MUNICIPALITY OF CHATHAM-KENT

FLOOD PROTECTION STUDY
FOR
ERIE SHORE DRIVE
IN THE
FORMER TOWNSHIP OF HARWICH

Todgham and Case Associates Inc.

Consulting Engineers

Chatham, Ontario

May, 1998

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May 15, 1998

To the Mayor and Council
of the Municipality of Chatham-Kent,
P.O. Box 640
Chatham, Ontario
N7M 5K8

Re: Erie Shore Drive – Flood Protection Study

Instructions:

The rise in the static water level in Lake Erie in 1997 brought with it the now all too familiar flood and wave attack impacts to the lakefront properties on Erie Shore Drive in the former Township of Harwich. The rising lake levels also posed a real flood threat to the Burk Drainage Works. The Council of that Municipality recognized the potential danger and at the Council meeting of April 22, 1997, passed a series of recommendations and allowed the Township to address the many problems associated with the high lake levels. One of the 16 recommendations adopted directed this firm to revisit design alternatives for long term protection works along Erie Shore Drive and update the long term protection cost estimates. This had been last studied in 1986.

The current study commenced while Terms of Reference were developed to define the extent of the technical, legal and planning studies required. The Terms of Reference were submitted to the Municipality in correspondence from Storey Samways Planning dated September 5, 1997. The Terms of Reference recommended that the technical report for shore protection take the form of a preliminary report under Section 10 of The Drainage Act. The application of this legislation would provide the Municipality with a mechanism to proceed with the study which ensures public participation and involvement. The Terms of Reference were adopted by Council.

Purpose of Report:

This report is a preliminary report under Section 10 of The Drainage Act. It does not commit Council or the property owners to any particular course of action. It is intended to provide the following:

- Background information.
- Design alternatives.
- Estimates of project costs.

- Preliminary cost distributions.

After public review, the Council of the Municipality of Chatham-Kent may take several courses of action such as:

- Take no further action.
- Instruction that a final report be prepared which includes any portion or all of the recommended works in the preliminary report.
- Instruct that additional options not previously considered be reviewed.

Should no further action be taken in this matter, all costs to date related to this report shall be borne by the Municipality.

Study Background:

Enclosed with this report is our Figure No. 1 which illustrates the area of the Burk Drainage Works, the extent of the previously constructed shore protection works, the extent of the shoreline exposed to Lake Erie and the approximate limits of the flooding which may be expected in the event of failure of the dyking system based on current lake levels.

The "Burk Drainage Works" generally refers to those lands in Registered Plan 420 and 421 in the former Township of Harwich. They are provided drainage by an extensive internal gravity and artificially pumped drainage system and are provided protection from Lake Erie and Rondeau Bay by an extensive system of dykes, groynes, and other protective works. The total area within the Burk Drainage Works is in excess of 647 hectares (1600 acres) and much of it lies below the current still water elevation of Lake Erie.

The study area extends along Erieau Shore Drive from the westerly end of McGeachy Pond to the Bisnett Sideroad (Station 1+00 to Station 4+150). There are approximately 133 properties located south of Erie Shore Drive which abut Lake Erie. Approximately 21 properties are located in a triangular shaped area located near the westerly end of the study area from Station 3+575 to Station 3+900. There are approximately 75 properties within the Burk Drainage Works which lie north of Erie Shore Drive. These are all agricultural in nature.

Approximately 542 hectares (1340 acres) of the agricultural area within the Burk Drainage Works is considered floodable. Figure No. 1 illustrates contour lines which define the limits to which lake flooding would extend if the dyke was to be breached. The land to the east of those contour lines are the low lying areas.

Virtually all of the major drainage schemes within the Burk Drainage Works are municipal drains constructed under The Drainage Act. Further, with the exception of portions of Erie Shore Drive from the west end of McGeachy Pond to the Bisnett Sideroad, the dyking

system which protects the Burk Drainage Works from Lake Erie and Rondeau Bay was constructed under the provisions of The Drainage Act. Clearly, the Council of the Municipality of Chatham-Kent is responsible to administer the continued repair and improvement of these drainage systems and protective works under The Drainage Act. It would appear that Council has several alternative courses of action open to it. These are:

1. Do nothing.

2. Abandon the existing shore protection systems but create new Municipal Land Control Policies in the area.

3. Maintain the existing systems to their current standards and create new Municipal Land Control Policies in the area.

4. Undertake major improvements to the existing systems.

The "Do nothing" option assumes that the Municipality will undertake no further works of maintenance, repair, or protection of Erie Shore Drive or the protection works associated with the Burk Drainage Works. This does not appear to be practical as Council is obliged under The Drainage Act to maintain and repair all existing municipal drainage systems. However, they are not necessarily compelled to improve the existing systems or construct new works. Further, we believe that Council is obliged to maintain Erie Shore Drive to a standard necessary for public access. It would not appear practical in the long term to jeopardize the municipal and private investment in the existing road and drainage systems. Therefore, it would appear prudent for the Municipality to consider a more effective long term solution for the protection of Erie Shore Drive and the lands and roads within the Burk Drainage Scheme.

The "No Work/New Controls" option assumes that the Municipality will undertake no further works of maintenance, repair, or protection of Erie Shore Drive. However, they could create new Municipal Land Use Policies which would add a measure of control on the future use of the property along Erie Shore Drive and in the Burk Drainage Works. This option may provide the Municipality with an opportunity to impose municipal controls on the use of various lands in this immediate area. However, as this option would still not include any physical works, it does nothing to address the fundamental shortcomings of the "do nothing" alternative.

The "Maintain and Repair/New Controls" option seems to be where the Municipality has focused most of its attention over the last number of years. Maintenance works contemplated under this option would be works which could be done by Municipal forces to provide temporary relief or protection to Erie Shore Drive and the lands in the Burk Drainage Works. In 1997, these works would include the purchase and installation of precast concrete blocks along the north side of Erie Shore Drive and the installation of rock chutes which direct flood events over Erie Shore Drive into the Lakeshore Drain without resulting in erosion damage. Similarly, the Municipality supplied and installed catch basins and road crossings at various locations along Erie Shore Drive in order to provide more effective surface water removal from the lands south of the road.

All of these maintenance works undertaken by the Municipality have focused on short term relief intended to prevent significant damage to Erie Shore Drive and the lands in the Burk Drainage Works. These works offer no direct protection to the properties along the lakeshore. It is also important to recognize that the Municipality has borne all costs of these maintenance works. There does not appear to be any legislative base which allows the Municipality to recover these particular maintenance costs from the properties affected by these works.

While these maintenance works have provided reasonably effective protection to Erie Shore Drive and the Burk Drainage Works, they resulted in inconvenience to the travelling public on Erie Shore Drive. This may also be a liability issue with the Municipality. Further, many lakefront property owners have expressed a view that a constant, effective, shore protection system is required to protect their properties as well as Erie Shore Drive and the agricultural lands to the north.

The Municipality has attempted to exercise some measure of control on the use of the lands along Erie Shore Drive and within the Burk Drainage Works by means of their Official Plan and Comprehensive Zoning Bylaws. Unfortunately, the current zoning bylaw is quite dated and an interim control bylaw has been placed on this area. This is only a temporary control measure which provides the Municipality with time to focus their needs and objectives and carry out more comprehensive investigations.

The "Major Improvements" option would seek a more permanent long term solution for the lands and roads currently affected by the flood events in this area.

Council could consider new capital works designed only for the protection of Erie Shore Drive and the agricultural lands north of the road in the Burk Drainage Works. As well, new capital works could be considered along the lakeshore which would provide protection to the lakefront properties, Erie Shore Drive and the lands in the Burk Drainage Works. The deputation's who appeared before the Council of the Township of Harwich made it very clear to Council that any works contemplated along Erie Shore Drive must focus on long term protection of the lakefront lots as well as the road in the agricultural lands. Therefore, this report focused on the most practical options of achieving this goal.

History of Burk Drainage Works:

A review of the records indicates that the Burk Drainage Works was originally constructed under the Municipal Drainage Act in accordance with a report prepared under The Drainage Act by the late George A. McCubbin dated March 25, 1914. Under the 1914 report, the intention was to construct a scheme which involved the embanking and pumping of the greater portion of the lands in the Third and Fourth Concessions, W.C.R. lying east of the Bisnett Sideroad and west of the Chesapeake and Ohio Railway.

The water caused to flow by gravity from the upper lands to the low-lying lands within the Burk Drainage Works were to be re-directed by means of large open channels and dyke systems in a manner which would prevent these flows from being discharged into the Burk

Drainage Works. Three external drains known as the Third Concession Drain, the Burk Drain, and the Beaver Creek Drain were constructed to cut off the upstream flows and discharge them by gravity into Lake Erie or Rondeau Bay. Earth embankments contained the flow within these channels and provided protection to the low lying lands within the Burk Drainage Works.

A system of open drains was then constructed within the low-lying lands and these drainage systems were provided outlet by means of mechanical pumping stations. In this manner, all low-lying lands within the Burk Drainage Scheme could be provided effective drainage. Over the years, several works of repair and improvement of the internal drainage system and pumping facilities have been undertaken under the provisions of The Drainage Act.

In addition, numerous reports have been prepared which provided for strengthening, raising and protecting the various embankments around the Burk Drainage Works and along the external and internal drains. Also, many improvements have been carried out along the shore of Lake Erie, as works of improvement under The Drainage Act, in order to protect the beach and thereby protect the embankment upon which the Dyke Road is located. This embankment forms a vital part of the Burk Drainage Works as it forms the southerly boundary of the protected area and serves as the only protection against Lake Erie.

Under reports prepared under the provisions of The Drainage Act in 1930, 1946, 1947, 1948, 1951 and 1968, wooden seawalls and wooden groynes were constructed along the shoreline of Lake Erie opposite the length of the Lakeshore Drain abutting the Dyke Road. The construction of the wooden seawalls and groynes was carried out primarily to protect the Burk Drainage Works and except for the 1968 report, the entire cost of the seawall and groyne construction projects was assessed against the lands within the Burk Drainage Works with no assessment being made against the residential lots along the shore of Lake Erie which lie between the Dyke Road and the water's edge. The only exception to this is the 1968 report where an estimated $11,500 out of the $68,000 total estimated assessment was levied upon 23 residential lots with the remaining $56,500 estimated assessment being levied against the lands within the Burk Drainage Area. The 23 residential lots assessed for the seawall and groyne construction of 1968 are located in Concession 4, W.C.R., Registered Plan 421, Part of Lots 455, 4678 to 470, and 472 to 476. This is a triangular area of land bounded by the Dyke Road and Lake Erie near the westerly limit of the study area between Station 3+575 and Station 3+900 on Figure 1.

In 1973, three major projects were undertaken on the dyke systems which protect the Burk Drainage Works. Major dyke reconstruction was undertaken at two locations along the Lake Erie shoreline and the third involved dyke reconstruction along the easterly boundary of the protected area adjacent to Rondeau Bay. These areas are identified as Area A1, A2 and A3 on Figure 1. The A1 and A2 sections along the Lake Erie shoreline involved the construction of approximately 1650 m of earthfill dyke with armour stone protection. All dyke works constructed at that time were done so under the provisions of The Drainage Act and special funding was provided under the A.R.D.A. program which existed at that time.

A report was prepared for the Lower Thames Valley Conservation Authority in 1986 which investigated several options for protection works through this same reach. The report ultimately recommended the following works:

- the relocation of the Lakeshore Drain to the north
- the construction of an earth berm north of the north edge of Lake Shore Drive
- the development of a municipal purchase program for the lots which abut the lake and lie south of Erie Shore Drive.

The L.T.V.C.A. at the direction of the former Township of Harwich received the report but took no action on it.

Lake Level Fluctuations:

The changes in the water level of Lake Erie are affected by several natural factors and man-made influences. The levels of the lake depend on storage capacity, outflow characteristics of the outlet channel, operating procedures of the regulatory structures and the supply of water received by the lake. The primary natural factors affecting the lake levels include precipitation on the lakes, runoff from the drainage basin, evaporation from the lake surface, inflow from upper lakes, and outflow into the downstream lake. Man-made factors include diversions into and out of the Great Lakes Basin, consumptive uses, dredging of outlet channels and the regulation of outflow.

The influence of all of these factors produce long term fluctuations in lake levels that extend from very low levels in 1926, 1935 and 1965 to the high levels experienced in 1972, 1986 and 1997. More than a century of records in the Great Lakes Basin indicate no regular predictable cycle. A plot of the average annual water level records on Lake Erie from 1918 to 1997 is attached as Figure 2. At its peak in June of 1997, Lake Erie was approximately .7 m above its long term average elevation for that month.

The seasonal fluctuations of Lake Erie are far less dramatic. The annual hydrologic cycle produces higher net basin supplies in the spring and early summer and low net supplies in the remainder of the year. The maximum lake level usually occurs in June and will be approximately .3 m above the season low which is experienced in December-January.

More significant water level fluctuations, lasting from several hours to several days, can be caused by wind effects and differences in barometric pressure over the surface of the lake. Storm surges of approximately .5 m are common through this reach of the lake.

Acting on all three categories of water level fluctuations are wind induced waves. Surface waves are the main cause of shore erosion. Localized flooding also occurs as a result of waves overtopping the existing shoreline protection system.

Existing Conditions:

A detailed topographical survey was conducted along the lakefront from the west end of McGeachy Pond to the Bisnett Sideroad. All existing shore protection systems which were

in place at that time were noted. As well, the impacts of potential flood events on lands, roads, and utilities in the Burk Drainage Works was also reviewed.

a) Wooden Seawall and Groynes

Wooden seawalls and wooden groynes have been constructed along the lakeshore under the provisions of The Drainage Act under reports of 1930, 1943, 1946, 1947, 1948, 1951, and 1968. Generally speaking, these walls have not been maintained by the Municipality nor the property owners. In fact, the majority of these wooden groynes have been destroyed by natural lake processes or have been replaced by privately installed systems.

The existing seawall and groynes systems were not designed to provide effective protection from the high lake levels experienced in 1973, 1986 and 1997. It does not appear that they have been effective in the development of any substantial sand beach at the current lake levels. It does not appear practical on the part of the Municipality to undertake a program to attempt to maintain or repair these wooden groyne systems.

AGRICULTURAL + RURAL DEV. ACT.

b) 1973 A.R.D.A. Dyke Works

The extent of the two sections of dyking in lakeshore protection installed in 1973 under the A.R.D.A. program is shown in Figure 1. An inspection of these dykes confirm that they have performed to their intended design standard. They have provided effective flood protection to the lands they were intended to serve. There has been virtually no requirement for maintenance on these dykes since their construction.

c) Lake Shore Drive

The high lake levels in 1986, in conjunction with several storm events during that period resulted in significant flooding over Erie Shore Drive. The overtopping of Erie Shore Drive caused serious erosion and loss of the north shoulder and portions of the north travelled lane of the road. All of the material was eroded into the Lake Shore Drain which abuts the north edge of the travelled portion of Erie Shore Drive for much of its length. Remedial measures were taken at the time by the Township of Harwich to protect the structural integrity of the road.

