Lake Sammamish Ordinary High Water Mark Study

Final Report

Prepared by:

The Watershed Company

Prepared for:

City of Bellevue
Planning and Community Development
P.O. Box 90012
11511 Main Street
Bellevue, WA 98009

August 2004

FINAL REPORT

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City of Bellevue
Planning and Community Development Department
P.O. Box 90012
11511 Main Street
Bellevue, Washington 98009-9012

Prepared by:

The Watershed Company
1410 Market Street
Kirkland, Washington 98033
(425) 822-5242 Fax (425) 827-8136
watershed@watershedco.com
http://www.watershedco.com

16 August 2004

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EXECUTIVE SUMMARY

The City of Bellevue's Department of Planning and Community Development, under the initiative of a citizen-based effort, has undertaken the task of formally determining the ordinary high water mark (OHWM) of Lake Sammamish along the City's shoreline for the purpose of establishing development setbacks. The eastern boundary of the City of Bellevue contains over 360 lots which border nearly 5 miles of Lake Sammamish shoreline. Prior to this study, the City of Bellevue did not have a defined elevation for the OHWM and would therefore require these property owners to have the OHWM delineated on-site prior to development along the shoreline. This would often include third-party consultants to make such a determination. The City of Bellevue, as do most jurisdictions which border Lake Sammamish, uses a defined setback from the OHWM to determine the extent of development encroachment toward the lake. The development of a formal OHWM elevation would have beneficial uses for both the City and shoreline property owners, to alleviate unnecessary costs and expedite development review time.

Under contract with the City of Bellevue, The Watershed Company developed and implemented a protocol to establish a statistically valid determination of the OHWM elevation on Lake Sammamish. This included an investigation into possible segmentation rules based on statistically valid results wherein each segment had a discreet and defensible OHWM. After analyzing the potential error involved in determining and measuring the OHWM, The Watershed Company determined that a minimum of 27 sample sites would be necessary to provide a statistically valid result. These 27 sites were evenly distributed into three hypothesized segments which were based on geography, fetch distance, and prevailing wind direction.

At each sampling location, The Watershed Company staff used a variety of physical indicators to determine the OHWM. These indicators included changes in vegetation and substrate, stains on stable structures such as piers, bulkheads, and boat lifts, evidence of erosion and/or deposition, the presence or absence of lichens, and debris lines. Once the OHWM had been determined, it was marked and surveyed using GPS (Global Positioning System).

The survey results were examined using statistical methods to characterize the data, test hypothesized values, support or refute segmentation rules, and search for correlations. The mean of all 27 OHWM determinations was 31.32 feet (NAVD 88) with a variance of 0.05 feet. There was no significant difference in the mean OHWM elevation for the three segments. However, the variances between the three segments varied significantly due to a wide range of values in the north segment (variance = 0.10 feet) compared to the middle and south segments (variances = 0.02 and 0.03 feet, respectively). Surprisingly, there was no significant correlation between the 27 OHWM elevations and their corresponding location on the shoreline. Thus, because the mean values between the three segments were not significantly different and no significant correlation was evident based on shoreline location, there is no statistical reason to segment the lakeshore with respect to OHWM.

The mean of the 27 OHWM elevations is somewhat lower than what was anticipated from examining historic lake level data gathered at the US Geological Survey gaging station on the lake. While there are several ways to interpret the legal description of OHWM with respect to gage data, most interpretations would place the historic OHWM higher than 31.32 ft. However, while this elevation is lower than expected, it does fit within the range of reported values from

other OHWM determinations around Lake Sammamish. Because 31.32 feet is the mean elevation of the 27 OHWM determinations, it can be presumed that approximately half of all sites have an OHWM elevation above that mean. Therefore, if the City used 31.32 feet as the set OHWM for building setbacks, many setbacks would be measured from an elevation lower than the true OHWM at that site. A more conservative approach would be to use a value that encompasses nearly all potential sites to ensure that all properties would be treated fairly by identifying an OHWM elevation no lower than what might be observed along the entire shoreline. Given the variability that was observed during this study, it may well be appropriate to set a value which is at or greater than two standard deviations above the mean which is equal to 31.76 feet. This would ensure with 95 percent confidence that a setback from a proposed development would likely not begin below the true OHWM. Ultimately the decision of where to set the OHWM for building setbacks is at the discretion of the City.

LAKE SAMMAMISH ORDINARY HIGH WATER MARK STUDY

1. INTRODUCTION

Lake Sammamish, the second largest lake in King County, was formed as the continental glaciers of the Pleistocene retreated, leaving behind a relatively long, narrow trough with water impounded by glacial debris. The lake extends nearly 8 miles north-south, is generally less than one mile wide, and has a maximum depth of just over 100 feet. The watershed contributing to the lake includes Issaquah Creek, Tibbetts Creek, Laughing Jacobs Creek, Lewis Creek, Vasa Creek, Phantom Lake Creek, Idyllwood Creek, and Pine Lake Creek, and a number of small or unnamed creeks. Water leaves the lake via the Sammamish River, which flows to Lake Washington and then to Puget Sound. In the early 1960s, the Sammamish River was dredged by the U.S. Army Corps of Engineers (Corps) to control flooding in the valley and the lake. This dredging reduced the elevation of high water events on the lake by several feet.

Lake Sammamish forms much of the eastern boundary of the City of Bellevue. As a result, the City enforces setbacks from the lake, which are measured landward of the ordinary high water mark (OHWM) of the lake. The City has adopted the definition of OHWM from the Shoreline Management Act (RCW 90.58.030) as follows (LUC 20.50.038):

> *that mark that will be found by examining the bed and banks and ascertaining where the presence and action of waters are so common and usual, and so long continued in all ordinary years, as to mark upon the soil a character distinct from that of the abutting upland, in respect to vegetation, as that condition exists on June 1, 1971, as it may naturally change thereafter, or as it may change thereafter in accordance with permits issued by the City or the Department of Ecology; provided, that in any area where the ordinary high water mark cannot be found, the ordinary high water mark adjoining fresh water shall be the line of mean high water.*

Up until this study, the City of Bellevue did not have a defined elevation for the OHWM of Lake Sammamish. Rather, prior to development, property owners have been required to have an OHWM determination completed at their site, which often incurred an added expense. Determining the OHWM at a particular property can be difficult, and property owners are often required to hire third-party consultants to examine their property and make such a determination. This requirement has placed an extra burden on owners, and often leads to confusion and contention. Further complicating OHWM determinations, the U.S. Geological Survey (USGS), which maintains water level gage data on the lake, uses a different datum[1] (NGVD 29) than the City of Bellevue (see discussion on page 8 regarding datum conversion and gage data). In addition, the US Army Corps of Engineers (Corps), which also uses the NGVD 29 datum, also has a different regulatory definition of the OHWM, to determine what areas they have

[1] Datum: the horizontal or base line, from which the heights of points are reckoned or measured. NGVD 29 refers to the National Geodetic Vertical Datum as set in 1929, and is commonly used by the USGS and the Corps. This datum was largely superseded by NAVD 88, the North American Vertical Datum set in 1988. The difference between them varies, but in the City of Bellevue, the zero elevation line in the NAVD 88 system is equivalent to the -3.585 feet line in the NGVD 29 system (Bedwell, pers. comm., 19 July 2004).

jurisdiction over. The use of different datums and regulatory definitions add to the confusion citizens and staff face when dealing with OHWM determinations. In this report, all elevations will be given in NAVD 88, followed by the equivalent elevation in NGVD 29 in parentheses.

To avoid placing this burden on property owners, and to reduce the potential for inconsistency and subsequent contention between property owners and the City, the Department of Planning and Community Development wishes to simplify the process of determining the OHWM on Lake Sammamish by establishing a fixed elevation or a set of rules by which the shoreline could be segmented according to varying degrees of the OHWM. A single fixed elevation for the OHWM would likely be the most straightforward and fair way to establish building setbacks. However, it has been theorized that the OHWM varies depending on the location of the property on the lake. Areas with a large wave fetch[2] or with an unobstructed exposure to the prevailing wind direction may have a higher OHWM than those properties with small fetches or in protected areas. If this is the case, the City could divide the shoreline into several sections, each with its own fixed OHWM elevation. In either case, property owners would then have a consistent, legally defensible, and easy to determine OHWM elevation on which to base their building setbacks.

The Watershed Company was hired by the City of Bellevue to determine the elevation of the OHWM at a statistically representative number of properties throughout the shoreline of the lake within City limits. Prior to commencing the study, The Watershed Company performed an error analysis to determine how many properties would need to be sampled in order to have a statistically valid result in the event that the shoreline needed to be divided into a maximum of three segments. In total, 27 properties were examined, distributed as evenly as possible across the shoreline within the City. The properties varied with respect to wave fetch, exposure to prevailing winds, shoreline slope, shoreline protection (bulkheads, etc.), and vegetation. The result of this study is a statistically sound description of the OHWM of Lake Sammamish within the City of Bellevue. The data from this report can be used by the City to develop guidelines for setbacks based on simple elevations, rather than more complex and potentially contentious individual determinations of the OHWM. The report does not address what the appropriate structure setback dimension should be. The information from this report will be utilized by the City of Bellevue to establish the appropriate elevation point from which the structure setback will be measured.

2. METHODS

Sample Size Estimation

Ensuring that this study follows the best statistical protocol is of utmost importance. Thus, having enough samples to ensure the results are statistically sound while limiting the size to control survey costs was the first step in the formulation of this study. A first-cut estimate of the appropriate sample size to achieve the desired statistical validity was made using the following equation (Zar 1999):

[2] Wave fetch is the distance traveled by waves with no obstruction. Generally, the longer the fetch, the larger the waves produced by any given wind.

$$n = \frac{s^2 t^2_{\alpha(2),(n-1)}}{d^2}$$

where n is the minimum sample size, s^2 is the population variance[3] estimated with n-1 degrees of freedom, d is the half-width of the desired confidence interval, and t is the two-tailed critical value of the Student's *t* statistic.

The population variance was hypothesized based on OHWM studies along other lakeshores and known variability around the Lake Sammamish shoreline in previous OHWM determinations made by The Watershed Company. Assuming a 95 percent confidence interval of 0.5 feet and an estimate of the population variance of 0.25 feet, a minimum of 18 sample sites is necessary. This estimate was later refined after performing an error analysis (see below).

Segmentation Hypothesis

Prior to starting the study, the City's shoreline was segmented into three hypothesized segments based on geographic differences related to the prevailing wind direction. Wind data from the nearest on-line weather station (Boeing Field) was gathered and analyzed over periods of high lake levels (generally November through March). Typically, winds during high lake levels are from the southeast or south-southeast, though winds from the north also occur rather frequently. King County Metro's *Lake Sammamish Modeling Program* verified the prevailing wind direction (Degasperi, pers. comm., 5 April 2004). Given the prevailing wind directions and the geography of the City's shoreline, it was hypothesized that the shoreline should be segmented into three sections. This segmentation hypothesis reflects the dual goal of obtaining roughly equal-length segments, and ensuring that within each segment, the wave fetch and orientation to prevailing wind directions are similar (see Figures 1-4). The three hypothesized segments were identified as follows:

> Segment 1: North section extends from north City limit to the north property line of parcel #9451300025, approximately 2.0 miles of shoreline;
>
> Segment 2: Middle section extends from the north property line of parcel #9451300025 to the north property line of parcel #3625059074, approximately 1.9 miles of shoreline; and
>
> Segment 3: South section extends from the north property line of parcel #3625059074 to the south City limit, approximately 1.0 miles of shoreline.

[3] The mean of the square of each value in a population divided by the mean of the population, or $\sum_{i=1}^{N} \left(\frac{X_i - \mu}{N} \right)^2$ where N is the population size, and μ is the population mean. The square root of the population variance is the standard deviation. A sample variance (s^2), with *n*-1 degrees of freedom, is an unbiased estimate used in place of the population variance.

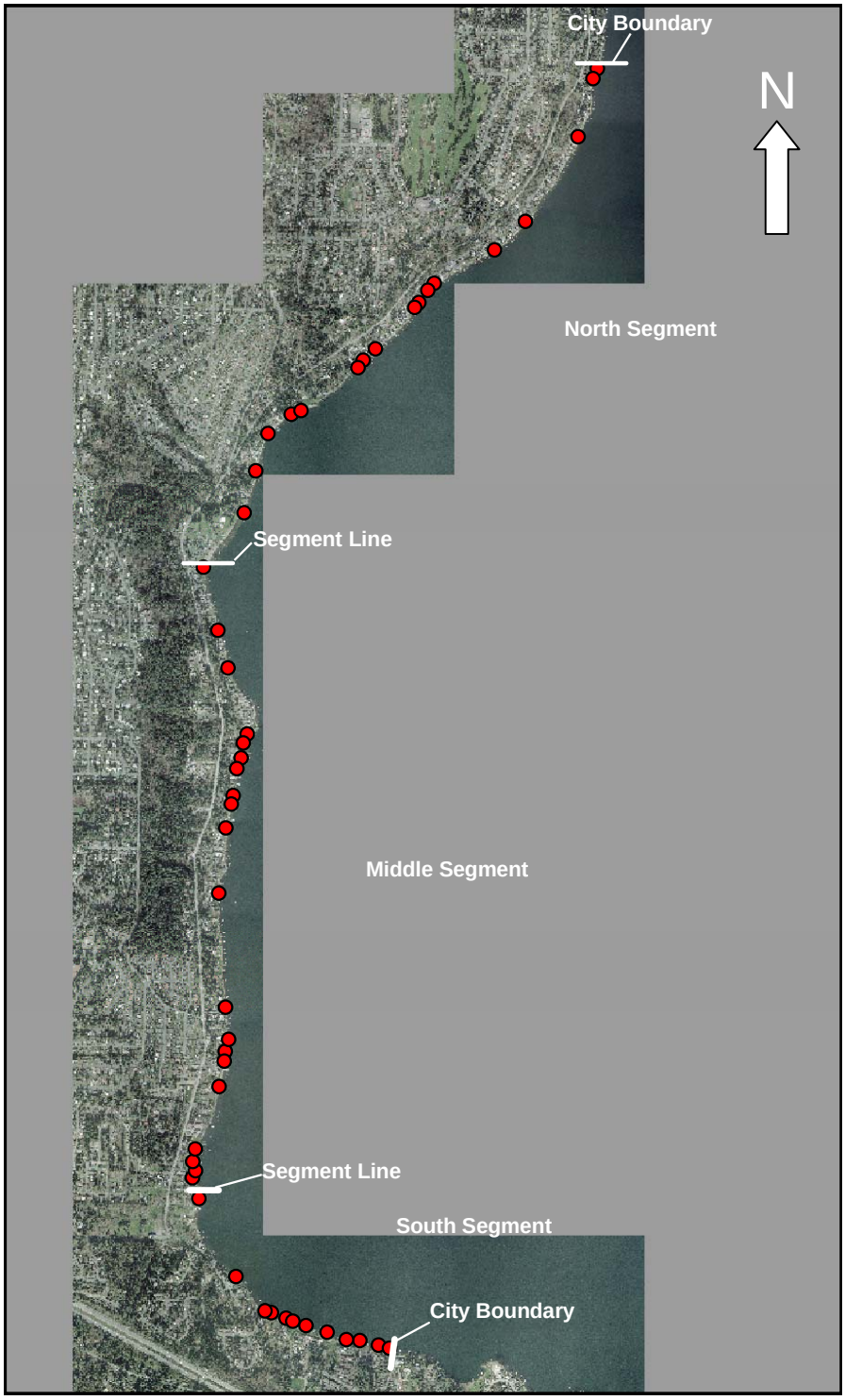

Figure 1. City of Bellevue shoreline of Lake Sammamish with segmentation lines and properties with Right-of-Entry.

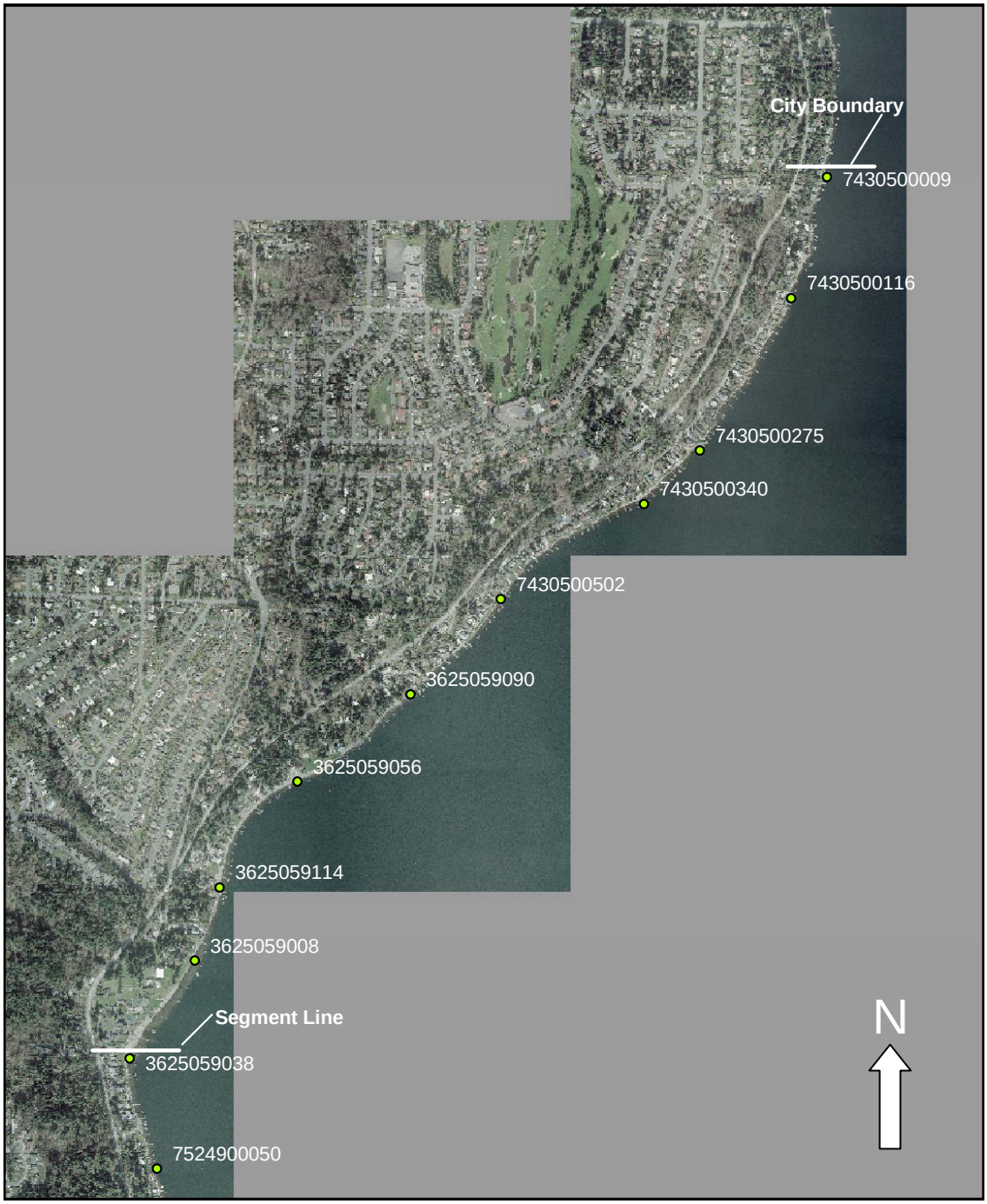

Figure 2. North segment (Segment #1) with selected site distribution and corresponding parcel numbers.

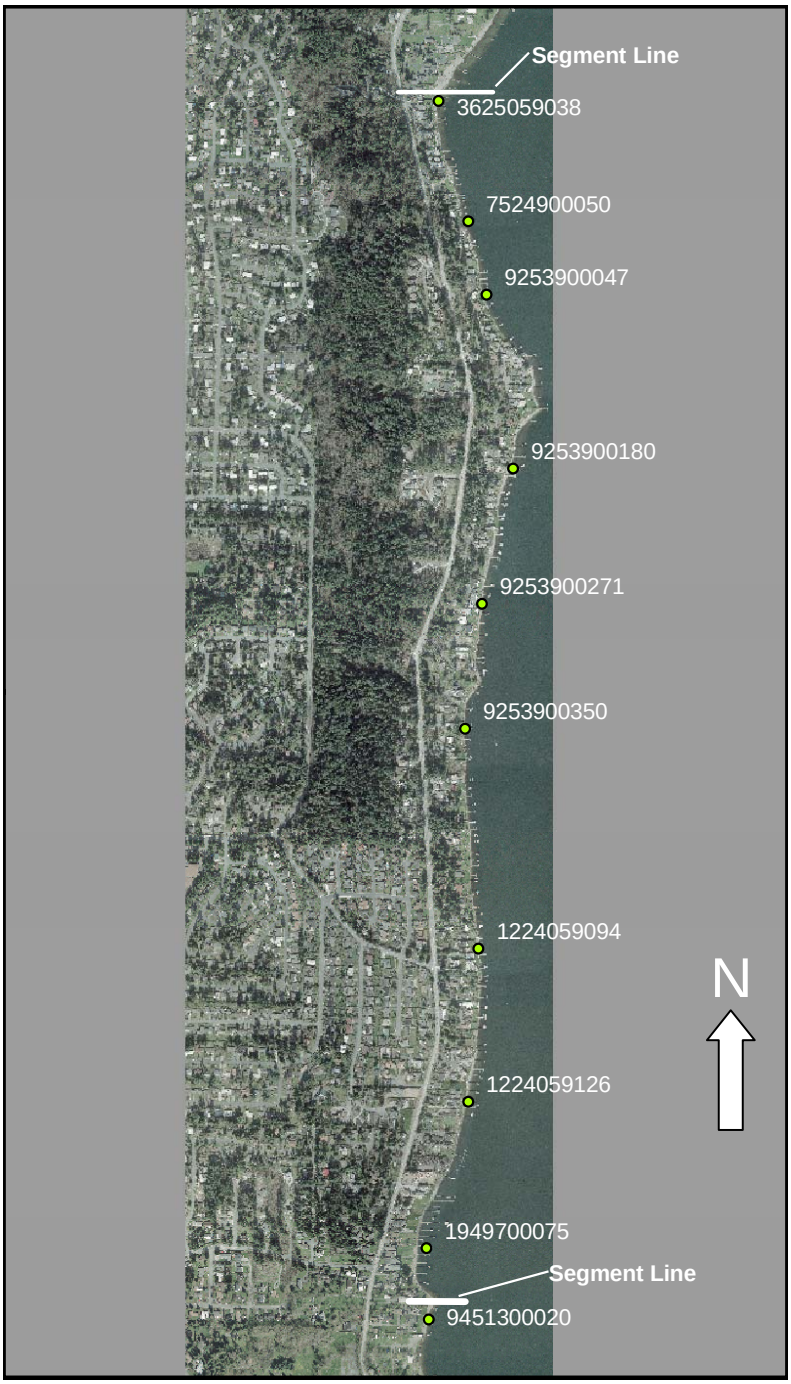

Figure 3. Middle segment (Segment #2) with selected site distribution and corresponding parcel numbers.

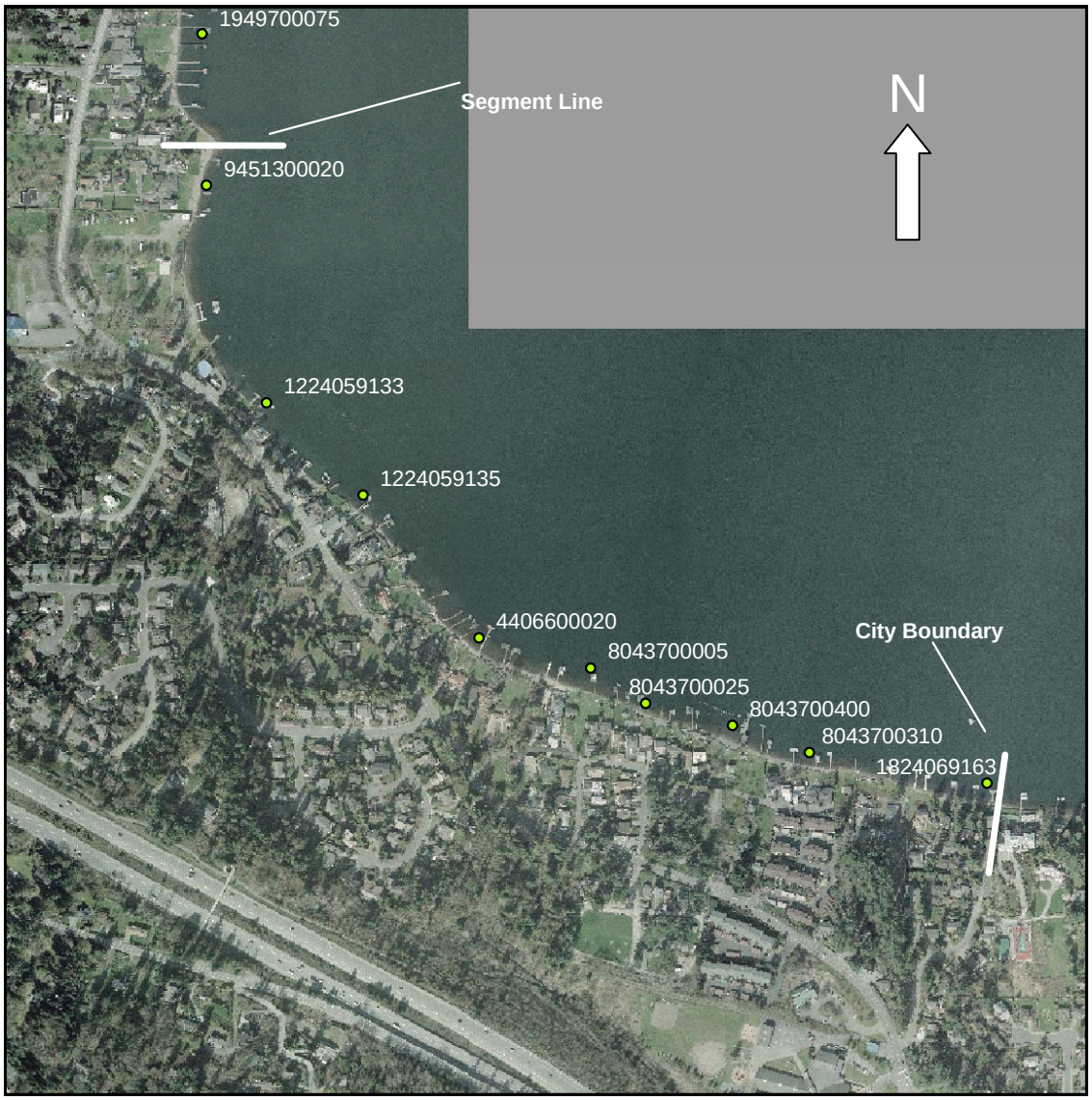

Figure 4. South segment (Segment #3) with selected site distribution and corresponding parcel numbers.

