Blue Point Recession Study 2004
St. Clair Region Conservation Authority

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Executive Summary

There is an ongoing need to monitor and assess Great Lakes shorelines to update and develop policies to protect loss of life and property from erosion. With the support of the municipality of Plympton-Wyoming, this study was initiated by the St. Clair Region Conservation Authority (SCRCA) to update recession rates for the Blue Point area. The study area is a point of land on Lake Huron known as Blue Point, between Sarnia and Hillsboro Beach. This part of the shoreline has the highest erosion rates in the SCRCA area of jurisdiction.

Lake Huron shoreline monitoring began in this area in the 1970's, with a shore damage survey conducted by Environment Canada (Boulden, 1975). The most recent shoreline study was conducted in 1991 by F.J. Reinders and Associates Canada Limited and Geomatics International. Past studies have found that the recession rate along the Blue Point shoreline is generally high at > 0.6 meters a year.

This study used Global Positioning System (GPS) technology to collect accurate positions of Top of Bank, Toe of Bank and Water Line. This data was compared with 1993 data to formulate an annual recession rate for the 11 year period from 1993 to 2004, all within a Geographic Information System (GIS). Using the results of the previous Reinders/Geomatics study, a long term recession rate was computed for the 1935-2004 period.

The results of this study indicate that the top of bluff and toe of bluff continue to recede. Recent low lake levels have reduced the toe of bluff erosion. However, looking at the top of bluff recession in the last 11 years the bluff is still undergoing substantial erosion. This conforms to the natural processes of shoreline erosion. Following high lake levels (mid 90's) and high toe erosion rates, the bluff will naturally recede over a period of time to achieve a more stable slope. This results in bluff movement and top of bluff recession (to achieve this more stable angle). The majority of the bluff is classified as high hazard with a less severe bluff erosion classification at and within close proximity to the point.

Based on the revised recession rates, and 2004 toe of bluff; the stable slope allowance and erosion hazard limit have not changed substantially. It is the recommendation of this Authority that the slight revision does not warrant re-mapping.

1.0 Introduction

1.1 Background /Rationale

Natural shoreline processes and changing lake levels on Lake Huron can result in severe erosion. The risk to property owners and public infrastructure can be high. There is an ongoing need to monitor and assess Great Lakes shorelines to update and develop policies to protect loss of life and property from erosion. Past studies on the shoreline have recommended that future development be directed away from eroding shorelines. This is the most proactive approach.

Lake Huron shoreline monitoring began in this area in the 1970's, with a shore damage survey conducted by Environment Canada (Boulden, 1975). The most recent shoreline study was conducted in 1991 by F.J. Reinders and Associates Canada Limited and Geomatics International. This study was a comprehensive look at the Lake Huron Shoreline from Sarnia to Hillsboro beach. This study compared 1989 aerial photography with 1935 Ontario Land Survey Mapping to determine long-term recession rates and erosion hazard lines. These calculations and delineated areas were accepted and included in the St. Clair Region Conservation Authority Shoreline Management Plan, a document used to direct and guide development. The Shoreline Management Plan (SMP) is a reference document for the shoreline municipalities, landowners and the public to understand the natural processes shaping the shoreline and make informed decisions. The SMP has been incorporated into municipal official plan and zoning by-law documents. Within the SMP, it is recommended that future development be directed away from eroding shorelines.

Figure A - Blue Point Bluff Erosion 1973 - St. Clair Conservation Authority

This report has been initiated by the St. Clair Region Conservation Authority to update recession rates for the Blue Point area. Landowners in the Blue Point area expressed a need for more up to date monitoring data. The existing recession rates were calculated based on 1935-1989 data. Recent low lake levels (1998-2004) has led to less erosion at the toe of the bluff in Blue Point and as such this study will determine if the long term top of bluff annual recession rate has significantly changed.

1.2 Objectives

The objectives of the Blue Point Recession Review Study were to:

1. Develop a repeatable and reliable methodology to determine top of bluff and toe of bluff recession.

2. Compile this data with the recession rates published in the Lake Huron Shoreline Erosion Hazard Delineation Study (1991), to determine an average annual long term recession rate for a 65 year period.

3. Follow the 1991 study criteria in dividing the area into uniform blocks (sections of shoreline) by which erosion hazard areas and stable slope allowance can be defined and compared to the 1991 shoreline study results.

4. Determine the beach limit (water level) and compare this delineation with that determined from the 1989 air photos.

5. Present maps to identify the top of bluff, toe of bluff, water level change and updated 100 year erosion hazard areas.

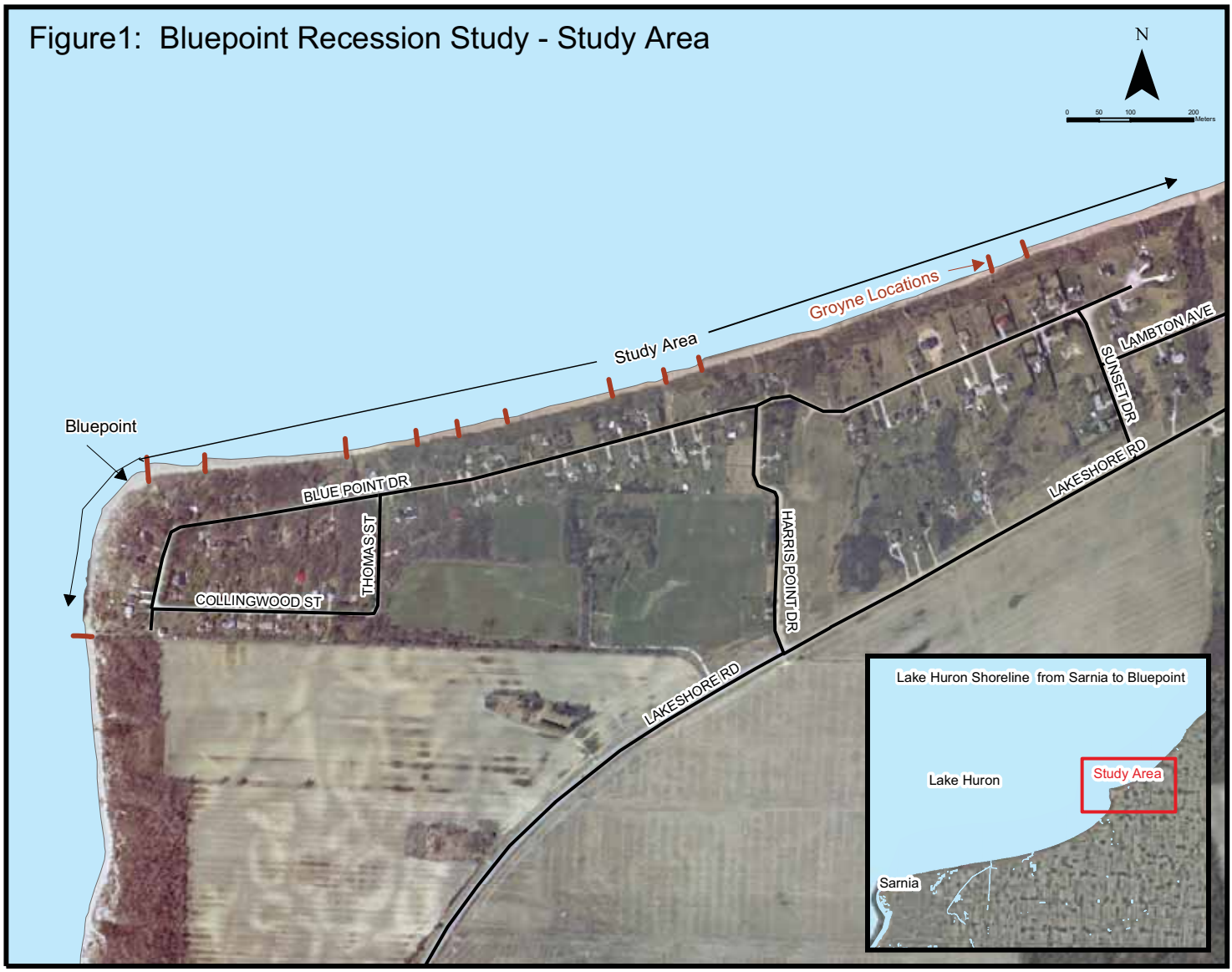
6. Note shoreline protection structures and shoreline vegetation through in-field investigation

1.3 The Study Area

The study area is a point of land on Lake Huron known as Blue Point, between Sarnia and Hillsboro Beach. It is a 2 km length of shoreline and is depicted on the attached map (Figure 1). Two shoreline residential communities are situated in the study area: Blue Point and Sunset Acres.

