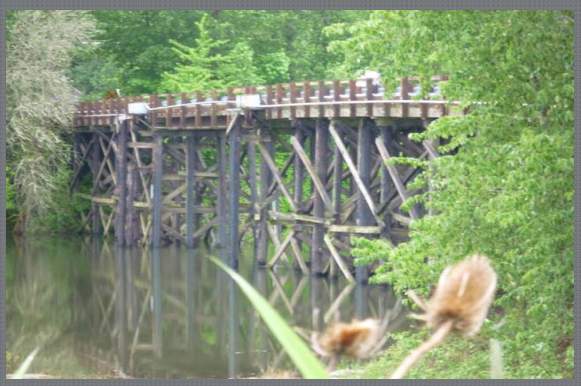
2012

Ridgefield Wildlife River 'S' Unit Access Bridge Lake River Navigation Assessment



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EXECUTIVE SUMMARY

This River Navigation Assessment surveyed existing traffic on Lake River to support preliminary planning for a new bridge to cross Lake River between the City of Ridgefield, Washington and the Ridgefield National Wildlife Refuge. The potential river traffic identified is primarily from two houseboat marinas, sailboats located at the marinas, a few recreational craft from the Port of Ridgefield boat ramp, Vancouver Lake Sailing Club's sailboats, and Vancouver Rowing Club's rowing boats. Houseboats were counted and indexed from aerial photography with LiDar Survey with an on-site survey to verify dimensions and identified new or replaced vessels.

The field study found that the current highest houseboats between the two marinas is three stories high, located on McCuddy's Marina, with a height of 34 feet. Two McCuddy's residents currently own and actively use their sailboats. The sailboats' masts are 48-feet and 55-feet tall (measured from water line to top of the mast). McCuddy's Marina residents live downriver of the existing bridge; therefore they do not currently have any existing clearance issues except for a Clark PUD (75'-V) power line paralleling Division Street in Ridgefield (see authorized permit in attachments).

Houseboats located at the second marina, Felida, are upriver of the existing bridge which currently limits vessel clearances. The current highest houseboat at Felida is 29-feet tall, and one sailboat with 34-foot mast(retractable).

In order to estimate the current and anticipated future traffic on Lake River, local people/organizations that rely economically on the river were interviewed as they have a significant stake in the new bridge construction. The interviewees provided information on current and anticipated future vessel traffic for the river. Future traffic, according to the representatives of each organization, will be dredges for the maintenance of the river, and three story high house boats (estimated at 34 feet) destined for Felida Marina.

It should be observed that the taller of the existing houseboats at Felida Marina were likely completed on-site, and considering the restrictions imposed by the existing bridge, the hulls of future three-story house boats would have to be moved upriver at an incomplete stage of construction and upper stories added on-site.

The USCG Bridge Division informed FHWA that they consider the entire length of Lake River to be under their jurisdiction. The USCG Bridge Division published data has previously determined that the tidally effected zone on Lake River ends at MP 3.3 (aligned with what portion of the river bathymetry is currently mapped and also just downstream of the existing bridge), but considers all of Lake River to be navigable.

The vertical clearance of a new bridge needed to accommodate current use will depend on location. If new bridge is located downriver of the existing bridge (MP 3.3

or less), clearance would have to be 34-feet high to accommodate all house boats, and 55-feet high to accommodate all sailing boats. For bridge alignments upriver (MP 3.3 or more) a clearance restriction matching the existing bridge low chord elevation of 40.5 feet (NGVD 1947) would maintain the current level of navigational access.

Datum correlation:

to covert NGVD 1947 to NGVD 1929 subtract 0.40 feet (reference 19)

to covert NGVD 1947 to Columbia River Datum(CRD) subtract 0.98 feet

US Army Corps of Engineers has an existing dredge project: "a channel 6-feet deep, 100-feet wide and 3-miles long from the Columbia River." This 100-foot wide channel width would need to maintained and not impacted during construction. To not impact the dredge channel, the recommended horizontal main span for any new bridge will need to be 100 feet + 20 feet from edge of dredge channel to centerline pier for a total main span of 140 feet.

A land use assessment is also included within the report (Appendix C). This is an assessment of existing tax lots, land use, and zoning, and potential development opportunities in the project area. The assessment study area includes the Ridgefield Wildlife Refuge, lands adjacent to Lake River, and associated connected waters.

Through discussion between FHWA and USCG, the guidance provided on how to determine vertical clearances for a bridge is to establish an approximate the average annual river stage with cross referencing to when the tallest vessels routinely use Lake River. After this water level is determined, add the height of vessels to be accommodated to determine the proposed vertical clearance. This would apply to all users downstream of the existing bridge. Upstream users' needs would be assessed, but if a new bridge is proposed at the current site, deference would be given to the existing clearance as this pre-dates any of the current upstream uses of Lake River.

The existing bridge has a low chord elevation of 40.5 feet NGVD 1947. In assessing the vertical clearance of the existing bridge is dependent upon the water level in Lake River correlated to the current river gage information. Lake River has USGS gage but has only been in service for two years. Over that time, Lake River gage has recorded high water level of 20.87 feet and a low of 6.12 feet (adjusted from NGVD 1929 to NGVD 1947). The US Fish and Wildlife service in 2000 performed a survey to update a WA Department of Natural Resources Permit and established Ordinary High Water at elevation 14.58 feet (NGVD 1947). Using this OHW as an average water level (which matches closely to the average between high and low events) this places the existing bridge vertical clearance at 40.5 – 14.58 = 25.92 feet (NGVD 1947).

There is slightly less than two years of USGS river stage data available for Lake River, but on the basis of that limited data it would appear that the average annual maximum river stage is between 19.5 and 20.87 feet (adjusted from NGVD 1929 to

NGVD 1947), the average annual river stage is between 8 and 13 feet, and the average annual minimum river stage is 6.12 feet (NGVD 1947). For this report and the decision making process, vertical and horizontal clearances are recommended as follows:

Location	Vertical Clearance (NGVD 1947)	Horizontal Clearance(denotes centerline pier to centerline pier spacing)
MP 0.0 to MP 3.3	55 feet + OHW(14.58 feet) +2'(freeboard) = 71.58 feet	140 feet
MP 3.3 to MP 11	25.92 feet	140 feet

Note: All clearances are referenced to NGVD 1947.

SECTION 1: INTRODUCTION AND OBJECTIVES

This River Navigation Assessment surveyed existing and future vessel traffic on Lake River to support preliminary design plans for a new bridge to cross Lake River between the City of Ridgefield, Washington and the Ridgefield National Wildlife Refuge. Types, sizes, and operational characteristics of the vessels that transit through Lake River and Vancouver Lake were identified. The area surveyed began at the mouth of Lake River, where it joins the Columbia River, and ended in Vancouver Lake. Vessels were counted and indexed from aerial photography, Reference 1 and Reference 2. Dimensions were estimated from an analysis of a 2005 LiDAR research, Reference 3 and Reference 4. An on-site survey verified dimensions and identified new or replaced vessels since 2005.

The two assessment methods used in the clearance study are discussed in Section 3. The desk top study consisted of importing geographical survey data into Rhinoceros 3D (Rhino), Reference 6, where approximate heights and lengths were measured. The second method was on-site survey, where FHWA representatives checked the accuracy of measures from the office activity and any changes that occurred subsequent to when the geographical data was taken. Results from the electronic data and on-site survey are in Section 5 Boat Inventory and Section 6 Houseboat Inventory.

Interviews seeking to characterize current and anticipated vessel traffic on Lake River were conducted with local people and organizations that rely economically or recreationally on the river, and therefore have a higher stake in the development of the new bridge. Current and future plans of these organizations are in Section 7.

Information from NOAA, USGS and the US Coast Guard were considered in order to assess the appropriate vertical reference datum and the potential role of fluctuations in river stage. Section 8 addresses these topics.

This report provides information about the study methods used, and existing conditions found on Lake River. The data in this report are appropriate for consideration in establishing agency positions regarding design of horizontal and vertical clearance for a new bridge.

SECTION 2: STUDY AREA DESCRIPTION

Lake River originates from Vancouver Lake and flows from south to north, toward its juncture with the Columbia River. An aerial view is provided in Figure 1. The area surveyed in this study extends from the Lake River entrance to Vancouver Lake. The juncture of Lake River with the Columbia River is the origin for distance measured along the axis of Lake River.

According to Reference 11 the U.S. Coast Guard has determined that tidal influence on Lake River extends to mile 3.3(due to limits of bathymetry), corresponding to a point slightly below (down river) the existing timber bridge over Lake River. By US definition, a waterway is navigable if it is "subject to the ebb and flow of the tide" or "presently used and/or susceptible to use in its natural condition, or by reasonable improvement, as a means to transport interstate or foreign commerce." McCuddy's Marina and Felida Marina have significant concentrations of houseboats. Houseboats result in the largest horizontal clearance demands for the Lake River population. McCuddy and Felida residents also have vertical uses that surpass houseboat heights. Though currently few in number (3), the masts of large sailboats impose the greatest vertical clearance demand. Furthermore, the sailboats are likely to transit Lake River from their respective customary mooring locations (2 in McCuddy's and 1 in Felida) to the juncture of Lake River and Columbia River with greater frequency than the relatively rare to non-existent movements of houseboats.

GPS waypoints taken during the on-site survey for landmarks identified in the study area are presented in Table 1. Lake River joins with Vancouver Lake at approximately river mile 11. According to US Army Corps of Engineers (USACE) there are 11 miles of navigable length along Lake River, and there are 3 miles identified as an authorized dredging corridor "under authorized project." (Reference 14).

