TECHNICAL GUIDE FOR
GREAT LAKES - ST. LAWRENCE RIVER SHORELINES

PART 6

MAPPING AND STAKING

HAZARDOUS LANDS

MAPPING AND STAKING HAZARDOUS LANDS

TABLE OF CONTENTS

LIST OF FIGURES

APPENDICES

TABLE OF CONTENTS

LIST OF FIGURES

APPENDIX A6.1

6.1 INTRODUCTION

Following the proper classification of a given shoreline by shore types (**Part 2: Recommended Shoreline Classification Scheme to Determine Shoreline Reaches**) and the determination of the appropriate policy standards for defining the *natural hazards* for that shore type (**Part 3: Flood Hazard**; **Part 4: Erosion Hazard**; and **Part 5: Dynamic Beach Hazard**), the final step is the determination of the *hazardous lands* limit which indicates the landward extent of the "area of provincial interest".

The intent of **Part 6: Mapping and Staking the Hazardous Lands Limit** is to provide an overview of the policy standards and provide some direction on the selection and application of the mapping or staking procedures that should be applied to determine the "areas of provincial interest". This includes:

- **Section 6.2** presents the policy direction for the definition and delineation of the *hazardous lands* limit as identified in the *Provincial Policy Statement* (1996) and the supporting *Natural Hazards Training Manual* (1996).
- **Section 6.3** outlines general procedures for mapping the hazardous lands which includes mapping the *flooding, erosion* and *dynamic beach hazards*
- **Section 6.4** outlines general procedures for staking the *hazardous lands* which includes staking the *flooding, erosion* and *dynamic beach hazards* (supported by Appendix A6.1)
- **Appendix A6.1** outlines methods to determine elevations and horizontal distances in the field using surveying techniques.

6.2 PROVINCIAL POLICY: HAZARDOUS LANDS

The "area of provincial interest", or *hazardous lands* as identified through the *Provincial Policy Statement* (Policy 3.1, Public Health and Safety: Natural Hazards for the shorelines of the *Great Lakes - St. Lawrence River System* (Figure 6.1) is based on the delineation of the furthest landward limit of the three key shoreline hazards:

- **flood hazard**
- **erosion hazard**
- **dynamic beach hazard**

Mapping of the *hazardous lands* (Figure 6.1) is simply the process of drawing a continuous line along the furthest landward limit of the three shoreline hazards.

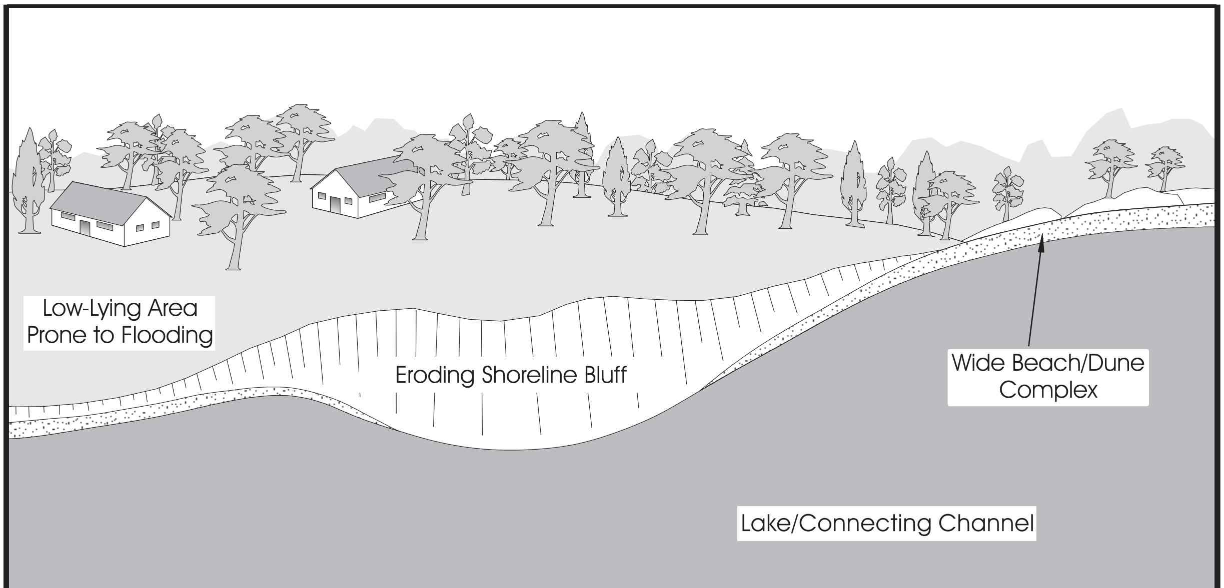
Applying the *hazardous lands* limit in the field will often require the **staking** of each applicable policy standard (*flooding hazard, erosion hazard and dynamic beach hazard*). However, the **mapped** location of the policy standard(s) may not coincide with the **staked** location of the same policy standard(s) on the day of the field investigation due to:

- changes in the configuration of the shorelines in response to local shoreline processes, or as a result of human-related activities (e.g., grading, placement of fill)

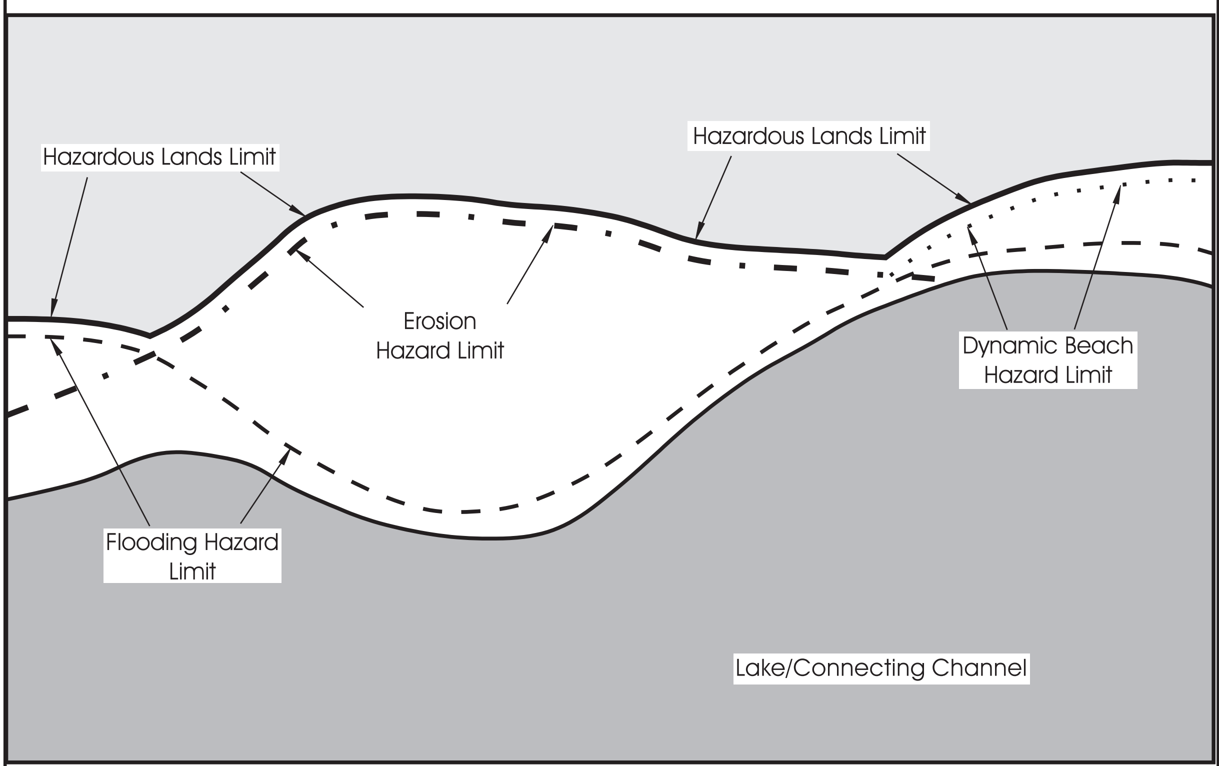
- inherent inaccuracies associated with the technique or medium (i.e., aerial photograph/historic maps) used to determine the components (e.g., 100 year flood level, average annual recession rate) of the standards

As such, the **map** location of the policy standards which shows the landward limit of the *hazardous lands* is to be considered a guide and should not be used exclusively in making final decisions on planning applications. Field **staking** of all the policy standards applicable to a reach is highly recommended to ensure that the correct location of the *hazardous lands* is identified.

Figure 6.1: Hazardous Lands



a) 3-D View of the Shoreline



b) Topographic View of the Shoreline

6.3 PROCEDURE FOR MAPPING THE HAZARDOUS LANDS

Prior to mapping the *natural hazards*, the shore types and alongshore boundaries of the shoreline reach be defined as outlined in Section 6.2.

The *flooding hazard*, as detailed in Part 3 of this Technical Guide, should be mapped first for all shoreline reaches. The *erosion hazard*, as detailed in Part 4 of this Technical Guide, should be mapped second and should be undertaken for all shoreline reaches excluding dynamic beach reaches. The *dynamic beach hazard*, as detailed in Part 5 of this Technical Guide, should be mapped last and only for those shoreline reaches that have been determined or classified as being a dynamic beach, including any erosion allowance.

It is important that all existing *natural hazards* are defined and mapped to ensure proper definition and mapping of the *hazardous lands.*

6.3.1 Mapping the Flooding Hazard

Mapping the *flooding hazard* essentially involves the delineation of the landward limit of the flood hazard as detailed in Part 3 of this Technical Guide.

The *flooding hazard* consists of the combined influence of the 100 year flood level plus a horizontal allowance for wave uprush and other water related hazards. Of the contributing factors:

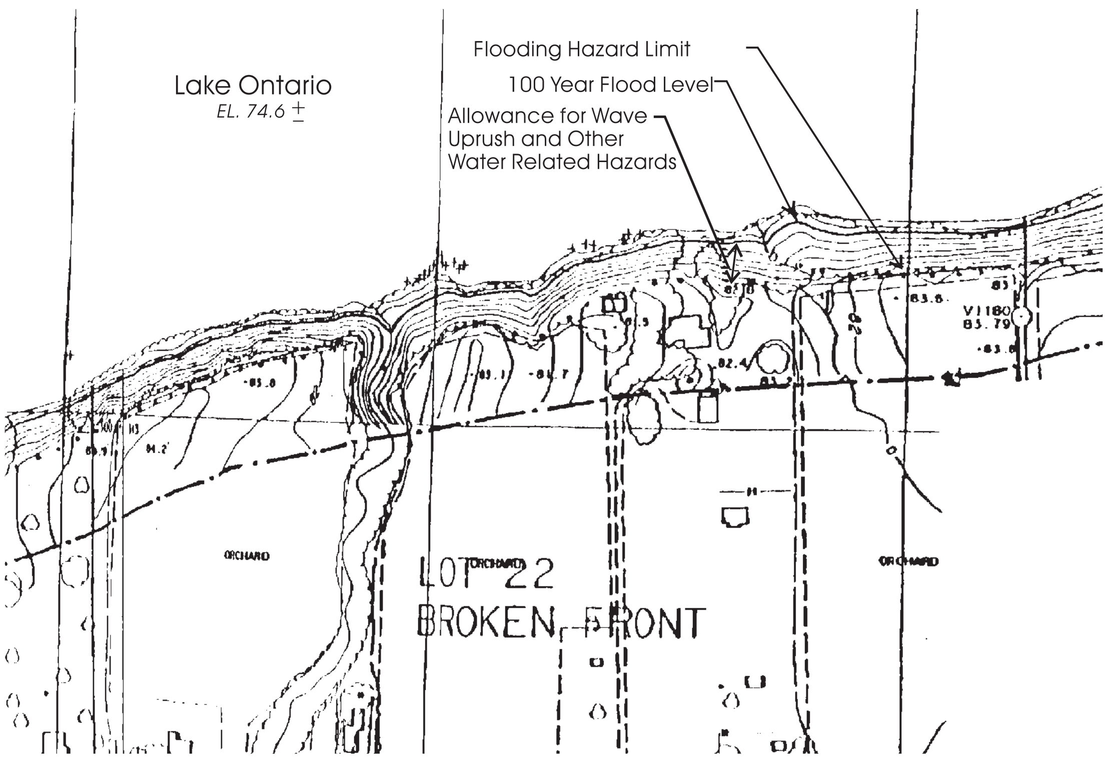
- the **100 year flood level** is a specified elevation represented on a map as a contour line; and
- the allowance for **wave uprush** and **other water related hazards** is a specified horizontal distance measured landward from the 100 year flood level contour.

