



DEPARTMENT OF  
**ECOLOGY**  
State of Washington

## Washington Oblique Aerial Photography

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## Publication and Contact Information

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# Washington Aerial Oblique Photography

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## Background and purpose

Reducing the cumulative and secondary impacts of growth on Washington's shorelines is a high priority for Ecology's Shorelands and Environmental Assistance Program (SEA). This requires tools that help monitor development activities and environmental changes. Washington has 28,000 miles of marine and freshwater shoreline, much of it difficult to observe because of challenging terrain, private property, and limited access points. In addition, most development consists of small-scale projects dispersed across a complex landscape. Documenting modest, but widespread, modifications such as bulkheads, docks and piers, and changes in riparian vegetation is impossible without high quality aerial imagery collected at relatively frequent intervals.

Ecology has made extensive use of oblique aerial photography to assist in the characterization and management our shorelines for the last 40 years. Ecology collected the first series in 1977 and have subsequently acquired photographs in the early 1990s, the early 2000s, 2006, and most recently, in 2016 (Appendix A). Since the late 1990s, Ecology has provided broad online access to these photos on a user-friendly platform associated with the agencies widely-used Washington Coastal Atlas map server.

The photos are a unique source of information for documenting shoreline characteristics. The oblique angle, high resolution, and continuous shoreline coverage allows planners and resource managers to identify relatively small changes in both the natural and the built landscape. They have become an essential tool for inventory, characterization, environmental mapping, and regulatory compliance. They are widely used by Ecology and others to illustrate technical reports, presentations, outreach materials, and planning documents.

During the past decade, many additional sources of excellent aerial imagery have become available (e.g. Google Maps, Bing), but while these are an excellent complement to the oblique photos, they have not replaced them. The shoreline oblique photography filling a unique niche in the remote sensing landscape.

Since the first oblique photos were acquired in the 1970s, Ecology has adapted its methods for contracting, capturing, organizing, and sharing the photos with a broad audience. Ecology has actively sought feedback and has made numerous changes to the photo program, including improving the quality and resolution and better integrating them with the Washington Coastal Atlas.

Ecology (with NOAA support) flew oblique photos in 2006, but had been unable to find funding to repeat coverage until this past year. Demand had increased from many user groups and there was need for more up-to-date imagery. For Ecology, this was particularly significant in our role supporting the comprehensive updates of Shoreline Master Programs throughout the state. These photos were critical as jurisdictions developed shoreline inventories, held public meetings, wrote restoration plans, and began to consider long-term monitoring and compliance programs.

In 2015, Ecology was awarded Project of Special Merit funds through NOAA's Coastal Zone Management (CZM) Section 309 Program to acquire new photographs, and in 2016, we

contracted for approximately 20,000 photos to be flown of about 4000 miles of shoreline. As in the previous round, we prioritized saltwater coastline and larger lakes, and with support from our Spills and Water Quality Programs, we also flew the entire Columbia and Snake Rivers in eastern Washington. All of these photos are available online through the Washington Coastal Atlas (<https://fortress.wa.gov/ecy/coastalatlus/>). A statement of work for Work in the coastal zone has been provided in Appendix B to assist other states interested in obtaining oblique aerial photos.

One of the objectives of our 2015-2017 project was to reassess methods for both acquiring photos and for making them readily accessible. We spoke to a wide range of users in a variety of different sectors in order to better understand both how they used the photos and what they would like to see improved. This report summarizes findings from these semi-structured interviews in order to:

- Characterize the unique aspects of these photos that make them useful and that distinguish them from alternative maps and imagery.
- Understand how and why different people use the Ecology photos in their work or in other activities.
- Document the history of this effort in order to help other states or groups assess how similar programs might be established or improved elsewhere.
- Identify both the utility and the limitations of the existing photos and website in order to improve how we capture and disseminate this information in the future.