Table 1 - Waypoints of Areas Surveyed

Location	Latitude	Longitude	River Mile
Mouth of Lake River	N45º 50.589'	W122º 46.916'	0
Port of Ridgefield Boat Ramp	N45º 48.964'	W122º 45.059'	2.4
North of McCuddy's Marina	N45º 48.964'	W122º 45.059'	2.4
South of McCuddy's Marina	N45º 48.696'	W122º 44.680'	3.0
D/S of Existing Bridge	N45º 48.438'	W122º 44.434'	3.3
North of Felida Marina	N45º 42.652'	W122º 43.481'	10.4
South of Felida Marina	N45º 42.381'	W122º 43.370'	10.7
Vancouver Lake Sailing Club	N45º 40.432'	W122º 42.045'	N.A
Vancouver Lake Rowing Club	N45º 40.200'	W122º 44.500'	N.A
Saint Helens Tidal Gauges	N45º 51.900'	W122º 47.800'	N.A

The aerial photos are from 2007 for McCuddy's Marina and 2011 for Felida, see Reference 1 and Reference 2. The Geographic Information System (GIS) data is from a 2005 Light Detection Land Ranging (LiDAR) survey, Reference 3 and Reference 4. The aerial photos were used to count and index the houseboats, as seen in Figure 2 and Figure 3. The houseboats were indexed from North (closer to Columbia River) to South (toward Vancouver Lake), and from West (toward Oregon) to East (toward Ridgefield/Clark County WA).

Figure 1. Aerial Picture of Area Surveyed (north is to the left)

2.1 McCuddy's Marina

The houseboat indexing for McCuddy's Marina is seen in Figure 2. Fifty five houseboats are identified from the Reference 1 aerial photography taken in 2007. During the field survey, the FHWA team had access to the entire length of the docks, but not permitted to board the houseboats and sailboats. However, houseboat owners were informed of the study by a letter prior to the verification work. When owners were present, permission to go aboard and obtain measurements with greater precision was requested. The survey team performed the study throughout the entire Marina.

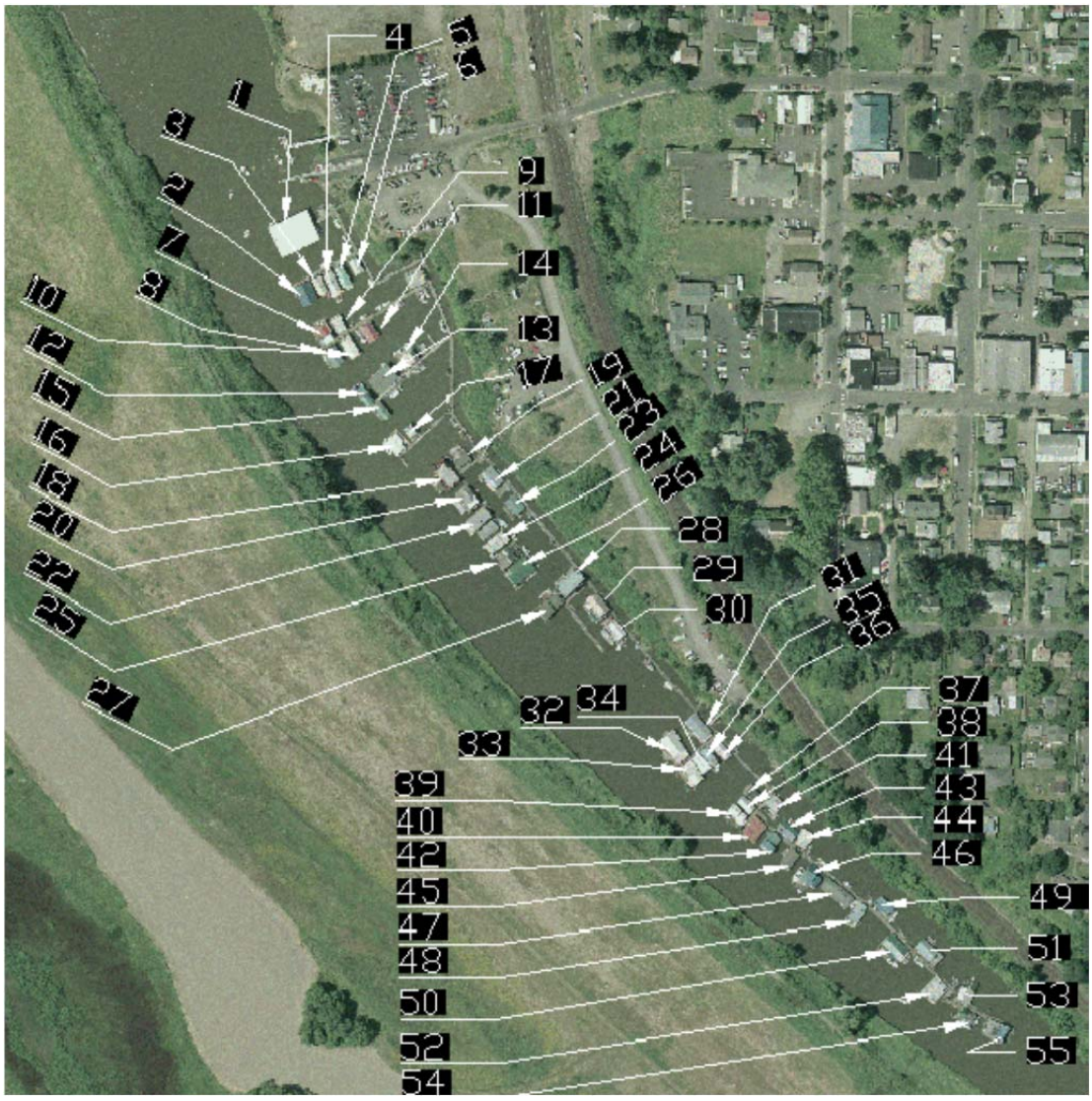

Figure 2. McCuddy's Marina

2.2 Felida Marina

The houseboat indexing for Felida Marina is seen in Figure 3. Forty three houseboats are identified from the Reference 2 aerial photography taken in 2011. During the field survey, the FHWA team had access to the entire length of the dock, but not permitted to board all watercraft. However, houseboat owners were informed of the study by a letter prior to the field verification work. Therefore, when owners were present, permission to go aboard and obtain measurements with greater precision was requested. The survey team performed the study throughout the entire Marina.

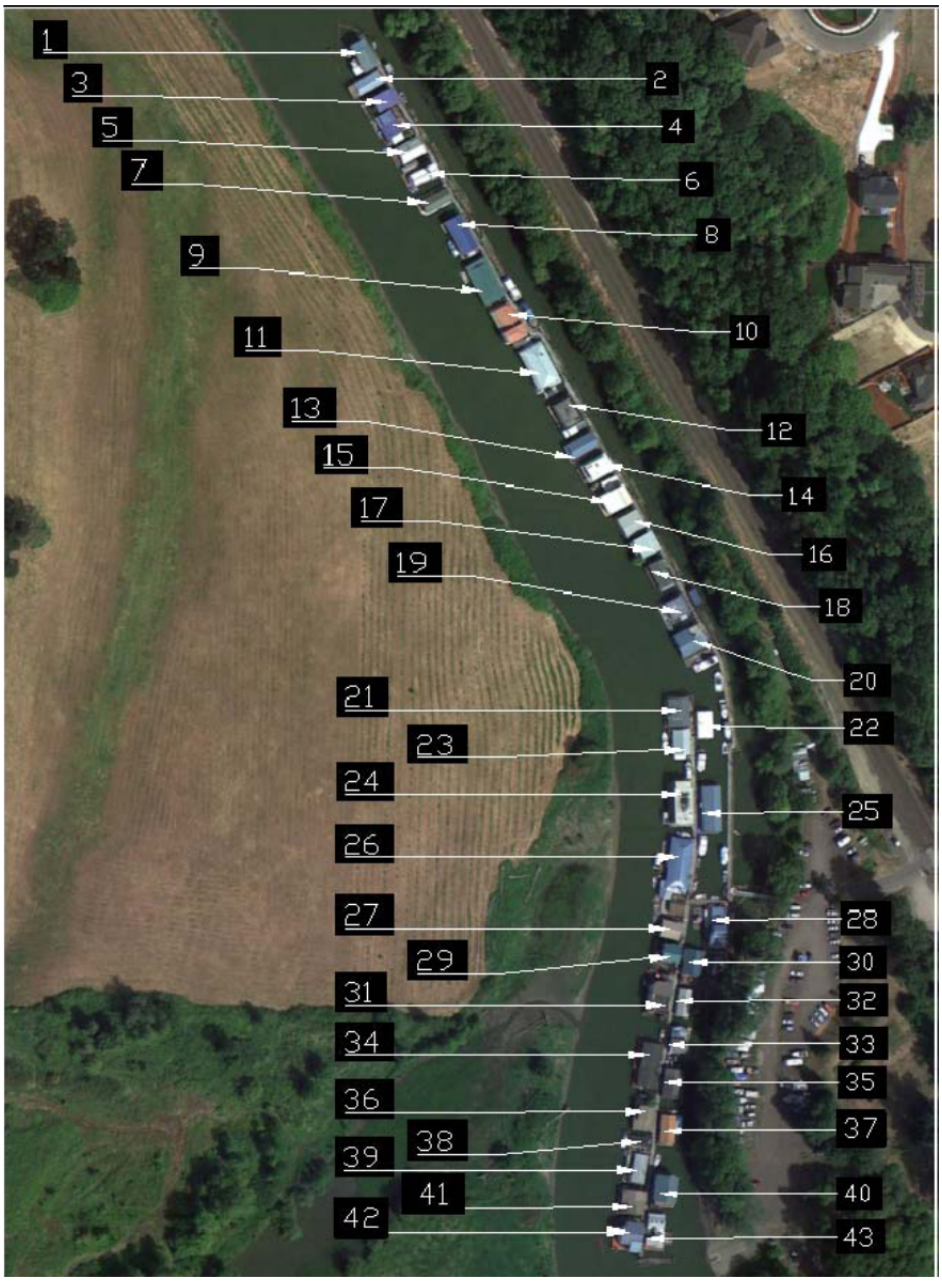

Figure 3. Felida Marina

SECTION 3: METHODOLOGY

Analysis of the houseboats at McCuddy's and Felida utilized two methods: electronic data analysis and on-site field measurements. The electronic data was used to find length, beam, and height of all houseboats present during a 2005 survey. Dimensions of the largest vessels were subsequently checked during the on-site survey.