Figure 6.2 shows an example of a mapped *flooding hazard*. The solid line represents the specified 100 year flood level contour. The *flooding hazard* is shown by the dotted line, and represents the horizontally measured allowance for wave uprush and other water related hazards measured from the 100 year flood level contour.

The procedure for mapping the *flooding hazard* is as follows:

- **Step 1** Find the appropriate 100 year flood level for the selected shoreline reach (see Appendix A3.1 for flood level information).
- **Step 2** Find the contour that corresponds with the 100 year flood level on 1:5000 or larger (e.g., 1:2000) scale map. The map should show 1 metre contours. If the flood level lies between two contour lines, the higher elevation contour line should be used.
- **Step 3** For the selected shoreline reach, draw a baseline parallel to the shoreline. Changes in the direction of the baseline should correspond with major changes in the shoreline orientation or configuration. Mark off points every 50 metres along this baseline.
- **Step 4** Convert 15 metres for Great Lakes shoreline, or 5 metres for connecting channels, or the appropriate distance obtained from a wave uprush study using accepted engineering principles, to a horizontal map distance using the map's scale.
- **Step 5** Measure this converted horizontal map distance perpendicular to the baseline and landward from the 100 year flood level contour at each of the marked points on the map. The landward point of this measure corresponds with the *flooding hazard* limit for that point location.

Figure 6.2: Mapping the Flooding Hazard Limit



- **Step 6** Connect all the landward points obtained in Step 5 to form a continuous line. This line delineates the *flooding hazard* for the selected shoreline reach.

- **Step 7** Repeat this process for the adjacent shoreline reaches. Connect the lines between shoreline reaches to delineate the landward extent of the *flooding hazard*.

6.3.2 Mapping the Erosion Hazard

Mapping the *erosion hazard* involves the delineation of the landward limit of the erosion hazard as detailed in Part 4 of this Technical Guide.

The *erosion hazard* consists of the combined influence of the stable slope, 100 times the average annual recession rate and/or an erosion allowance. There are three contributing factors:

- the **stable slope allowance** is a horizontal distance measured landward from the toe of the cliff/bluff/bank (i.e., standard 3 times the height of the cliff/bluff/bank or based on a study using accepted geotechnical principles);

- the **100 times the average annual recession rate,** applied where 35 years of recession rate information is available, is a horizontal distance measured landward from the landward extent of the stable slope allowance; and

- the **erosion allowance** of either:

  - a horizontal distance of 30 metres, in the absence of a known recession rate and in the absence of studies using accepted scientific and engineering principles, measured landward from the landward extent of the stable slope allowance or from the top of the cliff/bluff/bank, where slopes are considered to be "stable".

OR

  - a horizontal distance determined through studies using accepted scientific and engineering principles (e.g., connecting channels, bedrock shorelines, naturally well sheltered areas, or along the Lake St. Clair shorelines) measured landward from the landward extent of the stable slope allowance or from the top of the cliff/bluff/bank, where slopes are considered to be "stable".

Based on the above three contributing factors, defining the *erosion hazard* involves a two step process:

- **Step 1** selection of either:

  i) **the sum of the stable slope allowance plus 100 times the average annual recession rate measured landward from the toe of the cliff/bluff/bank** (i.e., where a minimum of 35 years of recession rate information does exist);

OR

  ii) **the sum of the stable slope allowance plus a 30 metre erosion allowance measured landward from the toe of the cliff/bluff/bank** (i.e., where a minimum of 35 years of recession rate information does not exist)

- **Step 2** compare (i) or (ii) selected above, with the following standard:

  iii) **30 metre erosion allowance measured landward from the top of the cliff/bluff/bank or from the first lakeward break in slope**

Whichever is the greater (e.g., (i) vs. (iii) or (ii) vs. (iii)) determines the landward limit of the *erosion hazard*.

For the purposes of clarification, the following section will provide a step-by-step procedure for mapping the erosion limit for each of the three erosion standards.

a) Mapping the Stable Slope Allowance Plus 100 times the Average Annual Recession Rate or a 30 metre Erosion Allowance

This method of determining the landward limit of the *erosion hazard* is applicable for shoreline locations where the average annual recession rate is known or where the recession rate is unknown (i.e., 30 metre erosion allowance). This procedure, illustrated in Figure 6.3, uses a historic-recent shoreline position map, toe of cliff/bluff/bank position points, stable slope ratio described in Section 4.4, and the average annual recession rates found in Section 4.5 and Appendix A4.2.

- **Step 1** For the selected shoreline reach, draw a baseline parallel to the shoreline. Changes in the direction of the baseline should correspond with major changes in shoreline orientation or configuration. Mark off points every 50 metres along this baseline, or use the same points used in mapping the *flooding hazard*.
- **Step 2** For each point along the baseline determine the height of the cliff/bluff/bank, following the procedure outlined in Section 4.4.1. Multiply this height by 3 or by the stable slope allowance defined by a study using accepted geotechnical principles (Section 4.4.2) and convert this to a map distance using the map scale.
- **Step 3** For each point determine the horizontal erosion allowance depending on the available information. This is either 100 times the average annual recession rate where recession information is available or a 30 metre erosion allowance. A study using accepted scientific and engineering principles may be permitted to determine the erosion allowance on bedrock shorelines, naturally sheltered areas, along connecting channels and along the Lake St. Clair shoreline. Convert this number to a map distance using the map scale.
- **Step 4** Add the horizontal distances from Step 2 and Step 3.
- **Step 5** Measure this horizontal map distance perpendicular to the baseline and landward from the toe of the cliff/bluff/bank corresponding with the specific point on the map. The landward point of this measure corresponds with the *erosion hazard* limit.
- **Step 6** Repeat steps 2 to 5 for all other points along the baseline.

b) Mapping the 30 metre Erosion Allowance Measured Landward from the Top of the Cliff/Bluff/Bank or the First Lakeward Break in Slope

This method of determining the landward limit of the *erosion hazard* is applicable for all shoreline locations and includes situations where the cliff/bluff/bank feature is naturally stabilized. This procedure, illustrated in Figure 6.4, uses a historic-recent shoreline position map, and the first lakeward break in slope or top of the cliff/bluff/bank position points described in Section 4.4.

- **Step 1** For the selected shoreline reach, draw a baseline parallel to the shoreline. Changes in the direction of the baseline should correspond with major changes in shoreline orientation or configuration. Mark off points every 50 metres along this baseline or use the same points used in mapping the *flooding hazard* and/or used to map the *erosion hazard* limit from Section 6.3.2a.

Figure 6.3: Mapping the Stable Slope Allowance Plus 100 times the Average Annual Recession Rate or a 30 metre Erosion Allowance

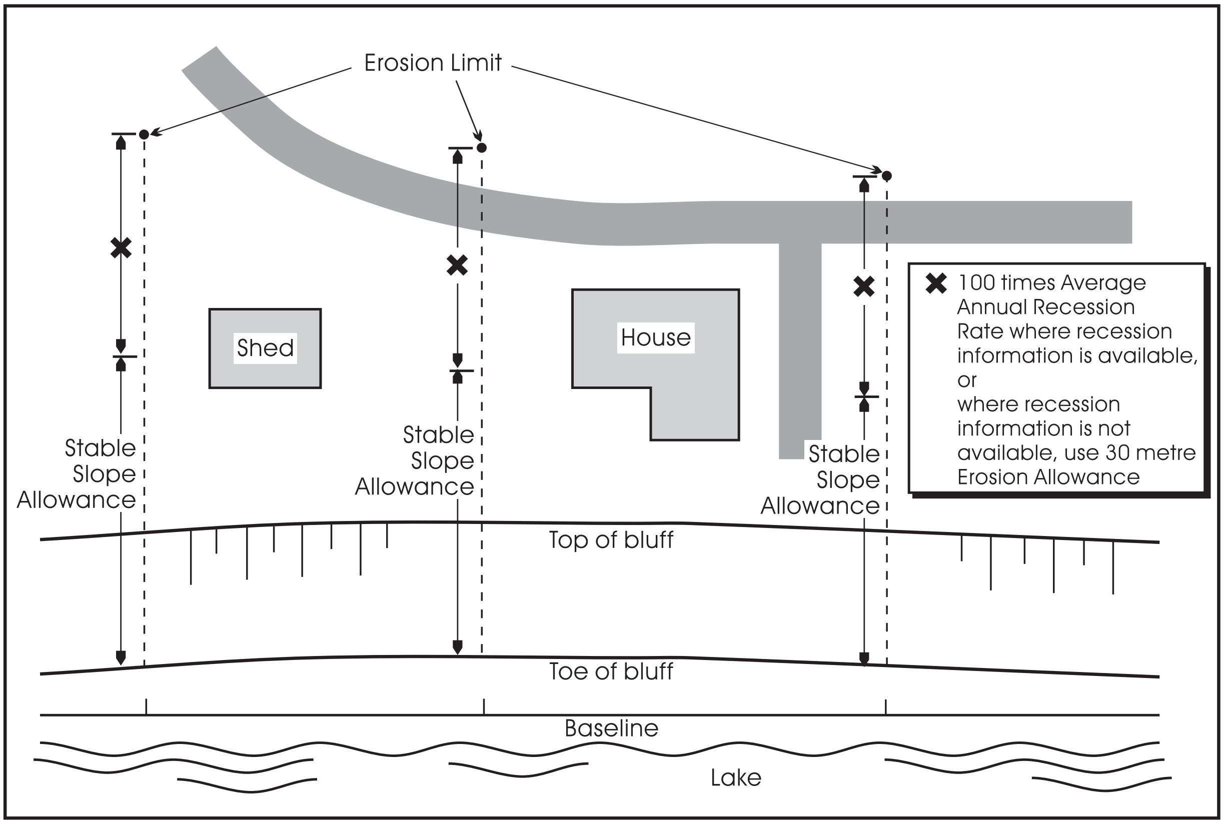
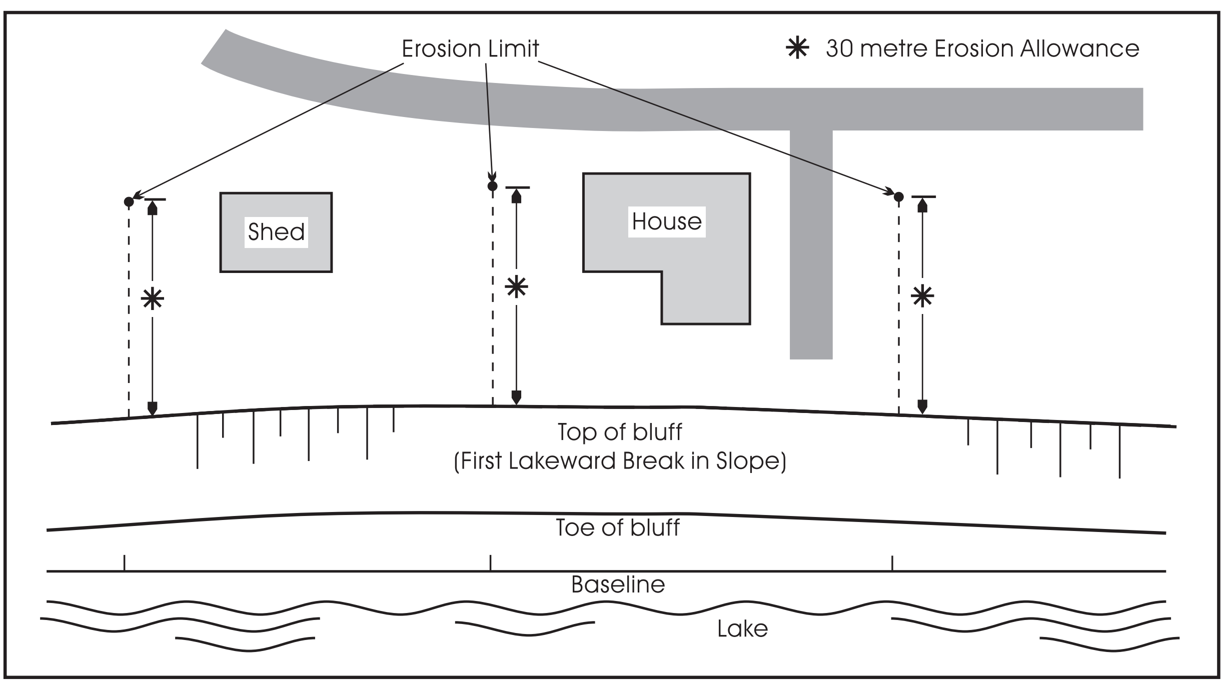