As no long term shore or flood protection program was implemented as a result of the 1986 experience, the Municipality simply rebuilt Erie Shore Drive after the lake levels subsided. The reconstruction took place in 1991. Although every effort was made to raise the centreline profile of the road where possible, this was extremely constrained by the very narrow platform width. The works did raise the road as much as 300 mm in places. However, this was never intended as a long term flood protection measure for the lands in the Burk Drainage Works.

Storm events, coupled with the high lake levels experienced in 1997 once again generated flood events over Erie Shore Drive. Again the Municipality undertook emergency remedial action to protect the structural integrity of the road. While these actions serve to

protect the Burk Drainage Works against catastrophic failure of Erie Shore Drive, it remains susceptible to isolated flood events caused by the large volume of water discharged into the scheme from the lake. Further, it must bear the cost of the additional pumping required to remove these flows.

Clearly, any long term solution should be aimed at providing additional flood protection to Erie Shore Drive and the Burk Drainage Works.

d) Lakeshore Properties

During the 1986 event and in the subsequent years, many property owners have constructed private shore protection systems along the lake frontage of their property. However, wind generated wave events on the high lake levels experienced in 1997 once again resulted in flood and wave damage to many of the permanent homes, cottages and residential lots along this reach of the shoreline. The degree of damage varied to some extent by the effectiveness of the private shore protection systems. There is little doubt that the beach area, the beach dune, and the residential structures between the lake and Erie Shore Drive absorb a great deal of the energy from wave attack and in fact, provide some considerable degree of protection to the Erie Shore Drive and lands to the north. However, since there is no consistency in the design of the private protection systems along the lakeshore, effective, long term protection against wave damage or flooding is not provided to the residential properties, Erie Shore Drive, or the lands in the Burk Drainage Works.

Private shore protection systems along the lakeshore cover a broad range of design standards and materials used. Some property owners have no protection at all while others have reasonably substantial steel sheet pile seawall and groyne systems. As there is no consistent design standard applied, there are several instances of private structures failing as a result of the activities, or lack thereof, on neighbouring properties.

The construction of private shore protection systems at various locations along this reach of the lakeshore continue on a near constant basis. Obviously, any long term shore protection option should provide a consistent level of protection to the properties along this reach of the lakeshore.

e) Utilities

The utilities which exist within the road allowance of Erie Shore Drive include Ontario Hydro, Bell Canada and a municipal watermain which serves the Erie Shore Drive residents as well as the Community of Erieau. The Ministry of the Environment currently administers the watermain at the expense of the local residents although this may change with the recent municipal amalgamation. Catastrophic failure of Erie Shore Drive will result in significant damage to these services.

Continuing erosion of the lakeshore at various locations along this reach have significantly reduced the relative proximity of the watermain to the lakeshore. The Ministry of the

Environment has installed armour stone and broken concrete along the shoreline at various locations in order to provide additional protection to the waterline. We understand that they have no intention of relocating the waterline. Should this become a municipal responsibility as part of the municipal restructuring, the new municipality must give consideration to the circumstance.

f) Access to Erieau

The Community of Erieau is accessible only by County Road No. 12 which passes through the centre of the Burk Drainage Works. This roadway has been constructed to an elevation which is significantly above that of the adjacent lands. However, various portions of the road are still below the potential flood elevations that would occur should catastrophic failure of Erie Shore Drive occur. In that case, the Community of Erieau would, in all probability, be cut off from public access, potable water, and electrical services. This would pose a significant threat to life and property.

Previous Engineering Study:

Todgham and Case Associates was commissioned by the Lower Thames Valley Conservation Authority to prepare an engineering study of this same area in 1986. The main purpose of the study was "*to determine the extent of the damage caused by the recent storm events, examine the reasons for flooding and examine the feasibility and cost of several alternative schemes for providing an improved degree of protection to the Burk Drainage Works as well as the potential benefits to be derived by providing this improved protection.*" That study was supported by a Coastal Engineering Study done by Keith Philpot Consulting Limited.

Although the focus of the study was the protection of the Burk Drainage Works, some of the options considered involved construction activities along the lakeshore which would consequently provide protection to the lakefront properties as well as Erie Shore Drive and the Burk Drainage Works. The most cost-effective lakeshore protection system described in that report consisted of a steel sheet pile wall parallel to the shore near the water's edge in conjunction with a steel sheet pile groyne field. However, this alternative was not supported by the Coastal Engineering Consultant on the basis that there was insufficient literal material to effectively fill the groynes. Further, it was anticipated that the vertical wall at the head of the beach could potentially accelerate the erosion of the near shore lakebed.

The preferred alternative recommended in the report included the relocation of the Lakeshore Drain north of Erie Shore Drive and the construction of an earth dyke immediately north of Erie Shore Drive. This option would provide maximum flood protection to the lands within the Burk Drainage Works. This option offered no protection whatever to the lakeshore properties south of Erie Shore Drive. However, it did include a program of municipal acquisition of properties along the lakeshore.

The total estimated cost of those works inflated to 1998 values is in the order of $10.8 million dollars. As these works would only provide protection to lands and roads within the

Burk Drainage Scheme, we would anticipate that any cost recovery program would be focused on the Municipality and the agricultural lands in the Burk Drainage Works.

Only a very rudimentary cost benefit analysis was carried out under that report. It was assumed that structural failure of Erie Shore Drive would result in the permanent loss of all agricultural lands which would be flooded. This was thought to be a reasonable assumption as catastrophic failure of the dyke would require very significant works of reconstruction and land reclamation only to achieve the same deficient level of protection that existed prior to the failure. At that point, allowing the flooded lands to remain so would require serious consideration.

Current Related Engineering Studies:

The Council of the former Township of Harwich had several meetings with groups and individuals who represented the interest of both the lakeshore property owners and the agricultural lands in the Burk Drainage Works. They also had discussions with various government agencies including Ministry of Municipal Affairs and Ministry of Natural Resources. The public representations to Council urged that a long term solution be investigated which would provide effective flood and wave damage protection to the lakefront properties, Erieau Shore Drive and the agricultural lands in the Burk Drainage Works. This obviously would involve works along the shoreline.

The Ministry of Natural Resources expressed the view that a consistent approach to lakeshore protection works would be in the best interests of all concerned. They stressed that any works along the lakeshore must be environmentally responsible and provide effective protection to a consistent standard. However, the Ministry of Natural Resources also was of the view that technical input was required from a recognized Coastal Engineering Specialist. As a result, W.F. Baird & Associates, a nationally recognized expert in coastal engineering was retained as part of the study team. Their report is attached in its entirety as Appendix "A".

The Baird report provides the technical background and develops the alternative long term shore protection options. It also contains short term protection options which may be implemented by individual property owners. These short term recommendations need not be part of any overall shore protection scheme but are intended to increase the effectiveness and improve the stability of the existing private systems which are found through this reach.

It was noted during our field investigation that several privately installed concrete and steel sheet pile seawalls and steel sheet pile groynes had failed. Proper design of any structure along the lakeshore requires not only coastal engineering data but also geotechnical data. Therefore, Golder Associates Ltd., a recognized geotechnical engineering firm was retained to complete the geotechnical investigation. This report clearly identifies the variability of the geotechnical conditions at various locations along the shoreline. It also recommends the appropriate geotechnical parameters required in the design of steel sheet pile walls and groynes or armoured earth dykes. This information is useful not only as part of this study, it may also be applied to the design of any private schemes on the properties.

The geotechnical report has not been appended to this report. However, a copy will be made available by the Municipality at no cost to any affected property owner who wishes one.

Proposed Works:

The Baird report recommends the division of the study reach into four distinct sections. Each section has unique features or conditions which distinguish it from neighbouring sections. The section reaches are identified on the attached plans labelled Figure No. 3 and 4. The proposed works in each section are summarized as follows:

Reach 1 (Station 3+900 to Station 4+150)

The recommended works include the reconstruction of the existing shore protection works as an armour stone revetment. The existing concrete rubble and armour stone materials would be salvaged from this reach for reuse. The underlying earth berm would be raised, widened and reshaped to produce a consistent cross-section with a finished elevation of at least 176.50 m. This would be very similar to the existing dyke system which exists along McGeachy's Pond. An appropriate geotextile would be placed on the reshaped earth berm and it would be covered with the salvaged material as well as additional armour stone. All of the works would take place on privately-owned lands. Appropriate allowances for the right of access onto the property to perform the works as well as the use of the land on which to construct the works will be required.

These works would provide effective long term erosion and flood protection to the lands and roads lying north of the revetment. However, this system would not enhance beach development through this reach.

Reach 2 (Station 3+575 to Station 3+900)

The recommended works through Reach 2 includes the installation of three armour stone hard points with beach. The armour stone hard points shall consist of a rock core extending from the shore lakeward approximately 30 m. The rock core would be covered with layers of filter rock and armour stone. The armour stone hard point would encourage beach development which in turn would provide flood protection during storm events. It may be necessary to initially prenourish the beach unless it can be clearly determined that sufficient natural material is available.

This option would not significantly reduce the access to the water through this reach. However, access through specific properties to permit construction would be required. The vast majority of construction would occur on the lake bed.

Reach 3 (Station 3+080 to Station 3+575)

The physical limitations through this reach severely limit the shore protection options available. The existing lots have so little depth that any shore protection system along water's edge would severely limit their development. The probability of regenerating a beach

sufficient to allow redevelopment of these lots as well as provide some degree of flood protection to them is remote. Erie Shore Drive and the Burk Drainage Works are already adequately protected by the previous works completed in 1973. Therefore, it is recommended that the Municipality consider municipal ownership of the lots through this reach. Acquisition at fair market value with life lease provisions could be considered.

Reach 4 (Station 0+045 to Station 3+080)

The recommended works include the construction of offshore breakwaters and steel sheet pile wall with beach. This design consists of a large offshore breakwater constructed parallel to the shore and connected to the shoreline by a steel sheet pile wall. The offshore breakwater would be constructed approximately 60 m lakeward. These structures would create semi sheltered embayments which would contain sediment and extend the beach and beach profile. It may be necessary to initially prenourish the beach unless it can be clearly demonstrated that sufficient natural material is available.

This option would not significantly reduce access to the water through this reach. It would also enhance the effectiveness of all existing private shore protection systems. The vast majority of the construction activities would occur on the lakebed although access through specific properties to permit construction would be required.

Project Cost Estimates:

The estimated project costs have been developed based on the preliminary design parameters described herein. A more detailed discussion is included in the Baird report which is attached as Appendix "A".

Recognizing that the construction costs will be impacted by the type of construction options specified, we have developed an estimate of cost for each specific reach. It is also recognized that detailed design, coupled with economies of scale may result in a net decrease in cost of approximately 10% in some reaches. This reduction has not been included in this report.

Further, a significant component of project cost in some reaches relates to the importation of sand and granular material to prenourish the embayments. If detailed study confirms that this may not be necessary, the elimination of this component of cost could result in the reduction in cost for some reaches in the order of 10% to 25%. These potential reductions have not been included in this estimate. We recognize that the resulting estimate is conservative but believe it must be clearly understood from the outset what the potential order of magnitude of costs can be.

The preliminary estimate of cost on a reach by reach basis including the potential engineering and contingency costs is as follows:

Reach 1	$676,000
Reach 2	780,000
Reach 3	570,000
Reach 4	7,585,000
TOTAL CONSTRUCTION COST	**$9,611,000**
Engineering (12%)	1,153,320
Contingencies (3%)	288,330
TOTAL PROJECT COST	**$11,052,650**

Assessment of Project Costs:

The cost of all projects undertaken under the provisions of The Drainage Act are assessable against the lands and roads which are affected by the works. In this instance, the works recommended in each of the defined reaches along the lakeshore affect different properties or groups of properties in different ways. Further, it is possible that the property owners and Council choose to proceed with works in one or more of the defined reaches. In that case, some groups of property may not be affected and therefore should not be involved in sharing the assessed costs. Therefore, we have developed a preliminary distribution of project cost for each of the four reaches.

The suggested distribution of project costs contained herein is not on a property by property basis. Generally, preliminary reports of this nature set out the total assessment that would be levied against the lands and roads affected by the work. This is intended to provide a general order of magnitude of potential assessments.

For the purposes of this preliminary assessment, we have assumed that all costs associated with providing protection to utilities will be the responsibility of the Municipality. A brief description of the cost distribution considerations for each reach is as follows:

a) **Reach 1**

- Direct wave damage and flood protection provided to one vacant lot on the lakeshore.
- Direct wave damage and flood protection provided to Erie Shore Drive.
- Flood protection provided to lands in Burk Drainage Works.
- Municipal services not severely threatened.
- Access to Erieau not severely threatened.

Lakefront Lots	5%	$ 38, 870
Erie Shore Drive	60%	$466,440
Lands in Burk Drainage Works	35%	$272,090
Total		**$777,400**

b) **Reach 2**

- Direct wave damage and flood protection provided to approximately 21 lots south of Erie Shore Drive.
- Minor amount of flood protection provided to Erie Shore Drive.
- Minor amount of flood protection provided to lands in Burk Drainage Works.
- Municipal services not severely threatened.
- Access to Erieau not severely threatened.

Lakefront Lots	80%	$717,600
Erie Shore Drive	10%	$ 89,700
Lands in Burk Drainage Works	10%	$ 89,700
Total		**$897,000**

c) **Reach 3**

- No private lots to remain in this reach.
- No threat to Erie Shore Drive.
- No threat to lands in Burk Drainage Works.
- Long term benefit as Municipal parkland.

Municipality of Chatham-Kent

Municipality of Chatham-Kent	100%	$655,500
Total	**100%**	**$655,500**

d) **Reach 4**

- Direct wave damage and flood protection provided to all lakefront lots.
- Direct wave damage and flood protection provided to Erie Shore Drive.
- Flood protection provided to lands in Burk Drainage Works.
- Municipal services threatened.
- Access to Erieau threatened.

Lakefront Lots	50%	$4,361,375
Erie Shore Drive	20%	$1,744,550
Utilities	6%	$ 523,350
Access to Erieau	4%	$ 348,925
Lands in Burk Drainage Works	20%	$1,744,550
Total		**$8,722,750**

A summary of the assessments levied on a reach by reach basis against the three primary assessable groups of properties is as follows:

SUMMARY

	Reach 1	Reach 2	Reach 3	Reach 4	Total	% of Total
Lakefront Lots	$38,870	$717,600		$4,361,375	$5,117,845	46%
Burk Drainage Works	$466,440	$89,700		$1,744,550	$2,300,690	21%
Municipal	$272,090	$ 89,700	$655,500	$2,616,825	$3,634,115	33%
Totals	**$777,400**	**$897,000**	**$655,500**	**$8,722,750**	**$11,052,650**	**100%**

We would recommend that all assessments levied against the agricultural lands in the Burk Drainage Works be developed on an equalized rate per acre basis. There is a total of approximately 1810 acres within the Burk Drainage Works. Therefore, the potential gross assessment against the agricultural lands, assuming that all four reaches are constructed as recommended, would be in the order of $1,271 per acre. Therefore, on this basis, a 100 acre parcel could anticipate a gross assessment of approximately $127,100.