The on-site field measurement had four objectives: i) to reconcile the electronic data; ii) to identify the exchange or addition of houseboats since the electronic data was acquired; iii) to verify the traffic and uses of the river; and iv) to account for sailboats(or other vessels taller than the house boats). Data verification involved two different field methods, a survey grade rod and an Abney level, each described in Section 3.2. The on-site survey found a height and at least one horizontal dimension (length or beam) of a measured vessel. If the owner was present and permission was given to board the vessel, then the second horizontal dimension could be measured. For houseboats that were not present during a 2005 survey, only the on-site data is available. In these cases, only one horizontal dimension may be known.

Not all houseboats were measured during the on-site survey. A houseboat was measured if it was i) new or replaced since the 2005 survey or ii) a 2 story houseboat as identified in the 2005 survey that was not adjacent to a taller houseboat. Among neighboring houseboats, only the tallest were measured. Photographs of the largest houseboats are in Appendix B.

To check for exchanged or new properties, sailboats, and overhead interferences, the FHWA team surveyors spent a day travelling the extent of Lake River into Vancouver Lake, documenting and measuring any existing obstructions to vertical clearance and identifying houseboats and other vessels with the potential to affect design clearances for the potential new bridge.

The extent of on-water use was verified through interviews with five different organizations that routinely engage in activities on Lake River and Vancouver Lake. These interviews provided a baseline for documenting current use and predicting future traffic on the greater Lake River waterway. The interviews are in Section 7 of this report.

After both analyses were concluded, results from both methods were compiled and compared. Wherever discrepancies were identified, on-site survey measurements were accorded a higher priority than measures from digital data analysis.

3.1 Digital Data Analysis

The Geographic Information System (GIS) data collected in the LiDAR survey, Reference 3 and Reference 4, generated a triangulated irregular network (TIN). TIN control points were contained in Design Files. When the drawing was opened in

Rhino, points representing the houseboats were visible. The highest and furthest apart points for each houseboat were identified. A bounding box for each houseboat was drawn between these points by connecting 6 points for the roof and 4 points for the base see Figure 4. If the points selected were incoherent, they were adjusted manually. Figure 4 is an example of the houseboat control point selection in Rhino.

The accuracy of the electronic data is approximately ±1/2 feet. The source of error comes primarily from the native accuracy of the GIS data, and the selection of 'points' to draw a bounding box around each houseboat. The bounding box provided the dimensions for maximum length, breadth, and height.

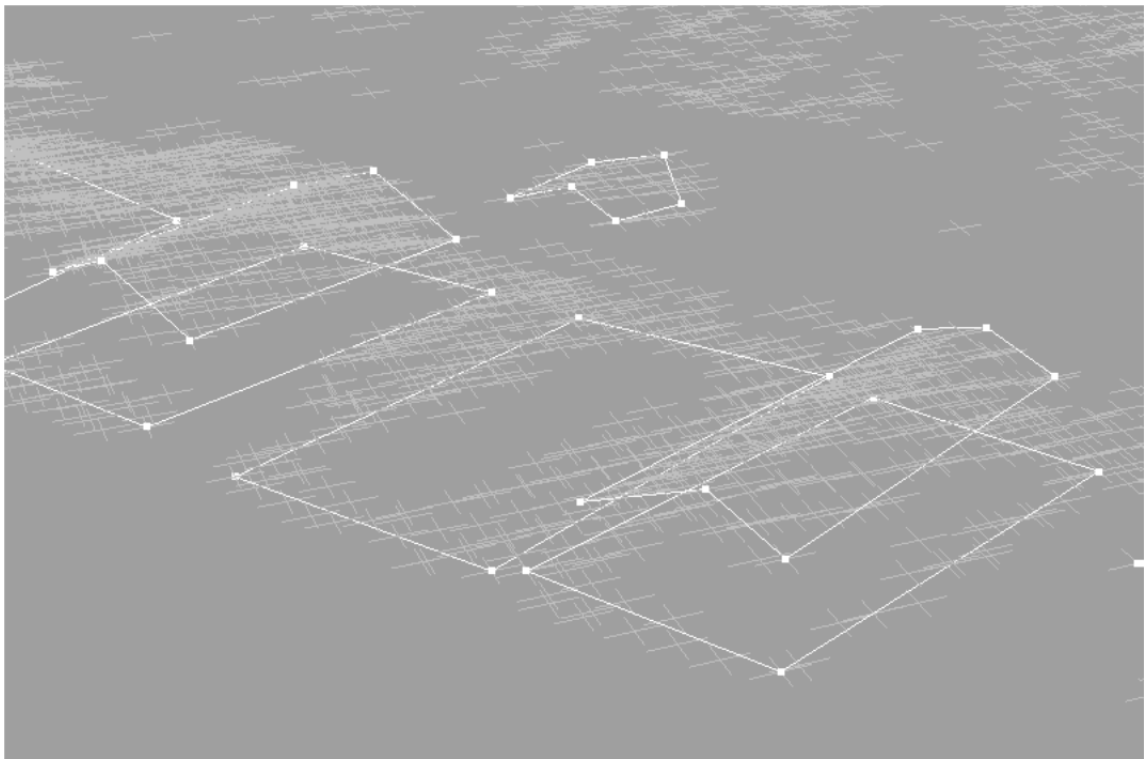

Figure 4 Bounding Box from TIN Control Points in Rhino3D

3.2 Field Verification

During the on-site survey the FHWA team documented existing objects that may impose marine navigation clearance restrictions, performed interviews with Lake River waterway users (see Section 7), accounted for new or revised properties and sailboats, and checked the precision of the GIS data analysis by identifying and measuring the tallest houseboats.

The first step of the field survey effort was to perform river reconnaissance through the entire length of Lake River and Vancouver Lake to check existing restrictions to navigation clearance and possible areas not identified prior to the trip. Following completion of this general reconnaissance a more meticulous field survey of

McCuddy's and Felida Marinas commenced in order to check for data precision, sailboats, and new or revised properties.

From the dock, the tallest points of each measured houseboat were identified, and based upon circumstances, either of two methods was used to find the height, see Section 3.2.1 and Section 3.2.2. Many houseboats were unattended preventing the field team from boarding the vessel to verify the outboard dimension. Measurements and GPS waypoints were obtained for all properties of significant height.

Interviews occurred on separate dates and times, and are detailed in Section 7.

3.2.1 Abney Level

The Abney level is a simple instrument often used by foresters to determine tree heights and grade elevations. The unit measures the angle between the height of the instrument and a point on top of the object. A linear baseline measurement then forms an imaginary right triangle to enable trigonometric computation of the height of the object.

Prior to field deployment, the FHWA team tested Abney level computations against the known heights of various objects. The accuracy of the Abney level computations could be verified to within 0.1 foot provided a good baseline measurement was executed. Errors in height correlate with errors in measurements of the baseline length according to the tangent of the measured angle.

Longer baselines correspond to smaller angles and reduced errors in estimated height. When using the Abney level in the field, baseline measurements were occasionally compromised by structural setbacks to the highest point or private property restrictions. During such situations the survey team computed elevations from different locations in an attempt to quantify the tallest possible height. For accuracy, a combination of measuring tape and survey rod were used to measure the baseline, the height of the instrument and the vessel freeboard. Overall, heights estimated using the Abney level are accurate within approximately ±2 feet.

3.2.2 25-foot Survey Rod

An extendable survey grade rod, measuring to hundredths of a foot, was used to directly measure those structures whose highest point was adjacent to the dock. This height measurement could be read from an eye level scale on the reverse side of the rod. In Appendix B there is a picture showing a team member measuring houseboat No. 29 at McCuddy's Marina. An independent observer could also read the height from the scale on the front of the rod. The survey rod has four sources of error i) the reading, ii) the location of the maximum height, iii) inaccuracy in the rod itself, and iv) the compression and movement of the rod. Error sources add to an approximate error of ±1foot.

3.3 Selection of Measurement Method

Height measurement error bands using the Abney Level are thought to be ±2feet, and height measurement error bands using the survey rod are thought to be ±1foot. Therefore, error bands were not the major factor taken into account when selecting a method to measure the height of any particular point, but rather the location and accessibility of the highest point. If a location was accessible, the survey rod was chosen for efficiency and better precision. If not, then the Abney level method was chosen as less intrusive.

SECTION 4: EXISTING HEIGHT OBSTRUCTIONS

The entire length of the study area was traversed during the survey, and existing height obstructions were identified and measured. During the on-site survey the FHWA survey team documented existing objects that may constitute restrictions to navigation clearances on Lake River. Table 2 provides a summary of existing obstructions to vertical clearance.

Table 2 - Existing Heights of Obstructions (measured at 13feet USGS river stage)

Object	Latitude	Longitude	Height
Power Line 1 (North of McCuddy)	N45º 49.127’	W122º 45.134’	> 70 ft
Existing Bridge	N45º 48.438’	W122º 44.434’	27.1 ft
Power Line 2 (Between Marinas)	N45º 45.780’	W122º 44.924’	> 70 ft
Power Line 3 (Between Marinas)	N45º 42.771’	W122º 43.538’	> 70 ft

Other than the existing bridge, the remaining obstructions are all high power line crossings and of no significance to recommending bridge clearances. Reference 15 shows Lake River and gives “Soundings and Clearances of Bridges and overhead cables in feet at the Columbia River Datum (Mean Lower Low Water during Lowest River Stages)”. The chart shows Power Line 1 and notes an authorized clearance of 75 feet. (Reference 15) The existing bridge is shown on the navigation chart but no clearance is noted.