This part of the shoreline is subject to the highest erosion rates in the SCRCA area of jurisdiction. The bluff base and nearshore lake bottom consists of St. Joseph till, a more erodible glacial deposit than that found at the point. At the point itself, the nearshore lake bottom consists of a stony till shelf that protects and created the point of land (W.F.B. and Associates, Coastal, Engineers, Ltd, 1992). The orientation of the shoreline in the study area is to the northwest and as such is exposed to wave action generated by winds blowing over the entire north-south of the lake. This is illustrated in Figure 1.

Figure1: Bluepoint Recession Study - Study Area



The shoreline in this area consists of newer and established residences (both cottages and permanent homes). There are shoreline protection structures (groynes and seawalls) throughout the study area.

Figure B - Blue Point Subdivision 1990 –St. Clair Region Conservation Authority

2.0 Methodology

2.1 Recession/Accretion Rate Determination

Recession rates were determined by comparing shoreline positions- one recent, one historical. With the advent of the widespread use of GIS (Geographical Information Systems), this process has become increasingly simpler. GIS facilitates more accurate and reliable analysis of the data. The GIS used was ESRI's ArcGIS , using ARCMap functionality. Recession distances, compiled and processed by GIS analysis, are transformed into annual recession rates using the number of years the comparison spans. Discussions of the methodology used to gather and compare two years of shoreline position are as follows.

2.1.1 2004 Data

The 2004 top of bluff, toe of bluff and waterline were determined using a Global Positioning System (GPS). The GPS unit used was a Trimble AgGPS 132 DGPS. GPS technology uses satellites to calculate positions on the earth's surface. In brief, a GPS receiver uses radio waves, and by measuring the precise time it takes for these waves to travel from the satellites to the GPS receiver, locations on the earth's surface can be obtained. The GPS used for this study was accurate to within less than a meter (0-99 cm). A minimum of three satellites are needed to determine an accurate location on the

earth. For a GPS receiver to 'receive' a signal from a satellite, that satellite must be in an orbit that the GPS can pick up. GPS is therefore dependent on the position on the satellites relative to the position of the GPS receiver.

In July of 2004, point locations (x,y coordinates) as well as z values (height) were obtained and logged to the GPS unit at approximately every 3 meters. The best results (ie. three or more satellites were in an orbit from which the GPS could receive a signal) were obtained after 12:00 noon. Data collection of the GPS locations was obtained by walking the Top of Bluff, Toe of Bluff and Water Line while holding the GPS receiver and continuously logging points to the GPS at approximately every 3 meters. This data was downloaded into the GIS as ESRI shapefiles. Within the GIS, the point locations were made into linear features using ArcMap functionality. At this stage, three lines; top of bluff, toe of bluff and beach/water interface were now available for comparison to the historical data.

2.1.2 Historical Data

The historical data utilized was 0.5 meter contour lines of the geographic Township of Plympton shoreline. The contours were produced by MIG Consulting Engineers from 1993 aerial photos for the purpose of sewer infrastructure. It was necessary to derive the toe and top of bluff from the MIG contours. According to Ministry of Natural Resources guidelines these features refer to the nearshore break in slope and the first landward break in slope respectively. Figures 2 and 3 illustrate the top and toe of bank delineated from the 0.5 m contours. The toe and top of bluff derived from the MIG 0.5 meter contours were the lines used to determine a recession rate for the purpose of this study. The beach/water interface delineation was taken from the Flood Damage Reduction Program (FDRP) maps, dating back to 1989, and corresponds with the water line shown on the FDRP maps.

2.1.3 Calculation of Recession/Accretion Rates for the 1993-2004 Period

Utilizing the 1993 and 2004 shoreline position, the Conservation Authority compared this data to define and update a new recession rate. Similar to the methodology within the 1991 Reinders/Geomatics study, points were used at approximately 50 meter intervals along the shoreline. At each point, the distance between the two years of shoreline features was measured. However, within the Reinders/Geomatics study there is no explanation of the angle/orientation of measurement between the points and the features. Thus, to obtain repeatable and reliable results, transect lines were created from the point locations already established at a perpendicular angle to the shoreline. ArcMap tools enable a line to be created perpendicular to a selected feature. The transect lines can be seen in Figure 4.

Once the transect lines were created, the method used to calculate the recession distances was straightforward. Measurements were taken along the transect line between the 1993 bluff base and bluff top as well as the 1989 beach and the 2004 bluff base, bluff top and beach. The results are found in Tables 1,2 and 3. In these tables, the "Reach" column identifies a particular segment of shoreline as established during Phase 1 of the Great