The 2016-2017 aerial photographs are available online through Washington's Coastal Atlas, along with all the previous photo series. In addition, Ecology has also begun work on an updated version of the Washington Coastal Atlas and specifically, in the way oblique photos are displayed and distributed.

## Unique character of oblique aerial shoreline photos

Several factors have contributed to the widespread popularity and use of Ecology's oblique shoreline air photos, despite the increasing availability of other sources of online imagery, such as Google Maps, Bing, or any of hundreds of topical map servers. These include the intuitive nature of the discrete images and the ease with which users can view and redistribute them, the clear association of an accurate date and time with each image, the availability of multiple time series, and their seamless integration with other shoreline data on Washington's Coastal Atlas.

### Photo quality and resolution

The photos are captured digitally in high resolution with natural color, resulting in a more appealing, flexible, and useful image than the alternatives available online. The high resolution allows users to zoom in to look closely at small but important details, and the overall quality of the images improves their value for illustration and presentation purposes.

### Discrete photographs

While the value of synoptic coverages such as those found on Google Earth or Bing is enormous, one of the more important aspects of Ecology's oblique photos is that they are flown and maintained as a series of discrete images. This makes downloading and organization of image files more straightforward and makes using the photos in presentations, reports, or other derived products much simpler.

### Continuous coverage of shoreline

Each series of the photos captures the entire shoreline, leaving no gaps. Some alternative photo sources include only select segments of shoreline based on specific features or characteristics. Ecology's continuous series is better for conducting inventories of shoreline features and development. It also helps provide a broader shoreline context. The Washington Coastal Atlas allows users to easily navigate intuitively through photos along the shoreline and it also allows them to print large images with long, continuous segments of shoreline all at once (Figure 1).



Figure 1 – Series of four photos illustrating continuity of coverage and typical overlap between images.

## Oblique view

The photos are taken from a low-flying plane slightly offshore, providing images with a familiar vantage point. Most people are more comfortable with this perspective than with traditional vertical imagery or even the oblique views offered through Google or Bing, which often have a distorted appearance or an uncomfortable viewing angle. These other sources remain a great complement to the oblique, however, and users often use the two together.

Ecology's oblique photos offer a perspective of shorelines that is particularly helpful for viewing coastal bluffs and forested shorelines, identifying landslides, and characterizing shoreline modifications (including steep structures such as bulkheads and stairways, which can be particularly difficult to identify in vertical imagery) and overwater structures such as piers and wharves.



Figure 2 – Oblique views provide unique perspective the shoreline itself, along with complex natural features and upland land use.

## Mobile access

The photos can be downloaded and accessed on laptops and tablets in either high or low resolution. This allows users to access digital copies in the field, even in areas where web connectivity is unreliable or unavailable. The next version of the Washington Coastal Atlas will further improve mobile access to both the maps and the oblique aerials.

## Time series

Ecology now has several series of comparable photos from different years. Flight and photo parameters have changed, but still allow straightforward comparison of particular segments of shoreline over time. Users can easily navigate between photographs of the same piece of shoreline, but captured during different years under similar conditions. Such comparisons allow for clear and direct evaluations of both man-made and natural changes to the shoreline environment over time.

## Monitoring shoreline change: Washaway Beach time series

Over the course of the last century shoreline erosion has erased much of what originally existed in the community of North Cove (Pacific County), particularly along a stretch of shoreline appropriately referred to as Washaway Beach.

This area continues to experience the most rapid rates of erosion on the US Pacific Coast – averaging roughly 100 feet per year.

Reliable data and information on erosion rates provides the basis for understanding risk and evaluating alternative approaches. However, Washaway Beach is a unique confluence of interacting physical conditions that remain only somewhat understood. Scientific studies are a significant investment and often do not occur as frequently as needed. Photos are used in the absence of scientific studies to monitor shoreline changes and communicate the severity of erosion loss.