Figure 6.4: Mapping the 30 metre Erosion Allowance from the Top of Cliff/Bluff/Bank or the First Lakeward Break in Slope



- **Step 2** Using the scale of the map, convert the 30 metre erosion allowance to a map distance. A study using accepted scientific and engineering principles may be permitted to determine the erosion allowance on bedrock shorelines, along connecting channels, along naturally sheltered shorelines, and along the Lake St. Clair shoreline.

- **Step 3** Measure this horizontal map distance perpendicular to the baseline and landward from the top of the cliff/bluff/bank or the first lakeward break in slope corresponding with the specific point on the map. The landward point of this measure corresponds with the *erosion hazard* limit.

- **Step 4** Repeat steps 2 and 3 for all other points along the baseline.

c) Mapping the Erosion Hazard Based on the Erosion Limits

Once the landward limits of the *erosion hazard* have been mapped, the *erosion hazard* for each point is then defined as the furthest landward point of all of the mapped *erosion hazard* limits (Figure 6.5). The *erosion hazard* for the entire reach is obtained by connecting all of the furthest landward points creating a continuous line.

The *erosion hazard* information (i.e., stable slope ratio, average annual recession rate, erosion allowance) used to produce the furthest landward distance for each point should be documented.

6.3.3 Mapping of the Dynamic Beach Hazard

Mapping of the *dynamic beach hazard* essentially involves the delineation of a line along a dynamic beach shore type that represents the landward limit of the dynamic beach processes. The *dynamic beach hazard* consists of the combined influence of the *flooding hazard* and a dynamic beach allowance.

Of the contributing factors:

- procedures for mapping the *flooding hazard* have already been described in Section 6.3.1; and

- the **dynamic beach allowance**, in the absence of studies using accepted scientific and engineering principles, is a horizontal distance of 30 metres measured landward from the *flooding hazard*

The *dynamic beach hazard* is to be mapped for all reaches identified as dynamic beaches, in accordance with the recommended shoreline classification scheme (i.e., Part 2: Recommended Shoreline Classification Scheme for Determining Shoreline Reaches and Part 5: Dynamic Beach Hazard), and is always carried out after the *flooding hazard* has been mapped.

a) General Procedure

For the purposes of clarification, the following section of this Technical Guide, illustrated in Figure 6.6, provides a step-by-step procedure for mapping the landward limit of the *dynamic beach hazard*.

- **Step 1** For the selected dynamic beach reach draw a baseline parallel to the shoreline. Changes in the direction of the baseline should correspond with major changes in shoreline orientation or configuration. Mark off points every 50 metres along this baseline, or use the same points used in mapping the *flooding hazard*.

- **Step 2** Map the *flooding hazard* in accordance with the procedure described in Section 6.3.1.

Figure 6.5: Mapping the Erosion Hazard Limit Based on the Erosion Allowance

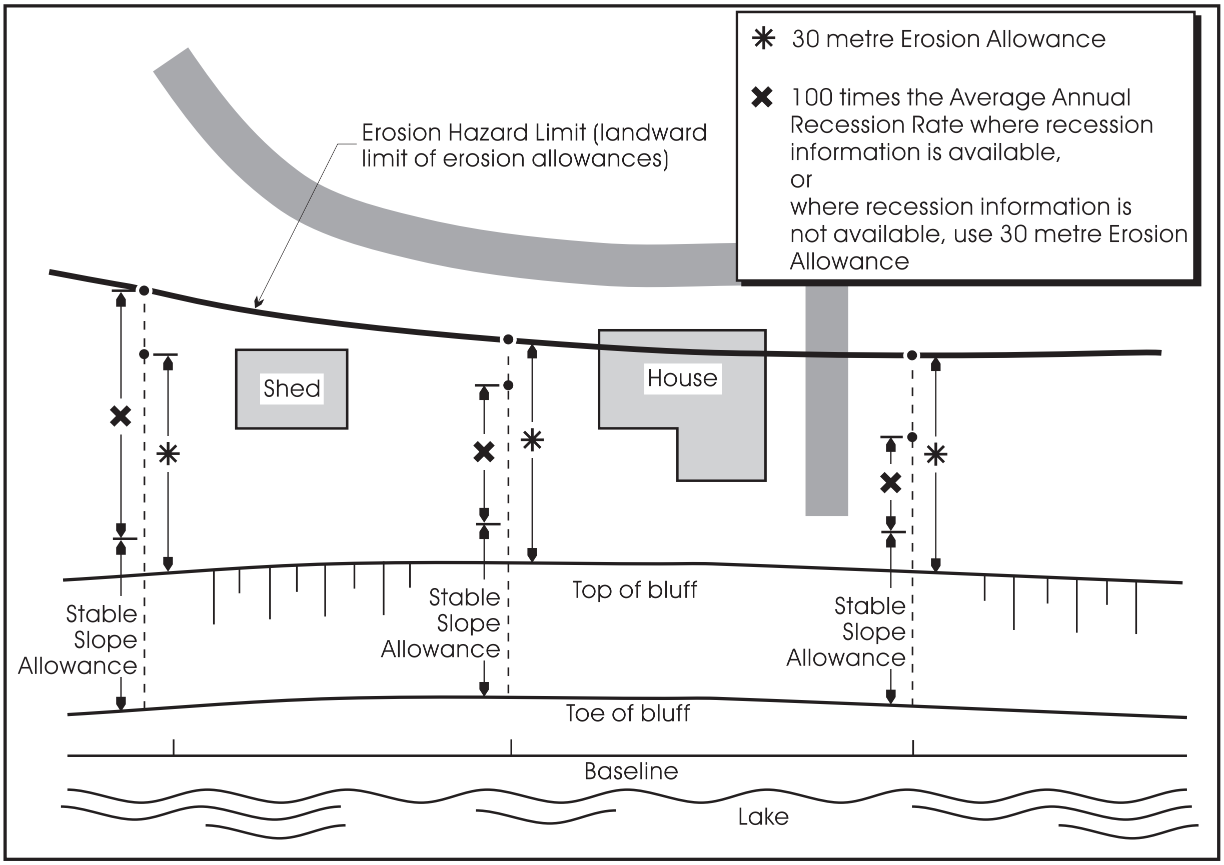
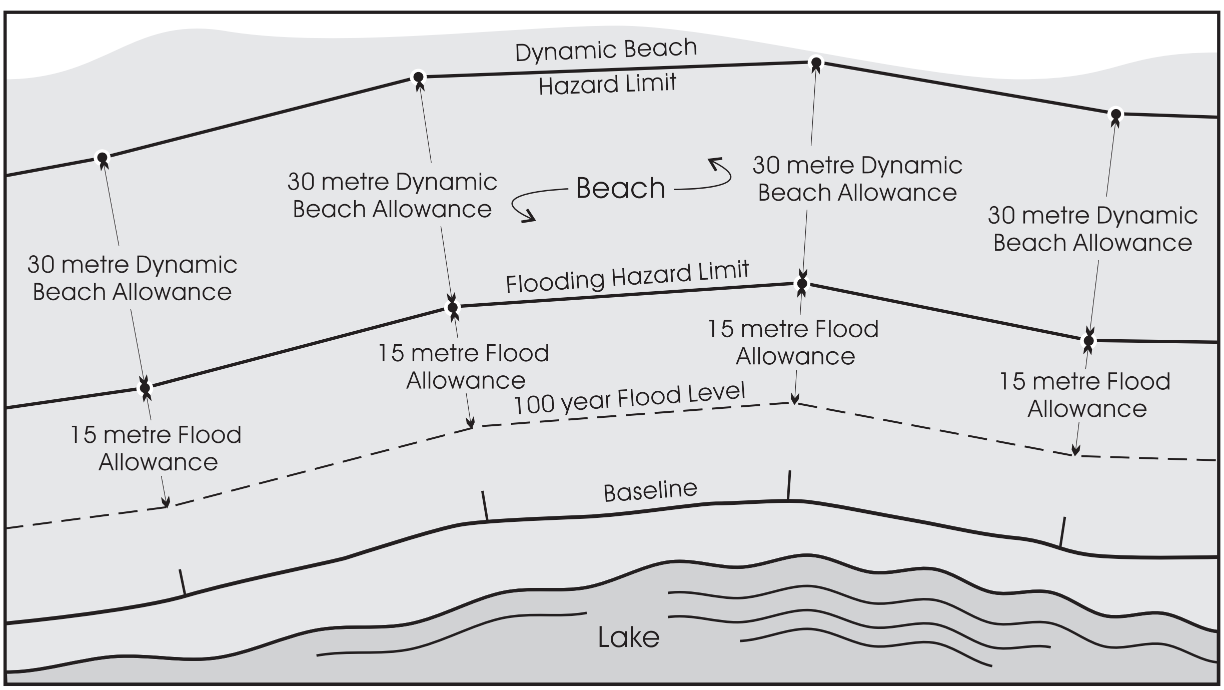


Figure 6.6: Mapping the Dynamic Beach Hazard Limit



- **Step 3** Using the scale of the map convert the 30 metre dynamic beach allowance, in absence of studies using accepted scientific and engineering principles, to a map distance. The dynamic beach allowance may vary due to natural factors. The following Section 6.3.3b provides more details.

- **Step 4** Measure this horizontal map distance (i.e., the dynamic beach allowance) perpendicular to the baseline and landward from the landward point of the *flooding hazard*. The landward point of this measurement corresponds with the landward limit of the *dynamic beach hazard*.

- **Step 5** Repeat steps 2 to 4 for all other points along the baseline.

- **Step 6** Connect all the landward points to form a continuous line. This line delineates the *dynamic beach hazard* for the selected dynamic beach reach.

b) Additional Factors

There are several circumstances under which natural factors may require redefining the landward limit of the *dynamic beach hazard*. These include:

- Where the beach is eroding, a horizontal distance representing 100 times the average annual recession rate should be added to the 30 metre dynamic beach allowance measured landward from the *flooding hazard* in Step 4(see Figure 5.5).

- Where a beach is backed by a cliff/bluff such that the initial determination of the *dynamic beach hazard* limit outlined in Step 4 lies landward of the toe of the cliff/bluff, the landward limit of the *dynamic beach hazard* should be mapped as the toe of the cliff/bluff (Figure 5.6).

- Where the beach exists on a narrow barrier system and the landward limit of the *dynamic beach hazard* falls within the marsh or bay that exists landward of the barrier, the *dynamic beach hazard* should be defined by the toe of the barrier slope on the landward side (i.e., the intersection of the unconsolidated material and the marsh or bay bottom) (Figure 5.7).