Should the recommended work in Reach 2 proceed, we recommend that only these 21 properties in the triangular area bounded by Erie Shore Drive and the Lake Erie Shoreline be levied the costs apportioned to the "lakefront lots". We would recommend the cost be recovered on an equalized rate per acre from these lots. This would result in an assessable rate of approximately $94,297 per acre. There are several very small parcels of land in this area which are in the order of .10 acres. The gross assessment against these lands, in that case, would be in the order of $9,430.

Should the recommended works in Reach 4 proceed, we recommend that only those 105 properties, which exist along the lakeshore, be levied the costs apportioned to the "lakefront lots". We would recommend that the cost be recovered on an equalized rate per metre frontage along the lakeshore. This would result in an assessable rate of approximately $2,506 per metre. The average lot has a lake frontage of approximately 20 m. The gross assessment against an average lot would be in the order of $50,120.

Grants:

The Municipality has made inquires to Mr. Jerry Pickard, MP regarding the potential for federal assistance in this matter. At this point, it is our understanding that no federal programs exist which could provide assistance to the property owners for this project.

The Municipality has contacted Mr. Jack Carroll, M.P.P. regarding the potential for provincial assistance. It was pointed out that should the works be completed under the provisions of The Drainage Act, those agricultural properties which are levied assessments are eligible for a 33-1/3 percent grant from the Ministry of Agriculture, Food and Rural Affairs. No grants are available under this program for non-agricultural or municipally owned properties. We understand that no grants are available under any existing programs managed by the Ministry of the Environment or the Ministry of Natural Resources.

The Ministry of Municipal Affairs announced funding of the Shoreline Property Assistance Act in the late fall of 1997. This program is directed towards private property owners as it provides funds in the form of a loan for private works. The original intention of the Provincial Government was to suspend funding under this program at the end of March, 1998. We understand that they are reviewing the extension of this program. However, it does not appear that this program will be of any significant benefit to this project.

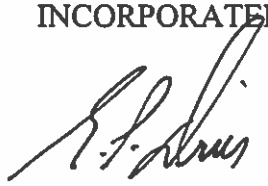
Conclusions:

We are satisfied that the report recommends sound technical alternatives which will produce long term wave impact and flood protection benefits to the lakefront lots, Erieau Shore Drive, and the lands in the Burk Drainage Works. We are also satisfied that the application of The Drainage Act is an appropriate mechanism to proceed with any portion of the recommended works. However, the significant costs to all parties involved in this project are of major concern.

We recommend that all issues be thoroughly discussed and the views of the public be clearly brought to the new Council of the Municipality of Chatham-Kent in order that they may be in a better position to decide the fate of this project.

Yours truly,

TODGHAM & CASE ASSOCIATES
INCORPORATED

Per: 

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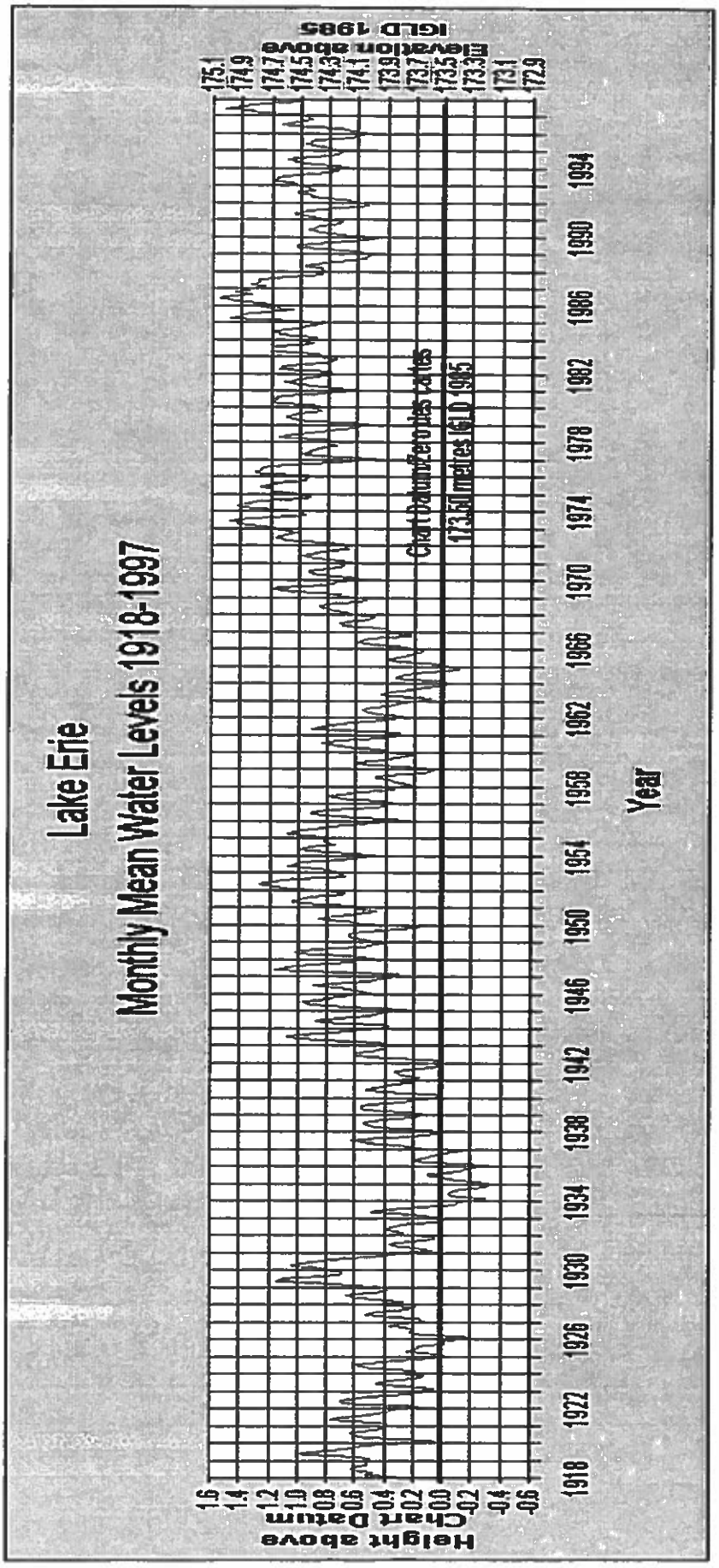
E.P. Dries, P. Eng.

FIGURE 2


Lake Erie
Monthly Mean Water Levels 1918-1997
Height above Chart Datum
Elevation above IGLD 1985
Year
Chart Datum refers to 1985
173.50 metres IGLD 1985
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
175.1
174.9
174.7
174.5
174.3
174.1
173.9
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1990
1994

APPENDIX "A"

SHORELINE PROTECTION ALTERNATIVES

FOR

ERIE SHORE DRIVE

Shoreline Protection Alternatives for Erie Shore Drive, Municipality of Chatham-Kent

Prepared for:

Municipality of Chatham-Kent

Prepared by:

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May 1998

TABLE OF CONTENTS

1 INTRODUCTION

Erie Shore Drive and the Burk Drainage Works are located on the north central shores of Lake Erie, west of Rondeau Bay and the Town of Erieau. The study area begins at the western terminus of the dyke works protecting McGeachy's Pond and extends westward to the outlet of Beaver Creek. The majority of the shoreline properties south of Erie Shore Drive are full time residences, and the land use north of the road is predominately agricultural. Erie Shore Drive separates the residences from the agricultural lands and was constructed on top of a dyke build to protect the area from flooding.

During the high lake levels in 1985 and 1986, many of the properties along Erie Shore Drive were damaged by storms and experienced significant shoreline erosion. The dyke and road were also damaged in some locations. In 1996 a series of reports were prepared by Todgham & Case and Philpott Consulting Ltd. to identify potential shoreline protection alternatives to eliminate shoreline erosion and protect the agricultural community from further damages associated with flooding. The coastal engineering report prepared by Philpott Consulting Ltd. (1986) recommended the construction of an armour stone revetment to protect the shoreline from further erosion and flooding hazards. The recommendation for the shoreline protection by Philpott was part of the overall management strategy for the area prepared by Todgham & Case (1986), which included the following works:

- the construction of an earth berm north of Erie Shore Drive for a distance of 2,000 m west of the west end of McGeachy's Pond;
- the purchase of all the properties south of the proposed berm by the Municipality;
- the construction of a clay dyke with armour stone protection along the lakeshore for a distance of 720 m east of the Beaver Creek Dam.

The findings of the reports were accepted by the Lower Thames Valley Conservation Authority and the Township of Harwich in 1986, however, insufficient financial support to implement the recommendations suspended the project and no further action was taken. Lake levels dropped in the late 1980's and shoreline erosion was no longer an urgent concern to the residents of Erie Shore Drive and the Township of Harwich. With the return of near record high lake levels in the summer of 1997, the community at Erie Shore Drive is again threatened by shoreline erosion and flooding hazards during severe storm events on Lake Erie.

Baird & Associates have been retained by Todgham & Case and the Township of Harwich to provide technical expertise in the assessment of shoreline erosion at Erie Shore Drive, develop protection alternatives, and prepare preliminary cost estimates.

This report has been prepared to outline the coastal engineering investigations completed for Erie Shore Drive and the development of preliminary design alternatives for shoreline

protection and flood mitigation. It should be noted that the designs presented in this report represent potential alternatives for shoreline protection at Erie Shore Drive and are not final engineering drawings. Prior to the implementation of the recommendations for shoreline protection in this report, a complete coastal engineering investigation must be completed by a qualified coastal engineer. Requirements for the detailed investigation include, but are not limited to: a hydrographic survey of the lake bed conditions in the study area, a detailed analysis of the wave and water level conditions, a regional sediment budget, identification of the potential impacts of coastal structures on the adjacent shoreline and the aquatic ecosystem, design and preparation of construction drawings and specifications, and agency approvals to construct the shoreline protection alternatives.

2 BACKGROUND INFORMATION

2.1 Study Objectives

Prior to the development of the guidelines for shoreline protection and the formulation of a study methodology, several key project objectives were identified. Based on input from Todgham & Case, the Township of Harwich, and representatives from the residents group and agricultural community, the following project objectives were identified:

- develop preliminary design alternatives for shoreline protection at Erie Shore Drive to reduce the threat of further shoreline erosion;
- provide recommendations to reduce the potential hazards associated with wave overtopping and flooding of the residential properties and the agricultural community at Erie Shore Drive;
- design shoreline protection alternatives such that the negative impacts on the adjacent properties, the downdrift shoreline, and the aquatic ecosystem are minimal;
- prepare preliminary cost estimates for the shoreline protection alternatives.

2.2 Guidelines for the Development of Shoreline Protection Alternatives

Once the project objectives were identified, the following guidelines were established for the development of the shoreline protection alternatives:

- stabilise the shoreline for a minimum of 25 years;
- incorporate beach development in the design alternatives to maintain the existing beach and improve access to the waters edge;
- develop innovative, cost effective solutions to protect the shoreline and reduce hazards associated with flooding;
- identify potential opportunities to phase the construction of the recommended design alternatives at Erie Shore Drive;
- the design alternatives must minimise potential impacts to the adjacent properties and the downdrift shoreline;
- provide recommendations for remedial measures to repair existing shoreline treatments and improve the level of short term protection on a site specific basis in the event that regional solutions are not implemented immediately.

2.3 Project Methodology

Based on the identification of project objectives and the development of guidelines for the shoreline protection alternatives, a project methodology was prepared to direct the activities of the investigation. The bullet points below summarise the study methodology followed during the investigation at Erie Shore Drive:

- site visit and preliminary meetings with Todgham & Case and the Township of Harwich;
- assessment of field data and existing shoreline conditions;
- development of preliminary design alternatives;
- meeting with stakeholders to discuss the development of preliminary design alternatives;
- prepare cost estimates for the design alternatives;
- preparation of a preliminary report and circulation for comments;
- final report outlining shoreline protection alternatives for Erie Shore Drive and recommendations for further studies;
- public meeting to present the findings of the investigation.

2.4 Previous Reports

The original review of the shoreline protection at Erie Shore Drive was completed by Dr. Robert Nairn in August 1986, while employed at Philpott Consulting Ltd. Dr. Nairn is presently the Principal in charge of the Toronto area office of W.F. Baird & Associates. Todgham & Case (1986) also prepared a companion report for the Burk Drainage Works and the Flood Protection Study. References are provided in Section 8.0.

The reports concluded that the adopted shoreline protection alternatives must provide reliable flood protection and promote the development of beaches in order to protect the underlying cohesive sediments from further erosion at Erie Shore Drive. The study determined that the use of vertical steel sheet pile walls and groins would not protect the cohesive profile from further erosion, especially at high lake levels. Also, the ability of the groins to trap beach sediment was questionable, especially at high lake levels. The lack of beach development at high lake levels increases the potential for wave overtopping and flooding during storms.

The study completed by Nairn (1986) recommended the installation of a sloping rock revetment, aligned to trap sand in pocket beaches. The revetment would provide long term erosion protection and reduce the risk of flooding. In locations of substantial beach development, the pocket beaches would protect the underlying cohesive profile from further downcutting and reduce the long term erosion rate.

3 EROSION PROCESSES AT ERIE SHORE DRIVE

3.1 Cohesive Shorelines

The shorelines on the north shore of Lake Erie can be broadly grouped into three categories:

- cohesive shores;
- sandy shores;
- bedrock shores.

In order to properly understand the erosion processes at a particular site, it is of critical importance to identify the shoreline type(s) within the limits of a study area. The erosion processes associated with the three categories outlined above are fundamentally different and the implementation of successful shoreline protection must accommodate for these differences during the design process.

The shoreline within the limits of the study area is classified as cohesive. On a cohesive shoreline, the erosion process is directly related to the removal of a cohesive sediments in the nearshore zone, at the waterline, and the bank. Even if sand is present on the beach or as a thin layer below the waterline, the cohesive sediments below the beach play the fundamental role in the rate of erosion and consequently, how the shoreline evolves over time. This differs fundamentally from a sandy shores were erosion (or deposition) is related to the net loss (or gain) of non-cohesive sediment, for a given area. Erosion on a sandy shore is a potentially reversible process while erosion on a cohesive shoreline is irreversible.

3.2 Principal Causes of Erosion on Cohesive Shorelines

Erosion processes on cohesive shores are different from those on sandy and bedrock shores and will be discussed briefly. On consolidated cohesive shores, the erosion process is irreversible because, once eroded, cohesive sediment (e.g. clay) cannot be reconstituted in a consolidated form in the energetic coastal environment. Furthermore, since the sand and gravel content is low in these deposits (often less than 20 per cent), erosion is not balanced by an equal volume of deposition within the littoral zone. The eroded fine sediments (silt and clay) are winnowed, carried offshore, and deposited in deep water in contrast to the sand fraction, which usually remains in the littoral zone.