Peer Review

The methodology developed by The Watershed Company and the City of Bellevue was peer reviewed by Terra Stat Consulting Group, a firm specializing in quantitative analysis for the natural sciences (Reed 2004). Terra Stat agreed that the proposed methodology would yield sound statistical data, but recommended an expanded error analysis that would include observation and survey error, explained below.

Sample Error Analysis

Per the recommendation by Terra Stat, an error analysis study was performed on five sample sites chosen from the south segment. These sites included a broad range of shoreline types, from natural to artificial (bulkhead) shorelines. OHWM determinations were made at each location and marked with stakes and flagging (see *OHWM Identification* below for protocol). The stakes were then surveyed using the same equipment, techniques, and surveyor as in the full analysis. This information provided an estimate of the sampling error, which includes variability in shoreline type (i.e. natural or artificial), surveying techniques, and OHWM demarcation.

The information gathered in this error analysis was used to calculate a refined estimate of the population variance of 0.10 feet. This revised population variance was used in the equation above to determine the appropriate sample size. The result indicated that a minimum of nine samples were necessary for statistical validity. In the event that the OHWM varied from one segment to the next, it was necessary to ensure that each segment had enough data points to provide a statistically valid sample. Since the three segments each need the same level of reliability, each segment needed a minimum of nine samples, for a total of 27 sample sites.

Site Selection

The City's GIS data (i.e. aerial imagery, parcel map, and bulkhead layer) was reviewed by The Watershed Company to select 150 shoreline properties that met the statistical needs of the study through proper spacing and distribution, while at the same time allowed for improved survey accuracy with minimal overhead cover (vegetation or other structures).

The City of Bellevue Transportation Department sent letters to the owners of each selected property requesting permission for The Watershed Company staff and survey personnel to access their shoreline. In total, 48 property owners responded by signing a right-of-entry form and returning it to the City. Nine sites in each of the three segments were chosen for OHWM determination. The sites were chosen to provide as close to an even distribution as feasible. The Watershed Company staff and survey personnel were provided with copies of the right-of-entry forms for each site chosen, and these forms were on-hand during all field work.

Historical Record Analysis

The Watershed Company obtained historic lake level data from USGS gaging station #12122000, located near the southern end of the study area, just north of Vasa Park (Fusté, pers. comm., 17 March 2004). This data consists of daily water level readings from January 30, 1939 to February 9, 2004. Annual peaks for each water year (October 1 to September 30) were

filtered out and analyzed. As expected, the annual peaks dropped by an average of several feet after the Sammamish River was dredged by the Corps in 1964. Various statistical analyses were performed on both the annual high water events and the full post-1964 record. The results were used for hypothesis testing (see *Results*), and in the field to help avoid using an erroneous field indicator that may have represented either an extreme event or human disturbance.

It should be noted, again, that the USGS uses a different vertical datum than the City of Bellevue. Hence, all readings from the USGS gage are referenced to the National Geodetic Vertical Datum from 1929 (NGVD 29), and must be converted to the North American Vertical Datum from 1988 (NAVD 88) used by the City. The difference between NGVD 29 and NAVD 88 in Bellevue is 3.585 feet. Since the NAVD 88 datum (i.e. 0 elevation) is lower than the NGVD 29 datum, it is necessary to add 3.585 feet to the USGS gage data in order to reference it to the City's information system. For example, a gage reading of 28 feet (NGVD 29) would convert to 31.585 feet for the City (NAVD 88). All data results reported in this study use the City's NAVD 88 datum, with the equivalent NGVD 29 elevation following in parenthesis.

OHWM Identification

Each of the 27 sites was visited by The Watershed Company staff between June 10 and June 17, 2004. Data forms developed by the Washington State Department of Ecology (Ecology 2003), were modified to only include information that would vary from site to site (Appendix A). These forms were used to document site conditions and to guide the determination of the OHWM placement. Erik Stockdale from Ecology also accompanied The Watershed Company staff on two site visits.

On each day that site visits occurred, the USGS staff gage located at the boat ramp of Lake Sammamish State Park was checked to determine the lake level that day. The lake level remained nearly constant throughout the field work.

At each site, The Watershed Company staff examined the shoreline for potential indicators of the OHWM. Such indicators included:

- changes in vegetation types between wetland and upland species (Figure 5)
- changes in sorting or slope of shoreline substrate
- debris lines (Figure 6)
- lichens on bulkheads or large shoreline rocks
- evidence of erosion, such as undercutting
- staining on pier stringers, pilings, boat lifts, ladders, etc. (Figure 7)
- staining on bulkheads or other fixed objects

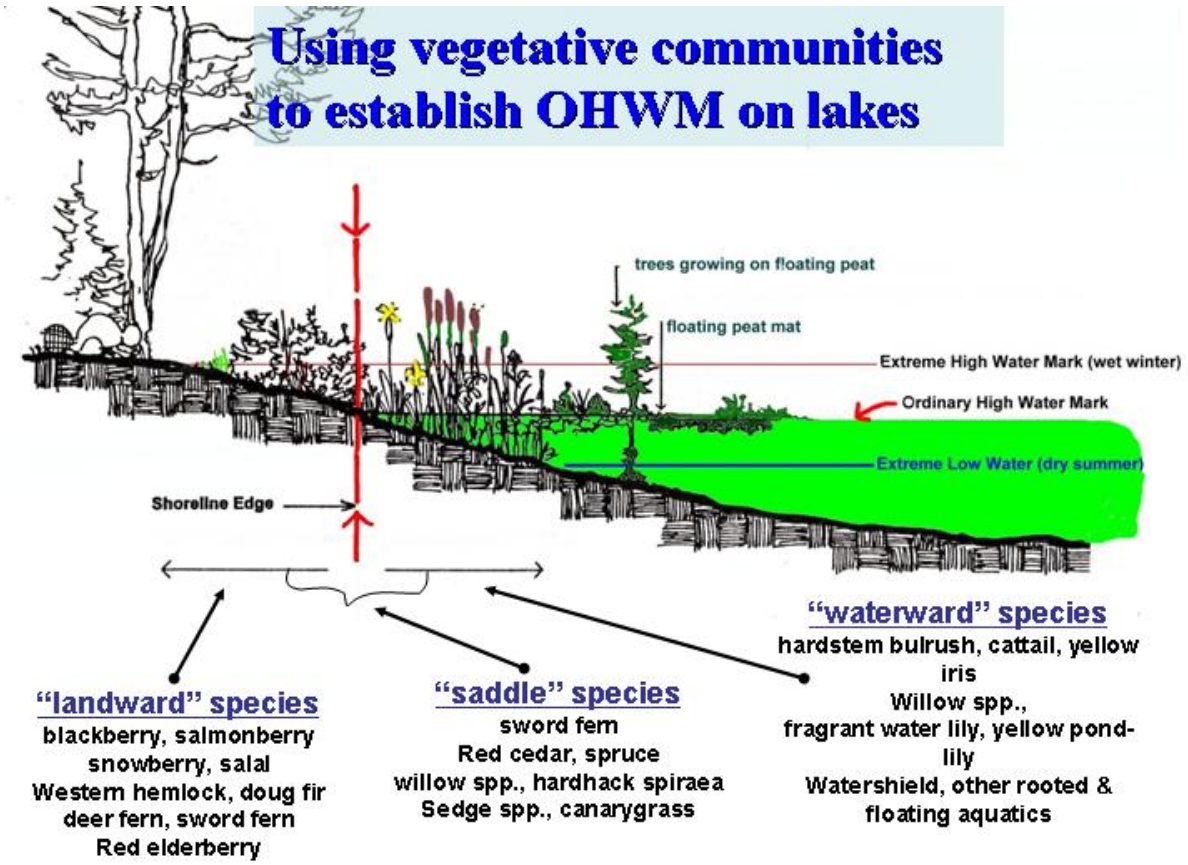

Figure 5. Example of transition in vegetation used in determining the OHWM (provided by the Department of Ecology).

Figure 6. Example of debris line indicator.

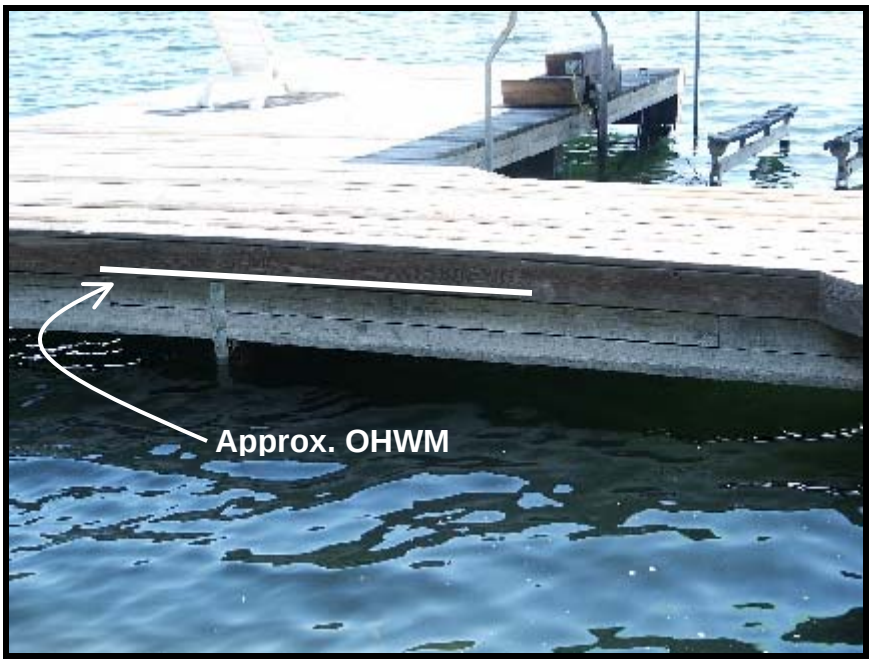

Figure 7. Example of stain marks on pier stringer and approximate line of the OHWM.

Typically, shoreline vegetation is one of the best indicators in locating the OHWM. As Figure 5 shows, in a natural setting shoreline vegetation transitions from "landward" or upland species to more "waterward" or wetland species at or near the line of the OHWM. "Saddle" species, which consist of vegetation that is tolerant of both dry and periodically wet conditions, will be present both above and below the OHWM. Unfortunately, the shoreline vegetation of Lake Sammamish within the City limits of Bellevue has been manipulated or completely removed to a point where these clear transitions are no longer evident. In such cases where shoreline vegetation was clearly altered, other indicators such as debris lines, stain marks, and erosion/deposition areas were used in conjunction to make a determination of the OHWM elevation. Neighboring shorelines were also visually inspected for similar indicators. Most shorelines examined had several potential OHWM indicators, but no shoreline had all the indicators listed.

The Lake Sammamish shoreline in Bellevue is nearly fully developed and as such, many of the typical OHWM indicators have been either manipulated or removed. Some shoreline disturbances, such as vegetation removal and rearranging beach material via raking or repeatedly walking along the same path, produced what appeared to be indicators. Not all indicators were deemed to accurately reflect the OHWM. A high water event in February 2004 with a gage reading of 32.37 (28.79) feet, was well above the mean annual peak event of 31.86 (28.28) feet as determined from historical records. Since the gage reading was higher than what would be considered a normal high water event, the debris line left by the February 2004 flood was assumed to be higher than the debris line of an ordinary high water event.

Once the various indicators were identified, their elevations were compared using an Abney level and stadia rod[4] to verify consistency. Elevations were also compared to the lake level at that time to ensure that the indicators were realistic (given the heavily disturbed state of the shoreline, some false indicators are possible). The final location of the OHWM was determined by the elevation of a preponderance of potential OHWM indicators. When the OHWM had been determined, the elevation was marked. In most cases, the mark was placed at the location where the indicator was most clearly observable. However, in the very few instances where the clearest indicator was under the cover of trees or buildings that would obstruct GPS signals, the marker was moved to a nearby location at the same elevation. Most markers were wooden stakes driven flush into the ground, such that the top of the stake would be at the elevation of the OHWM. Each stake was then marked using a small flag to allow the surveyor to find the stake easily. On some bulkheaded shorelines, the footing of the bulkhead was below the OHWM, and therefore a stake could not be used to mark the elevation. In these instances, the OHWM was marked using adhesive tape (Figure 8). A line was drawn on the tape corresponding to the OHWM, and the line was clearly labeled for later surveying.

Figure 8. Example of tape identification of the OHWM, shown by orange tape on the pier stringer.

Data forms were completed for each property where the OHWM was determined (see Appendix A). A photographic record of each property was also made, showing the various indicators observed, the vegetation on the shoreline (if any), and the fetch (Appendix B). Once the survey

[4] Abney level and stadia rod are simple hand-held surveying tools used to measure relative differences in elevation. For this study, a six inch non-magnifying Abney level was used in conjunction with a stadia rod marked to 1/100th of a foot. These tools were used only for estimating relative elevations, and not for any quantitative analysis.

was complete, each property was visited via boat, and photographs were taken of each site and the neighboring properties (see Appendix B). In most instances, the OHWM markers appear in the photos, though some are obscured by vegetation or structures.

Each marker was surveyed using static GPS to determine latitude, longitude, and elevation of the data point. GPS, or Global Positioning System, is a network of 24 satellites that broadcast their location and the exact time. A GPS receiver collects this data, uses it to determine how far the receiver is from each satellite, and then determines the location of the receiver using triangulation. Static GPS requires that the receiver stay at one location for an extended period of time collecting data, which is later processed via computer to provide a more precise measurement. The accuracy of surveyed elevations was certified to within 0.05 feet. To reduce the potential for tampering with markers, all properties were surveyed less than a week after the marker was placed. As part of the right-of-entry agreement, all markers were removed at the end of the project, unless a property owner specifically requested that it remain.

Statistical Analysis

The sample data were analyzed using SPSS 12.0 statistical software. The mean, median, range and standard deviation of the surveyed data were determined, and the following statistical tests were performed to assess the statistical validity of the data gathered and to determine what relationship, if any, the OHWM elevation has to several physical variables that might influence it:

Test for Normality: Tests for normality, including measures of skewness and kurtosis were performed to determine whether the data comes from a normal distribution.

Test for Outliers: SPSS software was used to identify any potential outlier data using box plots and Q-Q plots.

Hypothesis testing: Given the sample mean and standard deviation, one-sample t-tests were performed on the hypothesized mean derived from the historical record analysis. A one-sample t-test measures the difference between a group mean (i.e. mean of sample data) and a hypothesized population mean (i.e. OHWM of historical record) in order to accept or reject a hypothesis and derive the probability that a given observation would fall within the specified confidence interval.

Segmentation Rule Analysis: The OHWM values and corresponding means for each of the three segments were compared to the overall mean OHWM using Analysis of Variance (ANOVA) to determine whether the OHWM within any of the segments was significantly different from the overall mean. Tests for the homogeneity of variances were also conducted to see how the variability compares between each segment. In addition, regression analysis was used to test the significance of several independent variables that might affect the elevation of the OHWM, including latitude, longitude, wave fetch (longest distance to opposite shore), and wave fetch in the prevailing wind direction (Neter, et. al. 1996). Box plots were used to analyze non-numeric data that may influence OHWM elevations, including the direction of longest fetch, shoreline slope (shallow, moderate, or steep), the presence and extent of bulkheads, and the amount of shoreline vegetation.

3. RESULTS

Study Conditions

All OHWM determinations were made by Dan Nickel, Environmental Engineer, and Mark Indrebo, Fluvial Geomorphologist, of The Watershed Company, between June 10 and June 17, 2004. Data sheets from each site can be found in Appendix A. During the time of the site visits, the lake elevation per the USGS staff gage located at the Lake Sammamish State Park boat ramp near Issaquah read approximately 26.7 feet (NGVD 29), which converts to approximately 30.3 (NAVD 88). Per Chris Curran of the USGS, this staff gage was last calibrated in 1997 (pers. comm., 19 March 2004). The weather was warm and dry with only a few brief periods of rainfall. Precipitation over the previous few months was well below normal.

Site conditions varied widely between the 27 selected properties, encompassing a broad range of shoreline development with respect to vegetation, armoring, and shoreline use. The majority of the sites (18) contained bulkheads, with an additional four sites having armoring across some portion of the property. In all, only five sites did not have any bulkheads. Levels of shoreline vegetation[5] also varied considerably across all sites, with only one site fully vegetated, 12 sites partially vegetated, and 14 sites devoid of any significant vegetation. Vegetated shorelines were considered those that contain emergent, shrub, or tree cover. Grass lawns were not included in this designation. The lack of more fully vegetated shorelines is attributable to the level of development and the maintenance of view corridors, shoreline access, and the desire for higher use by having sand, gravel or lawn beach to the water's edge. The shoreline gradient[6] was characterized as shallow, moderate, or steep. The sites with shallow or moderate gradients were typically located near stream and stormwater outfalls that have transported and deposited sediments along their adjacent shoreline areas over time.

During the site visits, discussions with property owners were encouraged to help assess the historical condition of high lake levels. A number of property owners have lived on the lake for many years, and several remember the lake prior to the Corps dredging of the Sammamish River. Approximately half of the property owners were available to discuss their sites and the typical water levels encountered during the winter months. These conversations resulted in a wide range of responses, with some residents stating that their piers are submerged each winter, while others were adamant that the water levels never reach their bulkhead. These conversations were very informative in gathering site-specific conditions (i.e. wave forces, substrate movement, and shoreline use). However, because of their wide variability and the potential for property owner bias, these conversations were not given much weight in terms of specifically positioning the OHWM for each site.

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[5] Three levels were used to describe the amount of vegetation, not including lawn grasses, across the shoreline: "Full" represented shorelines with vegetation both below and above the OHWM for more than 75% of the width of the property; "partial" represented shorelines with vegetation below and/or above the OHWM for more than 10% of the width of the property; "none" represented shorelines with vegetation below and/or above the OHWM for less than 10% of the width of the property.

[6] Shoreline gradient was an estimation based on visual determinations of bathymetry both below and above the OHWM, but below any shoreline armoring. Pier lengths were also used as an indicator of gradient, since longer piers are often necessary in areas of shallow water, while shorter piers are often the norm with steeper gradients.

The Watershed Company created a GIS layer showing the location of each data point surveyed. Each point includes vertical elevation (NAVD 88) and horizontal location data, as well as a hyperlink to at least one photograph of the property and its surroundings.

Historical Record Analysis

The historical record of Lake Sammamish water elevations per the USGS gage located just north of Vasa Park (see Figure 9) was analyzed from 1965 through 2003 to determine the most appropriate hypothesis for the OHWM after the Sammamish River was dredged. There are several methods that were used to determine a hypothesized value. The first method determined the OHWM by finding the mean of the highest water level for each year, with a result of 31.86 (28.28) feet. Other methods are based on the phrase in the RCW "where the presence and action of waters are so common and usual, and so long continued in all ordinary years,…". Typically, most scientific fields consider any event with less than a 5% chance of occurring as "uncommon". Applying this criterion to the phrase above, a common or ordinary high water event would have a 95% chance of occurring in a given year, or alternatively, a recurrence interval of 1.05 years. The 1.05 year recurrence interval event on Lake Sammamish has a gage elevation of 31.01 (27.42) feet. Alternatively, this could be interpreted as the most common high water event (i.e. the mode of the annual high water levels), which was calculated to be 31.48 (27.90) feet and has a recurrence interval of 1.76 years. Finally, statistically, anything more than two standard deviations away from the mean would be considered uncommon. In this case, the mean elevation is 30.02 (26.44) feet and the standard deviation is 0.66 feet (derived from the entire post-1964 data set, not just the annual peaks). Hence, two standard deviations would result in a boundary at 31.34 (27.76) feet between "common" and "uncommon" lake levels.

In summary, there are at least four different methods that could be employed to determine the OHWM based on the historical record. Further analysis for the 39 years between 1965 and 2003 shows that, on average, the lake elevation of Lake Sammamish exceeds 31.86 (28.28) feet for 5 days each year, 31.48 (27.90) feet for 12 days each year, 31.34 (27.76) feet for 17 days each year, and 31.01 (27.42) feet for 32 days each year. The number of days of inundation necessary to make a clear mark upon the soil and differentiate upland and wetland vegetation is not always clear and may vary depending on the timing of the high water event. However, assuming that these exceedences are not occurring consecutively within each year, it is likely that more than five days each year would be necessary to make such a mark, especially if those five days occur in the winter months when most plants are dormant. Using the same rationale, it is likely that a value less than 17 days would be sufficient to make such a mark. Therefore, it is hypothesized that the OHWM elevation is somewhere between 31.86 (28.28) and 31.34 (27.76) feet.

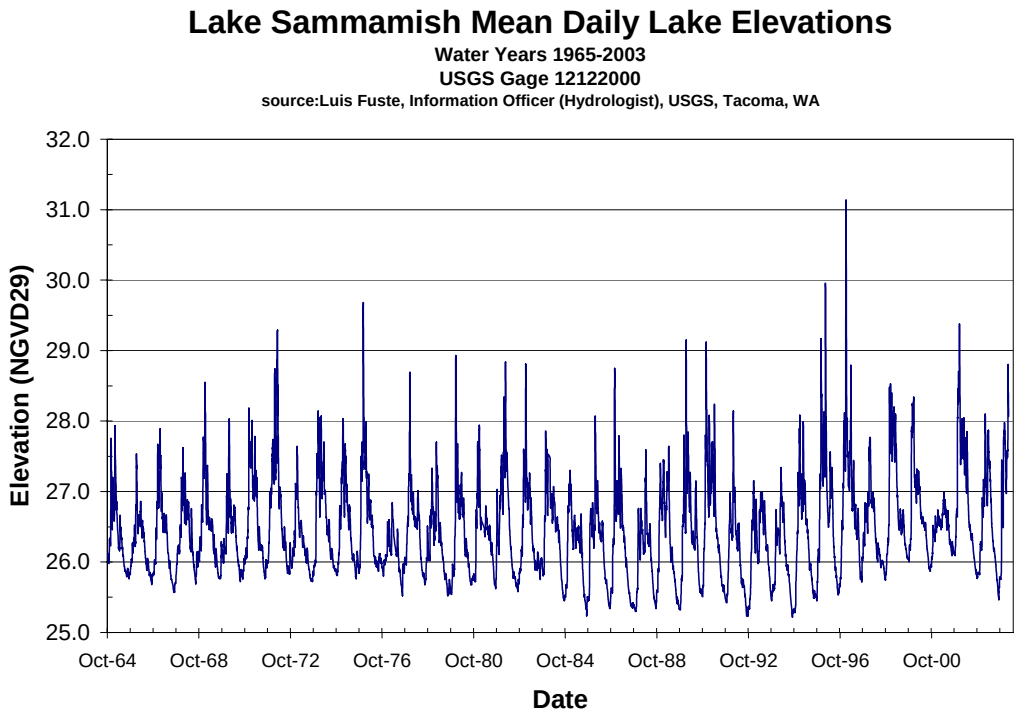

Figure 9. Lake Sammamish Water Hydrograph—years 1965 through 2003 (USGS gage #12122000).

Data Analysis

The sample data was analyzed using statistical software (SPSS 12.0) that follows peer-reviewed methodology. All statistical analysis results can be found in Appendix C. The information provided in this section is a summary and overall interpretation of the analysis with notations regarding the important and relevant information. All elevations are reported in City of Bellevue's datum (NAVD 88) followed immediately by the conversion to the Corps datum (NGVD 88) in parentheses.

Table 1 includes the descriptive analysis of all 27 data points. The overall mean is 31.32 (27.74) feet with a standard deviation of 0.22 feet. While the overall range of the data was 0.78 feet, extending from a low of 30.91 (27.33) feet to a high of 31.69 (28.11) feet, the 95 percent confidence interval around the mean was 0.17 feet.

Table 1. Statistical descriptives of all 27 data points.

			Statistic	Std. Error
Elev. (ft)	Mean		31.32	.04
	95% Confidence Interval for Mean	Lower Bound	31.24	
		Upper Bound	31.41	
	5% Trimmed Mean		31.33	
	Median		31.35	
	Variance		.05	
	Std. Deviation		.22	
	Minimum		30.91	
	Maximum		31.69	
	Range		.78	
	Interquartile Range		.33	
	Skewness		-.09	.45
	Kurtosis		-.96	.87

Measures of skewness[7] and kurtosis[8] are used to investigate any potential deviation from normality. The skewness reported in Table 1 indicates that while some level of skewness is present, the data does not differ significantly from the normal distribution. Furthermore, Kolmogorov-Smirnov and Shaprio-Wilk tests of normality (Table 2) show that since the significance is greater than 0.05, the data does not differ significantly from the normal distribution and therefore transformations of the data are not necessary. The level of kurtosis (-0.96) indicates that the data are not tightly clustered around the mean, but are more platykurtic. The histogram of all the data is shown in Figure 10, with the expected normal distribution curve also shown.

Table 2. Tests of normality.

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Elev. (ft)	.12	27	.20*	.97	27	.50

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

[7]Skewness is a measure of the symmetry of the data around the mean. A normal distribution (i.e. a "bell curve") is symmetrical, with an even number of data points above the mean as below.

[8] Kurtosis refers to the shape of the distribution, or how sharply the distribution peaks around the mean. A value near 0 represents the normal distribution and is said to be *mesokurtic*. Values significantly less than 0 represent distributions that are less clustered and have broad peaks and short tails and are said to be *platykurtic*. Likewise, values significantly greater than 0 represent data tightly clustered and forming a sharp peak around the mean, with long tails, and are said to be *leptokurtic*.

