological effects, and enforcement). Appendix A provides a broad analysis of the ecological effects of each change, while Appendix B includes photographs that provide examples of the various types of changes seen during the course of the project.

It was thought that the project itself might cause a change in behavior and thus compliance rates over the course of the study. It was expected that the increased monitoring effort and subsequent enforcement would improve the compliance rates before the second survey. However, given the longer than anticipated time to verify compliance and the generally slow pace of enforcement, residents at most non-compliant sites had not been contacted by various jurisdictions enforcement programs prior to the second survey taking place.

There are additional benefits at the local and regional level from conducting this project, including the ability to update both the KingStat's shoreline armoring indicator (http://your.kingcounty.gov/dnrp/measures/) and the Puget Sound Partnership's shoreline armoring dashboard indictor. It is anticipated that this project would also help each jurisdiction track the effectiveness their individual Shoreline Master Plans. This project will also help evaluate the cost-effectiveness of this type of monitoring throughout Puget Sound.

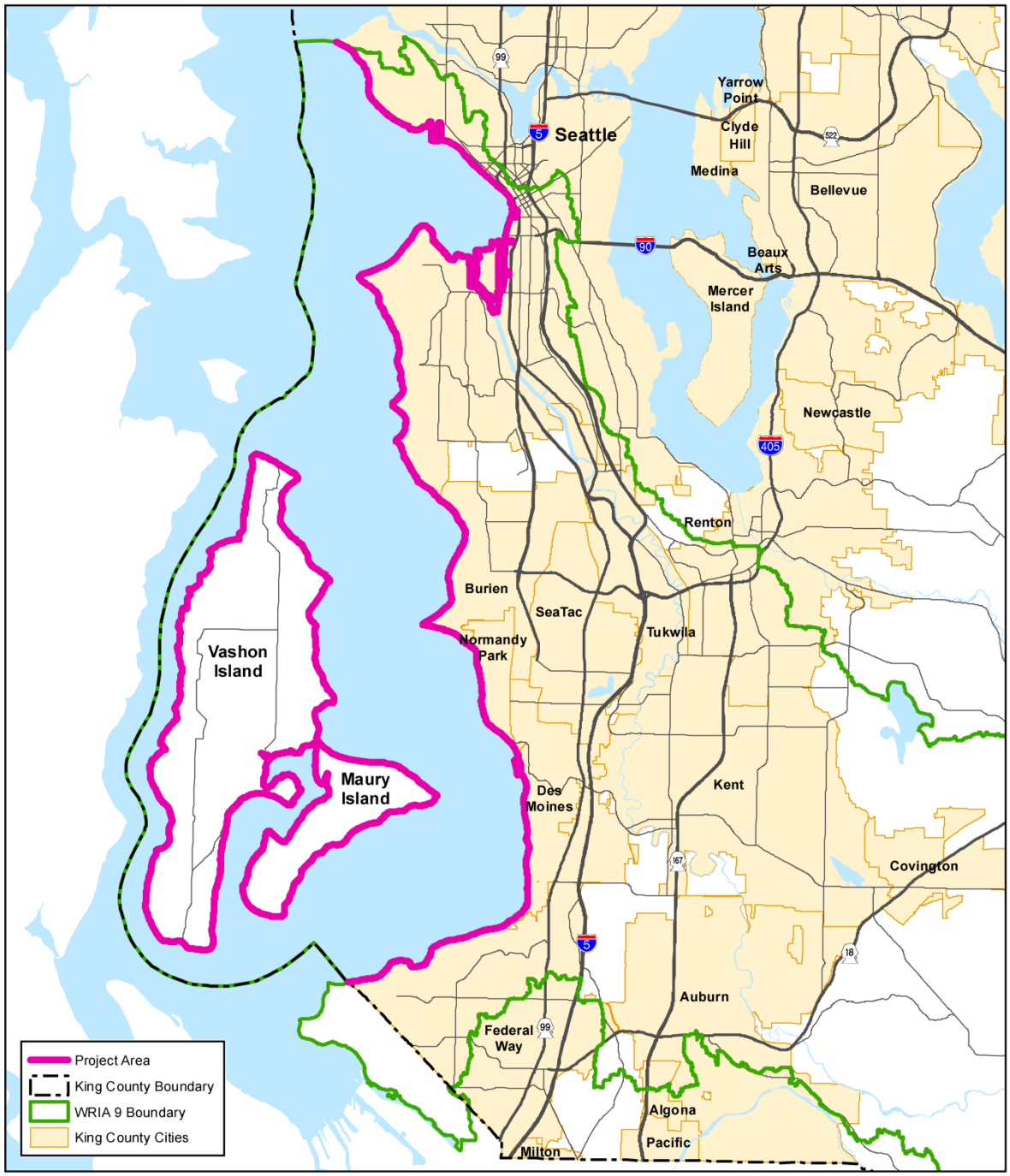

Figure 1. WRIA 9 Project Area

2.0. METHODS

2.1 Field Surveys

The primary research method consisted of surveying the entire WRIA 9 marine shoreline by boat. The surveys documented any new infrastructure that was not present during the 2004 surveys, any recent clearing activity, and any conditions that appeared to indicate that repairs or changes to existing infrastructure had been done recently. Specifically, the surveys assessed any changes to a subset of the 2004 baseline data (marine shoreline armoring, vegetation condition, boat ramps, overwater structures, breakwaters, and groins) and to other infrastructure or issues not previously documented in 2004. The latter category of changes included buildings (i.e. houses, sheds), mid-slope retaining walls, stairs to the beach, decks located near the water, and landslides.

The original intent of the project was to undertake surveys three years in a row to look at compliance rates over time. The hypothesis was that once shoreline landowners became more aware that someone was monitoring the shoreline for changes in condition the rates of non-permitted actions would decrease. However, given grant timelines only two years of surveys were undertaken and this hypothesis was not evaluated.

Two surveys were undertaken of the entire shoreline. Each survey took two days to complete. The surveys took place on Sept 10th and 12th of 2012 and on June 12th and 13th of 2013. A boat and pilot from the King County Environmental Lab were used to survey the shoreline. The boat was a shallow draft vessel that could travel relatively close to the shoreline at low tide.

Prior to each survey, a Trimble XT Global Positioning System (GPS) unit was loaded with background 2010 aerial photographs and baseline shoreline condition data from 2004. The GPS unit was used to both track where the boat was in relation to shore, as well as to compare the 2004 conditions to what was seen at the time of the survey. After the first day of surveying, a laptop with the same data was hooked up to the boat's GPS to greatly enhance the ability to compare existing to baseline conditions. A data dictionary was created that included standard descriptions of shoreline features to facilitate data gathering. The data dictionary included pull down menus for the type of change (i.e. armoring), associated material (i.e. wood, rock), status (i.e. new, major repair), steep slope (yes or no) and within 200 foot of the Ordinary High Water (OHW) and a comment field.

At every site where there appeared to be a change in condition, the surveyors documented the site's location by collecting GPS location data on the Trimble XT as well as with a separate GPS enabled camera. Multiple pictures were taken of each site. Generally at least one photograph was taken that zoomed in on the specific change as well as at least one picture that included multiple properties in the frame of view for additional reference points.

After the surveys, photographs and GPS data were downloaded and differential correction was undertaken in Pathfinder Office™ to improve the accuracy of the GPS location data. Once the GPS data were corrected they were imported into a geographic information system (GIS) and visually evaluated for accuracy and completeness. The location data associated with the individual field photographs was used to import individual field photos into GIS. Approximately 10% in 2012 and 2% in 2013 of the photographs did not have location data associated with the image's metadata. In those cases, location coordinates were manually input by comparing the image to the Trimble GPS data and aerial photographs.

It should be noted that surveys of some shoreline sections were more challenging than others. This was due to two primary reasons. First, during low tide, some areas required that the boat travel more than 500 feet off-shore in order to travel safely. While binoculars were used to track the shoreline, seeing some changes in condition was more challenging at that distance. Secondly, the sun's interaction with parts of the shoreline (west facing, steeper bluffs) created heavily shaded areas during part of the surveys, which made seeing some features challenging. These reasons caused some changes in condition to be missed in the 2012 survey. Therefore, at least some of the changes noted in 2013 were changes that occurred prior to the 2012 survey.

2.2 Analytical Methods

2.2.1 Data analysis

Changes in shoreline condition documented previously in the Status and Trends report (WRIA 9 Implementation Technical Committee, 2012) are not included in this report. It only covered changes in shoreline armoring and vegetation. Specifically, it report only documented changes from an armored shoreline to an unarmored shoreline or change in vegetation condition from dense or patchy trees along the shoreline to a different condition. Since those changes had already been documented, they were not documented again here.

Once the GPS data was imported into GIS, ancillary data was created for each issue noted in the field and appended to the imported GIS file. Each point was assigned a unique number identifier. Each point also had its parcel identification number, associated field photographs numbers and jurisdiction information added to the database. Each point went through a verification process to confirm that an actual change had occurred, when the change occurred, and to quantify the extent of change (i.e. length of bulkhead, area of vegetation clearing).

A combination of aerial, oblique and field photographs was used in the verification process. Aerial photography in the County's GIS library from 2012, 2010, 2009 (county wide), 2009 (Vashon/Maury Islands only), and 2007 were used. County wide oblique photos from 2011 and Department of Ecology statewide oblique photos from 2006 were also used. Field

photographs taken by Coastal Geologic Services in 2004 (Johannessen et al. 2004), Anchor Environmental in 2006 (Anchor Environmental 2006), King County in 2011 and 2012 were also used to verify conditions. Each group of photographs was assigned a column in the GIS file and was assigned an attribute of yes, no, unclear, or not applicable. Yes or no indicated that the change noted in the field was visible or not visible in that photograph. The unclear attribute was used when the aerial photograph did not show a clear enough picture of the change in question to be able to say one way or the other. Since the field photographs do not show the entire shoreline, there were many areas where there were no field photographs of the area in question. Those areas were attributed as "not applicable."

The status (new, major repair, minor repair, unclear) was initially established in the field, but later verified through analysis of various photographs. New indicates that there are no data showing that there was functioning shoreline infrastructure in that location previously. A visual approximation of 25% change or greater from baseline condition was used to differentiate between the minor repair and major repair categories. Unclear was used when it not possible to tell if a change in condition occurred or not. If after evaluating all available aerial images the change in question was still unclear, it was eliminated from further evaluation and is not included in the summary information in section three of this report.

Observations of landslides and clearing were noted in the field and potential causes were briefly evaluated in the field with further investigation carried out in the office. Slides were classified as unknown or anthropogenic in origin. Clearing issues were also roughly evaluated for any public safety issues based on best professional judgment. Clearing that occurred on a steep slope that was above residences, public roads, or public land was considered a potential public safety hazard. Changes in condition were also evaluated for potential hazards to navigation.

Once verifications of changes and compilation of ancillary data were completed, the data were broken out by jurisdiction. The pertinent data and field photographs were then shared with each jurisdiction. Jurisdictions were asked to determine if they had permitted the change in shoreline condition. If the change in condition was permitted at the time the condition changed, it was considered to be in compliance for the purposes of this project. If a jurisdiction was already in the process of addressing a permit issue or had already addressed a previously un-permitted change, the change in condition was still considered not in compliance for the summarized compliance information. Whether a change in condition was permitted was used to define the non-field verified compliance rate. Actual compliance has not yet been field verified by each jurisdiction. It is possible that once staff from a jurisdiction visit the site they will decide the change may have not needed a permit, and thus actually be in compliance.

Prior to initiating the project, several hypotheses were considered that might drive differences in compliance rate. One was the potential cultural differences between rural and urban landowners. Another hypothesis was that larger jurisdictions (Seattle and King County) have more staff resources than smaller jurisdictions allowing for more contact with their landowners and thus would have higher compliance rates. The other hypothesis

was that the denser the development of a particular area the more likely it would be in compliance because there would be more neighbors potentially watching what was going on in their neighborhoods. In addition to overall information by each jurisdiction, differences in compliance rates were compared between rural and urban areas, large cities versus small, and by property value, parcel density per mile of shoreline and parcel density within 500 feet of a parcel with a change in shoreline condition.

