COMMUNITY EROSION PROTECTION SYSTEM ANALYSIS

Coastal Zone Laboratory
University
of
Michigan

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The Coastal Zone Laboratory

The University of Michigan

Ann Arbor, Michigan

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PROJECT ORGANIZATION

This project was a multidisciplinary effort carried out by a number of the staff members from the Coastal Zone Laboratory at the University of Michigan.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0. INTRODUCTION

The information contained in this report is the result of an 8 month study carried out by the Coastal Zone Laboratory of the University of Michigan for the Michigan Department of Natural Resources. The major objective of the study was to explore various factors and issues associated with the erosion control provisions of Michigan Public Act 148 (1976), entitled Certain Public Improvements by Townships.

One of the objectives of Act 148 was to provide communities facing severe shore erosion problems a method that would allow a "community approach" to dealing with shore erosion. In general, this method enables communities to form special assessment districts for the purpose of constructing and financing coastal erosion control structures.

In creating the erosion control provision of P.A. 148 it is believed the drafters of the legislation which created such special assessment districts felt they would provide assistance in 2 basic ways:

(1) It would allow long term public bond financing for constructing erosion control structures or methods for groups of individual property owners.

(2) It would promote an "area-wide" approach (our quote) to construction of erosion control structures as contrasted by individual action by each property owner.

It seems likely that many parties interested in this Act believe that the special assessment district approach would provide several advantages:

(1) Economies of scale might be gained from constructing larger scale structures.

(2) Higher quality of construction might be obtained by joint action.

(3) More effective designs might be achieved by reducing the "interaction" that might occur when individual owners constructed their own particular control structure.

To date no unit of government in Michigan has elected to utilize this legislation for erosion control districts. The purpose of this study was to explore the feasibility of the special assessment district concept and to provide an overview of the various issues and factors that must be considered in the potential implementation of the Act by a given unit of government.

The approach, as stipulated by the contracting agency was to carry out the study for a "pilot area" in Michigan and, through a process of study and selection, the area chosen was Lincoln Township.

In considering the feasibility of the special assessment district concept the various design, economic, legal and environmental factors and issues were defined. The general level of analysis was of a "pre-design" nature, that is, the structural approaches suggested and the various factors associated with the alternative structures were intended to be indicative of the possible types of structures that might be used. Any final implementation of the concepts presented here would require detailed engineering design calculations and analysis. The intent of the results shown here is to give the reader an understanding of the basic issues involved in the special erosion assessment district concept as they relate to potential implementations of P.A. 148.

While the work was carried out for a specific site it is felt that many of the issues apply to many other coastal erosion situations. This is particularly true with respect to the legal issues involved in the use of the concept.

In regard to the structural alternatives presented it is important to remember that design of erosion control structures is very site specific. Thus the structures discussed here, while fairly common in application, may or may not be usable at other sites, depending upon local conditions. However, the methods of analysis and approach used here are applicable to any other site where the concept may be of interest.

2.0. THE EXISTING PROBLEMS

2.1. Site Location and Layout

The Community Erosion Protection System Analysis (CEPSA) seeks to analyze the relative advantages and disadvantages of a Community Erosion Protection System (CEPS), as provided by Michigan PA 148 of 1976, in comparison to the current practice of single parcel, individual protection. This major objective will be met by attaining three related subobjectives: 1) identifying the issues, problems and opportunities of a CEPS, (2) determining the existing and/or required data needed to address the socioeconomic, scientific/engineering, legal, and environmental aspects of a CEPS, and (3) determining the structural and nonstructural erosion protection alternatives available to a CEPS.

In order that the project provide results useful to shoreline communities in Michigan as well as impetus for a possible attempt to implement a CEPS, the analysis proceeded on a site-specific basis. Berrien County was chosen by the Coastal Program Unit (CPU) of the Michigan Department of Natural Resources (MDNR) as the shoreline reach from which the Coastal Zone Laboratory (CZL) was to select the shoreline community to be involved. The selection process used by the CZL is stated in Appendix A.

Selection of the study reach was based on its diversity and on discussions with the township officials as to areas of particular concern to them (Figure 2.1-1). The criteria used to measure its diversity were:

(a) A reach which contained multiple land use types.

(b) Varied land values and property sizes.

(c) An historic erosion problem.

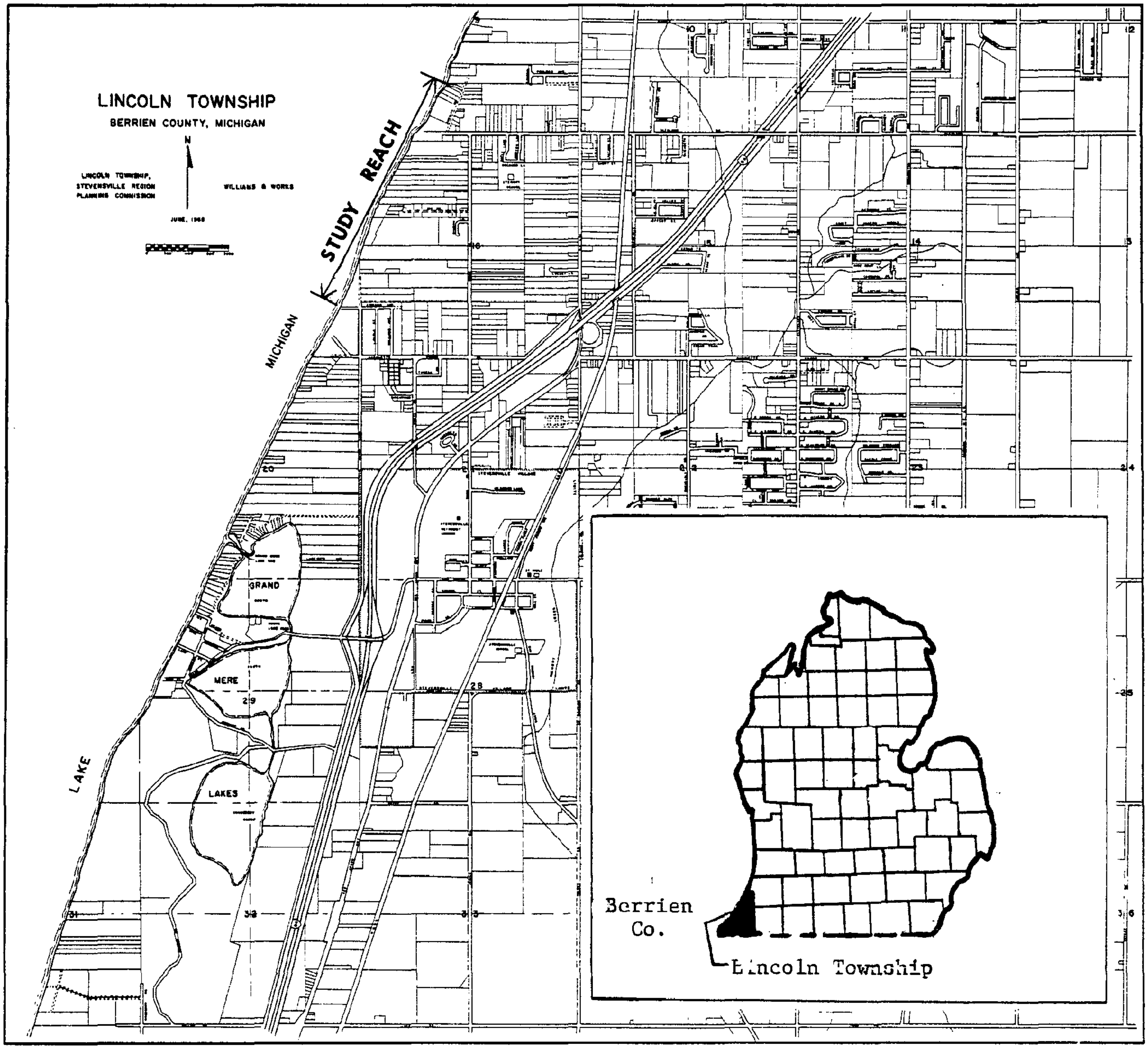


Figure 2.1-1. Study reach location.

(d) Existence of individual erosion protection structures, in varied degrees of repair and effectiveness.

Taking these things into account, a reach in the northern section of the township was selected. The reach covers 6000 feet of shoreline from the bend in Lake Forest Road to Chicago Avenue and includes 27 parcels of land (Figure 2.1-2).

Along the north end of the study reach, properties 10 through 60 are characterized by steep, moderately high bluffs and narrow beaches. The angle of the bluff in this section is about 60° (which is unstable, indicating active erosion) with an average height of 36 feet. Of these six lots, 3 are vacant and 3 have permanent residences on them, with 2 of the lots containing erosion protection structures. One of the structures, consisting of a wooden seawall in front of a concrete seawall, was not doing much to protect the bluff; while the other, a combination wooden groin and seawall, seemed to be developing a beach. There is a question, though, whether or not the structure or some other factor was causing the beach to develop because the adjacent property, the township park which did not contain any structure, was also developing a large beach area (Figure 2.1-3).

South of the township park is the largest commercial property in the reach, Surfside Apartments. Here the bluff angle drops in half to about 30°, increases in height to 42 feet, and is developing a grass cover even though there is some active erosion evident. The beach which developed off the township park carries over onto this property, but narrows down along south edge of property.

The next 9 properties (#90-#160) are very deep lots averaging 1200 feet, most of which contain permanent residences located a large distance

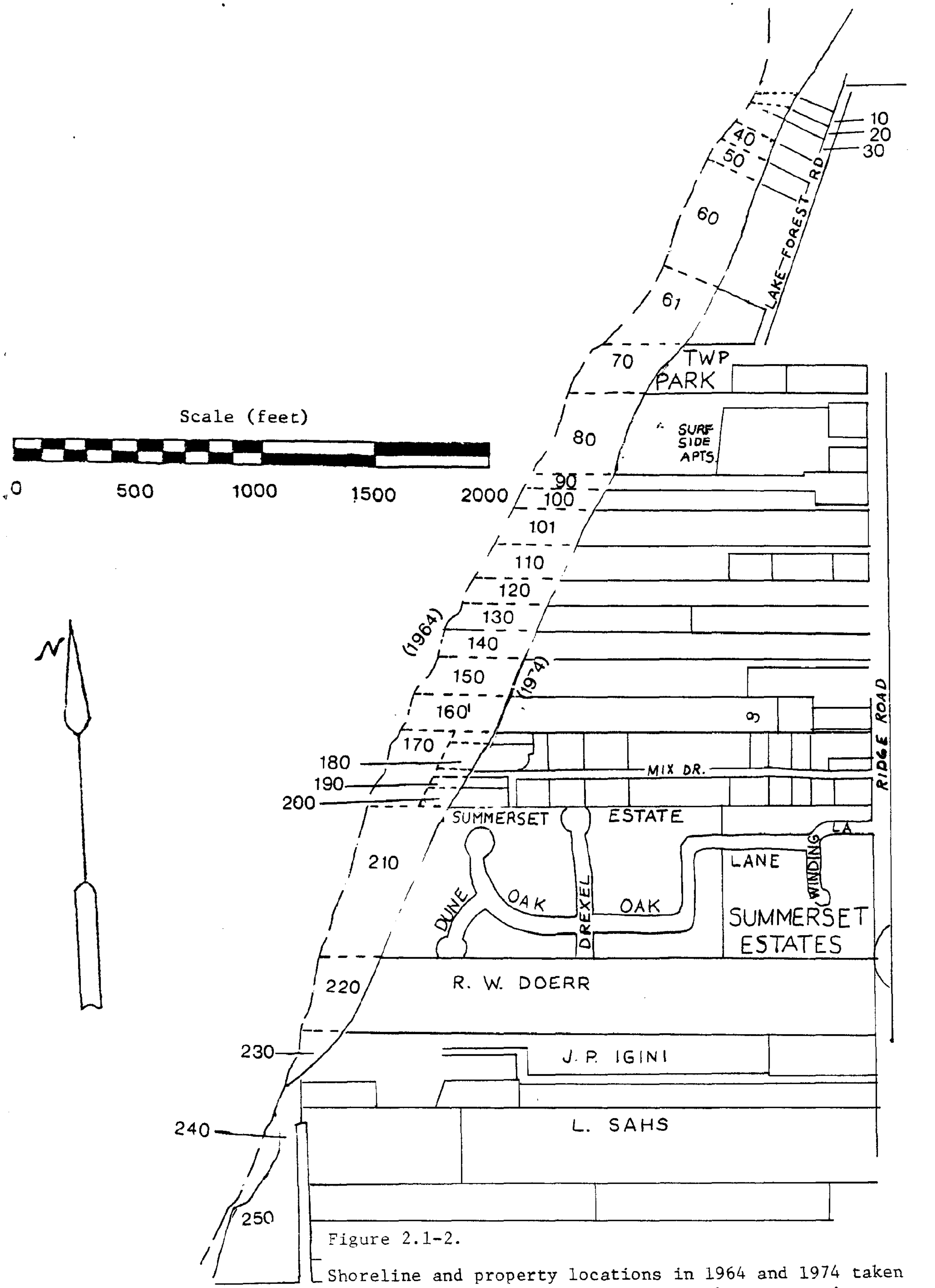


Figure 2.1-2.

Shoreline and property locations in 1964 and 1974 taken from aerial photographs of study reach. Due to inaccuracy in mapping and photography, actual recession cannot be measured from the map.

Figure 2.1-3. Beach accretion at the township park and properties 61/60 as photographed in May, 1979.

back from the bluff. One residence, though, is located very near the bluff and is protected by what seems to be a relatively effective structure. The structure consists of a wooden seawall with a set of wood pilings in front of it which appear to act as a wave energy absorber. A small beach seemed to be building behind the structure, but not nearly to the extent that was developing off the township park (Figure 2.1-4).

The next property, #170, is no longer in existence. Erosion has consumed all of the lot, leaving only the remnants of a foundation on the beach. Property #180 attempted protection by constructing a structure out of old oil tanks. These did not seem to have any positive effect or stability once placed on the beach (Figure 2.1-5). This situation highlights a common problem along much of Michigan's coast - inappropriate, ineffective, and inadequate shore protection without proper engineering.

The other commercial property in the reach is Summerset Estates. Summerset Estates owns 7 shoreline lots which, due to erosion, are no longer large enough on which to build a house. Beyond Summerset Estates the bluff rises to a height of 55 feet at an angle of 40°. There are 5 properties along this last stretch of shoreline, of which 3 are vacant lots and 2 have homes on them. Both of the homes are in danger due to erosion, but the last one in our reach is in imminent danger. The bluff here has eroded back to the building exposing some of the porch foundation (Figure 2.1-6). A steel seawall and wood piling wave absorber have been constructed to protect the bluff. Erosion of the bluff on adjacent properties indicates that the structure has been somewhat effective, although not totally effective as can be seen by the slumping in Figure 2.1-6.

2.2 Existing and Historic Erosion Problems

Our study reach and most of Lincoln Township has experienced high reces-

Figure 2.1-4. Combination wooden seawall and wood piling wave energy absorber, located in front of property #160, as photographed in May, 1979.

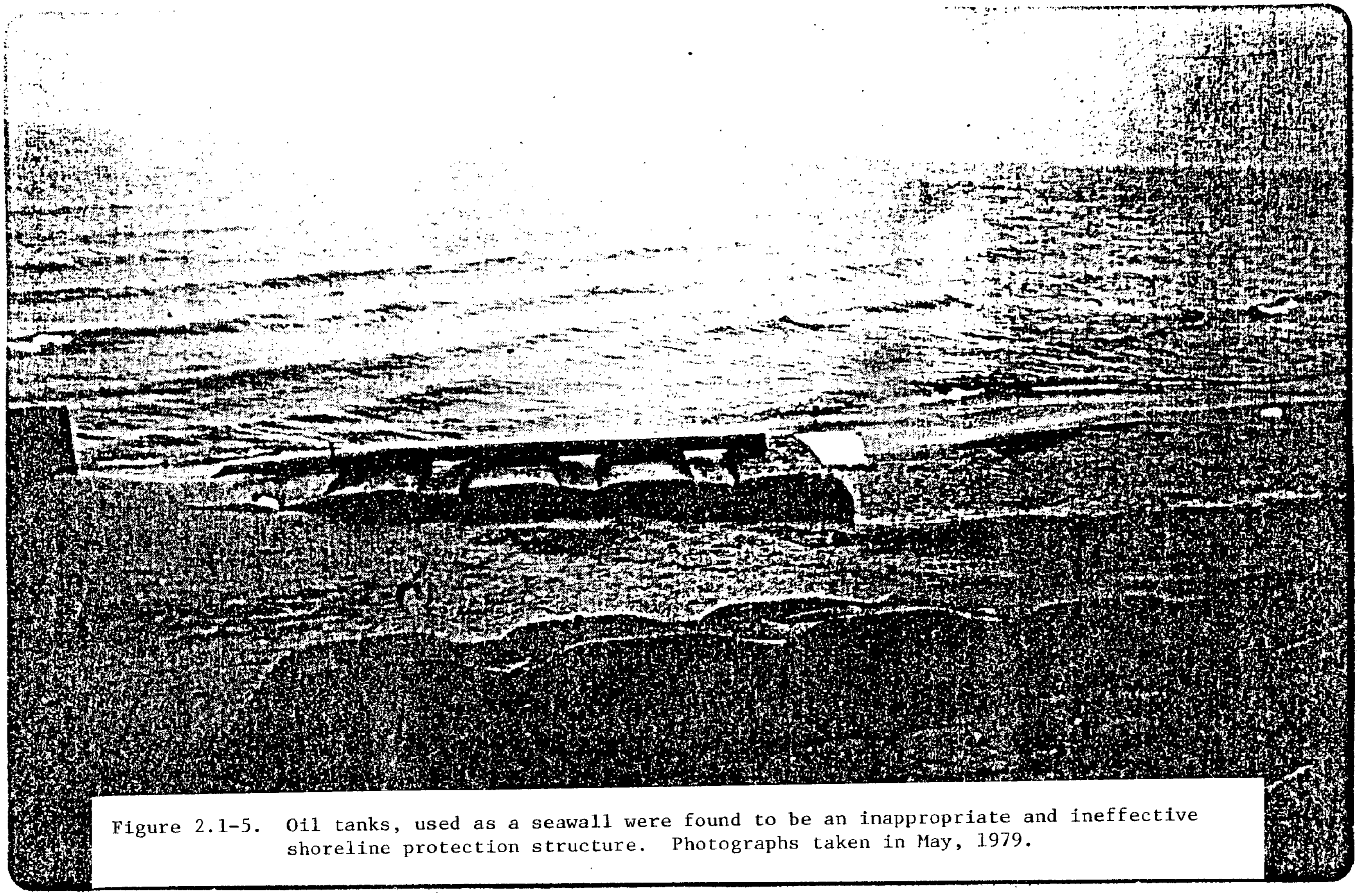


Figure 2.1-5. Oil tanks, used as a seawall were found to be an inappropriate and ineffective shoreline protection structure. Photographs taken in May, 1979.