The four primary mechanisms for the erosion of consolidated cohesive sediment are:

- abrasion by sand particles;
- pressure fluctuations associated with wave breaking induced turbulence which reaches the lake bed and turbulence associated with large scale eddies that may develop in the surf zone;
- through chemical and biological influences; and
- through wet/dry and freeze/thaw cycles when exposed to the atmosphere.

Sand can also provide a protective cover to the underlying cohesive substratum. However, only when the sand cover is sufficient to protect the cohesive substratum at all times will the shore revert to a sandy classification. At present, there is insufficient sand along the beaches of Erie Shore Drive to protect the cohesive profile completely. The fillet beach deposit on the west side of the navigation channel to Rondeau Bay is an example where the sand cover is capable of protecting the cohesive substratum at all times and the classification at this location reverts to a sandy shore.

At Erie Shore Drive several factors have contributed to the reduction of sand at the shoreline and in the nearshore zone: construction of shoreline protection updrift (to the west) which traps littoral sediments moving in a west to east direction, a reduction to the quantity of new sediment supplied to the littoral system due to the implementation of shoreline protection schemes to the west, sustained periods of high lake levels, and the construction of vertical structures (such as seawalls) at the shoreline, which deflect wave energy and erode beach deposits.

Many locations featuring cohesive shorelines on the Great Lakes are experiencing similar reductions in sand cover thickness' as Erie Shore Drive. Studies at these sites indicate that as the volume of sand in the nearshore zone and beach decreases, the rate of shoreline erosion will accelerate with time. Although there is insufficient data to confirm this hypothesis at Erie Shore Drive, the magnitude and frequency of damage sustained during the past and present high lake level appears to support the theory of a decreasing sand cover thickness.

Assuming the sand cover remains depleted at Erie Shore Drive, the cohesive substratum will continue to erode, possibly at accelerated rates. Previous efforts to eliminate shoreline erosion have focused on shoreline stabilisation with vertical structures and a range of non-engineered techniques. Unfortunately, regardless of whether these structures have been successful at protecting the shoreline in the short term (and most have not), they have done nothing to promote beach development and protect the nearshore lake bed from further downcutting. Consequently, the cohesive substratum has continued to erode, which ultimately leads to a deep nearshore zone and undermining of shore parallel structures, such as concrete seawalls.

4 SHORELINE REACHES AND EXISTING SITE CONDITIONS

4.1 Rationale for Shoreline Reaches

The study area from McGeachy's Pond to Beaver Creek covers over 3 km of shoreline, which ranges from unprotected sandy beach, to various forms of shoreline protection, including: vertical seawalls, groins, concrete blocks, and dumped concrete rubble. The field investigations identified two major deficiencies common to the majority of the shoreline protection installations: inadequate attention to critical design details for successful shoreline protection (i.e. toe conditions) and limited co-operation between adjacent land owners. Rather than addressing the erosion problems at Erie Shore Drive in a regional context, property owners have implemented their own shoreline protection measures with no (or only limited) co-operation between the adjacent properties.

Qualitative observations in the field indicated that the shoreline protection measures at Erie Shore Drive constructed on a property by property basis have a very limited design life before requiring maintenance or complete replacement. Also, the lack of co-operation between property owners often results in erosion at the property boundaries, and in the case of groins, downdrift impacts. Consequently, the residents are receiving a very poor return on their investment for non-engineered shoreline protection measures. It would be more economically viable to address the shoreline erosion and flooding hazards on a regional basis, rather than as individual property owners.

The identification of shoreline reaches provides the framework to address the erosion problems at Erie Shore Drive in a regional context and design alternatives that will provide unified shoreline protection and minimise the potential for impacts to the adjacent shoreline and downdrift locations.

The study area shoreline has been sub-divided into 4 reaches based on several physical characteristics, including: the width of land between the lake and road, the proximity of infrastructure (such as roads) to the shoreline, the existing shoreline conditions, and the distance of the residences from the waters edge (Figure 1). A summary of the location, length, and existing shoreline conditions are provided below for the 4 shoreline reaches at Erie Shore Drive.

4.2 Description of Shoreline Reaches at Erie Shore Drive

Reach 1 - Dumped Concrete Rubble and Sand Beach (3+900 to 4+160)
Reach 1 is located at the western limits of the study area and extends 260 m from Beaver Creek to the corner of Erie Shore Drive (at 3+900). Approximately half of the shoreline

is protected with dumped concrete rubble and the remainder of the reach is unprotected low bank with a beach. The width of the beach will vary with annual and long term fluctuations in lake levels. The stabilisation of Beaver Creek with steel sheet pile walls may have affected the natural sand bypassing process at the creek mouth and the transport of sand to the east (into Reach 1). A detailed survey of the lake bed would be required to assess the potential impact of Beaver Creek on regional sediment transport rates and this information is not available at this time. Although there is no residential development lakeward of Erie Shore Drive in Reach 1, further erosion of the shoreline, especially the unprotected sections, could threaten the road and lead to flooding of the residential and farm properties north of the road.

Reach 2 - Sand Beach and Partial Protection (3+575 to 3+900)

In general, the residences in Reach 2 are setback further from the shoreline than the properties in Reach 3 and 4. The greater setback distances has increased the short term tolerance for shoreline erosion and consequently many sections of the road have remain unprotected or feature only partial protection, such as the old wooden groins. The absence of vertical walls (and other forms of shoreline protection) has helped to maintain the beach deposits in Reach 2. However, the maintenance of the beaches in Reach 2 may have come at the expense of some moderate shoreline erosion. Due to the width of the sand deposit along the shoreline, the majority of the beaches still exist at the present high lake levels, while the beaches in Reach 3 and 4 to the east have completely disappeared. The development of shoreline protection alternatives should strive to maintain the existing beaches in Reach 2.

The properties with protection in Reach 2 consist of various non-engineered structures, such as dumped concrete rubble and concrete blocks at the back of the beach. The protection typically does not feature any filter stone or geotextile filter fabric and during storms wave forces are able to penetrate the rubble and continue to erode the shoreline. The installation of a steel sheet pile wall surrounding a cottage during the summer of 1997 at 3+825 has disrupted a large natural beach from 3+750 to 3+900 and backfilling behind the wall has removed the natural berm at the back of the beach that once provided flood protection. Since the construction of the steel sheet pile wall the potential for flooding and other water related hazards has increased dramatically for the properties landward of the old berm at 3+825.

Reach 3 - Dumped Concrete Rubble (3+080 to 3+575)

The majority of Reach 3 has been protected with dumped concrete rubble. There is insufficient bathymetry data for the reach to comment on the average nearshore conditions. However, visual observations suggest the nearshore area is very deep, and features a steep nearshore slope, which allows large waves to propagate towards the shore. The combination of high water levels, a deep nearshore area, the absence of a beach deposit and non-engineered shoreline protection has placed the cottages and homes in imminent danger during the winter storm season (i.e. October to April).

In 1973 a second road/dyke was built north of the original road at a higher elevation to protect the agricultural lands from flooding. The properties are very narrow (20 m on average) with locations that feature less than 12 m of land separating the waterline from the road. Future erosion of the shoreline in this reach, especially the unprotected areas, could result in significant damage to the low road and possibly the dyke.

Reach 4 - Deteriorated Shoreline Protection (1+000 to 3+080)

The shoreline in Reach 4 extends from 3+080 to the eastern limits of the study area at 1+000. The shoreline is protected with a wide range of structures, including: steel sheet pile walls and groins, dumped concrete rubble, concrete blocks, wooden groins, concrete walls, and steel gabions. At the present high water levels, the beach deposits are very narrow or non-existent for most of Reach 4. There are two exceptions, at 1+950 and 1+550, where the construction of longer groins has trapped sand on the western sides of the structures. It is critical to note that although the longer groins have helped the properties directly to the west of the groin installations, the shorelines immediately downdrift of the groins (1+875 and 1+500), have no beach deposit. The lack of beach development has exposed these properties to an elevated risk of shoreline erosion and may be responsible for the reduced property depth downdrift (to the east) of these two groins installations.

In most locations, the construction of shore parallel structures, such as vertical steel sheet pile walls, has created a very deep nearshore profile and the shoreline is generally devoid of any beach material. In area's without shoreline protection, similar conditions (deep steep nearshore) increase the threat of wave run-up and flooding during severe storm events. During high water periods (1986 and 1997) the proximity of the residences to the waters edge and the low main floor elevations of the buildings and surrounding lands exacerbates the problem.

There are two locations in Reach 4 were the homes have been removed or abandoned, (1+875 and 2+625). In both areas the shoreline protection is either in a state of disrepair or non existent. The unprotected shoreline in these locations is highly susceptible to further erosion, overtopping and flooding during storms, which could lead to damages to the road or dyke, and flooding of the agricultural lands.

5 PREPARATION OF DESIGN ALTERNATIVES

5.1 Waves and Water Levels

One of the most critical tasks during the design process for shoreline protection is the review of historic wave and water level data for the project area. The scope of this investigation did not warrant a comprehensive investigation of historical information, and consequently, only a general review of wave and water level conditions in the Rondeau area was completed. Given the objectives of the study, this level of effort was sufficient to prepare the preliminary design alternatives for shoreline protection outlined Section 5.3 of this report. Prior to the implementation of the recommendations in this report, a detailed wave and water level investigation should be completed to compliment the preliminary work outlined below.

To facilitate the design of coastal structures, water levels are often categorised by the probability of occurrence or a return period for a 100 year planning horizon. For example, a 10 year water level is expected to occur, on average, once every 10 years. Existing data from Baird's archives on Lake Erie was reviewed to select design criteria for the shoreline protection alternatives. Based on this preliminary analysis, the offshore wave conditions for a 20 year design event were estimated to have a significant wave height of 4.1 m and a wave period of 10 seconds. The 2, 10 and 100 year water levels, including an allowance for storm surges, are 174.7 m, 175.0 m, and 175.3 m respectively. These water level elevations do not include an allowance for wave uprush on a beach or a sloping coastal structure. Therefore, for the case of a natural sandy beach, breaking waves could reach elevations higher than the 100 year water level (i.e. > 175.3 m, IGLD '85). It is important to note that the first floor elevation of many of the residences is close to or below the 100 year water level of 175.3 m (IGLD '85).

5.2 Wave Overtopping and Flooding

Based on the selection of design water levels at Erie Shore Drive, a comprehensive review of existing methodologies to predict overtopping rates of coastal structures was completed. Several approaches were followed to predict the rate of overtopping for a typical beach profile, a sloping armour stone revetment and a vertical seawall, all with an identical crest and toe elevation. The results provided valuable data on the amount of wave overtopping sustained by the various shoreline protection alternatives given identical wave and water level conditions.

The results are presented in a spreadsheet format in Table 1 and summarised qualitatively in Table 2. It is clear that of the three types of shoreline protection, with identical crest

and toe elevations, a beach provides superior protection from wave overtopping when compared to a revetment, which provides better protection than a vertical wall. In other words, in order to minimise the hazards associated with wave overtopping and flooding, beach development is the preferred shoreline treatment. If beach development is not possible, a sloping structure, such as an armour stone revetment will provide superior protection from overtopping hazards than a vertical wall of the same height. This information was used to select crest elevations for the various shoreline protection alternatives discussed in Section 5.3.

The residents of Erie Shore Drive can calculate the crest elevation of their existing shoreline protection with a tape measure and a phone call. Follow the steps below:

1) On a calm day, call 676-1915 to determine the elevation of Lake Erie, as recorded by the Canadian Hydrographic Service at Erieau. A typical reading would be +1.0 m above chart datum,
2) Next, measure the vertical distance from the water level to the top of your shoreline protection (e.g. 1.5 m),
3) Combine the two values (e.g. 2.5 m) and add them to 173.5 m to determine the approximate crest elevation of the shoreline protection. This elevation can be compared to the results in Table 2 to determine the potential hazards (if any) associated with the present elevation of the shoreline protection structure during a severe storm.

This information has been outlined to provide a relative indication of the potential hazards associated with the existing shoreline protection structures at Erie Shore Drive. Given the size of the study area, it is impossible to quantify all the factors that contribute to the rate of wave overtopping, such as the depth at the base of the coastal structures. Consequently, the information provided in Table 2 should not be considered a reasonable substitute for a proper investigation by a qualified coastal engineer when designing shoreline protection or remedial measures at Erie Shore Drive.

5.3 Description of Alternatives for Regional Shoreline Protection

As outlined in Section 4.1, one of the primary factors in the deterioration of the shoreline conditions at Erie Shore Drive is the lack of co-operative between individual property owners in the design and construction of shoreline protection measures. Protection is often constructed in an ad hoc manner with little or no regard for the potential impacts to the adjacent or downdrift shoreline Also, construction works are generally re-active in response to flood and storm damage, rather than pro-active in their design and implementation.

The classification of the study area into reaches of similar shoreline conditions provides an appropriate scale to development design alternatives that will minimise potential

downdrift impacts and provide cost effective, long term protection from erosion and flood hazards. The alternatives discussed below were developed to address the erosion and flood problems on a regional scale and they are appropriate treatments for the entire shoreline within the reaches.

Offshore Breakwaters and Steel Sheet Pile Wall with Beach

The preliminary design drawings for the Offshore Breakwaters and Steel Sheet Pile Wall with Beach are presented in Appendix 'A1'. The design consists of large offshore breakwaters connected to the shoreline by a steel sheet pile wall to create a series of semi-sheltered embayments which help to contain sand and build beaches. A berm may be required at the back of the beach for flood protection in some locations. The offshore breakwaters are located approximately 60 m from the shoreline, are 50 m in length and 22 m wide at the lake bed, and have a crest elevation of 176.5 m. A substantial volume of sand is required to build the beach deposits between the offshore breakwaters. At this time, it is not possible to estimate the time for natural accumulation to fill the beach cells between the breakwaters, or quantify any potential downdrift impacts. It has been assumed that sand will be trucked to the site to pre-nourish the beach deposit. Further studies may indicate that imported sand is not required (or at least that naturally filling could reduce the requirement for imported sand), which would result in considerable cost savings for this alternative.

There are several significant advantages to this alternative over conventional shore parallel shoreline protection, including: development of a substantial beach deposit to protect the underlying cohesive profile from further downcutting, improved access to the waters edge, visual contact with the lake, and minimal maintenance. The disadvantage of the Offshore Breakwater and Beach alternative is the requirement for regional co-operation between property owners and the arrangement of cost sharing agreements.

Critical tasks in a future investigation to design the Offshore Breakwaters and Steel Sheet Pile Wall with Beach include: analysis of the local wave climate, regional sand budget and sediment transport study, investigations of potential impacts to the downdrift shoreline, and construction issues for the offshore structures.

