

Project Summary
FY 2017 NOAA Coastal Resilience Grants Program (NOAA-NOS-NRPO-2017-2005159)

Project Title: Building a resilient future for agriculture, salmon, and coastal communities in Snohomish County

Project Location: Snohomish County, Washington
Snohomish and Stillaguamish River Watersheds, Puget Sound

Project Category: Strengthening Coastal Communities

Funding Request: \$467,733
Non-federal Match: \$270,589
Other match: \$118,000
Overall Project Cost: \$856,322

Project Summary:

Puget Sound and the Snohomish Watershed received a Resilient Lands and Waters Initiative designation in 2015 through the President's Priority Agenda for Enhancing the Climate Resilience of America's Natural Resources. This designation recognized the potential for Puget Sound to be a national model for climate change adaptation – a place where increased cooperation and capacity could be leveraged to show others how to prepare for the impacts of climate change and extreme weather. Snohomish County's Sustainable Land Strategy (SLS) was recognized as a leader in the declaration. SLS is a group of members representing agencies, local jurisdictions, non-profit organizations, tribes, and farmers that have come together to plan for a resilient future for salmon, farms, and floodplains. The two highest priority barriers identified for developing a multiple benefit approach to resilience planning are a lack of detailed climate modeling data and identified agricultural resilience projects. This proposed project will fulfill both of those needs through detailed flood, groundwater and crop impacts modeling as well as creation of an Agriculture Resilience Plan.

Background: Washington's Puget Sound is the nation's second largest estuary and plays a critical role in the life-histories of several NOAA trust species as well as supports a population of more than 4 million people. The Snohomish and Stillaguamish River watersheds (see Map), represent a large portion of the Sound and host significant runs of nine salmonid species, three of them ESA-listed. The broad tidally influenced floodplains of these two main rivers in Snohomish County have extensive estuarine habitat and highly productive agricultural lands. Salmon recovery planning had identified restoration of estuary and floodplain habitat as a priority, often leading to conflicts between recovery interests and the agricultural community.

The *State of the Knowledge: Climate Change in Puget Sound* (2015) report identified the following major local impacts and vulnerabilities from climate change:

- **Dramatic decreases in snowpack** will completely alter the hydrologic regime of the region. Changes to river flow timing and magnitude threatens salmon runs and agricultural viability.
- **Increased average annual temperatures** will impact the economy and food production through elevated stream temperatures, introduction of new plant diseases and pests, and reduced water flows for irrigation, municipal use and salmon populations.
- **Sea level rise and ocean acidification** are already impacting tidal marshes, floodplains, groundwater levels, and wells that supply water to some neighborhoods.

Several studies, including the *Snohomish County Hazard Mitigation Plan* (2015) approved by FEMA and the *WRIA 7 (Snohomish River) Climate Change Impacts to Salmon Issue Paper* (2017) have pointed toward the need for community preparedness while at the same time identifying a lack of watershed specific climate modeling data. This proposal builds upon several existing grant-funded projects being completed for the region: sea level rise modeling funded by a NOAA Climate Resilience Grant, precipitation prediction estimates funded by King County, and streamflow predictions funded by the Bonneville Power Administration.

Project proposal: The proposed project will leverage ongoing research to provide critical climate modeling information for the Stillaguamish and Snohomish watersheds and fill data gaps that are hindering the ability of our flood managers, salmon recovery managers, and agricultural community to plan for and implement resilience projects.

The project objectives and actions are as follow:

Objective 1. *Develop actionable climate science to support local watershed resiliency planning.*

The University of Washington Climate Impacts Group, USGS, and Washington State University will develop projections of flood inundation, groundwater levels, and weather-related crop impacts.

Objective 2. *Build community knowledge of potential vulnerabilities and resilience strategies.*

A cornerstone of this work is educating the community, both decision makers and local landowners, as well as building the capacity of these groups to plan for a changing climate. Online tools will be created that allow users to access the flood, groundwater, and crop impacts modeling data interactively.

Objective 3. *Develop and design projects and practices to increase agricultural resilience.*

The current suite of salmon recovery projects for the Snohomish and Stillaguamish Rivers will be expanded to include agriculture resilience projects and practices to complete planning for this multiple benefit approach to watershed management.

Objective 4. *Develop a plan to guide future actions.*

The *Agriculture Resilience Plan* will serve as a model for other counties where collaborative efforts have been stalled due to lack of a unified agricultural voice or the technical ability to scope larger-scale agricultural resilience projects. It will provide a prioritized list of climate resilient agricultural projects and a protection plan for agricultural lands. The flood and groundwater modeling work will inform this plan as well be incorporated into climate resilient salmon planning and restoration project designs.

Evaluation: During the course of this planning project, several indicators from the *Community Resilience Indicators and National-Level Measures: A Draft Inter-agency Concept* (FEMA) will be measured to evaluate project success. The number of people reached and that implement resilience projects will be tracked to evaluate the success of outreach efforts. The effectiveness of integrating both climate science and agricultural projects into multi-benefit project packages will be evidenced by development of project packages that are agreed on by all SLS members. And the availability and use of this data through online platforms will be measured.

Timeline: The major objectives will be completed by the following dates.

- Hydrologic modeling (flow, inundation, groundwater) – September, 2018
- Hydrologic modeling data incorporated into online tool – December, 2018
- Crop modeling and tool development – December, 2019
- Outreach and information dissemination – Ongoing
- Agriculture resilience projects and BMPs scoped – December, 2020
- Agriculture Resilience Plan completed – December, 2020

Project Narrative
FY 2017 NOAA Coastal Resilience Grants Program (NOAA-NOS-NRPO-2017-2005159)

**Project Title: Building a resilient future for agriculture, salmon,
and coastal communities in Snohomish County**

The Snohomish River Watershed (see Map) in the Puget Sound received a Resilient Lands and Waters Initiative designation in 2015 through the President's Priority Agenda for Enhancing the Climate Resilience of America's Natural Resources. The designation highlights recent successes and builds momentum for efforts to prepare the region for an uncertain future through floodplain restoration, farmland preservation, and flood risk reduction. Snohomish County's Sustainable Land Strategy (SLS) and the Puget Sound Floodplains by Design (FbD) program were recognized as leaders in the declaration.