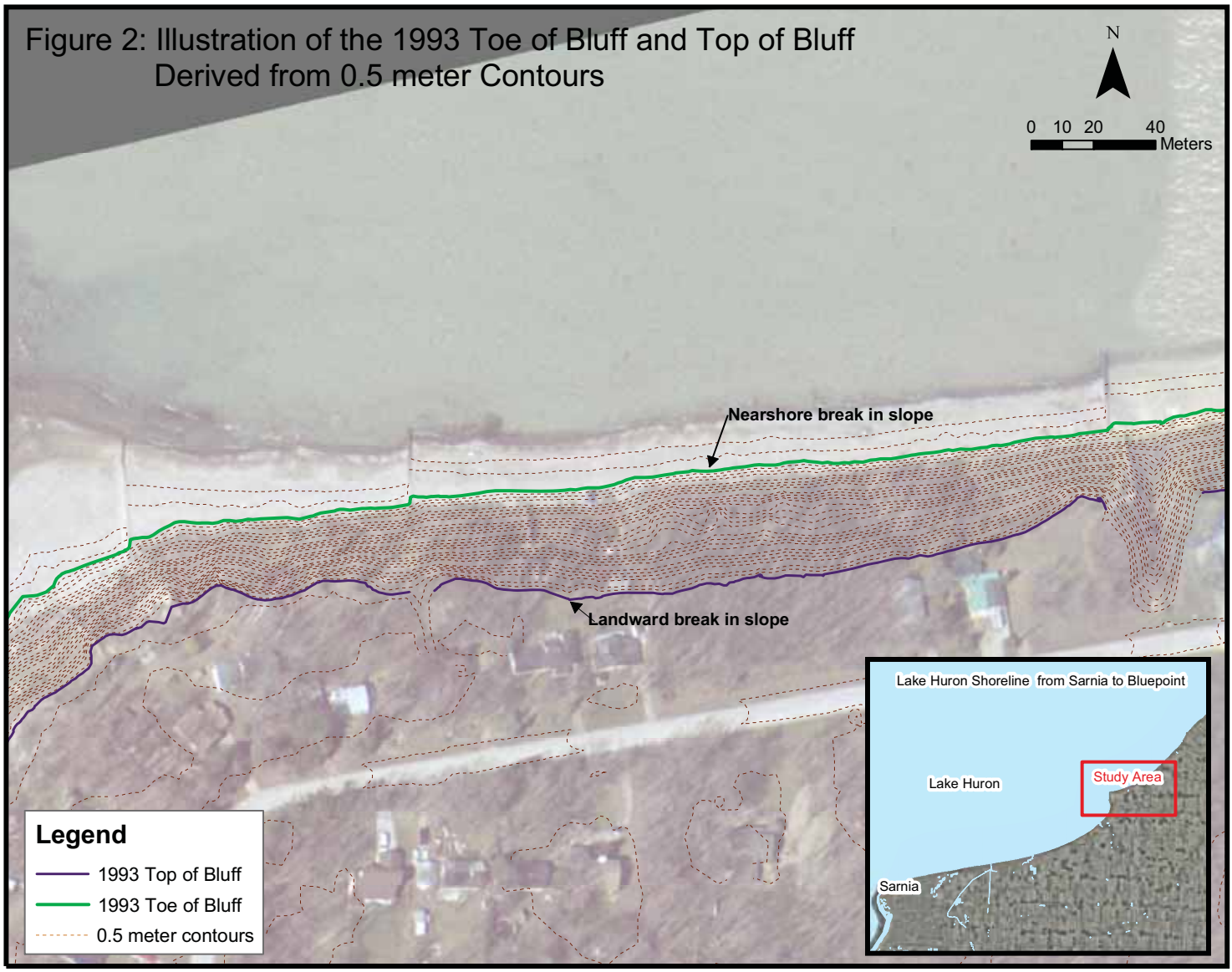
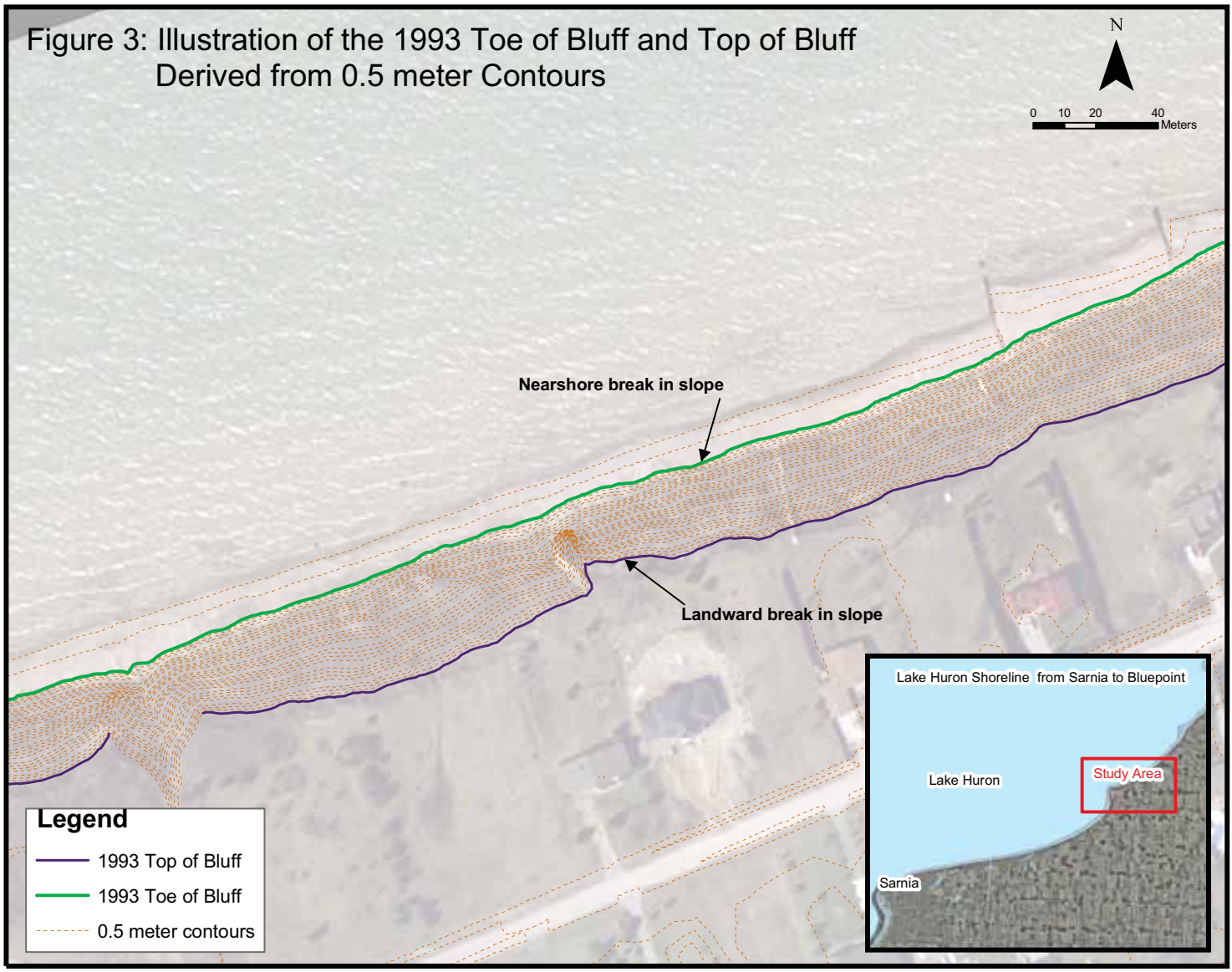


Figure 2: Illustration of the 1993 Toe of Bluff and Top of Bluff
Derived from 0.5 meter Contours
N
0 10 20 40
Meters
Nearshore break in slope
Landward break in slope
Lake Huron Shoreline from Sarnia to Bluepoint
Lake Huron
Study Area
Sarnia
Legend
1993 Top of Bluff
1993 Toe of Bluff
0.5 meter contours

Figure 3: Illustration of the 1993 Toe of Bluff and Top of Bluff Derived from 0.5 meter Contours



Lakes Water Level Reference Study. The reaches represent segments of shoreline that exhibit similar traits in terms of physiography. The Study area lies in part within reaches 575 and 574 (Reinders/Geomatics, 1991). The average annual recession/accretion rates for bluff top and base is the total variation in shoreline measurement in meters, divided by 11 years (2004-1993). Figures 4, 5, and 6 illustrate the top of bank recession, toe of bank recession and shoreline change respectively.

In the 1991 study by Reinders/Geomatics, each shoreline was further divided into 'blocks' which represent areas with relatively similar characteristics such as bluff height and recession rates. These same block divisions were used for this study to facilitate a comparison between the two studies. The blocks are illustrated in Appendix 1. The calculations discussed below within the erosion hazard section; stable slope allowance, erosion hazard limits and 30 meter policy setback were then calculated for each block.

2.1.4 New Recession Rates 1935-2004

It is generally recognized that recession rates should be obtained from the longest reliable record available (Reinders/Geomatics, 1991). In an attempt to determine long term recession rates, the recession findings from this study were combined with the recession distances found in the Reinders/Geomatics study. The results are found in Table 4. In this table, the first two columns are the recession distances in meters, as determined from each study. The next column identifies the average annual recession rate for the 65 year time period that the two studies spanned (54 years + 11 years). To calculate this number, the 1935-1989 years movement was added with the 1993-2004 years movement to get the total movement. This total was then divided by the number of years reported on in the two studies (54 + 11) to obtain an average annual recession rate for these years. The annual recession rate was then averaged for each block and reported in the final column of Table 4.

2.2 Erosion Hazard Determination

Erosion Hazard Limits define the limit of lands that are unsafe for development due to naturally occurring processes of erosion. The Erosion Hazard Limit attempts to delineate the areas undergoing loss of land and which may pose a threat to life and property from erosion processes (Shoreline Management Plan, 1996). Erosion hazard setbacks were determined using the 1935-2004 annual average recession rates.

Great Lakes Shoreline Erosion Hazard Lines are defined by the Ministry of Natural Resources (MNR), within their Provincial Policy Statement (1997) as being the greater of:

a) The stable slope allowance, plus 100 times the average annual recession; measured landward form the base of the bluff;

b) The stable slope allowance, plus 30 meters, measured landward from the base of the bluff; or

c) 30 meters measured landward form the top of the bluff.