- Where the beach profile is below the 100 year flood level, the *dynamic beach hazard* should be mapped as the lesser of the landward boundary between the beach and associated dune deposits (i.e., unconsolidated material) and the material forming the low plain (Figure 5.7a) or 30 metres measured landward from the first break in slope on the lee side of the first dune (Figure 5.8).

Where these factors apply, it is recommended that a study using accepted scientific and engineering principles be undertaken to ensure proper definition and delineation of the *dynamic beach hazard*.

6.4 PROCEDURE FOR STAKING THE HAZARDOUS LANDS

Once the mapping of the *hazardous lands* has been completed for a site, it may be necessary to stake the *hazardous lands*. The staking of the shoreline will be required as needed on a site-by-site basis.

6.4.1 General Procedure

Selection of an appropriate procedure for staking the *hazardous lands* depends on the accuracy of the mapping and the availability of reference points that exist for the site. Therefore confirmation that the mapping information is consistent with the existing site conditions should be done in the field.

Once the mapping has been checked, the following two methods may be applied when staking the *hazardous lands*.

Method 1: If the mapping is consistent and accurately reflects field conditions and there are existing accessible reference points then:

- measure the distance from the reference point to the *hazardous lands* from the mapping and stake this location. If it is unclear which standard represents the furthest landward limit, stake the *flooding hazard*, *erosion hazard*, and *dynamic beach hazard*. The furthest landward of these staked standards is the *hazardous lands* limit.

Method 2 : If mapping is unavailable, inadequate (i.e., existing mapping is not current, does not reflect existing conditions, or is at an inappropriate scale) or no accessible reference points are available then:

- A Bench Mark (BM) for vertical control or a Temporary Bench Mark (TBM) to determine an elevation from which the *hazardous lands* will be staked (see Appendix A6.1 for more information on bench marks and temporary bench marks). Staking the hazard limits will be required to determine the *hazardous lands* landward limit.

- A level is required. Other instruments such as a transit, theodolite, electronic distance measurement (EDM) or global positioning system (GPS) could also be used. (See Appendix A6.1 for further description of various levelling techniques.)

Figure 6.7 illustrates staking the *hazardous lands* landward limit.

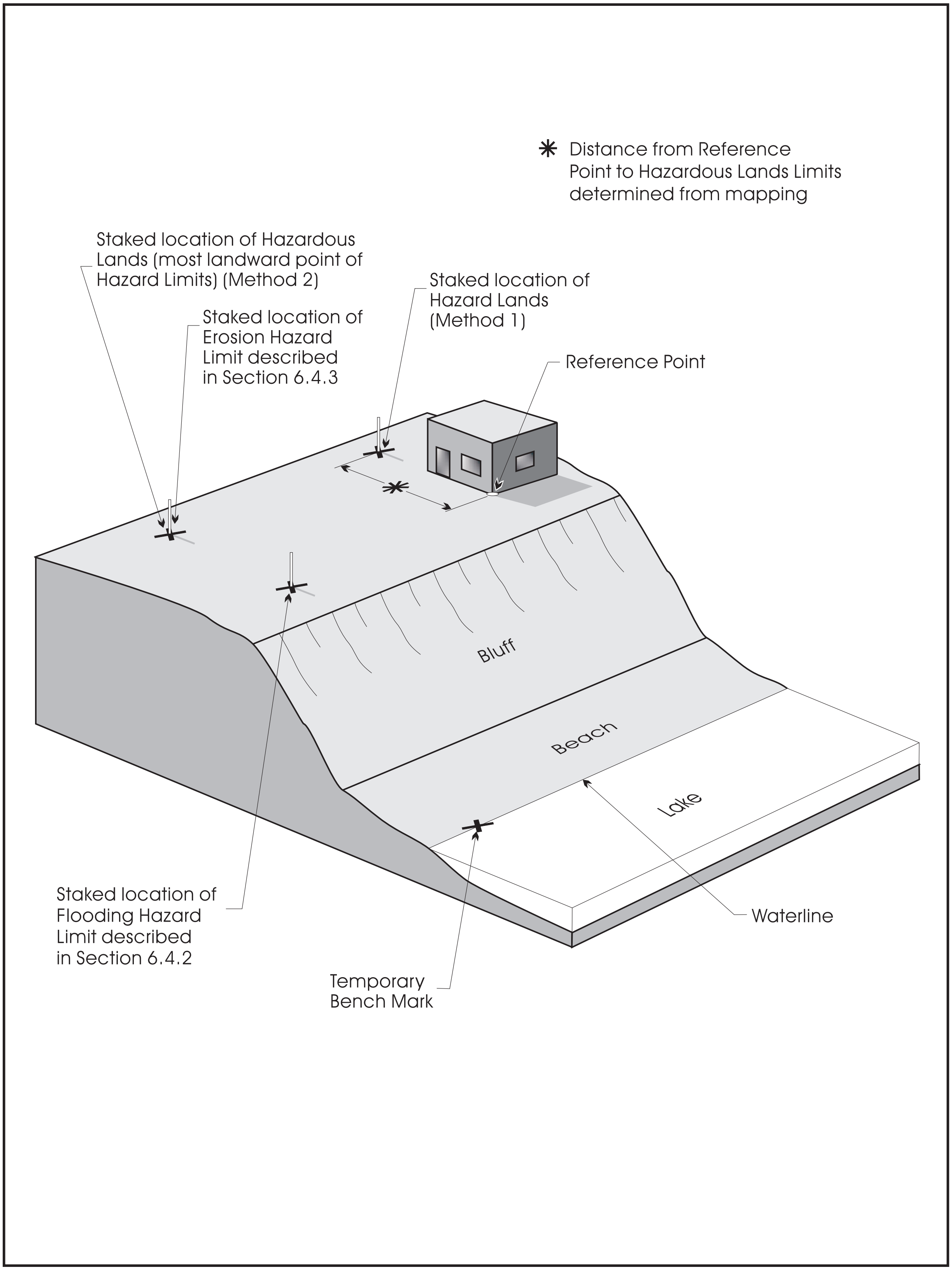
6.4.2 Staking the Flooding Hazard

The procedure for staking the *flooding hazard* depends on the existing mapping (i.e., reflects existing site conditions, or is at an appropriate scale), whether there are reference points for horizontal control, (i.e., distances), and the availability of bench marks (BM) or temporary bench marks (TBM) for vertical control, (i.e., elevations) for the site.

The *flooding hazard* consists of the 100 year flood level plus a flood allowance for wave uprush and other water related hazards as outlined in Part 3: Flooding Hazard of this Technical Guide.

Once the *flooding hazard* has been determined, it can be staked using one of the following methods depending on the existing mapping for the site and the accessibility of reference points.

Figure 6.7: Staking the Hazardous Lands Limit



Method 1: If the mapping is consistent, and accurately reflects field conditions and there are existing accessible reference points then:

- **Step 1** The distance measured from the reference point to the *flooding hazard* from the mapping (Section 6.3.1) is measured in the field from the reference point and staked (see Figure 6.8).

Method 2: If no mapping, inadequate mapping or no accessible reference points are available then:

- **Step 1** Establish the location of a BM or TBM to provide an elevation at the site. If the water level or elevation of a structure is used as the TBM, the same procedure is followed.
- **Step 2** Establish a point of known elevation at the site by bringing the BM or TBM elevation to the site using a levelling technique. (See Appendix A6.1 for further description of levelling techniques.)
- **Step 3** Calculate the difference in elevation of the known point established at the site and the 100 year flood level.
- **Step 4** Determine the location of the difference in elevation using a level and stake this location. This is the location of the 100 year flood level.
- **Step 5** A horizontal flood allowance for wave uprush and other water related hazards (i.e., 15 metres for the Great Lakes, 5 metres for connecting channels or an allowance for wave uprush and other water related hazards determined through a study using accepted engineering principles) must be added to the 100 year flood level. This horizontal flood allowance can then be measured from the location of the 100 year flood level with a tape and staked.

If necessary repeat the process to determine the location of the *flooding hazard* for several points using the applicable method. The need to repeat the process will vary depending on the length of shoreline of concern and/or if the orientation of the shoreline changes. Connect the staked points to form a continuous line which delineates the landward extent of the *flooding hazard*. Figure 6.8 illustrates staking the *flooding hazard*.

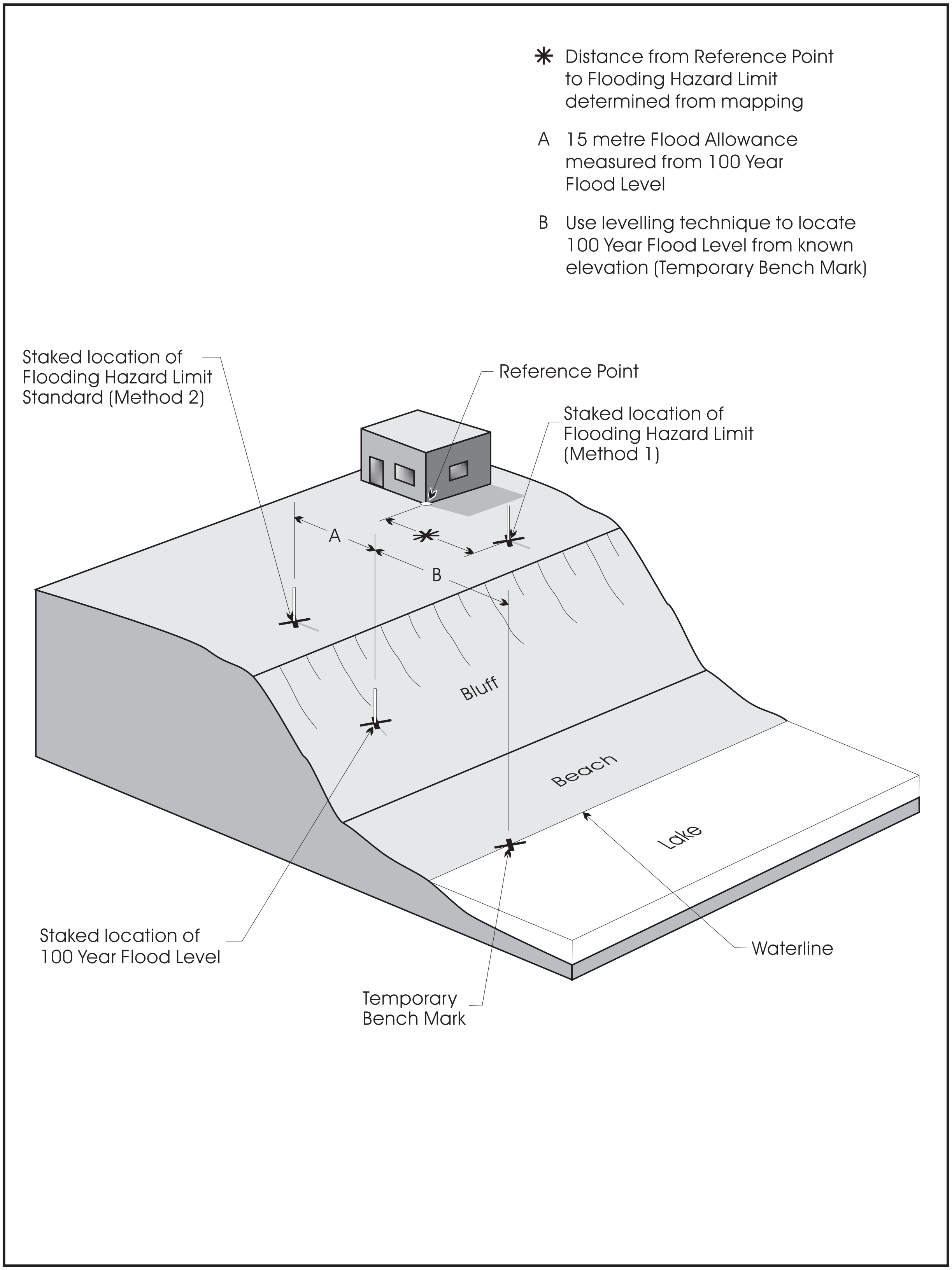
6.4.3 Staking the Erosion Hazard

Staking the *erosion hazard* essentially involves delineating the landward limit of the *erosion hazard* in the field. The *erosion hazard* is outlined in Part 4 of this Technical Guide.