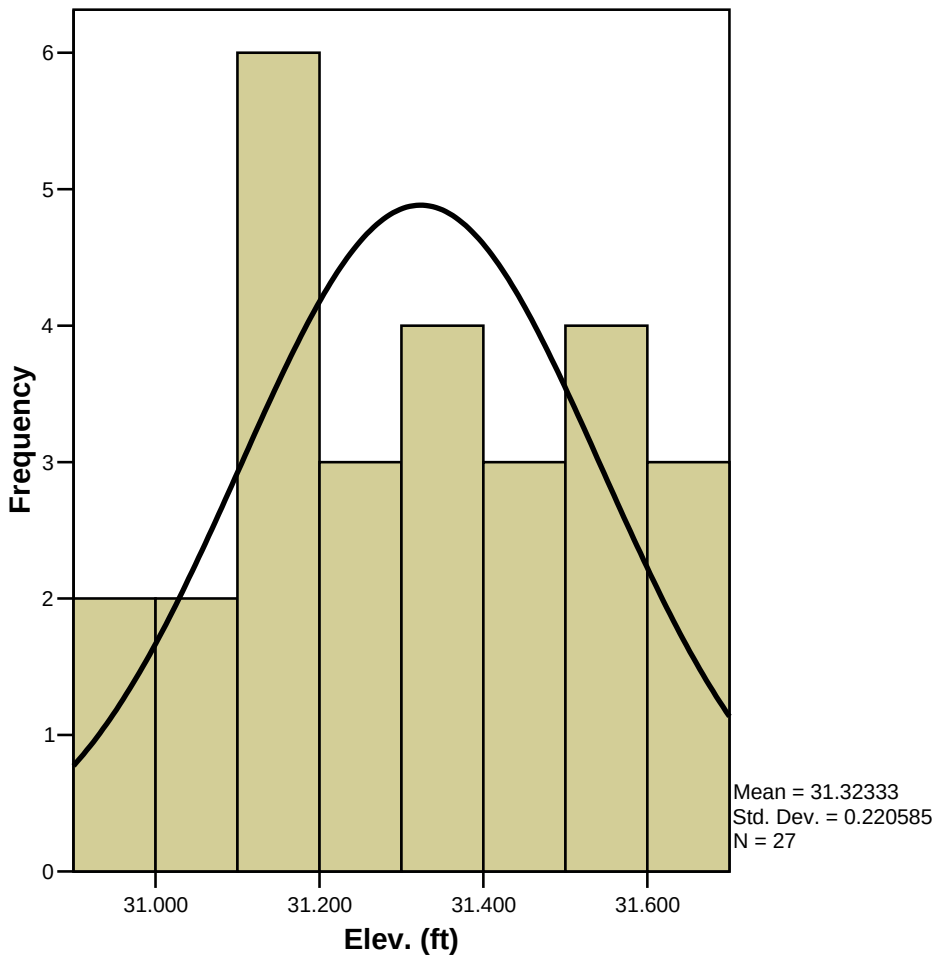

Figure 10. Histogram of all data with expected normal curve.

Examinations for outliers utilized box plots along with normal and detrended normal Q-Q plots (see Appendix C). No outliers were found and all data are considered valid. The five highest and five lowest OHWM elevations are reported in Table 3. While these are the extreme values compared to the remaining data, none of these points are considered to be outliers. Of the ten extreme values reported in Table 3, seven come from Segment 1 and the remaining three come from Segment 3.

Table 3. Extreme values.

			Case Number	Parcel Number	Value
Elev. (ft)	Highest	1	8	362505-9114	31.69
		2	6	362505-9090	31.67
		3	19	945130-0020	31.61
		4	2	743050-0116	31.59
		5	7	362505-9056	31.57
	Lowest	1	3	743050-0275	30.91
		2	9	362505-9008	30.96
		3	1	743050-0009	31.01
		4	24	804370-0025	31.06
		5	26	804370-0310	31.13

One-sample t-tests were used to examine the historical record and the corresponding hypothesis that the sample data is equivalent to the calculated OHWM of the historical record. Four tests were performed (Tables 4 through 7), one for each of the calculated historical values presented in the Methods (31.86 (28.28) feet, 31.48 (27.90) feet, 31.34 (27.76) feet, and 31.01 (27.42) feet). Based on these results, the mean of the annual peak events (31.86 (28.28) feet) and the mode of the annual high water events (31.48 (27.90) feet) are both significantly different from the mean of the sample data (significance of the 2-tailed t-test is less than 0.05). Similarly, the 1.05 year recurrence interval (elevation 31.01 (27.42) feet) is also significantly different. The historical level within two standard deviations of the overall historical mean, or the separation between "common" and "uncommon" lake levels (31.34 (27.76) feet) does not differ significantly from the mean of the sample data.

Table 4. One-sample t-test for historical value of 31.86 (28.28) feet.

	Test Value = 31.86					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Elev. (ft)	-12.642	26	.000	-.536667	-.62393	-.44941

Table 5. One-sample t-test for historical value of 31.48 (27.90) feet.

	Test Value = 31.48					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Elev. (ft)	-3.690	26	.001	-.156667	-.24393	-.06941

Table 6. One-sample t-test for historical value of 31.34 (27.76) feet.

	Test Value = 31.34					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Elev. (ft)	-.393	26	.698	-.016667	-.10393	.07059

Table 7. One-sample t-test for historical value of 31.01 (27.42) feet.

	Test Value = 31.01					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Elev. (ft)	7.381	26	.000	.313333	.22607	.40059

Many variables, both numeric and non-numeric, were studied to see if they might help describe the variability in the OHWM data. The numeric variables include easting (ft), northing (ft), latitude (minutes), predominant wave fetch distance (miles), and longest wave fetch distance (miles). The predominant wave fetch distance was calculated as the longest distance from the site across water to an opposing shoreline in the direction of the prevailing wind (southeast). The longest wave fetch distance was calculated as the longest distance from the site to a point across the water surface. Non-numeric variables that were assessed included the direction of the longest wave fetch (i.e. north, northeast, east, etc.), shoreline gradient (shallow, moderate, steep), shoreline armoring (full bulkhead, partial, none), and vegetation (fully vegetated, partial, none).

Scatterplots of the OHWM data versus each of the numeric independent variables were generated to visually assess any correlations. Based on these scatterplots, no significant correlation is apparent between the OHWM and any of the numeric variables. Figure 11 represents an example of the typical scatterplot. The remaining scatterplots can be found in Appendix C.

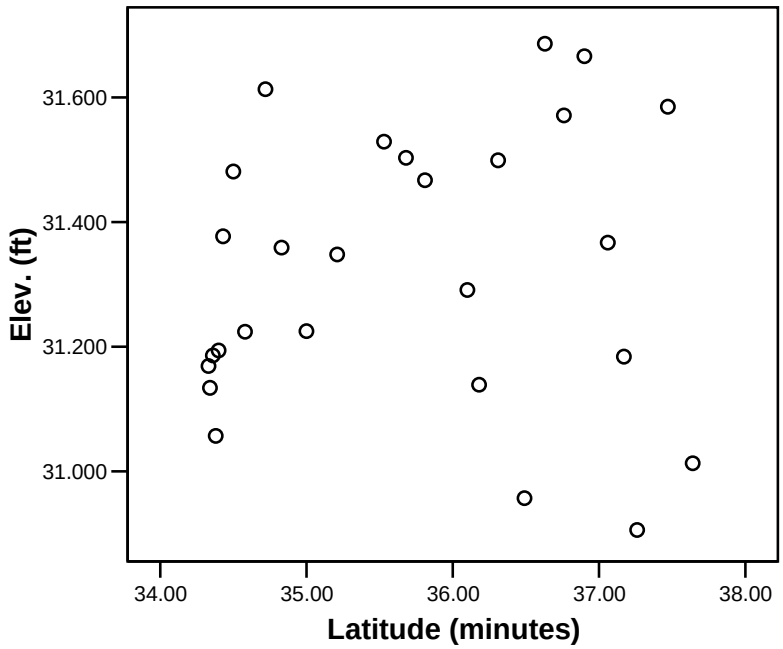

Figure 11. Scatterplot of latitude (minutes) versus OHWM elevation (ft) (R^2 value = 0.01).

Box plots of the OHWM data versus each of the non-numeric variables were also generated to visually assess any correlation. In addition to the box plots, the mean OHWM of each of the variable categories were compared to assess whether their means differ significantly from the overall mean. Based on these analyses, no significant correlation can be drawn from the non-numeric variables. However, a moderate association (Eta^2=0.31)[9] can be made between the OHWM elevations and the longest wave fetch direction (Figure 12 and Tables 8 and 9). Associations with shoreline gradient, shoreline armoring, and vegetation are weak and are not shown in this section, but can be found in Appendix C. The association with longest wave fetch direction indicates (but not significantly) that those sites that have their longest wave fetch from the south-southeast and southeast directions typically have higher OHWM values.

[9] Eta and Eta^2 are used in place of R and R^2 for non-linear relationships where Eta^2 represents the proportion of variation accounted for by the differences among the groups.

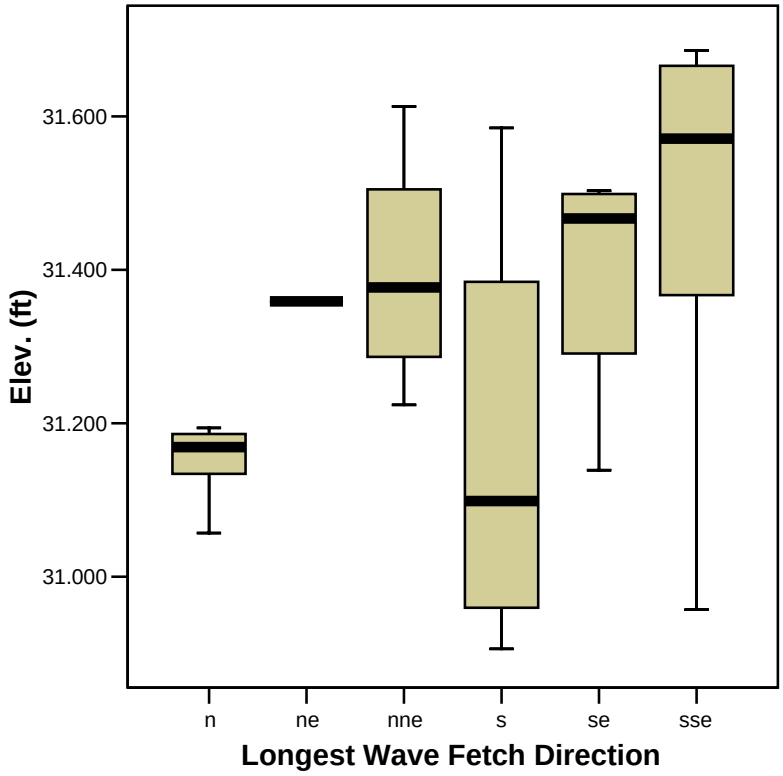

Figure 12. Box plot of longest wave fetch direction (mi) versus OHWM elevation (ft).

Table 8. ANOVA table[10] for longest wave fetch direction (mi) versus OHWM elevation (ft).

		Sum of Squares	df	Mean Square	F	Sig.
Elev. (ft) * Longest Wave Fetch Direction	Between Groups	.38	5	.08	1.82	.15
	Within Groups	.88	21	.04		
	Total	1.27	26			

Table 9. Measures of association for longest wave fetch direction (mi) versus OHWM elevation (ft).

	Eta	Eta Squared
Elev. (ft) * Longest Wave Fetch Direction	.55	.30

[10] An ANOVA compares the means for the different groups where "Between Groups" represents variation of the group means around the overall mean and "Within Groups" represents variation of the individual scores around their group means. Small significance values (<.05) indicate group differences.

Segmentation Analysis

In order to assess whether or not the hypothesized segmentation of the shoreline is appropriate for the City of Bellevue, the mean of each segment's OHWM values were compared using ANOVA to determine whether any of the segment means differed significantly from the overall sample mean of 31.32 (27.74) feet. The resulting data are listed in Table 6 and show a significance of 0.63, where a value less than 0.05 would indicate that one or more of the segment means differs from the overall mean. Figure 13 shows the comparison of mean values for each segment, with Segment 2 having a slightly higher mean (31.37 (27.79) feet) than Segment 1 (31.33 (27.75) feet) and Segment 3 (31.32 (27.74) feet). However, as indicated in Table 10 (significance greater than 0.05), Segment 2 does not differ significantly from the overall mean. Thus, without having significant variation among the mean OHWM values for each segment, creation of segmentation rules that reflect the hypothesized segmentation are unwarranted.

Table 10. ANOVA table for the comparison the mean values of the OHWM between segments.

		Sum of Squares	df	Mean Square	F	Sig.
Elev. (ft) * Segment	Between Groups	.05	2	.02	.47	.63
	Within Groups	1.22	24	.05		
	Total	1.27	26			

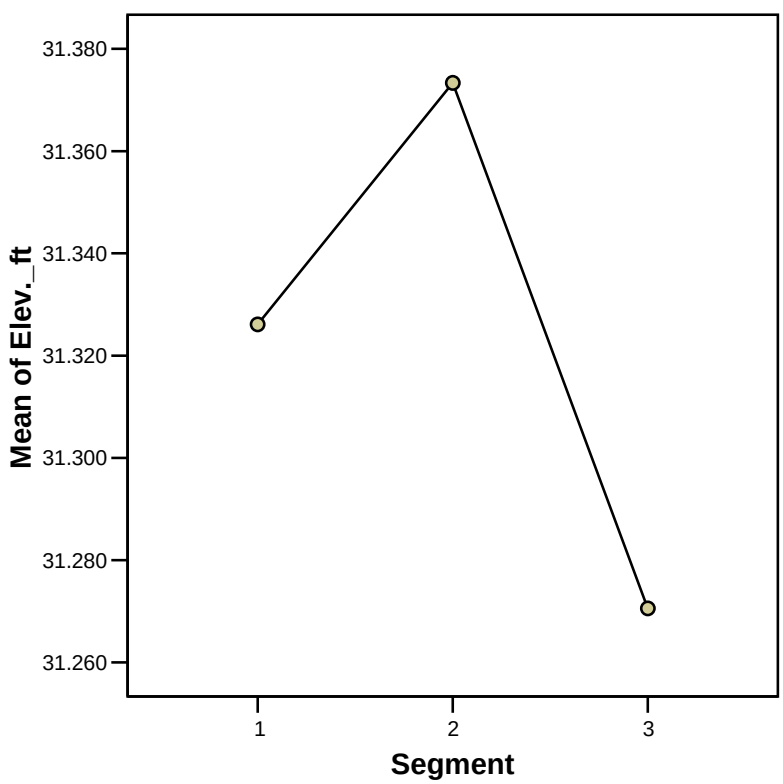

Figure 13. Comparison of segment means (north = 1, middle = 2, south = 3).

While the mean OHWM values for each segment may not differ significantly from the overall mean, the variances of the OHWM values within each segment are statistically different. A test for the homogeneity of variances (Table 11) using the Levene statistic shows a significance of <0.05, indicating that the variances among the three segments differ significantly. As can be seen in the line graph of OHWM elevation of sites from the north to the south end of the lakeshore (Figure 14) and a box plot of each segment (Figure 15), the OHWM values for Segment 1 (sites 1-9) vary widely and have a variance of 0.10. Segments 2 and 3 have significantly less variances (0.02 and 0.03, respectively).

Table 11. Test for the homogeneity of variances.

Elev. (ft)

Levene Statistic	df1	df2	Sig.
7.29	2	24	.00

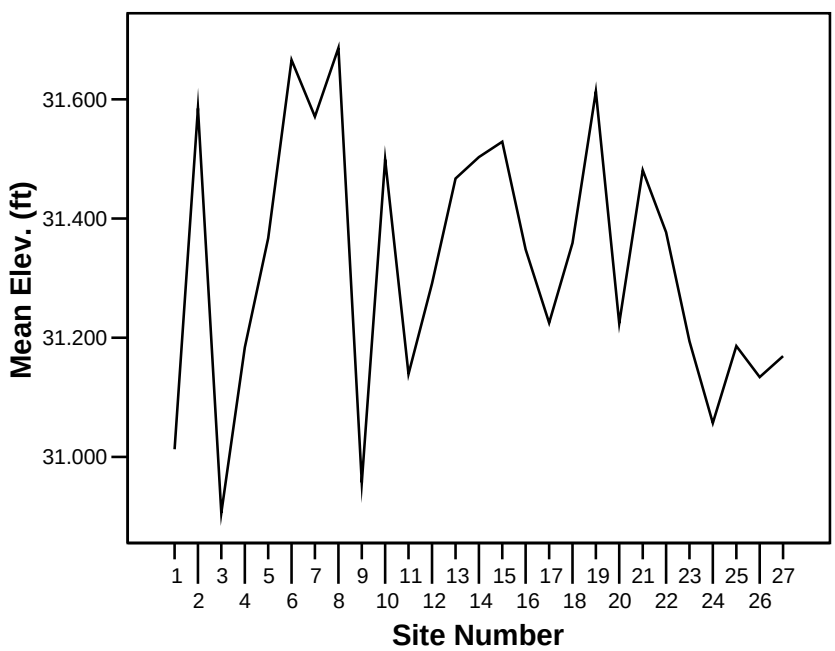

Figure 14. Line graph of the OHWM values for each segment.

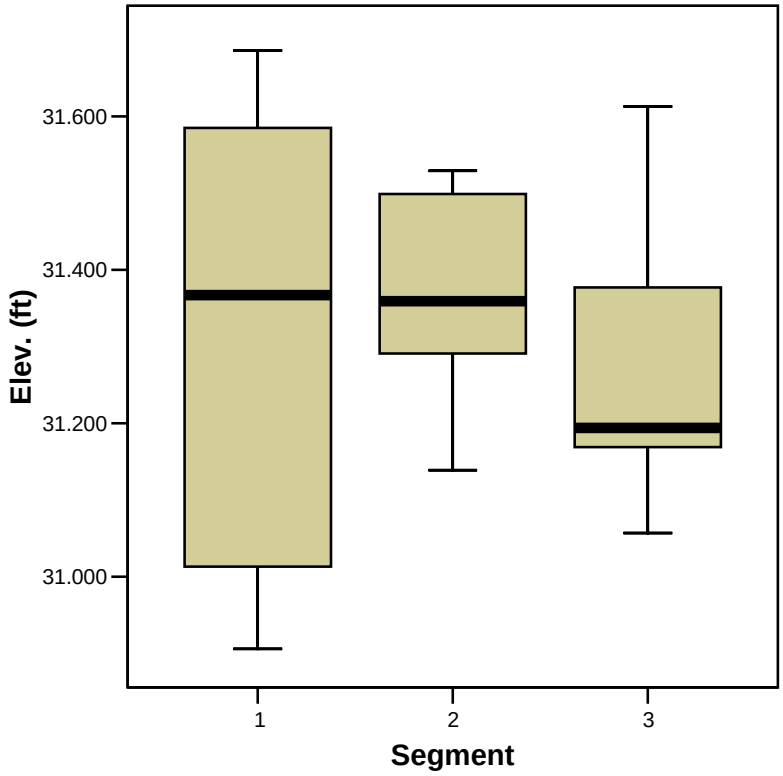

Figure 15. Box plot of the OHWM values for each segment.

Non-parametric tests were conducted on the sample data in place of the one-way ANOVA due to the non-constant variance which was observed among the three segments. A Kruskal-Wallis test was used to determine if the segments were indeed separate and distinct from each other (Table 12). The significance of the Chi-Square statistic was greater than 0.05, indicating that the three segment means did not differ from one another.

Table 12. Kruskal-Wallis non-parametric test statistics.

Ranks

	Segment	N	Mean Rank
Elev. (ft)	1	9	14.44
	2	9	15.67
	3	9	11.89
	Total	27	

Test Statistics

	Elev. (ft)
Chi-Square	1.06
df	2
Asymp. Sig.	.59

Although it is unlikely that segmentation of the shoreline is necessary given the results in Table 6, linear regression analysis was performed between the OHWM values and the numeric independent variables to further assess whether any correlations can be drawn with respect to the OHWM determinations. Not surprisingly, given the visual analysis of the scatterplots, no significant correlations were uncovered during this analysis. These regression results are presented in Appendix C.

4. DISCUSSION

The OHWM data gathered appears to be statistically sound. There were no outliers, the 95% confidence is ±0.09 from the mean value, and the variance is less than 0.05. These values all meet the parameters that the City intended to achieve with this analysis. The variance is also consistent with the previous sampling performed during the error analysis, indicating that the methodology used to determine and measure the OHWM has remained consistent. This indicates that the data gathered achieved the desired level of precision.

Historical Record Analysis

The mean OHWM elevation determined by this study was 31.32 (27.74) feet. This is lower than the value expected from the historical analysis of lake levels. While there are many ways to interpret how the OHWM elevation might be determined from gage data, the most common method is to place the OHWM elevation at the mean of the annual peak events. On Lake Sammamish, this elevation would be 31.86 (28.28) feet, or 0.54 feet higher than the field-derived mean. Alternatively, the mode of the annual peak water levels (i.e. the most common annual high water level) is 31.48 (27.90) feet, or 0.16 feet higher than the field-derived mean. T-tests indicate that both the mean and the mode of the annual high peaks differ significantly from the mean determined in this study. At the opposite extreme end, the 1.05 year recurrence interval event is 31.01 (27.42) feet, or 0.37 feet lower than the field-derived mean.

The field data agree closely with elevation derived from two standard deviations from the historic mean, which is only 0.02 feet higher than the field data mean. Other studies and other jurisdictions have found the OHWM to be as low as or lower than the mean value determined in this study. In other work on Lake Sammamish, The Watershed Company has found OHWM elevations to range between at 31.29 (27.71) feet and 31.79 (28.21) feet. The Corps has often used their own pre-determined OHWM elevation, which they deemed to be at 30.59 (27.00) feet. It is unclear how the Corps determined this level, but it likely involved hydrologic modeling conducted when the Sammamish River was dredged and the weir installed at the lake outfall. King County uses the same pre-determined OHWM level of 30.59 (27.00) feet for their development setbacks (King County 2003).

While the mean OHWM determined in this study is somewhat lower than expected, it is within the range of reported elevations for the OHWM on the lake. Furthermore, the mean from this study is higher than the 1.05 year recurrence interval event. The definition of the OHWM includes the words “in *all* ordinary years (emphasis added).” The lake level that can statistically be expected to occur in *all* ordinary years is the 1.05 year recurrence interval event. Because of wave action, it is logical to assume that the OHWM would be higher than the 1.05 year recurrence interval event, but not likely to be lower than that level. Since the mean from this study was higher than the 1.05 year event, and it fits within the range of reported values, there is no reason to suspect that the data is inaccurate, other than it is lower than what was originally anticipated from the historical record.

As mentioned earlier, one complicating issue with lake elevation is the use of more than one vertical datum. The USGS gage uses NGVD 29, while the City of Bellevue uses NAVD 88. To further complicate matters, there is a staff gage located near the boat ramp at Lake Sammamish

State Park that was referenced each day of field work. According to the information officer at the USGS who monitors both gages on Lake Sammamish, readings from that gage need to have 0.14 feet added to them to match the true NGVD 29 elevation (Curran, pers. comm., 19 March 2004). During the data analysis, this adjustment was called into question due to several discrepancies. To resolve these discrepancies and any future potential for error, the lake level was surveyed on July 11, 2004, and compared to both the USGS staff gage at the data-recording station and the staff gage at the boat ramp. The data indicate that the data recording station is accurate and that between 0.3 feet and 0.4 feet should be *subtracted* from the boat ramp gage readings. The USGS has been notified of this error in the boat ramp staff gage. Regardless of this potential error, several OHWM field indicators were utilized in almost all cases, supporting the final field determinations and the overall results. The range of OHWM values (30.91 (27.33) to 31.69 (28.11) feet) encompasses most of the hypothesized values from the historical record. Therefore, the mis-calibration of the boat launch staff gage likely had little, if any, effect on the mean OHWM determined in this study.

Survey Accuracy

This study used static GPS to determine elevations and locations. This method of surveying involves setting a GPS receiver in one location for an extended period of time – usually between 15 minutes and one hour, depending on the number of observable satellites and obstructions between the satellites and receiver. The data gathered is processed after-the-fact via specialized software. The post-processing analysis includes an error estimate. For all data collected, the estimated vertical error is less than 0.05 feet. All survey data was gathered, processed, and certified by Ken Green, a licensed surveyor, and his staff at GeoDimensions.

GeoDimensions also performed the survey that determined the error in the boat ramp calibration. For that survey, a stake that was left from the OHWM survey (at the owner's request) was used as a benchmark to determine the lake level, which was 29.54 (25.96) feet. Within two hours of that survey, the USGS gaging station staff gage was inspected, and water level was visually estimated (waves of approximately 0.1 feet affected the accuracy of this estimate) at 25.95 feet (NGVD 29) or 29.54 feet (NAVD 88), which matched the surveyed elevation. This finding supports the conclusion that the surveying methods achieved an accuracy within 0.05 feet.

Data Analysis

The distribution of the data gathered did not differ significantly from a normal distribution. Therefore, no transformation of the data was necessary to perform statistical analyses. The scatterplots and cross-correlations showed that there was no significant relationship between the OHWM and such variables as easting, northing, latitude, wave fetch from the prevailing wind direction, and longest wave fetch, nor any combination of those variables. Box plots and comparisons of group means did show a slight relationship between shoreline gradient and the OHWM, with moderate gradient shorelines having a higher group mean than either shallow or steep gradient shorelines. However, this relationship is not useful for developing a shoreline segmentation rule.

The segmentation analysis showed that the mean OHWM values for each segment were not significantly different from the overall mean, and thus indicated that segmentation of the

shoreline was likely not appropriate. These three means had a range of 0.10 feet, with the highest group mean (31.37 (27.79) feet) occurring in Segment 2 and the lowest group mean (31.27 (27.69) feet) occurring in Segment 3. Interestingly, while the means between segments were not significantly different, the variances varied significantly, with a much higher variance (0.10 feet) occurring in Segment 1. This indicates that the variables affecting the OHWM levels, such as wave fetch distance, direction, shoreline conditions, etc., are likely more variable in Segment 1. Although the regression analysis between these independent variables and the OHWM values did not show any significant relationships, even when using multiple regression techniques, it is likely that a concert of variables play a role in affecting the OHWM. This may even include characteristics which were not assessed, such as the angle of the shoreline compared to the prevailing wind direction and/or longest wave fetch direction and the extent to which neighboring structures (i.e. piers, groins, boats, etc.) may attenuate or refract wave energy. Properties located in Segment 3 generally had similar exposure to north winds, with little variation in whether the shoreline was perpendicular or at an oblique angle to the wave fetch. The one exception in Segment 3 was the north site (parcel #9451300020), which faced perpendicular to the southeast, or directly toward the prevailing wind direction. The OHWM at this site (31.63 (28.05) feet) was considerably higher than the rest of Segment 3. In contrast, properties in Segment 1 had a much wider degree of variability in terms of the angle of wave fetch and the corresponding structures that may or may not attenuate wave energy.

The higher variability observed in the OHWM toward the north end of the City of Bellevue's shoreline raises several questions about the OHWM around the remainder the lake's shoreline. It is possible that even greater values of the OHWM may be found further north or along the northeastern shore of the lake where the effects of the predominant wave fetch are the most significant. Additional studies of the OHWM throughout other local jurisdictions around the lake should be conducted to investigate the potential for higher OWHM elevations (Stockdale, pers. comm., 11 August 2004).