Puget Sound is well suited to demonstrate on-the-ground progress towards building resilient communities and ecosystems. The region has: exciting new watershed-based collaboratives, such as SLS, that is breaking down barriers between interest groups; a state funding program – Floodplains by Design – that has provided \$80 million to resilience-building infrastructure projects over the last five years; and an engaged state and federal agency family that has come together under a new Coordinated Investment initiative and Results Washington initiative. The White House designation of Puget Sound and the Snohomish Watershed as a place to showcase a climate resilient approach is indicative of this reality.

The Snohomish County Sustainable Lands Strategy is an innovative effort focused on overcoming barriers to resilience planning. In their approach, those with a stake in more resilient floodplains and communities build *integrated community and ecosystem resilience plans* to achieve “net gains” for rivers, farms, communities, and tribes. These efforts help communities build multiple benefit projects ready to break ground as funding opportunities, such as the Floodplains by Design grant program, become available. These partnerships provide a mechanism to ensure the tools, capacity building, planning, and communications work are strategically focused on preparing the region for extreme weather events, climate change, and changing ocean conditions.

The work described in this proposal will make substantive advances toward demonstrating that building a resilient future is good for at-risk communities, for the agricultural sector, and for fisheries and ecosystems in the Snohomish and Stillaguamish River watersheds of Puget Sound. The work has regional significance as it will serve as both a technical and engagement model to other watersheds in the Puget Sound. If this project is funded it will:

- *Run localized climate prediction models to identify and quantify climate-related hazards to agriculture and incorporate them into online tools for use by decision makers and the public.*
- *Launch an outreach campaign to educate partners and decision makers on the use and integration of these hazard tools into their planning work.*
- *Launch a comprehensive education campaign to landowners explaining the risks and opportunities associated with climate change. Work with the community to develop and design suites of projects that benefit agricultural, salmon recovery, and community resilience.*
- *Collaborate with jurisdictional partners to develop the goals and planning documents necessary to implement an integrated approach to land management.*

Background and Need

Washington's Puget Sound is the nation's second largest estuary - a unique inland sea that holds 16 major rivers, 2700 miles of shoreline and more than 7,000 species. The Sound plays a critical role in the life-histories of several NOAA trust species. Its basin supports more than 4 million people, and a thriving \$40 billion economy. Land conversion, however, has severely altered freshwater flows into the Sound, undermining productive floodplain and estuary habitats: 82% of historic wetlands, the most productive component of the system, have been lost. More than one-third of the shoreline has been modified or hardened. Upland land use changes combined with road and levee infrastructure have aggravated flooding. Average peak flows on most of the Sound's rivers have been steadily increasing over the last 20 years, increasing flood risk throughout the lowlands.

The Snohomish and Stillaguamish River watersheds (see Map) host significant runs of nine salmonid species, three of them ESA-listed. The broad tidally influenced floodplains of these two main rivers in Snohomish County have extensive estuarine habitat and highly productive agricultural lands. The coastal floodplains have a naturally high water table and provide one of the few places nationally where a variety of crops can be grown with minimal irrigation.

Today, levees confine much of the lower Snohomish and Stillaguamish Rivers, disconnecting the floodplains from the main channel, restricting channel migration, and thus confining sediment and hydrologic processes. These constrictions reduce the ability of river channels to store and route sediment and flood waters, leading to increased flood damages to agricultural lands and floodplain communities. These risks are rising as peak flows increase with climate change. Meanwhile, loss of floodplain connectivity and riverine processes has degraded or eliminated critical salmon habitat.

The Snohomish and Stillaguamish watersheds play important roles in the economy of Puget Sound. Located only 20 miles north of Seattle along the major I-5 transportation route, the Snohomish valley is one of the fastest growing regions in the country. The region's noted appetite for locally-produced food has increased the viability of agricultural producers, and new producers are expressing interest in locating to area. Unfortunately, infrastructure required to protect new development and farmlands from climate-related threats can conflict with ecological needs leading to impasses between farmers and people working to protect the estuarine wetlands and natural processes that sustain the region's salmon runs. This conflict has often stalled essential measures to keep farms viable while delaying work to recover endangered salmon and restoring Puget Sound.

The *State of the Knowledge: Climate Change in Puget Sound* (2015) publication prepared by the Climate Impacts Group at the University of Washington for NOAA and the Puget Sound Partnership, identifies the following major impacts to our region's natural resources and communities:

- **Dramatic decreases in snowpack** as well as timing of annual precipitation will completely alter the hydrologic regime of the region. The majority of Washington's water storage is in the form of mountain snowpack so farms, communities, and fish face water losses amplified by warming. Puget Sound watersheds rely on mountain snowpack to store water in the winter; high-elevation snows capture peak precipitation and release it in spring and early summer, when economic, environmental, and recreational demands for water throughout the region are greatest. The shift to more rain-fed systems has already pushed peak river flows earlier, reducing late summer flows to historic lows and increasing winter flood frequency and magnitude. This altered timing of flow threatens the viability and recovery of listed salmon. Increased winter flood damage, spring drainage challenges, and reduced summer precipitation threatens the viability of our agricultural industry.
- **Increased average annual temperatures** will impact the economy and food production through elevated stream temperatures, introduction of new plant diseases and pests, and reduced water

flows for irrigation, municipal use and salmon populations. Low summer flows and warmer stream temperatures are already a critical threat to the survival of salmonid populations. Increases in the length of the growing season, atmospheric CO₂ levels, and temperatures, on the other hand, may provide benefits to agriculture if not hindered by lack of water for crops.

- **Sea level rise and ocean acidification** will continue and have an enormous impact on the Snohomish and Stillaguamish River watersheds (which already experience unusually severe acidification, providing a preview of future conditions projected to occur in 50-100 years elsewhere). Rising sea levels are already impacting tidal marshes, floodplains, groundwater level, and wells that supply water to neighborhoods. More frequent king tides threaten shoreline infrastructure and habitats.

In addition, several additional local planning documents have addressed the community's needs as they relate to planning for current and future climate-related hazards.

The updated *Snohomish County Hazard Mitigation Plan* (2015), approved by FEMA, identifies numerous climate-related hazards including flooding, levee and dam failure, landslides, and severe weather. The plan states that "no modeling is currently available to develop quantitative estimates of the effect of climate change on natural hazard risks." The *WRIA 7 (Snohomish River) Climate Change Impacts to Salmon Issue Paper* (2017), prepared for the Lead Entity salmon recovery planning process, outlines the projected impacts of altered river hydrology and water temperatures on ESA listed salmon species. Recommended actions include increasing the capacity of rivers to be resilient to changing flow and restoring refuge habitat for juvenile salmon.