2.2.2 Ecological and Physical Effects

An assessment was made to quantify the potential effects of the observed changes on shoreline ecological condition. Defining the ecological effects of the changes in shoreline condition can be very challenging in any circumstance, but especially so after the change has occurred. For new docks, bulkheads or other infrastructure it is easier to describe the type of effects that typically have the potential to happen because the extent of change from the baseline condition is usually greater than the changes associated with repairing existing infrastructure. In the case of repairs to existing infrastructure however, the effects described are associated with the repair only. They do not include the original effects associated with the initial construction of the feature.

The baseline data on shoreline infrastructure were generally limited to location, area, length, and approximate elevation in relation to the Ordinary High Water (OHW) line. The data do not include general condition, material used for construction or the volume of material. The lack of detailed data on baseline condition made determining the ecological effects of repairs even more challenging.

Given that this assessment was done after the changes occurred, it is generally impossible to know what construction techniques or best management practices (BMPs) were used as part of construction. For unpermitted changes, it is generally not possible to know if project proponents followed the prescriptive construction times or other BMPs that minimize effects on migrating Endangered Species Act listed species or forage fish spawning seasons or in a manner protective of water quality. It is also not known if project proponents addressed potential water quality effects that construction activities of the types observed can easily create. Therefore, the effects described below in Table 1 should be considered potential effects that could be caused by the change observed in shoreline condition.

The evaluation of potential effects to shoreline processes primarily follows the format used by King County to analyze shoreline conditions in the characterization of marine shorelines for its Shoreline Master Plan update (King County 2007). Table 1 indicates the types of anthropogenic caused changes to processes as well as the physical and ecological effects of those changes that were used in the evaluation. Changes in a process can create corollary changes in how the physical and ecological environments are expressed. Where appropriate, descriptions of changes and analyses used previously mapped shoretypes (Johannessen et al. 2005) to provide context about the potential effects of the changes

encountered. The amount of sediment sources available or lost to a drift cell[1] was calculated as the linear shoreline length of feeder bluffs or exceptional feeder bluffs[2] that were present or lost when measured through surveys in 2005 (Johannessen et al 2005). There are at least three other types of effects which do not fit the format used in Table 1: 1) the potential water quality effect of casting concrete bulkheads in place; 2) the physical displacement of forage fish spawning habitat by any structure on the beach; 3) the increased risk to public safety through hazards to navigation or clearing of vegetation on steep slopes which may reduce slope stability.

[1] Drift cells are discreet reaches of marine shore in which littoral drift may occur without significant interruption and which contains sediment sources (feeder bluffs) and accretion shore forms created by such drift. Littoral drift is the process by which beach sediment is moved along the shoreline.

[2] Feeder bluff (FB) and Exceptional Feeder bluffs (EFB) were mapped in 2004. EFB classification was applied to rapidly eroding segments of shoreline that had the highest volume of sediment input per linear foot. Normal feeder bluffs have substantial, but periodic sediment input

Table 1. Summary of potential changes to processes and associated ecological effects caused by different shoreline activities.

Physical Process	Potential changes to process and physical effects	Potential ecological effects of changes
Sediment Delivery	Shoreline armoring at feeder bluffs decreases input; clearing of vegetation and construction of stairs can increase rate of delivery; Docks can create shell hash over time as shelled animals growing on the dock die and their shells accumulate on the sea floor.	Can reduce amount and quality of shallow water habitat; Can reduce the amount and quality of forage fish spawning habitat; Shell hash can reduce suitability of substrate for eelgrass to grow and can change the invertebrate species composition in that area.
Sediment Transport	Groins, shoreline armoring and docks can all decrease the rate or ability of sand and gravel to move along the beach as well as change the sizes of sand and gravel on the beach.	Can reduce amount and quality of shallow water habitat; Can reduce the amount and quality of forage fish spawning habitat.
Light Energy	Docks and aquaculture reduce the transmission of light during the day; houses and other buildings generally increase light at night; Clearing of vegetation can increase the delivery of light energy to the upper beach during the day.	Shade cast by docks and aquaculture can reduce the ability for eelgrass to grow and change the migration patterns of juvenile salmon. More light energy on the upper beach increases the temperature of the substrate, reduces humidity, increases rate of desiccation of intertidal organisms; Increase of light at night can affect migration patterns of invertebrates.
Organic Material Accumulation	Clearing of riparian vegetation reduces delivery of insects and both small material (leaves) and large wood; shoreline armoring and docks reduce the ability to store material that allows nutrient cycling to occur in the upper beach.	Clearing of vegetation can reduce prey amounts for juvenile salmonids; Shoreline armoring typically displaces the beach berm which then eliminates the beach's ability to accumulate detritus. The detrital based food web provides food for a variety of invertebrates which are eaten by shorebirds and fish.
Wave Energy	Aquaculture and docks intercept wave energy and reduce its interaction with the shoreline; shoreline armoring changes the way in which wave energy interacts with the shoreline and can cause coarsening of the beach. Over time shoreline armoring can also cause the beach to become steeper and narrower as the wave energy is not allowed to cause landward migration of the beach.	Can reduce the amount and quality of shallow water habitat; Can reduce the amount and quality of forage fish spawning habitat; Can alter the benthic and epibenthic invertebrate community composition.

3.0. RESULTS

The WRIA 9 marine shoreline (study area) is 92 miles long and has six different local governments with jurisdiction over the shoreline (Table 2 and Figure 1). The islands account for slightly over half of the study area. They are zoned rural while the mainland portion of the WRIA is incorporated by one city or another and generally has denser zoning. The information below presents many changes in shoreline condition observed during the study period that were not documented as part of the WRIA 9 Status and Trends Monitoring Report 2005-2010 (WRIA 9 Implementation Technical Committee 2012).

Table 2. Miles and percent of shoreline of each WRIA 9 marine jurisdiction.

Jurisdiction	miles	%
Burien	4.99	5%
Des Moines	5.83	6%
Federal Way	4.69	5%
Normandy Park	3.48	4%
Seattle	21.56	24%
Unincorporated King County	51.15	56%
total	91.70	100%

3.1 Shoreline Changes by Survey

3.1.1 The 2012 Survey

Surveys of the entire WRIA 9 shoreline took place on Sept 10 and 12 of 2012. Over 900 photographs were taken of various shoreline changes. There were 85 distinct changes noted in shoreline condition (Figure 2 and Table 3). Photographs of example changes can be found in Appendix B. Seventy percent of the changes found were repairs or complete rebuilds to existing infrastructure. Changes associated with shoreline armoring accounted for 63% of the changes noted, with most changes associated with repairs to existing shoreline armoring infrastructure. Only 4 of the 53 changes in shoreline armoring were new bulkheads which didn't exist in 2004 or where it was no longer functioning. Almost 12% of the changes noted were associated with docks and other overwater structures, while another 10% were associated with the clearing of vegetation along the shoreline. Most of clearing changes occurred in unincorporated King County. The remainder of the changes were composed of a mixture of alterations to the shoreline including new or substantially altered buildings, staircases, aquaculture facilities and ramps.

The majority of the changes (77%) occurred in unincorporated King County (Table 4). Unincorporated King County accounts for only 56% of the shoreline of WRIA 9, thus it had

a disproportionate share of the changes. The remainder of the changes were spread among the rest of the jurisdictions. All the changes in overwater structures occurred in unincorporated King County. Seven new overwater structures (i.e. docks and decks) as well as 3 minor repairs to existing docks were encountered during the survey. One dock had also been removed at Maury Island Marine Park.

Table 3. Type and status of changes for each survey.

		2012 survey		2013 survey		Both years combined	
Type	Status	#	%	#	%	#	%
Armoring	major repair	26	31%	10	17%	36	25%
Armoring	minor repair	22	26%	8	13%	30	21%
Armoring	new	5	6%	2	3%	7	5%
Stairs	all	7	8%	9	15%	16	11%
Docks	all	10	12%	5	8%	15	10%
Decks	all	0	0%	2	3%	2	1%
Clearing	all	8	9%	7	12%	15	10%
Houses	all	3	4%	7	12%	10	7%
Retaining wall	all	0	0%	7	12%	7	5%
Ramps	all	2	2%	2	3%	4	3%
Other	all	2	2%	1	2%	3	2%
	total	85	100%	60	100%	145	100%

Table 4. Number and percent of changes by jurisdiction and length/percent of shoreline.

Jurisdiction	2012		2013		Miles of shore
	#	%	#	%	
Burien	3	2%	11	18%	4.99
Normandy Park	1	1%	4	7%	3.48
Des Moines	2	2%	9	15%	5.83
Federal Way	5	6%	3	5%	4.69
Seattle	9	11%	5	8%	21.56
County	65	77%	28	47%	51.15
Total	85	100%	60	100%	91.70

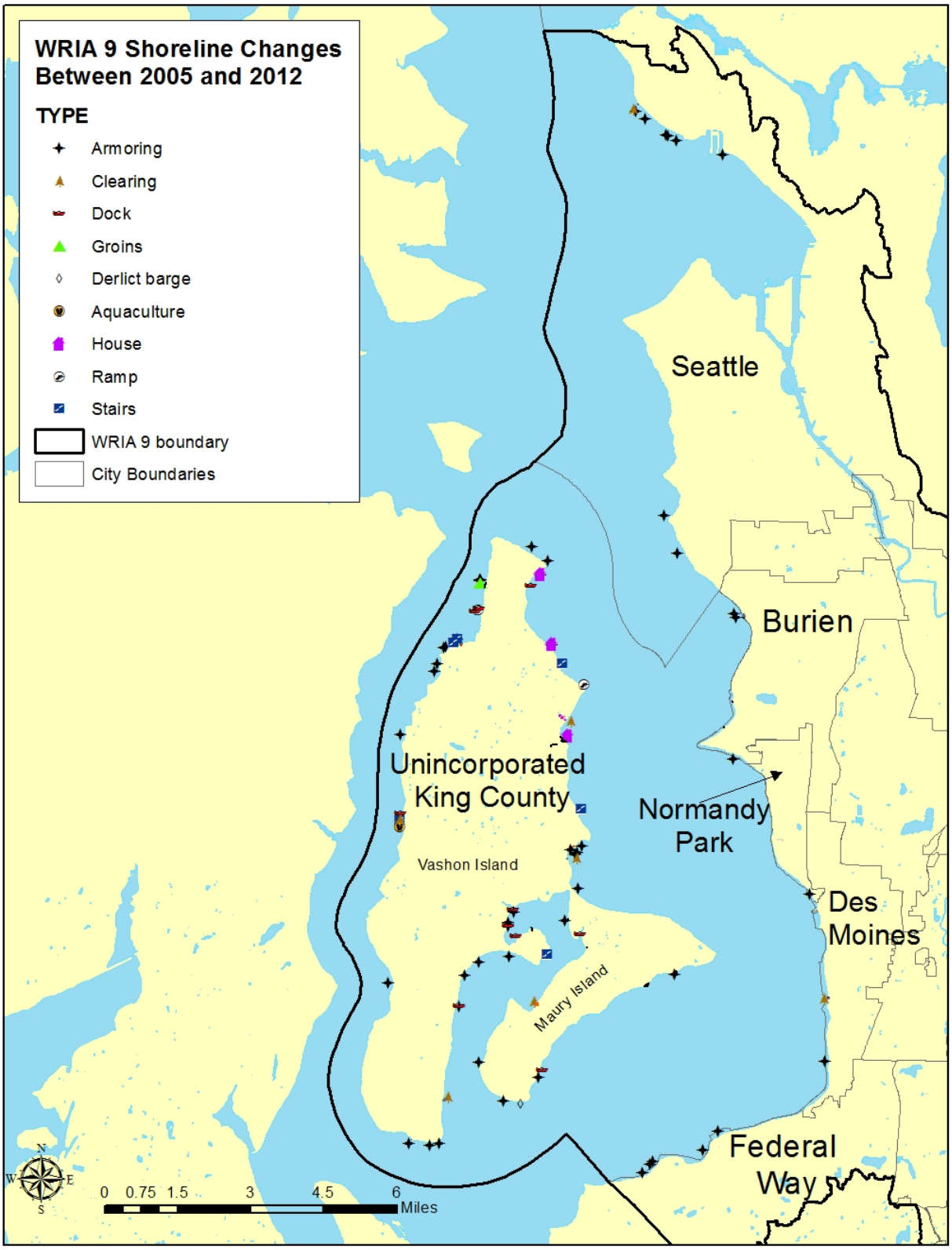

Figure 2. Locations of changes in shorline condition in 2012.