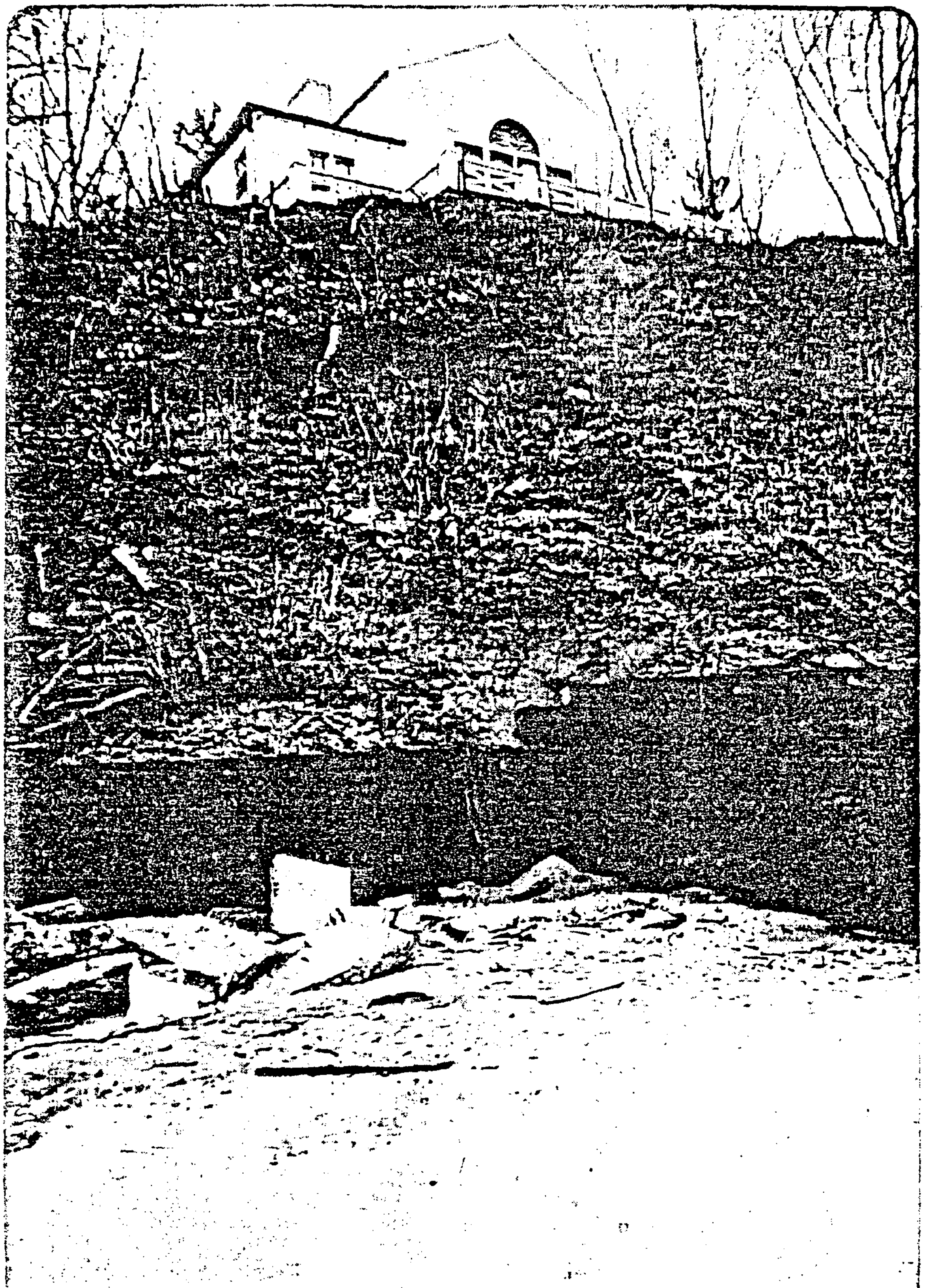


Figure 2.1-6. Steel seawall shoreline protection structure, protecting home which is in danger of toppling over bluff. Photograph taken in May, 1979.

sion rates over the past several years. This is influenced by many factors, both geographic and climatic. The major factors which control recession rates are shape, composition, and orientation of the beach and bluff; wind and wave climate; water level variations; and storm type and frequency. Along with these, some secondary factors which control erosion rates are ice cover and erosion due to runoff. The effects and interrelationships of these factors as they are related to structure design are discussed in Section 3.1.

Historically, erosion along the Michigan coast has been a problem which existed, but it has not received the public attention since the early 50's that it has over the past 10 years. This attention is caused by increased erosion rates which have been partially caused by increasing lake levels (Figure 2.2-1). It should be noted that lake levels alone will not increase erosion. A storm which creates waves of a certain size and force will deliver more of this energy to the bluff during high water periods than during low water periods, thus causing a higher erosion rate.

Studies done by many people over the past few years indicate that the long term erosion rate for our reach is between 1.4 and 4.2 feet per year (Table 2.2-1).

Table 2.2-1. Bluff recession rates calculated for our study reach.

Investigator	Time Interval	Recession Rate (ft/yr)
Powers (1958) (for all of Berrien County)	1830-1956	2.0
Beach Erosion Board (1956)	1830-1954	1.4
Michigan Department of Natural Resources (1974-75)	1938-1974	2.8-4.2

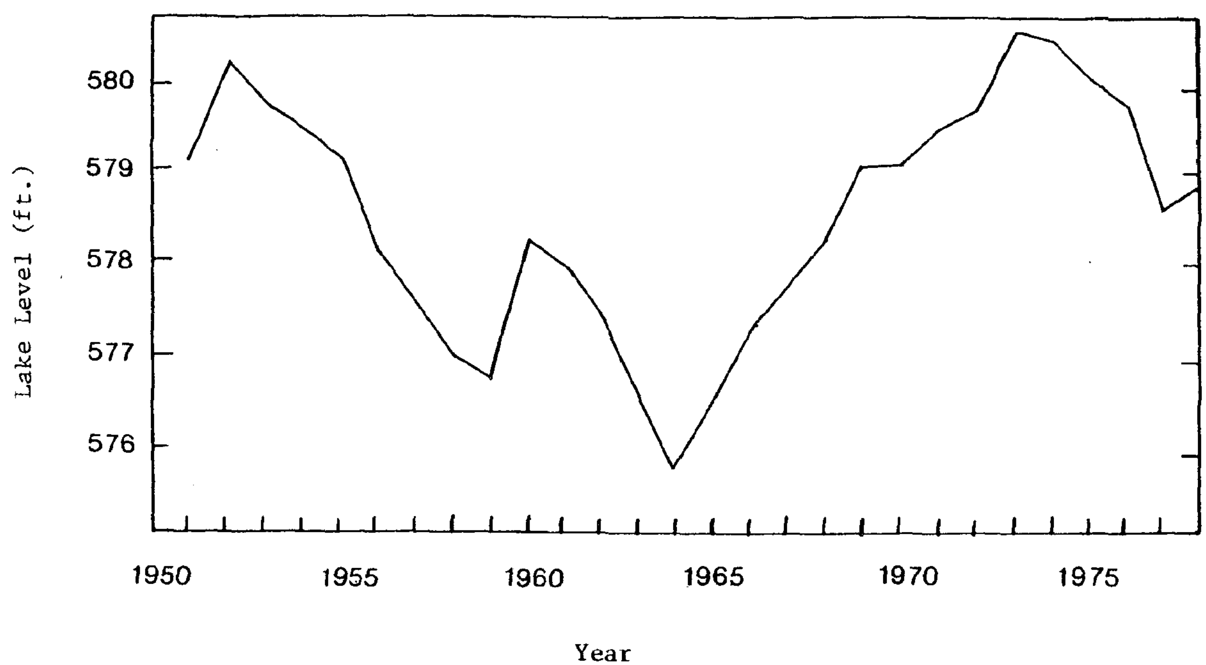


Figure 2.2-1. Annual average water level in Lake Michigan near Ludington, Michigan from 1951-1978 (IGLD, 1955).

It is expected that the rates determined by the Michigan Department of Natural Resources (MDNR) are more typical of the current long term rate because it includes the highwater period and increased development between 1965 and 1975 (see Figs. 2.2-2 and 2.2-3). These rates are much lower than that determined by Birkemeier (1979) for the high water period between 1970 and 1974.

Birkemeier's study used aerial photos from 1970 to 1974 and looked directly at our study reach. His findings indicate that prior to 1972 erosion along the reach was evenly distributed, but after 1972 it was higher along the northern 4 properties than the rest of the reach. The highest rates of erosion were recorded in this northern area, with a maximum of 65 feet in a 5 month period. It should be noted though, that recession occurs in discrete steps and recession rates determined from short periods of time may not be indicative of the overall long term rate. The average rate of bluff recession for this high water period reported by Birkemeier is 15.1 feet per year. It is not expected that the recession rate will stay at this high level, but will continue to fluctuate as both lake levels and storm frequencies change.

2.3. Potential Conflicts

The high amounts of erosion in the past few years has spurred State, local and public reactions. State action was taken through Public Act 245, (1970), The Shorelands Protection and Mangement Act, whose purpose was to provide planning and action for the wise use of Michigan's shorelands. The Act states:

> "The director shall designate a high risk erosion area upon his finding that erosion is causing or is likely to cause damage or

destruction to permanent buildings or structures . . . . Upon designation of a high risk erosion area, the director shall also set forth recommended shoreland use restrictions based upon a 30-year period of life of a permanent building or structure . . . ." (Michigan Public Act 245, 1970).

This action was carried out by the Michigan Department of Natural Resources (MDNR) in 1974-1975, and resulted in designation of high risk erosion areas. According to the MDNR our study reach and most of Lincoln Township is designated as a high risk erosion area with a minimum setback range of 85-125 feet and a recommended setback range of 115-155 feet from the edge of the bluff (Fig. 2.2-2).

The state has set forth three possible means of protecting a home in accordance with Act 245. These include:

(a) Adherence to the recommended setback distances set forth by the MDNR, or, if this requirement cannot be met, then

(b) construction of a movable home, or

(c) installation of a protective structure which will reduce erosion to the point where the home will be safe for 30 years.

Lincoln Township elected to develop a zoning ordinance which meets the MDNR requirements for protection of high risk erosion areas, thus superseding the MDNR permit requirements. The High Risk Erosion Overlay District of the Lincoln Township Zoning Ordinance (section 15) states:

> "The regulations herein contained are intended to effectively control unwise development of the shorelands where property damage during high water periods has or may result in structural property damage; actual loss of land; loss of recreational swimming beaches and/or lack of access to Lake Michigan", (Lincoln Township Zoning Ordinance, 1975).

The ordinance does this by identifying a setback distance, a regulation on tree cutting and/or removal of shore cover, a regulation on removal of sand or soil, and a regulation on shoreline protective structures.

2.2-2. Minimum set-back distances for Berrien Co., Michigan (from MDNR)

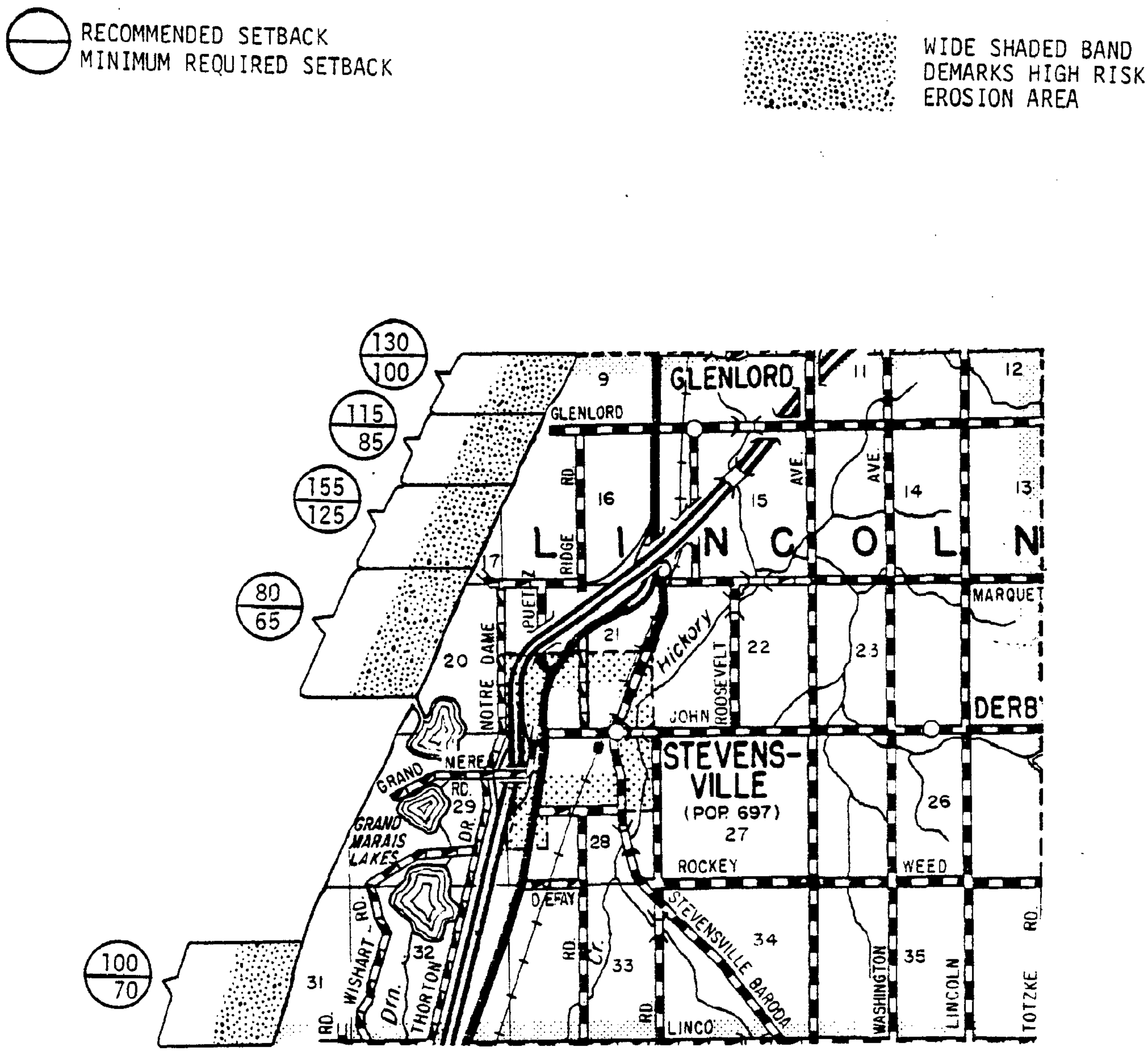
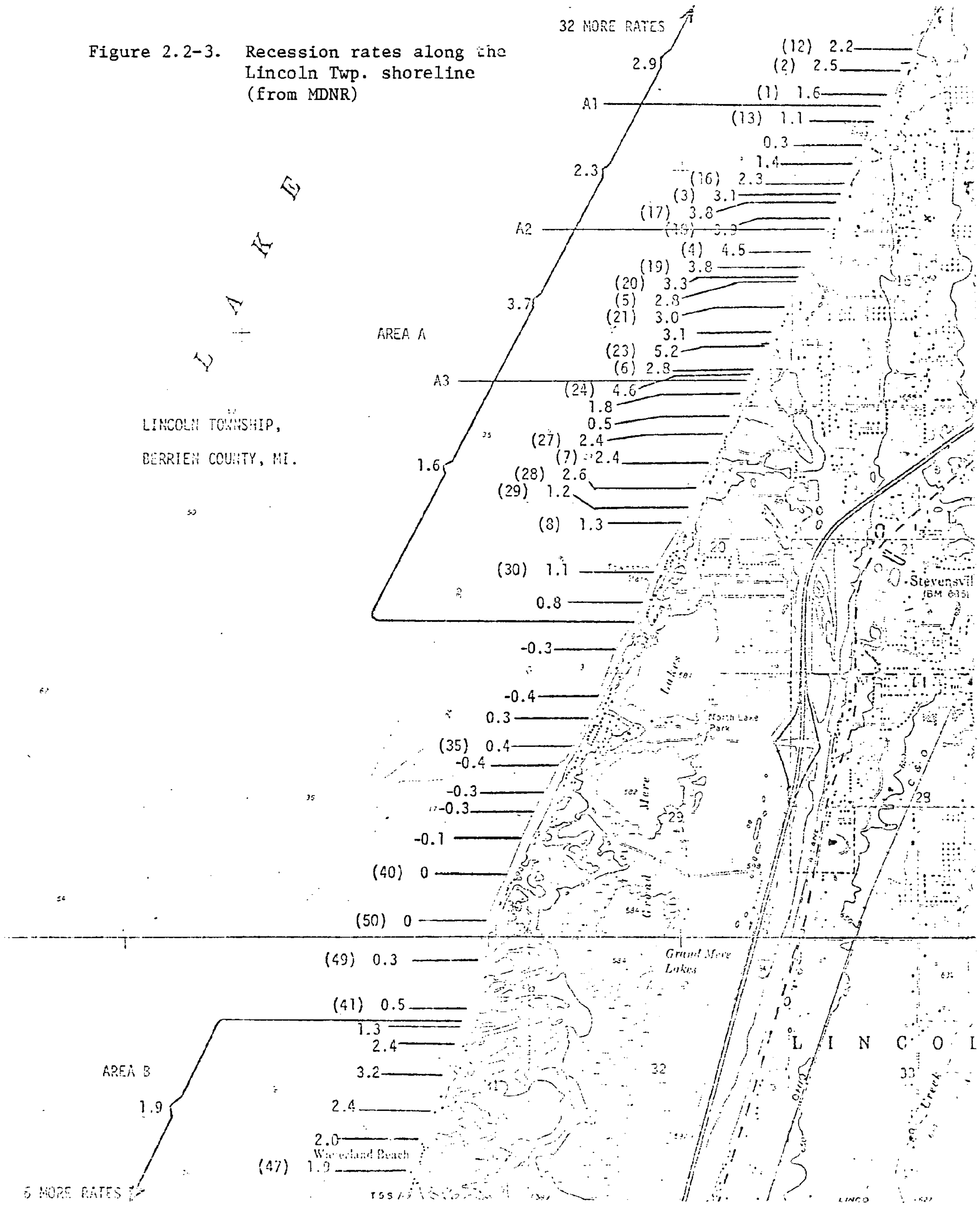


Figure 2.2-3. Recession rates along the Lincoln Twp. shoreline (from MDNR)



The regulation of major interest to our study is the regulation on shoreline protective structures (Section 15.8, Lincoln Township Zoning Ordinance). This regulation requires that any structure, whether permanent or temporary, which is constructed above the mean high water mark shall be subject to site plan review so that property owners can be alerted to possible impacts in high risk erosion areas.

The intentions of both the state and local agencies were good, but some public unrest has been generated. New shoreline property owners have a hard time understanding why they cannot build their home on the edge of the bluff, or at least closer to the bluff than the recommended setback, thus causing conflicts between the property owners and the Township. Although a CEPS could help alleviate the concerns about erosion of the bluff, it should not allow a home to be constructed any closer to the bluff edge than the minimum set-back distance.

A CEPS could cause conflicts with the non-shoreline property owners in the township. Talks with township officials have indicated that there is a long standing conflict between shoreline and non-shoreline property owners over public access to Lake Michigan beaches. Over the years the shoreland property owners have demanded that the beaches in front of their homes are private land and access was not allowed to the general public. This situation indicates that any action taken by the Township to sponsor or aid shoreline owners with Township time or funds may meet with opposition by the non-riparians. It should also be noted that a CEPS on a reach which contains public land requires that the whole township vote approval or disapproval. In our reach the amount of public land is small and thus will not have much of a say as to whether a CEPS is constructed, but if this were not the case and there were a large amount of public land within the reach, the general public could approve or stop an entire project.

Public sentiment must be considered during the development of a CEPS in order to meet the needs of both the shoreland and non-shoreland property owners. An attempt was made to address this problem with the Headlands Park design. This design, which is explained in more detail in Section 3.1., calls for the creation of two parks which extend out into the lake. These would serve the joint needs of the township by providing needed park facilities for the general public and providing erosion protection for the shoreland property owners. Even this design has problems, however, because there is no public access to the south park located off the Summerset Estates land and there is a lack of adequate public parking at both locations.

An apparent result of the present study is that the socio-economic considerations are as important as the scientific and engineering phases of a CEPS project. If a system of implementation has not been developed which will answer both the legal and public requirements of the township, it does no good to define an erosion problem and design a CEPS.

3.0. CEPSA: ANALYSIS AND CASE STUDY

3.1. Scientific/Engineering Considerations

The design of any shore protection structure requires knowledge of the coastal processes at the site. This involves information regarding the erosional history of the shoreline, winds, geology and soils, longshore transport, topography (onshore and offshore), currents, lake levels, ice, and, most importantly, waves. Then, given the information above, a technical analysis of various alternatives is required in order to narrow the number of choices to those most applicable to the particular shoreline in question. A preliminary design of these alternatives logically follows and allows a more detailed engineering, economic, environmental, and legal analysis on which to base the selection of the most appropriate shore protection system (SPS).