Armour Stone Headlands with Beach

The Armour Stone Headlands are large regional structures that extend lakeward approximately 60 m from the shoreline. At the lake bed, the width of the structure is approximately 24 m. The width of the crest is 9 m wide. The length of the headlands and their orientation to the local wave climate will facilitate the development of pocket beaches. The preliminary design drawings are presented in Appendix 'A2'. A flood berm may be required at the back of the structures and behind the beach. As with the Offshore Breakwaters, it has been assumed that each headland bay will require pre-nourishment, possibly coarse sand (2.0 mm in diameter) or cobble sized material. Further analysis is required to confirm this assumption. One alternative is the construction of a pilot structure(s) to evaluate beach development and the impacts on regional sediment transport rates.

The advantages if this alternative are very similar to the 'Offshore Breakwaters,' and include: development of a substantial beach deposit to protect the underlying cohesive profile from further erosion, improved access to the waters edge between the structures, visual contact with the lake, minimal maintenance. Again, the disadvantage of the Headland Beach alternative is the requirement for regional co-operation between property owners and cost sharing requirements to implement the design.

Critical tasks in a final design investigation for the Headland Beach alternative include: analysis of the local wave climate, regional sediment transport study, sediment bypassing investigations, assessment of potential impacts to the downdrift shoreline, and construction issues for the headlands.

Armour Stone Hard Points and Beach

The Armour Stone Headlands are small shore perpendicular structures that protrude from the shoreline and encourage beach development with minimal impact to alongshore sediment transport. A typical structure at Erie Shore Drive would extend lakeward by approximately 35 m. The dimensions of the crest and footprint are similar to the Armour Stone Headlands. Refer to Appendix 'A3' for the preliminary drawings.

At the shoreline and below the footprint of the structure the hardpoint provides permanent protection from further shoreline erosion and downcutting of the cohesive profile. Between the headlands, beach development is encouraged, which will protect the cohesive profile from erosion and provide flood protection during storms. Pre-nourishment of the beach deposit is recommended to reduce the potential for downdrift impacts. A flood protection berm may be required.

Some initial shoreline erosion may be experienced between the headlands, depending on their length, spacing, and the volume of the nourishment. Eventually the beach will reach an equilibrium alignment with the local wave climate and there will be no further erosion. This alternative is only viable in locations where there is a sufficient setback between the shoreline and the residences. The Headland Beach alternative provides improved access to the waters edge and limited impacts to the downdrift shoreline. However, as with the previous alternatives, regional co-operation between property owners is required.

Revetment

The armour stone revetment is a shore parallel structure that protects the shoreline from erosion and reduces the potential for wave overtopping and flooding. The preliminary design drawings are presented in Appendix 'A4'. A sloping structure is constructed of quarried rocks, typically in the range of 2 to 5 tonnes. The structure also requires smaller filter stone and geotextile filter fabric against the shoreline to absorb wave energy that penetrates the larger armour units. The selection of a crest elevation, 176.5 m IGLD '85, was based on the wave overtopping calculations outlined in Section 5.2. The toe conditions at the lake bed are critical to maintain the long term structural stability of the

shoreline protection. The preliminary design calls for at least 1 m of excavation into the underlying clay.

The Armour Stone Revetment will provide protection form shoreline erosion and reduce wave overtopping and flooding during storms. However, in most cases, if the revetment is aligned parallel to the shore, it will not encourage beach development and consequently will not protect the cohesive profile lakeward of the shoreline from further downcutting and erosion. Eventually, a deep nearshore area will develop and the revetment will be susceptible to undermining at the toe and ultimately will fail.

Access to the waters edge is restricted and the elevation of the structure may limit views to the lake. Although a revetment can be constructed on a property by property basis, successful installations require regional input from the land owners.

Municipal Ownership

In some locations at Erie Shore Drive, due to the limited width of the residential properties and the proximity of buildings to the waters edge it is not possible to design options for shoreline protection. In such locations, where the existing lots are less than 20 m in depth, Municipal ownership of the waterfront properties is one alternative. This will ensure that infrastructure, such as the road and utilities, are protected from future damage related to shoreline erosion.

5.4 Remedial Measures for Existing Shoreline Protection

Based on the field observations at Erie Shore Drive, several recommendations for remedial measures have been prepared to improve the condition of existing shoreline protection and the level of short term protection. Also, it is recognised that it could take several years to implement one of the regional alternatives outlined in Section 5.3. The remedial measures can be implemented on a property by property basis and may extend the design life of the shoreline protection by 5 to 10 years. The preliminary design drawings are presented in Appendix 'B'. Depending on the site specific conditions, the remedial measures may require permits from regulatory agencies.

Flood Protection Berm

The analysis of water levels and wave overtopping rates for the three typical shoreline conditions clearly identified the deficiency of many existing shoreline treatments in providing protection from flooding during storm events on Lake Erie. The construction of a flood protection berm at the back of the beach will improve the level of short term protection from wave overtopping and flooding hazards. However, shoreline erosion may continue and the flood berm may be damaged during severe storms and require maintenance in the future.

Toe Berm for Vertical Structures

In Reach 4 many of the properties are protected by vertical seawalls (i.e. steel sheet pile and concrete). The reflective nature of the vertical walls can lead to the erosion of the nearshore lake bed in front of these installations, which are generally in very poor condition. This has resulted in deep water at the toe of the structures, which allows large waves to propagate towards the shoreline. Consequently, scour and undermining at the toe of these structures is a common mode of failure. In many cases, field observations suggested that the failure of the walls was directly related to the impact of waves and scour at the toe of the walls. It is assumed that the construction of the vertical walls was not based on a proper coastal / geotechnical analysis of the local geologic conditions and thus the design was not able to accommodate scour or downcutting of the cohesive lake bed at the base of the wall. The construction of a toe berm, either with armour stone or large rip rap, will provide temporary protection from erosion at the toe of the wall and possibly improve structural stability.

Move Residences and Raise Elevations

In many locations shoreline erosion has resulted in the loss of a significant amount of land base in front of the private residences at Erie Shore Drive. During the present high water period, many buildings are located near or at the shoreline, which exposes the residences to potential hazards during storm events. The narrow strip of land also limits the development of design alternatives for shoreline protection, or, in some cases, completely eliminates the option of new shoreline protection. In these cases, the only viable remedial measure is to move the residences away from the lake and raise the foundation levels to protect the buildings from flooding hazards and wave damage. The main floor elevation should be a minimum of 0.2 m above the 100 year lake level, including an allowance for storm surge and wave runup.

Concrete Rubble with Filter Stone and Geotextile Filter Fabric

The use of concrete rubble as a method of long term shoreline protection is not recommended. However, if concrete rubble is installed for emergency situations, the effectiveness of the concrete in reducing the future shoreline erosion rate would be significantly enhanced if filter fabric was installed against the shoreline and filter stone was carefully placed on the geotextile prior to dumping the concrete in place. The concrete dimensions should be adequate to ensure stability during storm activity on the lake. Other important design considerations are crest elevation, slope details, and toe conditions. The details for the revetment cross section in Appendix 'A4' can be used as preliminary guidelines.

Segmented Offshore Breakwaters contained by the Existing Timber Groins

In locations were the structural integrity of the old timber wall and groins is sufficient, the existing compartments could be used to create segmented offshore breakwaters. The timber cribs would be filled with appropriately sized material (i.e. 1 to 2 tonne armour stone), to develop semi-contained breakwater structures which would intercept waves and partially shelter the shoreline during storms.

5.5 Regulatory Agencies

Prior to the construction of any shoreline improvements at Erie Shore Drive, the necessary permits must be obtained from all regulatory agencies. The implementation of the regional alternatives outlined in Section 5.3 will require approvals from the local Conservation Authority, the Ministry of Natural Resources, the Federal Department of Fisheries and Oceans, Environment Canada, and the Canadian Coast Guard. Agency approval for the remedial measures outlined in Section 5.4 will depend on the location of the proposed works and any encroachment below the waterline.

6 RECOMMENDATIONS FOR SHORELINE REACHES

6.1 Shoreline Protection Alternatives for Shoreline Reaches

Reach 1 - Dumped Concrete Rubble and Sand Beach (3+900 to 4+160)
The primary issue for Reach 1 is the close proximity of the road to the shoreline and the partial protection provided by the dumped concrete rubble. Further shoreline erosion, especially the unprotected sections of Reach 1, could result in significant damage to the road and temporarily disrupt transportation along Erie Shore Drive.

The development of regional solutions for this reach required careful consideration of downdrift impacts, especially the continued transport of sediment along the shoreline in a west to east direction past Beaver Creek. Consequently, shore perpendicular structures, such as offshore breakwaters and headlands are not recommended, due to their potential to impede the natural transport of sand into Reach 2 and beyond.

An armour stone revetment is recommended to provide cost effective, long term protection of the shoreline in Reach 1. A detailed site inspection would be required to determine the condition of the existing concrete rubble and make recommendations for the extent of the protection. Also, it may be necessary to set the revetment back from the existing shoreline or alter the present shoreline orientation. The approximate cost of the revetment is $2,600/m, as outlined in Table 3. Although short term remedial measures are not recommended for this reach, in the case of an emergency, additional concrete rubble could be added to the shoreline, with proper filter fabric and filter stone.

Reach 2 - Sand Beach and Partial Protection (3+575 to 3+900)
As outlined in Section 4.2, the residences in Reach 2 are setback further from the shoreline than Reach 3 and 4, which provides the unique opportunity to consider alternative shoreline treatments not available to locations were the buildings are located close to or at the existing shoreline. Also, the development of protection alternatives must consider the value of the existing beach deposit and the potential impact of shore perpendicular structures on the rate of alongshore sediment transport.

In light of the above design considerations, large shore perpendicular structures, such as the offshore breakwaters and armour stone headland were not considered for Reach 2. The Armour Stone Hard Points with Beach is recommended as a regional solution to the existing erosion problems in Reach 2. The hard points will stabilise the shoreline in several locations and encourage beach development between the structures. Although some initial erosion could be expected between the headlands, ultimately the shoreline will stabilise and provide long term protection, with improved access to the waters edge in many locations. It is recommended that the shoreline be pre-nourished between the hard points, possibly with coarse sand and gravel. The cost to protect the shoreline with

hard points, assuming the initial pre-nourishment, is approximately $2,600/m, or $260,000 per structure (see Table 3). Once the shoreline develops an equilibrium orientation (several months to 5 years), it may be necessary to construct a flood protection berm at the back of the beach.

As a regional alternative to the headland beach system, an armour stone revetment would also provide long term shoreline protection. As in Reach 1, the approximate cost for an armour stone revetment is $2,600/m. However, the existing beach deposit will likely erode with the construction of a revetment and completely disappear in less than 5 years. Access to the waters edge and a visual connection to the lake will be partially restricted by the crest elevation of the revetment (176.5 m IGLD '85).

There are several short term remedial measures that could be implemented on a property by property basis to provide some relief from erosion and flooding hazards during storms. The three alternatives include: the construction and maintenance of a flood protection berm at the back of the beach, reconstruct existing concrete rubble and blocks with proper filter fabric and filter stone, and the construction of segmented offshore breakwaters within the existing compartments of the timber groins.

Reach 3 - Dumped Concrete Rubble (3+080 to 3+575)

The residential properties in Reach 3 are only 20 m deep on average, with less than 12 m separating the shoreline from the road in some locations. Although the concrete rubble and other forms of shoreline stabilisation have saved some of the houses, many have been damage, abandoned or removed. Of the 29 properties in Reach 3, only 5 are permanent dwellings, 10 are seasonal cottages, and the remaining lots are vacant. In many locations there was no beach during the summer of 1997 and the field investigations also suggested the nearshore zone was very deep, especially in locations with a vertical wall.

Due to the proximity of the residences to the waters edge (i.e. they are at the shoreline in many locations) and the existing shoreline conditions, it would be extremely difficult and costly to engineer shoreline protection to last for 25 years, as outlined in the criteria for the development of shoreline protection alternatives (Section 2.2). Three potential regional solutions include: Offshore Breakwaters and Steel Sheet Pile Wall with Beach, Armour Stone Headland with Beach, and Municipal Ownership. The cost to protect Reach 3 with a large scale regional alternative is approximately $2.0 million for the 0.5 km of shoreline. Refer to Table 3 for details.

Municipal ownership of the properties in Reach 3 would allow the local government to take a pro-active approach to managing the erosion and flood hazards in Reach 3 that threaten Erie Shore Drive, the dyke, and the related infrastructure. The existing houses would be removed and the shoreline could be monitored to determine shoreline protection requirements in the future. It is not expected that shoreline erosion would threaten the road for 5 to 10 years.

The cost to implement Municipal ownership of Reach 3 is approximately $600,000, which is considerably less than attempting to stabilise the shoreline with a large regional alternative and protect the remaining residences. Considering the costs for shoreline protection in comparison to the property values in Reach 3, Municipal Ownership is the recommended alternative.

Reach 4 - Deteriorated Shoreline Protection (1+000 to 3+080)

The shoreline in Reach 4 extends over 2 km, from 1+000 to 3+050, and contains the majority of the residential properties along Erie Shore Drive. The shoreline downdrift (to the east) of Reach 4 is protected by the dyke works constructed in 1973. The dyke was constructed to protect the shoreline in the absence of a beach and may not be significantly impacted if sediment transport rates are altered by the shoreline protection alternatives implemented in Reach 4. The fillet beach between the dyke works and the harbour entrance to Rondeau Bay is a downdrift sink for sediment and has likely been stable or accreting for several decades. Consequently, it is unlikely that either the dyke works or the fillet beach will be significantly influenced by the type of shoreline protection implemented updrift (to the west). Therefor, downdrift impacts are not as critical in Reach 4 as other locations in the study area. This assumption would have to be confirmed in a final design investigation.

Four regional alternatives were considered for Reach 4. The recommended solution includes either the Offshore Breakwaters and Steel Sheet Pile Wall with Beach, or the Armour Stone Headland with Beach. Although these two options are considerably more expensive than the Armour Stone Hardpoints with Beach and the Revetment, they provide superior long term protection to the underlying cohesive profile, which is critical to ensure the long term stability of the regional option selected for Reach 4.

The large shore perpendicular structures will create semi-sheltered embayments that will contain beach material and reduce the rate of sediment moving along the shoreline in Reach 4. Both alternatives will provide long term shoreline protection, improve access to the waters edge and maintain the visual connection to the lake from the residences. It may be necessary to construct a flood protection berm in some locations. The cost for the recommended solutions is in the range of $3,700 to $4,000/m (refer to Table 3). Alternative regional solutions include a Revetment and the Armour Stone Hard Points and Beach. The approximate cost for these two alternatives is $2,600/m.

Due to the wide range in existing shoreline protection in Reach 4, there are numerous short term remedial measures that may provide temporary relief from flooding hazards and further shoreline erosion. The remedial measures must be selected based on the types of existing shoreline protection and proximity of the residence to the shoreline. They include: construction of flood protection berm, toe berm for vertical seawalls, move and raise residences, and reconstruct existing rubble and concrete blocks with filter fabric and filter stone.