Figure 3 – Map of Parcels from the Pacific County Assessor's Office; Red parcels have lost at least 50% of land mass to shoreline erosion as of May, 2015.

Figure 4 (right) – Time series of Ecology oblique photos of North Cove, Pacific County

1977



1997



2002



2006



2016



## Scale (length of shoreline included in each photo)

The distance from the shoreline at which the photos are captured was selected to strike an appropriate balance between providing detail and context. If photos are captured from too far away, they can lose detail and emphasis on the shoreline itself. If photos are captured from too close, they can lose context. Additionally, photos captured from too close could raise privacy issues and would require a larger number of photos to capture the entire shoreline.



Figure 5 – Comparison of full image and zoomed in portion. August 2016 photos, from Birch Bay, Whatcom County.

## Documentation and annotation

Each photo includes a simple date/time stamp, but no other markup. The clear date/time stamp on the face of the photo provides viewers with quick reference as to the year, season, and even the time of day. The date/time information remains attached to the photos regardless of how many parties they have been passed through, unless specifically cropped out. It remains intact when the photo is printed or when the image file is saved to a different file format or included in a report or presentation. At the same time, the time/date stamp is placed so as not to interfere in any way with observations of the shoreline and to allow a user to add additional annotation as needed. One of the drawbacks of standard online sources such as Google and Bing is that the dates of photography are difficult to determine with confidence.

The precise temporal data is key for using photos in technical work or legal proceedings. For example, it allows quick retrieval of preceding weather conditions or of the tide stage at the time of the flight. It allows use in enforcement when knowing when a development activity occurred is critical. The photos have often been used in legal proceedings where witnesses must testify to the date of the photos.

### **Site review: boat storage building variance permit**

#### *Problem*

Review of an Island County Shoreline Variance permit to authorize the repair and remodel of an existing boat storage building on Camano Island. The proposed remodeled structure was three feet higher than the previous storage building, mainly to meet new flood code requirements.

#### *Use of Photos*

Photos were used to compare the proposed building replacement with similar boat storage buildings in the community and to get an historical perspective on past direct access to Puget Sound. The building's direct water access had been eliminated by extending the bulkhead in front of the building. Photos were used to help prepare an analysis summary of the WAC 173-27-170 state variance permit criteria. The photos were particularly important for assessing a grant of special privilege, compatibility with other authorized uses, and cumulative impacts.

#### *Benefits*

Ecology's photos have superior resolution compared with similar photos on Bing or Google. They also can be easily screen shot with a date/time stamp for documentation.

#### *Positive Contributions*

The photos allow a more thorough assessment of many shoreline projects by both State and local shoreline planners. Over time, this will contribute to improved management of coastal development and reduce impacts to shoreline environments.

## Integration with Washington Coastal Atlas

The oblique photos are fully integrated with Washington’s Coastal Atlas – an online GIS map server developed in conjunction with ESRI. This makes searching for photos of a particular shoreline easy and intuitive. Users viewing other map data on the Atlas can readily pull up photos of different vintages for to complement observations from map data. This is often an important tool for clarifying ambiguous mapping or identifying errors.



Figure 6 – A view from Washington’s Coastal Atlas, showing coastal landforms and locations of 2016 aerial imagery along with actual oblique photo associated with point on the map.

## Additional photos

Some series included additional photos that captured non-standard perspectives of the coast, including longer reaches of shoreline and views of entire bays or coastal towns. These are popular shots that can provide more context to larger scale planning efforts, that capture larger-scale natural features, and that are particularly valuable in educational and outreach settings.





Figure 7 – View north of Ocean Shores



Figure 8 – Port Madison Bay on Bainbridge Island

# How are Ecology's oblique shoreline aerial photos used?

## Reconnaissance and planning field visits

The photos are used by state agencies and local government staff to prepare for and to increase the efficiency of more time- and resource-intensive field work and site visits and in some cases can substitute for field visits. The photos are used by technical staff and researchers to identify field sampling and reference sites and to strategize field logistics.