The objectives of this section are several. First, a general discussion of coastal processes will be presented to aquaint the reader with the many factors affecting the shoreline. Using this information, a discussion of the potential alternatives will follow, four alternatives chosen, and engineering considerations of each presented. For clarity of discussion the design calculations are presented in Appendix B. Note that as this is basically a pre-feasibility study, the considerations and designs presented are very general and are not intended for immediate application. Nor has an attempt been made to recommend any one of the alternatives as the SPS; rather the objective is to provide a variety of possible structures in order to allow a wider range of analysis of the feasibility of a CEPS.

3.1.1. Coastal Processes

The dominant factors with respect to coastal processes are winds, waves, and water level variations. Winds and waves are directly responsible for sediment movements and most of the shoreline erosion[1] while water level fluctuations separate the regimes of the two areas affected (foreshore and backshore) by changing the position of the shoreline.

Winds. Winds are important in that they produce a number of effects: 1) they are the generating force for waves and surface currents; 2) they cause short term lake level changes; and 3) they transport sand across the beaches, particularly the finer grain-sizes.

Wave generation by wind is a very complicated and little understood process, but some work has been done to simplify the problem. It is not the intent of this project to discuss these methods; suffice it to say that wind data can be used to predict wave forces by knowing four parameters: intensity, duration, direction, and fetch (the distance of water over which the wind blows). During the actual design stage, the usual practice is to collect data on these four parameters from historical records and such data is available for southern Lake Michigan. The process of calculating the waves from this data is called hindcasting. A wave hindcast may use sophisticated models, but it can be done using the Sverdrup-Munk-Bretschneider (SMB) curves. A hindcast usually results in the generation of the significant wave, discussed below.

Wind also changes lake levels over the short term. When the winds of a storm blow over the lake, the stress of the wind on the lake causes water literally to flow to the downwind side and "pile up" on that shore (i.e., the lake surface "tilts"). When the storm passes over, the water flows back and the lake level drops along that shoreline. The result is a "sloshing"

[1]There are terrestrial factors such as ground water seepage, rill and gulley formation, rain, etc. which contribute to shoreline and bluff erosion, but aside from groundwater seepage, winds and waves are the largest contributors.

effect, called a seiche, where the lake level will rise and fall several times, each rise being slightly lower than the preceding rise. The effect of the wind stress lake level change is to allow the wave energy to be expended closer to the bluff resulting in greater erosion.

Wind can also transport sand, especially the finer sand, shoreward. This action can cause a build-up of sand in a foredune or, if the bluff is low enough, it can blow sand over the bluff and away from the shoreline. If a sand dune has been denuded of vegetation anywhere (e.g., a footpath or vehicle tracks) a "blowout" can begin which will expand ever larger until the whole dune begins to migrate landward.

Waves. The position of a bluff along a coastline is the result of many interacting systems along that coastline. The most important of the systems is the wave climate, as the waves are the dominant form of energy delivery. Thus, an understanding of the nature of the waves in a specific area is basic to an understanding of the shoreline dynamics (and, thus, the bluff recession) in that specific area. In the Great Lakes, the principal source of waves is the wind.

Wind blowing over a body of water, such as Lake Michigan, creates oscillatory waves. An oscillatory wave is one in which no significant mass transfer of water takes place, but in which energy, both kinetic and potential, is transferred in the direction of wave movement. The distance over the water surface that the wind blows is called the fetch. Usually the average depth of the water in the fetch has an influence on wave generation so that the quantity "effective fetch", which accounts for this water depth, is used. On the Great Lakes, the effective fetch is also a function of the wind direction so that fetch direction must also be considered. The longer the wind blows from a particular direction (i.e., the duration), the stronger the wind blows (i.e., the speed), or the greater the effective fetch the larger the wave heights will be[2].

Since wind speeds are generally not constant over time, the average wind speed over a specific short term duration (48 hours or less) is usually used to determine the wave size generated by a wind blowing from a specific direction and effective fetch.

Once the wave size has been calculated, the energy density (the average wave energy per unit surface area) can be calculated. The formula for energy density, $\bar{E}$ is

$$\bar{E} = \frac{wH^2}{8}$$

where

H = deepwater wave height (ft)

w = unit weight of the water (lbs/ft^3).

For fresh water w is assumed to be 62.4 lbs/ft^3 so that the formula now is

$$\bar{E} = 7.8\ H^2.$$

The significance of the energy density becomes apparent when considering the rate at which this energy is transmitted forward. This rate is called the wave energy flux, $\bar{P}$, and is simply the energy density times the wave velocity, C. That is,

$$\bar{P} = \bar{E} \cdot C$$

where

$$C = \frac{gT}{2\pi}$$

[2]Wave height is the vertical distance from crest to trough while wave amplitude is the distance from the still water level to the wave crest. Amplitude is not equal to half the wave height.

and

g = acceleration due to gravity (32.2 ft/sec^2)

T = wave period (sec).

The wave period, T, is the amount of time it takes for similar points on successive waves to pass the same spot (for example, for two wave crests to pass by). The period is also a function of the wind and can be determined from the SMB curves.

The energy flux is used to determine the erosive power of the waves on the shoreline, the rate at which sediment eroded from the shoreline is removed from the area, etc.

Once a wave moves out of its generating area the wave height begins to fall and the period begins to increase. Therefore, at some distance from the generating area the energy density and energy flux should both decay to zero. However, for most of the Great Lakes, and especially Lake Michigan, the waves cannot move far enough away from the generating winds to decay by any significant amount. Thus, generally wave decay on Lake Michigan is considered unimportant.

The fact that the waves do not decay has important consequences as they approach the shoreline. As the wave remains steep, that is the ratio of the wave height to wave length remains high, several shallow water effects occur. It should be noted here that wave length is a function of the wave period where L, the wave length, is

$$L = \frac{gT^2}{2\pi} = 5.12\ T^2$$

As a wave approaches a shoreline with a sloping bottom the wave will refract, shoal, and reflect. Waves rarely approach a shoreline directly, thus one part of the wave "feels" the bottom before another part. That is, as waves extend to some depth below the surface, they will slow down when the lowest part of the waves drag on the bottom. As the waves generally are not approaching the shoreline directly, but at some angle, one part of the wave begins to drag on the bottom (and so, slow down) before another part. This causes the wave to bend, or refract, so that it approaches the shoreline more directly. This refraction, then, tends to spread the wave energy along the wave front, that is, it "stretches," which lowers the energy density. This process is analagous to sunlight passing through a prism and producing a spectrum. The spectrum is simply a "stretching" of the light wave to produce the individual colors.

In addition, the wave height also changes as the wave enters shallower water. Initially the wave height decreases, the result of refraction, but as the front part of the wave is entering increasingly shallower water, it is dragging more and more on the bottom and, thus, is slowing down. However, as the back part of the wave has not reached as shallow water as the front, it is still traveling at a faster rate. Therefore, the back of the wave catches up to the front of the wave and, as the water cannot go down through the bottom, it piles up, or shoals. Thus, the wave height increases and the energy density increases. This situation is analogous to a train where the engine suddenly slows down, or stops, and the trailing cars pile up. As the wave is slowing down due to drag on the bottom one would expect that the energy flux would decrease. However, although the front waves are slowing down the lakeward waves are catching up so that period is conserved. That is, the same number of waves will pass a given point in the same amount of time. This is accomplished by shortening the distance between waves the same way that any individual wave length shortens and causes the wave to shoal.

Now, just as the cars of the hypothetical train will derail, the wave will break, that is, spill over. As a rough rule-of-thumb, breaking will first occur in a depth of water equal to about three-quarters the wave height. Thus, the greater the wave height, the farther from shore it will first break. The oscillatory wave has now become a translatory wave in that water mass is now carried forward as well as energy. After the wave breaks it will reform and continue toward shore. However, each time the wave breaks considerable energy is lost and dissipated through mechanisms that are not well understood so that the wave reforms at only about half of its pre-breaking height. These processes of shoaling, breaking, and reforming continue until the wave reaches the shoreline.

When the wave reaches the shoreline its energy is sent in many directions. The principal direction is back out into the lake at an angle equal to the angle it made with the shoreline when coming in. This "reflected" wave interacts with the incoming waves to increase the height of some waves and reduce the height of others, a process that only confuses the energy density picture even more.

Currents. Currents in the Lincoln Township area are variable. Inshore they appear to take a generally northward set during the summer (altnough tiey are southward offshore) and southward set during the winter in response to the prevailing winds, although reversals are frequent and a recent study (Monahan and Pilgrim, 1975) has shown that in this area of Lake Michigan the coastal current pattern is not very clear.

As the process of wave refraction is rarely complete the wave does reach the shoreline at an angle. This wave travel can be thought of as an arrow pointing in the direction toward which the wave is moving. This arrow can be divided into two components that are at right angles to one another. One arrow points directly at the shoreline while the other points parallel to the shoreline. The component of the wave that corresponds to the onshore arrow does the eroding, while the component parallel to shore creates a current called the longshore current or littoral current.

Onshore/offshore currents also occur as the waves move toward the beach. The offshore in the vicinity of Lincoln Township contains sandbars and the innermost bar has an interesting effect on the onshore/offshore currents. As water moves offshore from the beach it is blocked by the sandbar and so it moves along the shoreline until it can breach the bar creating a "rip current". The intensity of these rip currents can sometimes be quite high and can carry significant amounts of material offshore.

Ice. Ice is very important to coastal processes because it can have two opposing effects. Wave heights are materially reduced within an ice field along the shoreline (which exists from mid-January to late March during a normal winter along the Lincoln Township shoreline) and during the period of consolidated ice cover, wave action is effectively eliminated. However, the action of ice can accelerate erosion processes. As the ice is pushed onto the beach, it tends to loosen the beach and bluff material. In addition, there is some loosening of bluff material by freezing interstitial water (i.e., in the spaces between grains of sand or particles of silt and clay). Some sediment impregnated in the ice at the shore and over the longshore bars may be carried elsewhere if the ice drifts away during the spring thaw. More importantly, because the bluffs are weakened by ice action during the winter, erosion probably occurs in a spectacular manner with the first major storm in the spring (Berg and Collinson, 1976).

Lake Level Variations. Basically, there are three major components contributing to level fluctuations on Lake Michigan: 1) rainfall and evaporation in the Lake Michigan-Huron basin, 2) the amount and rate of flow from Lake Superior, and 3) short-term fluctuations discussed above.

Hence, only mean monthly water levels and longer term variations are of interest (see Appendix B). The Chicago Diversion Canal has a negligible effect on lake levels while increased dredging in the St. Clair and Detroit rivers prior to 1964 has reduced extreme high levels as much as 0.59 feet (USCOE, 1973). Although many people believe lake levels rise and fall on a regular basis, no dominant cycle period has yet been established (other than the seasonal cycle).

Seibel (1972) and, more recently, Birkemeier (1979, draft) have established a lake level dependence of erosion rates. Although an exact relationship has not been determined, few would argue that the higher the lake level the higher the bluff erosion rate.

Littoral Processes. Littoral processes refer to those coastal processes occurring within the surf zone. It is important to understand these littoral processes in order to assess the potential effects of shore protection structures.

Three time scales of shoreline evolution can be distinguished: 1) the geological evolution over centuries, 2) the long term evolution from year to year, and 3) the short term evolution from season to season or during a major storm. For this report, the long-term evolution is of primary importance with the short term evolution appearing as a perturbation on the general beach configuration.

Four phenomena make up the action that waves have on shoreline evolution: 1) longhsore transport or littoral drift, 2) depletion by sea vs. accretion by swell, 3) lake level change, and 4) shore protection structures. The first three are discussed below and the fourth is discussed in the next section.

It is the littoral current that carries away the eroded material. The material that is transported along the shoreline by the littoral current is called the littoral drift and the quantity of littoral drift moved in a unit of time is called the littoral drift rate. The littoral drift rate is a function of the type of material, its grain size and specific gravity, the amount of material available for transport, the amount already in transport, and the amount of energy reaching the shoreline.

Normally, the material that comprises the littoral drift comes from a number of sources. These sources include rivers, nearshore sediments (which are suspended by turbulence created by the breaking waves), and local erosion. Additional sources include the wind and man's activities. The rivers that empty into Lake Michigan do not supply significant quantities of material to the littoral system and are, therefore, generally neglected. The most important contributor of material to the littoral system is local erosion. Littoral drift is transported as bed load or suspended load. Bed load transport is either rolled and skipped along the bottom or moved across the beach face in a zig-zag pattern in the direction of the littoral current, i.e., downdrift. As this direction is a function of the direction of the incoming waves, it is different depending that wave direction. Thus, the direction of longshore transport, or littoral drift, can reverse so that it will flow north some of the time and south some of the time. Generally, the winds have a predominant direction over long periods of time so that there will be a net movement of material in one direction over a long period of time. Bed load can be interrupted in its flow downdrift by natural obstacles (such as river discharge) or man-made obstacles (such as a groin or jetty). As the amount of material the littoral current can carry is a function of the amount of material already in transport, among other factors, an interruption of the littoral drift means that the current downdrift can carry more material. As local erosion is the most important source of material in the Great Lakes, the fact that the downdrift current can carry more material usually means that erosion is increased locally.

Suspended load is that material suspended in the water column. This material is usually of silt and clay size. Suspended load transport ceases as the water column loses turbulence (loses energy) and the particles settle out. As turbulence takes a long time to decay to the point where silts and clays can settle (even then, these materials take a long time to settle) the Great Lakes almost never reaches a point of no turbulence. Thus, the particles may take hundreds of years to settle to the bottom and stay there. However, as suspended load rarely affects the capacity of the littoral currents (their ability to carry a certain quantity of material) the basic function of suspended load is simply to transfer the finer materials to deep water.

It should be obvious that a great deal of beach material in the nearshore zone is in constant motion. The beach that is here today may be the beach a half-mile away tomorrow. The quantity of material moved, and how far it is moved, is a function of the energy density and energy flux. Thus, more material may be moved during one or two intense storms than during the rest of the year. Bluffs erode when the shoreline material is carried away. If no material is available for replacement from the updrift area, the offshore material is carried away as well. Thus, the water becomes deeper nearer to shore. This allows the waves to approach closer to shore before breaking. Therefore, they break less often, lose less energy in the breaking process, and expend more energy on the shoreline, thereby increasing erosion. This also means that there is more energy for the littoral currents to use to carry away material and so the eroded material is removed at a faster rate.

There is ample evidence indicating that beach erosion occurs when the wave steepness is large whereas beach accretion occurs when the wave steepness is small. The offshore motion of sand can be attributed to sea, i.e., waves generated by local wind; while onshore motion can be attributed to swell, i.e., waves generated at a great distance form the shoreline and which travel out of the wave generating area.

Beach erosion is enhanced by the wind effects on the mass transport in the wave (see Figure 3.1-1). A local onshore wind tends to push the surface mass of water toward the coast causing a return flow near the bed taking material away from the beach.

In the Great Lakes, either there is little or no wind or else the fetch is so short that only the sea condition exists. Since the sea condition predominates beach depletion tends to prevail over beach accretion. Therefore, a steady amount of erosion occurs under natural processes. The rate of loss of sediment is proportional to the wave energy arriving on the shoreline as well as a function of the characteristics of the coastal material.

Under sustained constant conditions, a beach profile would adjust to an equilibrium profile. Such a beach is generally concave upward (see Figure 3.1-2). For a concave beach a rise in lake level causes the apparent beach slope to steepen (see Figure 3.1-2a). On the other hand, if the lake level recedes, the apparent beach slope tends to be flattened (see Figure 3.1-2b). The subsequent readjustment of the beach slope requires the beach face to be displaced vertically along with lake level. Since this effect would require an accumulation of material on the beach the material would have to come from bluff erosion. Therefore, the beach face is displaced not only vertically, but also horizontally shoreward. If lake level recedes, a new berm would be built to cause an advance of the shoreline toward the lake and eventually the wind could reform sand dunes.

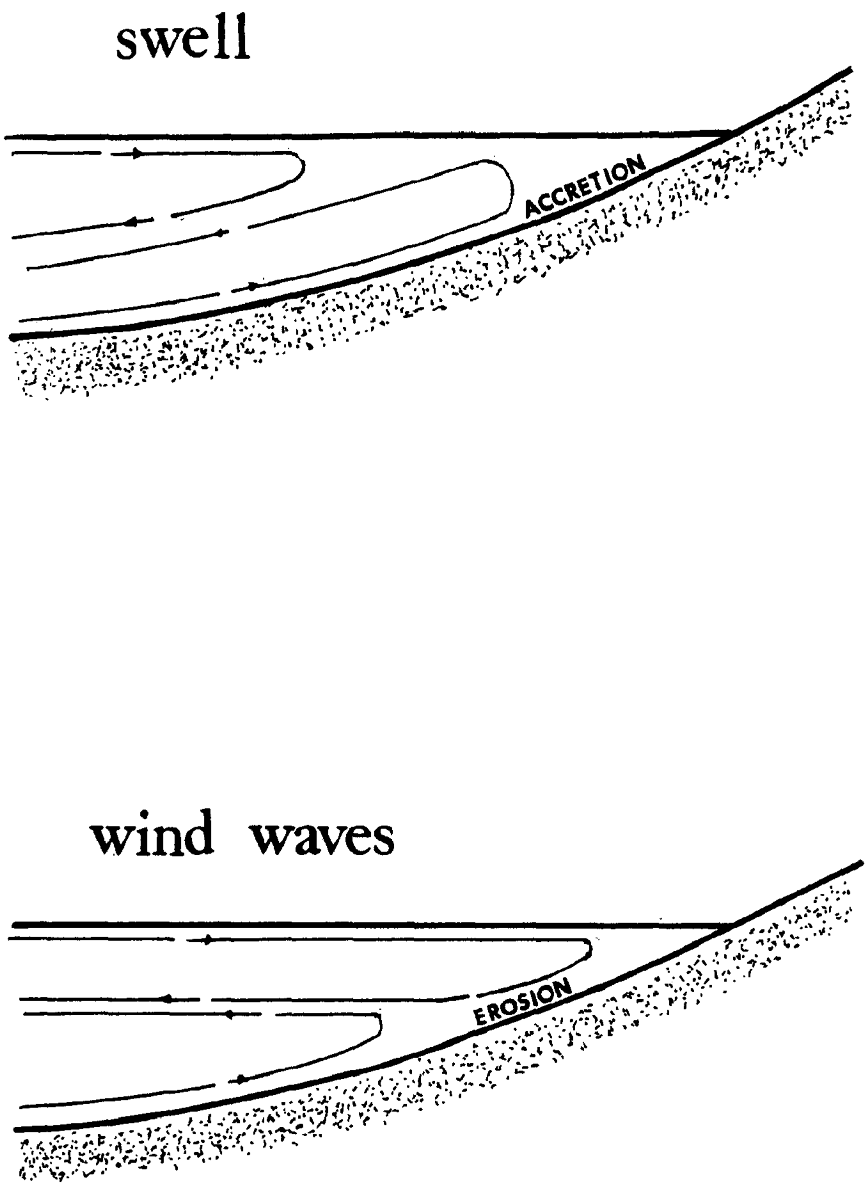
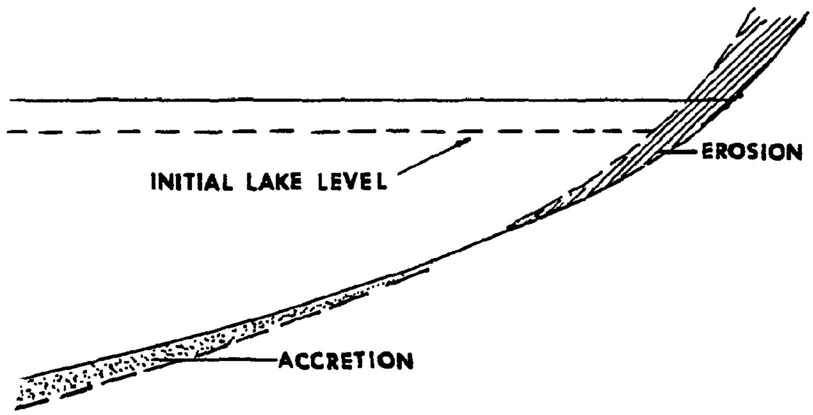
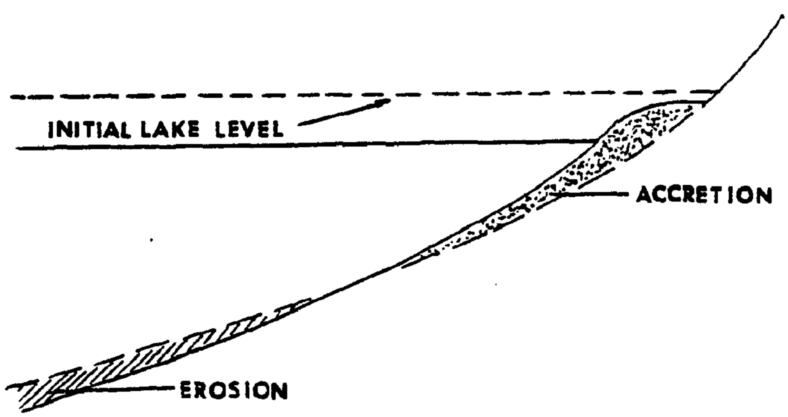


Figure 3.1-1. Enhanced beach erosion and accretion caused by wind/wave effects on the mass transport of sand.