Thus, in order to determine the erosion hazard delineation further calculations of stable slope allowance, 100 yr recession rate, and the equations outlined in the above mentioned policy statement need to be computed. The methods and descriptions of these computations are below.

2.2.1 Stable Slope Allowance

In areas of bluff shoreline the stable slope allowance is the area of crest formation after a stable slope has formed (Reinders/Geomatics, 1991)

For this study area, the stable slope allowance was calculated by taking the average bluff height of each block multiplied by 3. The stable slope allowance is measured landward from the toe of the bluff. This method for determining the stable slope allowance was used by Reinders/Geomatics (1991) and was taken from the Provincial Flood and Erosion Policy which states that;

"In the absence of studies using accepted geotechnical principles, allowance to achieve stable slope shall be defined as a horizontal setback equivalent to 3.0 times the difference in elevation between the first lakeward break in slope and the nearshore break in slope, measured landward from the toe (base) of the existing bluff."

2.2.2 Bluff Height Determination

Bluff Heights were determined using the 1993 contours. As described previously, the top of bluff was derived from the contours as the first landward break in slope while the toe of bluff is the nearshore break in slope. The elevation of these contour lines was used to determine bluff height. The average bluff height for each block was determined and reported in Table 5.

2.2.3 Erosion Hazard Calculation

The purpose of Table 5 is to determine the erosion hazard limit. The table consists of all the preliminary values which are needed to determine the erosion hazard limit. The annual recession rate and the average annual recession rate (meters/year) for each block are in columns 4 and 5. These were first reported in Table 4. The column headed "100yr Rec. rate" holds the values for 100 years of recession. The bluff height and stable slope allowance (3x bluff height) are presented in the next columns. The subsequent columns are the calculations needed to determine the erosion hazard limit as described in the MNR policy statement. They are simply named policy 1 and policy 2 where the greater of the two is reported under the column Erosion Hazard Limit

2.2.4 Erosion Hazard Mapping

For each measurement point (transect line), the stable slope allowance and the erosion hazard limit (bluff h *3 +100yrrr or bluff h*3 + 30 m, whichever was greater) were plotted. In addition to this, the third policy setback line (30 m from the top of bluff) was plotted to ensure that this line was not the greater of the setbacks. Erosion Hazard mapping (Figure 7) illustrates the 2004 erosion hazard limit compared with the erosion hazard limit derived in Reinders/Geomatics study. Figure 8 depicts the stable slope allowance determined in this study.

3.0 Results

3.1 Top of Bluff Changes

The 2004 top of bluff position presented a recession at each measurement location with the exception of transect 590. See map (figure 4) for an illustration of the recession.

The average annual recession rates in the 1993-2004 year period for each block range from -0.341 meters to -0.426 meters. This represents a moderate erosion hazard classification (Shoreline Policy Statement, 1993). Comparing these findings to the recession rates developed by Reinders/Geomatics, one can deduce short term trends that are occurring within the study area. For transects 583-586, all had significantly higher recession rates in the last 11 years. In the spring of 2004, a 1:100 year rain event caused extensive bank erosion in the location of transects 583-586 (Pers. Comm. Landowners). The bulk of the rain fell between 18:00 hours on May 22 and 18:00 hours on May 23 with an approximate total of 104.5 mm(St. Clair Conservation Authority, 2004).

Comparing Block 2, transects 587-590, the average annual recession rates for this block were very similar across the two studies. On the other hand, block three and four (transects 591-608 and 609-618) showed a lower average annual recession rate in the last 11 years compared with the average annual recession rate from 1935-1989. This is illustrated in Table 6 (columns 1 and 3).

Top of bluff long term recession rates (1935-2004) are very similar to Reinders/Geomatics study for 1935-1989 annual recession. The table below (Table 6), column 1 and 2, illustrates these results.

Table 6 Comparison of the Average Annual Recession Rates for each block between two studies

	Reinders/Geomatics 1935-1989 Average Annual Recession Rate (1)	SCRCA's 1935-2004 Average Annual Recession Rate (2)	1993-2004 Average Annual Recession Rate (3)
Block 1 *(transects 583-586)	-0.137	-0.183	-0.409
Block 2 (transects 587-590)	-0.396	-0.4	-0.426
Block 3 (transects 591-608)	-0.663	-0.612	-0.341
Block 4 (transect 609-618)	-0.782	-0.714	-0.407

*adjusted average annual recession rate to include only transects 583-586 as transect 583 was the start of the limit of the 2004 study

Figure C- Bank slumping in Block 1 (transects 583-586) Personal communication with landowners revealed that a 2004 rain event caused extensive top of slope sloughing 2004- St. Clair Region Conservation Authority

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According to Table 6, the 1935-2004 average annual recession is in the range of -0.183 to -0.714 meters. The majority of the bluff (blocks 3 and 4 span more than half the study area) falls within the high hazard classification with the recession ranging from 0.61-0.71 m/yr. The previous survey found the average annual recession was slightly higher at .66- 0.78 m/yr , and also fell within the high hazard classification. Hazard classification is a means of addressing the erosion hazard using a range of recession rates (Shoreline Policy Statement, 1993). The technical guidelines are as follows:

Erosion Hazard Classification	**Recession Rate (Meters/ Year)**
Stable of accreting	(-) to 0.0
Low	0.0 to 0.3
Moderate	0.3 to 0.6
High	0.6 to 1.2
Very High	1.2 to 2.0
Severe	>2.0

3.2 Toe of Bluff Changes

Overall the toe of bluff in this portion of the shoreline continues to recede. There were only two transect locations where the measurements of bluff change showed accretion- transects 584 and 597. This trend of receding bluff base was also observed in the Reinders/Geomatics study. They found an average overall recession of 28 meters for reach 574 and 7 meters for reach 575. The current study found the toe of bluff erosion to be lowest in block 1(transects 583-586) and highest directly east of the point (transects 587-590) in block 2. By far the greatest toe recession was found to be in the vicinity of transect 587 with a recorded recession distance of 8.25 meters. This significantly high recession record influences the recession average of block 2. Table 7 outlines the toe of bluff recession trend revealed in both studies and the lower recession rate in the last 11 years.

Table 7 Comparison of the Average Toe of Bluff Recession Rates for each block between the two studies

	Reinders/Geomatics 1935-1989 Average Annual Recession Rate (1)	1993-2004 Average Annual Recession Rate (3)
Block 1 *(transects 583-586)	-0.588	-0.038
Block 2 (transects 587-590)	-0.329	-0.490
Block 3 (transects 591-608)	-0.505	-0.231
Block 4 (transect 609-618)	-0.603	-0.138

Figure D- An example of a property located within Block 2 where the toe recession was found to the highest in the study area. Exposed slope, channeling and undercuts at the top of bluff are visible. St. Clair Region Conservation Authority- September 2004

3.3 Water level changes

The Great Lakes water levels fluctuate in irregular cycles according to world wide weather patterns and temperature. Seasonal variations also account for subtle changes in water levels when water is locked up in ice and snow or spring thaw runoff increases. According to Figure 6 the water level is substantially lower in 2004 than in 1989. Naturally, the water level of the lake plays a role in the potential erosion hazard. Higher lake levels result in more damaging wave action causing the toe of the bluff to erode and in turn cause instability throughout the upper portions of the bluff. The Great Lakes system experienced extremely low levels in the late 1920s, mid-1930s and again in the mid-1960s. Extremely high water levels were experienced in the 1870s, early 1950s, early 1970s, mid-1980s and mid-1990s (www.mqtinfo.org/planningeduc0026.asp). The Great Lake levels have been in a low trend since 1998.