## Site review

The photos are often used to develop a base level of familiarization with a particular site or project by identifying, reviewing, or confirming site conditions. Similarly, they are also used for enforcement purposes, documenting when activities are or are not completed, and verifying that projects follow permit conditions.

## Temporal comparison

The photos are used to answer a wide variety of questions related to viewing shorelines at different points in time. Some of these questions include: When was something built? Was a structure modified? Did modifications match permits? When was a change made? How quickly is the shoreline eroding? How have vegetation patterns changed over time?

## Visuals for presentations, websites, reports, and other documents

The oblique photos are a valuable resource as a visual aid for many purposes. They are used for presentations and posters at technical conferences, in trainings and workshops, and in work sessions for county staff and officials. In addition, they have become standard exhibits in shoreline hearings and legal proceedings. Photos are sometimes used as visual aids for commercial purposes, including in real estate brochures showing coastal properties. Similarly, shoreline property owners are often intrigued by the photos. The photos provide a unique view of their properties, provide local context, and help increase residents' understanding of their own shorelines.

### **Temporal comparison: wetland buffer study**

#### *Problem*

Developing a method that can be used by state agencies and local governments interested in collecting data on whether buffers are established and maintained according to the permit conditions and on their ecological condition.

#### *Use of photos*

Data from orthophotos were collected on four metrics that characterize compliance with permit requirements and the condition of the existing buffer. Orthophotos were used to create a base map to which parcel lines, wetland boundaries, and permit buffers were transferred. The oblique aerial photos were used to provide complementary information.

#### *Benefits*

The photos were used to obtain additional information about buffer condition when ground-checking was not an option.

#### *Positive contributions*

The method used GIS/GPS procedures to collect data rather than visiting sites to collect information. Site visits take more staff time. It is often difficult to obtain permission from land owners to access sites, and some sites are difficult to visit

## Investigating and documenting events: Ledgewood landslide

After the 2013 Ledgewood landslide on Whidbey Island, the New York Times used a photo from Ecology's oblique shoreline aerial photo database. This photo was used for baseline comparison purposes in a side-by-side slider arrangement allowing readers to move from viewing the 2006 oblique aerial photo to one captured soon after the slide.

Ecology's photos have been used by geologists to map landslides and to identify areas vulnerable to other hazards, such as floods and erosion. The oblique view provides an important perspective for mapping geologic features on steep slopes, which are often obscured in traditional vertical aerials.

Ecology's photos are regularly used in public presentations and workshops to illustrate a wide variety of coastal features in addition to hazards such as landslides. They provide a familiar, easy to understand view of shoreline habitats, development practices, and waterfront industries.



Figure 9 – Ecology oblique image 2006



Figure 10 – New York Times (Ted Warren) March 29, 2013

## Spill response

The oblique photos are used in a variety of ways to improve planning for hazardous materials events and to respond to spills when they occur. The photos have been used in developing geographic response plans and for identifying facilities and vulnerable shoreline types. When spills occur, the photos provide responders with a tool to rapidly evaluate the shoreline in the vicinity and to assess appropriate response strategies.

## Recreation

The Washington Coastal Atlas is often used to identify shoreline access points, and the photos provide valuable supplemental information such as park facilities, beach access, boat launches and docks, parking and other useful information. Boaters and kayakers use the photos when planning trips along the shoreline, including route planning, identifying moorages and landings, scouting facilities, and simply noting potential features of interest.

## Restoration

The photos are used to identify potential restoration opportunities, to characterize local shoreline conditions, and to locate appropriate reference sites. The photos are regularly used to illustrate sites in grant proposals and project reports.