A) lake level rise



B) lake level fall

Figure 3.1-2. Effects of lake level rise and fall on beach profile shape and slope.

In summary, it is obvious that coastal processes are really a complicated set of factors and forces which dynamically interact to produce a series of effects. Many of these interactions are poorly understood currently, particularly in the Great Lakes, but any coastal engineer designing an SPS must consider them if he/she is to produce an effective structure. However, perhaps the most important factor is waves, and so the engineer's first job is to try to get a good understanding of the wave climate applicable to the coastal area involved.

3.1.2. General Design Considerations

There are four basic coastal engineering problems defined by the U.S. Army Coastal Engineering Research Center (CERC, 1977): 1) shoreline stabilization, 2) backshore protection, 3) inlet stabilization, and 4) harbor protection. The problem set forth in this study, a community erosion protection system (CEPS) at Lincoln Township, deals with the first two of these problems. Nonstructural solutions (beach nourishment, vegetation, land use control, etc.) are possible, but they may be either politically difficult or insufficient in and of themselves to provide a meaningful solution for existing property owners. Proper coastal management is the best tool for the prevention of future problems, and Lincoln Township has an excellent record in this area (see Section 2.3.), but it does not solve the immediate problem. Thus, structural solutions must be examined.

There are several types of structural solutions available and these are considered in the next section. However, in this section the general considerations applicable to any structure are set forth. The details and application of the considerations are discussed in the following section and Appendix B.

There are six basic considerations for an SPS: 1) hydraulics, 2) sedimentation, 3) control structure, 4) legal, 5) environmental, and 6) economic.

The legal, environmental, and economic considerations are discussed elsewhere in the report and will not be pursued here. However, the first three considerations are appropriate and are discussed below. Most of the discussion presented in this section is based on the Shore Protection Manual (CERC, 1977) and Kureth (1976).

Hydraulic considerations include wind, waves, currents, storm surge, and basic bathymetry. Sedimentation considerations include the littoral material and processes. Control structure considerations include selection of the SPS evaluating type, use, and effectiveness. Any SPS can impact adjacent shorelines and so any considerations must involve methods to reduce these impacts.

For the purposes of this study, the wave hindcast based on wind data was considered unnecessary and the analysis proceeded directly to calculation of the "design wave". Hindcast information was available in a U.S. Army Waterways Experiment Station report published in 1976. The "design wave" or "significant" wave is defined as that particular wave which represents the significant design forces. See Appendix B for details in the calculation of the design wave, but the result was that wave that would return once in 20 years (referred to as the 20-year wave) from the northwest and is 18.7 feet high with a period of 10.5 seconds. Obviously, the wave would not be this large at the shoreline and so, represents deepwater conditions. It does provide the starting point for calculations to determine its characteristics in the surf zone. The results showed that this wave would be 16 feet high when it first breaks in 18 feet of water and would be about 7.6 feet high about 400 feet from shore (see Appendix B).

The design water level was chosen as the lake level likely to occur once in 10 years (the 10-year level) and includes the long-term lake level plus the one year short-term rise (the storm surge likely to occur once in a year). This level is 581.1 feet above the IGLD (1955) or 4.3 feet above chart datum. The combination of the 10-year level and 20-year wave represents the 200 year event, which is a standard parameter used by the U.S. Army Corps of Engineers in the Great Lakes. The 200 year event could also be the combination of the 10 year wave and the 20 year level, but it was felt that the 20 year wave would be more conservative. A more complete analysis is necessary during formal design to determine if this decision were correct.

For this study it was assumed that the offshore topography (bathymetry) could be represented by straight and parallel contours. This is not strictly the case so that, for formal design, this assumption should not be made (see Appendix B).

A separate littoral drift rate analysis was considered outside the scope of this report as several publications (e.g., USCOE, 1973; Birkemeier, 1979) cite a rate of 100,000 to 110,000 cubic yards per year in the St. Joseph area. Because there are several methodologies available for calculating littoral drift rates (e.g., USCOE, 1973, 1976, and 1977; Bajorunas, 1961 and 1970; Komar, 1976; and others) it may be beneficial to conduct an analysis of littoral drift rates during formal design, should that occur. The cited figure was used for this study.

The grain-size distribution of the sand along this shoreline is in the fine to medium sand size range. During the calculations for fill along this shoreline, samples should be taken so that the fill can either be matched or the quantity of overfill[3] can be calculated. Grain-size distribution and specific gravity analyses of these samples are required as the stability and loss rate of the fill are functions of these parameters as well as the littoral drift rate. For the purposes of this analysis, it was assumed that the fill material exactly matches the native (or existing) sand. Any changes in this assumption could affect costs of the alternatives, but should not affect relative comparisons. Control structure considerations follow. Further design considerations are found in Appendix B.

3.1.3. Shore Protection System Considerations

Shore protection systems (SPS) can be broken down into two basic types, both with onshore and offshore versions: shore parallel and shore perpendicular. Shore parallel types include seawalls, bulkheads, and revetments onshore and breakwaters offshore. Shore perpendicular types include groins, jetties, and detached breakwaters. For this study, one shore perpendicular, two shore parallel, and one hybrid were considered for further economic, legal, and environmental consideration. This section discusses the engineering aspects of these types in general and then discusses the selected structures in more detail.

A seawall is a structure, usually vertical, separating land and water areas and is primarily designed to prevent erosion or other damage due to wave action. A bulkhead is a structure or partition to retain or prevent sliding of the land. A secondary purpose is to protect the upland against damage from wave action. A revetment is a facing of stone, concrete, or etc., built to protect a scarp, embankment, or shore structure against

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[3]Overfill is that extra quantity of sand required to obtain the same long term effects as would be provided by the natural beach sand.

wave action or currents. These structures are generally used where there is a scant supply of littoral material and little or no protective beach, along a wharf or similar structure where a depth of water needs to be maintained, or where a shoreline needs to be preserved in an advanced position relative to adjacent areas.

These are considered together because their advantages and disadvantages are similar. There are three basic advantages to these structures:

- They provide positive protection
- They maintain the backshore in a fixed position
- They are relatively simple to construct

There are also three basic disadvantages:

- They are not effective in maintaining a beach
- They provide no protection to adjacent shores (and may cause or increase problems there) which will continue to erode and eventually expose flanks of the protected property
- They limit access to the beach

Planning criteria for these measures include determination of the overall shape of the structure, its location relative to the shoreline, height and length, construction materials and technique, and design of filter material.

Seawalls and bulkheads are usually constructed of wood or steel, but stone is occasionally used. When a wave strikes a seawall it does three things: it shoots up (and if there is a wind, over the top), it shoots down causing toe scour (necessitating toe protection), and it moves horizontally causing a current which carries away material scoured away from the toe. Although steel has a longer lifetime than wood, it has a tendency to accentuate these wave actions more than wood.

Revetments along a lake shoreline are best constructed of stone. The stone acts as a wave energy absorber and prevents this energy from attacking the bluff directly. However, wave runup (the vertical distance that a wave will carry above the water level) can cause a problem with overtopping, resulting in erosion behind the structure and eventual failure. Stone size is important and should be carefully designed (see Appendix B).

Offshore breakwaters are constructed parallel to shore to protect an area from wave action. They may serve as an aid to navigation (such as protection of a harbor entrance) or as a trap for littoral drift. These are almost always of rubblemound (stone) construction. An offshore breakwater acts as a littoral barrier by reducing the wave-driven littoral current so that the effectiveness as a littoral barrier is directly proportional to the breakwater's extent of wave attenuation. Offshore breakwaters in a series will have the same general effect as one long structure, but the effectiveness as a sand trap is reduced, which can be desirable. As sand is deposited behind the structure a lakeward projection forms which in turn begins to act as a groin,further increasing the effects. Over time the salient continues to grow lakeward until it attaches to the breakwater at which time it is called a tombolo and becomes a total littoral barrier. A breakwater in series probably would not create a complete tombolo so that it would not become a complete littoral barrier. Another way to achieve this effect is to reduce the height of the structure so that some wave energy goes over the top of the structure.

The largest single advantage of an offhsore breakwater is that it provides protection without impairing the usefulness of the protected beach, while a seondary advantage is that it provides a protected area for swimming. However, offshore breakwaters can be a severe littoral barrier and be expensive to build.

Perhaps the most common structure on the Great Lakes is the groin, yet its operation is poorly understood, a fact which is borne out by the limited and spotty success they have had in the Great Lakes. A groin is a narrow structure of wood, stone, steel, stone-filled wire-mesh baskets (gabions), sandbags, nylon tubes (Longard tubes), etc. generally constructed perpendicular to the shoreline for the purpose of trapping littoral drift to build a beach. Sometimes the groin is initially artificially filled with material to provide immediate protection. The intent is to move the shoreline lakeward so that waves break and swash farther from the bluff. Groins are desirable for several reasons:

- The resulting beach provides protection to upland areas as well as a potential recreation area.
- Their effect may spread over shoreline distances several times their length.
- As less structure per front foot is required, groins are often less expensive on a unit cost basis than many other structures

There are also several drawbacks to their use:

- Groins are not as effective as a seawall or revetment for continuous upland protection.
- They may be outflanked.
- They are ineffective in areas of low littoral drift unless periodically nourished.
- They can adversely affect adjacent downdrift properties.

Planning criteria include the need to determine the quantity of littoral drift in the problem area as well as groin dimensions and spacing, the need to determine initial artificial fill requirements (if any) as well as periodic maintenance (which in turn requires knowledge of the onshore/offshore transport), and the need to determine potential downdrift effects. Groin spacing is a critical parameter because if they are too close together wave activity will increase between them reducing their beach-building capability or if they are too far apart the resultant beach may not cover the entire reach between them. A good guide for spacing is 2-4 times the groin length (see Appendix B for further dimension design criteria).

A hybrid structure considered during this study is the headland park (H.P.). This structure requires the construction of a jetty, park fill "inside" (or downdrift) of the jetty, and beach fill "outside" (or updrift). This structure would be expected to act like a large groin in its operation thereby providing the same advantages and disadvantages as a groin with the added concern of the jetty stone size requirements. An added advantage is the creation of a new onshore recreational area which will allow greater access to the water. An added disadvantage is the increased potential for damage downdrift.

The discussion above was intended to present the various structure types in general terms. Below the discussion focuses on four alternatives, one onshore shore-parallel structure (rubblemound revetment), one offshore shore-parallel (rubblemound offshore breakwater), one onshore shore-perpendicular (timber groin), and one hybrid (headland park). It is beyond the scope of this study to focus on only one structure as the detailed analysis required for such a decision requires the next level of effort. Rather this study is an attempt to identify the range of potential problems of a CEPS and this objective requires the consideration of several shore protection structure types. Thus, the four SPS's discussed below do not necessarily constitute an implied or indirect recommendation. They are considered most likely to raise the largest number of considerations, however.

The Rubblemound Revetment. The specific design calculations for this structure (as well as the others) are presented in Appendix B and will not be repeated here; rather, a summary of the results is presented. See Fig. 3.1-3 for a cross-sectional view.

Several disadvantages of these structures have been mentioned previously and an attempt to address them became part of the design process (see Appendix B). In terms of limiting access to the beach, this should not be too serious as the height requirements are not severe and it should be possible to construct a stairway over the structure. In terms of beach protection a small (16,000 c.y.) beach is included. Although this beach may need to be replaced as often as every two to three years(depending on storm and lake level conditions) it will serve two very important purposes: protect the revetment and provide a supply of sand for downdrift properties. A more detailed analysis may indicate that a larger beach is more cost effective, but it is not considered prudent to have a smaller beach.

In terms of protecting the revetment, the beach should function well until sufficiently eroded. However, the revetment has been designed to withstand breaking wave attack in order to provide time for beach replacement with minimal maintenance on the revetment. A detailed analysis may be required to determine the proper balance between revetment maintenance and beach nourishment.

The most important function of the beach is a source of sand for downdrift areas. A shore parallel structure can affect downdrift properties by denying a local source of supply. A local source of sand can be important to local coastal processes in terms of littoral drift and a denial of that source can cause damage to adjacent properties. Thus, a beach lakeward of the revetment is necessary.

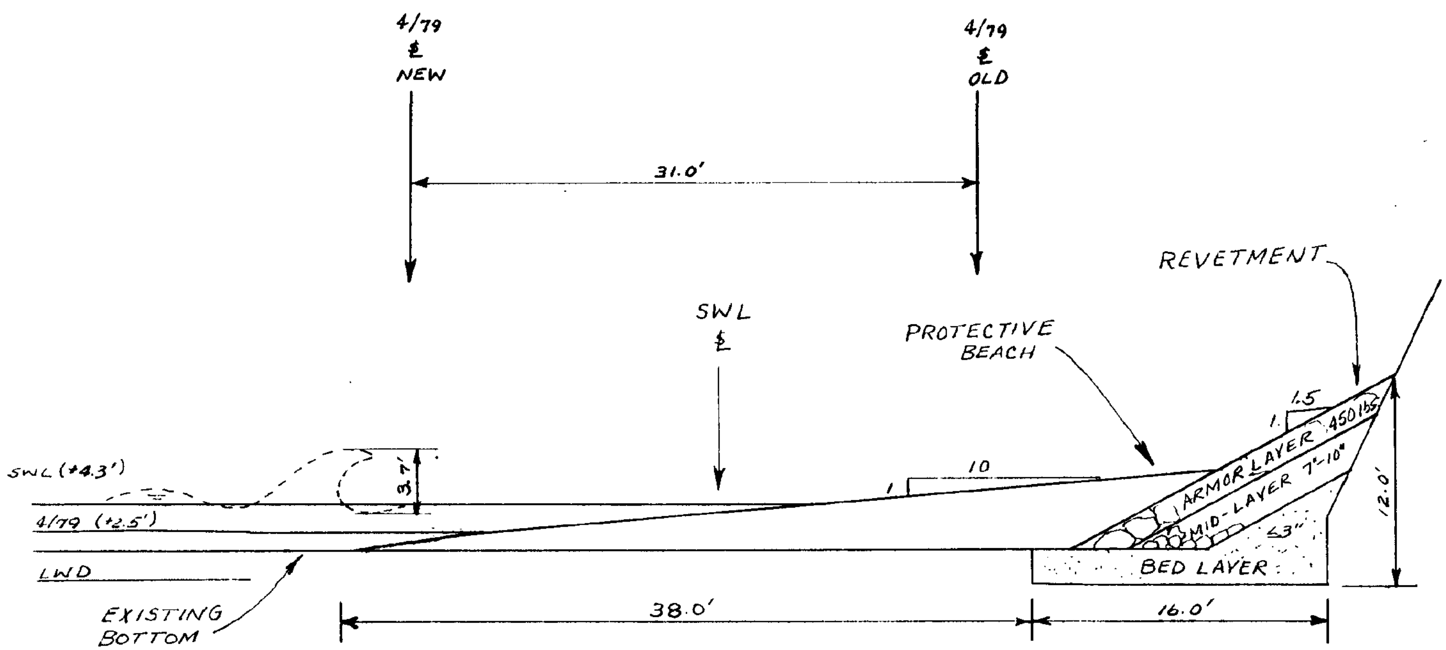

Figure 3.1-3. Preliminary engineering design for stone revetment.

The result of preliminary design calculations is presented in the following table and Figure 3.1-3.

Table 3.1-1

Material Requirements for the Revetment

Option

Material	Size	Quantity/ft	Total Quantity
Armor Stone	450 lbs	0.91cy	5,500 cy
Midlayer	7-10 in	0.89cy	5,400 cy
Bed Layer	$\leq$3 in	1.6 cy	9,700 cy
Sand	---	2.7 cy	16,000 cy

The Offshore Breakwater. As a shoreline protection method the offshore breakwater has had only limited application due to the fact that it is generally too expensive to construct. However, recently a modified version of the offshore breakwater was built at Presque Isle, Pennsylvania and has seen some limited success to date (Charles Johnson, USCOE, personal communication, 1979). At Presque Isle, the concept is basically a breakwater in series (as discussed earlier), but instead of a large offshore structure it was built in very shallow water (about 4 feet) and so it is quite small. A variety of spacings were tried in order to determine the proper spacing. Preliminary results indicate that the spacing is a function of the grain-size of the beach being protected. Generally, the smaller the grain-size the narrower the spacing.

As mentioned above, offshore breakwaters can be the most effective means of shore protection in that they can become a total littoral barrier. However, a total barrier to littoral drift would be very undesirable along the study reach because of the potential for damage downdrift. Thus, several design items were incorporated in order to facilitate beach build-up and shore protection while minimizing the littoral barrier effects. With respect to the structure itself, it was decided to build several short sections of 100 feet spaced about 200 feet apart with low elevations to allow some wave overtopping. This should allow sufficient wave energy to pass causing some littoral movement, yet enough wave energy would be blocked to reduce substantially erosion of the beach and bluff. An artificial beach has been designed for this structure (44,400 cubic yards) so that there is immediate protection for the bluffs and beaches (depending on the littoral drift rate, beach build-up could take years) and to allow proper littoral processes to occur thereby minimizing the impact on downdrift properties.

The design details are found in Appendix B. Figures 3.1-4, 3.1-5 and Table 3.1-2 summarize the results here.