The proposed project will provide critical modeling data to fill data gaps that are hindering the ability of our flood managers, salmon recovery managers, and agricultural community to plan for and implement resilience projects that mitigate the effects of climate change hazards on our coastal community. The project will result in several of the actions identified in the *Hazard Mitigation Plan* including: use of best available science to prepare for impacts, enhancement of education projects, strengthening community networks, incentivizing resilience projects, and protecting floodplain ecosystem functions. These documents as well as collaborative planning efforts under the Sustainable Lands Strategy, Local Integrating Organization, and Salmon Recovery Lead Entities has underscored the need for additional modeling showing to quantify impacts of climate related flooding, groundwater level rise, sea level rise, storm surges, and summer drought on the health of our rivers, fish populations, and agricultural industry. In addition, the need for broad community education and outreach coupled with incentives and technical support for climate resilient project implementation is critical.

Goals, Objectives, and Project Activities

The goals and objectives of this project involve acquiring cost-effective and scale-appropriate climate modeling data, disseminating this information to decision makers and the public, and scoping climate resilient multiple benefit projects to build a resilient future for coastal Snohomish County. The resulting online planning tools will inform development of a resilience plan for agriculture, updates to the goals in the salmon recovery plans, and siting and design of projects. This project ensures that climate science is translated and made available in ways that directly informs watershed management decision making.

Objective 1. Develop actionable climate science to support local watershed resiliency planning.

Anticipated outcome: Complete hazard and benefit impact assessment to flooding, groundwater, and agricultural crops.

1.1 – Streamflow, Sea-level Rise, and Inundation Modeling

Inundation (hydraulic) models, which are used to estimate the extent and depth of flooding, are a central tool for the proposed work. The University of Washington Climate Impacts Group (Mauger) will lead the effort to estimate future flood risk under current land use conditions: existing levees, diversions, and other infrastructure that may influence streamflow and flood extent. The intent of this work is to provide an initial look at the impacts of climate change as a basis for prioritization and planning discussions among stakeholders.

Existing datasets will be used to produce the historical and future climate inputs that serve as boundary conditions to the inundation model simulations. Climate projections will be synthesized into low, middle and high estimates in order to span a range of future conditions.

Sea level rise projections, currently being finalized as part of a Coastal Resilience grant from NOAA (FY2015 – *Improving risk communication and leveraging existing programs in Washington State to build capacity and enhance resilience in coastal communities* – sponsor: Washington Sea Grant), will include estimates of vertical land motion, which can affect the rate of sea level rise in the tectonically-active Pacific Northwest, as well as estimates of storm surge extremes.

Changes in precipitation extremes will be quantified using the Weather Research and Forecasting model (WRF) as well as an ongoing statistical analysis relating changes in precipitation extremes to the rate of warming. Both leverage ongoing funding from the Department of Homeland Security Critical Infrastructure Resilience Institute (Salathé) as well as other sources. Streamflow projections will be obtained from the forthcoming River Management Joint Operating Committee, Phase II effort (RMJOC-II), led by the University of Washington researcher (Nijssen). Runoff from the model will be routed to produce streamflow estimates at specific inundation model input points.

Through an external contract, SSBN Ltd. will employ an existing flood model that has previously been developed for the entire United States (Figure 1). (<http://www.ssbn.co.uk/case-studies/#nature-conservancy>). This 2D model will be re-configured for simulations covering the entirety of both the Stillaguamish and Snohomish watersheds with inputs from the National Levee database. This model is a new, streamlined approach to 2D modeling, using a higher resolution DEM along river channels and 30m resolution in uplands. If this new streamlined and very cost-effective approach (\$12,500 for two watersheds as opposed to ~\$200,000 for traditional 2D modeling) proves effective, the University of Washington has proposed expanding its use to the entire Puget Sound region to greatly improve the region's ability to plan for hydrologic changes.

Building on the historical simulations, SSBN will evaluate 6-10 scenarios of future flood risk. These will incorporate the streamflow, precipitation, and sea level rise projections described above. All results will be distilled into a set of maps and data files that provide gridded estimates of flood depth at the 30m model resolution. SSBN will deliver these as well as a report synthesizing the approach, model validation, and results of the flood modeling. The data will be made publicly available on an online interactive map created by The Nature Conservancy discussed in more detail in Objective 2.2.

1.2 – Groundwater Modeling

The impact of sea-level rise, storm surges, and increases flooding will then be used to determine the impact of that “coastal squeeze” on groundwater levels in the estuaries of the Snohomish and Stillaguamish Rivers (Figure 2). The USGS (Grossman) will lead this effort to model predicted changes to groundwater levels for the six climate scenarios described above. Rising groundwater levels are already threatening the ability of farmers to begin cultivation in the spring and salt water intrusion threatens both agricultural viability and freshwater habitat.

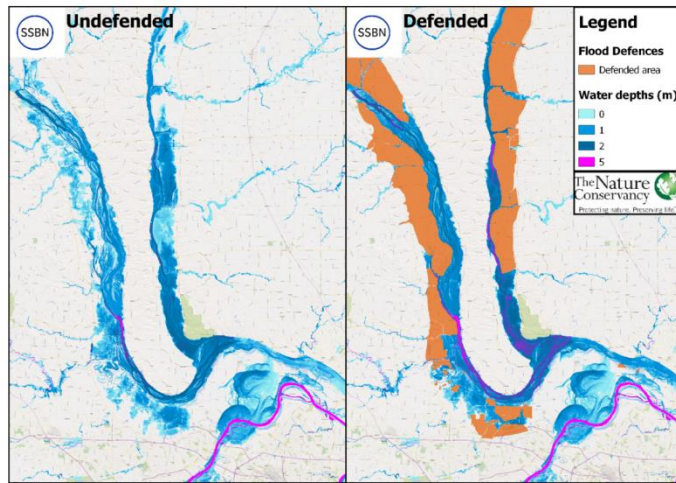


Figure 1: Example of hydraulic flood modeling completed by SSBN for The Nature Conservancy. This new approach has the potential to cost-effectively provide climate change flood scenario modeling to all of Puget Sound.