The procedure to follow when staking the *erosion hazard* depends on the existing mapping (i.e., does reflect existing site conditions, or is at an appropriate scale), whether there are reference points for horizontal control, the availability of bench marks (BM) or temporary bench marks (TBM) for vertical control, and on the steepness of the cliff/bluff/bank slope.

The steepness of the slope will dictate the type of surveying equipment and the technique that will be required to stake the *Erosion hazard*. For example, in areas where the site may be more difficult to stake, more sophisticated survey techniques (e.g., electronic distance measurement (EDM) or global positioning systems (GPS))

Figure 6.8: Staking the Flooding Hazard Limit



may be necessary (see Appendix A6.1 for further description of levelling techniques). The following provides a general guideline on the minimum types of survey equipment that could be used if the slope is:

- **< 18° (3:1)** — The slope will be gentle enough to walk up, the distance can be measured with a tape or level depending on the required accuracy. If greater accuracy is required other instruments that measure angles (e.g., transit, theodolite) should be used.

- **> 18° (3:1)** and **< 33° (1.5:1)** — At 18° (3:1) the slope will be gentle enough to easily walk up, at 33° (1.5:1) one will be unable to walk up the slope. As a minimum, a level and tape would be required for the gentler slopes. Instruments such as a transit or theodolite will be required for the steeper slopes and where greater accuracy is required.

- **> 33° (1.5:1)** — The slope will be too steep to walk up. One may require a professional surveyor or someone with experience with surveying. A transit, theodolite, EDM or GPS will be required in order to calculate angles and distances.

If mapping was produced in accordance with the procedures outlined in Section 6.3, use this information when staking the *erosion hazard*. If the mapping is inadequate (i.e., does not reflect existing site conditions, or is not at an appropriate scale) and there are no accessible reference points it is recommended to delineate the *erosion hazard* by staking:

- the **stable slope allowance plus 100 times the average annual recession rate** where there is recession rate information **or** where recession rate information is **not** available **a 30 metre erosion allowance**; and

- a **30 metre erosion allowance measured from the first lakeward break in slope**.

The most landward of these two points is the *erosion hazard*.

a) Staking the Stable Slope Allowance Plus 100 times the Average Annual Recession Rate or a 30 metre Erosion Allowance

Method 1: The mapping is consistent/accurately reflects field conditions and there are existing accessible reference points then:

- **Step 1** — The distance measured from the reference point to the *erosion hazard* limit (i.e., stable slope allowance plus 100 times the average annual recession rate or a 30 metre erosion allowance) from the mapping (Section 6.3.2) is measured in the field from the reference point and staked (see Figure 6.9).

Method 2: If no mapping, inadequate mapping or no accessible reference points are available then:

- **Step 1** — Establish the location of the BM or TBM to provide an elevation at the site. If the water level or elevation of a structure is used as the TBM, the same procedure is followed.

- **Step 2** — Establish a point of known elevation at the site by bringing the BM or TBM elevation to the site using a levelling technique (see Appendix A6.1 for further discussion of levelling techniques).

- **Step 3** — Determine the location of the toe of the slope. If the water level is against the toe of the slope one may assume that the point where the water level intersects the slope is the toe of the slope.

- **Step 4** Determine the elevation of the toe of the slope from the known point elevation by using a levelling technique.

- **Step 5** Determine the location of the top of cliff/bluff/bank or the first lakeward break in slope.

- **Step 6** Determine the elevation of the top of the slope by using a levelling technique. The steepness of the slope will determine the instrumentation that will be required.

- **Step 7** Once the difference in elevation of the slope (i.e. height of the cliff/bluff/bank) has been determined, calculate the horizontal distance for the stable slope allowance (i.e., 3 times the height of the cliff/bluff/bank or the stable slope allowance which was determined using accepted geotechnical principles).

- **Step 8** Transfer these horizontal and vertical distances from the toe the slope landward and stake the location of the stable slope allowance. This can be done by using a levelling technique or by using other instruments such as a transit, theodolite, electronic distance measurement (EDM) or global positioning system (GPS) depending on the steepness of the slope.

- **Step 9** A horizontal erosion allowance must be determined depending on the available information. The erosion allowance is either 100 times the average annual recession rate where recession rate data is available (i.e., minimum 35 years of data) or 30 metre erosion allowance. On bedrock shorelines, along connecting channels, along naturally, well sheltered shorelines, and along the Lake St. Clair shoreline, a study using accepted scientific and engineering principles may be permitted to determine the erosion allowance.

- **Step 10** Measure the horizontal erosion allowance from the stable slope allowance and stake this point. This is the *erosion hazard* limit.

If necessary, repeat the process to determine the location of the *erosion hazard* for several points using the applicable method. The need to repeat the process will vary depending on the length of shoreline of concern and/or if the orientation of the shoreline changes. Figure 6.9 illustrates staking the stable slope allowance plus 100 times the average annual recession rate or a 30 metre erosion allowance.

b) Staking the 30 metre Erosion Allowance Measured Landward from the Top of Cliff/Bluff/Bank or the First Lakeward Break in Slope

Staking the *erosion hazard* limit which delineates the top of the cliff/bluff/bank or the first lakeward break in slope does not rely on information from the mapping, the top of cliff/bluff/bank is determined in the field.

- **Step 1** Go to the top of the cliff/bluff/bank or the first lakeward break in the slope and measure landward the erosion allowance, this is your *erosion hazard* limit. The erosion allowance is 30 m. A study using accepted scientific and engineering principles may be permitted to determine the erosion allowance on bedrock shorelines, along connecting channels, along naturally, well sheltered shorelines, and along the Lake St. Clair shoreline.

If necessary, repeat the process to determine the location of the *erosion hazard* for several points. The need to repeat the process will vary depending on the length of shoreline of concern and/or if the orientation of the shoreline changes. Figure 6.10 illustrates staking the 30 metre erosion allowance from the top of cliff/bluff/bank or the first landward break in slope.

Figure 6.9: Staking the Stable Slope Allowance Plus 100 times the Average Annual Recession Rate or a 30 metre Erosion Allowance

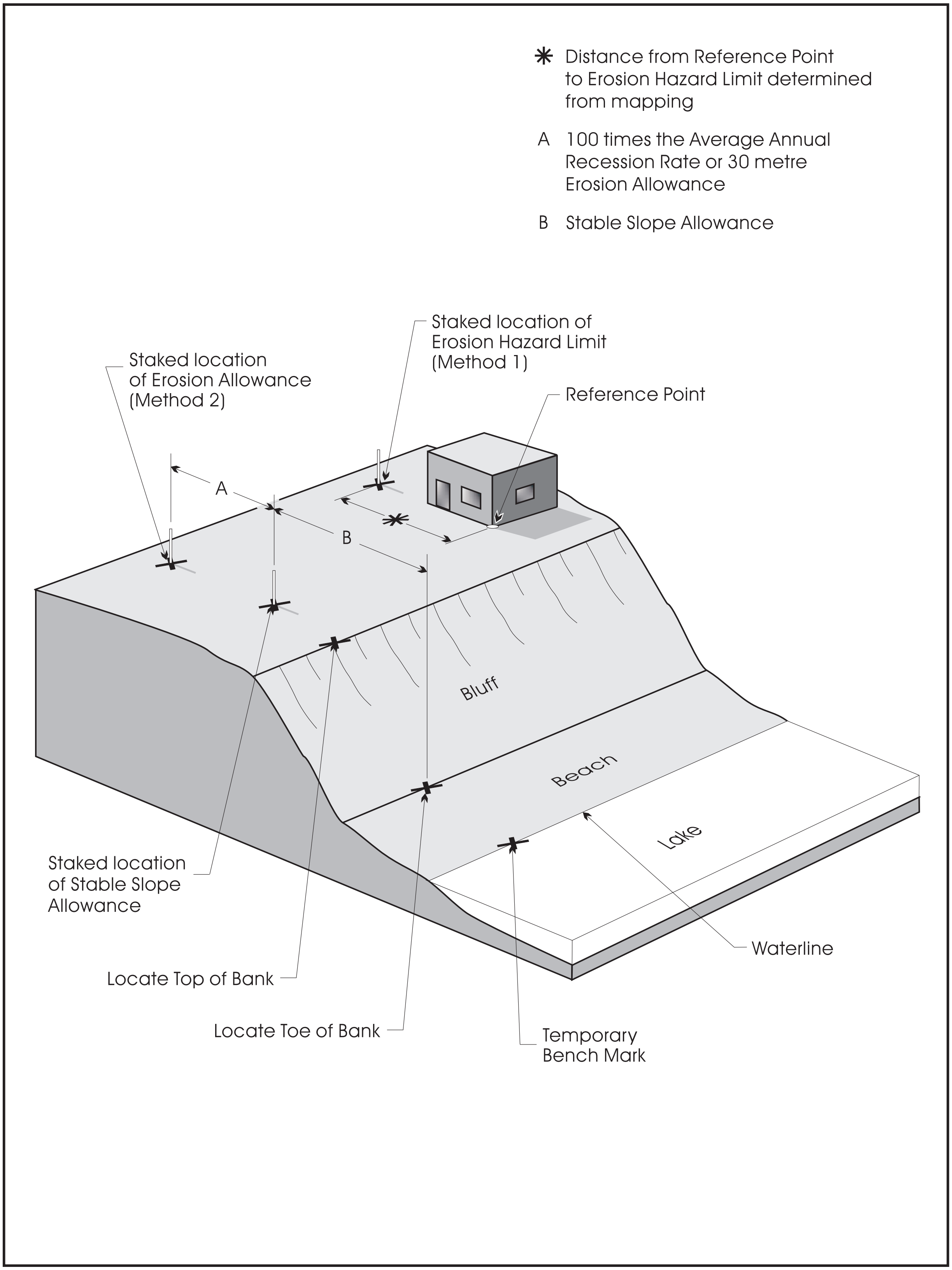
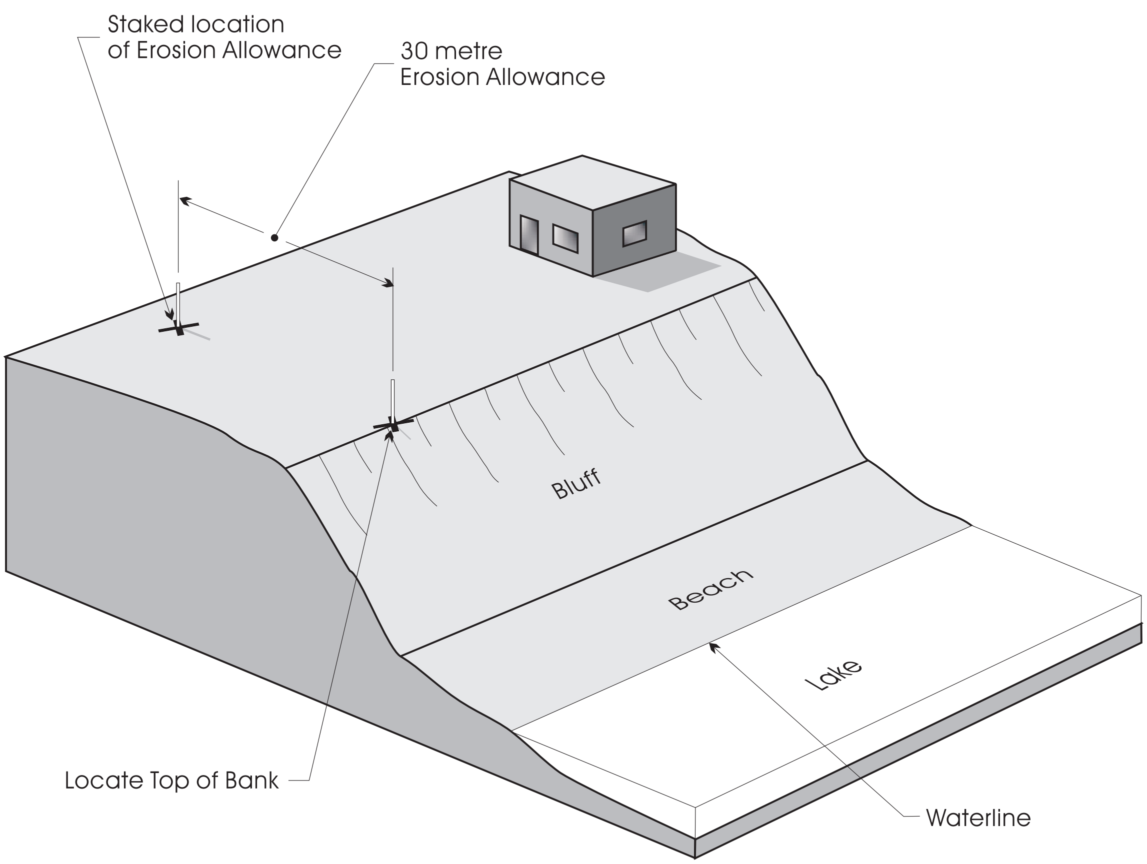