Table 3.1-2

Material Requirements for the Offshore Breakwater Option

Material	Size	Quantity per Structure	Quantity
Armor Stone	1.9 tons	500 cy	9,000 cy
Midlayer	6-12 in	324 cy	4,832 cy
Bed Layer	$\leq$3 in	254 cy	4,572 cy
Sand	___	2,200 cy	44,400 cy

A note of caution: this application of the offshore breakwater is very new and is still experimental. Much work needs to be done in order to determine proper engineering criteria. Thus, application of this option must be very carefully considered. Also, it is recommended that the beach material used for nourishment be either very closely matched or more stable than the native

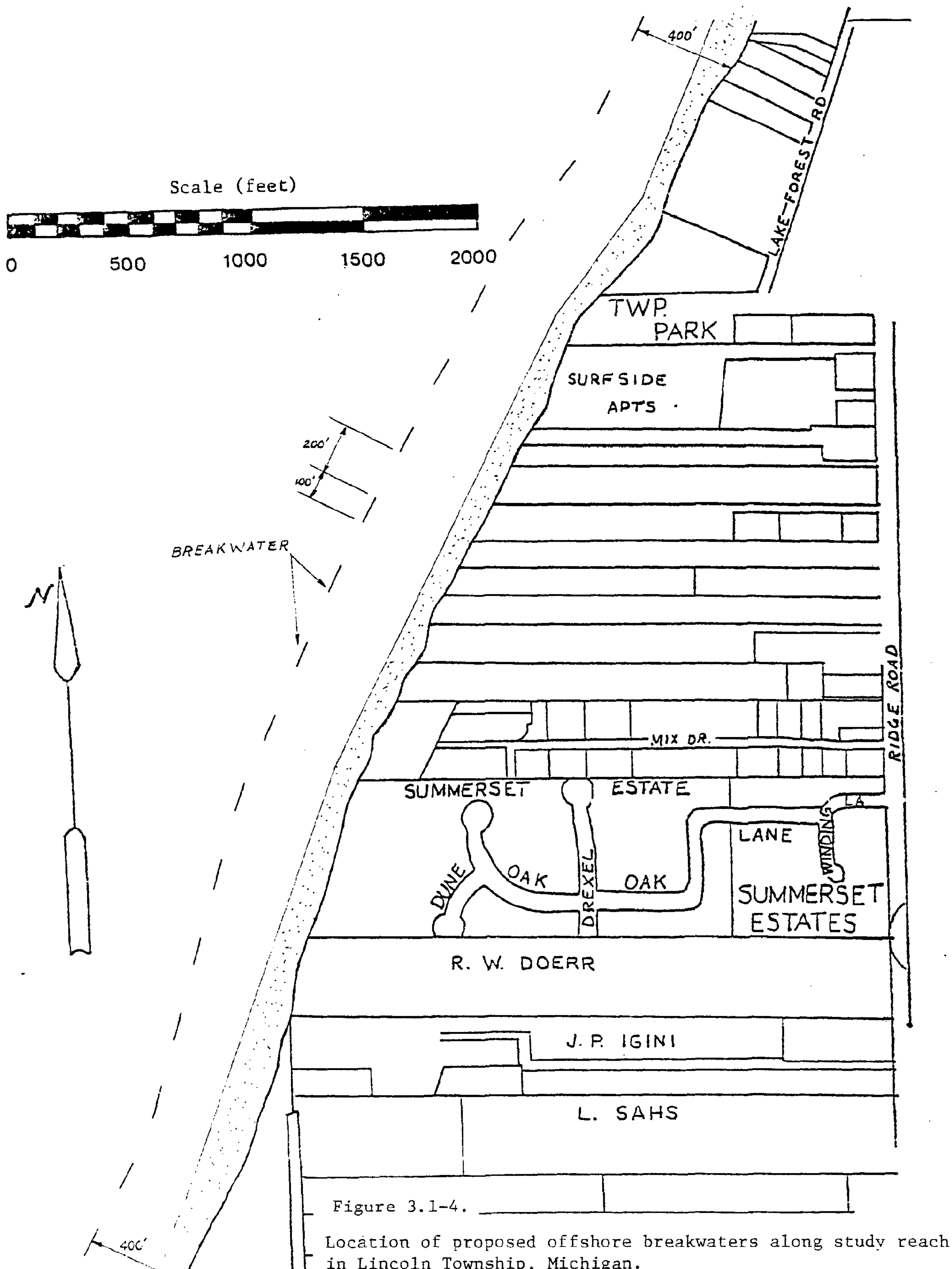

Figure 3.1-4.

Location of proposed offshore breakwaters along study reach in Lincoln Township, Michigan.

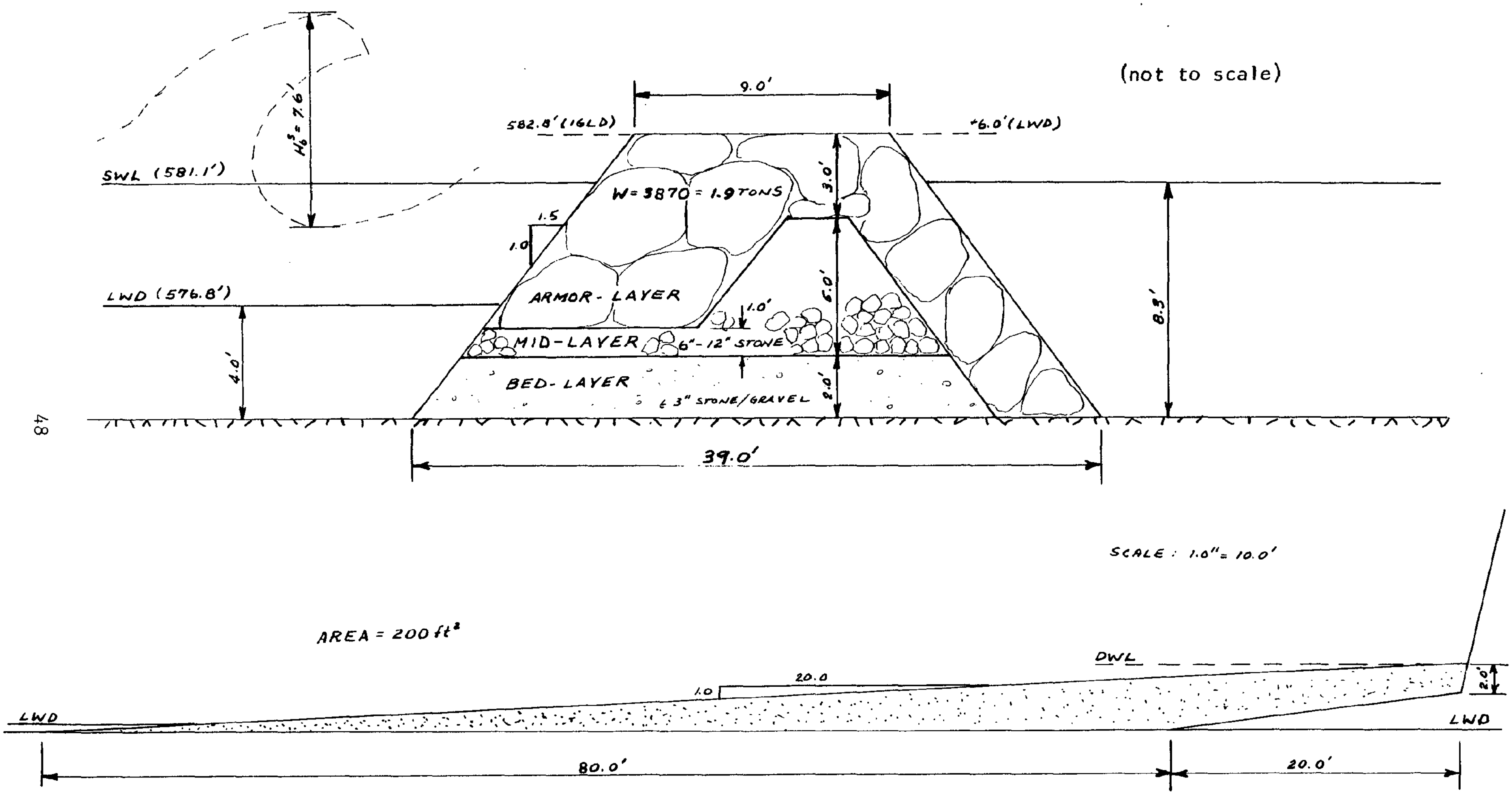

Figure 3.1-5. Preliminary engineering design for offshore breakwater.

sand. See SPM, volume II for details.

Groins. Groins are the most familiar shore protection structure in the Great Lakes. They have been constructed of a variety of materials including stone, gabions, timber, steel, sand bags, and Longard tubes. Unfortunately, the choice of material is rarely made properly considering local conditions. Indeed, it often appears that little consideration was given to the question as to whether or not a groin would even work at the particular location. As a result, groins often fail to do the job intended. There are several parameters to determine with respect to groins, including effective length, freeboard, depth, spacing, and the need for artificial nourishment. See Appendix B for the details of the considerations of these parameters.

Due to the spacing requirement (280 feet), 22 groins, each 141 feet long (from the toe of the bluff), will be required. This many groins at this length (effective length is 94 feet, see Appendix B) could have a substantial impact on littoral processes in the area by significantly interrupting the longshore transport of material. The actual severity of this problem is difficult to estimate as the actual littoral drift rate along this reach is unknown, but the problem is likely to be substantial. Also, a field examination of the study shoreline in April, 1979 indicated that the littoral drift rate could be well below the estimated 110,000 cubic yards per year. As a result, it could take years for these groins to build the protective fillets for which they were designed. Therefore, in light of the potential impact on littoral drift, and the time-frame for fillet build-up, it is strongly recommended that these groins be artificially filled with sand. Artificial nourishment of the groins will increase the initial construction maintenance costs of the groin field, but it will also increase its effectiveness while reducing its downdrift damage potential.

The detailed considerations of Appendix B are summarized here in Figures 3.1-6 and 3.1-7 and Table 3.1-3.

Table 3.1-3

Material Requirements for the Timber Groin Option

Material	Specifications	Quantity per Groin	Total Quantity
Timber Sheet Piling	2" x 8" (Wakefield)	55,692 BF*	1,225,224 BF
Timber Wales	8" x 10"	3,760 BF	82,720 BF
Timber Piles	12" dia.	2,398 LF	52,756 LF
Sand	---	4,595 CY	101,100 CY

* BF= board feet, LF= linear feet, CY= cubic yards

Timber was chosen as the construction material because studies have shown that despite the lower lifetime (and, therefore, the need to periodically rebuild) it is more cost-effective than steel and has better wave interaction characteristics. Sandbags rarely make good material for groins because they are subject to debris damage and vandalism and, even if grout filled, they tend to bury themselves in the sand. Gabions require lower wave energy conditions than exist along the study reach. Longard tubes are a possibility here, and may reduce construction costs. They have been used with moderate success in the Great Lakes and Europe (e.g., Belgium and Germany), but they require careful design and not many engineers are familiar with them. They have not been considered here due to a desire for brevity of this report.

The Headland Park Option. There are only two township parks in Lincoln Township on the shoreline. These parks are rather small and so use is limited. Therefore, there would appear to be a need for more shoreline park space. The idea of combining shore protection and parks is not new (Toronto

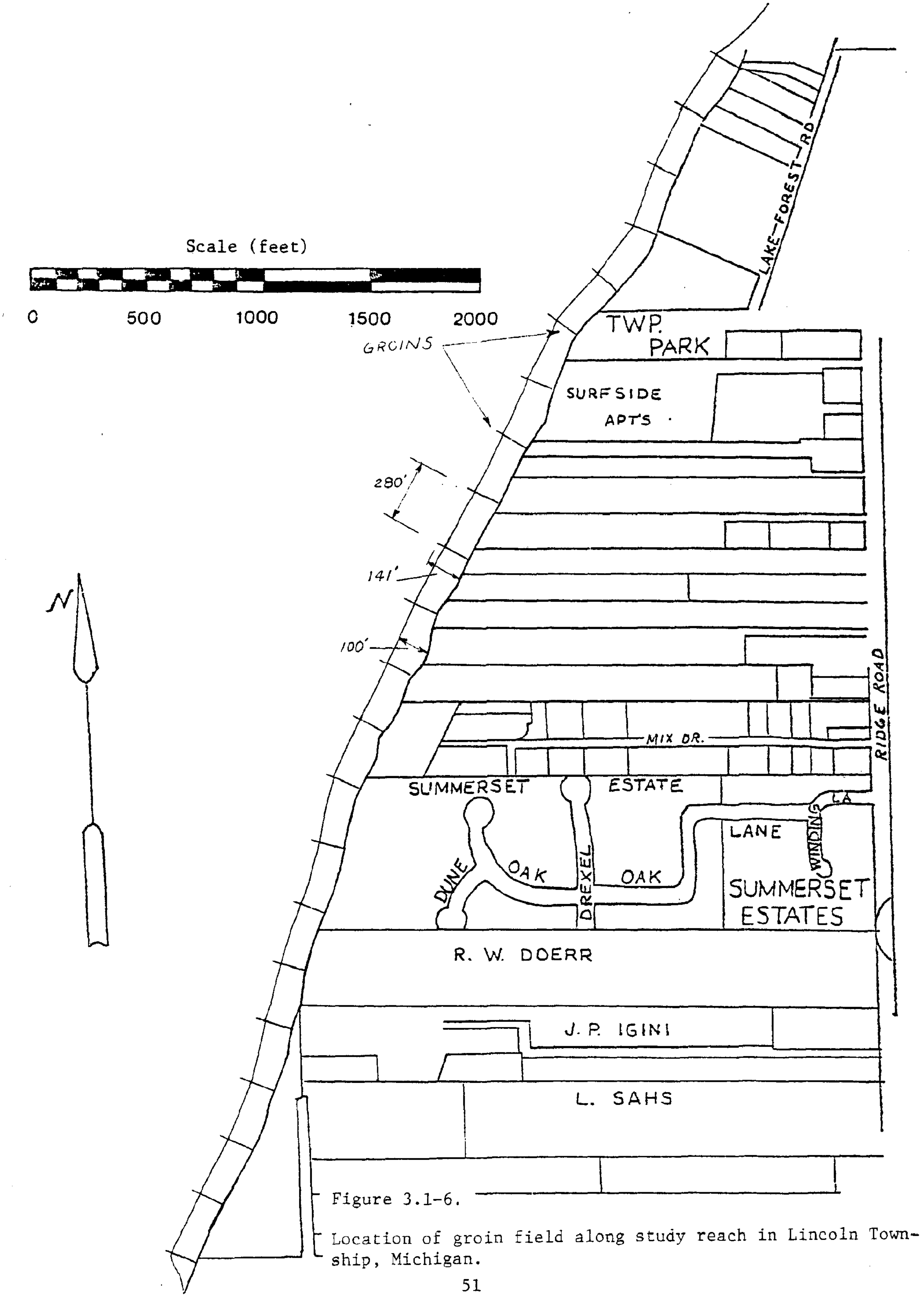

Figure 3.1-6.

Location of groin field along study reach in Lincoln Township, Michigan.

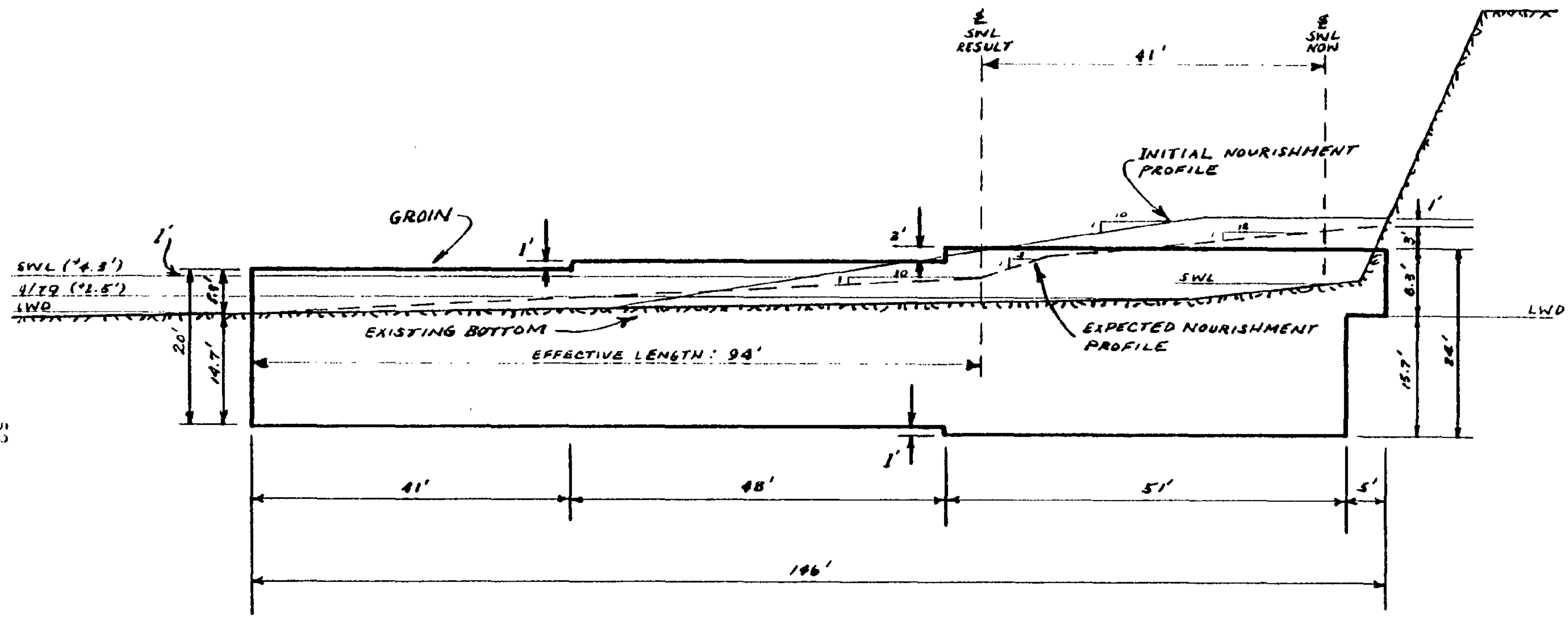

Figure 3.1-7. Proposed engineering design cross section of groin showing groin, existing beach profile, and expected beach profile after artificial nourishment.

has a large area of headland parks), but the application in the Great Lakes is limited (although the city of Chicago has explored this option).

As considered here, there would be two headlands spaced about 2400 feet apart and extending up to 400 feet offshore. Essentially, these structures would act as large groins 400 feet long and, thus, require similar considerations. The additional aspects include a crescentic jetty of radius equal to 400 feet and park fill. Also, 5 groins will be required downdrift of the southernmost headland park to protect that small section of the study reach.

The jetty would serve the purpose of protecting the park fill from wave attack while acting like a groin to protect updrift areas. Due to its crescentic nature it will have changing cross-sectional area and stone size requirements and this situation is represented by design parameters for three sections: A, B, and C. In order to promote immediate updrift protection and to hasten the development of littoral processes equilibrium, updrift fill is required.

The parkland fill slopes range from 1:75 to 1:190 so that grass and other vegetation should be feasible and desirable. These very low slopes should allow passive uses such as picnics as well as bathing and fishing. However, landscaping is not part of the cost considerations.

There are some obvious problems with this option that have not been solved. Parking needs would increase and this would require substantial upland area. The parking area should be properly drained to avoid bluff erosion due to runoff. Also, the southern headland park may not be politically feasible in that it is situated lakeward of only private property and so, security, access, and parking become very serious problems. However, as this section is intended to consider only the engineering aspects, the southern headland park is included to provide a better shore protection system. See Appendix B for further details.

Thus, Figures 3.1-8, 3.1-9, and 3.1-10 and Table 3.1-4 summarize the headland park option.

3.1.4. Summary and Conclusions

There are two basic types of shore protection devices: shore parallel and shore perpendicular. Any shore protection system will interact with the local coastal processes to produce both desirable and adverse effects. Thus, an understanding of these interactions is required for proper design.

General engineering considerations have been presented in this section and the calculations can be found in Appendix B. Four options are considered here: three options include one shore perpendicular type and two shore parallel types while the fourth is basically a shore perpendicular type with an added function -- creation of additional recreational areas.

Although no attempt has been made to recommend any one of these options as the SPS solely on engineering grounds, they have been designed considering local conditions so that each is considered applicable here. The main objective was to provide a variety of structures in order to allow a wider range of analysis of the feasibility of a CEPS.

One recommendation can be made, however. Prior to the decision to build a CEPS, if that should ever prove desirable, a more detailed engineering design process must be carried out. The level of detail discussed in this report was intended to provide sufficient information for cost estimates at the feasibility level and to illustrate concept requirements.