### **Restoration planning: aerials used in expert workshops**

The Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) is a large-scale effort to characterize coastal restoration needs and to identify restoration projects throughout Puget Sound. The PSNERP Nearshore Science Team carried out numerous studies of historical and current conditions, assessing shoreline change, and developing restoration strategies. At several times during this work, workshops were organized specifically to review the results of regional scale analyses. These workshops (called “fly-bys”) allowed experts to compare the GIS results with actual shoreline observations and relied heavily on Ecology’s oblique aerial photography.

## Shoreline Master Programs

The photos are used in almost every chapter of Washington’s Shoreline Master Program (SMP) Handbook to illustrate real examples of important planning concepts. They are also used to review and evaluate new SMPs and updates to existing SMPs submitted to Ecology by local jurisdictions for approval. Relatedly, they are sometimes used to evaluate the effectiveness of SMPs and justify required changes to local SMPs. In particular, they have repeatedly been used to develop inventories of shoreline bulkheads.

The fact that the photos provide continuous, high resolution coverage of the entire shoreline makes them essential for inventorying and characterizing shoreline features and preparing local Shoreline Inventory and Characterization reports, the initial step in all SMP Updates. The photos are regularly included in these planning documents and in public workshops and meetings to illustrate local conditions.

## **Inventory, characterization, and mapping: Tacoma Shoreline Master Program review and approval**

### *Problem*

The City of Tacoma recently underwent a comprehensive update of its Shoreline Master Program (SMP). During the update, the City's allowable uses for the shoreline along the Ruston Way waterfront became a hotly-debated topic. The area used to be one of Tacoma's primary shipping and industrial shorelines, but few of those businesses remained.

The updated SMP removed lay berthing from the list of allowable shoreline uses. During both the City and State comment periods, multiple citizens submitted comments in favor of the change. However, some people, including the property owner, objected to the change. Ecology needed to document the historical and current context of the shoreline to inform and support its decision to approve the new restriction.

### *Use of photos*

The photos were used to document and illustrate the historic and current uses along the shoreline. They were included in Ecology's Findings & Conclusions. Ultimately, the City Council chose to create a transition district in the area to address a long-standing and very contentious use of the shoreline. In this case, like so many, "a picture is worth a thousand words." The photo helped show the transition of the shoreline over time and bolstered Ecology's reason for supporting the change.

### *Benefits*

Ecology's oblique shoreline aerial photos make it easy to identify changes along a shoreline between specific known dates.

### *Positive contributions*

Context matters when talking about SMP regulations. The photos provide a shorthand for explaining the context of a specific regulation such as this one. In this instance, the Photos supported Ecology's decision and helped prevent further appeals.

## Improving the use of Ecology's oblique shoreline aerial photos

In addition to identifying the different ways stakeholders and partners were using the oblique shoreline photos (see previous section), we also sought input on how to improve the ways in which photos are captured, stored, or shared to allow stakeholders to leverage them for emerging uses. In general, users were able to make good use of the photos for a wide variety of applications and there was widespread awareness of the photos as a unique and valuable resource.

Interviews mentioned two aspects of the photos that they would like to see improved:

1. Capture the photos more frequently. In general, the less time that elapses between each set of photographs, the better. Enabling comparison of shorelines over time is one of the most important functions of the sets, and adding additional data points over time increases the specificity of comparisons. The majority of users are satisfied with the average time lapse between new sets of photos thus far, although the ten-year delay between the 2006 series and the recent 2016 series was becoming a concern.
2. Increase the amount of overlap between photographs as much as possible. This interest came from technical users who would like to use the oblique photos as a photogrammetric tool. While vertical imagery has long been used to extract accurate spatial and topographic information, this is much more difficult with oblique imagery. Increased overlap (50% or more) can allow for the creation of three dimensional models, which could potentially be used to quantitatively study bluff erosion, shoreline armoring, and elevation changes in a way that is currently only possible through on-the-ground survey work. Tools such as *Structure for Motion* are being increasingly used to obtain precise topographic data from oblique images. While these tools are currently in developmental stages, increasing the overlap between images as soon as possible is necessary to allow for future comparisons to current conditions. However, there would likely be significant costs, both financially and in terms of some existing uses of the Photos, and the vast majority of users would not need this increased overlap.