A combination of modeling and field data collection will be employed to establish and project groundwater response to surface water forcing (flooding and sea level rise). The model will demarcate habitat and land-use vulnerable to sea-level rise and groundwater ponding out to the year 2080. In addition to mapping the extent of projected groundwater ponding, estimates of the frequency distribution of ponding will be assessed and mapped. Today, tides have been shown to influence groundwater levels between one and three kilometers away from surface water in the unconfined coastal aquifers of the Skagit, Stillaguamish, and Grays Harbor river deltas. The model will exploit these relationships to assess groundwater response to changes in stream flow under climate change, higher sea level, and storm surges in the Stillaguamish and Snohomish River estuaries.

Existing groundwater dynamics, particularly the spatial extent and gradient of tidally-forced groundwater oscillations will be characterized through field research of groundwater level behavior along transects oriented away from the river channels. Three shallow groundwater level monitoring wells along two transects, one in the Snohomish and one in the Stillaguamish River estuary, will each be deployed with a continuous conductivity-temperature-depth (CTD) sensor. Water level data along with a time-series of barometric pressure will enable analyses of the tidal propagation in the groundwater across the coastal aquifers.

Future groundwater levels and ponding extent will then be estimated by extrapolating today's tidally driven groundwater level to scenarios with higher projected streamflows and sea levels and changing storm surge scenarios. This analysis will provide a more complete picture of the vulnerability of these currently diked and drained lands to groundwater ponding. The results will then be used to calculate initial estimates of pumping (drainage) effort and costs.

The groundwater analyses will be translated into language and images that can be understood by decision makers and stakeholders in our floodplains and will be used as the basis for the outreach efforts with decision makers and the public outlined in Objective 2.

1.3 – Crop modeling and tool development

The impacts of increased temperatures and higher atmospheric CO₂ levels have the potential to be hazards or benefits to agriculture in the region. Researchers at Washington State University have taken the lead in modeling these impacts in Eastern Washington so farmers can better adapt to changing conditions and manage for risk. On the west side of the state, however, where climate and agriculture

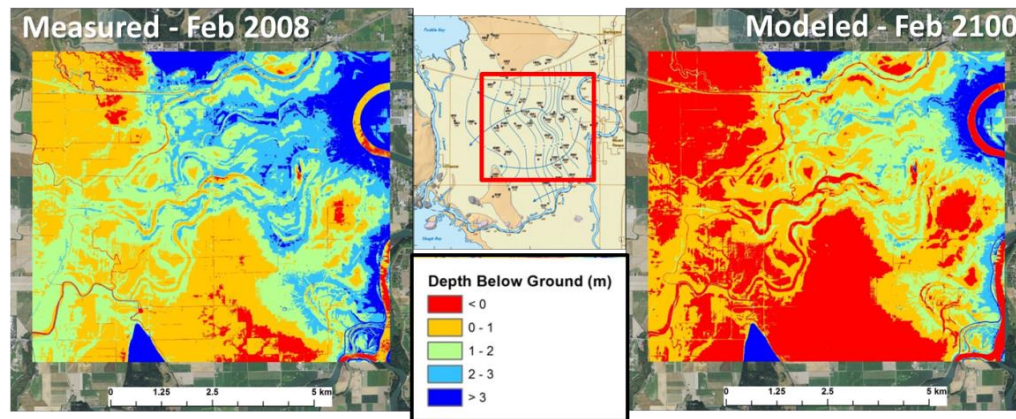


Figure 2. Example of measured depth to groundwater table across the central Skagit Delta in Feb, 2008 (left; Savoca et al, 2009), and modeled for the same area extrapolated for 3 ft of sea level rise by the year 2100 (right). Red areas indicate water level above land surface elevation (ponding).

are vastly different, there is a strong need for this research to be expanded. The Center for Sustaining Agriculture and Natural Resources at Washington State University (Rajagopalan) will take the lead in characterizing the potential impact of climate change on specific agricultural crops in Western Washington as well as create an online tool that will allow farmers to view climate projections for agriculturally relevant variables such as growing season length, frost risk, heat stress, and crop maturity timing for their specific location.

Crop Impacts Modeling: The potential impacts of climate change on Western Washington’s agriculture will be characterized by a large-scale hydrologic and cropping systems model (VIC-CropSyst). This modeling has already been completed for the Columbia River Basin on the east side of Washington State so minimal funding is needed to expand the effort. The modeling has been used to explore regional agricultural-resource management questions including long-term water supply and demand forecasts and impacts of temperatures and temporal climate shifts on regional agricultural production (Adam et al., 2014; Liu et al., 2014; Stockle et al., 2014; Yorgey et al., 2011; Malek et al., in review; Rajagopalan et al., in review). The VIC-CropSyst model (Figure 3) allows simulation of the interactions between hydrologic and biogeochemical processes and the effects of agricultural management. It includes a hydrologic component -VIC, as well as cropping system component- CropSyst. While VIC-CropSyst does not predict effects at the individual farm scale, its strength lies in assessing crop production and irrigation demands at regional scales under the impacts of climate change and farm management changes in irrigation, fertilization, crop, or rotation types.

The expansion of this model to Western Washington includes creating and processing input parameters (meteorological inputs, soil parameters, and crop parameters), crop model calibration, and running simulations to assess expected changes to crop yield and irrigation demands under climate-change projections, thus laying the foundation for exploring adaptation alternatives.

The historical climate driver for this research is the Gridded Surface Meteorological Dataset (Abatzoglou, 2011), which includes surface meteorological variables (i.e. temperature, precipitation, downward shortwave radiation, humidity and winds) at a spatial resolution of 4 km. For future climate projections to the year 2100, WSU will use downscaled global climate model (GCM) data from the Coupled Model Intercomparison Project 5 (Taylor et al., 2012) using the Multivariate Adaptive Constructed Analog method (Abatzoglou and Brown, 2012).