Figure 6.10: Staking the 30 metre Erosion Allowance from the Top of Cliff/Bluff/Bank



c) Staking the Erosion Hazard Limit based on the Erosion Allowances

Once the landward limits of the *erosion hazard* have been staked, the *erosion hazard* is the furthest landward of these staked erosion limits. If necessary, repeat this process to determine the *erosion hazard* for several points. Connect the furthest landward of the staked points to form a continuous line which delineates the landward extent of the *erosion hazard*.

6.4.4 Staking the Dynamic Beach Hazard Limit

The procedure which is to be followed when staking the *dynamic beach hazard*, outlined in Part 5, depends on the existing mapping, the accessibility of reference points and the availability of bench marks (BM) or temporary bench marks (TBM) for the site.

Field staking of the *dynamic beach hazard* is usually undertaken in one of two situations:

- to compare the general location of the landward limit of the *dynamic beach hazard* with physical shoreline features to determine whether the landward limit within a reach or series of reaches is appropriate for the local conditions or whether further studies be undertaken to define the landward limit of the *dynamic beach hazard*; or

- to locate the precise landward limit of the *dynamic beach hazard* with respect to an individual feature such as a building or property lot line.

In the first situation, the landward limit of the *dynamic beach hazard* should be determined at several locations along the shoreline. The level of precision required in this type of exercise is generally low, with horizontal positioning being in the order of plus or minus 2 to 3 metres. This degree of accuracy is considered adequate for these types of situations. Measurements may be made with the use of a standard tape measure.

In the second situation, where a precise definition of the landward limit of the *dynamic beach hazard* is required at a single shoreline location, the use of a levelling technique may be necessary.

If mapping was produced in accordance with the procedures outlined in Section 6.3.3, use this information when staking the *dynamic beach hazard*. If the mapping is inadequate (i.e., does not reflect existing site conditions, or is not at an appropriate scale) and there are no accessible reference points, delineate the *dynamic beach hazard* by staking the ***flooding hazard*** and the **30 metre dynamic beach allowance**.

Method 1: If the mapping is consistent/accurately reflects field conditions and there are existing accessible reference points then:

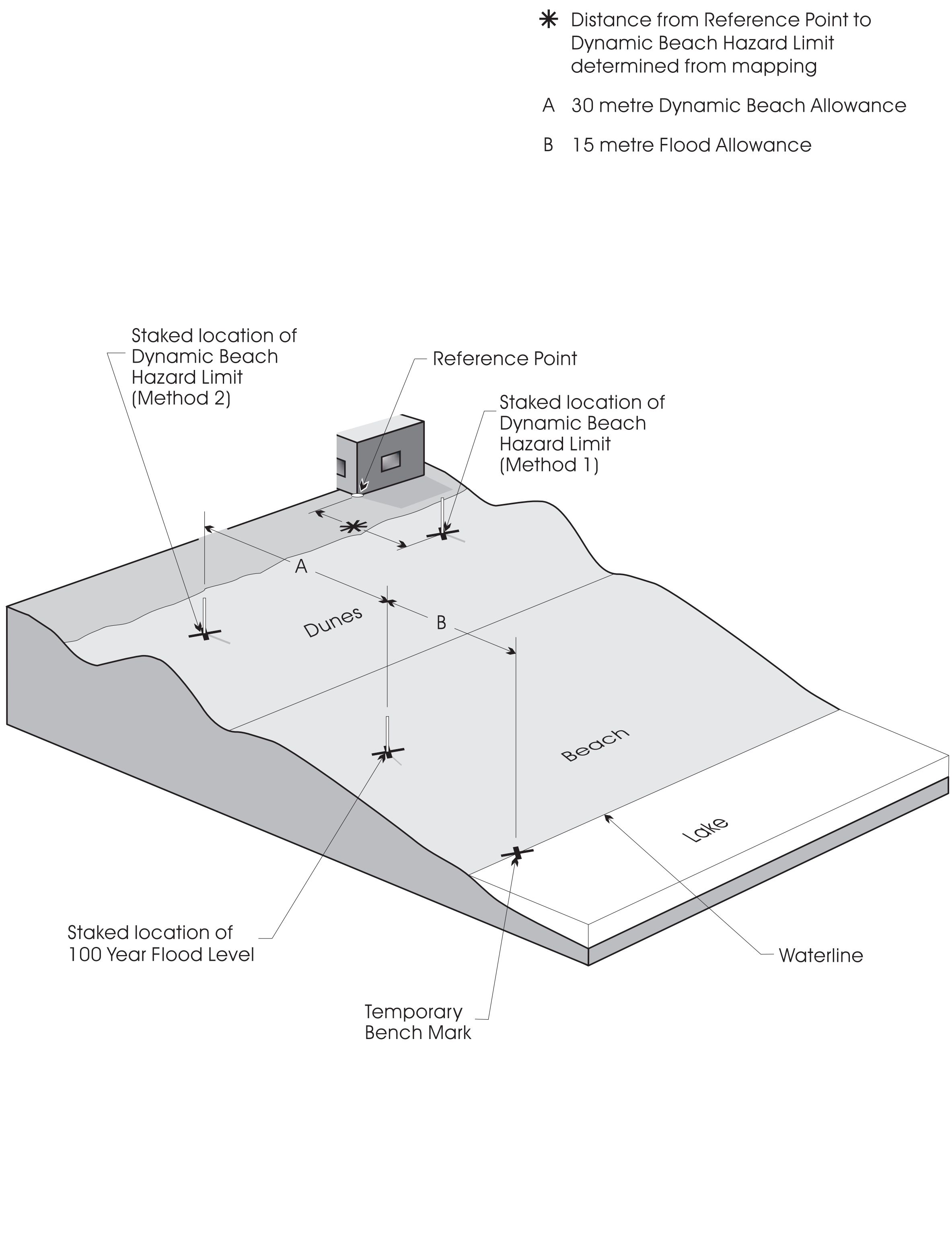
- **Step 1** The distance measured from the reference point to the *dynamic beach hazard* from the mapping (Section 6.3.3) is measured in the field from the reference point and staked (see Figure 6.11).

Method 2: If **no mapping**, **inadequate mapping** or **no accessible reference points** are available then:

- **Step 1** Stake the *flooding hazard* as described in Section 6.4.1

- **Step 2** From the *flooding hazard* add a horizontal distance for the dynamic beach allowance. The dynamic beach allowance will be 30 m or an allowance determined through an acceptable scientific and engineering study.

Figure 6.11: Staking the Dynamic Beach Hazard Limit



There are several additional factors which may complicate staking of the *dynamic beach hazard*. Where these factors apply, it is recommended that a study using accepted scientific and engineering principles be undertaken. The complicating factors include:

a) If the dynamic beach is eroding add 100 times the average annual recession rate to the 30 metre dynamic beach allowance. Therefore the *dynamic beach hazard* for an eroding dynamic beach will be the *flooding hazard* plus 100 times the average annual recession rate plus 30 metre dynamic beach allowance (Figure 5.5).

b) If the dynamic beach is backed by a cliff/bluff such that the initial determination of the dynamic beach *hazard* lies landward of the toe of the cliff/bluff, it is recommended that the landward limit of the *dynamic beach hazard* be staked as the toe of the cliff/bluff (Figure 5.6).

c) If the dynamic beach exists on a narrow barrier such that the initial determination of the *dynamic beach hazard* falls within the marsh or bay that exists landward of the barrier, it is recommended that the *dynamic beach hazard* be staked at the toe of the barrier slope on the landward side (i.e., intersection of the unconsolidated material and the marsh or bay bottom) (Figure 5.7).

c) If the dynamic beach profile is below the 100 year flood elevation, the landward limit of the *dynamic beach hazard* should be staked as the landward boundary between the beach and the material forming the low plain (Figure 5.7a) or 30 metres measured landward from the first break in slope on the lee side of the first dune (Figure 5.8). In this instance the *flooding* or *erosion hazard* may govern the *hazardous lands* landward limit. Where applicable, care must be taken to ensure that the *flooding* and *erosion hazard*s for the *river and stream systems* are also be considered.

· **Step 3** Stake this landward point which represents the *dynamic beach hazard*.

Repeat the process for several locations along the shoreline within the dynamic beach reach using the applicable method. Connect the staked points to form a continuous line which delineates the landward extent of the *dynamic beach hazard* for the reach being evaluated. Figure 6.12 illustrates staking the *dynamic beach hazard*.

TECHNICAL GUIDE FOR
GREAT LAKES - ST. LAWRENCE RIVER SHORELINES

APPENDIX A6.1

METHODS TO DETERMINE ELEVATIONS

AND HORIZONTAL DISTANCES

METHODS TO DETERMINE ELEVATIONS AND HORIZONTAL DISTANCES

TABLE OF CONTENTS

LIST OF FIGURES

A6.1 METHODS TO DETERMINE ELEVATIONS AND HORIZONTAL DISTANCES

The intent of Appendix A6.1 is to present some commonly used methods used to determine elevations and measure horizontal distances in the field. This includes a discussion on levelling techniques and known elevations.

A6.1.1 Levelling

Levelling is used to determine the difference in elevation between points (Figure A6.1.1). Starting from a point of known elevation, the elevation at points of interest can be determined by using one of the methods of levelling described below. Levelling methods which could be used to determine flood limits along the shoreline of the Great Lakes - St. Lawrence River System are:

- differential levelling,
- trigonometric levelling; and
- simple levelling procedure for short distances.

Each method varies in its complexity and required equipment. The purpose of the survey and the degree of accuracy required should determine which method should be applied.

a) Differential Levelling

The differential levelling consists of taking a series of foresight and backsight readings from points of known elevation to determine the elevation of a new points. The general procedure for this method of levelling is provided in the following steps and is illustrated in Figure A6.1.2.

- **Step 1** Hold a rod (e.g., measuring stick) vertically on a point of known elevation (Point 1, Figure A6.1.2).

- **Step 2** Using a levelled level take a reading of the rod at Position A (see Figure A6.1.2). This reading is known as a backsight and gives the vertical distance from the point of known elevation to the level line of sight. By adding the backsight to the known elevation, the elevation of the level line of sight, called the height of instrument, is determined.

- **Step 3** The rod is then moved to a point of unknown elevation (Point 2, Figure A6.1.2), and with the level in the same position a reading of the rod (i.e., foresight) is taken. By subtracting the foresight reading from the height of instrument, the elevation of the new point is established.

  This same instrument setup can be used to read several foresights and establish elevations at various points at the site as required.