3.4 Erosion Hazard Limit

The erosion hazard limit was defined using the greater of:

Policy 1 – stable slope allowance plus the 100 year recession rate, or
Policy 2 – stable slope allowance plus 30 meters

In block 1, policy 2, was the greater, as the lowest recession rate occurs in this locale. However for blocks 2, 3 and 4 policy 1 was the greater and so consequently this number was used to delineate the erosion hazard limit. At no measurement location within the study area was the 30 meter setback from the top of the bluff the greater of the setback limits.

The erosion hazard measurements concluded from this study are slightly less than the hazard measurements from Reinder/Geomatics (1991) study, in the range of 1-5 meters. More accurate bluff height measurements and slight changes in long term recession rates account for the differences in the erosion hazard calculations. The table below (table 8) compares the 1991 study's erosion hazard results to that determined in this study. Figure 7 depicts the comparison between the erosion hazard limit determined in the 1991 study and the new 2004 hazard limit. In this illustration, it is apparent that the erosion hazard limits from the two studies are very similar. Although the erosion hazard distance is less in 2004, the toe of bluff has moved landward and thus the delineated erosion hazard lines are comparable to the 1991 study

Table 8: Erosion Hazard Limit Setbacks between the two studies

	Reinders/Geomatics 1935-1989 Erosion Hazard Limit	1935-2004 Erosion Hazard Limit
Block 1	30 m (from top)	76.5 m (from toe)
Block 2	87.5m (from toe)	86.54 m (from toe)
Block 3	114.3 m (from toe)	109.25 m (from toe)
Block 4	124.6 m (from toe)	120.88 m (from toe)

3.5 Stable Slope Allowance

The stable slope allowance concluded from this study has changed by a maximum of 1.5 meters. Similar to the erosion hazard limit, the change in stable slope allowance reflects a more accurate bluff height measurement and recessional changes in the toe of slope position. Table 9 compares the 1991 study stable slope allowance to that determined in this study. Figure 8 depicts the comparison between the stable slope allowance from the 1991 study and the new 2004 stable slope allowance. In Figure 8, one can observe that the stable slope allowances between the two studies are alike. The minor differences in the stable slope allowance calculations between the studies are offset by the landward movement of the toe of the bluff. This explains why the delineated stable slope allowances are similar.

Table 9:Stable Slope Allowance between the two studies

	Reinders/Geomatics 1935-1989 Stable Slope Allowance	1935-2004 Stable Slope Allowance
Block 1	48	46.5
Block 2	48	46.5
Block 3	48	48
Block 4	48	49.5

3.6 Bluff Vegetation

Notes were taken on vegetation growing on the bluff face. There are portions of the bluff face that are well vegetated with complete vegetation cover over the face of the bluff including grasses, shrubs and trees. Other areas of the bluff are poorly vegetated and have visible rutting and toe erosion. There is no discernible trend between well vegetated slope face and lower recession rates. However the literature confirms that vegetation on the slope face will help to protect the bluff from erosion and retards the natural process of shoreline erosion. The following pictures are examples well vegetated slopes in the summer of 2004.

Figure E - An Example of a well vegetated bluff face
St Clair Region Conservation Authority- September 2004

Figure F -A well vegetated bluff, established with Crown Vetch (*Coronilla varia).*

Figure 5: Toe of Bluff Recession/Accretion
1993-2004

Figure 5: Toe of Bluff Recession/Accretion
1993-2004

Figure 6: Blue Point Recession Study
Water Line difference between 1989 and 2004

Figure 7: Bluepoint Recession Study
Erosion Hazard Limit

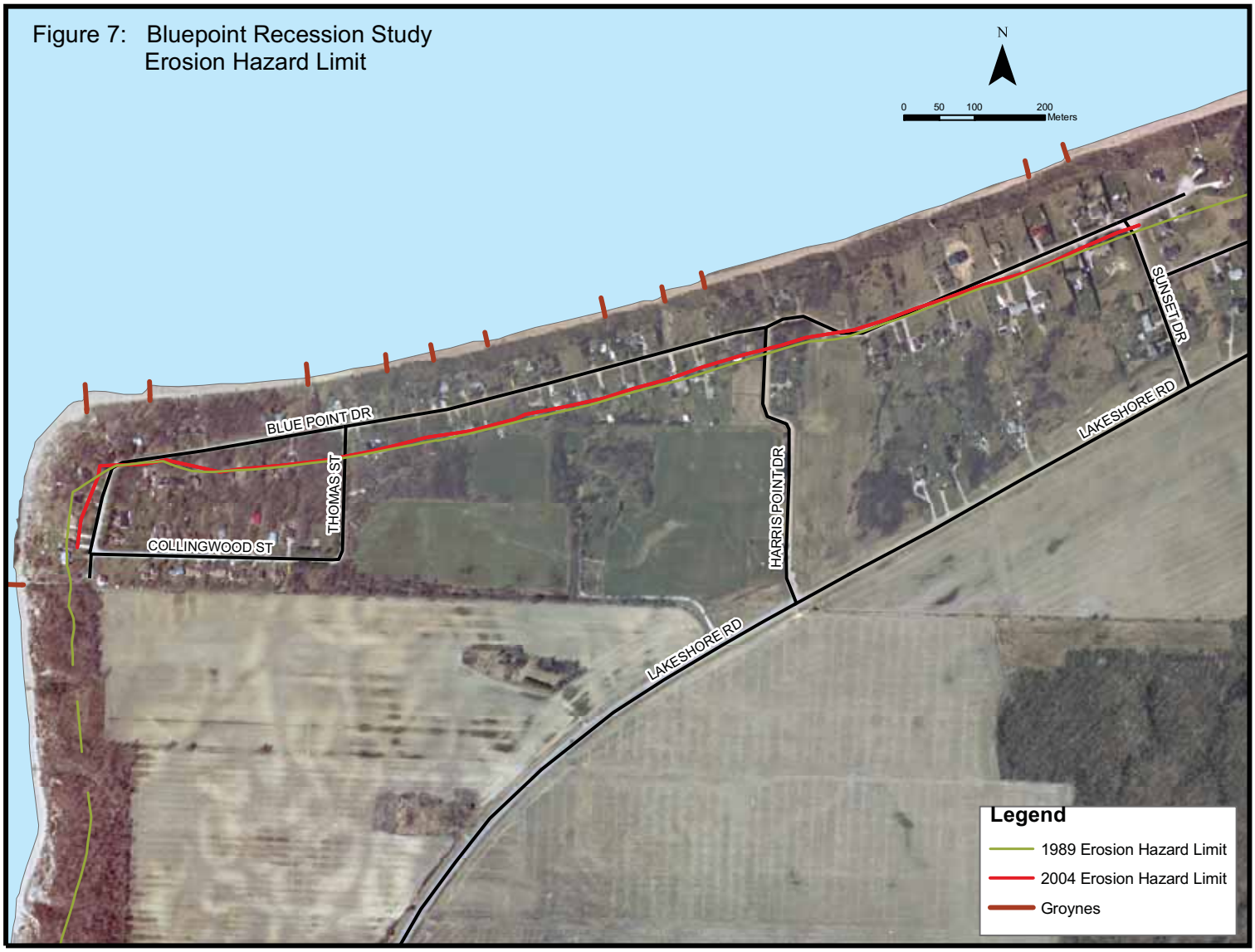
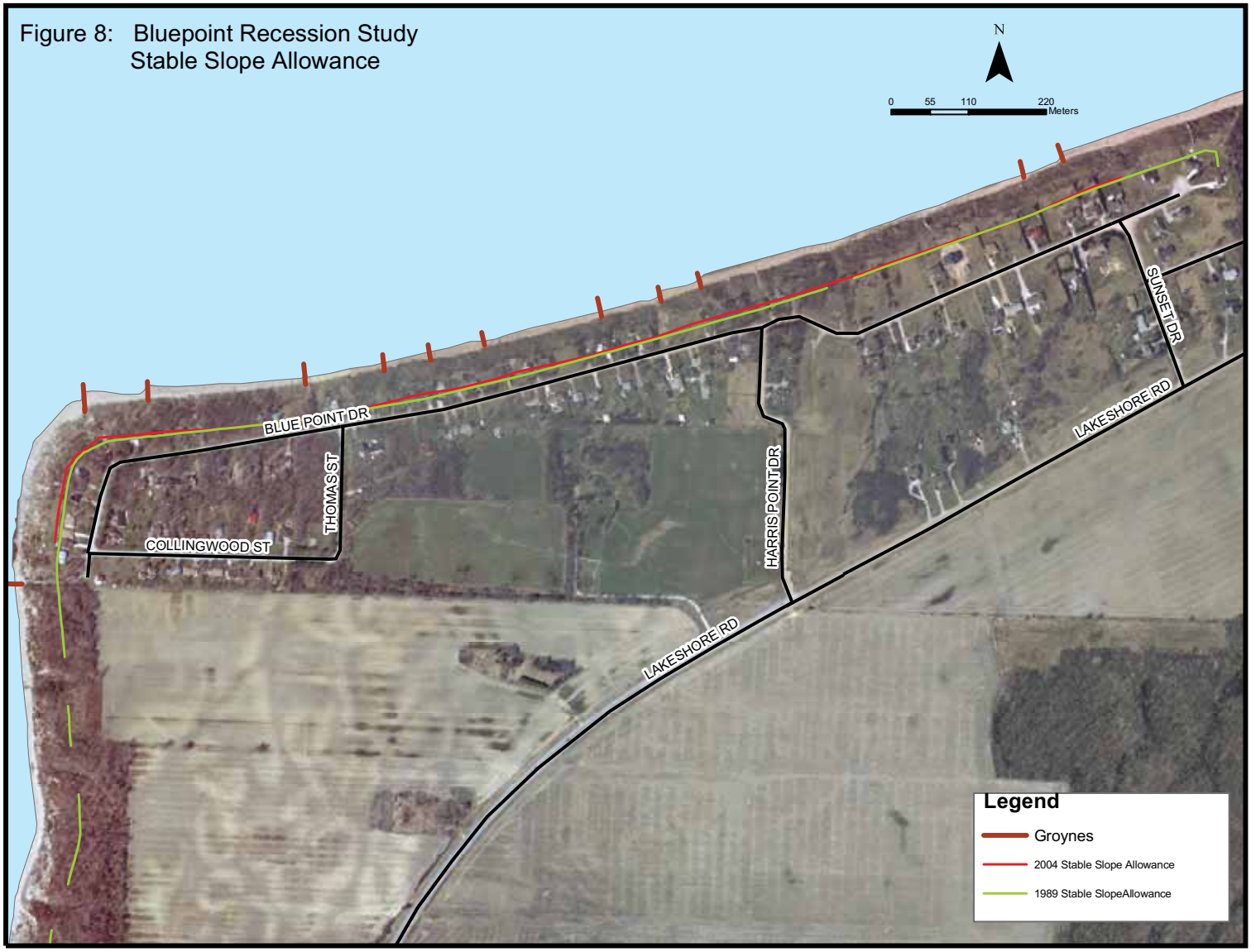