3.1.2 The 2013 Survey

The second set of surveys took place on June 12th and 13th of 2013. The first day of the survey covered the mainland portion of WRIA 9 as well as most of Maury Island. The second day of surveying completed the rest of Maury Island and all of Vashon Island. Over 500 photographs were taken of various shoreline changes. Many of the photographs show the same feature from different angles.

There were 60 changes noted in shoreline condition in 2013 (see Figure 3 and Table 3). Example photographs of changes can be found in Appendix B. When establishing the approximate date of when the change occurred, it was noted that some of the changes occurred prior to the 2012 survey, but were not noted during that survey. Thirty-three percent of the changes found were associated with shoreline armoring. Increases in the proportions of new houses, clearing, and retaining walls offset the decreases in changes to shoreline armoring. Changes in shoreline armoring accounted for 24 of the changes noted. Only 2 of the 24 changes in shoreline armoring were new bulkheads where one didn't exist previously. All of the changes in overwater structures (e.g. docks and decks) occurred in unincorporated King County. There was one new dock observed in Raab's Lagoon. Two of docks had their creosote pilings replaced with steel pilings along with minor modifications to the dock footprints. As with 2012, the majority of the observations of clearing occurred in unincorporated King County.

The largest number of changes (48%) occurred in unincorporated King County (see Table 4), which was a dramatic decrease from representing 78% of changes noted in 2012. Given that unincorporated King County accounts for 56% of the shoreline of WRIA 9, it accounted for a smaller share of the changes in shoreline condition per mile of shoreline. There were relatively large increases in the proportion of shoreline changes in the cities of Burien, Normandy Park and Des Moines between 2012 and 2013.

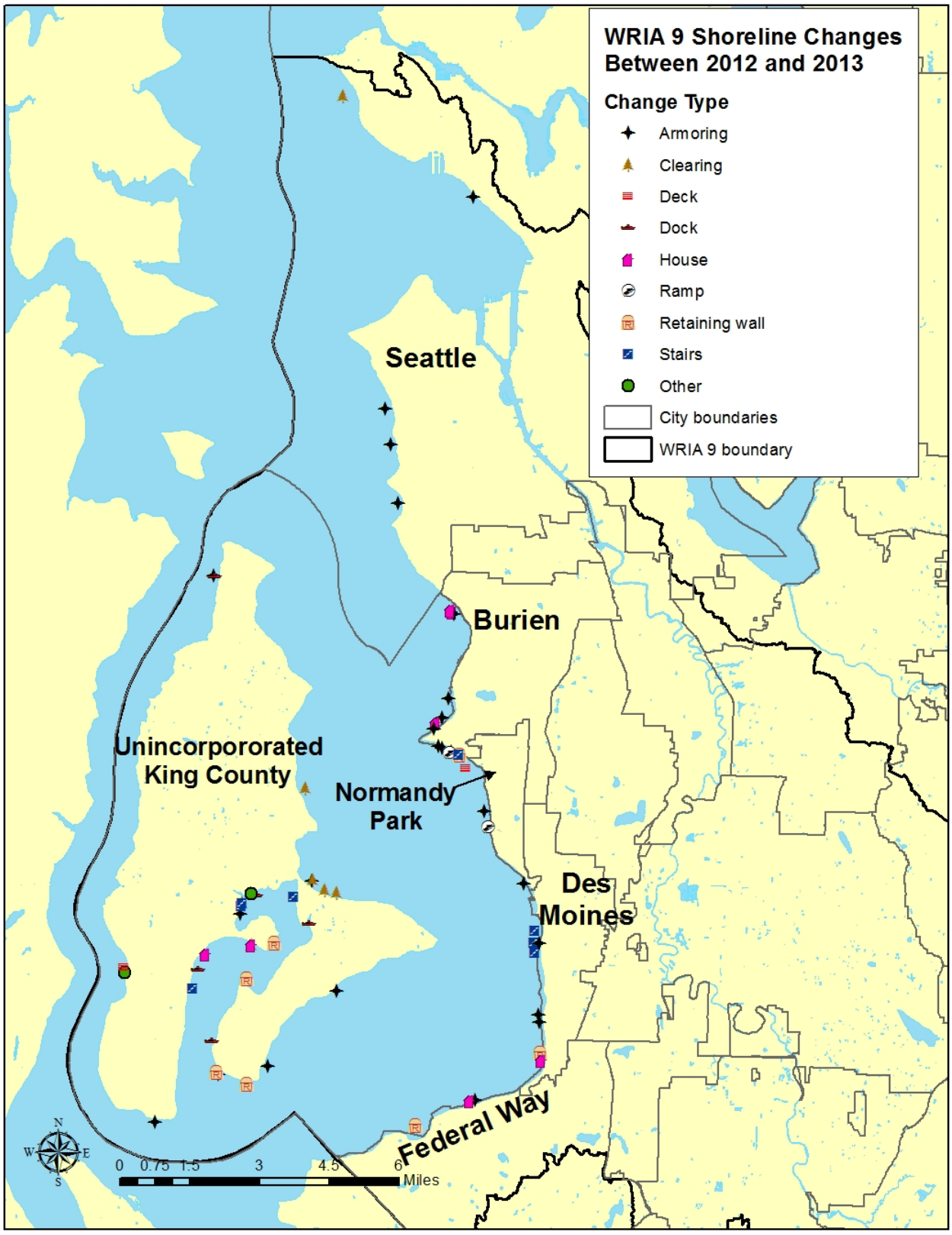

Figure 3. Locations of changes in shorline condition in 2013.

3.2 Compliance Rates

As part of the following section, compliance is defined as having gone through the appropriate local government to apply for and attain permits to undertake the change in condition that was observed during the surveys. Most of the changes that are described as 'not permitted' have not been field verified by the specific local government permitting staff as to whether or not a permit was needed. It is possible that once permitting staff visit the site they may decide that the change did not need a permit. Thus, the compliance rates described below should be considered unconfirmed or 'non-field verified'. They merely indicate whether or not the change was permitted. Each jurisdiction will need to verify on the ground conditions to confirm if a change was truly in compliance or not.

For all summary information included in this section, if a change in condition went through code enforcement in order to come into compliance, it was still considered not in compliance for the purposes of this report. This is because the change in condition was not originally permitted or in compliance when the change to shoreline condition occurred. This provides a more accurate representation of the initial compliance rate experienced. At the same time, it should also be noted that many of the observed changes that are considered to be out of compliance are likely actions that could be brought into compliance through the code enforcement process. It is likely that only a small number of the unpermitted changes observed would not be able to be permitted as they now appear. For example, King County's permitting department indicated that roughly 80% of the unpermitted changes in 2012 could be permitted while only 10% were likely changes that could not be permitted.

The analysis focused on local permits only. At this time, it is not clear if the any of changes encountered received Hydraulic Permit Approvals from the Washington Department of Fish and Wildlife (WDFW). Given the large number of changes in shoreline condition and time required to research each issue, WDFW was not able to verify if the conditions noted in these surveys were permitted or not. However, the permit process tends to be coordinated, such that if a landowner gets a permit from a local jurisdiction the landowner is typically required by that permit process to show permits from the WDFW. Therefore it is likely that any changes in condition with a local permit likely had a state permit, and vice versa.

When the type of change is combined across both years and the compliance rate is compared, changes associated with houses had the highest compliance rate, with 70% compliance (Table 5). Of the other types of changes, those associated with shoreline armoring had the next highest compliance rate with 38% (Table 5). The remaining types of changes had less than 30% compliance rates (Table 5).

Table 5. Compliance rate for both years combined by type of change.

	Permitted		Not Permitted	
	#	%	#	%
armoring	28	38%	45	62%
clearing	2	14%	12	86%
houses	7	70%	3	30%
docks	4	27%	11	73%
stairs	2	13%	14	88%
other	3	19%	13	81%

3.2.1 2012 Survey

A complete breakdown of which changes were permitted in each jurisdiction is included in Table 6. Only 19 or 22% of all the changes in shoreline condition that were observed throughout WRIA 9 were in compliance when the change in condition happened. The compliance rate for each jurisdiction varied from 0 to 100%, with an average rate across all jurisdictions of 34% (Table 7). There were no patterns seen when smaller sized jurisdictions were compared to larger sized jurisdictions. The compliance rate was much higher in the urban area (50%) than the rural area (14%).

Of all the types of changes in condition, only changes to shoreline armoring occurred with enough frequency to allow an evaluation of patterns between urban and rural areas. When all the types of shoreline armoring are combined, the urban areas had a compliance rate of 50% while the rural area (unincorporated King County) had a compliance rate of 20%. The average compliance rate for all types of shoreline armoring combined across all jurisdictions was 30%. Compliance rates of major and minor repairs followed similar patterns. In urban areas the compliance rate for major repairs was 56% and for minor repairs the compliance rate was 43%, whereas the rate for the unincorporated County area was 29% for major repairs and only 7% for minor repairs. The average compliance rate across all jurisdictions for major repairs was 38% while it was only 18% for minor repairs.

Table 6. Summary changes compliance status in 2012.

Jurisdiction	Type	Status	#	Permitted	NOT permitted	Closed code enforcement	Open code Enforcement
Burien	Armoring	Major repair	1	1			
Burien	Armoring	Minor repair	1	1			
Burien	Armoring	New	1	1			
Normandy Park	Armoring	Major repair	1			1	
Des Moines	Armoring	Major repair	1		1		
Des Moines	Clearing	Recent	1		1		
Federal Way	Armoring	Major repair	2		2		
Federal Way	Armoring	Minor repair	2	1	1		
Federal Way	Armoring	New	1		1		
Seattle	Armoring	Major repair	4	4			
Seattle	Armoring	Minor repair	4	1	3		
Seattle	Clearing	Recent	1	1			
County	Armoring	Major repair	17	5	11	1	
County	Armoring	Minor repair	15	1	13	1	
County	Armoring	New	3	1	2		
County	Clearing	Recent	6		6		
County	Dock	New	6	1	4	1	
County	Docks	Removed	1	1			
County	Docks	Minor repair	3		3		
County	Groins	New	1		1		
County	Stairs	New	7		6	1	
County	Houses	New	3		1	1	1
County	Aquaculture	New	1		1		
County	Ramps	New	2		2		
		Total	85	19	59	6	1
		%	100%	22.4%	69.4%	7.1%	1.2%

Table 7. Summary of which changes that were in compliance with local permits in 2012.

2012				
Jurisdiction	# of changes	% of total	% compliance	% Non compliance
Burien	3	3.53%	100%	0%
Normandy Park	1	1.18%	0%	100%
Des Moines	2	2.35%	0%	100%
Federal Way	5	5.88%	20%	80%
Seattle	9	10.59%	67%	33%
County	65	76.47%	14%	86%
total	85	100.00%		
Avg			34%	67%
2013				
Burien	11	18%	73%	27%
Normandy Park	4	7%	25%	75%
Des Moines	9	15%	56%	44%
Federal Way	3	5%	0%	100%
Seattle	5	8%	60%	40%
County	28	47%	29%	71%
Total	60	100%		
Avg			43%	57%

3.2.2 2013 Survey

A complete breakdown of which changes were permitted in each jurisdiction is included in Table 8. As seen in Table 8, only 25 or 42% of all the changes in shoreline condition that were observed throughout WRIA 9 were in compliance and permitted when the change in condition happened. The compliance rate within each jurisdiction varied from 0 to 73%, with an average rate across all jurisdictions of 43% (Table 7). The average of small and the one large city jurisdiction had roughly the same compliance rate (52% and 60% respectively) when all categories of change were combined. As in 2012, when the urban area was compared to the rural area the compliance rate was much higher in the urban area (55%) than the rural area (29%).