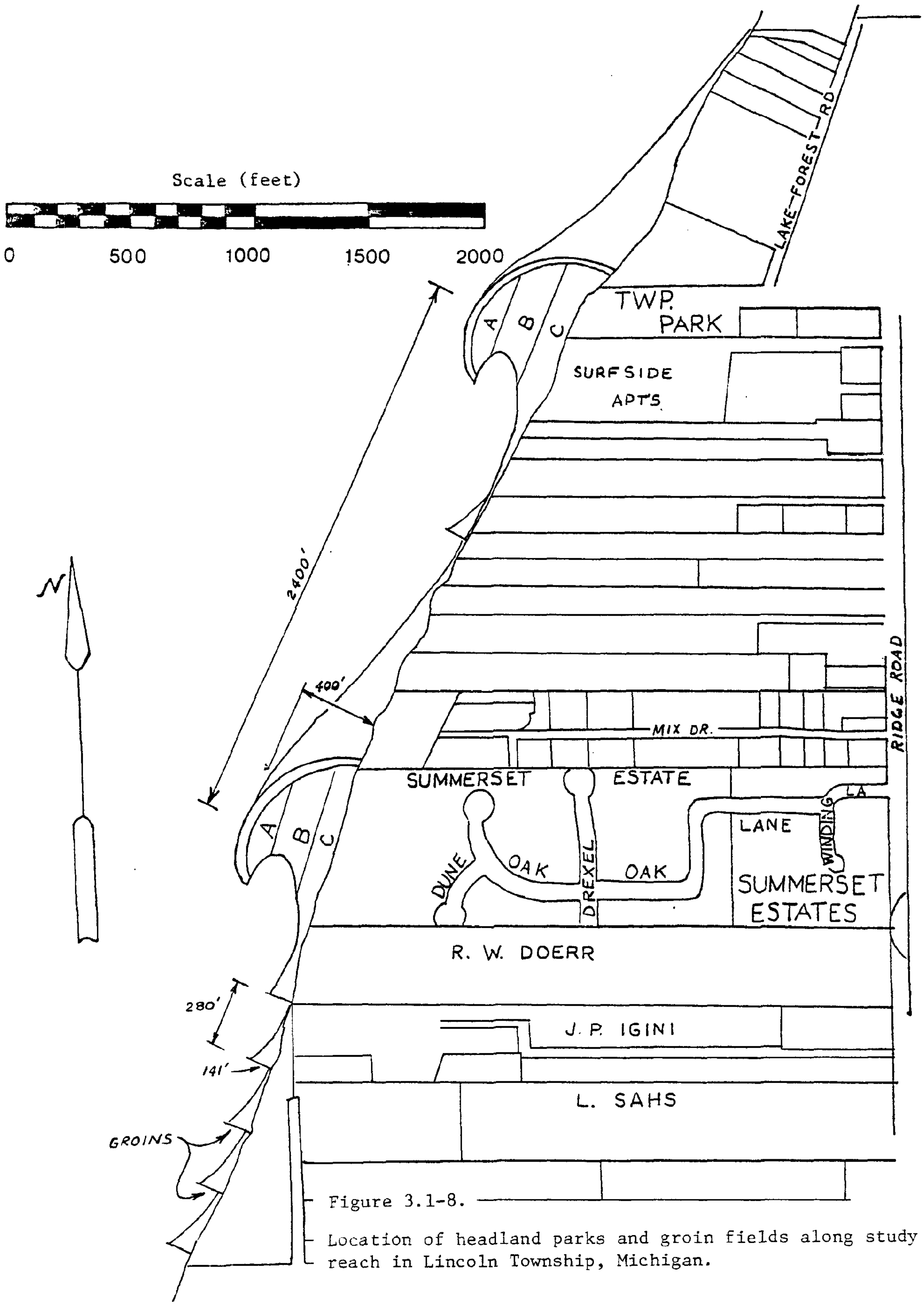

Figure 3.1-8.

Location of headland parks and groin fields along study reach in Lincoln Township, Michigan.

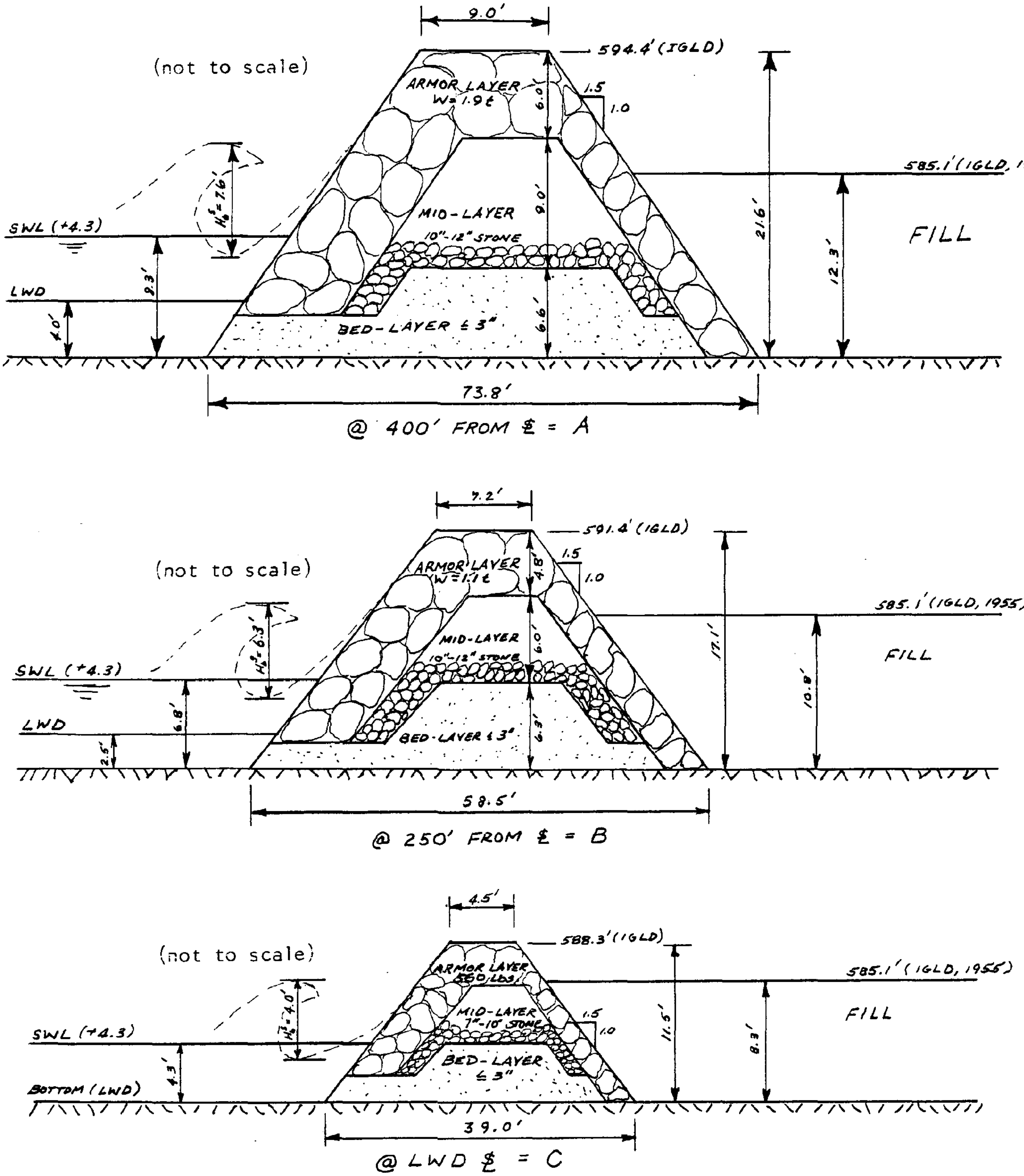

Figure 3.1-9. Proposed engineering design cross section of headland park through Sections A, B, and C, see Figure 3.1-8.

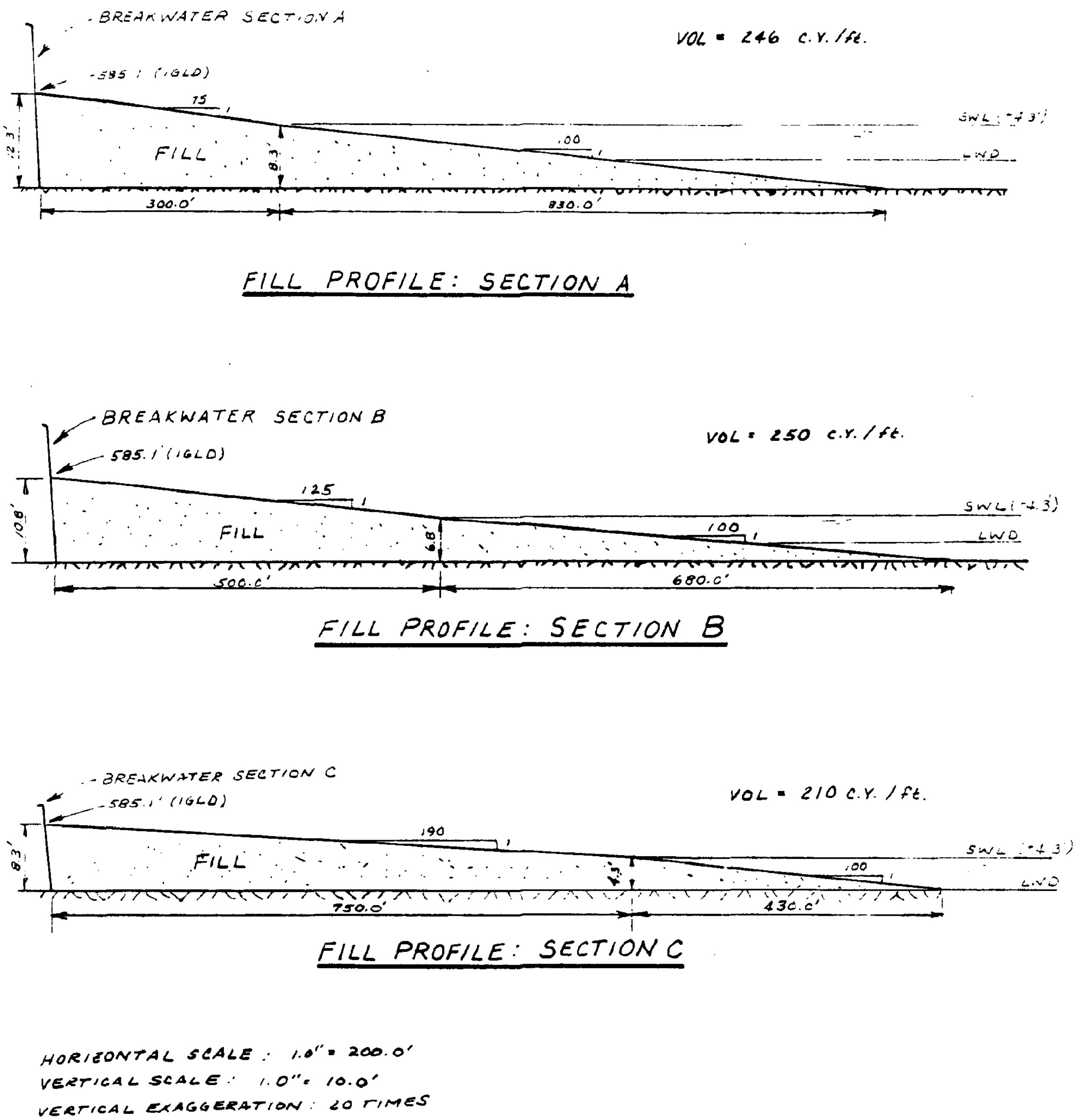

Figure 3.1-10. Proposed engineering design cross sections of headland park beach nourishment profiles for Sections A, B, and C. See Figure 3.1-8.

Table 3.1-4. Material Requirements for the Park Headlands Option.

Structure	Quantity per structure	Total quantity
Breakwater		
Section A		
Armor (1.9 tons)	9,028 C.Y.[a]	18,056 C.Y.
Midlayer (10"-12")	8,011 C.Y.	16,022 C.Y.
Bed layer (≤3")	8,580 C.Y.	17,160 C.Y.
Fill	24,600 C.Y.	49,200 C.Y.
Section B		
Armor (1.1 tons)	1,562 C.Y.	3,124 C.Y.
Midlayer (10"-12")	1,366 C.Y.	2,732 C.Y.
Bed layer (≤3")	1,647 C.Y.	3,294 C.Y.
Fill	37,500 C.Y.	75,000 C.Y.
Section C		
Armor (560 lbs)	427 C.Y.	854 C.Y.
Midlayer (7"-10")	373 C.Y.	746 C.Y.
Bed layer (≤3")	528 C.Y.	1,056 C.Y.
Fill	10,500 C.Y.	21,000 C.Y.
Groin		
Timber sheet piling (2" x 8" wakefield)	55,692 B.F.[a]	334,152 B.F.
Timber wales (8" x 10")	3,760 B.F.	22,560 B.F.
Timber piles (12"dia)	2,398 L.F.[a]	14,388 L.F.
Fill	4,600 C.Y.	27,600 C.Y.
Other fill	38,800 C.Y.	77,600 C.Y.

[a] C.Y. = cubic yards, B.F. = board feet, and L.F. = linear feet.

3.2. Legal Considerations

3.2.1. Legal Aspects

The impetus for the Community Erosion Protection System Analysis was Public Act No. 148 of 1976. The statute provides in part for "the construction, maintenance, repair or improvement of erosion control structures"[1] paid for initially by bonds issued by the township and ultimately through special assessments against the property benefited. Act 148 is an amendment to Act 188 of 1954 and Act 143 of 1974 and must be read in this context. The three acts together provide generally for public improvements by townships with not all sections being specifically applicable to the erosion control problem. The following is a general introduction to the provisions that directly effect our question.

> "Sec. 1. The township board shall have the power to make the hereinafter named improvements to provide for the payment thereof by the issuance of bonds as set forth in section 5 and to determine that the whole or any part of the cost of the improvements shall be defrayed by special asssesments against the property especially benefited thereby. The cost of engineering services, all expenses incident to the proceedings for the making of the improvements and the financing thereof, and not to exceed 1 year's interest on any bonds to be issued hereunder shall be deemed to be a part of the cost of the improvement."[2]

This section is important in that it gives authority for making the improvement and financing it to the township board. The board has the discretion to assess the entire cost or part of the cost to the benefited property. The cost includes engineering, administrative, and financing costs. This section does not provide any formula for calculating and apportioning the assessments, but leaves this to the board's discretion.

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[1] MCLA Sec. 41.722(h); MSA Sec. 5.2770(52) (h).

[2] MCLA Sec. 41.721; MSA Sec 5.2770(51).

Section 2[3] originally envisioned the construction of sewers, water mains, and public highways. In 1974 the maintenance and improvement of parks, the installation of foot bridges over highways, and the collection of garbage and rubbish was added. Bicycle paths and erosion control structures or dikes were first included under the 1976 amendments. In looking at the list several categories of improvements are apparent. Sewers, water mains, and garbage and rubbish collection benefit each property owner in a very direct and personal way. Highways, parks, foot bridges, and bicycle paths benefit the community as a whole, although not every property owner will use every park, foot bridge, bicycle path, or highway, nor use them to the same extent. The facilities are, however, equally available to the entire community and the individual's use of each is a matter of personal choice. Erosion control structures, in contrast, specifically benefit the protected shoreline properties. The township benefits only secondarily. If the property is not eroded as a result of protection, the township will not lose the property tax revenues from the affected properties. If the land does not disappear, the owner may improve the property and thereby increase the township's tax base. The members of the community do not benefit individually as there is no right to use the affected property unless it includes public land. The township board's assessment mechanism will have to vary accordingly.

Section 3(b)[4] gives the procedure for initiating action under the statute where the proposed improvement is an erosion control structure. If the township population is in excess of 5000, the township board may initiate the proposal, must notify by mail all land owners in the proposed assessment

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3 MCLA Sec. 41.722; MSA Sec 5.2770(52)

4 MCLA Sec. 41.723(b); MSA Sec. 5.2770(53) (b).

district whose names appear on the latest tax role. If record owners of more that 20% of the total land area in the assessment district file written objections to the proposed project, a petition signed by the record owners of at least 51% of the land in the final assessment district is necessary before the township board may proceed. The initiative for an erosion control structure can also arise by way of such a 51% petition. The reach of the shoreline to be protected will be described either in the petition or in the board resolution that intitiates the project. Water mains and sewers are included in sub-section (b) with erosion control structures or dikes. Highway improvement petitions require the signatures of record owners in a percentage not of total land area benefited, but of frontage on the highway improvements. The question of whether erosion control structures might more logically belong in this category will be discussed below.

Section 4[5] permits the township board either on the basis of a petition, if required, or on its own initiative to order plans by a registered engineer of the improvement, its location and the estimated cost. The plan and estimate are then filed by the board with the clerk and if the township board wishes to proceed, "it shall by resolution tentatively declare its intention to make the improvement and tentatively designate the special assessment districts against which the cost of the improvement or a designated part thereof is to be assessed."[6] A public hearing must be held, during which the petition, if required, the improvement, and the special assessment district are discussed. Notice must be published twice in a local newspaper and,

[5] MCLA Sec. 41.724; MSA Sec. 5.2770(54).

[6] ibid.

under the provisions of Section 4(a)[7], sent by first class mail to all owners or parties in interest, whose names appear on the latest ad valorum tax roles, at least 10 days prior to the hearing. If the township board changes the special assessment district to add property or increases the estimate of cost more than 10%, further notice must be given and the additional property owners must be provided with a hearing. If a petition was required and it is no longer sufficient because of the addition of property, a supplemental petition is necessary.

Under Section 5[8] if the township board still wants to go ahead with the improvement project after the plans have been received, it must pass a resolution to that effect approving the plan and estimate in their final form. The board must also determine that the petition, if required, contained the signatures of land owners of at least 51% of the land area in the special district. Any further challenge to the sufficiency of the petition must occur within 30 days from the board determination in the Circuit Court for the County in which the township is located. The board then finally establishes by resolution the special assessment district. The supervisor must then allocate the assessments against the land in the district, "which amounts shall be the relative portion of the whole sum to be levied against all parcels of land in the special assessment district."[9]

A further public hearing is required under Section 6[10], at which time the public may present objections to the assessment role. The assessment role

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[7] MCLA Sec. 41.724(a), MSA Sec. 5.2770(54) (a).

[8] MCLA Sec. 41.725, MSA Sec. 5.2770(55).

[9] ibid.

[10] MCLA Sec. 41.726; MSA Sec. 5.2770(56).

and notice of the hearing must be published twice in the local newspaper and the record owners must again be notified under the provision of Section 4(a).[11] The sufficiency of the petition can no longer be disputed; the issue for the hearing is the distribution of the total cost among the properties in the district. Where the improvement is either a water or sewer system, the cost is often allocated by dividing the total cost by the number of tie-ins to the water or sewer line. The distribution of cost according to the benefit received for an erosion control structure is considerably more complex and the issue will be discussed more fully below. Written objections to the assessments are to be filed with the clerk at or before the hearing or within a time period designated at the hearing. The board may confirm the assessment role or require the supervisor to revise or completely redo the role. Once confirmed by the board, the special assessment role can only be disputed in the Circuit Court for the county in which the township is located within 30 days of confirmation.

The remaining provisions of the statute are equally applicable to all improvements. They provide for collection of the assessments, the issuance and repayment of the bonds.

3.2.2. Land Area Benefited For Petition Drive

Where a petition is used to initiate an erosion control project or where a petition is required, the township board is not permitted to go ahead unless the petition is signed by the land owners of record of at least 51% of the assessment district.[1] One can ask why erosion control structures were placed in the same category, subsection (b), with water and sewer mains and not in subsection (a) with highway improvements. The need for sewer and water service is dependant upon the number of tie-ins needed and, therefore, the number of structures on the land. An undeveloped 10 acre parcel has the same potential for strucutres as 20 half acre lots each with one house. Signatures from the record owners of the 20 houses have the same weight as that of the owner of the undeveloped 10 acre piece. The land area is directly related to the benefit to be gained by the improvement. Benefited land area is a reasonable way of measuring approval or disapproval for purpose of a petition drive.

Highway improvements are different. They specifically benefit the land fronting on the highway, providing the owner or resident with potential access points. Although the whole parcel may benefit from having access to the public road system, the owner's options are directly related to the frontage on the improvement.