6.2 Cost Estimates for Preliminary Shoreline Protection Alternatives

The shoreline protection alternatives discussed in Section 6.1 and presented in Appendix 'A' are only preliminary designs. They have been prepared to identify the range of shoreline protection alternatives available to the residents at Erie Shore Drive and facilitate a discussion on the pros and cons of the different designs approaches (i.e. shore perpendicular structures vs. shore parallel protection). It is beyond the scope of this investigation to refine the designs to the level of detail required to prepare construction drawings or make accurate cost estimates. Consequently, it is necessary to make assumptions during the preliminary design process and it is prudent planning to error conservatively. The preliminary cost estimates presented in this report may be conservative.

With proper detailed information on lake bed conditions and the local wave climate, it may be possible to reduce the material volumes for the alternatives during a final design investigation. As discussed above, this type of exercise is beyond the scope of this investigation. However, based on our past experience with the design and construction of large coastal structures, the cost savings could be in the range of 10%. Estimates on the potential cost savings that may be realised during a final design investigation are summarised in Table 4. A second source of potential savings for the large regional alternatives is the natural accumulation of sand, rather than nourishing the beaches with sand trucked to the site. Again, a final design investigation would be required to determine the feasibility and potential impact of natural accumulation of beach sediments. If acceptable, natural accumulation could result in an additional 10 to 25% cost savings, as outlined in Table 4.

In summary, the cost estimates presented in Section 6.1 and Table 3 are preliminary and possibly conservative. With the completion of a proper final design investigation, potential cost savings could be in the range 10 to 35% for the various shoreline protection alternatives.

7.0 CONCLUSIONS

In the 11 years since the original reports were prepared by Philpott (1986) and Todgham and Case (1986), conditions have deteriorated at Erie Shore Drive. In order to implement the recommended shoreline protection alternatives outlined in Section 6.1, it is essential that action is taken in 1998 and not the next high water period. Without the implementation of the Regional Alternatives for Reaches 1, 2 and 4, it may not be possible to construct shoreline protection in the future due to further erosion of the land base in front of the residences and the road. It is expected that the conditions in Reach 3 will develop along the remainder of the shoreline in the future if no action is taken during the present high lake level period.

Preliminary water level information released in February 1998 by the Canadian Hydrographic Service suggests that Lake Erie water levels during the spring and summer of 1998 could be close to the all time record highs set in 1985/86. Consequently, the hazards associated with flooding and shoreline erosion at Erie Shore Drive during high lake levels will continue (at least for the near future).

7.1 Recommendations for Further Studies at Erie Shore Drive

The study objectives outlined at the onset of the investigation included: the preparation of preliminary designs for shoreline protection and flood control, the development of alternatives that minimise impacts on the adjacent shoreline and the aquatic community, and the completion of preliminary cost estimates. This report summarises the investigation completed by Baird & Associates and Todgham and Case to develop preliminary design alternatives for the shoreline reaches and the preparation of cost estimates to implement the recommendations.

With the completion of the study objectives, the following list of recommendations have been prepared to assist the Municipality, the Resident's Group and the Agricultural Community in building on the conclusions of this report and, ultimately implementing the recommendations for shoreline protection at Erie Shore Drive:

1. All the stakeholders must work collectively to establish priority areas based on the identification of the shoreline reaches at Erie Shore Drive. A consensus must also be reached on the type of shoreline protection alternative adopted for the individual reaches;
2. A co-operative effort must be taken to educate all the stakeholders on the importance of implementing the Regional Alternatives for shoreline protection at Erie Shore Drive;

3. The Regional Alternatives for shoreline protection must form the basis for an integrated plan, involving all the stakeholders, to implement the recommendations of this report, on a reach by reach basis;
4. Identify funding opportunities and existing resources of the stakeholders to implement the recommendations for shoreline protection;
5. Continue to monitor shoreline erosion and complete a detailed bathymetric survey required to commence the final design investigation;
6. Once the priority reaches have been established, retain a qualified coastal engineer to prepare detailed construction drawings and obtain all necessary approvals for the construction of the shoreline protection.

7.2 Construction Phasing for the Shoreline Protection Alternatives

If the large regional alternatives are selected for Reaches 1, 2 or 4, it may be possible to phase the construction activities over a period of several years. In fact, it may be desirable to construct one or two large structures and monitor the natural accumulation of beach sediments and the development of a long term stable shoreline orientation. The field information collected during the monitoring period would be used to assist the Engineer in refining the design for the coastal structures and maximising potential cost savings.

The development of a construction schedule that includes phasing the implementation of the shoreline protection must be part of the overall integrated plan for the study area which involves all the stakeholders.

8.0 REFERENCES

Keith Philpott Consulting Ltd., 1986. Burk Drainage Works Shore Protection Review, Harwich Township.

Todgham and Case Associates Incorporated, 1986. Township of Harwich Burk Drainage Works Flood Protection Study.

Canadian Hydrographic Service, Department of Fisheries and Oceans. Water Levels Bulletin, January 1998.

FIGURE 1 STUDY AREA AND SHORELINE REACHES

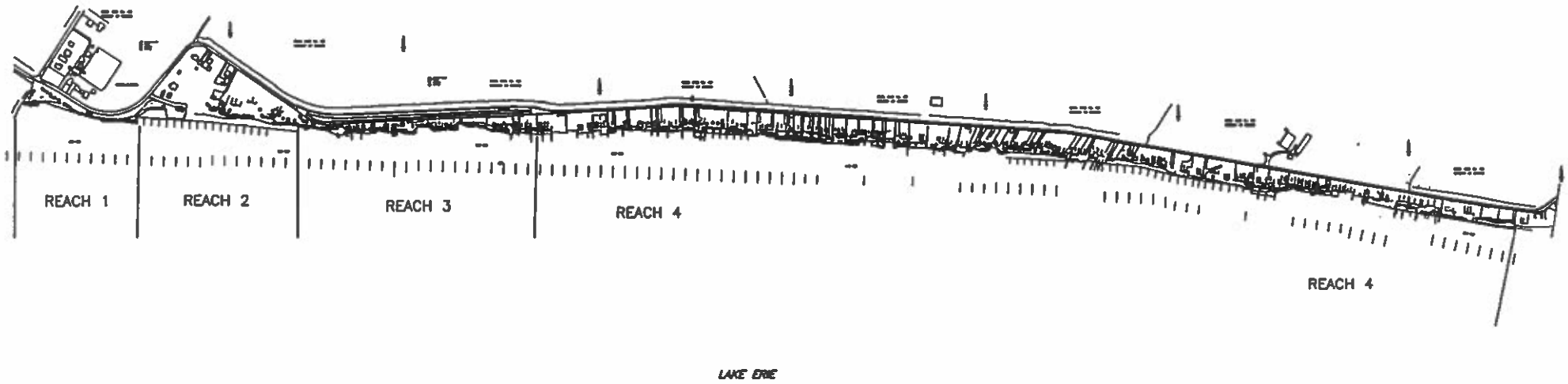


Table 1 Example of the Wave Overtopping Results

Wave Runup/OT Calculations - Misc. Approaches/Permeable Rock Structures

Note: required inputs are noted in bold

Project: Erie Shore Drive, Rubblemound Revetment Structures

Units (SI or US): SI
Elev. Datum: m CD

Assumptions:
nearshore slope (tan) 0.025
structure slope (cot) 1.5
Tm/Tp 0.85 (mean period/peak period)
gravity 9.806

Methodology:
nearshore Hs estimated using Goda (1985) (calculated by GODA_Hs macro)
armour stone weight (W) calculated using Hudson's equation with Kd = 3.5 (1977 SPM, 2 layers, rough, angular stone on 1:1.5 slope, breaking waves, trunk)
wave runup elevations estimated using Ahrens & McCartney (1975) and vdM & Stam (1992) assuming permeable core, with shallow water influence factor from de Waal & vdM (1992)
overtopping rates estimated using de Waal and vdM (1992)

								Wave Runup Elevations						Overtopping Rates (m3/s/m)				
								A & M, 1975		vdM & Stam, 1992				de Waal & vdM, 1992				
Return Period	Toe El.	WL	Depth	Hso'	Tp	Hsb	W	Surf Sim	Rs	Surf Sim	Rs	Isw	R2	Crest El. (m CD)				
WL/Waves	m CD	m CD	(m)	(m)	(s)	(m)	(t)	Parameter	m CD	Parameter	m CD	dW&vdM '92	m CD	2.50	3.00	3.25	3.50	3.85
2/20	0	1.2	1.2	4.1	10	1.2	0.2	7.64	2.5	6.49	2.8	1.00	3.5	0.005	0.001	0.001	0.000	0.000
10/20	0	1.5	1.5	4.1	10	1.4	0.3	7.14	3.0	6.07	3.3	1.00	4.2	0.018	0.006	0.003	0.002	0.001
100/20	0	1.8	1.8	4.1	10	1.5	0.4	6.72	3.4	5.71	3.9	1.00	4.8	0.052	0.019	0.011	0.007	0.003
2/20	-0.5	1.2	1.7	4.1	10	1.5	0.4	6.85	2.8	5.82	3.2	1.00	4.1	0.013	0.005	0.003	0.002	0.001
10/20	-0.5	1.5	2	4.1	10	1.7	0.5	6.48	3.2	5.51	3.7	1.00	4.8	0.036	0.014	0.009	0.006	0.003
100/20	-0.5	1.8	2.3	4.1	10	1.8	0.7	6.17	3.7	5.24	4.3	1.00	5.4	0.084	0.036	0.024	0.015	0.008
2/20	-1	1.2	2.2	4.1	10	1.8	0.6	6.27	3.0	5.33	3.6	1.00	4.7	0.027	0.011	0.007	0.005	0.003
10/20	-1	1.5	2.5	4.1	10	1.9	0.8	5.98	3.5	5.08	4.1	1.00	5.3	0.061	0.028	0.019	0.012	0.007
100/20	-1	1.8	2.8	4.1	10	2.1	1.1	5.73	4.0	4.87	4.7	1.00	6.0	0.124	0.059	0.041	0.029	0.017
2/20	-1.5	1.2	2.7	4.1	10	2.1	1.0	5.81	3.3	4.94	4.0	1.00	5.2	0.047	0.022	0.015	0.010	0.006
10/20	-1.5	1.5	3	4.1	10	2.2	1.2	5.58	3.8	4.74	4.5	1.00	5.9	0.093	0.046	0.033	0.023	0.014
100/20	-1.5	1.8	3.3	4.1	10	2.4	1.6	5.37	4.2	4.57	5.0	1.00	6.5	0.170	0.089	0.064	0.047	0.030
2/20	-2	1.2	3.2	4.1	10	2.3	1.4	5.44	3.6	4.62	4.4	1.00	5.8	0.072	0.037	0.027	0.019	0.012
10/20	-2	1.5	3.5	4.1	10	2.5	1.8	5.25	4.0	4.46	4.9	1.00	6.5	0.131	0.071	0.052	0.038	0.025
100/20	-2	1.8	3.8	4.1	10	2.7	2.2	5.08	4.5	4.32	5.4	1.00	7.1	0.222	0.124	0.093	0.070	0.047

Notes: shallow water influence factor =MIN(1,1-0.03*(4-d/Hb)^2) for m = 1/100; for other slopes, use 1.0

Table 2 Wave Overtopping Analysis - Qualitative Summary

Crest Elevation (IGLD '85)	Vertical Seawall	Sloping Revetment	Beach (1:4 slope)	Beach (1:8 slope)
176.0 m	damage to structure and possible failure	damage to crest	minor damage if back of beach is not protected (i.e. a beach curb)	minor damage if back of beach is not protected (i.e. a beach curb)
176.5 m	damage to crest and backslope	damage to crest if not protected	no damage	no damage
177.0 m	damage to crest and backslope if not protected	no damage	no damage	no damage
177.5 m	damage to crest if not protected	no damage	no damage	no damage

Definition of Terms

1. damage to structure - wave overtopping during severe storm events can lead to damage of a coastal structure, such as a seawall, even if it is properly designed. The amount of damage is sensitive to the crest height of the structure. The risk of damage increases as the crest elevation of the structure decreases.

2. damage to crest - wave overtopping during severe storm events can erode sediments behind a seawall and damage the top portion of the structure, even if properly designed.

3. damage to crest and backslope - wave overtopping during severe storm events can erode sediments behind a seawall and damage the top portion of the structure, even if properly designed. The erosion will extend up the backslope if not protected.

4. damage to crest and backslope if not protected - if the crest detail of a coastal structure is not designed properly, it will sustain significant damage during a severe storm event. The land directly behind the shoreline treatment must also be protected or erosion will occur during wave overtopping events.

5. minor damage if back of beach is not protected - wave runup on a beach can lead to damage/erosion at the transition from beach to table lands if formal protection, such as a beach curb, is not provided. A coastal dune is a form of natural protection.

6. no damage - no erosion or related hazards will occur to the shoreline treatment for the given crest elevation.

TABLE 3
RECOMMENDATIONS FOR SHORELINE REACHES

Reach 1 (3+900 to 4+160)

Alternatives	Type of Shoreline Protection	~Cost / m	$/Structure	Units	Total Costs
Recommended Solution	1. Revetment	$2,600		260	$676,000
Short Term Remedial Measures	1. Add filter stone layer and geotextile filter fabric below existing rubble	-			
	2. Concrete Rubble with filter stone and geotextile filter fabric	-			

Reach 2 (3+575 to 3+900)

Alternatives	Type of Shoreline Protection	~ Cost / m	$/Structure	Units	Total Costs
Recommended Solution	1. Armour Stone Hard Points with Beach	$2,600	$260,000	3	$780,000
Alternative Solution	2. Armour Stone Revetment	$2,600		325	$845,000
Short Term Remedial Measures	1. Add filter stone layer and geotextile filter fabric below existing rubble	-			
	2. Fill existing wooden groins to create segmented offshore breakwaters	-			
	3. Construct Flood Protection Berm	-			

Reach 3 (3+080 to 3+575)

Alternatives	Type of Shoreline Protection	~ Cost / m	$/Structure	Units	Total Costs
Recommended Solution	1. Municipal Ownership of Properties				
	permanent dwellings		$50,000	5	$250,000
	seasonal dwellings		$25,000	10	$250,000
	vacant lots		$5,000	14	$70,000
	TOTAL				$570,000
Alternative Solution	1. Offshore Breakwaters with Steel Sheet Pile Wall and Beach	$3,700	$670,000	3	$2,010,000
	2. Armour Stone Headland with Beach	$4,000	$720,000	3	$2,160,000
Short Term Remedial Measures	1. Add filter stone layer and geotextile filter fabric below existing rubble	-			
	2. Construct Flood Protection Berm	-			

Reach 4 (1+000 to 3+080)

Alternatives	Type of Shoreline Protection	~ Cost / m	$/Structure	Units	Total Costs
Recommended Solutions	1. Offshore Breakwaters and Steel Sheet Pile Wall with Beach	$3,700	$670,000	2,050	$7,585,000
	2. Armour Stone Headland with Beach	$4,000	$720,000	2,050	$8,200,000
Alternative Solution	1. Armour Stone Hard Points with Beach	$2,600	$260,000	2,050	$5,330,000
	2. Armour Stone Revetment	$2,600		2,050	$5,330,000
Short Term Remedial Measures	1. Add filter stone layer and geotextile filter fabric below existing rubble	-			
	2. Move Residence and Raise Elevation		$20,000		
	3. Construct Flood Protection Berm	-			
	4. Armour Stone Toe Berm	-			

Table 4 Potential Reductions to Cost Estimates

Regional Shoreline Protection Alternatives	Preliminary Cost Estimates (in report) (per meter)	Cost Estimates with Value Engineering (per meter)	Cost Estimates with Value Engineering and Natural Beach Accumulation (per meter)	Total Potential Savings (per meter)
Offshore Breakwaters and Steel Sheet Pile Wall with Beach	$3,700	$3,300	$2,300	35%
Armour Stone Headland with Beach	$4,000	$3,600	$2,600	35%
Armour Stone Hard Points with Beach	$2,600	$2,400	$2,100	20%
Armour Stone Revetment	$2,600	$2,350	n/a	10%

Note:

1) The cost estimates have been prepared to facilitate the comparision of the design alternatives presented in this report and are preliminary (not for construction budgeting).