Of all the types of changes in condition that occurred, only enough changes to shoreline armoring occurred to allow an evaluation of patterns between urban and rural areas. When all the types of shoreline armoring are combined, the urban areas had a compliance rate of 67% while the rural area (unincorporated King County) had a compliance rate of 40%. The average compliance rate for all types of shoreline armoring combined across all jurisdictions was 60%. There were not enough instances of changes within the new, major repair, or minor repair categories of shoreline armoring to describe patterns in the 2013 survey.

Table 8. Summary changes compliance status in 2013.

Jurisdiction	Type	Status	#	Permitted	NOT permitted	Closed code enforcement
Burien	Armoring	Major repair	2	2	0	
Burien	Armoring	Minor repair	2	1	1	
Burien	Armoring	New	1	1	0	
Burien	House	New	2	2	0	
Burien	House	removed	1	1	0	
Burien	Retaining wall	Minor repair	1	1	0	
Burien	Stairs	Major repair	1	0	1	
Burien	Ramp	Major repair	1	0	1	
Normandy Park	Armoring	Major repair	1	0	1	
Normandy Park	Armoring	Minor repair	1	1	0	
Normandy Park	Deck	Major repair	1	0	1	
Normandy Park	Ramp	new	1	0	1	
Des Moines	Armoring	Major repair	2	1	1	
Des Moines	Armoring	Minor repair	1	1	0	
Des Moines	House	New	1	1	0	
Des Moines	Retaining wall	New	1	1	0	
Des Moines	Stairs	new	2	0	2	
Des Moines	Stairs	Major repair	2	1	1	
Federal Way	Armoring	Minor repair	1	0	1	
Federal Way	House	Major repair#	1	0	1	
Federal Way	Retaining wall	Major repair	1	0	1	
Seattle	Armoring	New**	1	1	0	
Seattle	Armoring	Major repair	3	2	1	
Seattle	Clearing	Recent	1	0	0	1
County	Armoring	Major repair	2	2	0	
County	Armoring	Minor repair	3	0	3	
County	Clearing	Recent	6	1	5	
County	Dock	New	1	0	1	
County	Dock	Major repair	4	2	2	
County	Deck	Major repair	1	0	1	
County	Stairs	New	2	0	2	
County	Stairs	Major repair	2	0	2	
County	Houses	New	2	2	0	
County	Retaining wall	New	3	1	2	
County	Retaining wall	Minor repair	1	0	1	
County	Other	New	1	0	1	
		Total	60	25	34	1
		%	100%	41.7%	56.7%	1.7%

3.2.3 Compliance Evaluation

Describing the compliance data by rural versus urban in the previous section may not be appropriate because the reason for differences in compliance rates may not be linked to urban versus rural areas. A thorough evaluation of why changes occurred was not possible with the data that was collected as part of this project. However, the project included a modest evaluation of compliance data to explore whether compliance rates were related to shoreline parcel density, development patterns (i.e. sparse development at the bottom of bluffs) which vary across each jurisdiction or land values.

In order to compare parcel density to compliance rates, the number of parcels per mile of shoreline was evaluated for all WRIA 9 jurisdictions. Burien had the highest shoreline density with an average of 83 parcels per mile, while Seattle and unincorporated King County had the lowest with 39 parcels per mile (Table 9). While one would expect the rural area to have a lower number of parcels per mile than urban areas, much of the parcel pattern on Vashon and Maury islands was created before contemporary zoning patterns. Some areas of Vashon and Maury Islands have a very high density of parcels which offset the other areas with moderate sized parcels. Conversely, it was expected that Seattle would have the highest parcel density being the oldest and most populous city in the study area. The overall lower parcel density in Seattle is because several areas with relatively large parcel sizes along the Magnolia Bluff area, Lincoln Park and within Elliot Bay waterfront account for almost 6 miles of Seattle's 21 miles of shoreline.

Table 9. Compliance related to parcel density.

Jurisdiction	# of parcels per mile	# of parcels/mile with a permitted change	# of parcels/mile with a non-permitted change	% of parcels per mile with a permitted change	% of parcels per mile with a non-permitted change
Seattle	38.7	0.4	0.2	1%	1%
Unincorporated King County	39.4	0.3	1.5	1%	4%
Normandy Park	47.6	0.3	1.1	1%	2%
Federal Way	49.2	0.2	1.5	0%	3%
Des Moines	54.5	0.9	1.0	2%	2%
Burien	82.8	2.2	0.6	3%	1%

Both years of data were combined to compare compliance rates to parcel density. When the number of noncompliant parcels per mile is compared by jurisdiction, King County and Federal Way had the same highest rate of 1.5 parcels per mile of shoreline, while Seattle had the best rate of 0.2 parcels per mile of noncompliance (Table 9). Burien had the highest shoreline parcel density and also had the highest compliance rates, both by parcel density and based on the total percent that were permitted versus not (Table 9). This fits with the hypothesis that the denser the development pattern the more likely compliance will occur. However, this possible pattern of denser developed areas having higher compliance rates did not hold with the remaining jurisdictions.

In order to explore the parcel density issue at a finer scale, compliance rates were evaluated by the density of parcels 500 feet on either side of the parcel where a change in condition occurred in 2012. This should provide a more site specific evaluation of parcel density than the previous analysis which used parcel density of the entire jurisdiction. This more site specific evaluation showed that parcel density was roughly equal for compliant and non-compliant parcels throughout the study area and confounds the initial finding of higher compliance within Burien with the overall highest parcel density.

Permitted and non-permitted changes were compared with appraised value of land and improvements to see if any patterns arose. Both appraised land value and improvement value were higher for properties that had gone through the permit process compared to those that had not. There was almost a $200,000 difference in appraised improvement value between compliant and non-compliant properties. This may indicate that landowners believe that the permitting process is too expensive.

When evaluating compliance, it is important to note that the properties that did not have any changes occur during the two surveys were also in compliance with the existing rules and regulations. This is reflected in the rate of development activity that occurred between 2004 and 2013, as identified in the two surveys. The range of the percent of properties that had no development activity or were permitted was 96 to 99 % of all properties in WRIA 9 (Table 9).

3.3 Ecological Effects

The following subsections describe each of the important ecological or physical processes, the range and types of effects changes in condition can have on these processes and summarizes the effects of some of the changes found in the surveys. It is important to note that the actual effect of each change is very site specific; Appendix A provides a table with a breakout of each of the observed changes' potential impact. It is also important to note that both permitted and unpermitted changes in shoreline condition have the potential to create physical and ecological effects.

3.3.1 No effects

After evaluating the changes that were observed against the potential range of ecological effects described in Section 2.2.2, there were changes that occurred that did not appear to have any obvious effect (positive or negative) on shoreline conditions. For a complete list of changes that had no obvious effect see Appendix A.

In the 2012 survey, 40% of the changes to shoreline condition did not appear to have any obvious effects, and were spread throughout the study area (Table 10). No obvious effect occurred 54% of the time where a preexisting bulkhead had major repairs and 86% of the time where a preexisting bulkhead had minor repairs made to it (Table 11Table 11).

In the 2013 survey, 38% of the changes encountered did not appear to have any obvious effects and they were spread throughout the study area as in the 2012 survey (Table 10). No obvious effect occurred 60% of the time where a preexisting bulkhead had major repairs and 75% of the time where a preexisting bulkhead had minor repairs made to it (Table 11).

Table 10. Number and percent of changes with no obvious effect by jurisdiction.

Jurisdiction	2012				2103			
	Total Changes encountered		Changes with no obvious effect		Total Changes encountered		Changes with no obvious effect	
	#	%	#	%	#	%	#	%
Burien	3	4%	0	0%	11	18%	6	55%
Normandy Park	1	1%	1	100%	4	7%	3	75%
Des Moines	2	2%	0	0%	9	15%	3	33%
Federal Way	5	6%	4	80%	3	5%	1	33%
Seattle	9	11%	6	67%	5	8%	2	40%
King County	65	76%	23	35%	28	47%	8	29%
total	85	100%	34	40%	60	100%	23	38%

In both years, new bulkheads, clearing of vegetation, stairs to the beach, and changes to docks had high percentage of obvious effects.

Table 11. Number and percent of changes with no obvious effect by type and status of change.

Type	Status	2012				2013			
		Total Changes encountered		Changes with no obvious effect		Total Changes encountered		Changes with no obvious effect	
		#	%	#	%	#	%	#	%
Armoring	Major repair	26	31%	14	54%	10	17%	6	60%
Armoring	Minor repair	22	26%	19	86%	8	13%	6	75%
Armoring	New	5	6%	0	0%	2	3%	0	0%
Docks	All	10	12%	0	0%	5	8%	1	20%
Clearing	All	8	9%	0	0%	7	12%	0	0%
Stairs	All	7	8%	0	0%	9	15%	3	33%
Other	All	7	8%	1	7%	19	32%	10	53%

3.3.2 Ecological Effects

3.3.2.1 Sediment Delivery

The delivery of sediment to the beach via bank and bluff erosion is ecologically important because the beach ecosystem is highly dependent on the type of sediment present on the beach. The majority of material that makes up a beach originates from bluffs along Puget Sound. Without sediment input from bluffs, beaches can become sediment starved over time which leads to degraded habitat for a wide range of organisms that rely on the nearshore environment for some or all of their life cycle. Changes to bulkheads, clearing of vegetation and docks can change how much and the rate at which sediment reaches the nearshore.

Shoreline Armoring

The vast majority of the bulkhead repairs observed in both years did not affect the delivery of sediment since the bulkhead was already in place. Any impact to sediment delivery was already occurring before the current change in condition. .

In the 2012 survey, there were four new bulkheads, with two new bulkheads that will likely affect the amount of sediment reaching the beach both in the near term as well as longer term. This is because the three new bulkheads were installed on relatively active sources of sediment (feeder bluffs) for that particular drift cell while the other two were built on relatively stable transition zone shoreforms. In total, armored shoreline replaced 292 feet of Exceptional Feeder Bluff, 210 feet of Feeder Bluff, and 100 feet of Transition Zone.

The longest new bulkhead found in the surveys was an unpermitted 292 foot long log bulkhead located near Neill Point on the southeast tip of Vashon Island. The bulkhead is located at the very beginning of drift cell Ki-13-21[3]. The new bulkhead is composed of cabled logs along the toe of a bluff that was characterized as an exceptional feeder bluff in 2004 (Johannessen et al. 2005). The new bulkhead reduced the linear amount of available exceptional feeder bluff in the drift cell from 13% to 8% and increased the total loss of sediment sources from 67% to 75%. Given its location at the beginning of the drift cell, and its relatively large reduction of overall sediment sources, this bulkhead will likely have negative effects across the entire drift cell.

The other of the two new bulkheads that will likely have a short and long term effect is located on the northwestern side of Vashon Island, in drift cell Ki-11-5. The unpermitted new bulkhead was created from relatively small rock that likely came from the property. The 110 foot bulkhead is located at the beginning of the drift cell, which is approximately two-thirds of a mile long and 56% armored. The drift cell feeds Peter Point, which represents a rare salt marsh accretion shoretype. The new bulkhead reduced the amount of feeder bluff from 31% to 27% and increased the total loss of sediment sources from 22% to 31%. Given its location at the beginning of the drift cell and that is has reduced sediment

[3] See https://fortress.wa.gov/ecy/coastalatlas/tools/Map.aspx for a map showing the location of various drift cells noted.

sources by almost 10%, it will likely affect the entire drift cell including the salt marsh at Peter Point.

The other two new bulkheads will likely affect the amount of sediment reaching the beach over the long term, but not necessarily in the short term. These two permitted bulkheads were installed in front of a transition zone shoretype in Federal Way and Burien. Transition zone type shoreline was classified as a relatively stable bluff that appeared to be in equilibrium with the beach environment and not contributing much sediment to the beach system (Johannessen et al. 2005). With the predicted rates of sea level rise in Central Puget Sound, it is expected that transition zone shoretypes will eventually become active feeder bluffs.