Erosion control structures and the land benefited thereby do not logically fit into one or the other category. An erosion structure protects the shoreline edge of the property. The longer the shoreline, the longer the protection structure must also be. There is a reasonable relationship between the lake frontage and the benefit from the improvement. The benefit of erosion control also accrues to the entire parcel. The value of the property will decrease or at least fail to increase depending on the bluff recession rate. As the bluff approaches the structure, if there is one located on the land, its value will decline and when the distance is sufficiently small, the building will become valueless (Armstrong and Denuyl, 1977). Value attaches to a parcel of land as a whole and it can be seriously effected by erosion. It is for this reason that the legislature chose to put erosion control structures under subsection (b) and not under subsection (a) (Sen. Harry Gast, 1979, pers. comm.)

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[1] MCLA Sec. 41.723(b).

[2] Then Rep. Harry Gast was instrumental in the introduction and passage of the P.A. 148 of 1976.

Where shoreline parcels of land are not uniform in size and shape, where the values differ considerably, and where erosion patterns vary locally a township may experience difficulty in mustering 51% support for a community erosion control structure. Owners with a severe problem and valuable property of whatever size will support the improvement, while owners of lower value parcels do not have as much at stake and may be reluctant to support the petition. Neither a front footage nor a land area measurement for the requisite majority will necessarily be a rational basis on which to approve or disapprove the improvement. This section of the statute is, therefore, vulnerable to constitutional attack as a denial of equal protection under the 14th Amendment to the U.S. Constitution and Article I Section 2 of the Michigan Constitution of 1963.

The legislative finding of a connection between land area and erosion control is probably sufficient for the statute to survive a court challenge.

3.2.3 Implementing the statute

The problems faced by a township wishing to implement the statue to provide for erosion control are well illustrated by comparing this improvement to the sewer system case. When a township board decides either as a result of a petition or on its own initiative to put in a sewer system, the board can hire an engineering firm to design the system and estimate the cost. The board can request bids for the job and receive a secure figure before proceeding.

Because sewer systems are common, the residents of the township will know, or can easily discover, approximately what the tie-in will cost - that it will be roughly $1000 per parcel, not $100 or $10,000. They will know their property values will increase by at least the $1000 to be invested and that on resale, they will, at the very least, break even and not lose by their investment. The sewer system has a long and predictable life span. The property owners will have all this informatin available before they choose either to sign or not to sign the petition.

The erosion control system, is however, very different. There is a wide variety of structures that can be chosen at prices that can easily vary between $100/front foot to $1000/front foot, whether the average life span of the structure is projected to be 5 years or 20 years, and whether or not later estimates will be reliable. Where the land owner knows a great deal about a sewer system from the outset, he is in no such position in regard to an erosion control structure. While it may be easy to get 20% opposition to the project, very few landowners will be willing to sign a petition initially pledging him or herself to an unknown future expense without considerably more information.

In order to have a reasoned public approval or disapproval of the project the township will need to hire an engineering firm to carry out a feasibility study prior to asking the record owners in the proposed assessment district to support the plan. Although the statute would allow this possibility, the chances of success are limited for several reasons. If there is no petition from 51% of the effected landowners, which as stated above is unlikely without considerably more information available, the initiative must come from the township board. While the board might easily initiate a project for a water or sewer system, for a highway improvement, for a park or bicycle path, all of which are projects that benefit the community as a whole, the board may be very unlikely for political reasons to support a project that will benefit only the owners of specific private shoreline property. Objections from the owners of 20% of the property in the proposed special assessment district are likely. In view of these possibilities implementation of the statute as it exists presently for erosion control purposes will be difficult.

The statue provides for the inclusion of the "cost of engineering services, (and) all expenses incident to the proceedings for the making of the improvement and the financing thereof, . . ."[1]. If the project is initiated, approved, and constructed, the engineering and other expenses will be part of the assessments. Here again the distinction between erosion control and other improvements is important. Should the township board decide after the engineering study not to proceed with a sewer system, the cost of the engineering services can be paid for by the township out of general revenues and ultimately by the community as a whole. Park maintenance and improvement, highways, footbridges, water mains, and bicycle paths would all benefit the community as a whole. Should the ideas for any of these improvements be rejected after funds have been expended studying the projects, the township as a whole can be asked to pick up the tab.

Erosion control structures are different. They do not benefit the township as a whole except very indirectly. If such a project were initiated, but then rejected after an engineering study, who should bear the expense incurred prior to rejection? The study specifically benefits the shoreline property owners whose land would have been protected had the structure been constructed. The statute does not provide for assessment to the beneficiaries unless the improvement is ultimately built.[2] Should the township pay? Government routinely provides services for special segments of the population and which benefit the general public only indirectly. Welfare and unemployment payments are made to the unemployable and unemployed.

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1 MCLA Sec. 41.721; MSA Sec. 5.2770(51).

2 ibid.

Special education programs are maintained at great public expense for the mentally and physically handicapped. But these services are provided to individuals who through circumstances beyond their control are unemployable or handicapped. The owner of shoreland property could have bought inland property. The phenomenon of erosion is well known. The owner knew or should have known of the potential problem. It would seem unreasonable for the public to pay for the owner's mistake.

A logical solution to the problem is to amend the statute to provide for a two phase procedure. Under the first phase there would be, either as a result of petition signed by the record owners of 51% of the land in the special assessment district, or on the initiative of the township board, a feasibility study for a community erosion control system. Following the procedures in sections 4[3] and 4(a)[4] of the statute, the cost of the study would be paid by the township either directly or through a bond issue[5] and assessed against the property owners in the assessment district under the provisions of Sections 5[6] and 6[7] of the act.

The feasibility study is estimated to cost between $5 and $10 a foot for a 10,000 foot erosion area. It should provide the property owners with a choice of possible structures at varying costs, and with differing life expectancies. The property owners ought to be in a position to assess the potential improvement in regard to their property and its value and decide rationally whether to proceed.

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3 MCLA Sec. 41.724; MSA Sec. 5.2770(54).

4 MCLA Sec. 41.724(a); MSA Sec. 5.2770(54)(a).

5 MCLA Sec. 41.735; MSA Sec. 5.2770(65).

6 MCLA Sec. 41.725; MSA Sec. 5.2770(55).

7 MCLA Sec. 41.726; MSA Sec. 5.2770(56).

The second phase of the project would then proceed under the statute with another township board initiative or a petition in the same manner as a sewer system or water main improvement. Even if community erosion control structures become as common as sewer and water systems, the unique physical conditions encountered at different shoreline locations and the variety of structure designs, materials, costs, and life expectancies will make the feasibility study step necessary in implementing the projects. Section 4[8] provides in part:

> "Property shall not be added to the district nor any increase in estimate of cost in excess of 10% of the original estimate of cost shall be made unless notice be given as above provided, or by personal service upon the owners of the property in the entire proposed special assessment district and a hearing afforded to the owners."

Likewise where the special assessment district boundaries are changed, the original petition may be insufficient and a supplementary one may be necessary.

In summary the biphasic procedure has a number of advantages. The cost of each step will be born by the property owners who benefit from the statute. These owners will be assessed a relatively low cost for the feasibility study. As a result it will be easier to marshall the necessary support for the project. The affected land owners will then be part of the process for deciding whether to proceed and if so, what structures to build. The role of the township government will be more restricted than in the instances of other improvements under the statute. It will provide a mechanism and procedure to aid a special group of residents to act together for their common good and to finance their cooperative venture in a manner unavailable to them as individuals.

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8 See note 3 above.

3.2.4. Calculating the Benefit

The statute provides that "the whole or any part of the cost of the improvements shall be defrayed by special assessments against the property especially benefited thereby."[1] The amount assessed against each property "shall be the relative portion of the whole sum to be levied against all parcels of land in the special assessment district as the benefit to the parcel of land bears to the total benefit to all parcels of land in the special assessment district."[2] The formula seems simple enough. Given the benefit per parcel, the township supervisor will have no problem allocating the assessments.

The difficulty arises in calculating the benefit of an erosion control structure to individual pieces of land. Figure 3.2-1 illustrates some of the problems. (See also Section 3.3). Parcels B, C, F, and I are all vacant land areas. The values of the rest are relative to their size and the existing improvements. For purposes of the illustration we will assume that the waves strike the shoreline directly perpendicular to the proposed erosion control structure and that the effect is the same along the entire demonstration section. There are a number of ways to look at the benefit: by land area, by front foot of land, by lengths of the proposed structure, and by value of the property. It is immediately obvious that assessing all properties equally, as is the common practice with water and sewer systems, would not meet the requirements of the statute.

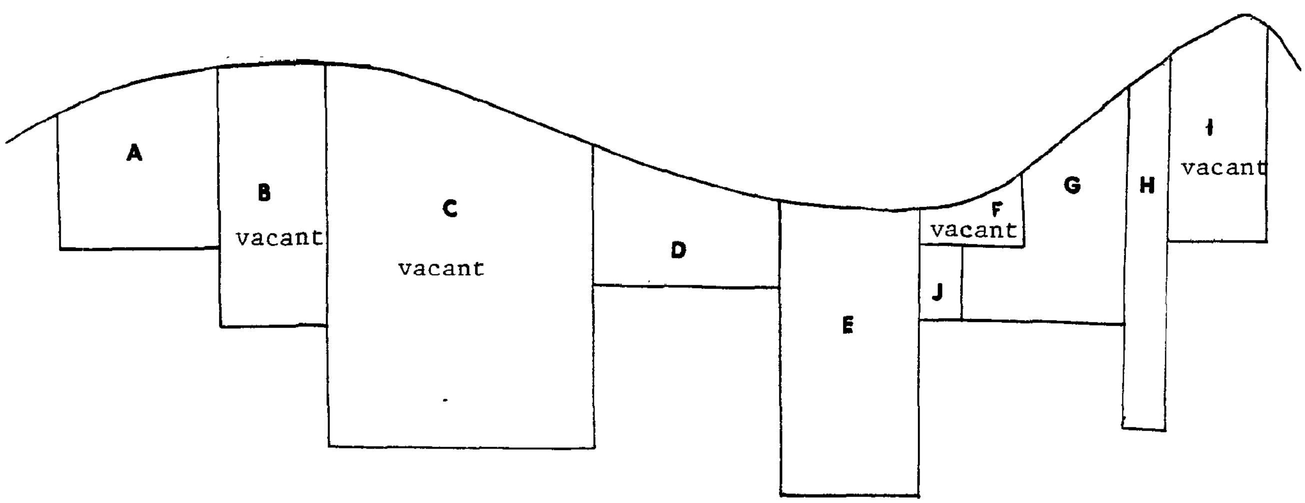
The relative benefit could be determined by property values. The owner of the most valuable parcel stands to lose the most if his or her land is lost through erosion. Lots F, C, and H valued at $5,000, $50,000, and

1 MCLA Sec. 41.721; MSA Sec. 5.2770(51).

2 MCLA Sec. 41.725; MSA Sec. 5.2770(55).

Figure 3.2-1. Parcel layout and information for illustrative example of problems associated calculating benefits.

Property	Assessed Value	Area	Frontage	A/F	$ per front ft.
A	$ 60,000	50,000	250	200	300
B	$ 10,000	61,000	160	381	26
C	$ 50,000	248,000	450	551	91
D	$ 60,000	60,000	300	200	300
E	$175,000	86,000	200	430	406
F	$ 5,000	18,500	185	100	500
G	$100,000	63,000	210	300	333
H	$500,000	44,000	80	550	909
I	$ 7,000	53,000	150	353	19.8



$500,000 respectively show why this method would not be appropriate. F is twice as wide as H and should lose twice as much land area per year with all other parameters being equal, yet the value of F is 10% that of H. C has 10% of the value of H, but approximately five times the total area and about five times the shoreline. C is presently unimproved, but at the density and quality of improvements on H, C could be worth $2,500,000.[3] It would be inequitable to assess the costs against C at 1.10 of H, knowing that a month later C could begin improving his or her property. F is a shallow lot in comparison to either C or H. If erosion were to continue equally and unabated, F will cease to exist when C and H are still valuable properties. E and H are the most valuable properties in our hypothetical sample. Where, however, the structures in H are located near the shore and in E are near the back lot line, the owner of H stands to lose his or her value much sooner than the owner of E if erosion continues unabated. This would increase the complexity and problems of assessing the benefit on the basis of property value.

The benefit might also be calculated on the basis of land area. D, H, and I are all approximately equal in land area, yet H has half the shoreline of I and about one quarter the shoreline of D. If erosion continued equally and unabated, D might be gone in 10 years, I in 20 years, and H in 40 years. For this reason the benefit cannot be said to be equal. Portions of a lot closer to the shoreline will benefit more than those positions farther inland. If the assessment district boundary did not follow the rear or inland property lines, but was set so many feet from the existing shoreline, as illustrated in Figure 3.2-2, land area would be a rational basis on which to compute benefits.

[3] Lincoln Township has a High Risk Erosion Overlay District created by Article XV of the Township Zoning Ordinance and established pursuant to the Shoreland Protection and Management Act, MSA Sec. 13.831-1845; MCLA Sec. 281.631-645. The ordinance limits construction and removal of vegetation in high-risk erosion areas. New construction must comply with shoreline setback requirements and requires a special use permit from the Board of Appeals.

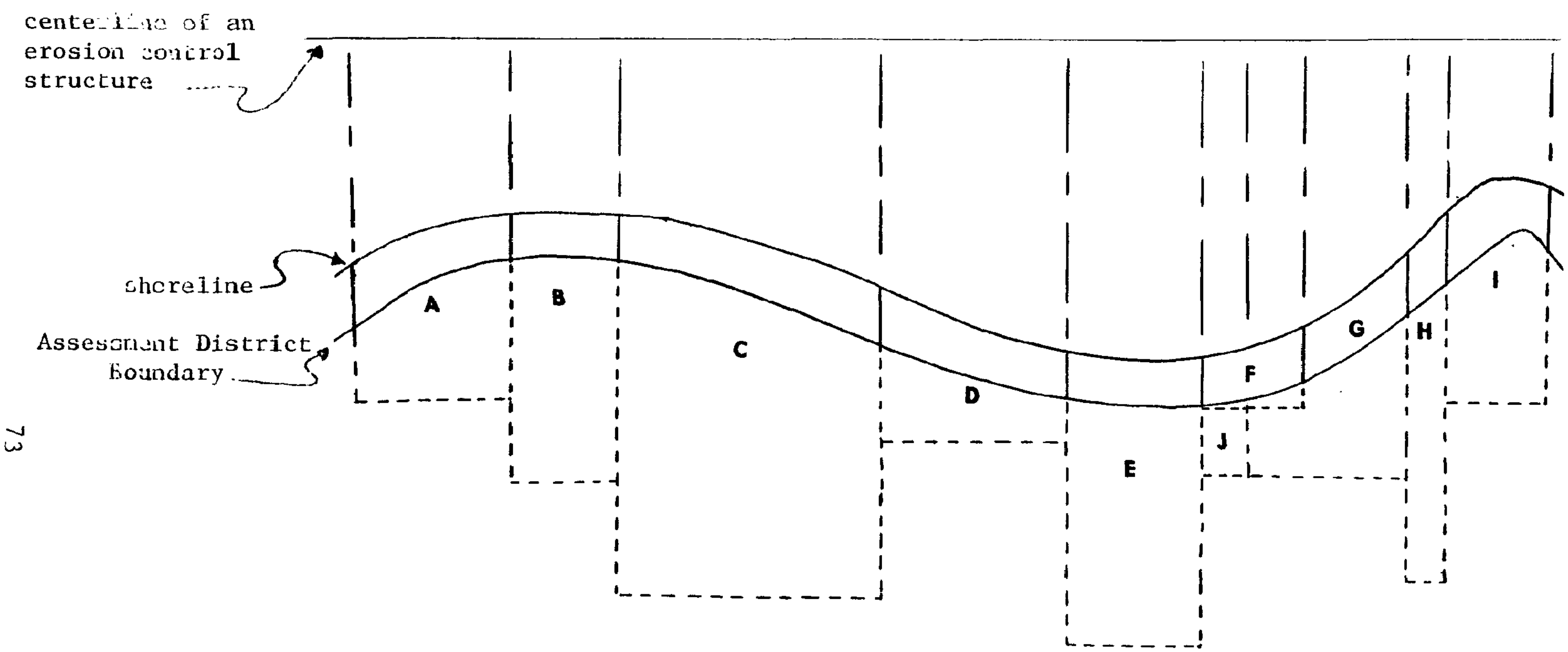


Figure 3.2-2. Example of possible assessment district boundary which follows the existing shoreline, not the rear or inland property lines. Assessment could be based on the proportionate share of the erosion protection structure.

This system will work quite well where there are no shallow lots. The assessment district rear boundary in Figure 3.2-2 was set arbitrarily at the distance from the shore equal to the intersection of lots E, F, and G. Land behind lot F, if F is a very shallow lot, may also be in danger if erosion is not controlled. The absence of erosion or a decrease in the rate of erosion would benefit lot J, even though it does not have any shore frontage. There is nothing in the statute to prevent the township board from setting the assessment district rear boundary through the middle of parcels of land, so long as the distance chosen from the shoreline bears a rational relationship to the point where the benefit ceases.[4] By the same token, the township board could include inland lots in the assessment district, if it found that they were benefited by the erosion control project. The township board ought to make a record of findings to support the boundaries of the assessment district.

The benefits could be computed on the basis of front footage as in the highway assessment example. There each piece of property is assessed according to the number of feet their property has on the proposed highway improvement. The wide shallow parcel, D, is assessed more than the deep narrow lot H. Where the erosion control project is placed directly on the shore, this might be the most reasonable method. But where the erosion control structure is placed offshore, problems with this method can be seen by comparing lots G, F, and B. They all have approximately the same number of feet of shoreline. B's shoreline, however, given our assumption that the action of the waves is straight toward the shoreline and equal at all points, receives the full brunt of erosion. The shorelines of F and G are at an angle to the direction of the waves, and the impact will be different. Lot G illustrates a further

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[4] U.S. Constitution equal protection section of 14th Amendment.

problem because of its L-shape. If the parcel were assessed on the basis of front foot, the owner would not be paying for the benefit to the land behind F. The owner of G, unlike that of J, would be paying, but at a somewhat decreased proportion. The owner of J would be getting a free ride, unless the township board found that the benefit to the back land was very minimal.

In order to avoid the B vs. G problem mentioned above, where the angle of the shoreline to the approaching wave is different, the benefit could be calculated by extending the property lines out to the erosion control structure and assessing the shoreline property owners according to the number of feet of the structure directly in front of the property. See Fig. 3.2-2. The township board would still have to make findings that the benefit to J and the inland portions of the lots was minimal.

This method would eliminate problems presented by the curvature of the shoreline. The method could also be used where the township board finds that when all of the variables of offshore effects, waves, currents, changes in wind direction and storms are averaged together over the lifetime of the erosion control system, that the benefit is equal to the shoreland owner's proportionate share of the system.

The statute does not specifically provide a method for calculating the benefit. It would be inappropriate to propose an amendment with a specific formula for this calculation. As the discussion above indicates, the method chosen will depend upon the reach involved, the property pattern, and the structure contemplated. The formula should, however, be set forth in a township resolution, along with the reasons for the choice. The statute ought to be amended to provide for this resolution.

It is important to note that the front foot or land area requirements used for purposes of the petition drive[5] are not necessarily the same as those used for calculating the benefit.

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[5] MCLA Sec. 41.723; MSA Sec. 5.2770(53).

Four different possible erosion control systems have been proposed for the study reach in Lincoln Township, an offshore breakwater, timber groins, rubblemound revetment, and a headland-groin construction. The calculations of the benefit to the property owners will vary with the alternative chosen. The easiest cases are the timber groin and rubblemound revetment proposals. Each of these would be constructed on the shoreland and the cost could best be allocated according to the percentage of construction that is placed on each individual owner's property. Although under the statute, the township has the authority to assess "the whole or any part of the cost"[6] against the benefited property owners, where the township does not benefit from the groin or revetment, the entire cost would probably be assessed to the property owners. The township board is free to contract with these shoreline owners, picking up some of the cost in exchange for increased public access to the shore.