While it is surprising that a more significant correlation did not exist between the OHWM elevations and their corresponding horizontal locations (i.e. northing, easting, and/or latitude), the fact that the mean OHWM values between the three segments are not statistically different supports the use of one value for the OHWM along the City's Lake Sammamish shoreline. According to this study, a mean value of 31.32 (27.74) feet was determined to be the overall mean OHWM. The upper bound of the 95 percent confidence interval was 31.41 (27.83) feet, indicating that there is a 5 percent chance that the true population mean is greater than 31.41 (27.83) feet. The standard deviation around the mean was 0.22 feet, indicating that 95 percent of all points would be below 31.76 (28.18) feet (2 standard deviations from the mean).

In using this information to determine an appropriate single value for the OHWM, from which structure setbacks are measured, a conservative method would be to use a value that would encompass nearly all potential site conditions. This would ensure that nearly all properties would be held to an OHWM elevation no lower than what would be observed for a given site and that all sites would be treated fairly. Given the variability that was observed during this study and the standard deviation around the mean OHWM, setting a value near 31.76 (28.18) feet would ensure, with 95% confidence, that the setback for any proposed development would not begin waterward of the true OHWM. Ultimately, it is the City of Bellevue's discretion to propose an elevation based on the results of this study.

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APPENDIX A

Ordinary High Water Mark Data Sheets

The Watershed Company

Ordinary High Water Mark Determination Data Form

Date: 6/14/04 **Team:** MI/DN **Site Name:** Photakis
Address: 1856 W. Lake Samm. Pkwy NE **KC Parcel #:** 743050-0009
Site Location: north end of North segment **Waterbody:** Lake Sammamish

What is the fetch and exposure of the site in relation to wind and wave energy?

This site is probably the shortest wave fetch in the segment, nearly perpendicular to City of Sammamish shoreline

How quickly does the nearshore bathymetry drop off? Is it shallow?

Drops off quickly—very steep lot with funicular down to the shoreline with heavy tree cover across the entire lot.

FIELD DATA

Staff Gage Reading: ~26.7 feet

Y N	
☐☒ Has the shoreline been filled?	☒☐ Is there a dock on the property or nearby?
☒☐ Is the shoreline bulkheaded (describe below)	☒☐ Are there stain marks on the dock stringers?
☒☐ Stain lines on bulkhead?	☐☒ Is beach supplemented with gravel?
☐☒ Lichen on bulkhead?	☐☒ Erosion, exposed / washed gravels on shoreline?
☐☒ Undercutting of bulkhead / other structures?	☐☒ Is there an associated wetland?

Draw a cross section of the lake shoreline *(include OHWM, upper/lower limits, vegetation, substrate):*

*Bulkhead is both at and above the ohwm depending on location

Describe the substrate on the shoreline:

Gravel/cobble along shoreline with boulder protection which functions as bulkhead. Lack of further protection indicates that the site doesn't receive huge amounts of wave force

Vegetated: ☐ Fully ☒ Partial ☐ None | ***Substrate:*** ☐ Sand ☒ Gravel ☐ Silt ☐ Clay ☒ Rock

List the dominant species of plants according to zone:

Definitely above OHWM	*Likely above OHWM*	*Likely below OHWM*	*Definitely below OHWM*
Ivy	Grasses	Birdsfoot trefoil	Softrush
Grasses	Bittersweet nightshade	Willow	Iris
Clover	Plantain	Yellow loosestrife	Purple loosestrife
Ornamentals		Iris	
		Reed canarygrass	

Additional Notes / Discussion:

Bulkhead: shoreline protected by misc. sized and distributed rocks, but not true bulkhead. Stake was placed on adjoining lot to the north (also owned by Mr. Photakis) back in small beach cove. Indicators used were water marks on the rocks and pier, along with a clear vegetation line on the north property. Elevations were matched and verified using sight level and stadia rod. Spoke with tenant.

The Watershed Company

Ordinary High Water Mark Determination Data Form

Date: *6/10/04* ***Team:*** *MI/DN* ***Site Name:*** *Payne*
Address: *1618 W. Lake Samm. Pkwy NE* ***KC Parcel #:*** *7430500116*
Site Location: *North end of north segment* ***Waterbody:*** *Lake Sammamish*

What is the fetch and exposure of the site in relation to wind and wave energy?

To the south, the wave fetch is very long, but property is nearly perpendicular to Sammamish shoreline

How quickly does the nearshore bathymetry drop off? Is it shallow?

Very steep gradient which drops off quickly.

FIELD DATA

Staff Gage Reading: ~26.7 feet

Y N
☒☐ Has the shoreline been filled? ***partially***
☒☐ Is the shoreline bulkheaded (describe below)
☒☐ Stain lines on bulkhead?
☒☐ Lichen on bulkhead?
☐☒ Undercutting of bulkhead / other structures?
☒☐ Is there a dock on the property or nearby?
☒☐ Are there stain marks on the dock stringers?
☐☒ Is beach supplemented with gravel?
N/A Erosion, exposed / washed gravels on shoreline?
☐☒ Is there an associated wetland?

Draw a cross section of the lake shoreline *(include OHWM, upper/lower limits, vegetation, substrate):*

*Bulkhead both at and above the ohwm depending on location

Describe the substrate on the shoreline:

The shoreline contains a gravel mix that is likely manipulated during the year. Owner is major wakeboard manufacturer and obviously uses the shoreline heavily. Therefore gravel composition isn't considered a determining factor.

Vegetated: ☐ Fully ☐ Partial ☒ None | ***Substrate:*** ☐ Sand ☒ Gravel ☐ Silt ☐ Clay ☐ Rock

List the dominant species of plants according to zone:

Definitely above OHWM	*Likely above OHWM*	*Likely below OHWM*	*Definitely below OHWM*
Grasses	Iris	Iris	
Ornamentals	Birdsfoot trefoil	Bittersweet nightshade	
	Bittersweet nightshade	Reed canarygrass	
	Curly dock		

Additional Notes / Discussion:

Gravel and vegetation are not very good indicators but stain lines are clearly evident on the pier stringers, moorage piles and the concrete bulkhead, especially along the concrete staircase arm which extends onto the gravel shoreline. South end of property contains recently constructed concrete block wall with landscaping area behind. No signs of erosion at or above this wall. Stake/flag was placed near edge of on-shore boat cover. Spoke with owner.

The Watershed Company

Ordinary High Water Mark Determination Data Form

Date: 6/10/04 **Team:** MI/DN **Site Name:** Haradas
Address: 1244 W. Lk Samm Pkwy NE **KC Parcel #:** 7430500275
Site Location: Near middle of north segment **Waterbody:** Lake Sammamish

What is the fetch and exposure of the site in relation to wind and wave energy?

Fetch is very long. Site is more exposed than two sites to the north, with shoreline facing southeast.

How quickly does the nearshore bathymetry drop off? Is it shallow?

Shoreline gradient drops off very quickly.

FIELD DATA

Staff Gage Reading: ~26.7 feet

Y N
☐☒ Has the shoreline been filled?
☒☐ Is the shoreline bulkheaded (describe below)
☐☒ Stain lines on bulkhead?
☐☒ Lichen on bulkhead?
☐☒ Undercutting of bulkhead / other structures?
☒☐ Is there a dock on the property or nearby?
☒☐ Are there stain marks on the dock stringers?
☒☐ Is beach supplemented with gravel? ***possible***
☒☐ Erosion, exposed / ***washed*** gravels on shoreline?
☐☒ Is there an associated wetland?

Draw a cross section of the lake shoreline *(include OHWM, upper/lower limits, vegetation, substrate):*

*rock bulkhead is well above the ohwm

Describe the substrate on the shoreline:

Various sized gravel composition—sorting is clearly evident to the south of the pier with good sorting of gravels below the ohwm.

Vegetated: ☐ Fully ☐ Partial ☒ None | ***Substrate:*** ☐ Sand ☒ Gravel ☐ Silt ☐ Clay ☐ Rock

List the dominant species of plants according to zone:

Definitely above OHWM	*Likely above OHWM*	*Likely below OHWM*	*Definitely below OHWM*
Kinnikinnick	Dock	Birdsfoot trefoil	Willow seedlings
Ornamentals	Bittersweet nightshade		Yellow iris
	Reed canarygrass		
	Clover		

Additional Notes / Discussion:

Vegetation is not a good indicator since it has been controlled so much. However, some young sprouts are rising through the substrate below the ohwm. Water marks on the pier and associated fenders indicate that the ohwm is near the deck elevation. Rock wall does not show signs of watermarks or erosion and is well above the ohwm. A sharp gradient is clear along the gravel shoreline representing a probable ohwm location. Debris has been raked and piled along the north property line. Stake placed near south property line, south of boat.

The Watershed Company

Ordinary High Water Mark Determination Data Form

Date: 6/10/04 **Team:** MI/DN **Site Name:** Heberling
Address: 1090 W. Lk. Samm. Pkwy NE **KC Parcel #:** 7430500340
Site Location: Middle of north segment **Waterbody:** Lake Sammamish

What is the fetch and exposure of the site in relation to wind and wave energy?

Long wave fetch to south end of lake. Shoreline is angled to face the southeast. South side of pier is very exposed to the fetch, with gravels building up against south side.

How quickly does the nearshore bathymetry drop off? Is it shallow?

Shoreline is shallower than others. Has a gentle gradient.

FIELD DATA

Staff Gage Reading: ~26.7 feet

Y N
☐☒ Has the shoreline been filled?
☒☐ Is the shoreline bulkheaded (describe below)
☐☒ Stain lines on bulkhead?
☐☒ Lichen on bulkhead?
☐☒ Undercutting of bulkhead / other structures?
☒☐ Is there a dock on the property or nearby?
☒☐ Are there stain marks on the dock stringers?
☐☒ Is beach supplemented with gravel?
☒☐ Erosion, exposed / washed gravels on shoreline?
☐☒ Is there an associated wetland?

Draw a cross section of the lake shoreline *(include OHWM, upper/lower limits, vegetation, substrate):*

*Bulkhead located just above the ohwm

Describe the substrate on the shoreline:

There is a clear transition between med/large gravel and smaller gravel sizes just below a clear debris line. The concrete bulkhead is a huge concrete pad (likely a building pad at some point). Gravels have been pushed up against the south side of pier and the concrete bulkhead.

Vegetated: ☐ Fully ☒ Partial ☐ None | ***Substrate:*** ☐ Sand ☒ Gravel ☐ Silt ☐ Clay ☐ Rock

List the dominant species of plants according to zone:

Definitely above OHWM	*Likely above OHWM*	*Likely below OHWM*	*Definitely below OHWM*
Field horsetail	Mint	Mint	Yellow iris
Japanese knotweed	Birdsfoot trefoil	Birdsfoot trefoil	Loosestrife
	Bittersweet nightshade	Willow seedlings	Softrush
		Dogwood seedlings	Hardstem bulrush (neigh.)

Additional Notes / Discussion:

Vegetation is not a very good indicator although trefoil and loosestrife are growing abundantly along shoreline with horsetail apparently at or above the ohwm. It is likely removed from the shoreline annually by the homeowner. There is a clear line in the gravels where gravels have been sorted and there is a distinct gradient shift. Key factor is a clear water mark on the pier stringers. This elevation matches the gravel sorting line. Stake placed in gravel close to concrete bulkhead. Spoke with owner.

The Watershed Company

Ordinary High Water Mark Determination Data Form

Date: *6/10/04* ***Team:*** *MI/DN* ***Site Name:*** *Selset, Ron*

Address: *830 W. Lk Samm Pkwy NE* ***KC Parcel #:*** *743050-0502*

Site Location: *Middle of north segment* ***Waterbody:*** *Lake Sammamish*

What is the fetch and exposure of the site in relation to wind and wave energy?

Very long wave fetch with clear exposure to the south end of the lake

How quickly does the nearshore bathymetry drop off? Is it shallow?

Moderate shoreline gradient. Piers are all fairly short, indicating that the gradient increases rapidly.

FIELD DATA

Staff Gage Reading: ~26.7 feet

Y N

☒☐ Has the shoreline been filled?
☒☐ Is the shoreline bulkheaded (describe below)
☐☒ Stain lines on bulkhead?
☐☒ Lichen on bulkhead?
☐☒ Undercutting of bulkhead / other structures?
☒☐ Is there a dock on the property or **nearby**?
☒☐ Are there stain marks on the dock stringers?
☒☐ Is beach supplemented with gravel? **possibly**
☒☐ Erosion, exposed / **washed** gravels on shoreline?
☐☒ Is there an associated wetland?

Draw a cross section of the lake shoreline *(include OHWM, upper/lower limits, vegetation, substrate):*

*Bulkhead located at or above the ohwm

Describe the substrate on the shoreline:

Shoreline has been heavily modified, with new concrete work above ohwm which likely functions as bulkhead/retaining wall. Junk piles up at south end of lot. Neighboring properties to the north are also family. Mixed gravel composition with sorting occurring at and below ohwm.

Vegetated: ☐ Fully ☒ Partial ☐ None | ***Substrate:*** ☐ Sand ☒ Gravel ☐ Silt ☐ Clay ☐ Rock

List the dominant species of plants according to zone:

Definitely above OHWM	*Likely above OHWM*	*Likely below OHWM*	*Definitely below OHWM*
Grasses	Birdsfoot trefoil	Birdsfoot trefoil	Birdsfoot trefoil
Dandelion	Dock	Dock	Willow seedlings
	Mint	Mint	Yellow loosestrife
	Knotweed	Purple loosestrife	

Additional Notes / Discussion:

Gravel sorting is a key indicator along with water marks on the pier skirting on adjacent pier to the north. Water mark and gravel line are at similar elevation, verified by sight level. Vegetation is very disturbed, although some emergent growth is coming through, and shoreline is heavily modified. So indicators are poor. Spoke with owner regarding historic levels.

The Watershed Company

Ordinary High Water Mark Determination Data Form

Date: 6/10/04 **Team:** MI/DN **Site Name:** Bohman
Address: 630 W. Lk Samm Pkwy NE **KC Parcel #:** 362505-9090
Site Location: Middle of north segment **Waterbody:** Lake Sammamish

What is the fetch and exposure of the site in relation to wind and wave energy?

Very long wave fetch with clear exposure to the south end of the lake

How quickly does the nearshore bathymetry drop off? Is it shallow?

Moderate shoreline gradient but all piers are still short, indicating that the gradient increases further out from shore.

FIELD DATA

Staff Gage Reading: ~26.7 feet

Y N
☐☒ Has the shoreline been filled?
☒☐ Is the shoreline bulkheaded (describe below)
☐☒ Stain lines on bulkhead? **washed bulkhead**
☒☐ Lichen on bulkhead? **upper section**
☒☐ Undercutting of bulkhead / other structures?
☒☐ Is there a dock on the property or nearby?
☒☐ Are there stain marks on the dock stringers?
☐☒ Is beach supplemented with gravel?
☒☐ Erosion, **exposed / washed** gravels on shoreline?
☐☒ Is there an associated wetland?

Draw a cross section of the lake shoreline *(include OHWM, upper/lower limits, vegetation, substrate):*

Describe the substrate on the shoreline:

Gravel mix—sorting is not as clear as on other sites and thus is more difficult to detect. Several debris lines along the shoreline.

Vegetated: ☐ Fully ☒ Partial ☐ None | ***Substrate:*** ☐ Sand ☒ Gravel ☐ Silt ☐ Clay ☐ Rock

List the dominant species of plants according to zone:

Definitely above OHWM	*Likely above OHWM*	*Likely below OHWM*	*Definitely below OHWM*
Himalayan blackberry	Bittersweet nightshade	Reed canarygrass	Willow seedlings
Grasses	Reed canarygrass	Yellow loosestrife	Purple loosestrife
	Birdsfoot trefoil	Birdsfoot trefoil	

Additional Notes / Discussion:

Indicators are more difficult than on previous sites. Adjacent concrete wall on south property line (groin) has distinct water mark. Used this to compare to deck elevation of pier (which is ~1.3 feet above water line and obviously inundated at high water based on wear and tear). Some erosion below the concrete ramp near the ohwm. Veg is not very clear indicator—many non-native invasives. Note: a large rock has fallen from the top of the bulkhead—it has lichen on it at or below the ohwm, but likely fell this past winter.

The Watershed Company

Ordinary High Water Mark Determination Data Form

Date: *6/10/04* ***Team:*** *MI/DN* ***Site Name:*** *Smith*

Address: *380 W. Lk Samm Pkwy NE* ***KC Parcel #:*** *362505-9056*

Site Location: *South end of north segment* ***Waterbody:*** *Lake Sammamish*

What is the fetch and exposure of the site in relation to wind and wave energy?

Very long wave fetch with clear site to south end State Park. High wave energy is apparent on site, with very wide gravel beach

How quickly does the nearshore bathymetry drop off? Is it shallow?

Nearshore bathymetry drops off quickly as evidenced by short piers although upland gradient is much more gradual

FIELD DATA

Staff Gage Reading: ~26.7 feet

Y N

☐☒ Has the shoreline been filled?
☐☒ Is the shoreline bulkheaded (describe below) *
☐☒ Stain lines on bulkhead?
☐☒ Lichen on bulkhead?
☐☒ Undercutting of bulkhead / other structures?

☒☐ Is there a dock **on** the property or nearby? **Joint-use**
☒☐ Are there stain marks on the dock stringers? **steps**
☐☒ Is beach supplemented with gravel?
☐☒ Erosion, exposed / washed gravels on shoreline?
☐☒ Is there an associated wetland?

Draw a cross section of the lake shoreline *(include OHWM, upper/lower limits, vegetation, substrate):*

**shoreline is bulkheaded, but far above the ohwm. May be historic bulkhead prior to dredging of the samm river.*

Describe the substrate on the shoreline:

Very natural gravel beach. Extremely high wave energy up and down the shoreline

Vegetated: ☐ Fully ☒ Partial ☐ None | ***Substrate:*** ☒ Sand ☒ Gravel ☐ Silt ☐ Clay ☐ Rock

List the dominant species of plants according to zone:

Definitely above OHWM	*Likely above OHWM*	*Likely below OHWM*	*Definitely below OHWM*
Grasses	Cottonwood	Cottonwood seedlings	Iris
	Mint	Mint	
	Bittersweet nightshade	Yellow loosestrife	
	Birdsfoot trefoil	Birdsfoot trefoil	
		Dock	
		Willow herb	

Additional Notes / Discussion:

Large site has an expansive gravel beach with wide gravel bands and two distinct drift lines. Joint-use pier has some minor indicators with water marks on steps, but is too high to have water lines on the stringers. Neighbor to the south has stringer marks which correspond to the upper gravel band. Vegetation indicators are poor—owner likely controls veg growth along the shoreline. Looks like it has been sprayed. Stake/flag place near iris along south property line. Spoke with owner regarding historic levels.

The Watershed Company

Ordinary High Water Mark Determination Data Form

Date: *6/14/04* ***Team:*** *MI/DN* ***Site Name:*** *Wery*
Address: *110 W Lk Samm Pkwy NE* ***KC Parcel #:*** *362505-9114*
Site Location: *South end of north segment* ***Waterbody:*** *Lake Sammamish*

What is the fetch and exposure of the site in relation to wind and wave energy?

Overall fetch is still very long, but this site is angled more perpendicular toward Sammamish shoreline than the other sites to the north

How quickly does the nearshore bathymetry drop off? Is it shallow?

Moderate slope. Nearshore is shallow and sandy.

FIELD DATA

Staff Gage Reading: ~26.7 feet

Y N
☐☒ Has the shoreline been filled?
☒☐ Is the shoreline bulkheaded (describe below)
☐☒ Stain lines on bulkhead?
☐☒ Lichen on bulkhead?
☐☒ Undercutting of bulkhead / other structures?
☒☐ Is there a dock **on** the property or **nearby**?
☒☐ Are there stain marks on the dock stringers? **ladder**
☒☐ Is beach supplemented with gravel? **sand**
☒☐ Erosion, exposed / washed gravels on shoreline? *****
☐☒ Is there an associated wetland?

Draw a cross section of the lake shoreline *(include OHWM, upper/lower limits, vegetation, substrate):*

*minor movement of gravel along the shoreline. The shoreline looks like it has been supplemented with sand sometime in the recent past. Bulkhead is positioned above the ohwm with lots of vegetation growing in front.

Describe the substrate on the shoreline:

Sand and gravel mix. Shallower site than others to the north. Existing veg may play a role in minimizing wave impacts, thus keeping more substrate intact.

Vegetated: ☐ Fully ☒ Partial ☐ None | ***Substrate:*** ☒ Sand ☒ Gravel ☐ Silt ☐ Clay ☐ Rock

List the dominant species of plants according to zone:

Definitely above OHWM	*Likely above OHWM*	*Likely below OHWM*	*Definitely below OHWM*
Grasses	Birdsfoot trefoil	Birdsfoot trefoil	Iris
Horsetail	Bamboo	Reed canarygrass	Willow
	Ornamentals	Willow	Yellow loosestrife
	Plantain	Yellow loosestrife	Cottonwood seedlings
	Spirea	Spirea	
		Cottonwood seedlings	

Additional Notes / Discussion:

Bulkhead is likely pre-1960 (before dredging) and is well above the ohwm. Stake placed in middle of lot. Indicators used are: water mark on pier ladder since deck is well inundated during high water. Veg is abundant in the nearshore with fairly clear line at edge of grass. Sand has been added in the past, covering a lot of the site.

The Watershed Company

Ordinary High Water Mark Determination Data Form

Date: 6/14/04 **Team:** MI/DN * **Site Name:** Spady
Address: 148 W. Lk Samm Pkwy SE **KC Parcel #:** 362505-9008
Site Location: South end of north segment **Waterbody:** Lake Sammamish

What is the fetch and exposure of the site in relation to wind and wave energy?

Very long wave fetch to the State Park

How quickly does the nearshore bathymetry drop off? Is it shallow?

Low gradient site—all nearby piers are long

FIELD DATA

Staff Gage Reading: ~26.7 feet

Y N

☒☐ Has the shoreline been filled? **some**
☒☐ Is the shoreline bulkheaded (describe below)
☒☐ Stain lines on bulkhead?
☒☐ Lichen on bulkhead?
☒☐ Undercutting of bulkhead / other structures?
☒☐ Is there a dock on the property or nearby?
☒☐ Are there stain marks on the dock stringers?
☒☐ Is beach supplemented with gravel? **Sand possible**
☒☐ Erosion, exposed / washed gravels on shoreline?
☐☒ Is there an associated wetland?

Draw a cross section of the lake shoreline *(include OHWM, upper/lower limits, vegetation, substrate):*

Describe the substrate on the shoreline:

Gravel and sand mix. Gravel is pushed up against south side of pier during seasonal storms. In turn, gravel is eroded away from base of concrete block bulkhead along south end of property.

Vegetated: ☐ Fully ☒ Partial ☐ None | ***Substrate:*** ☒ Sand ☒ Gravel ☐ Silt ☐ Clay ☐ Rock

List the dominant species of plants according to zone:

Definitely above OHWM	*Likely above OHWM*	*Likely below OHWM*	*Definitely below OHWM*
Grasses	Birdsfoot trefoil	Birdsfoot trefoil	Birdsfoot trefoil
Ornamentals	Bittersweet nightshade	Bittersweet nightshade	Cottonwood seedlings
			Willow seedlings
			Iris
			Yellow loosestrife

Additional Notes / Discussion:

Met Erik Stockdale (DOE), H. Bedwell, and M. Paine (City) at the site to discuss process. Complicated site with many indicators. Line along bulkhead is confusing due to erosion near south side of pier, but this is likely due to extreme high event this past year. Other clear indicators used were: water line on stringers, water marks along bulkhead at the south property line, veg distribution to the north of the pier, and gravel bands to the north of the pier. Elevations were cross checked with sight level to confirm consistency. Site agreed upon by all parties and stake placed in gravel along north side of pier.

The Watershed Company

Ordinary High Water Mark Determination Data Form

Date: *6/14/04* ***Team:*** *MI/DN* ***Site Name:*** *Hillier*

Address: *418 W Lk Samm Pkwy SE* ***KC Parcel #:*** *362505-9038*

Site Location: *North end of middle segment* ***Waterbody:*** *Lake Sammamish*

What is the fetch and exposure of the site in relation to wind and wave energy?

Long fetch to south end of lake

How quickly does the nearshore bathymetry drop off? Is it shallow?

Fairly shallow shoreline with long piers

FIELD DATA

Staff Gage Reading: ~26.7 feet

Y N

☐☒ Has the shoreline been filled?
☒☐ Is the shoreline bulkheaded (describe below)
☐☒ Stain lines on bulkhead?
☐☒ Lichen on bulkhead?
☒☐ Undercutting of bulkhead / other structures?
☒☐ Is there a dock on the property or **nearby**?
☒☐ Are there stain marks on the dock stringers?
☐☒ Is beach supplemented with gravel?
☒☐ Erosion, exposed / washed gravels on shoreline?
☐☒ Is there an associated wetland?

Draw a cross section of the lake shoreline *(include OHWM, upper/lower limits, vegetation, substrate):*

Bulkhead is only partial. Some logs laid along shoreline add protection and some concrete bulkhead portion along south property line. Existing boathouses protect most of the shoreline.

Describe the substrate on the shoreline:

Gravel/sand mix. Shoreline is clearly utilized by children quite often (tether ball), so it is disturbed. The areas near the property line and on adjacent properties were used as indicators. Boat houses are present on adjacent properties along both property lines that have relatively undisturbed substrate.

Vegetated: ☐ Fully ☒ Partial ☐ None | ***Substrate:*** ☒ Sand ☒ Gravel ☐ Silt ☐ Clay ☐ Rock

List the dominant species of plants according to zone:

Definitely above OHWM	*Likely above OHWM*	*Likely below OHWM*	*Definitely below OHWM*
Ornamentals	Grasses	Birdsfoot trefoil	Purple loosestrife
Grasses		Bittersweet nightshade	Yellow loosestrife

Additional Notes / Discussion:

Met Erik Stockdale (DOE) at this site. Poor indicators on the majority of the property due to frequent use. Good indicators = adjacent pier water marks and gravel sorting on property to the south which extends into boathouse. Two debris lines are clear within the boathouse. Upper line discounted as extreme event of the past year. Lower debris line matches with gravel sorting and water marks as well as the other elevations we have been documenting. Upper line is too far above the existing water level.