The vertical distance between the bottom of the existing bridge and the surface of the water was measured on site at 34.0 feet. At about the beginning of the 2011 water year, on or about 29 September 2010, the United States Geologic Survey, Water Resources Division (USGS) established a new stream gauging station 14213090, identified as “Lake River at Ridgefield, WA”, at the location of the existing wooden bridge. At the time that the survey team obtained field measures of the existing bridge clearances the USGS river stage was 7.89(NGVD 1929), 8.29 feet (NGVD 1947), or 7.31 feet (CRD), according to Reference 8.

The 2010 Bridge Inspection and Appraisal Report, Reference 13, shows the vertical and horizontal bridge span clearance at 33 feet and 55.5 feet, respectively. The vertical reference datum associated with the 11 feet water level shown in Reference 13, from whence the 33 foot vertical clearance is determined, is not identified. The bridge’s horizontal navigation clearance was confirmed at 55.5 feet. Vessel traffic from, or destined to, upriver of the bridge must pass through the bridge span. The existing bridge is pictured in Figure 6.

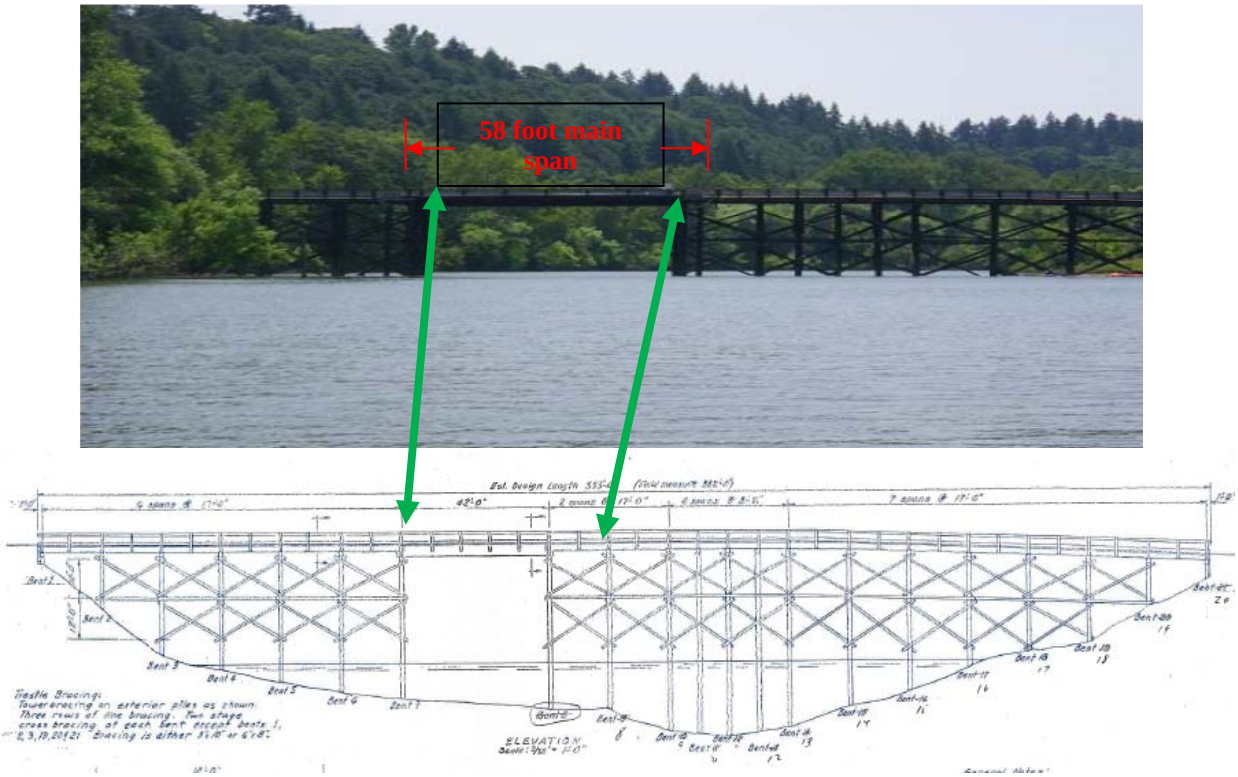

Figure 5. Existing Bridge

Prior to 1981, the bridge had a 42 main span. Figure 5 illustrates the original bridge, and how the 42-foot main span was replaced by combining this span with an adjacent 16 foot span to create the new 58-foot span. This modification to increase the main span was at the request by a private contractor to the US Fish and Wildlife Service as a one-time-only removal and replacement to facilitate the dredging contract of Vancouver Lake at the expense of the private contractor.

SECTION 5: BOAT INVENTORY

The boats operating on Lake River are recreational craft, small workboats, and houseboats. Many of the small craft operating on Lake River are launched from the Port of Ridgefield public boat ramp while many of the resident vessels are docked at the marinas. During the onsite survey, an average of 20 boats per day were seen using the boat ramp. The largest sailboats in the study area are listed in Table 3. In general, sailboat masts of this size are only removed with mechanical assistance (e.g., cranes). The tallest sailboat is pictured in Figure 6. The boat was recognized as a Cheoy Lee Offshore 40. The mast height is 55feet.

The Vancouver Lake Sailing Club (VLSC) and Vancouver Rowing Club contribute to vessel traffic on the north end of Vancouver Lake. The sailboats, rowing shells, and related craft have smaller beam than the houseboats, and therefore do not affect horizontal clearance requirements.

FHWA team members traveled to Felida and McCuddy's marine on 10/23/2012. The team located sailboat N0.1, 3, and 4 from Table 3. The owner of the boat # 4 was not present but a neighbor reported that the owner doesn't use the boat. The FHWA team interviewed the owner of Boat No. 1. Observations of both boats are noted:

FHWA observations of sailboat No. 4 is as follows:

- Last date of boat licensing- 2000
- No outboard or inboard motor
- Boat covered in moss
- All teak wood members on the boat have been removed or rotted away
- Rigging ropes appear to be in very poor shape
- Mast is retractable

FHWA observation of sailboats No. 1 and 3 at McCuddy's

- Boats are in good working order
- Boats are currently licensed
- Boat travel downstream to the Columbia year round

Table 3 - Sailboats Inventory

	Location	GPS Position	Mast Height	Length
Sailboat No.1	McCuddy's	N45º 48.921' W122º 44.994'	48ft	31ft
Sailboat No.2	McCuddy's	N45º 48.905' W122º 44.969'	32ft	26ft
Sailboat No.3	McCuddy's	N45º 48.720' W122º 44.695'	55ft	40ft
Sailboat No.4	Felida	N45º 42.401' W122º 43.344'	34ft	23ft
Group of Sailboats	VLSC	N45º 40.432' W122º 41.895'	⊩ 28ft	⊩ 20ft

Figure 6 Largest Sailboat No. 3–55-foot Height

SECTION 6: HOUSEBOAT INVENTORY

The houseboat inventory includes 95 houseboats from the two marinas. At McCuddy's Marina, there were three additional houseboats identified on-site that were not in the aerial photos. The new houseboats are located at the north end of the Marina. New houseboats were indexed by their relative cardinal direction to the nearest previously indexed houseboat. For example, the new three-story houseboat, S23, is south of Houseboat 23.

Table 4 summarizes the houseboats, including maximum dimensions. McCuddy's Marina, has 52, a net change of minus three (-3) from the LiDAR research. 6 were no longer there, 3 were new, and 5 were rebuilt. 35 of the houseboats were single story, 16 were two stories high, and 1 was three stories high. At McCuddy's Marina, the maximum height was 34 feet, and maximum beam 42 feet. The tallest houseboat is S23, Figure 7. At Felida Marina, the number of houseboats was 43, a net change of zero (0) since the LiDAR research, 3 were rebuilt. 17 of the houseboats were single story, and 26 were two stories high. At Felida Marina, the maximum height was 29 feet and maximum beam 50 feet. The tallest houseboat at Felida is No. 13, Figure 8. All houseboats at the two marinas with more than one floor are tabulated in Appendix A.

The houseboat traffic is minimal. No houseboats were seen transiting the river during the site visit. On-site data collection shows that from 2011 to 2012, for Felida, 3 houseboats were rebuilt, and from 2007 to 2012, for McCuddy's, six houses moved out, and three either moved in or were built on-site.

Table 4 - Houseboat Counts and Statistics

	McCuddy's Marina	Felida Marina
Additional Houseboats between 2010 and 2012	-3 (6 not there, 3 new ones, and 5 rebuilt)	0 (3 rebuilt)
Houseboats 2012 (quantity)	52	43
2-story Houseboats (quantity)	16	29
3-story Houseboats (quantity)		0
Houseboats with height ≥27 ft	1	1
Houseboats with height ≥20 ft	9	15
Maximum Width (ft)	42	50
Maximum Height (ft)	34	29

Figure 7. Tallest Houseboat at McCuddy's Marina, No. S23–34 ft

Figure 8. Tallest Houseboat at Felida Marina, No. 13 – 29 ft

SECTION 7: USER INTERVIEWS

Five groups using the river were contacted for this study: Port of Ridgefield, McCuddy's Marina, Felida Marina, Vancouver Sailing Club, and Vancouver Rowing Club. The group representatives discussed their current and anticipated activities related to bridge clearance and provided additional opinions about Lake River.

7.1 Port of Ridgefield

The Port of Ridgefield was represented by Mr. Brent Grenning. Mr. Grenning's comments are summarized as follows:

The port's main activity affecting clearance criteria is a public boat ramp, located at the north end of McCuddy's Marina. Common vessels using the area are fishing vessels, and small pleasure boats. Occasionally, small barges with crane equipment are seen heading towards Vancouver Lake. Typically, the barges dismantle equipment to clear the existing bridge.