2) The costs reflect the engineers best estimate based on material and labour costs in the Fall of 1997.

3) The cost estimates are subject to change.

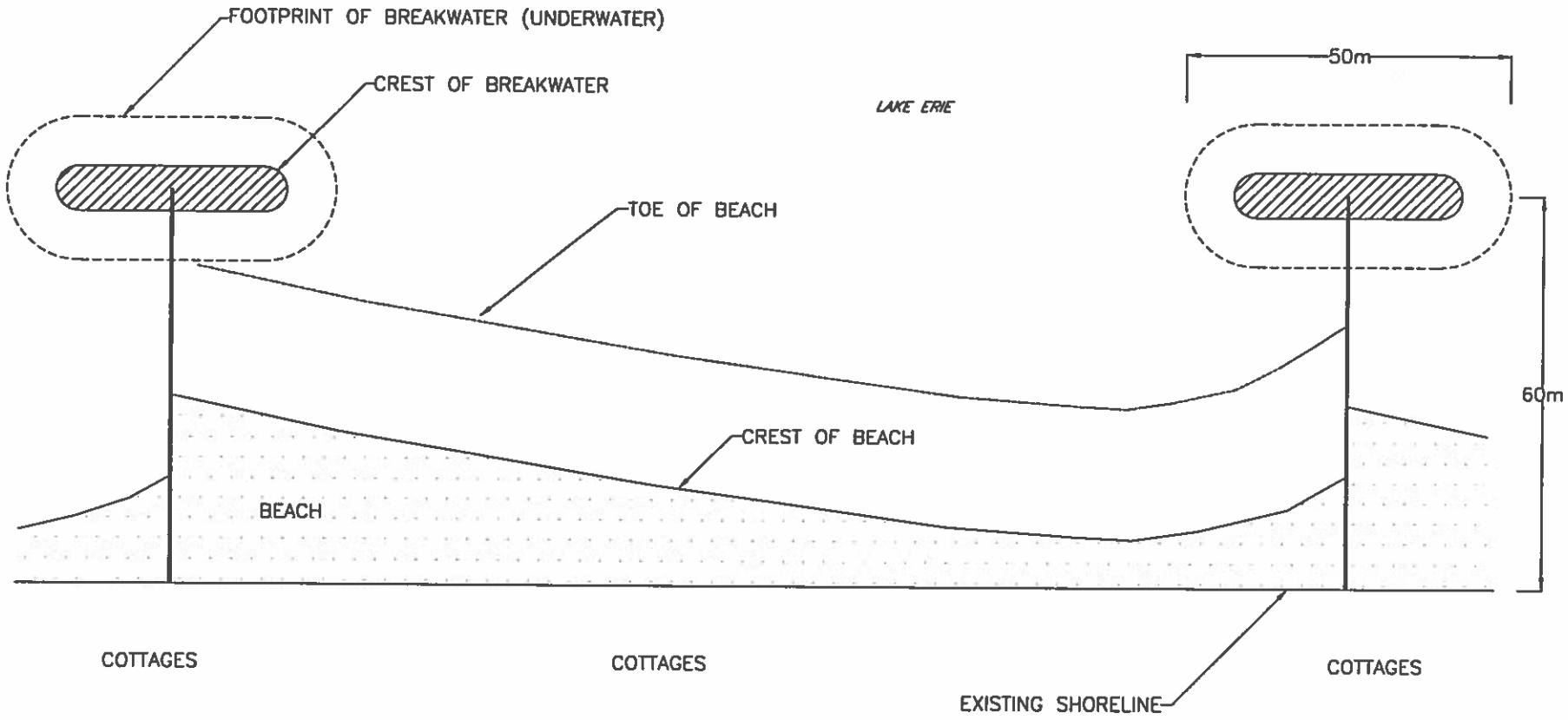
APPENDIX 'A'

Regional Shoreline Protection Alternatives

APPENDIX 'A1'

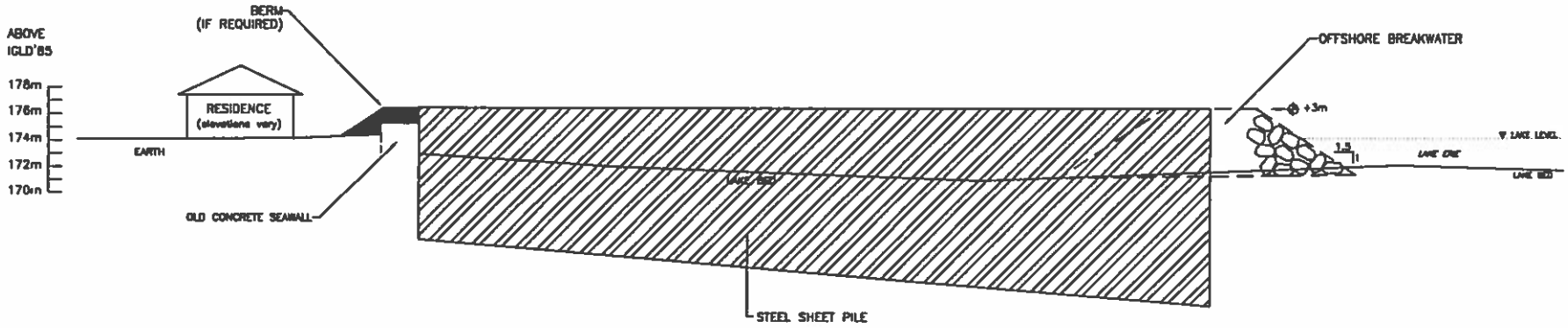
Offshore Breakwater with Steel Sheet Pile Wall and Beach

OFFSHORE BREAKWATER
WITH STEEL SHEET PILE WALL AND BEACH
(TYPICAL)



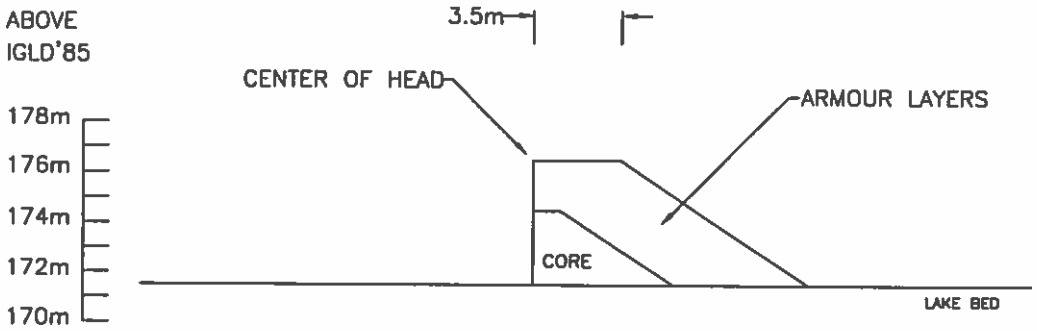
NOT FOR CONSTRUCTION

OFFSHORE BREAKWATER
WITH STEEL SHEET PILE WALL AND BEACH
(TYPICAL)

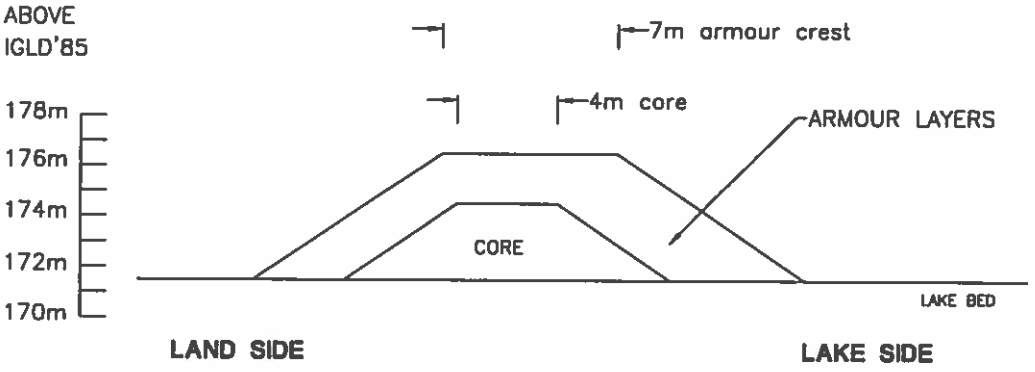


NOT FOR CONSTRUCTION

OFFSHORE BREAKWATER
(TYPICAL)



HEAD SECTION



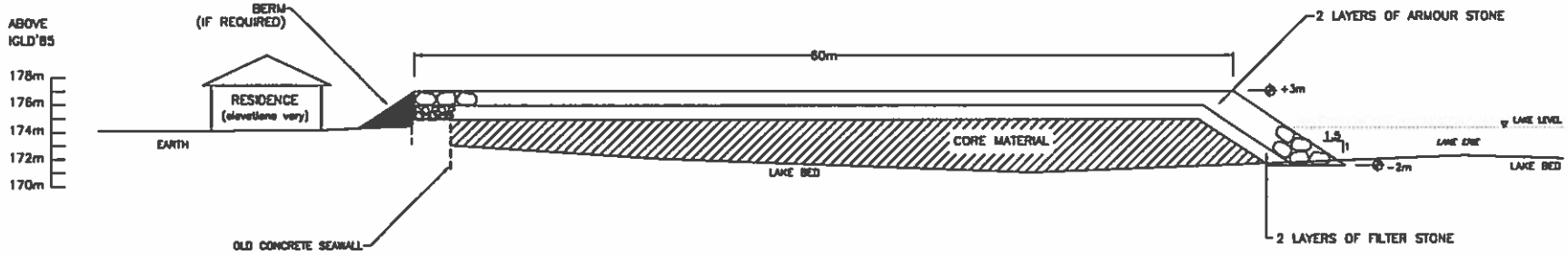
TRUNK SECTION

NOT FOR CONSTRUCTION

APPENDIX 'A2'

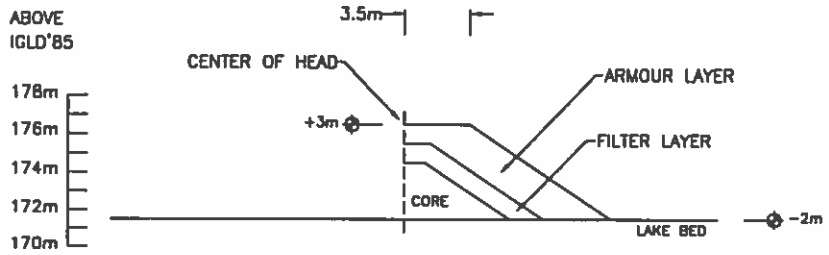
Armour Stone Headland with Beach

ARMOUR STONE HEADLAND WITH BEACH
(TYPICAL)

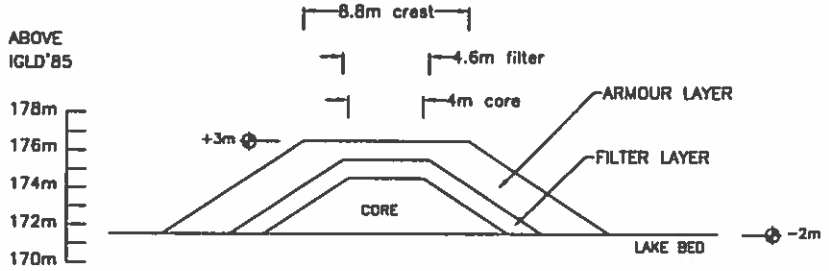


NOT FOR CONSTRUCTION

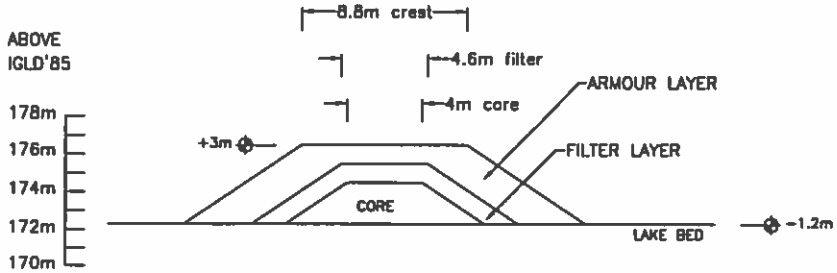
ARMOUR STONE HEADLAND WITH BEACH
(TYPICAL)



HEAD SECTION



TRUNK SECTION (OFFSHORE)



TRUNK SECTION (AT SHORE)

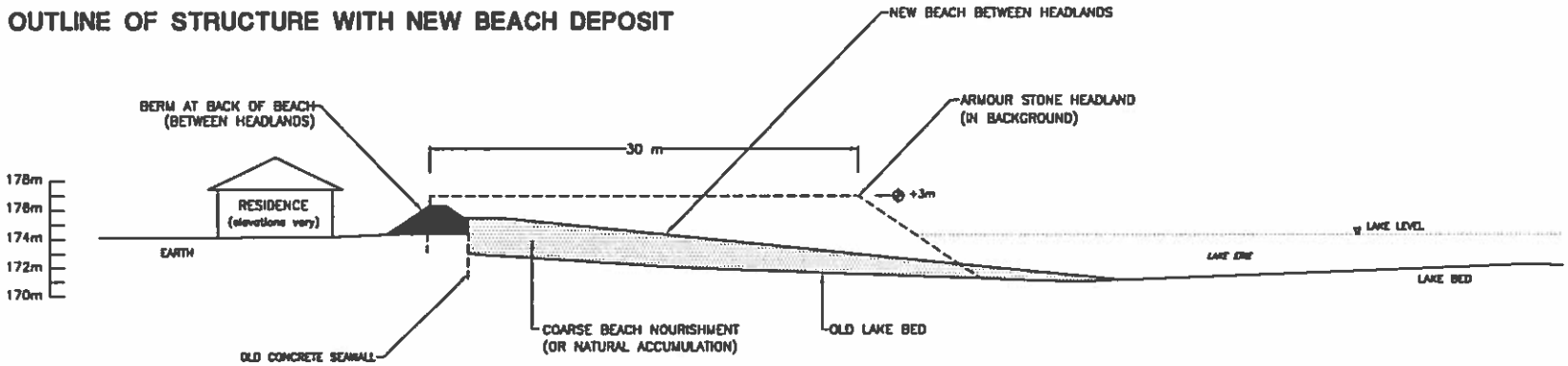
NOT FOR CONSTRUCTION

APPENDIX 'A3'