The Watershed Company

Ordinary High Water Mark Determination Data Form

Date: *6/15/04* ***Team:*** *MI/DN* ***Site Name:*** *Howard*

Address: *542 W. Lk Samm Pkwy SE* ***KC Parcel #:*** *752490-0050*

Site Location: *North end of middle segment* ***Waterbody:*** *Lake Sammamish*

What is the fetch and exposure of the site in relation to wind and wave energy?

Long fetch to south end of the lake. Wave hits oblique to the shoreline since the shoreline is angled to the NE

How quickly does the nearshore bathymetry drop off? Is it shallow?

Nearshore is shallow for the first 20 feet and then drops off quickly

FIELD DATA

Staff Gage Reading: ~26.7 feet

Y N

☒☐ Has the shoreline been filled?
☒☐ Is the shoreline bulkheaded (describe below)
☒☐ Stain lines on bulkhead?
☐☒ Lichen on bulkhead?
☐☒ Undercutting of bulkhead / other structures?
☒☐ Is there a dock **on** the property or nearby?
☒☐ Are there stain marks on the dock stringers?
☐☒ Is beach supplemented with gravel?
☐☒ Erosion, exposed / washed gravels on shoreline?
☐☒ Is there an associated wetland?

Draw a cross section of the lake shoreline *(include OHWM, upper/lower limits, vegetation, substrate):*

OHWM appears to hit up on the existing timbered bulkhead.

Describe the substrate on the shoreline:

Sand/gravel mix with clear gravel banding. Gravel and sand is piled up near the south property line to where ohwm meets the substrate instead of the bulkhead. In this area, sorting of gravel at the ohwm is more clear.

Vegetated: ☒ **near full** ☐ Partial ☐ None | ***Substrate:*** ☒ Sand ☒ Gravel ☐ Silt ☐ Clay ☐ Rock

List the dominant species of plants according to zone:

Definitely above OHWM	*Likely above OHWM*	*Likely below OHWM*	*Definitely below OHWM*
Grasses	Birdsfoot trefoil	Birdsfoot trefoil	Soft rush
Ivy	Horsetail	Bittersweet nightshade	Iris
Ornamental	Reed canarygrass	Reed canarygrass	Purple loosestrife
	Iris	Iris	marsh cinquefoil

Additional Notes / Discussion:

Indicators = stain lines on pier stringers and concrete piling which supports the timbered bulkhead. Stain lines are on wood bulkhead, but they are too variable to account for. Veg line and gravel sorting is evident at south end of property. Stake placed along south property line. Spoke with neighbor to the south regarding dock inundation.

The Watershed Company

Ordinary High Water Mark Determination Data Form

Date: 6/15/04 **Team:** MI/DN **Site Name:** Brown (just sold house)
Address: 842 W. Lk Samm Pkwy SE **KC Parcel #:** 925390-0047
Site Location: North end of middle segment **Waterbody:** Lake Sammamish

What is the fetch and exposure of the site in relation to wind and wave energy?

Very similar fetch to previous site (Howard). Long oblique fetch.

How quickly does the nearshore bathymetry drop off? Is it shallow?

Very quick drop off of bathymetry. Short docks

FIELD DATA

Staff Gage Reading: ~26.7 feet

Y N

☒☐ Has the shoreline been filled?
☒☐ Is the shoreline bulkheaded (describe below)
☒☐ Stain lines on bulkhead?
☐☒ Lichen on bulkhead?
☐☒ Undercutting of bulkhead / other structures?
☒☐ Is there a dock on the property or nearby?
☒☐ Are there stain marks on the dock stringers?
☐☒ Is beach supplemented with gravel?
☒☐ Erosion, exposed / washed gravels on shoreline?
☐☒ Is there an associated wetland?

Draw a cross section of the lake shoreline *(include OHWM, upper/lower limits, vegetation, substrate):*

Parts of the timbered bulkhead to the north of the pier have eroded to expose the base of the bulkhead. Otherwise, the ohwm appears to meet substrate to the south of the pier.

Describe the substrate on the shoreline:

Sand and small gravels with some large rocks protecting the nearshore section of the existing pier structure. With the large rocks, the pier then acts as a groin, holding gravels on south side from migrating.

Vegetated: ☐ Fully ☒ Partial ☐ None | ***Substrate:*** ☒ Sand ☒ Gravel ☐ Silt ☐ Clay ☐ Rock

List the dominant species of plants according to zone:

Definitely above OHWM	*Likely above OHWM*	*Likely below OHWM*	*Definitely below OHWM*
Grasses	Iris	Iris	Iris
Laurel		Birdsfoot trefoil	Purple loosestrife
Pine tree		Bittersweet nightshade	

Additional Notes / Discussion:

Stains on the pier are not very good indicators because the lines are highly variable. White leach line gives good approximation. Used shoreline veg and soil at south end of property where there is a clear mark or transition in the soil. Gravel has been sorted out with sand above this point. Site lacks upper debris line, but it may have been removed for sale of house. Stake/flag placed in gravel to the south of the pier.

The Watershed Company

Ordinary High Water Mark Determination Data Form

Date: 6/15/04 ***Team:*** MI/DN ***Site Name:*** Dunlop
Address: 1422 W. Lk Samm Pkwy SE ***KC Parcel #:*** 925390-0180
Site Location: Middle of middle segment ***Waterbody:*** Lake Sammamish

What is the fetch and exposure of the site in relation to wind and wave energy?

More exposed than previous two sites, facing SE with only slightly oblique fetch from south end of lake

How quickly does the nearshore bathymetry drop off? Is it shallow?

Pretty quick drop off. Adjacent piers to south are short, but piers to the north are longer. This property is just south of a "point"

FIELD DATA

Staff Gage Reading: ~26.7 feet

Y N
☐☒ Has the shoreline been filled?
☐☒ Is the shoreline bulkheaded (describe below)
☐☒ Stain lines on bulkhead?
☐☒ Lichen on bulkhead?
☐☒ Undercutting of bulkhead / other structures?
☒☐ Is there a dock on the property or nearby?
☒☐ Are there stain marks on the dock stringers?
☐☒ Is beach supplemented with gravel?
☒☐ Erosion, exposed / washed gravels on shoreline?
☐☒ Is there an associated wetland?

Draw a cross section of the lake shoreline *(include OHWM, upper/lower limits, vegetation, substrate):*

Describe the substrate on the shoreline:

Gravel/sand mix, forming bands of sorted gravels. Shoreline has been cleaned of any debris lines

Vegetated: ☐ Fully ☒ Partial ☐ None | ***Substrate:*** ☒ Sand ☒ Gravel ☐ Silt ☐ Clay ☐ Rock

Veg on upper zone (landscaped—apparently as part of shoreline plant plan for pier)

List the dominant species of plants according to zone:

Definitely above OHWM	*Likely above OHWM*	*Likely below OHWM*	*Definitely below OHWM*
Cedar	NONE (shoreline cleaned)	NONE (shoreline cleaned)	Iris
Red osier dogwood			Yellow loosestrife (neigh)
Red huckleberry			

Additional Notes / Discussion:

Trex dock shows water lines on both sides (south side has dark black line above, which is also clear on the fenders—north side has white leachate). On-shore indicators are poor due to maintenance of shoreline and obvious foot traffic. Used gravel band sorting with small gravels above and below line which corresponds to stain marks. More weight applied to gravel sorting since decking is likely newer and doesn't represent good historical measure. Stake placed to north of pier.

The Watershed Company

Ordinary High Water Mark Determination Data Form

Date: *6/15/04* ***Team:*** *MI/DN* ***Site Name:*** *Ghassamikia*

Address: *1802 W. Lk Samm Pkwy SE* ***KC Parcel #:*** *925390-0271*

Site Location: *Middle of middle segment* ***Waterbody:*** *Lake Sammamish*

What is the fetch and exposure of the site in relation to wind and wave energy?

Long fetch. Site is clearly exposed directly to the south end of the lake

How quickly does the nearshore bathymetry drop off? Is it shallow?

Sharp gradient change at shoreline. Very short piers nearby.

FIELD DATA

Staff Gage Reading: ~26.7 feet

Y N

☒☐ Has the shoreline been filled?
☒☐ Is the shoreline bulkheaded (describe below)
☒☐ Stain lines on bulkhead?
☐☒ Lichen on bulkhead?
☒☐ Undercutting of bulkhead / other structures?
☒☐ Is there a dock **on** the property or **nearby**?
☒☐ Are there stain marks on the dock stringers?
☒☐ Is beach supplemented with gravel? **possible**
☒☐ Erosion, exposed / **washed** gravels on shoreline?
☐☒ Is there an associated wetland?

Draw a cross section of the lake shoreline *(include OHWM, upper/lower limits, vegetation, substrate):*

Shoreline is protected by rock bulkhead along the south to middle portion of the property above the ohwm. The City has a sewer easement with a pump station that extends out into the lake and is made of concrete.

Describe the substrate on the shoreline:

Gravel mix with cobbles under low water. Shoreline is used frequently and maintained such that veg and gravel indicators are non-existant.

Vegetated: ☐ Fully ☐ Partial ☒ None | ***Substrate:*** ☐ Sand ☒ Gravel ☐ Silt ☐ Clay ☐ Rock

Veg is only present just north of the pier adjacent to City sewer pump station

List the dominant species of plants according to zone:

Definitely above OHWM	*Likely above OHWM*	*Likely below OHWM*	*Definitely below OHWM*
Ornamentals	Iris	Iris	Purple loosestrife
Grasses		Bittersweet nightshade	Pacific willow
		Reed canarygrass	Yellow loosestrife

Additional Notes / Discussion:

Substrate on shoreline is heavily manipulated—nearly all veg is gone and gravels and debris lines have been disturbed. Very clear water marks on the pier stringers and along the concrete wall of the City's serer pump station. Used these indicators to place stake in substrate although stake placement did not have any indicators itself. Verified location using sight level and stadia rod. Spoke with property owner.

The Watershed Company

Ordinary High Water Mark Determination Data Form

Date: *6/15/04* ***Team:*** *MI/DN* ***Site Name:*** *Camden*
Address: *2034 W. Lk Samm Pkwy SE* ***KC Parcel #:*** *925390-0350*
Site Location: *Middle of middle segment* ***Waterbody:*** *Lake Sammamish*

What is the fetch and exposure of the site in relation to wind and wave energy?

Long fetch with clear exposure to south end of lake

How quickly does the nearshore bathymetry drop off? Is it shallow?

Fairly quick drop off with short piers

FIELD DATA

Staff Gage Reading: ~26.7 feet

Y N
☐☒ Has the shoreline been filled?
☐☒ Is the shoreline bulkheaded (describe below)
☐☒ Stain lines on bulkhead?
☐☒ Lichen on bulkhead?
☐☒ Undercutting of bulkhead / other structures?

☒☐ Is there a dock **on** the property or **nearby**?
☒☐ Are there stain marks on the dock stringers?
☒☐ Is beach supplemented with gravel? **possible**
☒☐ Erosion, exposed / washed gravels on shoreline?
☐☒ Is there an associated wetland? **Although wetland conditions exist near stream**

Draw a cross section of the lake shoreline *(include OHWM, upper/lower limits, vegetation, substrate):*

Describe the substrate on the shoreline:

Gravel mix—south end of property has been cleared in the shoreline area (aerial photo shows abundant veg cover to the south of the pier)—not sure if they filled with gravel/cobble, or if they allowed excavated portion to erode away.

Vegetated: ☐ Fully ☒ Partial ☐ None | ***Substrate:*** ☐ Sand ☒ Gravel ☐ Silt ☐ Clay ☐ Rock

List the dominant species of plants according to zone:

Definitely above OHWM	*Likely above OHWM*	*Likely below OHWM*	*Definitely below OHWM*
Grasses	Bittersweet nightshade	Iris	Iris
Himalayan blackberry	Birdsfoot trefoil	Bittersweet nightshade	Purple loosestrife
Dandelion		Dock	Dock
		Marsh cinquefoil	Yellow loosestrife
		Willow herb	Reed canarygrass
		Small-fruited bulrush	Small-fruited bulrush

Additional Notes / Discussion:

Stain lines on stringers and gravel sorting just below upper drift line are key indicators. Shoreline has clearly been manipulated south of the pier—drain lines installed in lawn, which discharge to manipulated gravel beach. Stream flows down near south property line. Lot is very wide. Stake/flag place to the north of the pier.

The Watershed Company

Ordinary High Water Mark Determination Data Form

Date: *6/15/04* ***Team:*** *MI/DN* ***Site Name:*** *Keenholtz*

Address: *2626 W. Lk Samm Pkwy se* ***KC Parcel #:*** *122405-9094*

Site Location: *South end of middle segment* ***Waterbody:*** *Lake Sammamish*

What is the fetch and exposure of the site in relation to wind and wave energy?

Moderate fetch at nearly all angles.—site faces directly east

How quickly does the nearshore bathymetry drop off? Is it shallow?

Fairly quick drop off with short piers all around

FIELD DATA

Staff Gage Reading: ~26.7 feet

Y N

☒☐ Has the shoreline been filled?
☒☐ Is the shoreline bulkheaded (describe below)
☒☐ Stain lines on bulkhead?
☐☒ Lichen on bulkhead?
☐☒ Undercutting of bulkhead / other structures?
☒☐ Is there a dock **on** the property or **nearby**?
☒☐ Are there stain marks on the dock stringers?
☐☒ Is beach supplemented with gravel?
☒☐ Erosion, exposed / washed gravels on shoreline?
☐☒ Is there an associated wetland?

Draw a cross section of the lake shoreline *(include OHWM, upper/lower limits, vegetation, substrate):*

Describe the substrate on the shoreline:

Gravel/sand mix below railroad tie bulkhead. ohwm clearly is up on the bulkhead. Some gravel bands are evident, but these are well below the ohwm

Vegetated: ☐ Fully ☐ Partial ☒ None | ***Substrate:*** ☒ Sand ☒ Gravel ☐ Silt ☐ Clay ☐ Rock

Some veg in spots, but very minor

List the dominant species of plants according to zone:

Definitely above OHWM	*Likely above OHWM*	*Likely below OHWM*	*Definitely below OHWM*
			Yellow loosestrife
			Birdsfoot trefoil
			Iris
			Small fruited bulrush

Additional Notes / Discussion:

Timbered bulkhead extends below ohwm with a rock bulkhead above the timbered bulkhead with a gravel area in between. Stain lines on pier stringer and wood bulkhead used as primary indicators. Wet veg is growing in patches but cannot be used to determine lines because of bulkhead. Tape placed on bulkhead next to neighbor property to the north. Spoke with owner.

The Watershed Company

Ordinary High Water Mark Determination Data Form

Date: 6/15/04 ***Team:*** MI/DN ***Site Name:*** Reece
Address: 3010 W. Lk Samm Pkwy SE ***KC Parcel #:*** 122405-9126
Site Location: South end of middle segment ***Waterbody:*** Lake Sammamish

What is the fetch and exposure of the site in relation to wind and wave energy?

Moderate, near Vasa Park

How quickly does the nearshore bathymetry drop off? Is it shallow?

Shallower than most of the other sites. Longer piers indicates shallower gradient.

FIELD DATA

Staff Gage Reading: ~26.7 feet

Y N
☒☐ Has the shoreline been filled?
☒☐ Is the shoreline bulkheaded (describe below)
☐☒ Stain lines on bulkhead?
☐☒ Lichen on bulkhead?
☐☒ Undercutting of bulkhead / other structures?
☒☐ Is there a dock **on** the property or **nearby**?
☒☐ Are there stain marks on the dock stringers?
☐☒ Is beach supplemented with gravel? *****
☐☒ Erosion, exposed / washed gravels on shoreline?
☐☒ Is there an associated wetland?

Draw a cross section of the lake shoreline *(include OHWM, upper/lower limits, vegetation, substrate):*

*neighbor to the north has filled their beach with sand. Bulkhead is made of small concrete blocks which extends down below the ohwm.

Describe the substrate on the shoreline:

Sand/gravel mix—very little exposed shoreline, even at low water. Bulkhead appears to have been recently replaced with the concrete blocks.

Vegetated: ☐ Fully ☐ Partial ☒ None | ***Substrate:*** ☒ Sand ☒ Gravel ☐ Silt ☐ Clay ☐ Rock

List the dominant species of plants according to zone:

Definitely above OHWM	*Likely above OHWM*	*Likely below OHWM*	*Definitely below OHWM*
Grasses		Horsetail	Iris
			Loosestrife

Additional Notes / Discussion:

Site has been heavily manicured—lacks very good indicators since bulkhead is recent. Pier stringers provide only true indicator along with neighboring properties. Tape placed on stringer. Note: neighbor to the south has recently modified their shoreline bulkhead with top well below owhm (breakwater??) and huge LWD. Strange design.

The Watershed Company

Ordinary High Water Mark Determination Data Form

Date: *6/15/04* ***Team:*** *MI/DN* ***Site Name:*** *Seel*
Address: *3268 W. Lk Samm Pkwy SE* ***KC Parcel #:*** *194970-0075*
Site Location: *South end of middle segment* ***Waterbody:*** *Lake Sammamish*

What is the fetch and exposure of the site in relation to wind and wave energy?

Minimal wave fetch. Site is just north of Vasa Park.

How quickly does the nearshore bathymetry drop off? Is it shallow?

Very shallow. Vasa Creek is nearby which contributes to transport sand and fines which have been washed up on shore.

FIELD DATA

Staff Gage Reading: ~26.7 feet

Y N
☐☒ Has the shoreline been filled?
☐☒ Is the shoreline bulkheaded (describe below)
☐☒ Stain lines on bulkhead?
☐☒ Lichen on bulkhead?
☐☒ Undercutting of bulkhead / other structures?
☒☐ Is there a dock **on** the property or **nearby**?
☒☐ Are there stain marks on the dock stringers?
☐☒ Is beach supplemented with gravel?
☐☒ Erosion, exposed / washed gravels on shoreline?
☐☒ Is there an associated wetland?

Draw a cross section of the lake shoreline *(include OHWM, upper/lower limits, vegetation, substrate):*

Describe the substrate on the shoreline:

Very gradual slope with sand and gravel mix

Vegetated: ☐ Fully ☐ Partial ☒ None | ***Substrate:*** ☒ Sand ☒ Gravel ☐ Silt ☐ Clay ☐ Rock

Only minor veg growing at water level—grass begins well above the ohwm

List the dominant species of plants according to zone:

Definitely above OHWM	*Likely above OHWM*	*Likely below OHWM*	*Definitely below OHWM*
Grasses		Willowherb	Purple loosestrife
Ornamentals			Iris
			Yellow loosestrife
			Reed canarygrass

Additional Notes / Discussion:

Water stains on stringers and fenders. Other indicators are poor due to lack of veg along shoreline and the manipulation of gravels and removal of debris lines. Minor gravel banding is evident, but foot traffic has altered it somewhat. Flag/stake place in gravel at same location as stringer stains. Owner says dock only occasionally gets under water—recent storm this year pushed large body of sand up to the grass line.

The Watershed Company

Ordinary High Water Mark Determination Data Form

Date: *6/17/04* ***Team:*** *MI/DN* ***Site Name:*** *Norelius*
Address: *17130 SE 35th St* ***KC Parcel #:*** *9451300020*
Site Location: *North end of south segment* ***Waterbody:*** *Lake Sammamish*

What is the fetch and exposure of the site in relation to wind and wave energy?

Short fetch to south end of lake, but site is perpendicular to State Park and likely receives more wave energy than other sites in the south segment

How quickly does the nearshore bathymetry drop off? Is it shallow?

Moderate slope to shoreline

FIELD DATA

Staff Gage Reading: ~26.7 feet

Y N
☐☒ Has the shoreline been filled?
☒☐ Is the shoreline bulkheaded (describe below) *
☐☒ Stain lines on bulkhead?
☐☒ Lichen on bulkhead?
☐☒ Undercutting of bulkhead / other structures?
☒☐ Is there a dock **on** the property or **nearby**?
☒☐ Are there stain marks on the dock stringers? **
☐☒ Is beach supplemented with gravel?
☒☐ **Erosion**, exposed / washed gravels on shoreline?
☐☒ Is there an associated wetland?

Draw a cross section of the lake shoreline *(include OHWM, upper/lower limits, vegetation, substrate):*

*Concrete retaining walls are located above the ohwm
**Pier has been jacked up so the stain marks no longer relate to ohwm locations

Describe the substrate on the shoreline:

Sand/gravel mix with clear sorting of gravel composition

Vegetated: ☐ Fully ☐ Partial ☒ None | ***Substrate:*** ☒ Sand ☒ Gravel ☐ Silt ☐ Clay ☐ Rock

Area is likely sprayed to control veg growth

List the dominant species of plants according to zone:

Definitely above OHWM	*Likely above OHWM*	*Likely below OHWM*	*Definitely below OHWM*
Kinnikinnick	Grasses		Few cottonwood seedlings
	Weedy upland species		

Additional Notes / Discussion:

Site lacks definitive indicators—stains are present on the pier, but the pier has been jacked up so that marks are no longer indicative of past water elevations. Veg is non-existent because owner apparently sprays the shoreline. Shoreline cleared of debris. Gravel sorting is best indicator—stake/flag placed just below erosion line in the soil and right at last sorting point.

The Watershed Company

Ordinary High Water Mark Determination Data Form

Date: *6/17/04* ***Team:*** *MI/DN* ***Site Name:*** *Anderson*

Address: *3820 W Lake Samm Pkwy SE* ***KC Parcel #:*** *1224059133*

Site Location: *North end of south segment* ***Waterbody:*** *Lake Sammamish*

What is the fetch and exposure of the site in relation to wind and wave energy?

Long wave fetch to the north but perpendicular to south end of Sammamish shoreline

How quickly does the nearshore bathymetry drop off? Is it shallow?

Very quick drop off

FIELD DATA

Staff Gage Reading: ~26.7 feet

Y N

☒☐ Has the shoreline been filled?
☒☐ Is the shoreline bulkheaded (describe below)
☒☐ Stain lines on bulkhead?
☒☐ Lichen on bulkhead?
☒☐ Undercutting of bulkhead / other structures?
☒☐ Is there a dock on the property or **nearby**?
☒☐ Are there stain marks on the dock stringers?
☐☒ Is beach supplemented with gravel?
☒☐ **Erosion**, exposed / washed gravels on shoreline?
☐☒ Is there an associated wetland?

Draw a cross section of the lake shoreline *(include OHWM, upper/lower limits, vegetation, substrate):*

Assessment of neighboring property to the southeast (cousin of Mr. Anderson). Site has 5-foot-tall concrete bulkhead which extends below ohwm. Mr. Anderson has a rock bulkhead, also below the ohwm, but is not good location for survey marker.

Describe the substrate on the shoreline:

Small gravels are near bulkhead, shifting to larger gravels and then cobble below low water

Vegetated: ☐ Fully ☐ Partial ☒ None | ***Substrate:*** ☐ Sand ☒ Gravel ☐ Silt ☐ Clay ☐ Rock

List the dominant species of plants according to zone:

Definitely above OHWM	*Likely above OHWM*	*Likely below OHWM*	*Definitely below OHWM*
Grasses			Yellow loosestrife
ornamentals			

Additional Notes / Discussion:

Same lot and location as preliminary study. Verified tape location (missing). Indicators = stain lines on vertical concrete bulkhead, lichen on wall, erosion of Mr. Anderson rock bulkhead. Site lacks veg and any shoreline of exposed gravel near the ohw level. Tape placed on concrete bulkhead. Spoke with owner.

The Watershed Company

Ordinary High Water Mark Determination Data Form

Date: *6/17/04* ***Team:*** *MI/DN* ***Site Name:*** *Layton*
Address: *3942 W. Lk Samm Pkwy SE* ***KC Parcel #:*** *122405-9135*
Site Location: *Middle to north end of south segment* ***Waterbody:*** *Lake Sammamish*

What is the fetch and exposure of the site in relation to wind and wave energy?

Long fetch to the north

How quickly does the nearshore bathymetry drop off? Is it shallow?

Fairly steep gradient

FIELD DATA

Staff Gage Reading: ~26.7 feet

Y N
☒☐ Has the shoreline been filled? **partial**
☒☐ Is the shoreline bulkheaded (describe below)
☒☐ Stain lines on bulkhead? **minor**
☒☐ Lichen on bulkhead?
☐☒ Undercutting of bulkhead / other structures?
☒☐ Is there a dock **on** the property or **nearby**?
☒☐ Are there stain marks on the dock stringers?
☐☒ Is beach supplemented with gravel?
☐☒ Erosion, exposed / washed gravels on shoreline?
☐☒ Is there an associated wetland?

Draw a cross section of the lake shoreline *(include OHWM, upper/lower limits, vegetation, substrate):*

Rock bulkhead along west portion of the site. Relatively exposed to the east, except for fence along east property line.

Describe the substrate on the shoreline:

Sand/gravel mix

Vegetated: ☐ Fully ☒ Partial ☐ None | ***Substrate:*** ☒ Sand ☒ Gravel ☐ Silt ☐ Clay ☐ Rock

List the dominant species of plants according to zone:

Definitely above OHWM	*Likely above OHWM*	*Likely below OHWM*	*Definitely below OHWM*
Grasses	Iris	Iris	Iris
Ornamentals	Birdsfoot trefoil	Birdsfoot trefoil	Hardstem bulrush
	Bittersweet nightshade		Yellow loosestrife
			Cottonwood seedlings

Additional Notes / Discussion:

Three stains are clear on fence along the east property line. Previous sample survey positioned stake on the lower mark. After re-evaluation, we deemed the middle mark to be more accurate. This revised mark matched up with stains on the jet-ski lift, topo breaks in the shoreline gravels, veg breaks, and marks on the rock bulkhead. The marks on the bulkhead are not as clear, but are useful in verifying location. All indicators matched up with middle line on fence. Flag placed along east property line. Spoke with owner.

The Watershed Company

Ordinary High Water Mark Determination Data Form

Date: *6/16/04* ***Team:*** *MI/DN* ***Site Name:*** *Bond*
Address: *4050 W Lk Samm Pkwy SE* ***KC Parcel #:*** *440660-0020*
Site Location: *Middle of south segment* ***Waterbody:*** *Lake Sammamish*

What is the fetch and exposure of the site in relation to wind and wave energy?

Long fetch to the north

How quickly does the nearshore bathymetry drop off? Is it shallow?

Shallower than most sites. Long piers.

FIELD DATA

Staff Gage Reading: ~26.7 feet

Y N
☒☐ Has the shoreline been filled?
☒☐ Is the shoreline bulkheaded (describe below)
☐☒ Stain lines on bulkhead?
☐☒ Lichen on bulkhead?
☐☒ Undercutting of bulkhead / other structures?
☒☐ Is there a dock on the property or nearby? **Joint use**
☒☐ Are there stain marks on the dock stringers?
☐☒ Is beach supplemented with gravel?
☐☒ Erosion, exposed / washed gravels on shoreline?
☐☒ Is there an associated wetland?