Figure 8: Bluepoint Recession Study
Stable Slope Allowance



4.0 Discussion/Conclusions

This study was initiated to determine a new recession rate for a portion of the Lake Huron shoreline known as Blue Point. The previous recession rate was determined in 1991 in a study by Reinders/Geomatics. As well, this study provides updated erosion hazard limits and stable slope allowances, both regulatory delineations used to protect property and people from retreating shorelines.

The following is a summary of the findings and main trends visible within the study area:

- The top of bluff continues to recede. This study concludes that there has been an increase in the rate of top of bluff recession close to the point and an insignificant change in recession rates throughout the greater part of the study area. For example, at Block 3, the average annual rate of recession dropped from 0.663 m/yr to 0.612 m/yr, a change of 5 centimeters. Block 3 consists of Lake Huron shoreline from 200 m west of Thomas Street to just east of Harris Point Drive. Although there has been an increase in the top of bluff recession within the last 11 years close to the point, the long term recession (1935-2004) is classified as low to moderate hazard classification. East of the point, the majority of the study area is within the high hazard classification.

- Overall the toe of bluff continues to recede. This trend of receding bluff base was also observed in Reinders/Geomatics study. The toe of bluff recession rate is substantially lower in the last 11 years than that determined in the 54 year period from 1935-1989. That said, block 2 showed a slight increase in the rate of recession in the last 11 years however a high recession record at transect 587 influenced the block average.

- GPS technology is an accurate and efficient method of updating site specific shoreline survey data. Landowner permission is required to access private property.

In summary, recent low lake levels have reduced the toe of bluff recession. However, looking at the top of bluff recession in the last 11 years the bluff is still undergoing substantial erosion. This conforms to the natural processes of shoreline erosion. Following high lake levels (mid 90's) and high toe erosion rates, the bluff will naturally recede over a period of time to achieve a more stable slope. This results in bluff movement and top of bluff recession (to achieve this more stable angle). The majority of the bluff is classified as high hazard with less severe bluff erosion classification at, and within close proximity to, the point.

5.0 Recommendations

Based on the revised recession rates and 2004 toe of bluff, the erosion hazard limit and stable slope allowance have not changed substantially. The slight revision does not warrant re-mapping. The Conservation Authority advises that the erosion hazard limit delineation and the stable slope allowance delineation determined in 1991 remain in the municipal planning documents.

6.0 References

Boulden, R.S. , 1975. Ontario Great Lakes Shore Damage Survey, Technical Report. Environment Canada – Ontario Ministry of Natural Resources.