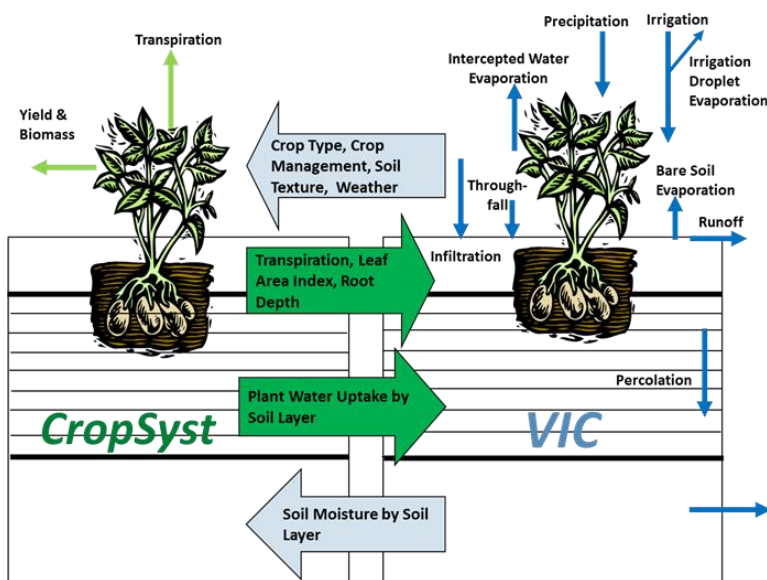


Figure 3. The VIC-CropSyst integration model will be used to assess climate changes on crop production in Western WA. CropSyst is a crop growth and biogeochemistry sub-module that is run jointly with VIC, a hydrologic model. Note: this schematic was created to emphasize the hydrologic processes that are impacted by crop growth and irrigation and does not include a variety of other key processes, such as the snow melt and accumulation, simulated by VIC and N cycles simulated by CropSyst.

Online Crop Impacts Projection Tool: WSU’s Center for Sustaining Agriculture and Natural Resources has developed a Crop Impacts Projection Tool for Eastern Washington, a map-based tool that allows farmers to visualize projected climate changes in their specific location (Figure 4). The tool helps users visualize projections for agriculturally relevant variables –changes in growing season length, growing degree-day accumulation, frost risk, heat stress, precipitation patterns, crop maturity timing, etc. – in an interactive manner. For example, farmers may use this tool to decide if double cropping (two crops back-to-back in one season) may be an economically viable option. The tool also allows users to explore future crop-growing conditions with a historical perspective through the concept of spatial analogs in the Western Continental US. Using the Mahalanobis statistical distance measure (De Maesschalck et al., 2000), spatial analogs give an indication of locations whose current growing conditions are similar to future growing conditions in one’s location of interest (e.g., parts of Washington could be expected to have future growing conditions similar to current conditions in parts of California).

As part of this project, WSU will extend the geographic scope of the tool to include crop-growing areas in Western Washington. Field-level crop land-cover data created by the Washington Department of Agriculture (WSDA CDL, 2015) will be aggregated to the grid size of the future climate projections. WSU and the Conservation District will also create a training material for the tool in the form of a webinar or recorded Powerpoint presentation.

The model results and online tool will help stakeholders gain a better understanding of what the climate drivers of agriculture look like in the future, take advantage of potential benefits to growing conditions, and implement changes in management that better account for projected risk.

Deliverables:

- Inundation modeling completed for Stillaguamish and Snohomish River watersheds
- Groundwater modeling completed for Stillaguamish and Snohomish River estuaries

- Crop impact modeling completed for Western Washington
- Crop Impacts Projection Tool completed and accessible to public online

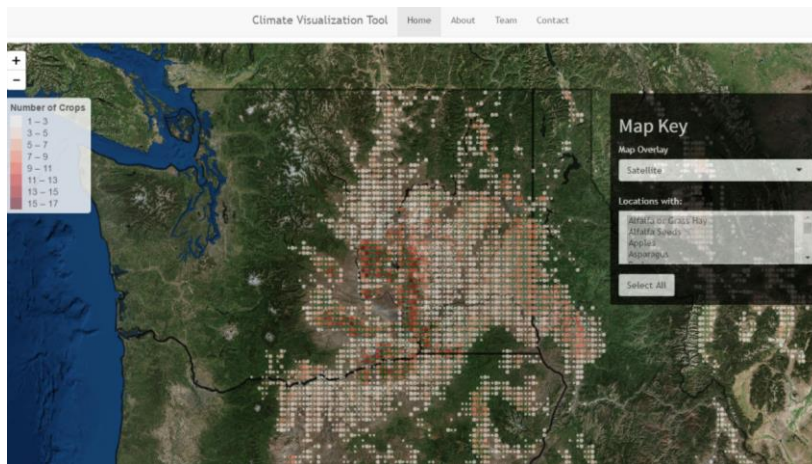


Figure 4. The Crop Impacts Projection tool, currently covering the east side of Washington State and Oregon, will be expanded to include Western Washington. The tool allows farmers to see projected impacts to agriculturally significant variables such as changes in growing season length, growing degree-day accumulation, frost risk, heat stress, precipitation patterns, and crop maturity timing for their specific location.

Objective 2. Build community knowledge of potential vulnerabilities and resilience strategies.

Anticipated outcome: Local and regional decision makers, local landowners, and partner jurisdictions will understand modeled impacts of climate change on flooding, groundwater, and crops and have the tools necessary to develop resilience plans and projects.

2.1 – Education and outreach in Snohomish County

Local education will consist of outreach to two groups within Snohomish County – partner agencies including members of the Sustainable Lands Strategy effort and local landowners, specifically agricultural producers.

The Snohomish Conservation District has taken the lead in developing a scientifically based climate resilience approach to agricultural impacts in Snohomish County. Discussions and presentations at stakeholder meetings over the last year have grown the project team to include partners interested in salmon recovery and flood planning. With the support of the Sustainable Lands Strategy members representing agencies, local jurisdictions, non-profit organizations, tribes, and farmers, this project has now become a coordinated effort to develop resilience strategies for our two main watersheds – the Stillaguamish and Snohomish Rivers. Stakeholders have been engaged in the process of developing the project goals, objectives and modeling approach through a series of sub-committee planning groups (Hydrologic modeling, Alternative agriculture, Outreach, and Land preservation). These committees will continue to present results and receive guidance from Salmon Recovery Lead Entity groups, Local Integrating Organizations under the regional direction of the Puget Sound Partnership, and an Agriculture Advisory Committee. The Agriculture Advisory Committee, comprised of local farmers, was created specifically to inform the development of a resilience plan for agriculture.