Another bulkhead located in Tramp Harbor and was originally considered a new rock bulkhead during the survey, but was later reclassified as a major repair because the County's Department of Permitting and Environmental Review permitted it as such. While the original wooden bulkhead was considered present in the 2004 baseline surveys, it was considered nonfunctioning in 2010 as part of the Status and Trends report analysis (WRIA 9 Implementation Technical Committee 2012). Erosion of the feeder bluff was occurring behind the remains of the failed bulkhead. The rebuilt bulkhead is approximately 100 feet long and occurs at the beginning of drift cell Ki-13-6, which is four miles long. The increase in armoring increased the total loss of sediment sources within this drift cell from 29% to 30%. While the total area affected by the bulkhead is relatively small, given that this bulkhead occurs within the first quarter of the drift cell the reduction of sediment will likely affect a relatively large area over time.

In the 2013 survey, two new bulkheads were encountered, both of which were permitted. The first bulkhead replaced 57 feet of feeder bluff shoreline that was located between two existing bulkheads and represents a loss of sediment delivery. The bulkhead that replaced 57feet of feeder bluff occurred in last third of drift cell Ki-7-2. This drift cell feeds the north side of Three Tree Point in Burien. The drift cell is armored for slightly over 95% of its length and had less than 1% of its sediment sources intact. The new bulkhead eliminated the last known source of sediment for this drift cell.

The other bulkhead encountered was a 100 foot long bulkhead located on an accretion shoreform. The 100 foot long bulkhead should not affect the sediment delivery and is a temporary structure associated with construction near the Fauntleroy ferry dock.

Clearing

Clearing of vegetation along steep shoreline slopes or bluffs can increase the rate of sediment delivery by destabilizing the slope and increasing the frequency of landslides. While surficial erosion can happen relatively quickly, more significant slope destabilization can take several years to manifest itself due to the time it takes for roots to rot and lose their tensile strength. Only one of the 15 occurrences of clearing was permitted.

In the 2012 survey, there were eight occurrences of clearing with only one permitted. There were four instances of recent unpermitted clearing on Vashon Island that could

potentially increase the rate of sediment delivery. There was no evidence of surficial erosion of slope instability at the time of the survey. There was one instance in Des Moines near Saltwater State Park where the survey observed a landslide in area that the author had observed an unpermitted clearing and tree topping the year prior during a site visit to the Park. The remaining three instances did not likely affect sediment delivery.

In the 2013 survey, only one of the seven instances of clearing appeared likely to cause slope stability issues. The landowner of this site in Seattle had already addressed the issue by replanting the entire cleared area as part of mitigation for the unpermitted clearing that had gone through an enforcement action. It is likely that given the lag time between the previous vegetation's roots rotting and the new vegetation's ability to help strengthen the slope stability, the site will still be vulnerable to increased instability for some time.

Docks

In the 2012 survey, all ten changes associated with docks or overwater structures occurred along Vashon and Maury Islands. Six unpermitted changes were very minor modifications to existing docks or new overwater decks that barely extended out into the intertidal such that they would not likely have an effect related to sediment delivery (creating shell hash). Of the other four changes associated with docks, three have the potential to create limited areas of shell hash substrate. Only one of these three docks was permitted. The remaining change in dock condition was a permitted removal of a substantial dock from Maury Island Marine Park. Given the age of that dock and its original location in subtidal waters, it likely generated enough shell hash that it will take time for natural sedimentation to restore the substrate in the area of the dock.

In the 2013 survey, all five changes associated with docks or overwater structures occurred along Vashon and Maury Islands. The three unpermitted and one of the two permitted changes to the docks likely changed the amount of shell hash that would be generated over time because the two new structures are close to shore. One permitted change was shortening the length of an existing dock, which will likely result in a net positive change in the long term. However, it likely generated enough shell hash over the years that it will take time for natural sedimentation to restore the substrate in the area of where the dock previously extended.

3.3.2.2 Sediment Transport

Throughout the study area, the observed changes were likely to have relatively little effect on sediment transport. However, it should be noted that the baseline conditions for sediment transport throughout the study are degraded with 151 groins, over two hundred overwater structures, as well as 51% of the 92 miles of the shoreline have bulkheads that are physically located below the Ordinary High Water line.

2012

Two new unpermitted groins were found in drift cell Ki-11-2. This drift cell already had the largest number of groins throughout the study area, with 25 of the 151 groins. The groins were constructed in locations that replaced old nonfunctioning groins. The new

groins are roughly 20 feet long and protrude above the beach approximately 1 foot. The length of new groins is about one-fourth the average size of groins in this drift cell.

As with the sediment delivery, the repaired bulkheads generally did not impair sediment transport beyond the existing degraded baseline condition. Of the five new bulkheads described earlier in the sediment delivery section (3.3.2.1), three of them did not likely have any effects on sediment transport because they were constructed far enough back on the beach that they would not interfere with the movement of sediment along the beach. The unpermitted log bulkhead at Neill Point and the permitted rock bulkhead in Tramp Harbor were both built below the Ordinary High Water line and thus can affect the amount of sediment moving along the beach.

Of the ten changes associated with overwater structures three were decks that extended over the water and three were minor repairs to existing docks. These six unpermitted changes likely did not affect sediment transport. The complete removal of the large dock at Maury Island Marine Park likely affected sediment transport positively by allowing free movement of sediment wood along the shoreline. Of the remaining three docks, one unpermitted structure was located within Raab's Lagoon. There is no movement of sediment along the beach within the lagoon, so the dock did not affect sediment transport. The remaining two docks (one permitted and one not) extend far enough out into the intertidal where they may affect sediment transport, but it is not clear to what extent.

2013

No new groins were found in the 2013 survey. Of the two new permitted bulkheads, one was built between two existing bulkheads and was set back into the slope. Thus it is very unlikely to cause any effect on sediment transport. The temporary bulkhead likely effected sediment transport while it was in place, but the effects should dissipate after it is removed. Similar to 2012, most of the bulkhead repairs did not affect the movement of sediment along the beach because the repairs occurred within the existing footprint. However, one permitted repair in Des Moines was constructed by placing large rocks in front of an existing 25 foot wall. Given the rock structure extends further offshore, it likely is acting like a short groin and affecting sediment transport.

Only one change (unpermitted) associated with overwater structures likely had an effect on sediment transport. The small preexisting overwater structure was previously open underneath it, allowing sediment to move unhindered along the shore. In the 2013 survey, it was observed that the area below the structure had been enclosed by boards, thus causing the structure to act like a groin as well as an overwater structure.

3.3.2.3 Light Energy

As noted in Table 1, the way light energy reaches the shoreline can be changed in ways that both increase or decrease the amount of light energy during the day or at night. The following section is broken into changes to light energy during the day versus changes at night.

Daytime

Changes to light energy in the daytime include the reduction of light reaching the bottom of Puget Sound by overwater structures (e.g. docks) and other infrastructure that can block light, like aquaculture. The light energy reaching the upper beach can increase through the removal of vegetation near the shoreline.

2012

All the changes in overwater structures occurred in unincorporated King County. Four of the ten changes associated with docks were large enough and far enough offshore that they may affect the growth of eelgrass and migration patterns of salmonids. The largest effect was created by the removal of the dock at Maury Island Marine Park. This effect was positive. Of the ten docks where changes were noted, this dock was the largest and extended out the farthest into the subtidal zone. Of the other three that had relatively larger effects, one was permitted as a complete rebuild, but was not initially built to King County Standards. The County is working with the landowner to allow more light to travel through the dock in order to address shortcomings in the existing design. One of the other two larger docks was located in Raab's Lagoon and was built without permits over the subtidal waters in the lagoon. This dock also had solid decking which did not allow light penetration. The dock was removed in January of 2013 as part of a now closed code enforcement case. The remaining dock is located on the south shores of Maury Island and extends out into the intertidal waters approximately 50 feet. In 2004, there was a dock in this location; however, it was noted in the WRIA 9 Status and Trends Monitoring Report (2012) that it was no longer present. A new dock of roughly the same size, configuration and location was built after 2010. This unpermitted dock has solid decking and casts a strong shadow over the beach in aerial photographs.

There was one aquaculture operation found in the middle of the west side of Vashon Island. This unpermitted operation included an aggregation of mesh bags that were tied to various floats. The operation occurred 150 feet offshore in the lower intertidal zone and occupied approximately 2,000 feet^2 of the intertidal zone. The mesh bags had a variety of organisms growing on them. The density of the bags along with the organisms growing on them was such that it would likely limit light penetration. During the 2013 survey it was verified that the aquaculture operation was located within an eelgrass bed.

Increases to light energy in the upper intertidal zone occurred through clearing activities unassociated with other actions. Of the eight instances of clearing noted along the shoreline, only four of the instances cleared vegetation along the upper intertidal such that there would be a definitive increase in light energy. Three of these clearings occurred on Vashon and Maury Islands and were unpermitted activities. The remaining instance of clearing occurred in Seattle and was permitted. Approximately 1.8 acres of area was cleared and 610 feet of shoreline was affected.

Increases to light energy also occurred by removing vegetation during construction of shoreline armoring. Of the 52 changes to shoreline armoring that were noted, only four were instances where vegetation was clearly removed as part of the permitted repair work.

Three of these instances affected relatively small areas (less than several trees). The remaining instance was a permitted bulkhead repair spanning three properties that removed approximately 3,000 feet^2 of trees and shrubs along 200 feet of shoreline.

2013

As in the 2012 survey, all five changes associated with docks occurred in unincorporated King County. None were far enough off-shore that they would affect eelgrass growth through decreasing the amount of light reaching the sea floor. However, two of the five were far enough into the intertidal that they might affect the migration patterns of salmonids at high tide. The two permitted changes of the five docks actually had positive changes in condition. In one case a 180 foot long dock was shortened, creosote piles were replaced with steel piles and had its last 30 feet modified so more light would filter through the decking. The other 300 foot long dock had all of its decking modified to allow greater light infiltration as well as all its creosote pilings replaced with steel piles.

Increases to light energy in the upper intertidal zone occurred through clearing activities unassociated with other actions. Of the seven instances of clearing noted along the shoreline, five of the six unpermitted actions cleared vegetation near the upper intertidal such that there would be a clear increase in light energy. Approximately 0.9 acre of area was cleared and 450 feet of shoreline were affected.

Of the 20 changes to shoreline armoring that were noted, none had obvious vegetation removal associated with them. Increases to light energy occurred by removing vegetation during construction of retaining walls and staircases. Of the 16 occurrences, only three likely had an effect that was not already accounted for. These three (one permitted and two unpermitted) actions accounted for approximately 150 feet of shoreline and 0.1 acres of vegetation removed.

Nighttime

Human development near water bodies can increase the amount of light interacting with the surface of the water, which can in turn affect how animals migrate and behave. Light can be increased through buildings built near the shoreline, by lights placed on docks, and by the clearing of vegetation near the shore that allows light from further away to reach the water. Some bulkhead repairs can also clear vegetation along the water.

2012

It is not clear if all or any of the nine new or repaired overwater structures have lighting associated with the structure, but each has the possibility of generating light. Similarly, the six unpermitted and one permitted stairs might or might not be lighted at night. All eight instances of clearing noted along the shoreline are associated with dwelling structures and thus can affect the amount of light reach the shoreline at night as there is less vegetation between the dwelling and the water to block the light from reaching the water. The same is true for the four bulkheads described above that had vegetation removed as part of the repair work. Two unpermitted new houses as well as one new permitted accessory structure were also encountered on Vashon. These buildings are highly likely to be generating light at night that spills over into Puget Sound.

2013

It is not clear if all or any of the five new or repaired overwater structures have lighting associated with the structure, but each has the possibility of generating light. Similarly, the eight unpermitted and one permitted change associated with stairs might or might not be lighted at night. All seven instances of clearing (two permitted, five unpermitted) noted along the shoreline are associated with dwelling structures and thus can affect the amount of light reaching the shoreline at night as there is less vegetation between the dwelling and the water to block the light from reaching the water. Five of the instances are more likely to have increased the amount of artificial light reaching the shoreline given the extent and where the vegetation was removed. Of the seven changes associated with houses, three of the permitted structures are likely to increase the amount of artificial light while the house removal should reduce the amount of artificial light reaching the shoreline at night.