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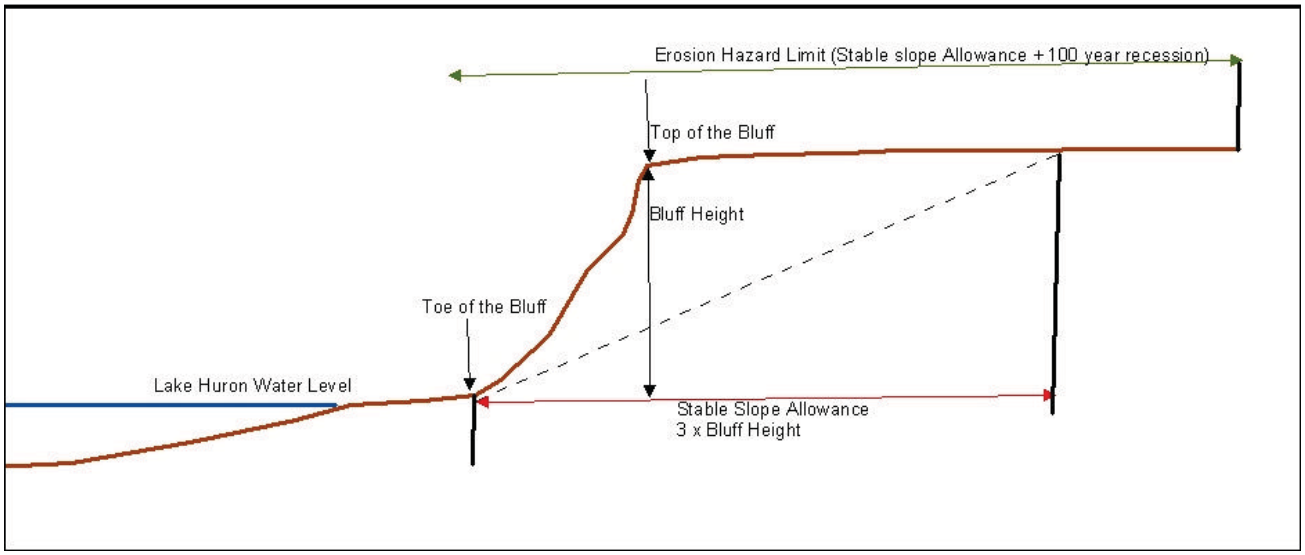
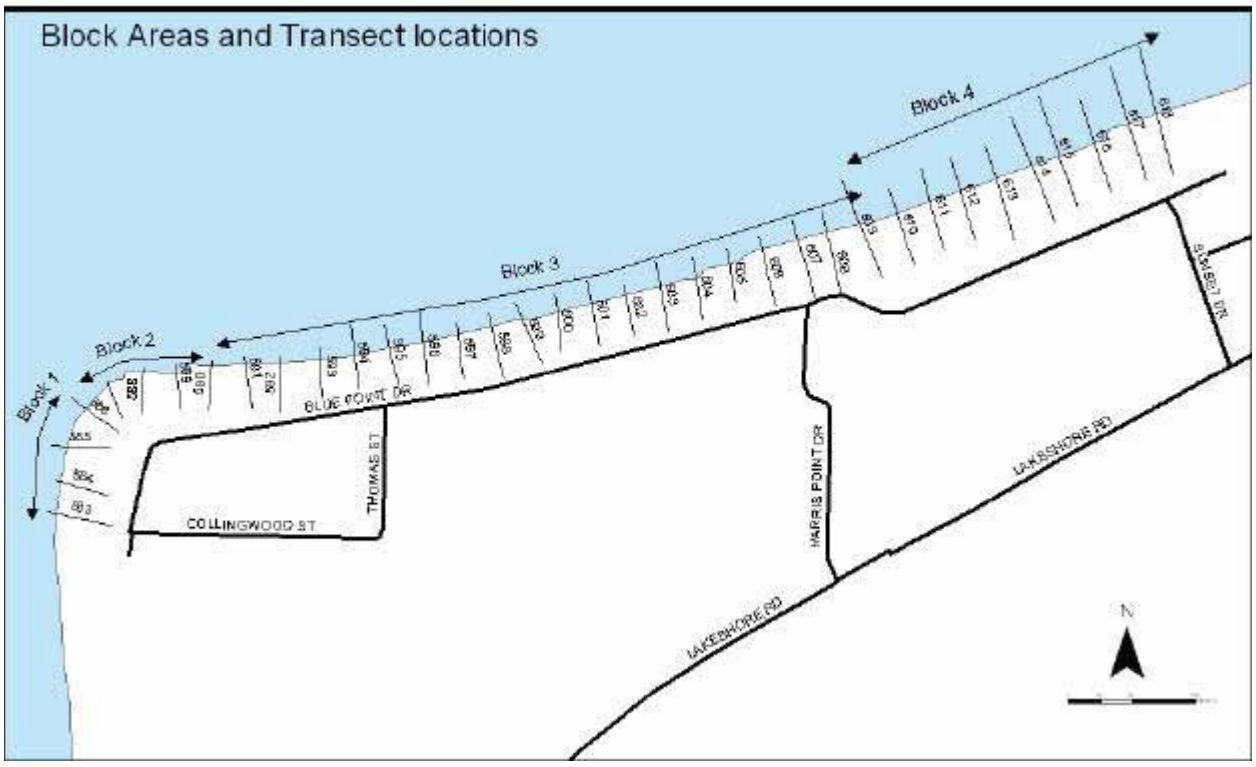
Appendices

Appendix I – Glossary
Appendix II - Top of Bluff, Toe of Bluff and Shoreline Recession/Accretion Data Tables

Appendix I – Glossary

Shoreline Features -Schematic diagram showing the Shoreline Features and Hazard Zones





Appendix II -Top of Bluff, Toe of Bluff and Shoreline Recession/Accretion Data Tables

Table 1: Top of Bank Recession/ Accretion 1993-2004

Reach	Block	Transect Number	Rec/Acc Distance (Meters)	Annual Average Rec/Acc	Average Annual Rec/Acc for each block
575	1	583	-3.664	-0.333	-0.409
575	1	584	-3.089	-0.281	-0.409
575	1	585	-6.015	-0.547	-0.409
575	1	586	-5.217	-0.474	-0.409
574	2	587	-7.889	-0.717	-0.426
574	2	588	-6.905	-0.628	-0.426
574	2	589	-7.007	-0.637	-0.426
574	2	590	3.070	0.279	-0.426
574	3	591	-1.377	-0.125	-0.341
574	3	592	-2.971	-0.270	-0.341
574	3	593	-3.445	-0.313	-0.341
574	3	595	-2.734	-0.249	-0.341
574	3	596	-3.814	-0.347	-0.341
574	3	597	-3.856	-0.351	-0.341
574	3	598	-1.154	-0.105	-0.341
574	3	599	-3.169	-0.288	-0.341
574	3	600	-5.990	-0.545	-0.341
574	3	601	-3.151	-0.286	-0.341
574	3	602	-6.528	-0.593	-0.341
574	3	603	-3.566	-0.324	-0.341
574	3	605	-4.623	-0.420	-0.341
574	3	606	-2.024	-0.184	-0.341
574	3	607	-7.008	-0.637	-0.341
574	3	608	-4.676	-0.425	-0.341
574	4	609	-7.019	-0.638	-0.407
574	4	610	-3.092	-0.281	-0.407
574	4	611	-6.078	-0.553	-0.407
574	4	612	-5.098	-0.463	-0.407
574	4	613	-5.695	-0.518	-0.407
574	4	614	-6.040	-0.549	-0.407
574	4	615	-1.074	-0.098	-0.407
574	4	616	-4.481	-0.407	-0.407
574	4	617	-3.016	-0.274	-0.407
574	4	618	-3.190	-0.290	-0.407

Table 2: Recession and Accretion Rate Data for Toe of Bank 1993-2004

Reach	Block	Transect	Rec/Acc Distance (Meters)	Average Annual Rec/Acc	Average annual Rec/Acc for each block
575	1	583	-1.913	-0.174	-0.038
575	1	584	1.952	0.177	-0.038
575	1	585	-0.608	-0.055	-0.038
575	1	586	-1.104	-0.100	-0.038
574	2	587	-8.255	-0.750	-0.490
574	2	588	-3.132	-0.285	-0.490
574	2	589	-4.509	-0.410	-0.490
574	2	590	-5.662	-0.515	-0.490
574	3	591	-5.418	-0.493	-0.231
574	3	592	-5.022	-0.457	-0.231
574	3	593	-3.957	-0.360	-0.231
574	3	594	-4.930	-0.448	-0.231
574	3	595	-3.652	-0.332	-0.231
574	3	596	-1.491	-0.136	-0.231
574	3	597	0.281	0.026	-0.231
574	3	598	-3.475	-0.316	-0.231
574	3	599	-3.183	-0.289	-0.231
574	3	600	-0.078	-0.007	-0.231
574	3	601	-1.880	-0.171	-0.231
574	3	602	-1.913	-0.174	-0.231
574	3	603	-2.339	-0.213	-0.231
574	3	604	-2.807	-0.255	-0.231
574	3	605	-0.230	-0.021	-0.231
574	3	606	-1.040	-0.095	-0.231
574	3	607	-2.391	-0.217	-0.231
574	3	608	-2.229	-0.203	-0.231
574	4	609	-0.810	-0.074	-0.138
574	4	610	-1.354	-0.123	-0.138
574	4	611	-0.591	-0.054	-0.138
574	4	612	-1.572	-0.143	-0.138
574	4	613	-0.757	-0.069	-0.138
574	4	614	-2.032	-0.185	-0.138
574	4	615	-2.438	-0.222	-0.138
574	4	616	-2.479	-0.225	-0.138
574	4	617	-2.248	-0.204	-0.138
574	4	618	-0.941	-0.086	-0.138