The Port's forecasted activity is maintenance in the form of dredging the lower river.

Comments provided but unrelated to their current use:

Emergency vessels may also pass by the Port of Ridgefield during a flood stage. This traffic was seen previously in 1996. At such time, emergency vessels struggled to go under the existing bridge. Furthermore, the water at Lake River is relatively stationary, meaning it can take a considerable amount of time for the Lake River stage to recede to normal conditions. In addition, sailboats with 40 feet or higher masts are often on Lake River.

7.2 McCuddy's Marina

McCuddy's Marina was represented by Mr. Mark McCuddy. Mr. McCuddy's comments are summarized as follows:

The main activity of his Marina is houseboats. Any change in activity is not anticipated; the marina has a three story high houseboat and a sailboat with a mast of approximately 55 feet. The tallest sailboat currently going under the bridge is 30-feet tall due to the depth of the river.

7.3 Felida Marina

Felidas Marina's only activity in the present and future is houseboats. Felida's Management, was represented by Mr. Mike Roe. Mr. Roe's comments are summarized below:

It is anticipated that house boat heights will be three stories high. During some on-site interviews, some of Mr. Roe's clients stated that some houses were built on site, and some were brought up the river from another marina. House No.42 at Felida Marina transited under the

current bridge. Mr. Roe concluded by stating his personal preference is have the new bridge top of piling provide 100 feet of vertical clearance.

7.4 Vancouver Lake Sailing Club

The Vancouver Lake Sailing Club Information Officer, Erik Troelsen, described the club's vessel traffic and fleet. Mr. Troelsen's comments are summarized below:

> *VLSC may host over a hundred vessels during regattas. However, such boats are typically trailer transported to the lake. Every few years club members sail on Lake River to and from St Helens, north of Ridgefield on west shore of the Columbia River. Future plans include sailing on Lake River every few years. The VLSC fleet consists majorly of Lightning's, Lasers, Fireballs, Hobie Cats and A-Cats, with a maximum height of 28 feet.*
>
> *Dock maintenance is another potential future use of the river. Dock pilings are often adjusted and contractors use Lake River for access to the club.*

7.5 Vancouver Lake Rowing Club

Vancouver Rowing Club was represented by Mr. Alan Stewart. Mr. Stewart's comments are summarized below:

> *None of the Rowing Club's activities will affect the current criteria.*

SECTION 8: CLEARANCE DEMAND

8.1 River Stage Fluctuation

The river stage on Lake River reflects three primary processes: 1) fresh water river flow; 2) astronomical tide effects; and 3) storm surges.

In Reference 7 NOAA states that the time, but not necessarily the magnitude, of astronomical tide maxima and minima can be predicted on the Columbia and Willamette Rivers, and presumably, by extension, Lake River, in the Portland area. However, because the river stage is dominated by the fresh water river flow process it is difficult to predict the magnitude of tidal effects in advance. When the river flow is high the effect of astronomical tide is small, and when the river flow is low the effect of astronomical tide is more noticeable. The dominant effect is river flow.

For the reasons given in the preceding paragraph NOAA declines to predict the magnitude of tidal fluctuations above Harrington Point, WA which is located approximately 63 miles downriver from Ridgefield, WA.

8.1.1 River Stage in the Portland Area

The U.S. Coast Guard Bridge Division in a meeting with FHWA on September 24, 2012 informed FHWA that for Lake River using the average annual maximum is not warranted given the historic, current, and forecasted uses of Lake River. The U.S. Coast Guard Bridge Division suggested establishing water elevation when high vertical users are likely to use Lake River to access the Columbia River and using this as the water level basis for vertical assessment.

8.1.2 River Stage on Lake River

The USGS station 14213090 on Lake River at Ridgefield is a new river stage gage that has only been in operation since 29 September 2010. The zero datum of this gage is NGVD (1929) (Reference 16). The minimum stage measured by the USGS Lake River station was 5.72 feet (NGVD 1929) or 6.12 feet (NGVD 1947) and the maximum stage was 20.47 feet (NGVD 1929) or 20.87 feet (NGVD 1947), a range of 14.75 feet. Anecdotal reports regarding Lake River suggest that annual river stage may fluctuate through a range of 6 to 10 feet. Two essentially annual maxima have been measured since inception of the USGS Lake River gage. A maximum of 20.47 feet (NGVD 1929) was measured and recorded on 2 June 2011, and a maximum of 19.34 feet (NGVD 1929) on 3 April 2012. The average of these two sampled annual maxima is 19.91 feet.

It is suspected that the river stage at Lake River is highly correlated with that at the Columbia River at Vancouver, WA. Based on that suspension/assumption it is possible to predict that the river stage at Lake River might be on-the-order-of 22.00 feet ±0.75 when the Columbia River at Vancouver was at 25.0 foot river stage (NGVD 1929). The available

data suggests that the average annual maximum river stage at Lake River is likely to be between 19.1 and 22.0 feet. FHWA conducted on site interviews with the larger boat owners to determine what river gage elevation do they typically and ideally operate at. The large sailboat at Felida was found not to be sea worthy, and the two vessels at McCuddy's only travel downstream to the Columbia River. One of the vessel using Lake River year round, while the other typically uses Lake River only in the summer months. Both vessels have traveled out Lake River at all river stages.

For the existing bridge, assuming OHW (14.58 feet NGVD 1947) as the average operating river stage, the existing bridge provides 40.5 feet – 14.58 feet = 25.92 feet of vertical clearance (NGVD 1947) or 24.94 feet (CRD).

For all new bridges downstream of the existing, the two largest vessels only travel downstream from their current locations. The owners informed FHWA there was no desire to travel upstream as the river is too narrow and too shallow but with all alignment options downstream of the existing will need to traverse McCuddy's Marina, and that the current use of high air draft (distance from water level to top of mast) is your round, initial assessments will be made for a range navigational clearances. At the extreme end, a maximum annual average river stage is estimated at 20.5 feet (NGVD 1947) and a mean annual average river stage estimated at 14.58 feet (NGVD 1947). The resulting minimum bottom chord elevation of any new bridge would be, 1- 55 feet + 2 feet (free board) + 20.5 feet = 77.50 feet (NGVD 1947) to 2- 55 feet + 2 feet (free board) + 15.58 feet = 71.58. For initial assessments, FHWA will use 71.58 feet (NGVD) to perform initial screening. If options are carried forward more detailed navigational needs assessment will be developed.

8.2 Maximum Heights Found

Along the river, from north (Columbia River) to south (Vancouver Lake), the air draft dimensions of the tallest houseboats are given in Figure 12 with respect to river mile between the north and south end of McCuddy's Marina (river miles 2.4 and 3.0 respectively) and referenced from the maximum annual elevation derived above. Three street locations from Reference 18 are noted with vertical red lines. At and above river mile 2.63 (Pioneer St. Op. 2), there are 6 houseboats taller than or equal to 20 feet and 1 houseboat taller than or equal to 27 feet. At and above river mile 2.75 (Sargent St.), there are 3 houseboats taller than or equal to 20 feet and no houseboats taller than or equal to 27 feet. At and above river mile 2.78 (S. Main Ave.), there are 2 houseboats taller than or equal to 20 feet and no houseboats taller than or equal to 27 feet. The height of the existing bridge is shown in blue dotted line presuming a USGS Lake River stage of 20 feet.