Draw a cross section of the lake shoreline *(include OHWM, upper/lower limits, vegetation, substrate):*

Bulkhead is short, vertical painted concrete structure. Owner swears water never reaches the base of the bulkhead.

Describe the substrate on the shoreline:

Sand/small gravel with shallow gradient

Vegetated: ☐ Fully ☐ Partial ☒ None | ***Substrate:*** ☒ Sand ☒ **small gravel** ☐ Silt ☐ Clay ☐ Rock

List the dominant species of plants according to zone:

Definitely above OHWM	*Likely above OHWM*	*Likely below OHWM*	*Definitely below OHWM*
Grasses		Iris (adjacent property)	Iris

Additional Notes / Discussion:

Poor indicators across the site besides water stains on the stringers. No apparent undermining of the bulkhead. Owner says he has never seen water above the wall and rarely does it ever reach the base. Adjacent property to the east has minor gravel bands—the lower of which corresponds to the stain on the pier. Stake placed in gravels near middle of lot.

The Watershed Company

Ordinary High Water Mark Determination Data Form

Date: *6/16/04* ***Team:*** *MI/DN* ***Site Name:*** *Olson*
Address: *17620 SE 40th Pl* ***KC Parcel #:*** *804370-0005*
Site Location: *Middle of south segment* ***Waterbody:*** *Lake Sammamish*

What is the fetch and exposure of the site in relation to wind and wave energy?

Long fetch to the north

How quickly does the nearshore bathymetry drop off? Is it shallow?

Very quick drop-off, short piers

FIELD DATA

Staff Gage Reading: ~26.7 feet

Y N
☐☒ Has the shoreline been filled?
☐☒ Is the shoreline bulkheaded (describe below)
☐☐ Stain lines on bulkhead? **N/A**
☐☐ Lichen on bulkhead? **N/A**
☐☒ Undercutting of bulkhead / other structures?

☒☐ Is there a dock on the property or nearby?
☒☐ Are there stain marks on the dock stringers?
☐☒ Is beach supplemented with gravel?
☒☐ **Erosion**, exposed / washed gravels on shoreline?
☐☒ Is there an associated wetland?

Draw a cross section of the lake shoreline *(include OHWM, upper/lower limits, vegetation, substrate):*

Describe the substrate on the shoreline:

Sand and small gravel beach. No bulkhead. Lawn extends down to the water with eroding shoreline (very slowly eroding). Lawn looks fairly natural with very little treatment, if any.

Vegetated: ☒ Fully ☐ Partial ☐ None | ***Substrate:*** ☒ Sand ☒ Gravel ☐ Silt ☐ Clay ☐ Rock

List the dominant species of plants according to zone:

Definitely above OHWM	*Likely above OHWM*	*Likely below OHWM*	*Definitely below OHWM*
Grasses	Birdsfoot trefoil	Yellow loosestrife	Yellow loosestrife
Clover	Plantain	Iris	Marsh cinquefoil
Plantain		Reed canarygrass	
Dandelion			

Additional Notes / Discussion:

Unprotected shoreline with lawn to the edge. Used water mark on stingers and very clear veg line. There is a definite break in shoreline topography. Spoke with the owner and neighbor at length regarding historic levels. Stake placed near middle of lot.

The Watershed Company

Ordinary High Water Mark Determination Data Form

Date: *6/16/04* ***Team:*** *MI/DN* ***Site Name:*** *McDonald*

Address: *17624 SE 40th Pl* ***KC Parcel #:*** *804370-0025*

Site Location: *Middle of south segment* ***Waterbody:*** *Lake Sammamish*

What is the fetch and exposure of the site in relation to wind and wave energy?

Long to north end

How quickly does the nearshore bathymetry drop off? Is it shallow?

Fairly quick drop off

FIELD DATA

Staff Gage Reading: ~26.7 feet

Y N

☒☐ Has the shoreline been filled?
☒☐ Is the shoreline bulkheaded (describe below)
☒☐ Stain lines on bulkhead?
☐☒ Lichen on bulkhead?
☐☒ Undercutting of bulkhead / other structures?
☒☐ Is there a dock **on** the property or **nearby**?
☒☐ Are there stain marks on the dock stringers?
☐☒ Is beach supplemented with gravel?
☒☐ Erosion, exposed / **washed** gravels on shoreline?
☐☐ Is there an associated wetland?

Draw a cross section of the lake shoreline *(include OHWM, upper/lower limits, vegetation, substrate):*

Rock bulkhead across entire site is located above the ohwm.

Describe the substrate on the shoreline:

Gravel mix with sand

Vegetated: ☐ Fully ☐ Partial ☒ None | ***Substrate:*** ☒ Sand ☒ Gravel ☐ Silt ☐ Clay ☐ Rock

The only veg is above the rock bulkhead **Gravel is predominant**

List the dominant species of plants according to zone:

Definitely above OHWM	*Likely above OHWM*	*Likely below OHWM*	*Definitely below OHWM*
Ornamentals	Grass	Iris	
Grass			

Additional Notes / Discussion:

Shoreline lacks many key indicators. Pier is new (stringers/decking). Owner says dock goes under water regularly, but it looks like they probably raised the deck by 6". Indicators used = stain on boat lift and gravel band along shoreline that generally corresponds to stain on neighbors pier to the east. There is a higher band and possible water mark on some of the bulkhead rocks, but this was discounted to extreme events. Stake placed near E. property line.

The Watershed Company

Ordinary High Water Mark Determination Data Form

Date: *6/16/04* ***Team:*** *MI/DN* ***Site Name:*** *Sambica*
Address: *17700 W Lk Samm Pkwy SE* ***KC Parcel #:*** *8043700400*
Site Location: *Middle to south end of south segment* ***Waterbody:*** *Lake Sammamish*

What is the fetch and exposure of the site in relation to wind and wave energy?

Long fetch to north end of lake

How quickly does the nearshore bathymetry drop off? Is it shallow?

Shallower than most sites with gradual sandy beach extending into water.

FIELD DATA

Staff Gage Reading: ~26.7 feet

Y N
☐☐ Has the shoreline been filled? **unknown**
☒☐ Is the shoreline bulkheaded (describe below)
☐☒ Stain lines on bulkhead?
☒☐ Lichen on bulkhead?
☐☒ Undercutting of bulkhead / other structures?
☒☐ Is there a dock on the property or nearby?
☒☐ Are there stain marks on the dock stringers?
☒☐ Is beach supplemented with gravel? **Sand possible**
☐☒ Erosion, exposed / washed gravels on shoreline?
☐☒ Is there an associated wetland?

Draw a cross section of the lake shoreline *(include OHWM, upper/lower limits, vegetation, substrate):*

Describe the substrate on the shoreline:

Sandy beach with small gravels—shoreline is used as swimming beach so it is heavily manipulated.

Vegetated: ☐ Fully ☒ Partial ☐ None | ***Substrate:*** ☒ Sand ☒ Gravel ☐ Silt ☐ Clay ☐ Rock

East and west ends are vegetated

List the dominant species of plants according to zone: **Used west end of property**

Definitely above OHWM	*Likely above OHWM*	*Likely below OHWM*	*Definitely below OHWM*
Grasses	Birdsfoot trefoil	Birdsfoot trefoil	Softrush
	Horsetail	Iris	Iris
	Grasses	Mint	Yellow/purple loosestrife
	Dandelion		Pacific willow

Additional Notes / Discussion:

Previous stake from sample survey still present. Verified its location with several indicators—clear water mark on concrete bulkhead, veg line on adjacent property to the west, and sand deposition and soil marks. Stake was verified to be located correctly in between two canoe racks at the west end of the property.

The Watershed Company

Ordinary High Water Mark Determination Data Form

Date: *6/16/04* ***Team:*** *MI/DN* ***Site Name:*** *Kramer*

Address: *17840 SE 40th Pl* ***KC Parcel #:*** *804370-0310*

Site Location: *Southeast end of south segment* ***Waterbody:*** *Lake Sammamish*

What is the fetch and exposure of the site in relation to wind and wave energy?

Long fetch to the north

How quickly does the nearshore bathymetry drop off? Is it shallow?

Bathymetry quickly drops off. Piers are of moderate length compared to others around the lake.

FIELD DATA

Staff Gage Reading: ~26.7 feet

Y N

☒☐ Has the shoreline been filled?
☒☐ Is the shoreline bulkheaded (describe below)
☐☒ Stain lines on bulkhead?
☐☒ Lichen on bulkhead?
☐☒ Undercutting of bulkhead / other structures?

☒☐ Is there a dock **on** the property or **nearby**?
☒☐ Are there stain marks on the dock stringers? **Neigh.**
☐☒ Is beach supplemented with gravel?
☒☐ Erosion, exposed / **washed** gravels on shoreline?
☐☒ Is there an associated wetland?

Draw a cross section of the lake shoreline *(include OHWM, upper/lower limits, vegetation, substrate):*

Describe the substrate on the shoreline:

Gravel mix with sand and smaller gravels below low water

Vegetated: ☐ Fully ☒ Partial ☐ None | ***Substrate:*** ☒ Sand ☒ Gravel ☐ Silt ☐ Clay ☐ Rock

Just upland above bulkhead (roses)—shoreline likely cleaned of all veg annually

List the dominant species of plants according to zone:

Definitely above OHWM	*Likely above OHWM*	*Likely below OHWM*	*Definitely below OHWM*
Ornamentals	Upland groundcovers		
Rose			
Japanese maple			

Additional Notes / Discussion:

Site lacks very good indicators. On-site floating dock doesn't provide appropriate water marks. Boat lift does have good line. Neighboring property to the east has marks on the pier stringers that matched elevation of boatlift mark. On shore, veg is non-existent, although some groundcover creepage from the rockery is above the ohwm. Gravel bands are not very clear. Stake placed in ground to match water marks on boatlift and stringer.

The Watershed Company

Ordinary High Water Mark Determination Data Form

Date: *6/16/04* ***Team:*** *MI/DN* ***Site Name:*** *Frese (vacant house)*

Address: *4004 181st Ave SE* ***KC Parcel #:*** *182406-9163*

Site Location: *Southeast end of south segment* ***Waterbody:*** *Lake Sammamish*

What is the fetch and exposure of the site in relation to wind and wave energy?

Long fetch to the north

How quickly does the nearshore bathymetry drop off? Is it shallow?

Very steep gradient, short piers

FIELD DATA

Staff Gage Reading: ~26.7 feet

Y N

☒☐ Has the shoreline been filled?
☒☐ Is the shoreline bulkheaded (describe below)
☐☐ Stain lines on bulkhead? **not clear**
☐☒ Lichen on bulkhead?
☒☐ Undercutting of bulkhead / other structures?
☒☐ Is there a dock on the property or nearby?
☒☐ Are there stain marks on the dock stringers?
☐☒ Is beach supplemented with gravel?
☐☒ Erosion, exposed / washed gravels on shoreline?
☐☒ Is there an associated wetland?

Draw a cross section of the lake shoreline *(include OHWM, upper/lower limits, vegetation, substrate):*

Describe the substrate on the shoreline:

Sand/gravel mix transitions to sand quickly below the existing water level. Poor gravel sorting above the water level.

Vegetated: ☐ Fully ☒ Partial ☐ None | ***Substrate:*** ☒ Sand ☒ Gravel ☐ Silt ☐ Clay ☐ Rock

List the dominant species of plants according to zone:

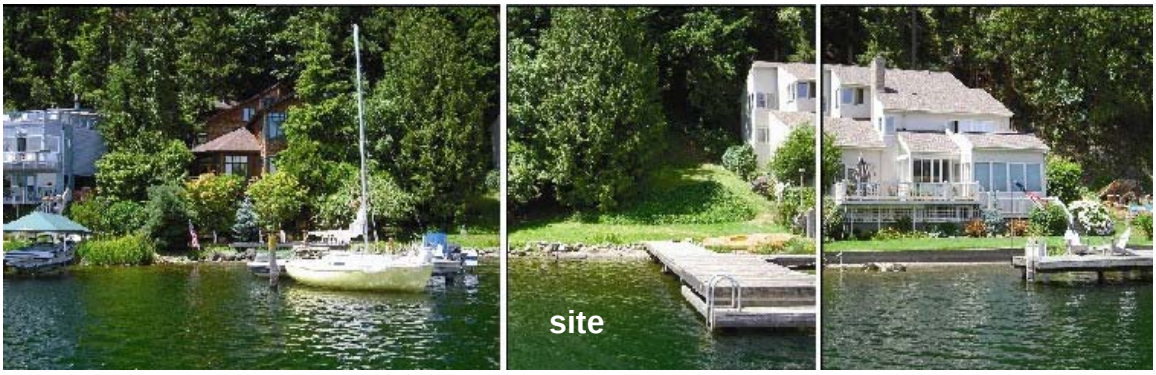
Definitely above OHWM	*Likely above OHWM*	*Likely below OHWM*	*Definitely below OHWM*
Ornamentals	Bittersweet nightshade	Birdsfoot trefoil	Willow
Grasses	Grasses	Dock	
	Horsetail	Plantain	
		Reed canarygrass	

Additional Notes / Discussion:

House is vacant—for sale. Indicators are very poor. Dock is below the ohwm so it lacks any stain lines. Neighbor pier to east has stains on stringers and boatlift that were used to estimate ohwm. On-site we used a poor veg line and poor gravel sorting just below the existing bulkhead to aid the determination. Verified ballpark estimate to today's lake level. Stream flows along west property line. Stake placed near east property line.

APPENDIX B

Photographs of Each Study Site



Site #1

Site #2

Site #3

Site #4

Site #5

Site #6

Site #7

Site #8

Site #9

Site #10

Site #11

Site #12

Site #13

Site #14

Site #15

Site #16

Site #17

Site #18

Site #19

Site #20

Site #21

Site #22

Site #23

Site #24

Site #25

Site #26

Site #27

APPENDIX C

Statistical Analysis Results

DESCRIPTIVE SUMMARY: All Data

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Elev. (ft)	27	100.0%	0	.0%	27	100.0%

Descriptives

			Statistic	Std. Error
Elev. (ft)	Mean		31.32	.04
	95% Confidence Interval for Mean	Lower Bound	31.24	
		Upper Bound	31.41	
	5% Trimmed Mean		31.33	
	Median		31.35	
	Variance		.05	
	Std. Deviation		.22	
	Minimum		30.91	
	Maximum		31.69	
	Range		.78	
	Interquartile Range		.33	
	Skewness		-.09	.45
	Kurtosis		-.96	.87

M-Estimators

	Huber's M-Estimator(a)	Tukey's Biweight(b)	Hampel's M-Estimator(c)	Andrews' Wave(d)
Elev. (ft)	31.33	31.33	31.33	31.33

a The weighting constant is 1.339.
b The weighting constant is 4.685.
c The weighting constants are 1.700, 3.400, and 8.500
d The weighting constant is 1.340*pi.

Percentiles

		Percentiles						
		5	10	25	50	75	90	95
Weighted Average(Definition 1)	Elev. (ft)	30.93	31.00	31.17	31.35	31.50	31.62	31.68
Tukey's Hinges	Elev. (ft)			31.18	31.35	31.50		

Extreme Values

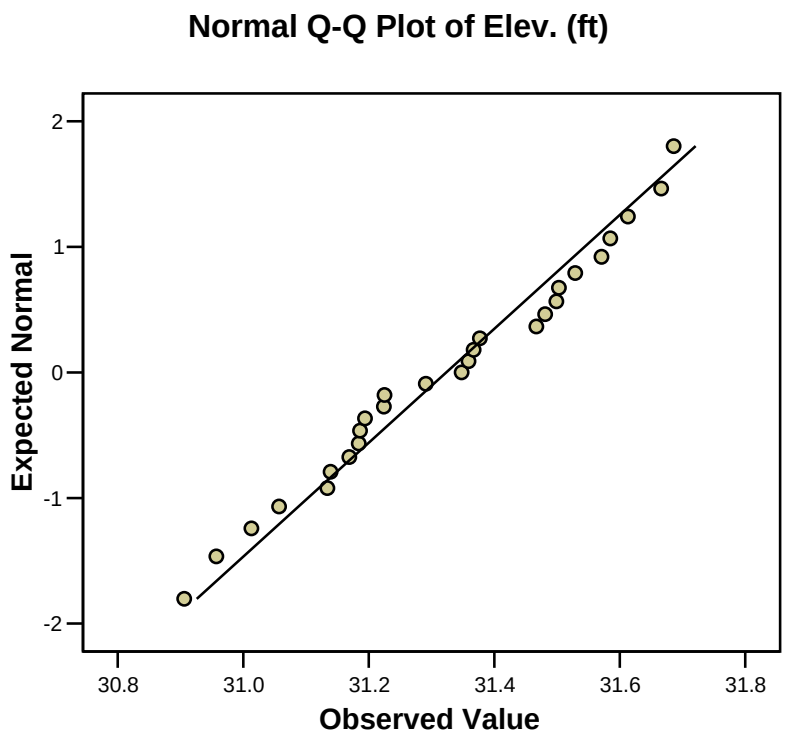
			Case Number	Parcel Number	Value
Elev. (ft)	Highest	1	8	362505-9114	31.69
		2	6	362505-9090	31.67
		3	19	945130-0020	31.61
		4	2	743050-0116	31.59
		5	7	362505-9056	31.57
	Lowest	1	3	743050-0275	30.91
		2	9	362505-9008	30.96
		3	1	743050-0009	31.01
		4	24	804370-0025	31.06
		5	26	804370-0310	31.13

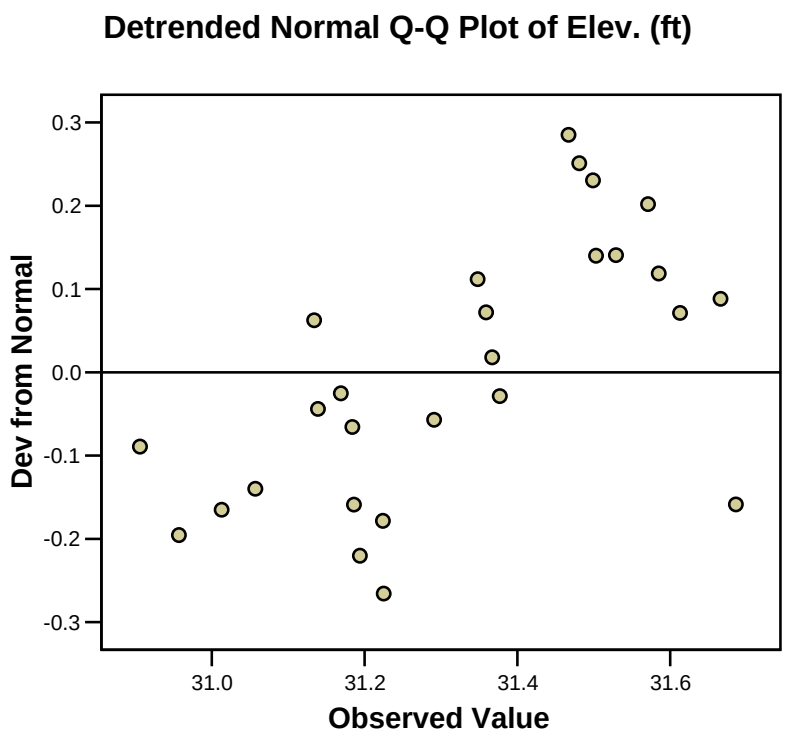
Tests of Normality

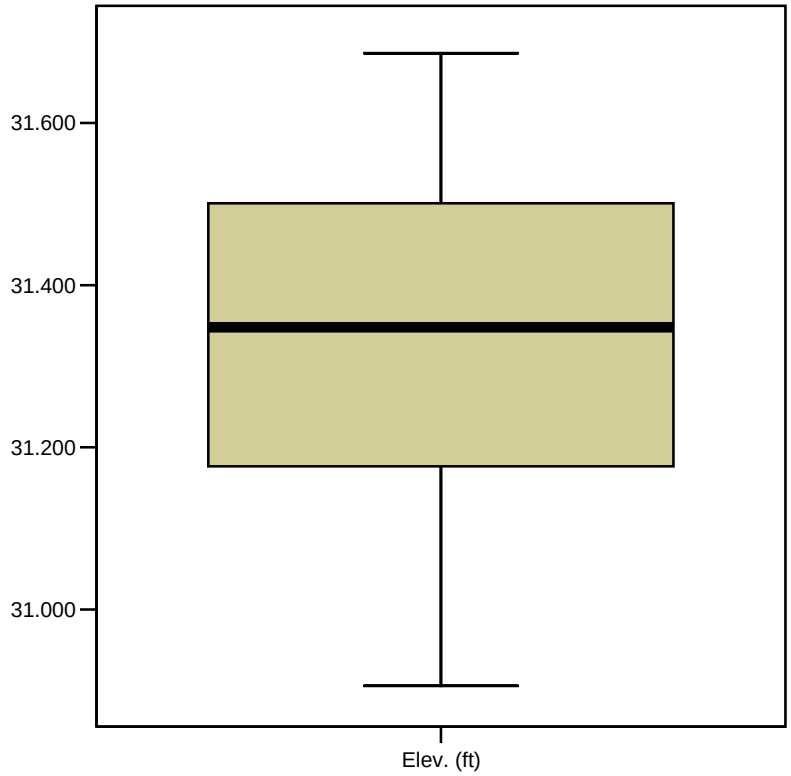
	Kolmogorov-Smirnov(a)			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Elev. (ft)	.12	27	.20(*)	.97	27	.50

* This is a lower bound of the true significance.
a Lilliefors Significance Correction

EXAMINATION FOR OUTLIERS: Q-Q plots and boxplots






31.600
31.400
31.200
31.000
Elev. (ft)

T-TESTS: for examination of historical record

Test Value = 31.86 feet

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Elev. (ft)	27	31.32333	.220585	.042452

	Test Value = 31.86					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Elev. (ft)	-12.642	26	.000	-.536667	-.62393	-.44941

Test Value = 31.48 feet

	Test Value = 31.48					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Elev. (ft)	-3.690	26	.001	-.156667	-.24393	-.06941

Test Value = 31.34 feet

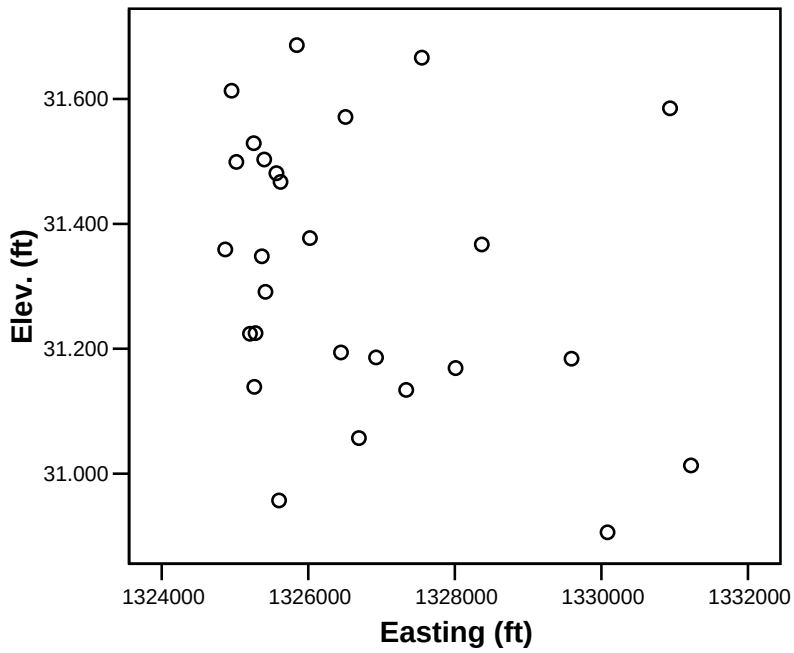
	Test Value = 31.34					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Elev. (ft)	-.393	26	.698	-.016667	-.10393	.07059

Test Value = 31.01 feet

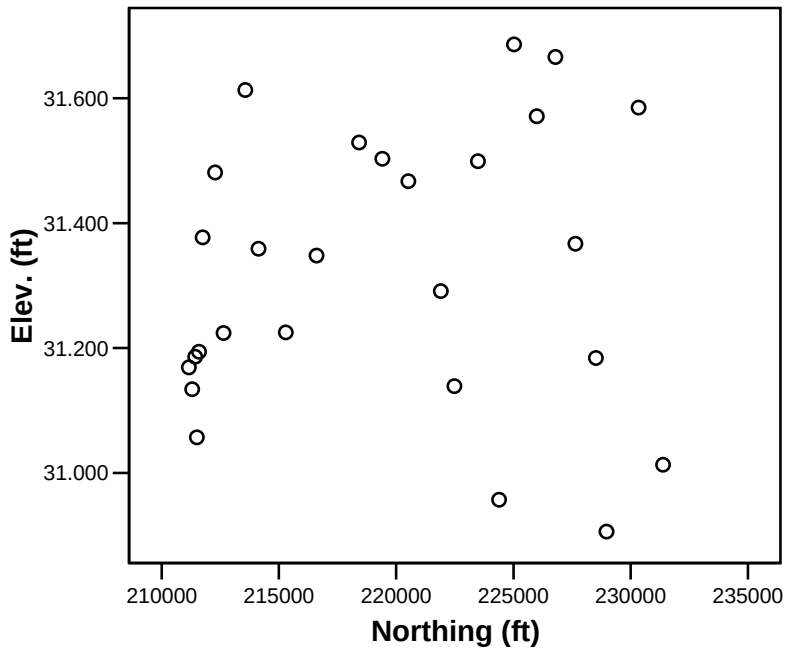
	Test Value = 31.01					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Elev. (ft)	7.381	26	.000	.313333	.22607	.40059