Driven in part by the most recent 2016-2017 photo series, Ecology is currently updating the air photo application on the Washington Coastal Atlas. Besides addressing problems with legacy code, the revisions will improve the ability to locate photos and to compare photos from different time series. Accessing and downloading high resolution images will be easier and more emphasis will be made improving access mobile platforms, including phones. Integration with the Washington Coastal Atlas will be further improved as the Atlas itself undergoes updates in the coming 1-2 years.

# Appendices

## Appendix A: Oblique Aerial Photograph Annotated Timeline

*1976-1977:* Ecology obtained the first set of vertical color photos of the coastal zone through a contract with the Department of Highways (now the Department of Transportation) – half in 1976 and the remainder during 1977. These photos were at a scale of 1” to 500’, but excluded the Pacific Coast of Washington and Willapa Bay and Grays Harbor. Then in June of 1977, Bud Kimball Photography photographed and developed negatives of oblique views of Washington’s entire coastal zone. These photos were taken at approximate scale of 1” to 400’ on the beach. The beach area usually covers the bottom quarter of the photography. Color prints of the vertical and oblique images were purchased and duplicate sets for local governments and Ecology’s regional offices were made available as funding allowed.

*1992:* In the early 1990s, Ecology had NOAA support to investigate the impacts and management of shoreline armoring on Puget Sound. One element of this project was a detailed inventory of Thurston County shorelines. Because they would be useful for inventorying bulkheads, new oblique aerials for the entire marine shoreline were flown from 1992-97 (the extended timeframe due to limited funding), and Ecology obtained 8”x10” prints and 35mm slides of each photo. In the mid-1990s, Ecology found funds to scan those images. These were initially intended to be distributed on CDs with navigational software but widespread access to the internet altered this plan. In the late 1990s, Ecology’s Coastal/Shorelands Section worked together with its GIS team to develop the original shoreline air photos website. This became one of the most popular sections of the Department of Ecology’s website.

*1995:* After the success of the first set of photos and the growing interest, Ecology’s Shorelands and Environmental Assistance Program (SEA) developed the “SEA Program Air Photo Strategy.” The Strategy set four goals to guide the collection, maintenance, and use of air photos for shoreline management:

1. Build and maintain an air photo collection that meets the resource management needs of the SEA Program
2. Ensure easy and ongoing access to air photos
3. Provide public access to air photos
4. Establish SEA Program Air Photo Work Group

*1998-2002:* In the late 1990s, Ecology staff in the Coastal/Shorelands Section conceptualized an online atlas. Ecology’s GIS team worked with the Environmental Systems Research Institute (ESRI) to develop the Washington Coastal Atlas, which incorporated many data layers, including the oblique aerial photos, into that early version of the Washington Coastal Atlas.

*2000:* By the end of the 1990s, the most recent batch of photos was dated and losing relevancy. Ecology contracted for a new set of photos between 2000 and 2002 with NOAA assistance. Ecology staff also scanned and added the older 1976-1977 photos to the shoreline air photos website and to the Washington Coastal Atlas.

*2006-2007:* Again, with NOAA's assistance, Ecology obtained funding to fly another round of photos. Ecology included larger western Washington lakes and several river segments to explore the utility of the photos on freshwater shorelines. Ecology's Spills Program also provided additional financial support, which allowed the Columbia and Snake Rivers and eastern Washington lakes to be photographed.

*2016:* Ecology secured funding for new aerial oblique photos in the most recent NOAA Coastal Zone Management competitive grant opportunity in 2016. These photos have been completed by a new contractor (the 1992, 2000, and 2006 sets were all flown by the same company). As in 2006-2007, Ecology's Shorelands Program secured additional funds from other agency programs (Spills and Water Quality) to photograph rivers and lakes in Eastern Washington.