3.3.2.4 Wave Energy

As noted in Table 1, aquaculture operations and docks can intercept wave energy and reduce its interaction with the shoreline. Shoreline armoring can also affect how wave energy interacts with the shoreline depending on what elevation the armoring is located at. The deeper into the intertidal zone the armoring goes the greater the negative effect of the armoring. Over long periods of time, shoreline armoring is likely to cause the beach to become narrower and steeper in response to the wave energy acting on a shoreline that cannot move landward.

2012

The one new unpermitted aquaculture operation along the Colvos side of Vashon is likely reducing wave energy. Of the nine changes related to overwater structures three of the unpermitted changes were such minor repairs to the existing structure that the wave energy reaching the shore was likely unchanged from its previous condition. Two of the changes were associated with decks that extended over the water with only a few pilings in the water. Given their location high in the intertidal and small number of pilings, they likely have a very minor effect on wave energy. The new unpermitted dock in Inner Quartermaster Harbor appears to be a short floating dock that does not have any pilings associated with it. It is also in an area with little wave energy due to its isolated geographic location. The new unpermitted dock in Raab's Lagoon likely had little effect on wave energy due to the lagoon's isolation from waves by the weir at the outlet. The new unpermitted dock on the south side of Maury Island extends offshore approximately 40 feet, but has relatively small pilings providing support for the structure. It is likely only creating a minor effect on wave energy. The final over water structure is a permitted dock north of Fern Cove on Vashon Island. This dock extends offshore approximately 70 feet. Given its size, it likely has a greater effect on wave energy than most of the previously mentioned changes. Given the relatively large size of the dock that was removed at Maury Island Marine Park, it likely had a positive change on how wave energy interacts with the shoreline.

Most of the bulkhead repairs should not change how wave energy interacts with the shoreline because the structure affecting wave energy was already in place. Of the new bulkheads noted, three of the six likely did not have a large effect on how wave energy interacts with the shoreline because the bulkhead was placed at or above the Ordinary High Water line. These three bulkheads include the unpermitted bulkhead on Maury Island, the unpermitted bulkhead in Federal Way and the permitted bulkhead in Burien. Each of these bulkheads either had drift wood in front of it or in front of bulkheads on adjacent properties that were located at approximately the same tidal elevation. The other three bulkheads (two unpermitted, one permitted) were located on Vashon and Maury Islands. Each of the new structures was located in the intertidal such that wood and other material could not build up in front of the bulkhead. Their location lower in the intertidal means that wave energy will interact more often with them and create more pronounced effects than the other bulkheads. There was one unpermitted wooden ramp on Vashon Island that extended into the upper intertidal such it would affect how wave energy interacted with the shoreline.

2013

There were no new aquaculture operations found in the 2013 survey, though the one noted in the 2012 survey was still in operation at the time of the 2013 survey. Three of the five changes associated with overwater structures likely had no effect on wave energy. Two of these were modifications to existing structures (one permitted, one unpermitted) such that there was no change to the in-water portions of the structures. The one new unpermitted dock is located in Raab's Lagoon, which has a protective berm and weir that block wave energy from interacting with structures in the lagoon. Of the remaining changes, one likely had a positive effect on wave energy while the other had a relatively small negative effect. As described above, one of the permitted docks was shortened in length and the number of pilings was reduced. Thus the existing dock should have a reduced effect on how wave energy hits the shoreline. The remaining change was an unpermitted change to a ten foot wide by ten foot long overwater structure with the area underneath the deck enclosed by planks.

Of the 20 changes in shoreline armoring several likely had minor changes to how wave energy reaches the shoreline. A bulkhead associated with a permitted major repair on Vashon Island was actually moved back several feet and should reduce the effects the armoring on wave energy. However, the toe of the bulkhead is still below OHW and thus it will have an effect. The temporary bulkhead near the Fauntleroy ferry dock likely changed wave energy while it was in place, but the project sponsor's permit conditions indicated that they had to restore the conditions once the bulkhead was removed. So, this effect was relatively minor and should be temporary in nature. Two permitted repairs included placing rock or cement deeper into the intertidal, thus increasing the level of effect of wave energy to the beach. The new permitted bulkhead that replaced the unarmored feeder bluff in Burien was also located below OHW. While the new bulkhead is not as deep into the intertidal area as the adjacent bulkheads, it is still below OHW, thus it is affecting how wave energy interacts with the upper beach.

3.3.2.5 Organic Material

The effects of changes in organic material accumulations on beach ecosystems are not well understood. Recent work has shown that there are definitive differences in invertebrate communities between beaches that can accumulate organic material compared to beaches that can't due to a bulkhead or other infrastructure (Tonnes 2008 and Sobocinski 2003). Large portions (~51%) of the marine shoreline in WRIA 9 are not capable of supporting the detrital based food web due to shoreline armoring that is located below the OHW line. Changes to this part of the ecosystem can occur both in a reduction of organic material reaching the beach as well as changes to the beach that don't allow organic material to accumulate.

The changes in shoreline condition associated with clearing vegetation reduced the delivery or input of detrital material to the beach. This includes the annual leaf litter created by deciduous trees each autumn as well as the large or coarse woody material from tree trunks and branches. Clearing the marine riparian vegetation also reduces the amount of insects that fall into Puget Sound waters and are eaten by threatened species like Chinook salmon.

2012

Two instances of unpermitted clearing occurred higher up on a bluff, above an existing road. In these two cases, the clearing primarily affected the amount of leaf litter and insect fall out as any logs or branches would have been deposited on the road and removed. Two unpermitted changes associated with clearing included the topping of many deciduous trees along the water and along the top of the bluff. This reduced both the leaf litter and coarse woody material delivered to the beach. Three unpermitted changes associated with clearing involved clearing almost all the vegetation from the top of the bluff to the toe of the bluff. These three instances on Vashon and Maury Islands dramatically reduced the amount of source material reaching the beach.

As with other potential effects, most repairs to existing bulkheads generally did not change the baseline level of effects on organic material because the baseline condition represented a relatively degraded condition. However, six bulkhead repairs (three permitted, three not permitted) removed a variety of trees and shrubs reducing the amount of leaf litter and coarse material reaching the beach. The one instance of permitted clearing in Seattle had similar level of effects as the bulkhead repairs because several trees were removed as part of demolishing the existing house.

Docks can affect how detritus builds up on a beach in much the same way it affects sediment transport and wave energy. In the case of docks and decks that were repaired or constructed along Vashon and Maury Islands they do not appear to be affecting the build - up of organic material on beaches because each of those overwater structures is associated with a bulkhead that extends below the OHW line. In these cases the existing bulkheads are the primary limiting factor related to the detrital food web. The large dock that was removed at Maury Island Marine Park did previously have an effect on how detritus built

up on the beach. The permitted removal of the dock has allowed the detrital material to more evenly distribute along the down drift beach.

Of the new bulkheads that were constructed, three were built below the OHW line. These two unpermitted and one permitted bulkheads on Vashon and Maury Islands displaced the beaches' ability to form normal beach berms where detritus would build up and accumulate. In a similar fashion, one new unpermitted wooden boat ramp extended into the intertidal area along Vashon. Thus in these four cases, the organic accumulation function of the beach berm appears to have been reduced or eliminated.

2013
All seven instances of clearing noted along the shoreline will likely result in a loss of leaf litter input and potentially large woody material. Six of the instances of clearings occurred on Vashon and Maury Islands and five were unpermitted. The remaining instance of clearing occurred in Seattle and was originally unpermitted. The site has already been addressed through replanting as part of mitigation.. The estimate of the total area cleared of vegetation in 2013 was approximately 2.4 acres.

None of the repairs to existing bulkheads changed the baseline level of effects on organic material because the baseline condition represented an already degraded condition. The one new permitted bulkhead that was constructed in Burien was built below OHW and thus it will not allow for detrital material to build up in front of it. The permitted temporary bulkhead near the Fauntleroy ferry dock had a similar effect while it was in place, but the effects should be temporary.

As with wave energy, most of the changes associated with docks did not change how organic matter accumulates on the beach. The unpermitted new dock in Raab's Lagoon is located such that it could displace or smother animals and material that accumulate near the high tide line.

3.3.2.6 Other Effects

Several other effects do not fit neatly in the structure of Table 1. These include effects to public safety, water quality and direct displacement of forage fish habitat.

Public safety
As originally described in the scope of work, this project would evaluate any increased risk to public safety through hazards to navigation or by clearing vegetation and destabilizing steep slopes. During the course of the surveys there were no obvious permanent signs of hazards to navigation. In 2013, one dock on Vashon had its length reduced which could reduce risks to navigation with Quartermaster Harbor.

In the 2012 survey there was a derelict barge that was grounded near the Piner Point Natural Area on Maury Island could have been classified as a hazard, especially if it had become ungrounded and floated out into boat traffic. King County undertook several efforts to get the barge removed before the winter, but was unable to arrange for its

removal and proper disposal given its relatively isolated location. In December of 2012 there was an extreme high tide event that battered the barge against the shoreline and broke it into many small pieces. King County has worked over the course of 2013 to remove most of the remains of the barge.

While most of the instances of clearing noted in 2012 and 2013 occurred on or adjacent to steep slopes, the majority occurred on a single parcel that extended from the house all the way to Puget Sound. Thus the landslide hazard risk associated with the clearing is limited to the private landowner's infrastructure and land. In the 2012 survey, two unpermitted instances of clearing occurred on a slope above a public road, one on Maury Island and the other on Vashon Island. One location above Dockton Road shows signs of recent topping of trees as well as older signs of tree topping. The current condition is that most of the mature trees have been topped. The other location is located above 86th Street Southwest on Vashon Island. In this case, most of the vegetation (trees and shrubs) from the top of the bluff down to immediately above the road was recently cleared. In both of these cases, the removal of vegetation on the slope likely increases the risk of future landslides immediately above a public road.

Water Quality

As noted at the beginning of this ecological effects section, it is impossible to know what or if best management practices were used when the changes to infrastructure were made. Many of the changes may have had effects on water quality depending on how they undertook the construction activity. Most of the water quality effects would be fairly temporary in nature and many organisms would be able to accommodate temporary increases in turbidity. Of the potential water quality effects that may have been created by construction activities, interaction of water with wet cement appears to have the largest potential affect and thus is described below.

Several of the changes in shoreline condition involved using concrete that was cast in place as part of the repair or rebuild. Fresh concrete should not come in contact with aquatic areas and requires special handling above and beyond other bulkhead construction techniques. Wet concrete can leach into adjacent water bodies altering the pH such that organisms are not able to live in the vicinity of the structure until it cures completely and no longer causes spikes in pH. The larger the amount of curing concrete and the longer it is in contact with water, the more problematic it is. The weather and oceanographic conditions can also affect the exchange of water in contact with curing cement. Thus winder days or geographic locations with more exposure to wind are more likely able to buffer the effects of changes in pH by having large amounts of water circulate in front of the bulkhead.

There were five changes in shoreline condition in the 2012 survey that involved concrete. Two of the changes involved bulkheads that were relatively high on the beach such that there would be relatively little contact between the bulkhead and concrete except at very high tides. Each one had drift wood on the beach in front of the bulkhead. One of these bulkheads was on Vashon Island while the other bulkhead was located within Seattle. Two

of the remaining three cement bulkheads repairs occurred on Vashon and Maury islands. The Maury Island bulkhead repair was limited to about 35 feet of the lower foot of the bulkhead. At the time of the survey, the cement forms were still in place in front of the bulkhead. The forms did not appear to be sealed such that seawater would not be in contact with the cement at high tide. The Vashon Island bulkhead spanned two parcels and was approximately 160 feet long and four feet high. The final cement bulkhead was located in Des Moines and was approximately 150 feet long by three feet high. None of the cement bulkhead repairs were permitted.

In the 2013 survey, there was one bulkhead encountered during the survey that was repaired with cement. In this case, the bulkhead was permitted and should have had water quality protections in place as part of the permit conditions.