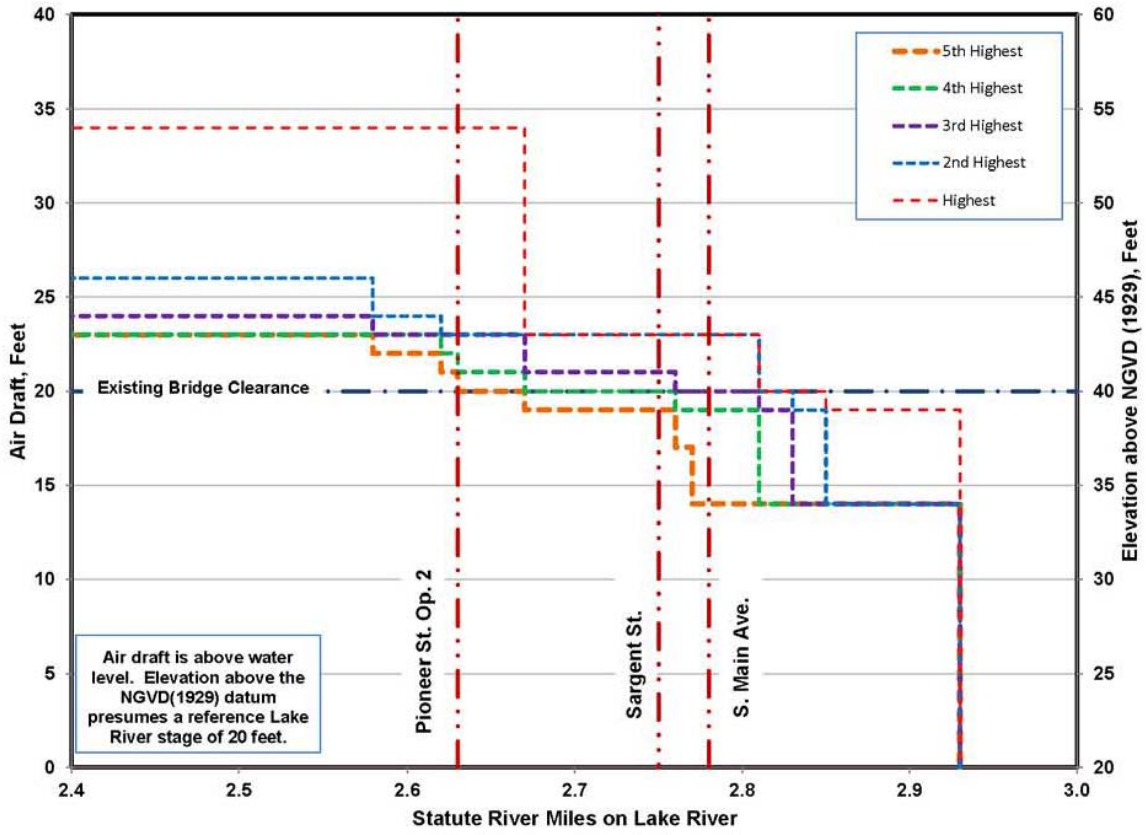

Figure 9. Air draft of 5 tallest houseboat upriver of river mile on Lake River

8.3 Dredge Limits Set by USACE

US Army Corps of Engineers dredged channel project depths are with respect to Columbia River Datum (CRD), which is 0.98 feet above NGVD (1927). The Federal Navigation Project Chart No. 18524 from 2001, Reference 10, describes the existing project: "a channel 6 feet deep, 100 feet wide and 3 miles long from the Columbia River." The dredged depth of 6 feet dates back to 1925. According to Reference 5, the dredge depth was set by the US Army Corps of Engineers to facilitate commerce from shallow draft vessels. It is unlikely that the river will be dredged to a deeper depth. Based on Reference 10 it appears that the historical USACE dredged channel project extends from the juncture of Lake River with the Columbia River and ends at an upriver point roughly corresponding with the south extent of McCuddy's Marina. Accordingly, it is reasonable to expect that deeper draft vessels may be unable to navigate above the historical end of the USACE dredged channel project. Absolute navigation draft limitations throughout Lake River will depend on the river stage.

8.4 Concluding Observations

Depending on the location of the new bridge, the house boats, together with the sailboats docked at the McCuddy's Marina, are the source of the greatest demand for bridge navigational clearances. If the new bridge is located downriver of the existing bridge, clearance is controlled by current sailboat use. The tallest sailboat measures 55 feet and combined with 2 feet of free board results in a required clearance of 57 feet. For river navigation purpose this dimension would be additive to a base Lake River water level of 14.58 feet for a total clearance of 71.58 feet (NGVD 1947) or 70.60 (CRD). For bridge alignments upriver of the existing bridge, a clearance restriction matching the existing low chord elevation would be preserved which is 40.5 feet (NGVD 1947) or 39.52 feet (CRD).

The choice of reference Lake River stage for the vertical clearance is significant to the establishment of the absolute elevation of the underside of any fixed civil structure spanning Lake River. Using USCG in guidance provided on the September 24, 2012 meeting, combined with FHWA interviews of three tallest sailboat owners, and extrapolating the Lake River data to provide for an average annual river stage(OHW) for Lake River a base water surface is estimated to be 14.58 feet with respect to NGVD (1947).

In setting design minimum clearances for the new bridge some margins (assume 2 feet unless matching existing bridge) beyond the dimensions of the design vessels should be included, both to account for inaccuracies in measurement and for vessel maneuvering misalignment when passing the bridge.

Location	Vertical Clearance (NGVD 1947)	Horizontal Clearance *(denotes centerline pier to centerline pier spacing)*
MP 0.0 to MP 3.3	55 feet + OHW(14.58 feet) +2'(freeboard) = 71.58 feet	140 feet
MP 3.3 to MP 11	25.92 feet	140 feet

SECTION 9: REFERENCES

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4. RNWRstudyArea.dgn, HDR Engineering, 13 June 2012

5. House R&H Committee 69th Congress 1st Session, United States Congress, 1925

6. Rhinoceros, McNeel North America, www.rhino3d.com, Version 4.0

7. 2011 NOAA Tide Predictions: Saint Helens, Oreg., Station ID: 9439201, National Oceanographic and Atmospheric Administration, http://tidesandcurrents.noaa.gov/get_predictions.shtml?year=2011&stn=1038+Astoria&secstn=Saint+Helens,+Oreg.&thh=%2B3&thm=31&tlh=%2B5&tlm=44&hh=*0.0&hl=*0.0&footnote=wc5

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16. “Re: Datum (vertical elevation reference) for Lake River at Ridgefield, WA, USGS gage 14213090”, email John Clemens 28 August 2012

17. Clark County Public Works, July 1990 Memo to file, Datum adjustments NGVD 1929 to 1947.

18. Lake River Crossing Location Options, working document, email from B C Minor, US Department of Transportation, Federal Highway Administration (FHWA) to M Traffalis (FHWA) 23 August 2012, forwarded to D B Owings, HDR, 23 August 2012.

Appendix A Table of Houseboats at McCuddy's and at Felida Marinas with 2 or more stories

Houseboats are indexed from north to south and labeled in Figure 2 and Figure 3, Section 2 Study Area Description. Dimensions presented are the maximum found from the on-site measurements.

McCuddy's Marina Houseboats Greater than 1 story tall

Houseboat (No.)	Length	Beam	Height	Estimated Accuracy (ft)	GPS Latitude	GPS Longitude
4	---	25	23	± 2.0	N45º 48.979'	W122º 45.018'
7	46	24	19	± 0.5	N45º 48.944'	W122º 45.944'
11	-----	37	26	± 2.0	N45º 48.937'	W122º 45.011'
12	-----	34	24	± 0.5	N45º 48.921'	W122º 45.994'
18	63	42	18	± 2.0	N45º 48.893'	W122º 45.951'
20	47	39	22	± 2.0	N45º 48.888'	W122º 45.939'
21	63	35	18	±2.0	N45º 48.893'	W122º 45.927'
22	52	31	18	±2.0	N45º 48.879'	W122º 45.934'
S23	53	----	34	±2.0	N45º 48.875'	W122º 45.902'
26	49	38	13	±2.0	N45º 48.862'	W122º 45.911'
29	49	----	21	± 0.5	N45º 48.853'	W122º 45.873'
32	63	31	17	±2.0	N45º 48.806'	W122º 45.837'
33	48	34	23	± 0.5	N45º 48.799'	W122º 45.834'
42	44	30	23	± 2.0	N45º 48.775'	W122º 45.788'
46	----	41	20	± 0.5	N45º 48.768'	W122º 45.767'
47	68	24	14	±2.0	N45º 48.758'	W122º 45.755'
55	40	34	19	± 2.0	N45º 48.714'	W122º 45.675'

Felida Marina Houseboats Greater than 1 story tall

Houseboat (No.)	Length	Beam	Height	Estimated Accuracy (ft)	GPS Latitude	GPS Longitude
1	44	36	20	±0.5	N45º	W122º 43.474’
3	50	25	20	±0.5	N45º	W122º 43.442’
4	47	42	18	±2.0	N45º	W122º 43.441’
6	47	24	20	±0.5	N45º	W122º 43.432’
8	57	29	15	±2.0	N45º	W122º 43.417’
10	55	42	17	±0.5	N45º	W122º 43.397’
13	49	----	29	±2.0	N45º	W122º 43.361’
14	46	28	21	±2.0	N45º	W122º 43.368’
15	47	42	25	±2.0	N45º	W122º 43.364’
16	40	33	18	±2.0	N45º	W122º 43.356’
17	38	33	18	±0.5	N45º	W122º 43.354’
20	46	43	17	±2.0	N45º	W122º 43.336’
21	43	35	17	±2.0	N45º	W122º 43.340’
23	39	36	17	±2.0	N45º	W122º 43.341’
24	34	31	23	±0.5	N45º	W122º 43.334’
26	73	50	15	±2.0	N45º	W122º 43.340’
27	37	29	21	±2.0	N45º	W122º 43.341’
28	57	----	23	±0.5	N45º	W122º 43.329’
29	34	----	23	±0.5	N45º	W122º 43.338’
31	67	----	24	±0.5	N45º	W122º 43.338’
32	49	33	22	±2.0	N45º	W122º 43.337’
33	53	----	19	±0.5	N45º	W122º 43.342’
37	51	34	18	±2.0	N45º	W122º 43.342’
40	50	34	25	±0.5	N45º	W122º 43.341’
42	42	28	24	±2.0	N45º	W122º 43.354’
43	39	25	25	±0.5	N45º	W122º 43.348’