Table 3: Shoreline Change 1989-2004

Reach	Transect	Shoreline Change(meters)	Rec/Acc
575	583	1.733	accetion
575	584	2.524	accetion
575	585	2.547	accetion
575	586	9.422	accetion
574	587	17.992	accetion
574	588	8.823	accretion
574	589	10.729	accretion
574	590	9.082	accretion
574	591	7.678	accretion
574	592	5.421	accretion
574	593	4.170	accretion
574	594	12.512	accretion
574	595	10.723	accretion
574	596	11.570	accretion
574	597	8.683	accretion
574	598	7.094	accretion
574	599	7.446	accretion
574	600	2.756	accretion
574	601	0.820	accretion
574	602	-0.854	recession
574	603	9.651	accretion
574	604	9.037	accretion
574	605	4.560	accretion
574	606	1.682	accretion
574	607	1.418	accretion
574	608	-0.019	recession
574	609	-1.116	recession
574	610	2.196	accretion
574	611	1.523	accretion
574	612	2.105	accretion
574	613	-0.347	recession
574	614	-1.663	recession
574	615	-1.860	recession
574	616	7.272	accretion
574	617	8.690	accretion
574	618	7.907	accretion

Table 4: Top of Bluff Recession Rates 1935-2004

Reach	Block	Transect Number	Total Recession from 1935-1989 (meters)	Total Recession from 1993-2004 (meters)	Ave. Annual Rec Rates 1935-2004 total movement/total years	Ave. Annual rec Rates 1935-2004 for each block
575	1	583	-7.7436	-3.664	-0.176	-0.183
575	1	584	-2.4451	-3.089	-0.085	-0.183
575	1	585	-6.5210	-6.015	-0.193	-0.183
575	1	586	-12.8380	-5.217	-0.278	-0.183
574	2	587	-30.3620	-7.889	-0.588	-0.400
574	2	588	-14.2641	-6.905	-0.326	-0.400
574	2	589	-14.6718	-7.007	-0.334	-0.400
574	2	590	-26.0831	3.070	-0.354	-0.400
574	3	591	-34.8451	-1.377	-0.557	-0.612
574	3	592	-37.0867	-2.971	-0.616	-0.612
574	3	593	-35.4564	-3.445	-0.598	-0.612
574	3	594	n/a	n/a	n/a	-0.612
574	3	595	-36.4754	-2.734	-0.603	-0.612
574	3	596	-33.0113	-3.814	-0.567	-0.612
574	3	597	-32.4000	-3.856	-0.558	-0.612
574	3	598	-32.1964	-1.154	-0.513	-0.612
574	3	599	-33.0113	-3.169	-0.557	-0.612
574	3	600	-39.1246	-5.990	-0.694	-0.612
574	3	601	-47.8867	-3.151	-0.785	-0.612
574	3	602	-43.6077	-6.528	-0.771	-0.612
574	3	603	-31.5851	-3.566	-0.541	-0.612
574	3	604	n/a	n/a	n/a	-0.612
574	3	605	-40.5508	-4.623	-0.695	-0.612
574	3	606	-35.6605	-2.024	-0.580	-0.612
574	3	607	-30.3620	-7.008	-0.575	-0.612
574	3	608	-33.6226	-4.676	-0.589	-0.612
574	4	609	n/a	-7.019	n/a	-0.714
574	4	610	-40.9585	-3.092	-0.678	-0.714
574	4	611	-47.8867	-6.078	-0.830	-0.714
574	4	612	-40.9585	-5.098	-0.709	-0.714
574	4	613	-40.5508	-5.695	-0.711	-0.714
574	4	614	-43.2000	-6.040	-0.758	-0.714
574	4	615	-45.0338	-1.074	-0.709	-0.714
574	4	616	-40.3472	-4.481	-0.690	-0.714
574	4	617	-36.2718	-3.016	-0.604	-0.714
574	4	618	-44.6267	-3.190	-0.736	-0.714

Table 5: Erosion Hazard Limit for 1935-2004

Reach	Block	Transect Number	Annual Rec. Rate (from 1935-2004)	Avg. Annual Rec. Rate for each block (from 1935-2004)	100yr Rec. Rate	Bluff Height	Stable Slope Allowance Bluff H * 3	Policy 1 (100yrrr+ssa)	Policy 2 (SSA +30 m)	Erosion Hazard Limit
575	1	583	-0.176	-0.183	-18.28	15.5	46.5	64.78	76.5	76.5
575	1	584	-0.085	-0.183	-18.28	15.5	46.5	64.78	76.5	76.5
575	1	585	-0.193	-0.183	-18.28	15.5	46.5	64.78	76.5	76.5
575	1	586	-0.278	-0.183	-18.28	15.5	46.5	64.78	76.5	76.5
574	2	587	-0.588	-0.400	-40.04	15.5	46.5	86.54	76.5	86.54
574	2	588	-0.326	-0.400	-40.04	15.5	46.5	86.54	76.5	86.54
574	2	589	-0.334	-0.400	-40.04	15.5	46.5	86.54	76.5	86.54
574	2	590	-0.354	-0.400	-40.04	15.5	46.5	86.54	76.5	86.54
574	3	591	-0.557	-0.612	-61.25	16	48	109.25	78	109.25
574	3	592	-0.616	-0.612	-61.25	16	48	109.25	78	109.25
574	3	593	-0.598	-0.612	-61.25	16	48	109.25	78	109.25
574	3	594	n/a	-0.612	-61.25	16	48	109.25	78	109.25
574	3	595	-0.603	-0.612	-61.25	16	48	109.25	78	109.25
574	3	596	-0.567	-0.612	-61.25	16	48	109.25	78	109.25
574	3	597	-0.558	-0.612	-61.25	16	48	109.25	78	109.25
574	3	598	-0.513	-0.612	-61.25	16	48	109.25	78	109.25
574	3	599	-0.557	-0.612	-61.25	16	48	109.25	78	109.25
574	3	600	-0.694	-0.612	-61.25	16	48	109.25	78	109.25
574	3	601	-0.785	-0.612	-61.25	16	48	109.25	78	109.25
574	3	602	-0.771	-0.612	-61.25	16	48	109.25	78	109.25
574	3	603	-0.541	-0.612	-61.25	16	48	109.25	78	109.25
574	3	604	n/a	-0.612	-61.25	16	48	109.25	78	109.25
574	3	605	-0.695	-0.612	-61.25	16	48	109.25	78	109.25
574	3	606	-0.580	-0.612	-61.25	16	48	109.25	78	109.25

Reach	Block	Transect Number	Annual Rec. Rate (from 1935-2004)	Avg. Annual Rec. Rate for each block (from 1935-2004)	100yr Rec. Rate	Bluff Height	Stable Slope Allowance Bluff H * 3	Policy 1 (100yrrr+ssa)	Policy 2 (SSA +30 m)	Erosion Hazard Limit
574	3	607	-0.575	-0.612	-61.25	16	48	109.25	78	109.25
574	3	608	-0.589	-0.612	-61.25	16	48	109.25	78	109.25
574	4	609	n/a	-0.714	-71.38	16.5	49.5	120.88	79.5	120.88
574	4	610	-0.678	-0.714	-71.38	16.5	49.5	120.88	79.5	120.88
574	4	611	-0.830	-0.714	-71.38	16.5	49.5	120.88	79.5	120.88
574	4	612	-0.709	-0.714	-71.38	16.5	49.5	120.88	79.5	120.88
574	4	613	-0.711	-0.714	-71.38	16.5	49.5	120.88	79.5	120.88
574	4	614	-0.758	-0.714	-71.38	16.5	49.5	120.88	79.5	120.88
574	4	615	-0.709	-0.714	-71.38	16.5	49.5	120.88	79.5	120.88
574	4	616	-0.690	-0.714	-71.38	16.5	49.5	120.88	79.5	120.88
574	4	617	-0.604	-0.714	-71.38	16.5	49.5	120.88	79.5	120.88
574	4	618	-0.736	-0.714	-71.38	16.5	49.5	120.88	79.5	120.88