Forage fish

Sand lance and surf smelt spawn on the upper portion of marine beaches in WRIA 9 from October to February. They spawn on the beach from approximately the plus five tidal elevation up to the mean higher high tide line where drift logs accumulate. As noted in other sections, many of the existing bulkheads in WRIA 9 encroach on this habitat, physically reducing the spawning habitat capacity for these species which make up a large portion of the Puget Sound food web (Pentilla 2007).

In both years, most bulkhead repairs did not increase the level of effect that the structure has on forage fish spawning habitat. In the 2012 survey, one permitted bulkhead repair in Burien had a temporary construction pad built on top of the majority of forage fish spawning habitat in that location. That temporary construction pad was removed by the June 2013 survey, thus any effects should have been temporary. Of the new bulkheads in 2012, three were constructed such that they displace the upper beach habitat and thus reduce the availability of spawning habitat. The two bulkheads on Vashon were unpermitted, while the bulkhead on Maury Island was permitted.

In the 2013 survey, the two new permitted bulkheads noted during the survey have the potential to affect the amount of spawning habitat available. The temporary bulkhead located near the Fauntleroy ferry dock occurred on an area with documented spawning of surf smelt and sand lance. Though the bulkhead was temporary it is unclear how long the site will need to readjust after the upper beach fill is removed such that it will be restored to its previous condition. The other new bulkhead that was noted in Burien was located near known surf smelt spawning habitat. There is a documented spawning beach within 200 feet on either side of the bulkhead.

The aquaculture operation encountered in the 2012 survey was located within an eelgrass bed. While this has the potential to effect the quality of potential herring spawning habitat, herring are not known to spawn along the Colvos side of Vashon Island.

3.4 Enforcement

Each jurisdiction was asked a variety of questions about their enforcement process in order to understand factors that might account for differences in compliance rates. All of the jurisdictions in the study area rely on a complaint based system for code enforcement. Only one of the jurisdictions indicated that inspectors look for and attempt to address adjacent code violations when they are in the process of investigating a specific complaint. Otherwise, staff from the various jurisdictions do not actively look for code violations, but rely on citizens to report possible violations.

All jurisdictions within the study area indicated that they have a process for bringing any of the potential code violations into compliance with existing laws. This typically requires the landowner to apply for the appropriate permits within thirty days of being notified of the potential violation. Depending on the jurisdiction, the fines for non-compliance range from a set daily fee for each day the site is out of compliance at the high end to double the original permit costs at the lower end.

In a limited number of cases the non-compliant structure is not something that can be permitted based on the existing code or how it was constructed. This appears to be fairly rare for the changes noted in this study. King County had 76 unpermitted changes in shoreline condition identified during the surveys and only 5 were considered to be not permittable based on a review by permit staff. Some of these five may be able to be permitted depending on specific site conditions or if the landowner is willing to reconfigure the design of the structure. None of the other jurisdictions noted that the unpermitted changes were not permittable.

Of the different jurisdictions, King County had the largest number of potential violations. King County is in process of addressing these potential violations in a transparent and public manner, beginning with outreach efforts to describe the study's purpose and results to residents, along with education about the importance of regulatory compliance and permitting processes. The county then intends to work with property owners to investigate and resolve potential compliance issues that may have been identified in this study.

One of the pilot project's initial goals was to include information and analysis on the enforcement process associated with the changes observed during the two surveys. For most of the changes observed, information on enforcement actions associated with the changes encountered will not be available for this report. Code enforcement activities generally take a fair amount of time to process and come to a resolution.

Of the 96 total changes in shoreline condition that were not permitted, eight of them were already in enforcement process when they were encountered during the surveys (Table 6 and Table 8). Seven of the eight unpermitted changes already in the enforcement process were encountered in 2012 with six of seven on Vashon and Maury Islands.

Five of the six unpermitted activities identified in 2012 on Vashon-Maury Islands had already been through the entire code enforcement process (Table 6). In one case, after several years of working towards permitting the new dock under an "already built construction" permit, the landowner choose to remove the dock versus trying to get it permitted. In the end, it is likely that the dock was not permitted after the fact because the landowner sold the house and needed to resolve the enforcement case quickly. In another case, the landowner removed the unpermitted creosote bulkhead and applied for and received permits to install a new rock bulkhead in its place. The remaining three cases involved permitting the structures through "already built construction" permits where the landowner did not make changes to the structures that were out of compliance. In 2012, one case was listed as an open enforcement case. It is still open because to come into compliance the landowner needs to get a new septic system permitted and approved as part of coming into compliance.

There was also one enforcement case in the city of Normandy Park that is now closed. The unpermitted shoreline change in Normandy Park was a new wooden bulkhead in the southern portion of the city. Before the city could investigate the issue, an extreme high tide event in December of 2012 removed the new bulkhead (personal communication Chad Tibbits, City of Normandy Park Planner). It is unknown where the remains of the bulkhead went. With the change in condition being rectified by nature, the enforcement case is considered closed.

In 2013, one site in Seattle was encountered that had already gone through the enforcement process. The site previously had about half an acre of vegetation cleared. The site was replanted with native vegetation.

In summary, time constraints did not permit an examination of enforcement activities that may result from data gathered for this report. The identified changes that already had enforcement actions underway or were closed cases were a mix of undertaking the permitting process after the fact and mitigating the ecological effects of the initial unpermitted activity.

4.0. DISCUSSION

This report describes changes in Puget Sound shoreline condition of WRIA 9 that occurred between 2005 and 2013. Two boat-based surveys were undertaken to quantify and characterize the types of changes observed. The surveys covered the entire 92 miles of the WRIA 9 marine shoreline, including the jurisdictions of Seattle, Burien, Normandy Park, Des Moines, Federal Way, and unincorporated King County. The report also identifies whether these changes were permitted by local jurisdictions, and also summarizes the ecological effects of the types of shoreline changes observed.

The surveys found that the majority of changes observed were associated with repairs or rebuilds of existing shoreline armoring infrastructure. There were roughly equal amounts of changes in clearing of shoreline vegetation, new or modified stairs, and docks. The report documented that non field verified compliance rates (defined as having a permit for each change in condition observed) ranged from 0 to 100% and averaged 34% for the changes noted in the 2012 survey and 43% for the changes observed during the 2013 survey. The report also documented that approximately 40% of the changes observed in the two surveys did not appear to have any ecological or physical effect on shoreline habitats. The other 60% of changes had a range of ecological and physical impacts from relatively short term small impacts to relatively long term and large in overall area affected. The data from these surveys indicate that there has been a increase in the overall amount of shoreline armoring and decrease in the amount of trees and shrubs along the shoreline.

One of the challenges of this project has been documenting changes in condition from one year to the next. In both years, there were a variety of sites that looked like there was a change in condition during the survey (e.g. bright, clean rocks), but after a comparison of many different aerial photos (vertical and angled or oblique), it was determined that there was likely no change in condition. For some sites it was not possible to determine if there had been a change in condition, so their status was listed as unclear and the issue was not pursued further. It was also challenging to confirm whether a change in vegetation condition (i.e. clearing) happened unless it occurred within a year of the survey. It is likely that the amount of clearing has been underrepresented by these surveys. In general, verifying a change in condition took more time than originally anticipated due to the amount of time needed to verify a change. This project is fortunate that King County has aerial photographs covering the project area in two year intervals going back to 2005.

The second year's survey took place ten months after the 2012 survey and found almost as many changes as were noted from the time period of 2005 to 2012. This does not necessarily mean the rate of change increased. There are several potential reasons that explain this apparent discrepancy or relatively high number of changes found in 2013 after only 10 months had passed. First, it is likely that many more changes occurred between 2005-2012 that were not observed or noted because they were no longer obvious given the length of time between surveys. Changes in condition noted in 2013 where the structure was rebuilt in roughly the same footprint were only obvious because the structure was so

new. Similarly, it was difficult to note changes to vegetation condition a year or two after the change occurred because changes are mostly obvious shortly after clearing.

Another potential reason is that in the last 10 months, the study area experienced relatively high amounts of rain over the winter season and the highest tide on record. Based on news reports at the time of the high tide event in December of 2012, higher levels of damaged bulkheads and onshore structures were expected for the 2013 surveys. The high amounts of rain caused numerous dramatic mudslides along the marine bluffs north of Seattle. Small scale sliding may have been responsible for the relatively large number of new retaining walls that were seen in the 2013 survey. Both of these events may have created the need for more repairs and modifications to shoreline infrastructure than in a typical year. And finally, about 10% of the changes noted in 2013 were changes in condition where the change was made prior to 2012, but not noticed during the 2012 survey.

The study found that many of the changes to shoreline condition were unpermitted. It should be emphasized that actual compliance rates have not been field verified at this time (i.e., whether or not a permit was actually needed). It is possible that the non-field verified compliance rates will improve as enforcement staff begin to work with landowners around if the changes in condition observed in this study still require a permit after enforcement staff have had a firsthand look at the changes. It is suggested that a future project be undertaken to evaluate the enforcement responses to the unpermitted changes noted in this report.

Two similar studies have recently been done in other parts of Puget Sound that had compliance rates ranging from 50% to 80%. Along the 53 miles of the City of Bainbridge Island, Washington Department of Fish and Wildlife evaluated recent shoreline changes against their permit database of state Hydraulic Project Approvals (HPAs) in 2012. While they did not evaluate if projects had local city permits, they found that 80% of the changes had received an HPA for the work done. The San Juan Initiative undertook surveys of 34 miles of different sections of several islands within the San Juan archipelago. They evaluated a smaller subset of shoreline changes (shoreline armoring and docks) and found that 50% of the changes did not have a state or county permit. It is unclear why the other study areas had higher non-field verified compliance rates. One possibility is that the WRIA 9 study was more comprehensive and evaluated all changes in shoreline condition, while the other two studies focused on a subset of shoreline changes. Alternatively, it may be that there are proportionally more landowners in WRIA 9 doing work along the Shoreline without permits, but because the study methodologies were not identical we did not attempt to do a comparative analysis.

Because of the timing of this study it was not possible to make an assessment of enforcement efforts undertaken by jurisdictions. The enforcement actions that were noted were already taking place prior to this study being implemented. The permitting process can be an educational opportunity for the landowner regarding the importance of physical and ecological processes. Also, it can help to lessen both the effects from construction techniques as well provide an opportunity to work with the landowner, to ensure that the project is designed and constructed in a manner that minimizes ecological effects. To the

extent that there were circumstances where required permits were not obtained, the nonpermitted projects represent missed opportunities to work with landowners to improve the outcome on the ground.

The WRIA 9 Status and Trends Monitoring Report: 2005-2010 (2012) indicated that since 2004 the amount of shoreline armoring in WRIA 9 had decreased across the larger WRIA, by almost 600 feet. This was due mostly to the large restoration project (~1000 feet) at Seahurst Park in Burien that offset the increases in shoreline armoring found in unincorporated King County, Federal Way, and Normandy Park over the same time period. The amount of new shoreline armoring found through the course of this study offset all of the gains from shoreline restoration projects over the past 8 years. Between 2004 and June of 2013, approximately 1,500 feet of shoreline armoring had been removed through restoration and mitigation projects, but there has been a net increase in the amount of shoreline armoring in WRIA 9 by approximately 70 feet.

The WRIA 9 Status and Trends Monitoring Report: 2005-2010 (2012) also indicated that there had been an overall loss of both densely treed shoreline as well as patchily treed shorelines throughout the WRIA from 2004 to 2009. The majority of the clearing of treed shorelines noted over both years of this project was in the rural area of unincorporated King County and most instances of clearing were unpermitted. The 2012 survey found that roughly 3 acres of vegetation had been cleared while the 2013 survey found an additional 2.5 acres had been cleared between the two survey dates. Most instances of clearing were near houses, suggesting that they may have been associated with efforts to create unobstructed views of the water, or as part of remodeling an existing house. The findings in this report indicate that there has been a continuing loss of treed shorelines on Vashon and Maury Islands between 2009 and June of 2013.

Given the number of changes in shoreline condition that were found through boat-based surveys that were missed in the recent aerial photograph analysis, it is recommended that jurisdictions consider surveying shoreline conditions at least every two years to gain a better understanding of changes and to assist them in managing their shoreline resources. This recommendation applies to both tracking Shoreline Master Plan implementation as well as salmon recovery plan implementation.