Appendix B Pictures of Tallest House Boats

Felida's Marina

House No.1

House No.3

House No.6

House No.10

House No.17

House No.28

House No.24

House No.29

House No.31

House No.33

House No.40

House No.43

McCuddy's Marina

House No.4

House No.7

House No.11

House No.12

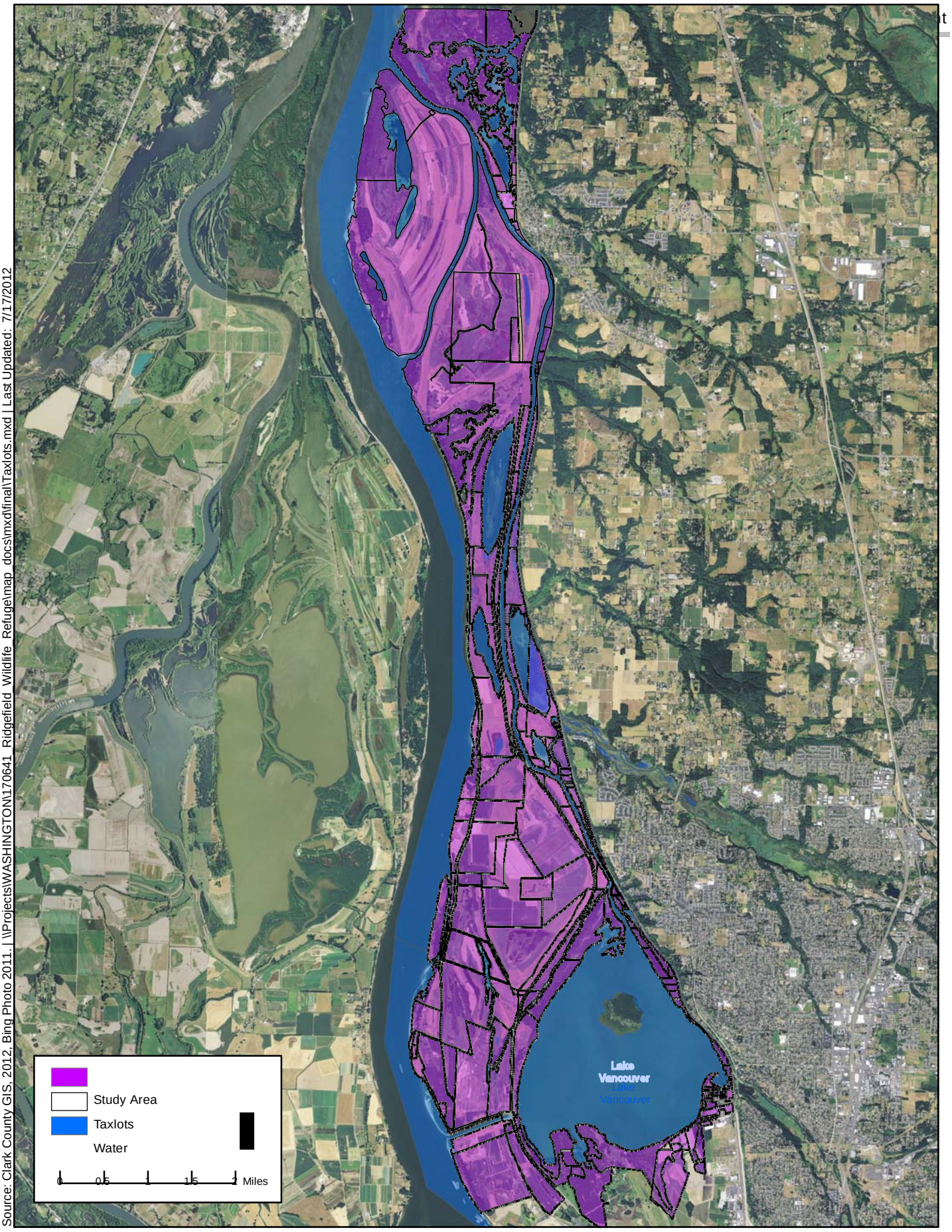
House No.20

House No.29

House No.33

House No.46

Appendix C Land Use



Source: Clark County GIS, 2012, Bing Photo 2011. | \Projects\WASHINGTON\170641_Ridgefield_Wildlife_Refuge\map_docs\mxd\final\Taxlots.mxd | Last Updated: 7/17/2012

Taxlots

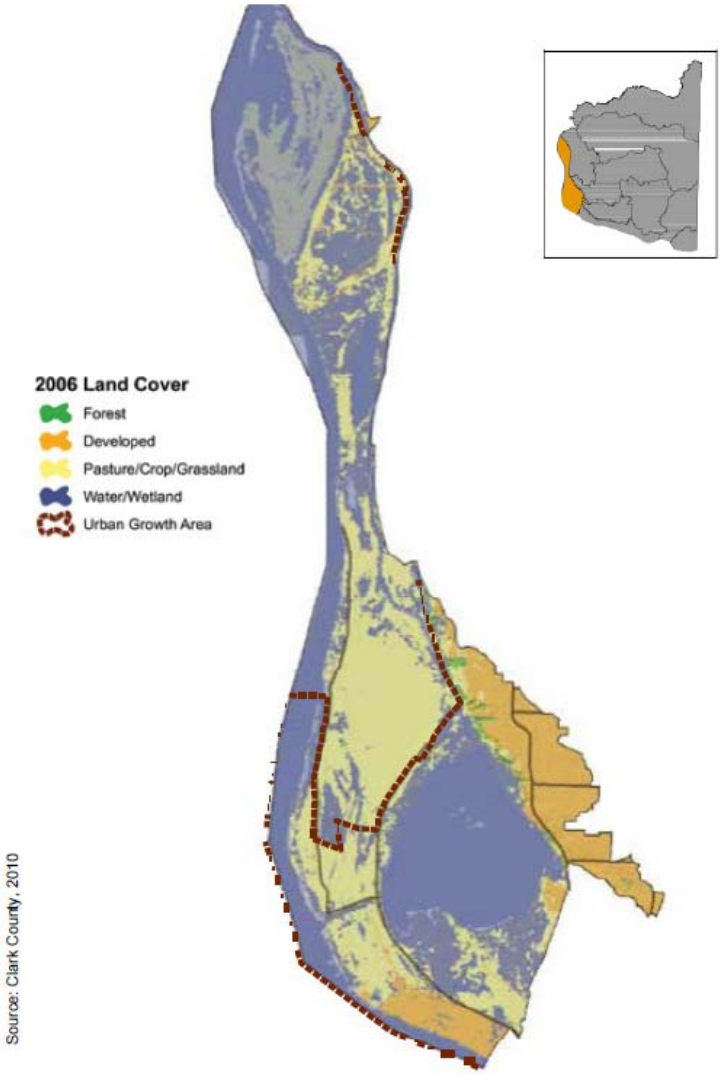
FIGURE 1

Western Federal Lands | Ridgefield Wildlife Refuge | Land Use Memorandum

Land Uses

The study area is located within the Vancouver Lake/Lake River Watershed. This watershed encompasses three subwatersheds: Lakeshore in the southeast section of the study area, Vancouver Lake in the southern section of the study area, and Lake River in the central and northern sections of the study area. Most of the watershed lies within the Columbia River floodplain, with stream channels draining from the surrounding hills into Vancouver Lake and Lake River.

Figure 2 shows land cover in the study area, which is dominated by water/wetland and pasture/crop/grassland. Developed land is concentrated in the Lakeshore subwatershed and the Port of Vancouver. Forest land is minimal.



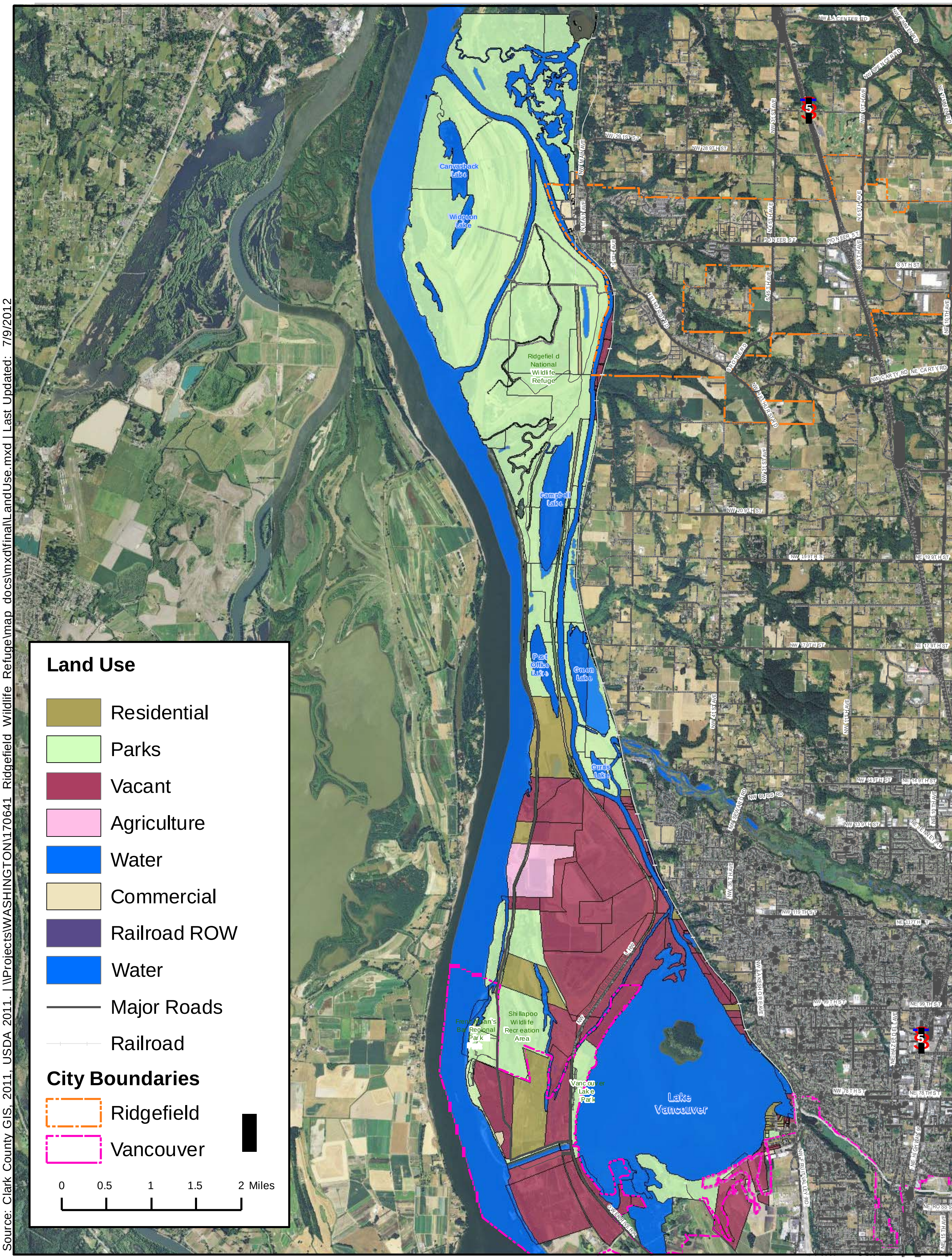
Land Cover in the Vancouver Lake/Lake River Watershed
Figure 2

As shown on Figure 3, land uses in the study area include residential, parks, agricultural, commercial, vacant lands, waterbodies, and road/railroad rights-of-way (Clark County, 2011). However, the majority of the study area consists of park/wildlife land, vacant/agricultural lands, and waterbodies. Very little commercial land is located in the northern and southern parts of the study area. Based on the GIS data, the majority of land in the southern section of the study area is "vacant"; however based on review of the 2011 aerial photographs, much of the vacant land appears to be used for agriculture.