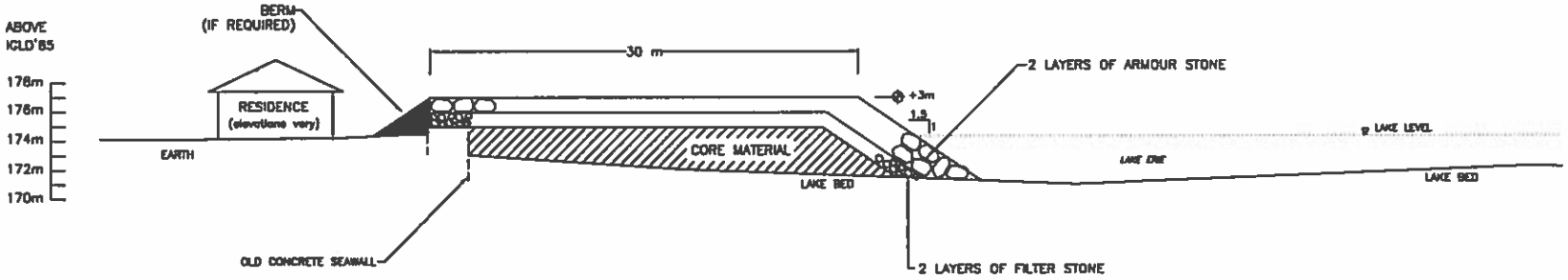
Armour Stone Hard Points with Beach

ARMOUR STONE HARD POINT AND BEACH
(TYPICAL)

OUTLINE OF STRUCTURE WITH NEW BEACH DEPOSIT

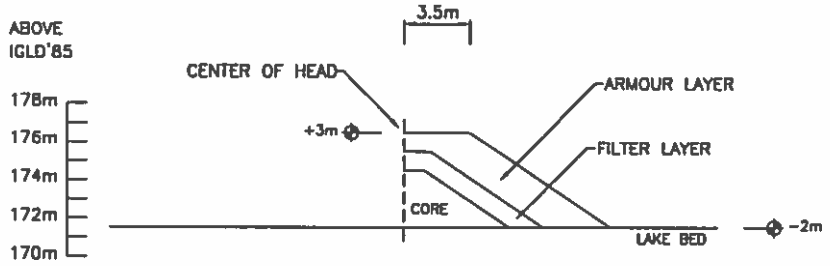


DETAIL OF STONE AND CORE MATERIAL

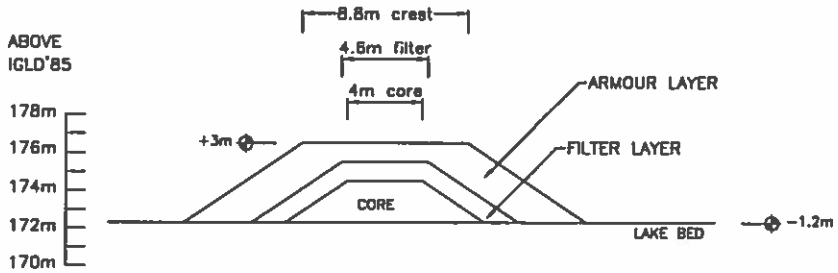


NOT FOR CONSTRUCTION

ARMOUR STONE HARD POINT WITH BEACH
(TYPICAL)



HEAD SECTION



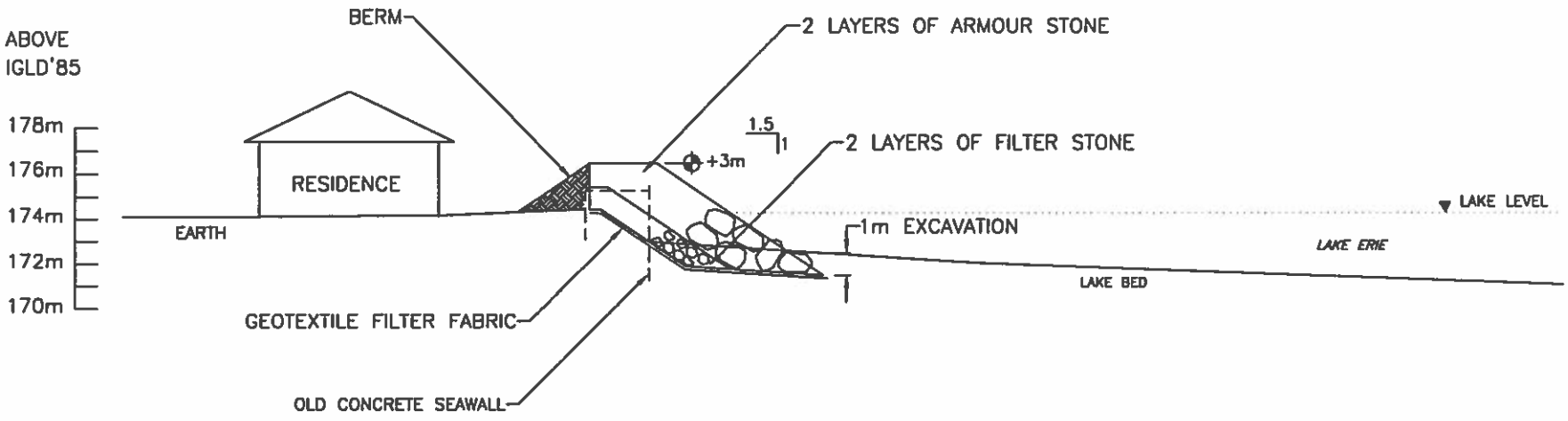
TRUNK SECTION

NOT FOR CONSTRUCTION

APPENDIX 'A4'

Armour Stone Revetment

ARMOUR STONE REVETMENT WITH OPTIONAL BERM
(TYPICAL)

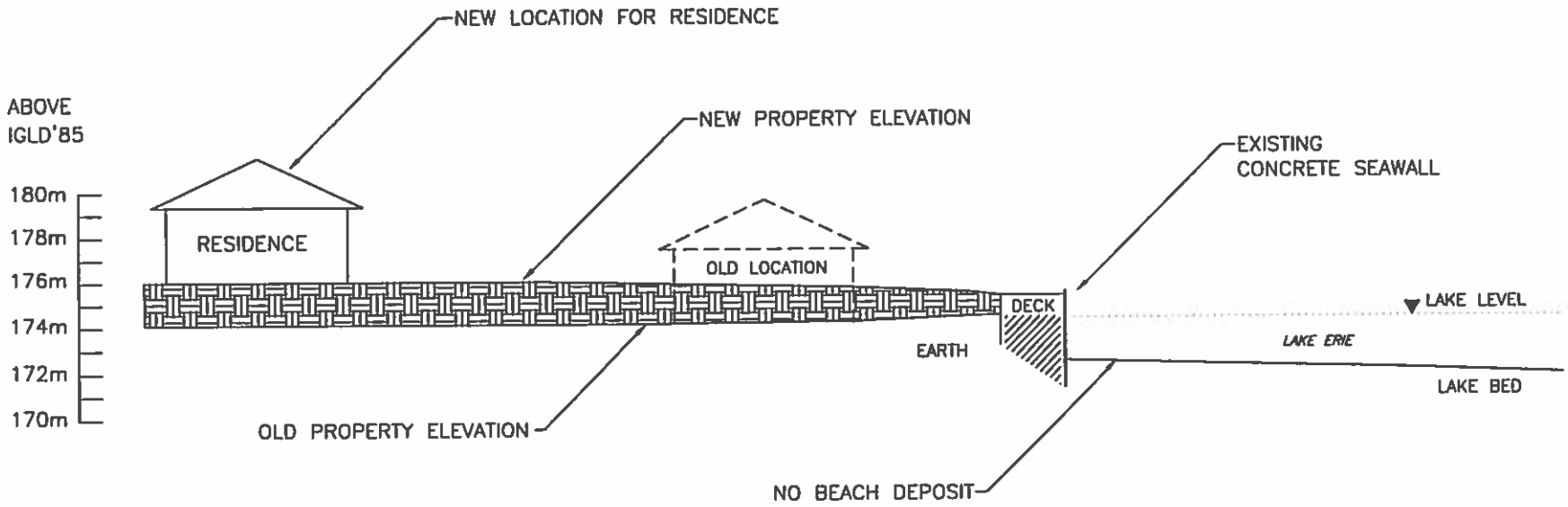


NOT FOR CONSTRUCTION

APPENDIX 'B'

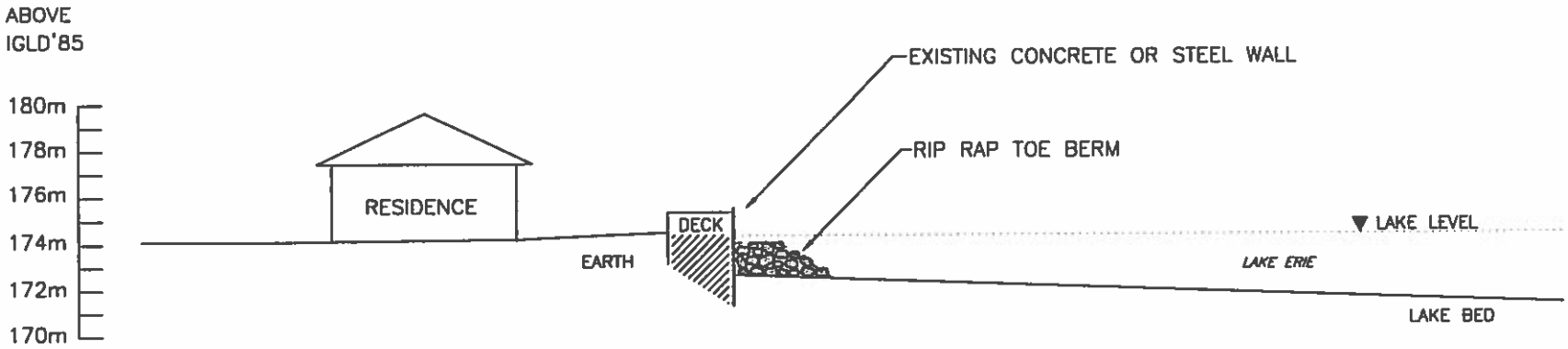
Short Term Remedial Measures

MOVE RESIDENCE AND RAISE PROPERTY ELEVATION
(TYPICAL PROFILE)



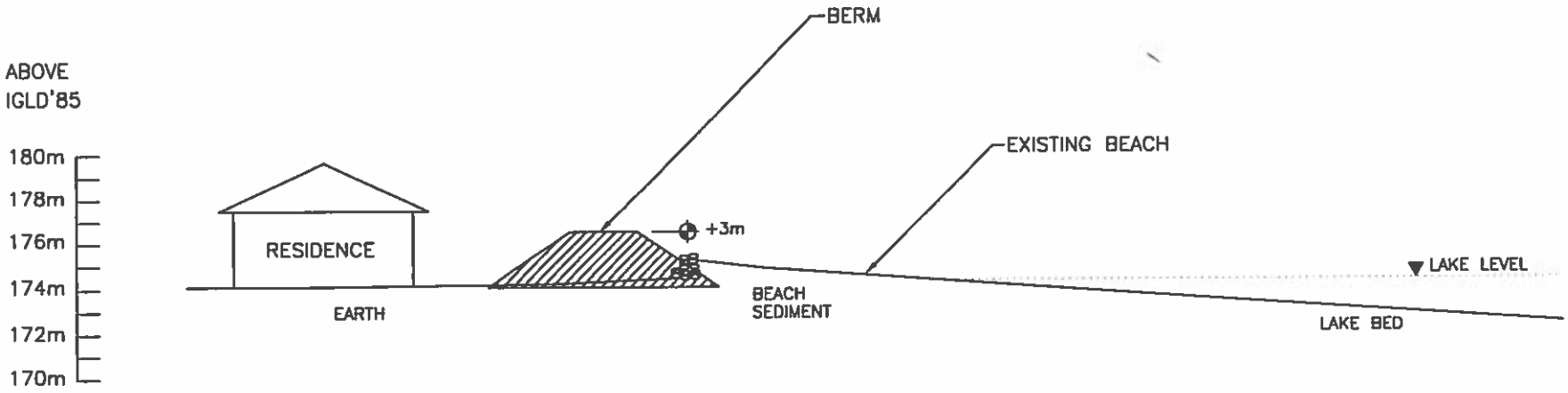
NOT FOR CONSTRUCTION

RIP RAP TOE BERM
(TYPICAL PROFILE)



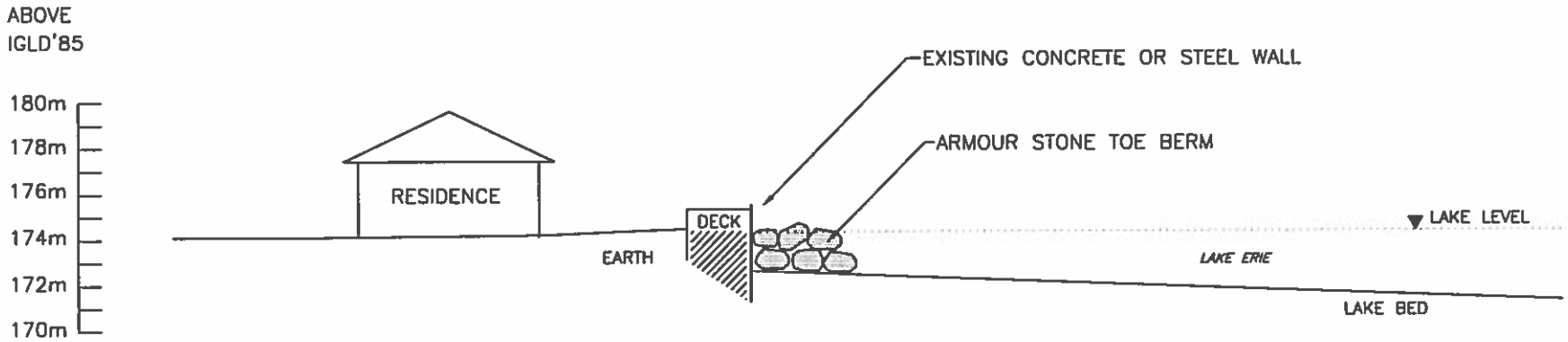
NOT FOR CONSTRUCTION

FLOOD PROTECTION BERM
(TYPICAL PROFILE)



NOT FOR CONSTRUCTION

ARMOUR STONE TOE BERM
(TYPICAL PROFILE)



NOT FOR CONSTRUCTION