- **Step 4** After the foresights are completed, the rod is held at one of the points that have been surveyed while the level is moved to a new location and levelled (Position B, Figure A6.1.2).

- **Step 5** A backsight reading of the rod is taken to determine the new height of instrument. The backsight point elevation is known from the previous foresight reading.

- **Step 6** The rod is then moved forward to the next point of unknown elevation for a foresight reading.

The steps outlined above are then repeated to find the elevation at the required point (Point "Z", Figure A6.1.2).

Figure A6.1.1: Theory of Levelling

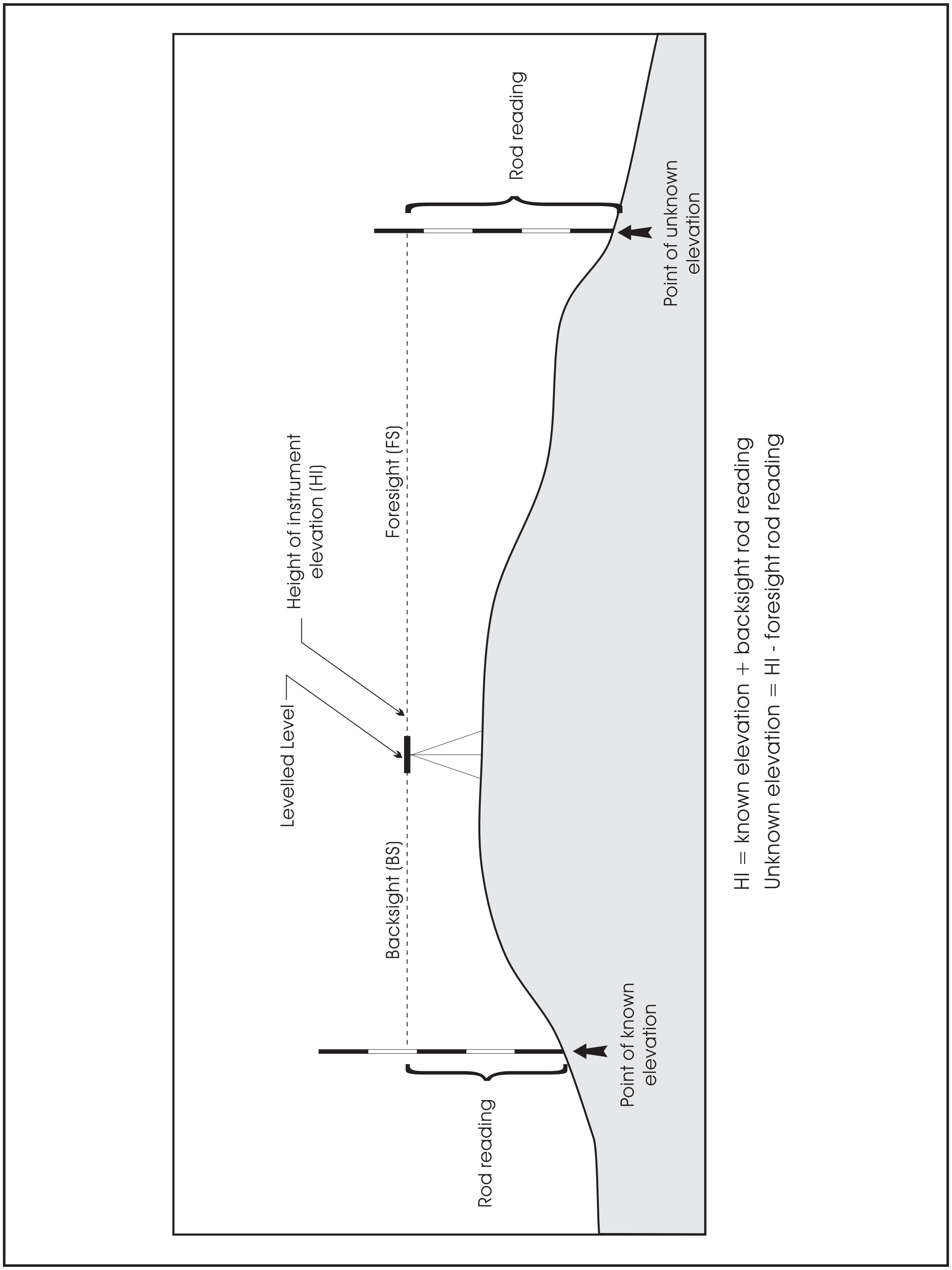
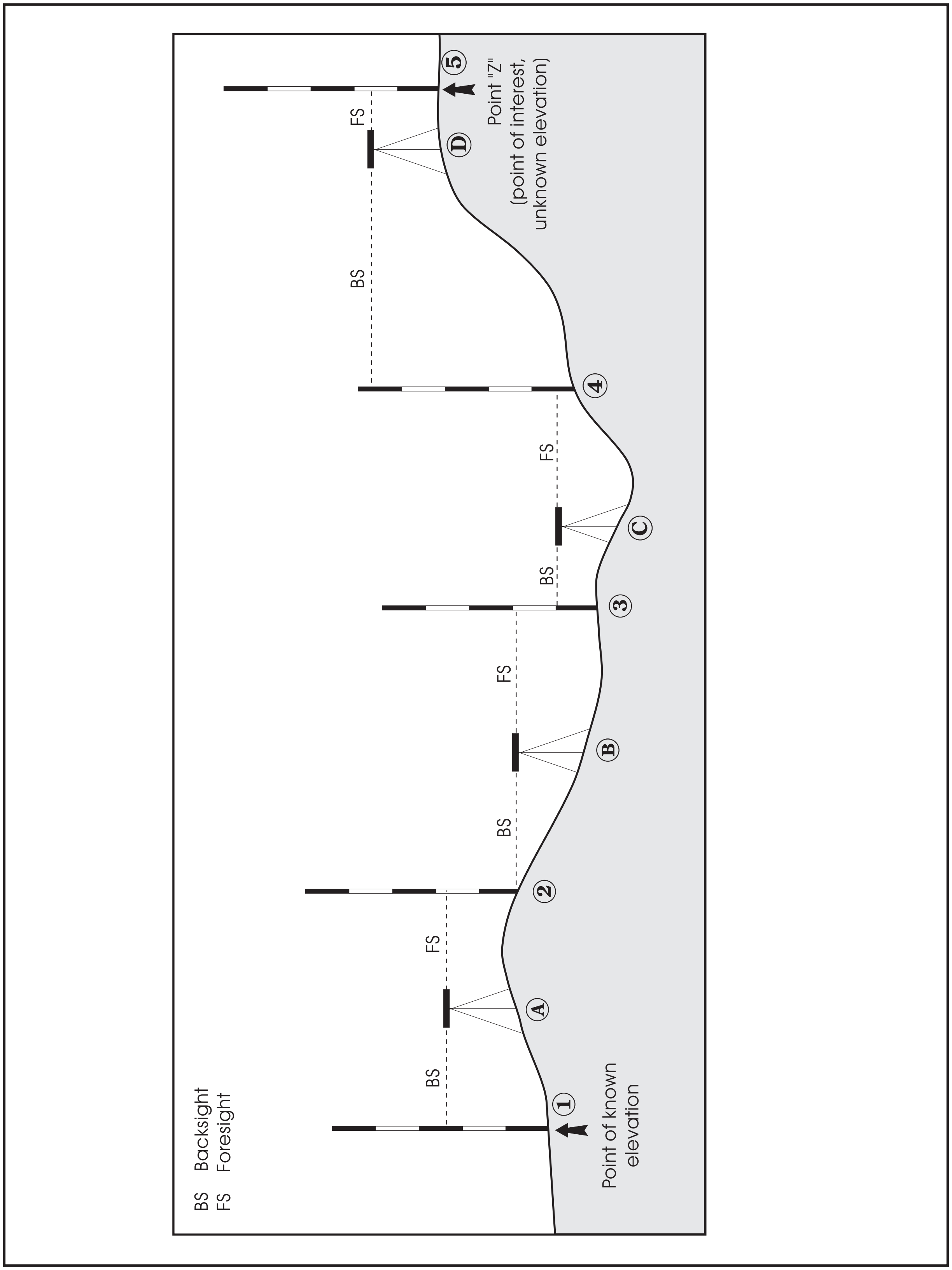


Figure A6.1.2: Differential Levelling Operation



b) Trigonometric Levelling

A second method of levelling, known as trigonometric levelling, uses vertical angles, above or below a horizontal plane, a horizontal distance and applies the fundamentals of trigonometry to determine the differences in elevation between a point of known elevation and a point of unknown elevation (Figure A6.1.3).

Trigonometric levelling requires field measurements of the horizontal distance or slope distance between the instrument and the rod, the vertical angle from the instrument height to some point on the rod, and the rod reading at that point. Usually, the distance between the instrument and the rod is determined either by using a tape or stadia readings.

In addition, trigonometric levelling requires the use of a total station, transit or theodolite, since vertical angles must be measured. Total stations are the more appropriate instrument since they electronically compute the angle and distance.

For further information on this method of levelling and general procedure steps see the references provided in Section A6.1.4.

d) Simple Levelling Procedure for Short Distances

Transferring elevations accurately or over longer distances requires proper equipment and procedures, and should be carried out by a professional surveying firm or engineering consultant. However, in situations where a vertical accuracy of ±0.25 m is acceptable, a simple procedure can be used to transfer elevations over a short distance.

A graphic description of this simple method for estimating the elevation of given point on the shoreline is shown in Figure A6.1.4. To use this method, a few simple tools are required:

- a tape measure;
- two poles, one 2.5 to 3 m long and another about 1.2 m long, both marked off in 10 cm intervals; and
- a carpenter's level.

This simple method for levelling and transferring elevation over short distance is best done by two people, however, one person can carry out the procedure providing:

- the numbering on the long pole is visible from a distance; and
- one of the poles has a hook for attaching the measuring tape so the horizontal distance between the two poles can be measured.

The simple levelling procedure involves the following steps:

- **Step 1** Plant the two poles vertically in the ground, the short pole at the point of known elevation and the long pole at a point of interest. Use the carpenter's level to ensure that the poles are vertical. The top of the long pole must be higher than the top of the short pole to be able to determine the difference in elevation between the poles.

- **Step 2** Put the carpenter's level on top of the short pole so that the carpenter's level is level. Sight along the top of the level and note the position on the long pole where the horizontal sight line intersects the long pole (Distance B, Figure A6.1.4).