The park/wildlife areas include Vancouver Lake Park, Shillapoo Wildlife Recreation Area, and Ridgefield National Wildlife Refuge. Bachelor Island is part of the Ridgefield National Wildlife Refuge and is accessible only by boat.

The study area includes many waterbodies including lakes, streams, sloughs, and rivers. Named waterbodies include Vancouver Lake, Curtis Lake, Green Lake, Post Office Lake, Canvasback Lake, Widgeion Lake, Lake River, and the Columbia River.

The study area contains several roads and a railroad line. NW Lower River Road/Highway 501 runs north-south along the western study area boundary. NW Erwin O Rieger Memorial Highway runs along the western side of Vancouver Lake. The Ridgefield National Wildlife Refuge road runs throughout the refuge and connects to W Bachelor Island Road and Bachelor Island. Various dirt roads appear to run through the study area. The Union Pacific/Burlington Northern railroad runs along the eastern study area boundary, from south of Vancouver Lake to north of the confluence of Lake River with the Columbia River.



Source: Clark County GIS, 2011, USDA 2011. | \\Projects\WASHINGTON\170641 Ridgefield Wildlife Refuge\map docs\mxd\final\LandUse.mxd | Last Updated: 7/9/2012

Land Use

FIGURE 3

HDR ONE COMPANY | Many Solutions

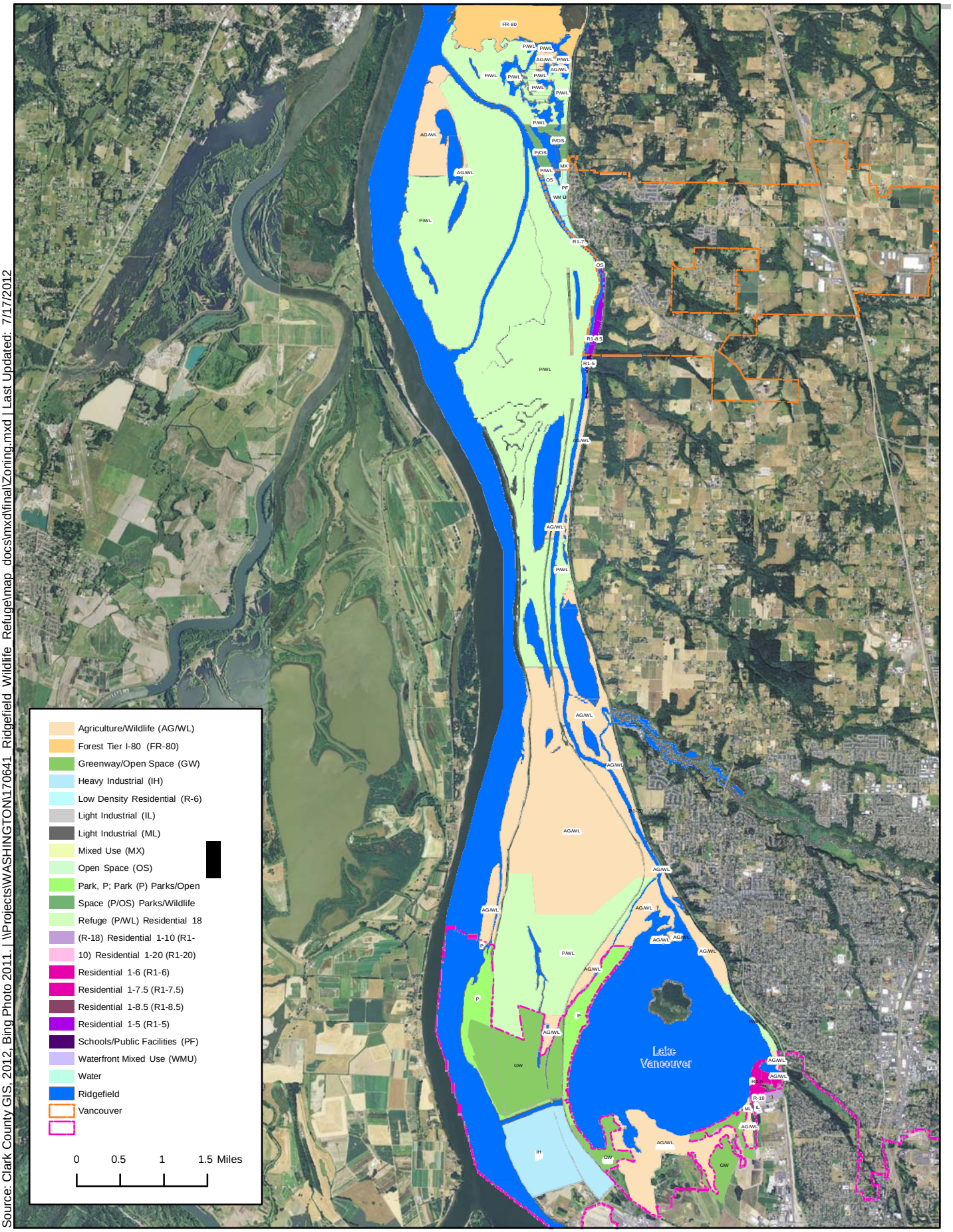
Zoning Designations

The zoning designations in the study area are shown in Figure 4 and listed in Table 1. Table 1 also includes allowed and limited/conditional uses. It is assumed that uses not listed as allowed or limited/conditional are prohibited. Most of the land is zoned Agricultural/Wildlife (AG/WL) or a variation of Park (GW, OS, P, P/OS, and P/WL).

Table 1: Zoning Designations

Jurisdiction	General Zones*	General Allowed Uses	General Limited/Conditional Uses
City of Vancouver	GW, P	Environmental, wildlife, park and recreation	Agriculture, environmental, park and recreation (many are not allowed in Vancouver Lake park areas), utilities
	R-6, R-18	Single-family residential (min 5,500 and 1,800 sf lots)	Retail, civic and institutional
	IL, IH	Industrial, manufacturing, research/development, warehousing activities, general office uses	Retail
City of Ridgefield	PF, P/OS	Parks, open space and recreational, educational	Public facilities, utilities
	WMU	Upper story residential, commercial, retail, recreation/open space, public service facilities	Light industrial
	RLD-4	Single-family residential (min 8,500 sf lots), park and recreation, agriculture	Public facilities and utilities, PUDs
Clark County	FR-80, AG/WL	Single-family residential (min 80 or 160 acres per lot), agriculture, wildlife	Park and recreation (golf courses prohibited), public service facilities, resources other than agriculture, utilities
	P/WL	Wildlife refuge**	**
	R1-5, R1-20	Single-family residential (min 4,000 and 20,000 sf lots), agriculture, parks, utilities	Recreation, services
	ML	Light industrial, manufacturing, wholesale trade, agriculture, utilities	Utilities, transportation and warehousing, waste management, services

** Figure 4 is based on Clark County zoning data (Clark County, 2011) whereas Table 1 zone data is based on the respective jurisdiction's zoning code and map; therefore, the information in Table 1 does not necessarily match that of Figure 4.*
***Zoning information for this zone was not available in the Clark County Unified Development Code (2012).*
Sources: City of Vancouver, 2004; City of Ridgefield, 2012; and Clark County, 2012.



Source: Clark County GIS, 2012, Bing Photo 2011. | \Projects\WASHINGTON\170641 Ridgefield Wildlife Refuge\map docs\mxd\final\Zoning.mxd | Last Updated: 7/17/2012

Zoning

FIGURE 4

Western Federal Lands | Ridgefield Wildlife Refuge | Land Use Memorandum

Shoreline Management Act and Growth Management Act

Washington's Growth Management Act (GMA) requires local governments to manage Washington's growth by identifying and protecting critical areas (i.e., wetlands, aquifer recharge areas, frequently flooded areas, geologically hazardous areas, and fish and wildlife conservation areas) and natural resource lands. The Shoreline Management Act (SMA) requires local governments with "shorelines of the state" (i.e., marine waters, streams and rivers with greater than 20 cubic feet per second mean annual flow, lakes 20 acres or larger, and wetlands and 100-year floodplains associated with waterbodies) to prepare and adopt a Shoreline Master Program to provide for the accommodation of appropriate uses that require a shoreline location, protection of shoreline environmental resources, and protection of the public's right to access and use the shorelines. The SMA and GMA thus induce development conditions and impact mitigation for shorelines and critical areas. Therefore, depending on the resources present and potential development impacts, these laws can limit development. Based on the major presence of water, wetland, wildlife habitat, and floodplain in the study area, most of the land of the study area would be subject to SMA, GMA, and related local jurisdiction development restrictions.

Development Opportunities

New development opportunities are limited to the vacant lands. There could be some industrial development potential on the vacant lands south of Vancouver Lake in the IH, IL, and ML zones. There is also some development potential for residential, or other allowed or limited/conditional uses listed in Table 1, on the vacant lands in the City of Ridgefield zoned RLD-4, southeast of Vancouver Lake in the City of Vancouver zoned R-6, and adjacent to the railroad in Clark County zoned R-5 and R-20. The vacant lands zoned AG/WL could only be developed for single-family residential (160 acres per lot), agricultural, and wildlife uses. The "vacant" lands zoned GW and P/WL are not really vacant, but are used for park and wildlife refuge. Due to the extent of the Ridgefield Wildlife Refuge and Shillapoo Wildlife Area, critical areas, water and shorelines, and zoning standards on the vacant lands, there is limited development potential within the study area.

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