## Appendix B: Statement of Work for 2016 Oblique Aerial Photos (Coastal Zone)

The Washington State Department of Transportation (WSDOT), through itself and/or its consultants, shall provide to the Department of Ecology (Ecology) oblique aerial photographs of marine and freshwater shorelines of Washington State. At a minimum, this will include all 3,300 miles of saltwater shoreline and 500-1000 miles of freshwater shoreline.

Ecology shall be provided with photos taken in 2016 in the 15 counties referenced below, which includes all saltwater shoreline and the larger lakes in the counties following:

1. Whatcom
2. Skagit
3. San Juan
4. Island
5. Snohomish
6. King
7. Pierce
8. Thurston
9. Mason
10. Kitsap
11. Jefferson
12. Clallam
13. Grays Harbor
14. Pacific
15. Wahkiakum (north bank of the Columbia River to the Wahkiakum-Lewis line)

The purpose of the Work is to provide an updated aerial photographs on Ecology's Coastal Atlas website, where previous series of similar photos are already available:

<https://fortress.wa.gov/ecy/coastalatlantools/ShorePhotos.aspx>

WSDOT, through itself and/or its consultant, will provide the photographs and appropriate supplemental data. Ecology staff is responsible for incorporation of the photos and information onto the website.

### **TASK ONE: Aerial Photographs**

Aerial photos will be acquired during late spring or summer of 2016. Based on the mileage of shoreline, Ecology expects there to be approximately 20,000-24,000 photos, with the following specifications:

General specifications:

- Photographs will be provided in digital format and provided to Ecology as JPG images, with embedded time and location information.
- All photographs will be carried out within optimal ranges of sun angle and cloud cover.
- Saltwater shorelines will be flown during periods of low tide, which are generally best during early summer.

- Lakes and other freshwater shorelines will be flown with consideration of vegetation conditions and water levels.
- The photographs will be taken from an altitude of 1400-1800 feet at an angle of 30-45 degrees above horizontal.
- Photographs will be acquired with a minimum 12-14 megapixel camera and lens suitable for capturing 900-1100' of shoreline per image (5-7 photos per mile), with sufficient overlap to assure no gaps in coverage along the shoreline.
- Photos will be of high quality, with particular attention to sharpness, exposure, and color.
- All photos will include a date/time imprint on the front of the image.
- -50mm (normal) focal length target using full frame DSLR
- -Down Angle Target (from horizon)

Any changes to flight and photograph specifications must be agreed upon, in writing, between Ecology and the WSDOT and its consultants.

Deliverable: Photos will be delivered to Ecology on DVDs, organized by county. Photos will be provided as JPG images, including embedded location and time information. Deliverables will include 20,000-24,000 digital aerial photographs. Photos will be geo-tagged and time/stamped.

Schedule: Photos will be acquired between May and August 31, 2016. Photos will be provided to Ecology no less than monthly during the course of the Work, with all photos delivered no later than the final date of the Agreement (September 30, 2016).

## **TASK TWO: Data Table**

WSDOT and/or its consultant will provide a spreadsheet (EXCEL) that includes records for every photo and for each, includes a date and time, location (latitude/longitude), and pointers to physically adjacent shoreline photos (to left and to right). Location information will include county name and to where feasible, geographic location (text) or landmarks. Table format will be developed in advance in agreement with Ecology.

Deliverable: Excel spreadsheet with all required information, updated as photos are delivered. To be provided by email and on DVD with photos. WSDOT and/or its consultant will provide a spreadsheet that includes the date and time of each photo, the county, the approximate center point (latitude/longitude) for later GIS processing, and pointer to adjust shoreline photos. Spreadsheet structure will be developed in advance in agreement with Ecology.

Schedule: Spreadsheet containing updated photo information provided on no less than monthly during the course of the project. The final spreadsheet to be provided no later than the final date of the contract (September 30, 2016).