The largest component of the outreach strategy will involve educating and engaging local landowners. We want to build community through shared knowledge of potential climate risks and vulnerabilities as well as provide funding, technical expertise, and incentives for project implementation. Projects will increase our agricultural community's resilience to changing flooding and climate scenarios.

Snohomish County has a very diverse agricultural community. While the District has had great success reaching a variety of types of farmers (livestock, equestrian, crop, organic, forage), we have not done enough to reach all demographics. For example, in the Snohomish River floodplain, we have a large population of Hmong farmers from Vietnam and Laos that grow and sell cut flowers. Language and cultural barriers have inhibited our ability to reach this community with our programs. We propose to work with partners at Washington State University and consultants to develop a creative and culturally appropriate outreach approach. This will involve social marketing research into effective messaging and outreach techniques. We expect these activities to include workshops, community meetings, and outreach materials involving the use of local translators and community spokespeople.

Initial outreach events with agricultural producers will focus on educating them about the impacts of climate related hazards in their specific location. Follow-up events will enlist landowners in the development of resilience project packages involving salmon restoration projects, agricultural drainage projects, and flood protection projects.

2.2 – Online tool development and marketing

A key to successful outreach to landowners is being able to display the hazard related information in a way that is easily understandable and publicly accessible. These same criteria apply to ensuring the information is used by decision makers and local planners. For this reason, two existing online tools will be adapted and expanded to display hydrology related and crop related climate predictions.

Floodplains by Design Decision Support Tool – The Nature Conservancy (TNC) will build the new modeling data into its Floodplains by Design Decision Support Tool, developed as a pilot for the Lower Snohomish River in 2014 (Figure 5). The tool, recently awarded an ESRI Special Achievement for GIS award, utilizes downscaled climate change information linked with hydrologic and hydraulic modeling to visualize a range of alternative flooding scenarios and their associated economic impacts in the Lower Snohomish.

The project partners intend to greatly enhance the Decision Support Tool and utilize it for outreach activities through this grant. Flooding scenarios will be expanded to include the entire mainstem river and major tributaries of both the Stillaguamish and Snohomish Rivers; groundwater modeling and sea level rise mapping will be added, and the user interface will be improved.

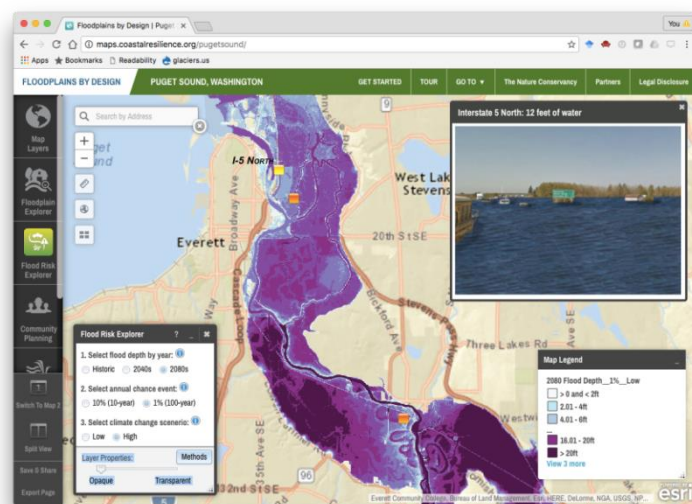


Figure 5. The Floodplains by Design Decision Support Tool, an online tool created by The Nature Conservancy, currently allows users to explore climate change impacts to flood inundation in the lower Snohomish River basin. The image is a geo-tagged photo of the I-5 freeway, showing the water level estimated from a high-end future climate scenario. The proposed work

would expand the coverage of data to include all of the Snohomish and Stillaguamish River floodplains and add the groundwater modeling results in the estuary. Source: <http://coastalresilience.org>

Crop Impacts Projection Tool – Washington State University will expand their Crop Impacts Projection Tool described in Objective 1.3 to include Western Washington. This tool will then be used during the local education and outreach in Snohomish County to agricultural producers. The Snohomish Conservation District will provide the technical assistance to supplement this tool, allowing farmers to use the information provided to develop a plan for their property that includes best management practices to build soil health, increase water holding capacity, reduce runoff, and diversify crops.

2.3 – Regional information dissemination

Snohomish County is leading the region in development of a collaborative planning process for fish, flooding and farming that integrates climate change projections in a meaningful way. For this reason, several aspects of this project have the capacity to greatly improve the region's ability to plan for changes in flooding and climate related hazards.

Through this project, we will create a Climate Resilience Learning Network of partners and decision makers wanting to share technical, planning, and outreach information. Partners that have expressed interest include PCC Farmland Trust, The Nature Conservancy, King County, Whatcom Conservation District, US Forest Service, Washington State University and Extension, Natural Resource Conservation Service, and the University of Washington Climate Impacts Group. The format of this network will be decided by the participants but could include meetings or email groups.

In addition, the Snohomish Conservation District and project partners will showcase the technical tools developed and planning documents created through this project. Several other counties and conservation districts have expressed a similar desire to create a resilience plan for agriculture but have been unsure how to begin or acquire funding. The Crop Impacts Projection Tool will be created for all of Western Washington and therefore available for use by partners in other counties. The flood inundation modeling approach, if successful, can very cost-effectively be replicated in other counties and uploaded on The Nature Conservancy's same online tool.

Through various presentations at regional forums (Puget Sound Conservation District Caucus, Salmon Recovery Funding Board Conference, Puget Sound Natural Resource Alliance), the project partners will disseminate the successes, failures, and next steps of this proposed work.

Deliverables:

- Minimum of 10 events to educate and engage local landowners
- Floodplains by Design Decision Support Tool updated to include inundation and groundwater modeling results for Stillaguamish and Snohomish Rivers
- Crop Impacts Projection Tool completed and accessible to public (see Deliverables for Obj. 1)
- Minimum of 4 presentations at regional forums

Objective 3. Develop and design projects and practices to increase agricultural resilience.

Anticipated outcome: Current suite of salmon recovery projects for the Snohomish and Stillaguamish Rivers is expanded to include agriculture resilience projects and practices to complete planning for this multiple benefit approach to watershed management.