SCATTERPLOTS: analysis of numeric variables

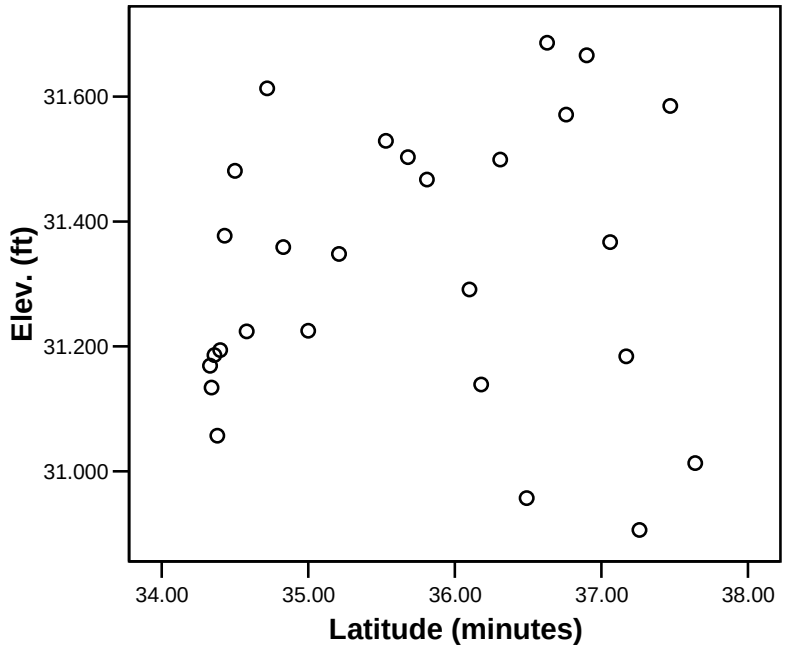
Scatterplot: Easting (ft) vs. OHWM Elevation (ft)



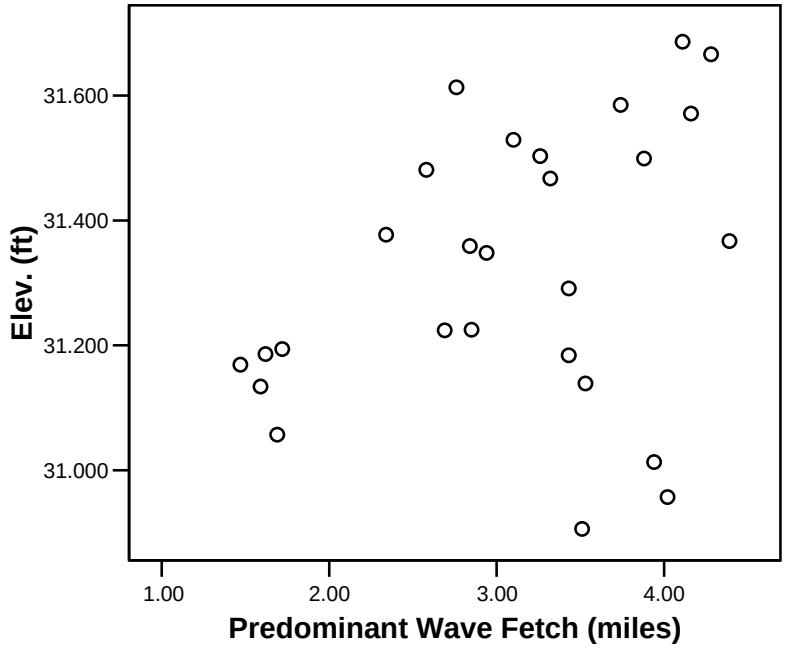
Scatterplot: Northing (ft) vs. OHWM Elevation (ft)



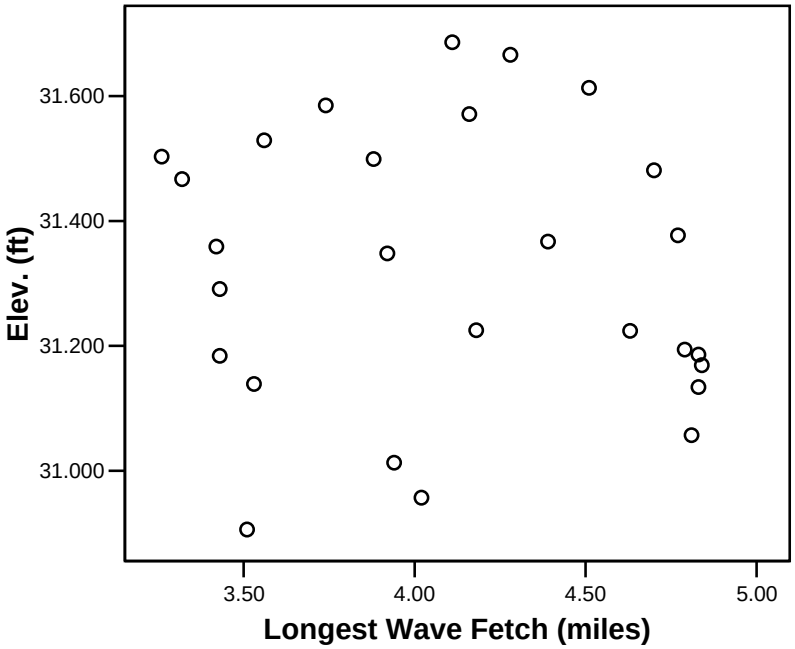
Scatterplot: Latitude (minutes) vs. OHWM Elevation (ft)



Scatterplot: Predominant wave fetch (miles) vs. OHWM Elevation (ft)



Scatterplot: Longest wave fetch (miles) vs. OHWM Elevation (ft)

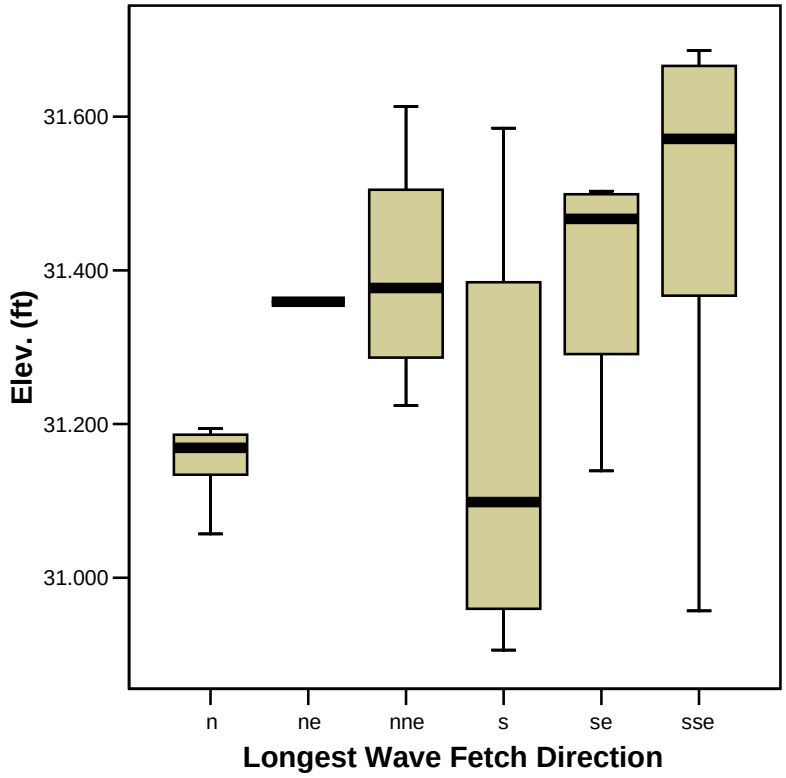


BOXPLOTS and analysis for non-numeric variables

Longest Wave Fetch Direction

Case Processing Summary

	Longest Wave Fetch Direction	Cases					
		Valid		Missing		Total	
		N	Percent	N	Percent	N	Percent
Elev. (ft)	n	5	100.0%	0	.0%	5	100.0%
	ne	1	100.0%	0	.0%	1	100.0%
	nne	7	100.0%	0	.0%	7	100.0%
	s	4	100.0%	0	.0%	4	100.0%
	se	5	100.0%	0	.0%	5	100.0%
	sse	5	100.0%	0	.0%	5	100.0%



Report

Elev. (ft)

Longest Wave Fetch Direction	Mean	N	Std. Deviation	Range
n	31.15	5	.06	.14
ne	31.36	1	.	.00
nne	31.40	7	.15	.39
s	31.17	4	.30	.68
se	31.38	5	.16	.36
sse	31.45	5	.30	.73
Total	31.32	27	.22	.78

ANOVA Table(a)

			Sum of Squares	df	Mean Square	F	Sig.
Elev. (ft) * Longest Wave Fetch Direction	Between Groups	(Combined)	.38	5	.08	1.82	.15
	Within Groups		.88	21	.04		
	Total		1.27	26			

a The grouping variable Longest Wave Fetch Direction is a string, so the test for linearity cannot be computed.

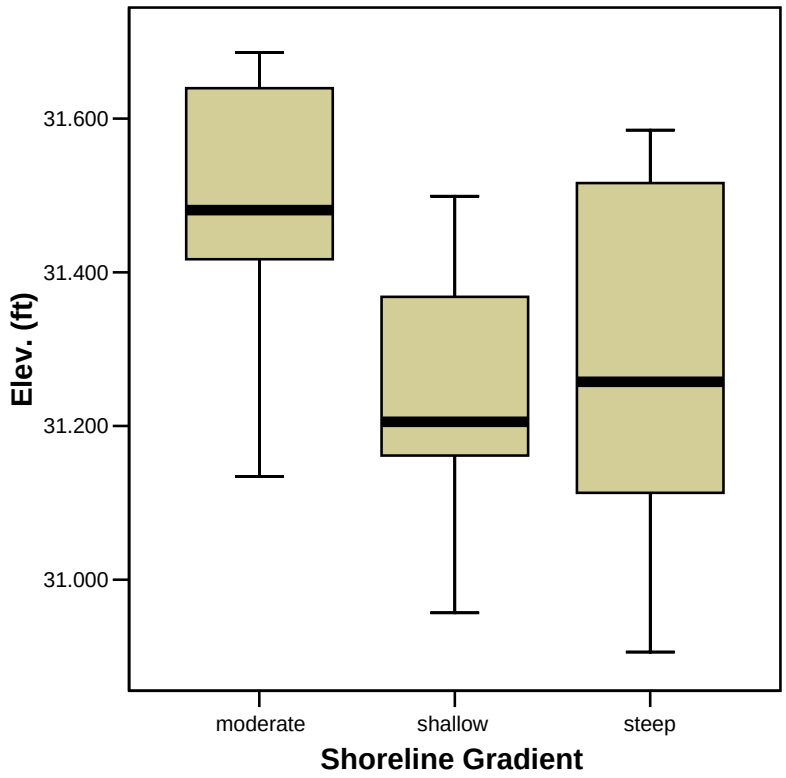
Measures of Association

	Eta	Eta Squared
Elev. (ft) * Longest Wave Fetch Direction	.55	.30

Shoreline Gradient

Case Processing Summary

	Shoreline Gradient	Cases					
		Valid		Missing		Total	
		N	Percent	N	Percent	N	Percent
Elev. (ft)	moderate	7	100.0%	0	.0%	7	100.0%
	shallow	8	100.0%	0	.0%	8	100.0%
	steep	12	100.0%	0	.0%	12	100.0%



Report

Elev. (ft)

Shoreline Gradient	Mean	N	Std. Deviation	Range
moderate	31.49	7	.19	.55
shallow	31.24	8	.17	.54
steep	31.28	12	.23	.68
Total	31.32	27	.22	.78

ANOVA Table(a)

			Sum of Squares	df	Mean Square	F	Sig.
Elev. (ft) * Shoreline Gradient	Between Groups	(Combined)	.26	2	.13	3.16	.06
	Within Groups		1.00	24	.04		
	Total		1.27	26			

a The grouping variable Shoreline Gradient is a string, so the test for linearity cannot be computed.

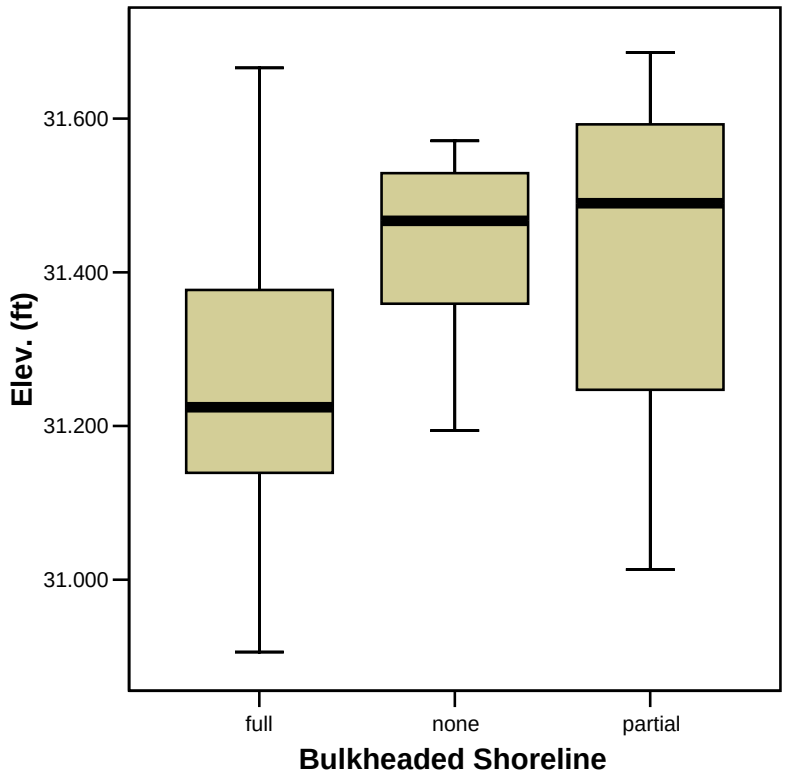
Measures of Association

	Eta	Eta Squared
Elev. (ft) * Shoreline Gradient	.46	.21

Bulkheaded Shoreline

Case Processing Summary

	Bulkheaded Shoreline	Cases					
		Valid		Missing		Total	
		N	Percent	N	Percent	N	Percent
Elev. (ft)	full	18	100.0%	0	.0%	18	100.0%
	none	5	100.0%	0	.0%	5	100.0%
	partial	4	100.0%	0	.0%	4	100.0%



Report

Elev. (ft)

Bulkheaded Shoreline	Mean	N	Std. Deviation	Range
full	31.27	18	.22	.76
none	31.42	5	.15	.38
partial	31.42	4	.29	.67
Total	31.32	27	.22	.78

ANOVA Table(a)

			Sum of Squares	df	Mean Square	F	Sig.
Elev. (ft) * Bulkheaded Shoreline	Between Groups	(Combined)	.13	2	.07	1.40	.27
	Within Groups		1.13	24	.05		
	Total		1.27	26			

a The grouping variable Bulkheaded Shoreline is a string, so the test for linearity cannot be computed.

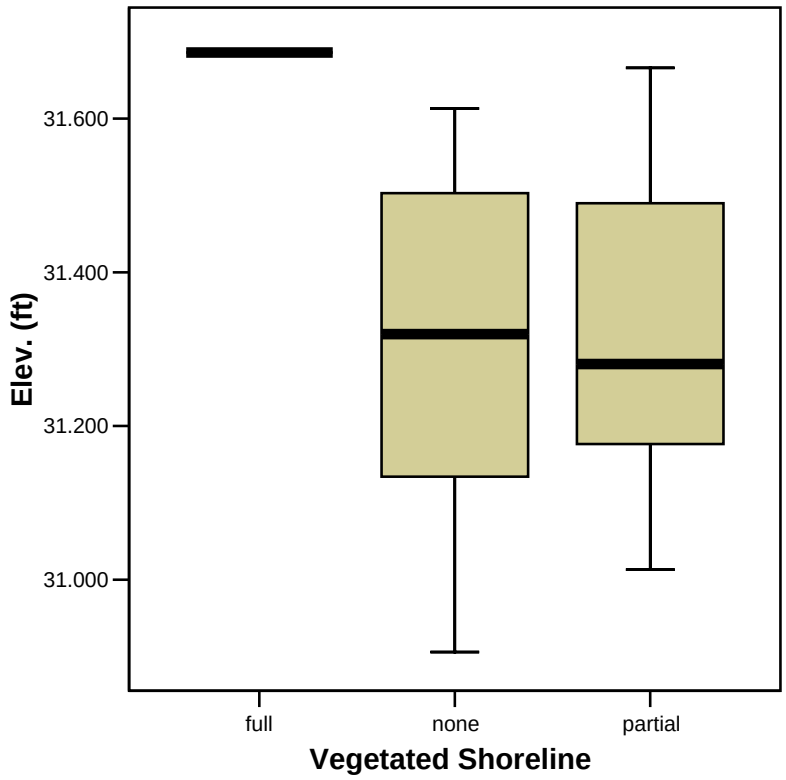
Measures of Association

	Eta	Eta Squared
Elev. (ft) * Bulkheaded Shoreline	.32	.10

Vegetated Shoreline

Case Processing Summary

	Vegetated Shoreline	Cases					
		Valid		Missing		Total	
		N	Percent	N	Percent	N	Percent
Elev. (ft)	full	1	100.0%	0	.0%	1	100.0%
	none	14	100.0%	0	.0%	14	100.0%
	partial	12	100.0%	0	.0%	12	100.0%



Report

Elev. (ft)

Vegetated Shoreline	Mean	N	Std. Deviation	Range
full	31.69	1	.	.00
none	31.30	14	.23	.71
partial	31.32	12	.20	.65
Total	31.32	27	.22	.78

ANOVA Table(a)

			Sum of Squares	df	Mean Square	F	Sig.
Elev. (ft) * Vegetated Shoreline	Between Groups	(Combined)	.14	2	.07	1.51	.24
	Within Groups		1.12	24	.05		
	Total		1.27	26			

a The grouping variable Vegetated Shoreline is a string, so the test for linearity cannot be computed.

Measures of Association

	Eta	Eta Squared
Elev. (ft) * Vegetated Shoreline	.33	.11

SEGMENTATION ANALYSIS:

comparison of group means

Descriptives

	Segment			Statistic	Std. Error
Elev. (ft)	1	Mean		31.33	.11
		95% Confidence Interval for Mean	Lower Bound	31.08	
			Upper Bound	31.57	
		5% Trimmed Mean		31.33	
		Median		31.37	
		Variance		.10	
		Std. Deviation		.32	
		Minimum		30.91	
		Maximum		31.69	
		Range		.78	
		Interquartile Range		.64	
		Skewness		-.20	.72
		Kurtosis		-1.98	1.40
	2	Mean		31.37	.05
		95% Confidence Interval for Mean	Lower Bound	31.27	
			Upper Bound	31.48	
		5% Trimmed Mean		31.38	
		Median		31.36	
		Variance		.02	
		Std. Deviation		.14	
		Minimum		31.14	
		Maximum		31.53	
		Range		.39	
		Interquartile Range		.24	
		Skewness		-.50	.72
		Kurtosis		-.97	1.40
	3	Mean		31.27	.06
		95% Confidence Interval for Mean	Lower Bound	31.13	
			Upper Bound	31.41	
		5% Trimmed Mean		31.26	
		Median		31.19	
		Variance		.03	
		Std. Deviation		.18	
		Minimum		31.06	
		Maximum		31.61	
		Range		.56	
		Interquartile Range		.28	
		Skewness		.98	.72
		Kurtosis		.02	1.40

Case Processing Summary

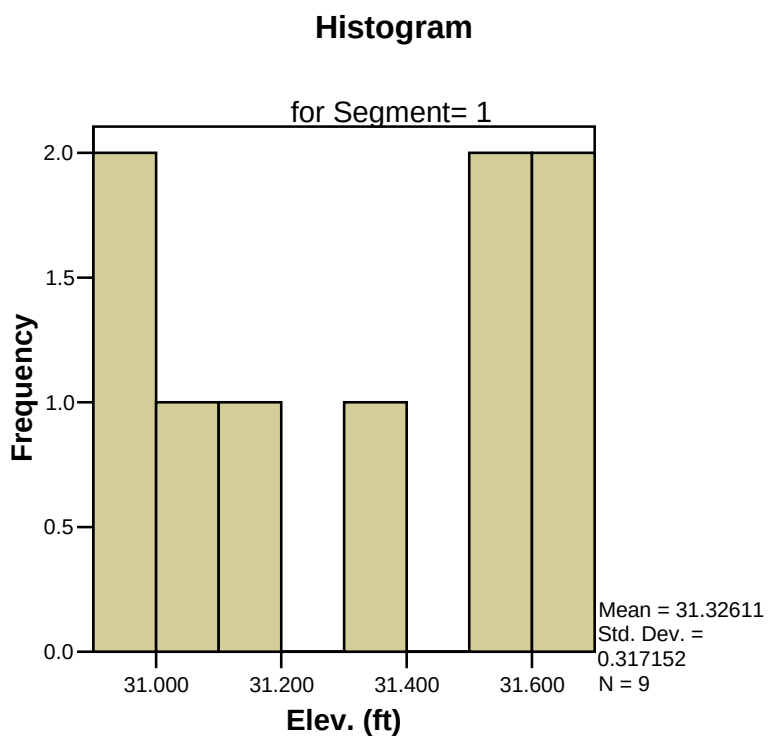
	Segment	Cases					
		Valid		Missing		Total	
		N	Percent	N	Percent	N	Percent
Elev. (ft)	1	9	100.0%	0	.0%	9	100.0%
	2	9	100.0%	0	.0%	9	100.0%
	3	9	100.0%	0	.0%	9	100.0%

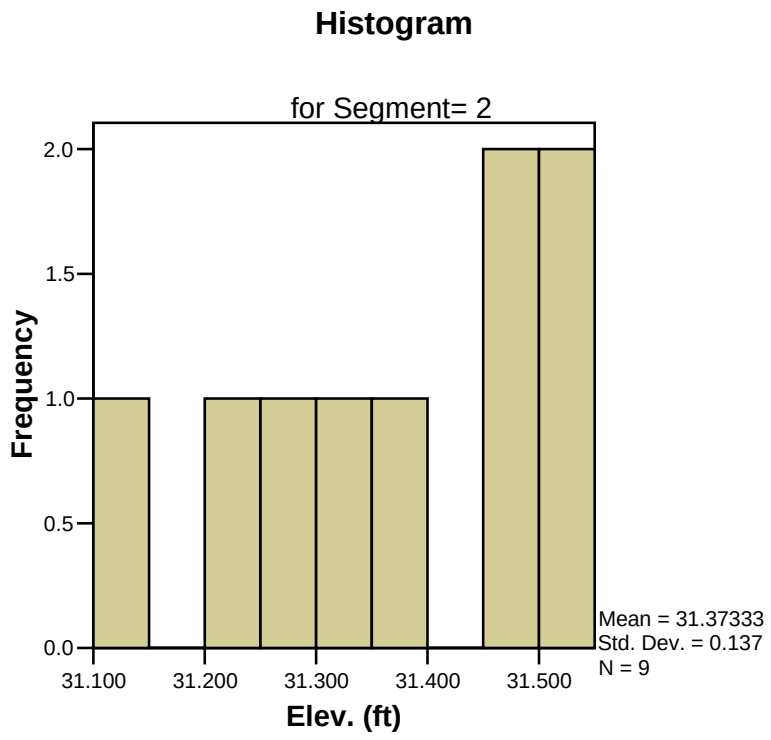
Tests of Normality

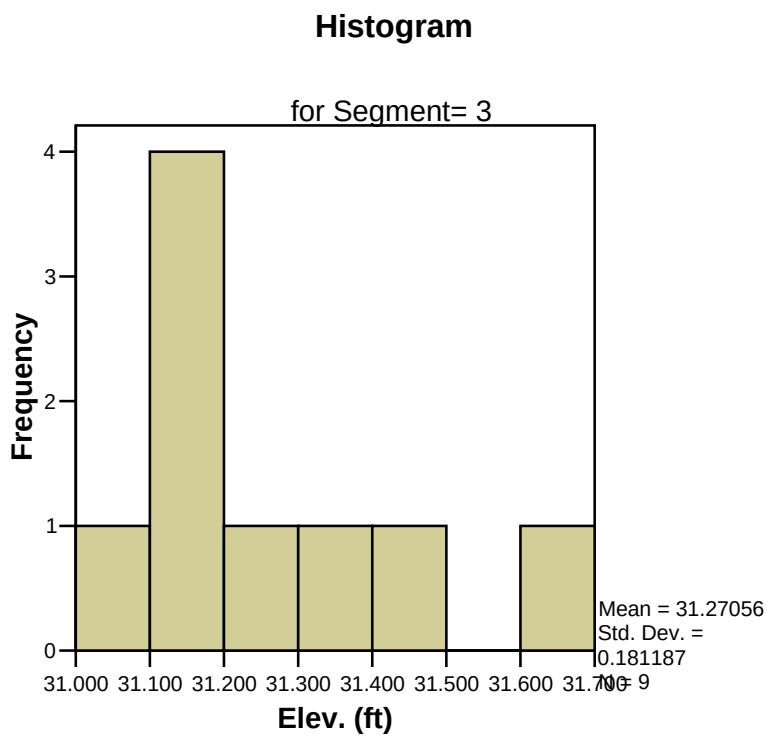
	Segment	Kolmogorov-Smirnov(a)			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Elev. (ft)	1	.22	9	.20(*)	.88	9	.14
	2	.20	9	.20(*)	.92	9	.42
	3	.27	9	.06	.89	9	.22

* This is a lower bound of the true significance.
a Lilliefors Significance Correction