Finally, it is important to note that this study did not identify why people are not getting permits. A separate study could be undertaken in the future to try to understand the reasons for noncompliance. Understanding why this is occuring would help jurisdictions craft specific and culturally relevant responses in both the urban and rural environments that could help improve the compliance rates seen over the course of this study.

5.0. REFERENCES

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Appendix A

Physical and ecological effects for each change observed

Year	id #	Type	Status	Permitted Yes or No?	Jursidiction	Sediment delivery			Sediment transport	Light Energy			Organic Material		Wave Energy		Other Effects		
						↓ In sediment	↑ Rate clearing	Shell hash	↓ rate of movement	↓ Light transmission	↑ Light transmission day	↑ Light transmission night	↓ Input	↓ Storage	↓ Wave energy	Change in interaction with shore	Potential WQ effects concrete	Forage fish displacment	Hazard to public safety
2012	45	Armoring	Major Repair	Y	Burien						X	X	X						
2013	11	Armoring	Major Repair	Y	Burien														
2013	12	Armoring	Major Repair	Y	Burien														
2013	14	Armoring	Minor Repair	N	Burien														
2012	19	Armoring	Minor Repair	Y	Burien				X							X		X	
2013	13	Armoring	Minor Repair	Y	Burien										X	X		X	
2012	85	Armoring	New	Y	Burien	X													
2013	17	Armoring	New	Y	Burien	X							X		X	X		X	
2013	19	House	New	Y	Burien							X	X						
2013	20	House	New	Y	Burien								X						
2013	21	House	Removed	Y	Burien														
2013	22	Ramp	Major Repair	N	Burien														
2013	23	Retaining wall	Minor Repair	Y	Burien														
2013	24	Stairs	Major Repair	N	Burien														
2012	0	Armoring	Major Repair	N	County												X		
2012	1	Armoring	Major Repair	N	County														
2012	3	Armoring	Major Repair	N	County											X		X	
2012	5	Armoring	Major Repair	N	County								X			X			
2012	6	Armoring	Major Repair	N	County								X			X			
2012	7	Armoring	Major Repair	N	County														
2012	9	Armoring	Major Repair	N	County														
2012	10	Armoring	Major Repair	N	County									X		X			
2012	35	Armoring	Major Repair	N	County														
2012	38	Armoring	Major Repair	N	County														
2012	46	Armoring	Major Repair	N	County														
2012	49	Armoring	Major Repair	N	County														
2012	8	Armoring	Major Repair	Y	County								X						
2012	26	Armoring	Major Repair	Y	County				X					X	X	X			
2012	31	Armoring	Major Repair	Y	County														
2012	32	Armoring	Major Repair	Y	County						X	X	X						
2012	44	Armoring	Major repair	y	County												X		
2013	48	Armoring	Major Repair	Y	County								X		+	+			
2013	49	Armoring	Major Repair	Y	County														
2012	2	Armoring	Minor Repair	N	County														
2012	4	Armoring	Minor Repair	N	County														
2012	27	Armoring	Minor Repair	N	County														
2012	33	Armoring	Minor Repair	N	County														

Year	id #	Type	Status	Permitted Yes or No?	Jursidiction	Sediment delivery			Sediment transport	Light Energy			Organic Material		Wave Energy		Other Effects		
						↓ In sediment	↑ Rate clearing	Shell hash	↓ rate of movement	↓ Light transmission	↑ Light transmission day	↑ Light transmission night	↓ Input	↓ Storage	↓ Wave energy	Change in interaction with shore	Potential WQ effects concrete	Forage fish displacment	Hazard to public safety
2012	36	Armoring	Minor Repair	N	County														
2012	37	Armoring	Minor Repair	N	County														
2012	39	Armoring	Minor Repair	N	County														
2012	40	Armoring	Minor Repair	N	County														
2012	41	Armoring	Minor Repair	N	County														
2012	42	Armoring	Minor Repair	N	County														
2012	47	Armoring	Minor Repair	N	County														
2012	48	Armoring	Minor Repair	N	County														
2012	81a	Armoring	Minor Repair	N	County														
2012	51	Armoring	Minor Repair	N	County												X		
2013	50	Armoring	Minor Repair	N	County														
2013	51	Armoring	Minor Repair	N	County														
2013	52	Armoring	Minor Repair	N	County														
2012	34	Armoring	Minor Repair	y	County														
2012	43	Armoring	Minor Repair	y	County														
2012	28	Armoring	New	N	County	X			X					X		X		X	
2012	64	Armoring	New	N	County	X								X		X		X	
2012	30	Armoring	New	y	County	X			X					X		X		X	
2012	65	Clearing	Recent	N	County		X				X	X	X						
2012	76	Clearing	Recent	N	County		X				X	X	X						
2012	77	Clearing	Recent	N	County		X				X	X	X						
2012	80	Clearing	Recent	N	County							X	X						X
2012	81	Clearing	Recent	N	County							X	X						X
2012	82	Clearing	Recent	N	County		X					X	X						
2013	58	Clearing	Very recent	N	County		X				X	X	X						
2013	60	Clearing	Very recent	N	County		X				X		X						
2013	61	Clearing	Very recent	N	County						X		X						
2013	62	Clearing	Very recent	N	County		X				X	X	X						
2013	63	Clearing	Very recent	N	County		X				X	X	X						
2013	59	Clearing	Very recent	Y	County						X	X	X						
2013	64	Deck	Major Repair	N	County														
2013	67	Dock	Major Repair	N	County														
2013	68	Dock	Major Repair	N	County					X					X	X			
2013	65	Dock	Major Repair	Y	County						+						+		
2013	66	Dock	Major Repair	Y	County						+					+	+		
2012	53	Dock	Minor Repair	N	County							X							
2012	73	Dock	Minor Repair	N	County							X							

Year	id #	Type	Status	Permitted Yes or No?	Jursidiction	Sediment delivery			Sediment transport	Light Energy			Organic Material		Wave Energy		Other Effects		
						↓ In sediment	↑ Rate clearing	Shell hash	↓ rate of movement	↓ Light transmission	↑ Light transmission day	↑ Light transmission night	↓ Input	↓ Storage	↓ Wave energy	Change in interaction with shore	Potential WQ effects concrete	Forage fish displacment	Hazard to public safety
2012	75	Dock	Minor Repair	N	County							X							
2012	70	Dock	New	N	County							X							
2012	71	Dock	New	N	County							X							
2012	72	Dock	New	N	County			X	X	X		X			X				
2012	83	Dock	New	N	County			X		X		X							
2012	84	Dock	New	N	County							X							
2013	69	Dock	New	N	County					X									
2012	63	Dock	New	Y	County			X	X	X		X			x				
2012	86	Dock	Removal	y	County			+	+	+		+		+		+			
2012	50	Groins	New	N	County				x										
2013	71	House	New	Y	County														
2013	72	House	New	Y	County							X							
2013	73	other	New	N	County								X						
2012	54	Other	Recent	N	County												X		
2012	69	Other-Aquaculture	New	N	County					X					X				
2012	57	Other-house	New	Y	County							X							
2012	60	Other-house	Recent	N	County							X							
2012	61	Other-house	Recent	N	County							X							
2012	62	Other-ramp	New	N	County									X	X			X	
2012	58	Other-ramp	Recent	N	County														
2012	68	Other-stairs	New	N	County							X							
2012	67	Other-stairs	New	Y	County							X							
2012	52	Other-stairs	Recent	N	County							X							
2012	55	Other-stairs	Recent	N	County							X							
2012	56	Other-stairs	Recent	N	County							X							
2012	59	Other-stairs	Recent	N	County							X							
2012	66	Other-stairs	Recent	N	County							X							
2013	75	Retaining wall	Minor Repair	N	County								X						
2013	77	Retaining wall	New	N	County								X						
2013	78	Retaining wall	New	N	County								X						
2013	76	Retaining wall	New	Y	County						X		X						
2013	80	Stairs	Major Repair	N	County					X		X			X	X			
2013	81	Stairs	Major Repair	N	County					X		X			X	X			
2013	82	Stairs	New	N	County														
2013	83	Stairs	New	N	County						X	X	X						
2012	20	Armoring	Major Repair	N	Des Moines						X	X	X				X		

Year	id #	Type	Status	Permitted Yes or No?	Jurisdiction	Sediment delivery			Sediment transport	Light Energy			Organic Material		Wave Energy		Other Effects		
						↓ In sediment	↑ Rate clearing	Shell hash	↓ rate of movement	↓ Light transmission	↑ Light transmission day	↑ Light transmission night	↓ Input	↓ Storage	↓ Wave energy	Change in interaction with shore	Potential WQ effects concrete	Forage fish displacment	Hazard to public safety
2012	20	Armoring	Major Repair	N	Des Moines						X	X	X				X		
2013	32	Armoring	Major Repair	N	Des Moines										X	X		X	
2013	33	Armoring	Major Repair	Y	Des Moines				X					X	X	X		X	
2013	34	Armoring	Minor Repair	Y	Des Moines	X									X	X			
2012	79	Clearing	Recent	N	Des Moines		X					X	X						
2013	35	House	New	Y	Des Moines														
2013	36	Retaining wall	New	Y	Des Moines														
2013	38	Stairs	Major Repair	N	Des Moines		X				X		X						
2013	41	Stairs	Major Repair	Y	Des Moines														
2013	39	Stairs	New	N	Des Moines		X				X		X						
2013	40	Stairs	New	N	Des Moines						X	X	X		X	X			
2012	21	Armoring	Major Repair	N	Federal Way														
2012	24	Armoring	Major Repair	N	Federal Way														
2012	25	Armoring	Minor Repair	N	Federal Way														
2013	42	Armoring	Minor Repair	N	Federal Way														
2012	22	Armoring	Minor Repair	Y	Federal Way														
2012	23	Armoring	New	N	Federal Way	x													
2013	45	House	Major Repair	N	Federal Way							X	X						
2013	46	Retaining wall	Major Repair	N	Federal Way								X						
2012	29	Armoring	Major Repair	N	Normandy Park														
2013	25	Armoring	Major Repair	N	Normandy Park														
2013	26	Armoring	Minor Repair	Y	Normandy Park														
2013	28	Deck	Major Repair	N	Normandy Park														
2013	29	Ramp	New	N	Normandy Park									X	X	X			
2013	1	Armoring	Major Repair	N	Seattle														
2012	11	Armoring	Major Repair	Y	Seattle														
2012	12	Armoring	Major Repair	Y	Seattle														
2012	15	Armoring	Major Repair	y	Seattle														
2012	17	Armoring	Major Repair	Y	Seattle												X		
2013	2	Armoring	Major Repair	Y	Seattle														
2013	3	Armoring	Major Repair	Y	Seattle												X		
2012	13	Armoring	Minor Repair	N	Seattle														
2012	14	Armoring	Minor Repair	N	Seattle														
2012	16	Armoring	Minor Repair	N	Seattle														
2012	18	Armoring	Minor Repair	Y	Seattle						X	X	X						
2013	4	Armoring	New	Y	Seattle									X	X	X		X	
2012	78	Clearing	New	Y	Seattle						X	X	X						
2013	9	Clearing	Recent	N	Seattle	X	X												

Appendix B

Photographic examples of changes oberved

Figure B-1. An example of a rebuilt or major repair bulkhead.

Figure B-2. An example of a new bulkhead.

Figure B-3. An example of a major repair to a bulkhead and a new overwater structure.

Figure B-4. An example of a permitted minor repair to a concrete bulkhead occurring at the time of the survey.

Figure B-5. An example of a new dock.

Figure B-6. An example of a rebuilt dock.

Figure B-7. An example of new wooden groins.

Figure B-8. An example of clearing of trees on a steep slope.

FigureB-9. An example of clearing and tree topping along a steep slope above a public road.

Figure B-10. An example of a site with a rebuilt set of stairs.

Figure B-11. The one example of an aquaculture operation.

Figure B-12. An example of a new house and associated clearing.

Figure B-13. An example of new retaining walls.

Figure B-14. An example of a new boat ramp.