3.1 – Climate resilient agricultural projects

The Sustainable Lands Strategy members have been collaborating for the last six years with the goal of developing multiple benefit approaches to floodplain management that provides net-gains for both salmon recovery and commercial agriculture. A key gap in development of these project packages has been the information, modeling, and technical expertise necessary to develop projects needed by the agricultural community. The impact assessment (Objective 1) and outreach efforts with the agricultural community (Objective 2) will lead to the scoping and design of agricultural resilience projects such as water management projects (drainage, efficiencies, storage), infrastructure improvements (pump station efficiencies, dike maintenance or alterations, flood gate improvements), or flood and erosion protection projects (riparian forests, flood fencing, bank stabilization).

An assessment of current agricultural land-use combined with the flood and groundwater modeling results will be used to identify priority agricultural landscapes where infrastructure improvements would be the most beneficial, cost-effective, and resilient to climate impacts into the future. Priority agricultural lands will also be included in a strategy for farmland protection being led by PCC Farmland Trust, a non-profit land trust.

The Snohomish Conservation District will contract with an engineering firm to develop 30% conceptual designs for several projects to facilitate the acquisition of construction funding.

3.2 – Climate resilience agricultural best management practices defined

In addition to the larger projects described above, resiliency can be improved on individual farms through implementation of agricultural best management practices (BMPs). The Conservation District will work with researchers from Washington State University and WSU Extension, Natural Resources Conservation Service (NRCS), and other agencies and conservation districts to develop a suite of recommended practices to improve on-farm resilience to drought, higher temperatures, and flooding. We expect these practices to include techniques for building soil water holding capacity, increasing flood protection, storing water, and diversifying income sources. Specific BMPs are likely to include compost or biochar, agroforestry, and cisterns or raingardens. These BMPs have multiple benefits as they also improve water quality and salmon habitat. The District will conduct a literature search to explore the effectiveness of such practices and is in process of planning a State of the Research Workshop for May, 2017 with partners WSU, NRCS, and the Whatcom Conservation District. Requested grant funds will be allocated to meet research data gaps.

Deliverables:

- Minimum of two agricultural resilience projects designed to 30% level (number of projects is largely dependent on scale – this assumes larger landscape-scale projects)
- Report of climate resilient, locally relevant agricultural best management practices

Objective 4. *Develop a plan to guide future actions.*

Anticipated outcome: Completion of an Agriculture Resilience Plan will bring the voice of agriculture to the Sustainable Lands Strategy table, resulting in the successful development of a multiple benefit approach to watershed planning.

4.1 – Agriculture Resilience Plan

The Snohomish Conservation District, under advisement of an Agriculture Advisory Committee comprised of local farmers, and under technical direction from stakeholders engaged in the various project committees, will complete an *Agriculture Resilience Plan*. The Plan will include the following:

- Summary of the projected impacts to agriculture (Objective 1 modeling) to include both hazards and potential benefits
- Tools available (online) for farm-scale risk-management planning and larger landscape-scale project planning
- Maps showing proposed projects to improved agricultural resilience and associated costs (where available)
- Map prioritizing agricultural lands for preservation efforts (at risk of conversion)
- Recommended best management practices to improve on-farm agricultural resiliency

The *Agriculture Resilience Plan* will serve as a model for other counties where collaborative efforts have been stalled due to lack of a unified agricultural voice or the technical ability to scope larger-scale agricultural resilience projects. It will also provide a prioritized approach for funding acquisition that, along with preliminary designs for several projects, will pave the way for swift project implementation.

4.2 – Salmon restoration project scoping and design

The Snohomish and Stillaguamish River salmon recovery plans were approved by NOAA in 2005 and included 10-year and 50-year restoration goals. With the passing of the target date for the 10-year goals, the Stillaguamish Lead Entity planning groups underwent a comprehensive process of updating their goals based on new best available science. Because no locally specific climate impact modeling for flooding, groundwater, and sea level rise was available, we expect this new information to inform further refinement of or prioritization of these goals. The Stillaguamish Lead Entity awarded funding for the Conservation District to complete the hydrologic and hydraulic modeling for the Stillaguamish River (included as match) to inform salmon restoration project siting and design. In the Snohomish River, a 10-year update was not completed. A definitive plan for completing this update is not yet in place but Snohomish County acknowledges the benefit that this new modeling data will provide. Staff from the Snohomish Lead Entity Technical Committee are on the project planning team so as to ensure the modeling parameters are appropriate to inform salmon recovery goals, project siting, and design. Funding for this sub-task will enable the Conservation District to engage in these processes, ensure the technical knowledge is transferred, and provide the datasets to planners and decision makers.

Deliverables:

- Completion of *Agriculture Resilience Plan*
- Technical knowledge and modeling results supplied to lead entity salmon planning groups for incorporation into project prioritization, siting, and design

Evaluation

During the course of this planning project, several indicators from the *Community Resilience Indicators and National-Level Measures: A Draft Inter-agency Concept* (FEMA) will be measured to evaluate project success.

- Healthy Behaviors and Community Preparedness – As a result of the outreach and education efforts in Objective 2, we expect landowners to adopt resilience practices. This will primarily consist of agricultural best management practices at the farm-level. At the landscape level, this will involve drainage and diking districts being willing to scope and plan flood and drought resilience projects. We will conduct follow-up surveys with landowners participating in outreach and educational events with the **goal of changing behavior in 3% of participants**. We expect this number to increase over time as the “early adopters” inspire others to take action.
- Habitat Quality – This project will result in packages of projects developed that have multiple benefits for fish, farms and flooding. The success of this indicator will be measured by **the**

number of project packages developed that are supported by both salmon recovery and agriculture interest groups.

- Risk Identification – The inundation, groundwater and agricultural modeling will allow decision makers and the community to plan for climate associated risk. This indicator will be measured by the **completion of these modeling tasks, public availability through the online tools, and educating local jurisdictions and decision makers how to use the data.**
- Planning Integration – The data and tools created can be used for multiple planning purposes by local jurisdictions and decision makers. As in Risk Identification, this will be measured through success of educational efforts.