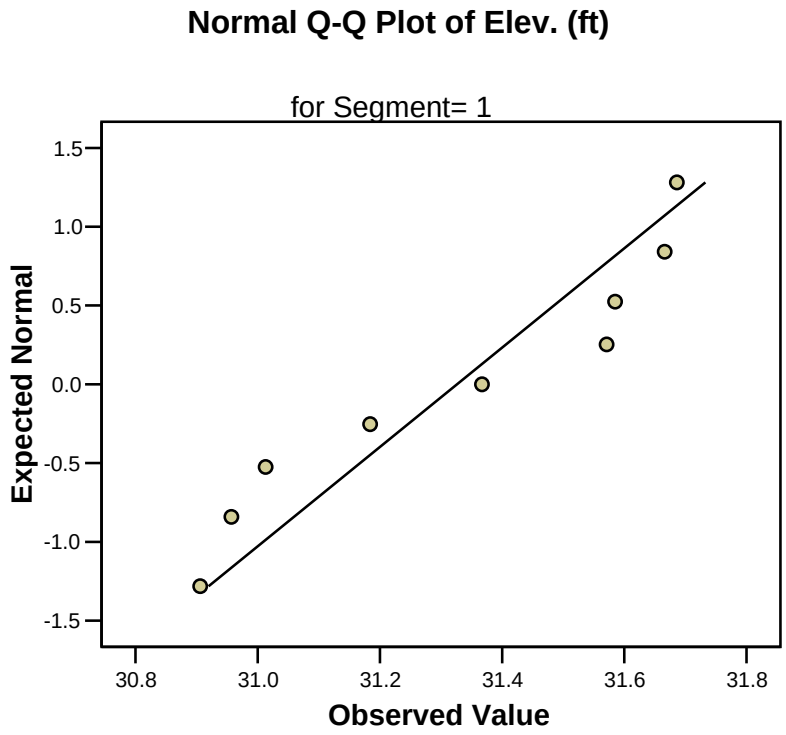
Histograms

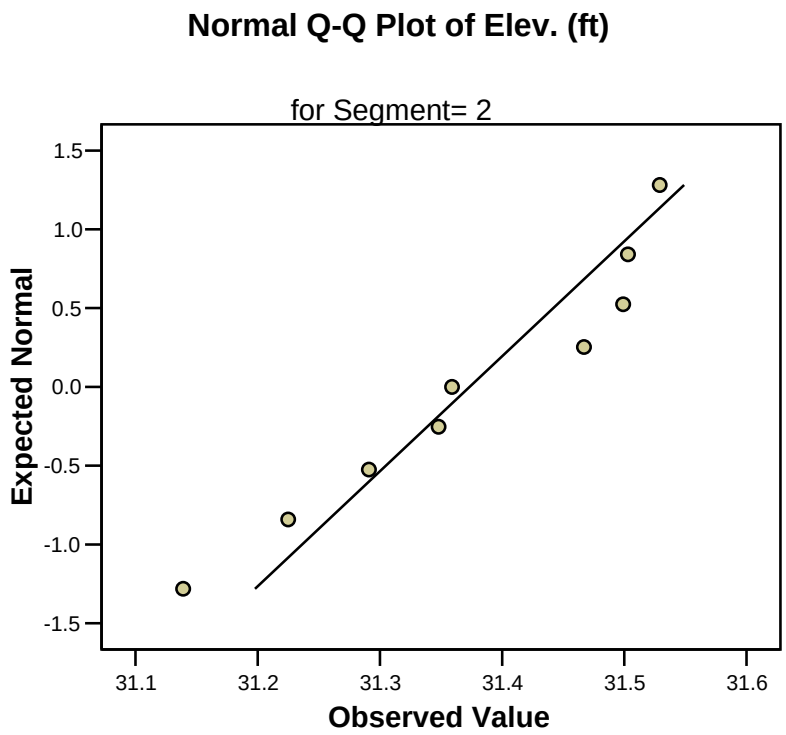


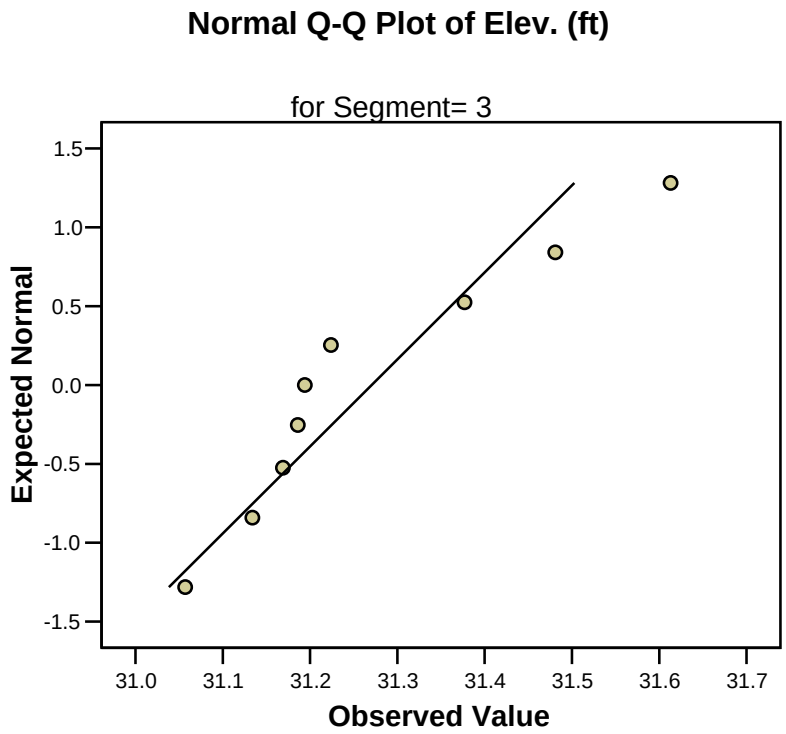

Histogram
for Segment= 2
Frequency
2.0
1.5
1.0
0.5
0.0
31.100
31.200
31.300
31.400
31.500
Elev. (ft)
Mean = 31.37333
Std. Dev. = 0.137
N = 9


Histogram
for Segment= 3
Frequency
4
3
2
1
0
31.000
31.100
31.200
31.300
31.400
31.500
31.600
31.700
Elev. (ft)
Mean = 31.27056
Std. Dev. =
0.181187
N = 9

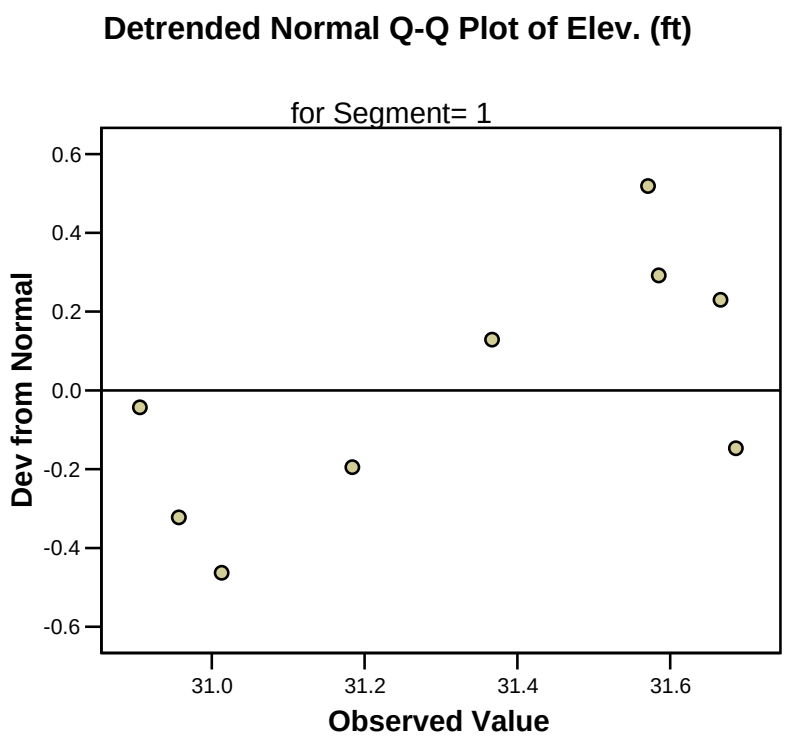
Normal Q-Q Plots

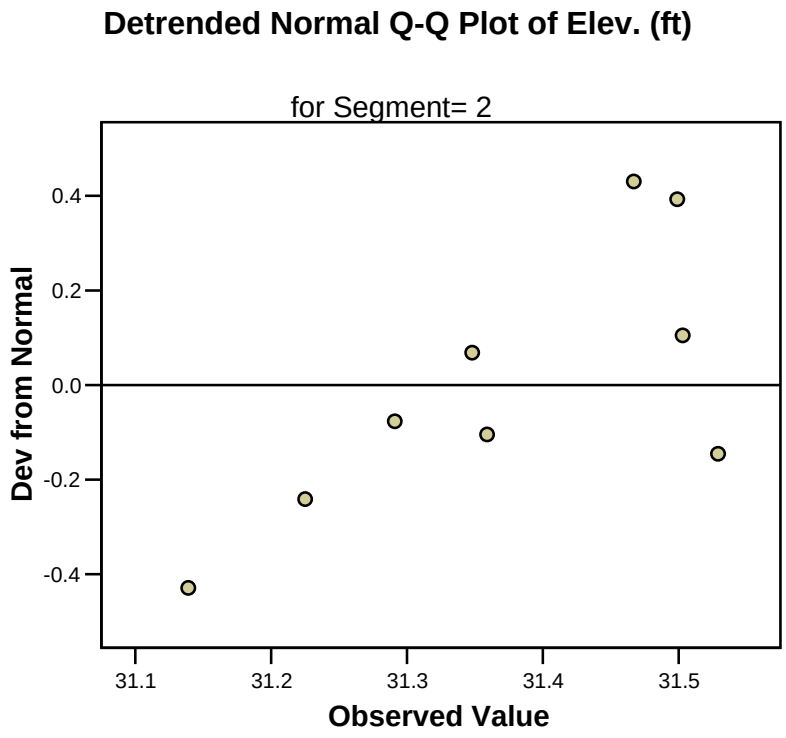


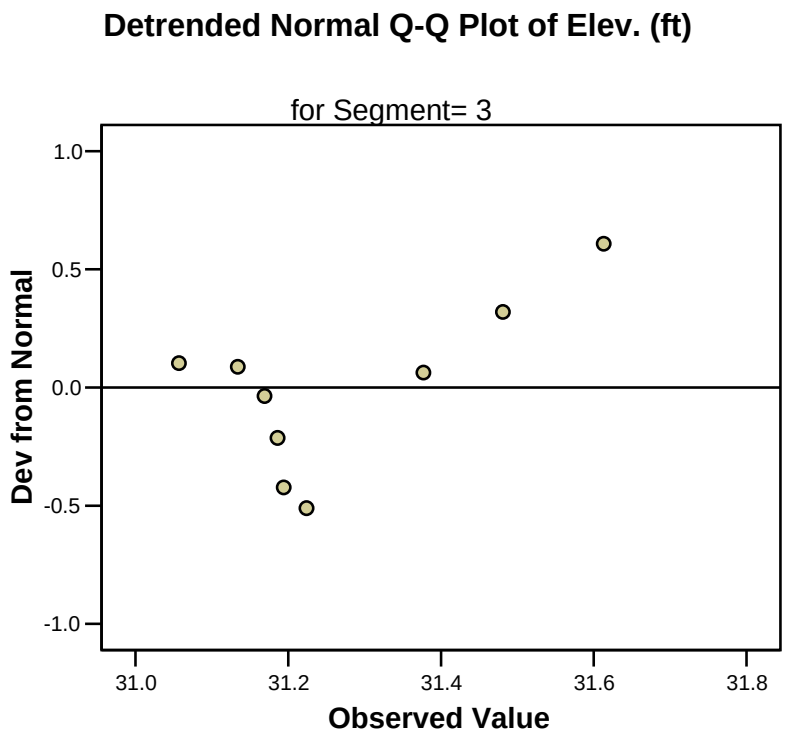




Detrended Normal Q-Q Plots




Detrended Normal Q-Q Plot of Elev. (ft)
for Segment= 2
Dev from Normal
0.4
0.2
0.0
-0.2
-0.4
31.1
31.2
31.3
31.4
31.5
Observed Value


Detrended Normal Q-Q Plot of Elev. (ft)
for Segment= 3
Dev from Normal
1.0
0.5
0.0
-0.5
-1.0
31.0
31.2
31.4
31.6
31.8
Observed Value

ANOVA Table

			Sum of Squares	df	Mean Square	F	Sig.
Elev. (ft) * Segment	Between Groups	(Combined)	.05	2	.02	.47	.63
		Linearity	.01	1	.01	.27	.61
		Deviation from Linearity	.03	1	.03	.67	.42
	Within Groups		1.22	24	.05		
	Total		1.27	26			

Measures of Association

	R	R Squared	Eta	Eta Squared
Elev. (ft) * Segment	-.10	.01	.19	.04

Oneway ANOVA to test homogeneity of variances

Test of Homogeneity of Variances

Elev. (ft)

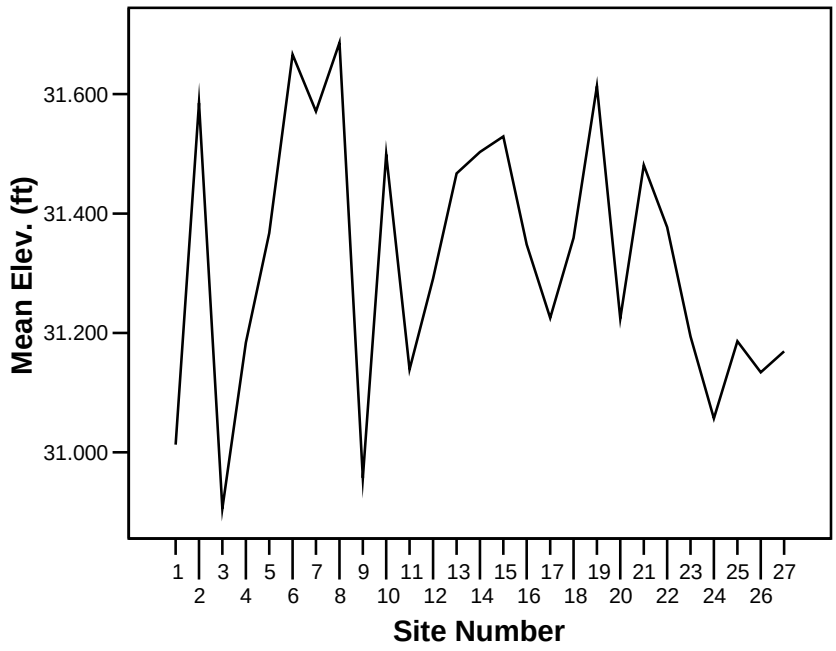
Levene Statistic	df1	df2	Sig.
7.29	2	24	.00

ANOVA

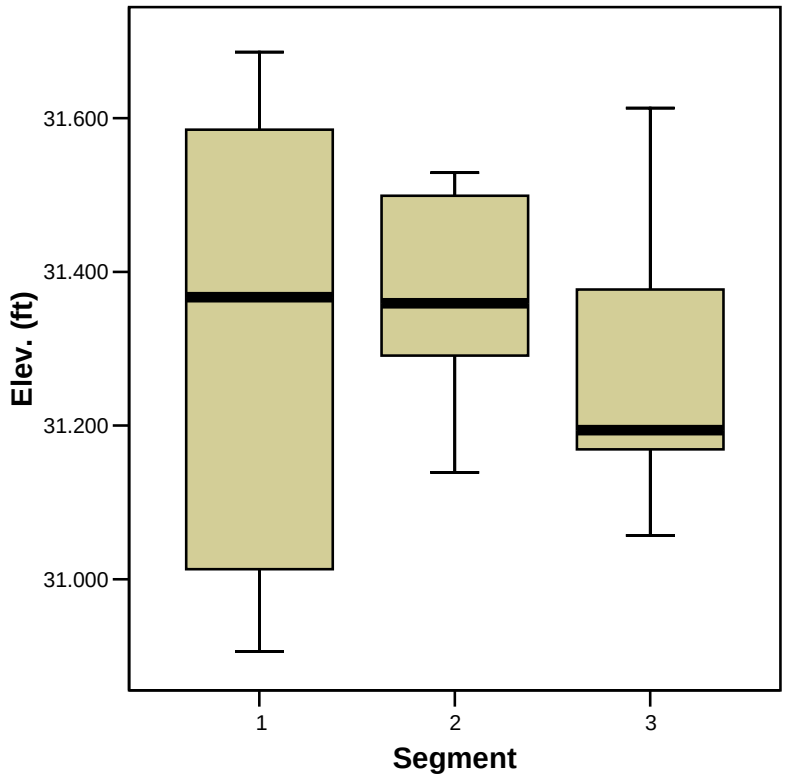
Elev. (ft)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.05	2	.02	.47	.63
Within Groups	1.22	24	.05		
Total	1.27	26			

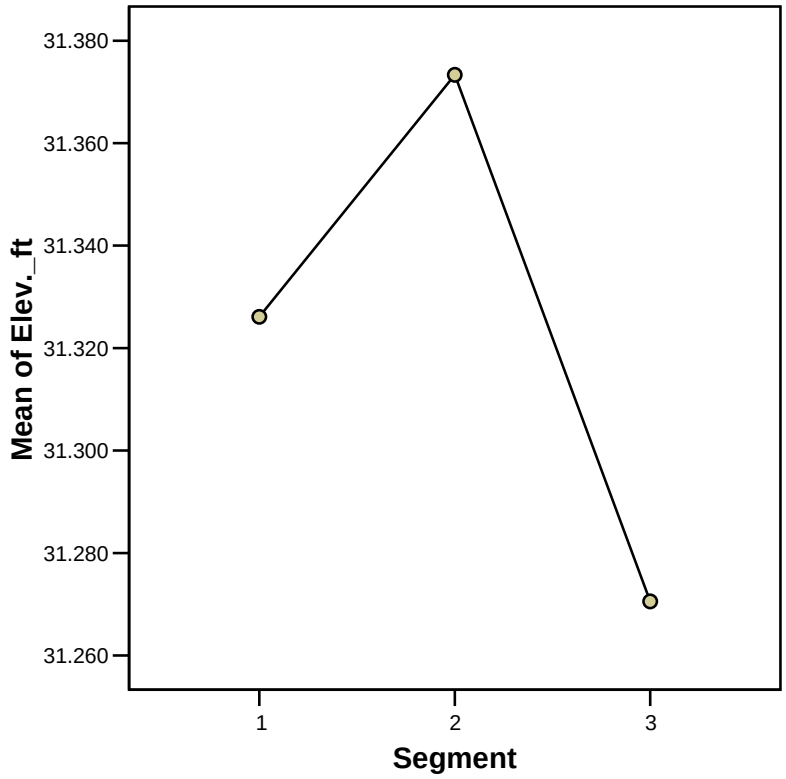
Line graph of OHWM elevation (ft) from north to south



Boxplot comparison of segment data



Line graph comparison of segment means (north=1, middle=2, south=3)



NON-PARAMETRIC TESTS

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Elev. (ft)	27	31.32333	.220585	30.906	31.686
Segment	27	2.00	.832	1	3

Kruskal-Wallis Test

Ranks

	Segment	N	Mean Rank
Elev. (ft)	1	9	14.44
	2	9	15.67
	3	9	11.89
	Total	27	

Test Statistics(a,b)

	Elev. (ft)
Chi-Square	1.062
df	2
Asymp. Sig.	.588

a Kruskal Wallis Test
b Grouping Variable: Segment

Median Test

Frequencies

		Segment		
		1	2	3
Elev. (ft)	> Median	5	5	3
	<= Median	4	4	6

Test Statistics(b)

	Elev. (ft)
N	27
Median	31.34800
Chi-Square	1.187(a)
df	2
Asymp. Sig.	.552

a 6 cells (100.0%) have expected frequencies less than 5. The minimum expected cell frequency is 4.3.
b Grouping Variable: Segment

REGRESSION ANALYSIS:

Numeric independent variables

Descriptive Statistics

	Mean	Std. Deviation	N
Elev. (ft)	31.32	.22	27
Northing (ft)	219574.93	6950.89	27
Easting (ft)	1326680.11	1876.89	27
Latitude (minutes)	35.71	1.14	27
Predominant Wave Fetch (miles)	3.08	.89	27
Longest Wave Fetch (miles)	4.10	.55	27

Correlations

		Elev. (ft)	Northing (ft)	Easting (ft)	Latitude (minutes)	Predominant Wave Fetch (miles)	Longest Wave Fetch (miles)
Pearson Correlation	Elev. (ft)	1.00	.08	-.30	.08	.33	-.11
	Northing (ft)	.08	1.00	.56	1.00	.89	-.59
	Easting (ft)	-.30	.56	1.00	.56	.17	-.02
	Latitude (minutes)	.08	1.00	.56	1.00	.89	-.59
	Predominant Wave Fetch (miles)	.33	.89	.17	.89	1.00	-.59
	Longest Wave Fetch (miles)	-.11	-.59	-.02	-.59	-.59	1.00
Sig. (1-tailed)	Elev. (ft)	.	.34	.06	.34	.05	.30
	Northing (ft)	.34	.	.00	.00	.00	.00
	Easting (ft)	.06	.00	.	.00	.20	.46
	Latitude (minutes)	.34	.00	.00	.	.00	.00
	Predominant Wave Fetch (miles)	.05	.00	.20	.00	.	.00
	Longest Wave Fetch (miles)	.30	.00	.46	.00	.00	.
N	Elev. (ft)	27	27	27	27	27	27
	Northing (ft)	27	27	27	27	27	27
	Easting (ft)	27	27	27	27	27	27
	Latitude (minutes)	27	27	27	27	27	27
	Predominant Wave Fetch (miles)	27	27	27	27	27	27
	Longest Wave Fetch (miles)	27	27	27	27	27	27

Model Summary(b)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.57(a)	.32	.16	.20

a Predictors: (Constant), Longest Wave Fetch (miles), Easting (ft), Predominant Wave Fetch (miles), Northing (ft), Latitude (minutes)
b Dependent Variable: Elev. (ft)

ANOVA(b)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.41	5	.08	1.99	.12(a)
	Residual	.86	21	.04		
	Total	1.27	26			

a Predictors: (Constant), Longest Wave Fetch (miles), Easting (ft), Predominant Wave Fetch (miles), Northing (ft), Latitude (minutes)
b Dependent Variable: Elev. (ft)

Regression analysis between Easting (ft) and OHWM elevation (ft)

Descriptive Statistics

	Mean	Std. Deviation	N
Elev. (ft)	31.32	.22	27
Easting (ft)	1326680.11	1876.89	27

Correlations

		Elev. (ft)	Easting (ft)
Pearson Correlation	Elev. (ft)	1.00	-.30
	Easting (ft)	-.30	1.00
Sig. (1-tailed)	Elev. (ft)	.	.06
	Easting (ft)	.06	.
N	Elev. (ft)	27	27
	Easting (ft)	27	27

Model Summary(b)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.30(a)	.09	.05	.21

a Predictors: (Constant), Easting (ft)
b Dependent Variable: Elev. (ft)

ANOVA(b)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.11	1	.11	2.47	.13(a)
	Residual	1.15	25	.05		
	Total	1.27	26			

a Predictors: (Constant), Easting (ft)
b Dependent Variable: Elev. (ft)

Coefficients(a)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	78.052	29.75		2.62	.01
	Easting (ft)	.000	.00	-.300	-1.57	.13

a Dependent Variable: Elev. (ft)

Regression analysis between Northing (ft) and OHWM elevation (ft)

Descriptive Statistics

	Mean	Std. Deviation	N
Elev. (ft)	31.32	.22	27
Northing (ft)	219574.93	6950.89	27

Correlations

		Elev. (ft)	Northing (ft)
Pearson Correlation	Elev. (ft)	1.00	.08
	Northing (ft)	.08	1.00
Sig. (1-tailed)	Elev. (ft)	.	.34
	Northing (ft)	.34	.
N	Elev. (ft)	27	27
	Northing (ft)	27	27

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.08(a)	.01	-.03	.22

a Predictors: (Constant), Northing (ft)

ANOVA(b)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.01	1	.01	.17	.69(a)
	Residual	1.26	25	.05		
	Total	1.27	26			

a Predictors: (Constant), Northing (ft)
b Dependent Variable: Elev. (ft)

Coefficients(a)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	30.754	1.390		22.131	.000
	Northing (ft)	.000	.000	.082	.410	.685

a Dependent Variable: Elev. (ft)

Tabulated Data

Site Number	Segment	Name	King County Parcel Number	OHWM Elevation (ft)	Northing (ft)	Easting (ft)	Latitude (minutes)	Predominant Wave Fetch (miles)	Longest Wave Fetch (miles)	Longest Wave Fetch (Direction)	Shoreline Gradient	Bulkheaded Shoreline	Vegetated Shoreline
1	1	Photakis	743050-0009	31.013	231380.302	1331222.410	37.64	3.94	3.94	s	steep	partial	partial
2	1	Payne	743050-0116	31.585	230337.742	1330936.960	37.47	3.74	3.74	s	steep	full	none
3	1	Haradas	743050-0275	30.906	228968.461	1330083.918	37.26	3.51	3.51	s	steep	full	none
4	1	Heberling	743050-0340	31.184	228518.839	1329592.880	37.17	3.43	3.43	s	shallow	full	partial
5	1	Selset, R.	743050-0502	31.367	227644.194	1328368.706	37.06	4.39	4.39	sse	moderate	full	partial
6	1	Bohman	362505-9090	31.666	226792.760	1327551.081	36.90	4.28	4.28	sse	moderate	full	partial
7	1	Smith	362505-9056	31.571	225994.644	1326508.574	36.76	4.16	4.16	sse	steep	none	none
8	1	Wery	362505-9114	31.686	225026.908	1325843.794	36.63	4.11	4.11	sse	moderate	partial	full
9	1	Spady	362505-9008	30.957	224389.665	1325602.040	36.49	4.02	4.02	sse	shallow	full	none
10	2	Hillier	362505-9038	31.499	223487.716	1325018.942	36.31	3.88	3.88	se	shallow	partial	partial
11	2	Howard	752490-0050	31.139	222482.962	1325263.925	36.18	3.53	3.53	se	shallow	full	partial
12	2	Brown	925390-0047	31.291	221901.415	1325416.730	36.10	3.43	3.43	se	steep	full	none
13	2	Dunlop	925390-0180	31.467	220519.490	1325622.797	35.81	3.32	3.32	se	moderate	none	partial
14	2	Ghassemikia	925390-0271	31.503	219409.700	1325399.137	35.68	3.26	3.26	se	steep	full	none
15	2	Camden	925390-0350	31.529	218421.626	1325255.833	35.53	3.10	3.56	nne	steep	none	partial
16	2	Keenholts	122405-9094	31.348	216604.960	1325366.509	35.21	2.94	3.92	nne	steep	full	none
17	2	Reece	122405-9126	31.225	215291.021	1325280.556	35.00	2.85	4.18	nne	shallow	full	none
18	2	Seel	194970-0075	31.359	214132.452	1324867.474	34.83	2.84	3.42	ne	shallow	none	none
19	3	Norelius	945130-0020	31.613	213567.542	1324953.985	34.72	2.76	4.51	nne	moderate	full	none
20	3	Anderson	122405-9133	31.224	212638.108	1325205.456	34.58	2.69	4.63	nne	steep	full	none
21	3	Layton	122405-9135	31.481	212280.925	1325565.894	34.50	2.58	4.70	nne	moderate	partial	partial
22	3	Bond	440660-0020	31.377	211746.265	1326022.757	34.43	2.34	4.77	nne	shallow	full	none
23	3	Olsen	804370-0005	31.194	211590.931	1326446.746	34.40	1.72	4.79	n	steep	none	partial
24	3	McDonald	804370-0025	31.057	211502.247	1326691.186	34.38	1.69	4.81	n	steep	full	none
25	3	Sambica	804370-0400	31.186	211429.710	1326926.014	34.36	1.62	4.83	n	shallow	full	partial
26	3	Kramer	804370-0310	31.134	211300.470	1327337.037	34.34	1.59	4.83	n	moderate	full	none
27	3	Frese	182406-9163	31.169	211161.947	1328011.660	34.33	1.47	4.84	n	steep	full	partial