Figure A6.1.3: Trigonometric Levelling

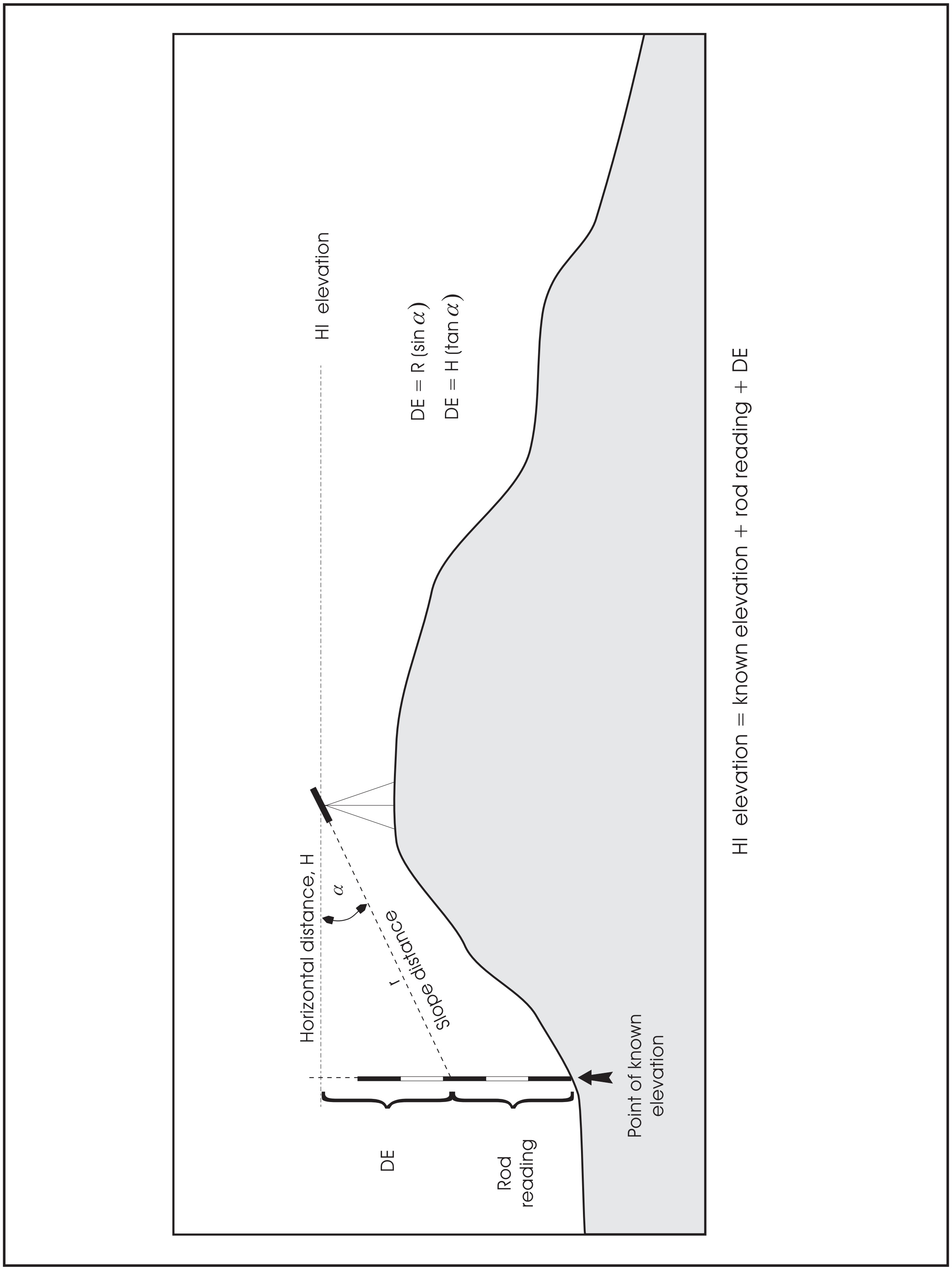
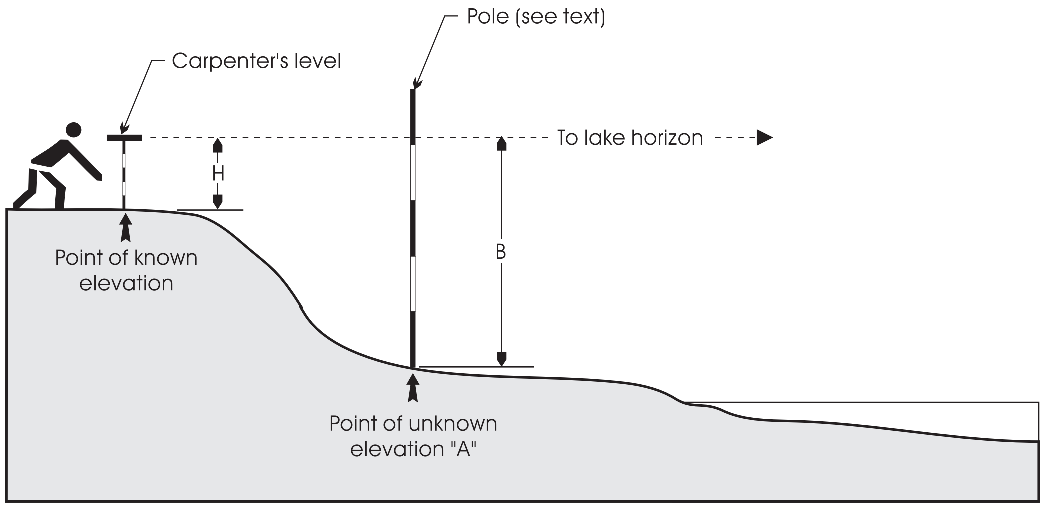
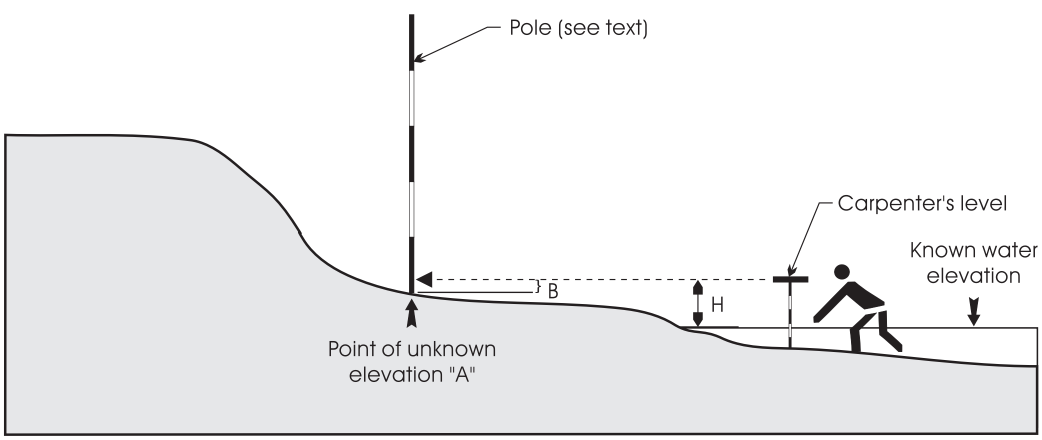


Figure A6.1.4: Simple Levelling Procedure



Elevation of point "A" = elevation of known point + H - B



Elevation of point "A" = known water level elevation + H - B

- **Step 3** Measure the vertical distance from the point of known elevation to the sight line (i.e., the top the carpenter's level on the pole) (Distance H, Figure A6.1.4). The elevation of the point of interest is then determined as follows:

elevation of point = known elevation + H - B.

This procedure can be repeated for several points of interest. Figure A6.1.4 shows this method of determining the elevation at a point by using either a bench mark (i.e., point of known elevation) or a water level.

A6.1.2 Known Elevations

To accurately establish the 100 year flood level elevation in the field requires a known elevation as a starting point. Three common sources of known elevations are:

- bench marks,
- topographic mapping; or
- water levels.

Elevations are generally referenced with respect to a datum. There are four different datums commonly referenced for shoreline areas. Elevations on land are usually referenced to Geodetic Datum as determined by the Geodetic Survey of Canada (GSC). For example, elevations on the 1:2000 scale FDRP shoreline mapping are referenced to GSC. Lake levels are referenced to the datum for each lake which is called chart datum. Chart datum provides elevations above the International Great Lakes Datum (IGLD). Within certain municipalities, older plans and maps may be referenced to the municipal datum. The municipality should be consulted to find further information on this datum.

The differences between the land-based Geodetic Datum (GSC) and the water-based International Great Lakes Datum (IGLD) are not constant, but vary slightly with latitude and elevation. In addition, the datums are adjusted occasionally to account for glacial uplift. For example, starting in 1992, the Great Lakes water levels are no longer referenced to IGLD (1955). They are now based on the IGLD (1985). Additional information on converting between GSC, IGLD (1955) and IGLD (1985) is provided in Appendix A3.1 of this Technical Guide.

a) Bench Marks (BM)

A bench mark is defined as a relatively permanent object, natural or artificial, bearing a marked point whose elevation is known. A bench mark may be further qualified as permanent bench mark (BM) or temporary bench mark (TBM).

Permanent bench marks are marked in a permanent manner where they will not be disturbed by normal activity or frost action. The marks usually consist of metal caps or disks set in concrete or stone posts, in rock outcrops, or in concrete or masonry. The disks have inscribed on them the name of the organization which set the mark, the name or number of the mark for future identification, and the date the mark was set.

Temporary bench marks are set for comparatively short time periods and may consist of a spike in a tree, a wooden stake driven into the ground or a point on a bridge abutment, culvert or building steps.

The location, description and elevation of the nearest BM can be determined by contacting the engineering or public works department of the local municipality or through the Ministry of Transportation of Ontario (MTO). Local land surveyors may also be helpful in finding BM information.

b) Topographic Mapping

The primary source of known elevations along a given shoreline is provided through the Canada-Ontario Flood Damage Reduction shoreline mapping program. On these maps, spot elevations on a variety of physical features including roadways, walls, and in areas of flat terrain, are provided and can be used as points of known elevation.

To improve the overall reliability of the known elevations, the vertical accuracy of ±0.5 m can be used in conjunction with water level information to confirm elevation measurements.

c) Water Levels

For practical purposes, a body of stillwater will generally assume a level surface elevation. If the weather is calm, it can be assumed that the water level at the site is relatively the same as the water level at an established water level gauging station. The water level elevation can be used to define a TBM (i.e., point of known elevation) for the site.

Water level gauging stations, maintained by the Canadian Hydrographic Service (CHS), Fisheries and Oceans Canada, can be found at various locations around the Great Lakes. See Appendix A3.2 for the CHS gauge locations and telephone numbers for the automated voice message of the water level at the time of the call. Assistance and advice on the gauge stations (i.e., where the best gauge for your location is, if one needs to make additional allowances at some locations) can be obtained from the CHS.

On a calm day the water level can be used by taking a reading on the water with a level. Elevations from topographic mapping can then be used to cross check the water level. To establish a more precise elevation at a site the water level method of transferring elevations can be used. A step by step procedure is described below.

i) Water Level Method of Transferring Elevations

For shoreline areas bordering large bodies of water, such as lakes or large bays the water level method of transferring elevations can be used to determine a known elevation at a site. This method may be used for transferring elevations from up to 16 kilometres away.

The water level method of transferring elevations involves the following steps:

- **Step 1** Two points are selected, one which the elevation is known and will be carried forward (i.e., near point), and the other to which the elevation will be transferred (i.e., far point). A temporary bench mark is established below the water surface at each of the points. It is important that the elevation of the near point be accurate. To ensure the accuracy of the elevation, the level line which was run to establish the near point elevation must be double run.

- **Step 2** Rods are held on each of the bench marks and the elevation of the water surface is read. Observations are made simultaneously at both points at 5 minute intervals for a period of 30 minutes on 2 separate days.

  Observations must follow certain precautions including:

  - Water level observations must be made on calm days since the wind can build up water on the leeward side of the lake and can also create rough water making reading difficult.

- Observations must not be made on opposite sides of causeways or narrow straits, or in lakes connected only at high water stages. These conditions result in a lag in water movement and in different levels of water at the two points.

- In all cases, the use of running water in rivers should be avoided.

- **Step 3** The difference in readings is the difference in elevation between the points. The difference is added to the elevation of the near point to establish the elevation of the far point.

A6.1.3 Measuring Horizontal Distances

Usually horizontal distances are measured using a tape. A tape is stretched between two points and the distance is measured while the tape is held horizontal. For locations that are more difficult to measure (e.g., steep bluffs) other survey methods (e.g., stadia readings using a transit or theodolite and rod) could be used. For further description of other methods available refer to the references at the end of this appendix.

A6.1.4 References

The following references are provided for more detailed information about surveying techniques and equipment used.

Davis, Raymond E., Francis S. Foote, James M. Anderson and Edward M. Mikhail. Surveying Theory and Practice (6th ed.) McGraw-Hill Book Company.

Kavanagh, B.F. and S.J. Glenn Bird, 1989. Surveying Principles and Applications (2nd. ed.). Englewood Cliffs, New Jersey: Prentice-Hall Inc.

Kissam, Philp, 1966. Surveying Practice The Fundamentals of Surveying (2nd. ed.). United States: McGraw-Hill Book Company.