Milestone Schedule

Milestone Schedule		2018				2019				2020			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Objective 1. Develop actionable climate science to support local watershed planning.													
1.1 Streamflow, sea level rise, and inundation modeling													
1.2 Groundwater modeling													
1.3 Crop modeling and tool development													
Objective 2. Build community knowledge of potential vulnerabilities and resilience strategies.													
2.1 Education and outreach in Snohomish County													
2.2 Online tool development and marketing													
2.3 Regional information dissemination													
Objective 3. Develop and design projects and practices to increase agricultural resilience.													
3.1 Climate resilient agricultural projects													
3.2 Climate resilient BMPs defined													
Objective 4. Develop a plan to guide future actions.													
4.1 Agriculture Resilience Plan													
4.2 Salmon restoration project scoping and design													
Light blue: interim processes and products													
Dark blue: final products													

Partnerships

The Snohomish Conservation District has been an active member of the Sustainable Lands Strategy, a group comprised of members representing agencies, local jurisdictions, non-profit organizations, tribes, and farmers. This project will continue to be advised by this collaborative multi-jurisdictional group (see attached Letter of Support). Cindy Dittbrenner will act as the Project Manager. Dittbrenner leads the Natural Resources team at the District, comprised of farm and habitat resource professionals. She has over 15 years of experience collaborating with the community and leading project teams.

An advisory committee for *Objective 1: Develop actionable climate science to support local watershed resiliency planning*, includes representatives from the salmon recovery lead entity planning effort as well as leading climate scientists. These include Snohomish County Surface Water Management (Mike Rustay, Sr. Biologist and Zach Brown, Modeling Engineer), University of Washington Climate Impacts Group (Guillaume Mauger), USGS (Eric Grossman) and The Nature Conservancy (Jamie Robertson). Guillaume Mauger is a lead researcher for the Climate Impacts Group (UW), has a PhD in Climate Science, and was lead author on the *State of Knowledge Report: Climate Change in Puget Sound* (2015). Kirti Rajagopalan (WSU) will lead the crop impacts modeling and has a PhD in Civil Engineering.

An advisory committee for *Objective 2: Build community knowledge of potential vulnerabilities and resilience strategies*, includes representatives from the Snohomish Conservation District, The Nature Conservancy (Heather Cole) and Puget Sound Partnership (Dan Calvert). In addition to Dittbrenner's extensive experience working with landowners and District staff experience outreaching to the agricultural community, Cole has a Masters in International Development and Environmental Analysis with an emphasis in Participatory Learning Methods and Calvert has a PhD in Environmental Sciences and policy with an emphasis in Social Learning.

Development of the resilience plan for the agricultural community along with project scoping and design will require robust partnerships with the local farmers and established agricultural groups. The Agriculture Advisory Committee, already in the process of being formed, will be comprised of representatives of the local diking/drainage/flood control districts, the Snohomish Farm Bureau (see Letter of Support), Cattlemen's Association, Snohomish County Agriculture Advisory Board, and the Agricultural Caucus of the Sustainable Lands Strategy.

Other partners and their roles are described in the table below:

Organization	Role
Snohomish Conservation District	Project management, outreach, and development of Agriculture Resilience Plan
University of Washington – CIG	Streamflow, sea level rise, storm surge, and inundation modeling
USGS	Groundwater modeling
Washington State University - Center for Sustaining Ag. and Natural Resources	Crop impacts modeling and tool development
WSU Extension	Assistance with outreach to diverse communities
Whatcom Conservation District	Integration in state-wide agricultural planning , technical support
Snohomish County Surface Water Management	Modeling technical advice and salmon planning integration
The Nature Conservancy	Expand the Floodplains by Design Decision Support tool and outreach efforts
Sustainable Lands Strategy	Project facilitation and project package development
NOAA	Technical support
NRCS	Involvement in agricultural research planning
Tulalip Tribes	Salmon planning integration
PCC Farmland Trust	Prioritize farmland protection as part of Agriculture Resilience Plan
Local Integrating Organizations	Integration of Puget Sound Action Agenda priorities and standardization of sea level rise data standards

Public Engagement and Outcomes

The anticipated outcome of *Objective 2: Build community knowledge of potential vulnerabilities and resilience strategies*, is for local and regional decision makers, local landowners, and partner jurisdictions to understand modeled impacts of climate change on flooding, groundwater, and crops and have the tools necessary to develop resilience plans and projects. Public engagement is absolutely critical if this approach is to succeed. Our goal is to achieve public buy-in of the resilience strategies that are developed as a result of this effort. In particular, the agricultural community needs to feel that the *Agriculture Resilience Plan* represents their interests as it is used to develop multiple benefit approaches to resource management. To do this, the outreach approach must be comprehensive, collaborative, and innovative.

Locally, the techniques planned for public engagement will enhance public awareness, build community and collaboration amongst landowners, and encourage civic engagement. Through the development of the Learning Network and associated presentations, the dissemination of knowledge to other jurisdictions and decision makers will lead to the integration of this work into other planning efforts both locally and regionally. Decision-makers will be better enabled to consider the costs and benefits of difference resilience projects or actions as well as develop adaptation strategies.

See Objective 2 for more details.

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Data Management Plan
FY 2017 NOAA Coastal Resilience Grants Program (NOAA-NOS-NRPO-2017-2005159)

**Project Title: Building a resilient future for agriculture, salmon, and coastal communities
in Snohomish County**

The NOAA Environmental Data Management Committee (EDMC) Data Sharing Policy for grants and cooperative agreements stipulates that environmental data and information collected and/or created under NOAA grants/cooperative agreements must be made visible, accessible, and independently understandable to general users, free of charge or at minimal cost and in a timely manner.

During the grant period, the following types of data will be collected:

- Modeling data results from streamflow (hydrologic), inundation (hydraulic), and groundwater models for multiple climate scenarios.
- Modeling data results for impacts to crops on the west side of Washington.

These data will be compiled and managed by Snohomish Conservation District and shared with the collaborating scientists and partners. Environmental data and information collected will be made visible, accessible, and available to users in a timely manner, free of charge or at minimal cost that is no more than the cost of distribution to the user. The data will be available via reports from the grantee to NOAA as well as online. Hydrologic modeling results will be incorporated into the Floodplains by Design Decision Support Tool managed by The Nature Conservancy and as such, easily available to the public. Crop impacts modeling results will be made available in the Agriculture Resilience Plan and online through the Crop Impacts Projection Tool, also available to the public. Data specific to a particular parcel that is collected during the formation of a Farm Plan, however, may be redacted under RCW 89.08.560.

Any data made available to the public will be accompanied by the following statement: “These environmental data and related items of information have not been formally disseminated by NOAA, and do not represent and should not be construed to represent any agency determination, view, or policy.”

Contact Cindy Dittbrenner at cindy@snohomishcd.org for more information or to make a data request.