The offshore breakwater involves a more complicated benefit assessment problem of the type discussed in general terms above. As it is designed for this specific reach, the breakwater is not one continuous structure, but a line of interrupted breakwater segments. There will be shoreline properties opposite both the segments and the spaces between. The structure as a whole is designed to protect the reach as a whole; the assessment should be divided accordingly. One way the township supervisor could elect is to treat the breakwater as a continuous structure, extrapolate the property lines to the structure, and calculate the percentage of the whole length intersected by the individual owner's property lines (as in Fig. 3.2-2). The assessment would be that percent of the total cost. The township board would have to take testimony and find that these percentages did in fact bear a valid relationship to the benefits

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6 See note 1, supra.

received. In this case as well, the benefit accrues to the shoreline property owners almost exclusively and only to the township indirectly by protecting its existing tax base, with the exception of public land. Barring a contract between the board and the protected shoreline property owners for increased public access or other public benefit, the township board is likely to assess the entire cost against the affected properties.

The headland proposal, on the other hand, can benefit the township as a whole and the board has a great deal of leeway for cost and benefit allocation, The more northerly of the two headlands is adjacent to a township park and would increase the parkland to be used by the township as a whole. The other headland is adjacent to private property and unless ready public access could be secured, the cost ought not to be born, even in part, by the township. The cost of the back fill and groins, that support and supplement the headlands and the erosion protection they afford, can be assessed against the shoreline property owners. In order to properly exercise its discretionary function under Section 1,[7] the board will need expert advice on how to allocate the cost of the headlands and on how to protect itself in the event of legal challenge. The township board should make extensive findings and base the benefit allocation and cost assessment on these findings.

The headland proposal has legal ramifications not presented by the other proposed erosion control systems. The headlands would be built in front of riparian land and could interfere with the riparian rights of access to navigable water[8] and the right to wharf out to navigable waters.[9] The riparians might sue for removal of the fill and/or removal of any permanent structures

[7] See note 1, supra.

[8] Rice v. Naimish, 8 Mich App 698 (1967).

[9] Obrecht v. National Gypsum Co., 361 Mich 399, 105 NW 2d 143 (1960); Obrecht v. Director of Conservation, 361 Mich 399, 105 NW 2d 143(1960).

constructed on the headlands. The ownership of the headlands is also at issue. The riparian right to wharf out to navigable waters includes the right to fill, both subject to state and federal permitting procedures.[10] Title to the land created by the fill must be conveyed to the riparian property owner under the Great Lakes Submerged Lands Act.[11] Part of the more northerly headland would then belong to Surfside Apartments and most of the more southerly headland would then belong to Summerset Estates. The township board can avoid these problems by entering into agreements with these riparians, that this riparian right will not be lost, that they will not own the headlands and that they will not have to bear the cost of the headlands. These types of contract may not be feasible because of the price exacted by the riparians and the political consequences in the township.

3.2.5. Permitting Procedures

Most community erosion protection system designs will be built in the waters of the Great Lakes or connnecting waterways. Any filling and construction project in these waterways requires a permit from the federal and state governments. Although the state and federal permitting procedures provide for a joint application to avoid duplication and promote efficient processing of the application, it is important to consider the statutes at both state and federal levels that mandate permitting and the public policies and interests these statutes are designed to protect. Copies of the application form and relevant federal and state information are included at the end of this section.

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[10] See Permitting Section.

[11] MSA Sec. 13.700 (1)-(15); MCLA 322.701-715.

Michigan Permitting Procedures

The State of Michigan has three statutes, the "Great Lakes Submerged Lands Act"[1], the "Inland Lakes and Streams Act of 1972"[2], the "Shorelands Protection and Management Act of 1970"[3] in addition to the Coastal Management Program submitted to the National Oceanic and Atmospheric Administration of the U.S. Department of Commerce on May 19, 1978. Proposed community erosion protection systems must be consistent with the Coastal Management Program policies, any zoning by the city[4] or county[5] government and applicable regulation by the Water Resources Commission[6] under the Shorelands Protection and Management Act, and the permit requirements of the Inland Lakes and Streams Act or the Great Lakes Submerged Lands Act depending on whether or not the proposed site is in the connecting waterways or the Great Lakes themselves.

The Inland Lakes and Streams Act applies to the connecting waterways[7] and a permit is required for any construction, dredging, filling or alteration of the waterway.[8] The permit application is submitted to the Department of Natural Resources. The Department sends copies of applications for review to local governments, appropriate agencies, and adjacent riparians. A public hearing on the permit application will be had either if specifically requested by the applicant, riparian owner, or governmental agency or at the discretion of the department. The department must "consider the possible effects of the

1 MSA Sec. 13.700(1)-(15); MCLA Sec. 322.701-715.

2 MSA Sec. 11.475(1)-(15); MCLA Sec. 281.951-965.

3 MSA Sec. 13.1831-1845; MCLA 281.631-645.

4 MSA Sec. 13.1838; MCLA Sec. 281-638.

5 MSA Sec. 13.1837; MCLA Sec. 281.637.

6 MSA Sec. 13.1842; MCLA Sec. 281.642.

7 MSA Sec. 11.475(2)(f); MCLA Sec. 281.952(f).

8 MSA Sec. 11.475(3); MCLA Sec. 281.953.

proposed action upon the inland lake or stream and upon waters from which and into which waters flow and the uses of all such waters, including uses for recreation, fish and wildlife, aesthetics, local government, agriculture, commerce and industry."[9]

Where the erosion control structure is to be located in the Great Lakes, a permit would be required under the Great Lakes Submerged Lands Act, which includes "the Great Lakes and the bays and harbors thereof."[10] The permit is required for dredging, filling or placing other materials on the bottom land of the Great Lakes."[11] Under this statute the department is charged with ascertaining "the public trust will not be impaired or substantially injured."[12] Subsection (b)[13] allows permits for filling by local units of government for "public purposes." Community erosion protection structures proposed by township governments ought to meet this requirement, if designed to prevent or minimize effects on adjacent riparians and natural resources.

Federal Permitting Procedures

The primary federal statutes involved in the permitting procedures are the River and Harbor Act of 1899[14], the Federal Water Pollution Control Act

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[9] MSA Sec. 11.475(7); MCLA Sec. 281.957.

[10] MSA Sec. 13.700(1); MCLA Sec. 322.702.

[11] MSA Sec. 13.700(3); MCLA Sec. 322.703.

[12] MSA Sec. 13.700(5)(a); MCLA Sec. 322.705(a).

[13] MSA, see note 12, supra.

[14] 33 USC 401, 403, 404, 407.

Amendments of 1972[15], the Coastal Zone Management Act of 1972[16], the National Environmental Protection Act of 1969.[17]

River and Harbor Act of 1899

The River and Harbor Act of 1899 was the first of the regulatory statutes. Its basic thrust was to facilitate commerce on federal navigable waters. Section 9[18] required a permit for the construction of a dam or dike in navigable waters from the U.S. Army Corps of Engineers and the consent of Congress if the waterway was interstate and the consent of the applicable state legislature if the water was intrastate.

Section 10 of this statute[19] requires a permit from the Corps of Engineers for construction of structures such as piers, breakwaters, bulkheads, revetments, power transmission lines, and aids to navigation, in navigable waters. Permits are also required for any dredging, channelization, or filling in navigable waters. Where any of these proposed projects is located in non-navigable waters, but may affect navigability in navigable waters a permit is required. Most community erosion protection structures will require a Sec. 10 permit.

Navigability

Sections 9 and 10 require permits for certain activities in navigable waters. What are navigable waters for federal permitting purposes? The power to regulate navigable waters comes from the Commerce clause of the U.S. Consti-

15 33 USC.

16 16 USC 1456(a).

17 42 USC 4321-4347.

18 33 USC 401.

19 33 USC 403.

tution[20] and the waterways defined as navigable have expanded as the commerce power increased. The case of Daniel Ball[21] was the first to define navigable waters as those waters presently used to transport interstate or foreign commerce. The definition was expanded to include all waters used for interstate or foreign commerce in the past[22] and all waters susceptible to such commerce in their ordinary condition with reasonable improvement[23], and all waters subject to the ebb and flow of the tide.[24] Section 33 CFR 329 defines federal navigable waters and lists four categories of waterways. The first three are subject to U.S. Army Corps permits under Sec. 9, 10, 13 of the River and Harbor Act of 1899, and the fourth category gives the Corps jurisdiction over further waters for purposes of the Federal Water Pollution Control Act Amendments of 1972, which will be discussed below. The four categories are briefly; 1) coastal and inland waters, lakes, rivers, and streams that are navigable waters of the U.S. as defined by the cases cited above[25]; 2) tributaries to U.S. navigable waters; 3) interstate waters and their tributaries; 4) all other waters of the U.S. Each of these categoreis includes the adjacent wetlands.

Federal Water Pollution Control Act Amendments of 1972

Section 13 of the Rivers and Harbors Act of 1899 has been modified by the Federal Water Pollution Control Act Amendments of 1972[26], hereinafter re-

20 Article I Sec. 8.

21 Daniel Ball v. United States 77US557(1871).

22 Economy Light and Power Co. v. United States 256US113 1192D.

23 United States v. Appalachian Power Co. 311 U.S. 377 (1940).

24 United States v. Moretti 478F. 2d 418 (5th Cin. 1975).

25 see notes 22-24.

26 see note 15.

ferred to as FWPCA. Originally Sec. 13 prohibited the discharge of "refuse matter" into U.S. navigable waters. Sec. 13 still applies to all dumping unless a National Pollution Discharge Elimination System, hereinafter referred to as NPDES, permit has been obtained under Sec. 404 of the FWPCA. This permit is also obtained through the U.S. Army Corps of Engineers. Although the construction of an erosion control structure would not explicitly call for dumping waste into the water, the fill used in the construction may contain pollutants and an NPDES permit is, therefore, required.

The shoreward limit of federal regulatory juridiction is the ordinary high-water mark on fresh water which includes the Great Lakes and the mean high-water mark for tidal waters except the east coast, where it is defined as the mean higher high-water mark. Does the federal government jurisdiction extend to include the wetlands for purposes of the FWPCA? The court in United States v. Holland[27] held:

> "The Court is of the opinion that the mean high-water line is no limit to Federal authority under the FWPCA. While the line remains a valid demarcation for other purposes, it has no rational connection to the aquatic ecosystem which the FWPCA is intended to protect. Congress has wisely determined that federal authority over water pollution properly rests on the commerce clause and not on past interpretations of or acts designed to protect navigation. And the commerce clause gives Congress ample authority to activities above the mean high-water line that pollute the waters of the United States."

This holding has been followed in the Court of Appeals for the Sixth Circuit which includes the Detroit area[28] and in the federal district court for the district.[29]

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27 373 F. Supp. 665 (A.D. Fla., 1974).

28 United States v. Ashland Oil and Transportation Co., 504 F 2d 1317(6th Cir, 1974).

29 United States v. Riverside Bayview Homes, Inc., Civil Action Nol 77-7676041 (E.D. Mich., Feb.24, 1977).

Harbor Lines

Section 11[30] of the River and Harbor Act of 1899 allows the Secretary of the Army to establish a harbor line, also known as a pierhead or bulkhead line, and allowed the construction of piers, docks, and wharves on the landward side of the line without a permit. The intention of the statute was to promote commerce by obviating the need for a permit within these boundaries and protect navigation on the waterward side of the harbor line. Since May 27, 1970, however, a permit is required for all action, which would otherwise require a permit, commenced after that date shoreward of the harbor line.[31] The existing and future harbor lines have since been used as "guidelines for defining, with respect to the impact on navigation interests alone, the offshore limits of open pile structures (pierhead lines) or fills (bulkhead lines)."[32] This same permit procedure applies for any construction, filling, or dredging on navigable waters, whether within the limits of the harbor line or extending beyond this line. Activity beyond the harbor line requires either the establishment of a new harbor line or modification of an existing one. Both of these steps require the specific authorization of the Chief of Engineers.[33] Normal permitting is carried on at the level of the District Engineer.

Coastal Zone Management Act. Section 397(C)[34] of the Coastal Zone Management Act, hereinafter referred to as CZMA, requires that a non-federal applicant for a federal permit for a project affecting land or water uses in the state's coastal zone must have state certification that the project

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30 33 USC 404.

31 33 CFR 328.5(b).

32 Ibid.

33 33 CFR 328.5(b).

34 16 USC 1456(c).

complies with the State's approved[35] Coastal Zone Management Program before a federal permit may be issued. Michigan has an approved Coastal Management Program, so any proposed structures must comply with it before any federal permit can be issued.

National Environmental Policy Act. The National Environmental Policy Act, of 1969[36], hereinafter referred to as NEPA, is also important to permittin procedures for proposed community erosion control systems. If the District Engineer of the U.S. Army Corps of Engineers determines "that the decision on the application is not a major Federal action significantly affecting the quality of the human environment" no environmental impact statement, hereinafter referred to as EIS, must be filed with the application. In every case the District Engineer must prepare an Environmental Assessment which will either be the EIS or an Environmental Assessment.[37] Although the U.S. Army Corps of Engineers is the most obvious federal agency involved in this type of project, another federal agency may, as a funding source or for some other reason, be the lead agency responsible for preparing the EIS.

Permit Evaluation Criteria. The general policies for evaluating the permit applcations are set forth in 33 CFR 320.4. The original 1899 considerations of commerce and navigation have been considerably expanded. Subsection (a) requires a "public interest review." This requirement has been a part of the Corps review procedure since Dec. 18, 1968.[38] It received its first judicial review in Zabel v. Tabb.[39] Fish and wildlife, conservation, pollution, aesthetics and ecology were also criteria specifically required

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35 Approved by the Secretary of Commerce.

36 See note 18, supra.

37 430F 2d 199 (15th Cir., 1970).

38 33 CFR

39 430 F 2d 199 (15th Cir., 1970)

as of 1968. The list of criteria to be considered under public interest now include: "conservation, economics, aesthetics, general environmental concerns, historic values, fish and wildlife values, flood damage prevention, land use, navigation, recreation, water supply, water quality, energy needs, safety, food production, and in general, the needs and welfare of the people."[40]

Subsection (2) provides general criteria for evaluating every permit application:

> "(i) the relative extent of the public and private need for the proposed structure or work,
> (ii) the desirability of using appropriate alternative locations and methods to accomplish the objective of the proposed structure or work,
> (iii) the extent and permanence of the beneficial and/or detrimental effects which the proposed structure or work may have on the public and private uses to which the area is suited; and
> (iv) the probable impact of each proposal in relation to the cumulative effect created by other existing and anticipated structures or work in the general area."

The township will have to give thorough consideration to the "public interest" in the application for a permit.

The other criteria that must be evaluated for every permit application are:

"(b) Effect on wetlands

(c) Fish and Wildlife

(d) Water quality

(e) Historic, scenic, and recreational values

(f) Effect on limits of the territorial area

(g) Interference with adjacent properties or water resource projects

(h) Activities affecting coastal zones

(i) Activities in marine sanctuaries

(j) Other Federal, state, or local requirements."[41]

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40 33 CFR 320.4(a)(1).

41 33 CFR 320.4.

Public Hearings. A public hearing on a permit application will be held where the application is for a FWPCA Sec. 404, MPRSA Sec. 103 or federal project permit and at the discretion of the Department of the Army where a public hearing will assist in the decision making.[42] Where the public notice does not state that a hearing will be held on one of these projects, anyone may request such a hearing.[43] Where the applcation is for a River and Harbor Act Sec. 10 permit, a hearing will be held where requested and when the District Engineer determines that there is sufficient public interest to warrant a hearing.[44] A public hearing must be held in cases of doubt, with the discretion residing in the Department of the Army.[45] The purpose of a public hearing is to acquire information useful in considering the application and allowing the public an opportunity to present information and opinions.[46]

Each of the federal statutes mentioned in this section is being implemented by the appropriate federal agency according to the rules set forth in the Code of Federal Regulations. Before applying for the required permits from the U.S. Army Corps of Engineers or other lead agency for the construction of an erosion control device one should consult the applicable regulations.

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42 33 CFR 327.4(a).

43 33 CFR 327.4(b).

44 33 CFR 327.4(c).

45 33 CFR 327.4(d).

46 33 CFR 327.3(a).

JOINT APPLICATION FORM FOR PERMITS FROM

FOR OFFICIAL USE ONLY

CORPS OF ENGINEERS DEPARTMENT OF THE ARMY (Section 10, R&H Act 1899) ☐ (Section 404, FWPCA 1972) ☐	CORPS PROCESS NO.	STATE OF MICHIGAN DEPARTMENT OF NATURAL RESOURCES (Act 346, P.A. 1972) ☐ (Act 247, P.A. 1955) ☐	DNR FILE NO.

PLEASE TYPE OR PRINT — SEE INSTRUCTION SHEET

1. Applicants Name First Last

2. Complete mailing address of applicant

Telephone no. during business hours

A/C ( ) ____________

A/C ( ) ____________

3. Location where proposed activity exists or will occur.

Address:

Street, road or other descriptive location

In or near city or town

State Zip Code

4. Legal description of upland property at project site

County ____________

Township/City/Village ____________
(Circle one) (Name)

T ______ R ______ Section ______

Metes and Bounds:

5. Name of Waterway

6. Name of subdivision

7. Lot Number(s)

8. Reason for proposed project, its purpose and intended use.

Check proposed use:
- ☐ Private
- ☐ Public
- ☐ Commercial
- ☐ Other (Explain)

9. Is applicant the owner of above described property? Yes ☐ No ☐ If not, attach name and address of record owner.

10. Describe the proposed activity; include a description of the structures proposed, the type, composition and quantity of materials from any dredging or fill proposed.

11. State why you believe the project will not cause pollution, impair or destroy the water or any natural resources.

12. State whether any alternatives to the project have been considered. If so, describe.

13. State below the name and address of any property owners' association, where the proposed project will be located, and the names and addresses of adjacent riparians. When the action involves a stream, state names and addresses of opposite riparians also.

FOR CASHIER'S USE ONLY — DO NOT WRITE IN THIS SPACE

- -

FEE VALIDATION DOCUMENT

14. Name of Remittor

Address

1972 Public Act 346 Permit Application Fee

STATE FORM
Rev. 7

15. Name, address and telephone of applicant's authorized agent for permit application coordination.

16.

Date activity is proposed to commence. ______________________

Date activity is expected to be completed. ______________________

17. Name, address and telephone of contractor, if any.

18. Is any portion of the activity for which authorization is sought now complete?

Yes ☐ No ☐ If the answer is "Yes" give explanation. Month and year the activity was completed ______________. Indicate the existing work on plan drawings.

19. List all approvals or certifications required by other Federal, state or local agencies for any structures, construction, discharges, deposits or other activities described in this application.

Issuing Agency	Type Approval	Identification No,	Date of Appl.	Date of Approval

20. Has any agency denied approval for the activity described herein or for any activity directly related to the activity described herein? Yes ☐ No ☐

(If "Yes" explain)

21. Is there at present any litigation in process involving this property? Yes ☐ No ☐

If "Yes" explain.

22. Application is hereby made for a permit or permits to authorize the activities described herein. I certify that I am familiar with the information contained in this application, and that to the best of my knowledge and belief such information is true, complete, accurate and is in compliance with the State Coastal Zone Management Program. I further certify that I possess the authority to undertake the activities proposed in this application.

______________________ ______________________

Date Signature of Applicant and Title

The application is to be signed by the person desiring to undertake the proposed activity or may be signed by a duly authorized agent if accompanied by a statement signed by the applicant designating the agent.

A STATE APPLICATION FILING FEE OF $25.00 IS REQUIRED WITH ALL NON-GOVERNMENTAL APPLICATIONS. THE FILING FEE IS REQUIRED ONLY FOR PROJECTS LOCATED ON AN INLAND LAKE OR STREAM.

No State filing fee is required to be submitted with an application for projects located on the Great Lakes, i.e., Lakes Michigan, Huron, Superior, St. Clair or Erie.

Make checks payable to "State of Michigan" (payment of the fee does not guarantee permit).

The U.S. Army, Corps of Engineers, will notify you of the appropriate Federal filing fee when their permit application review has been completed and a preliminary determination has been made that a permit will be issued. Fees are assessed as follows: (1) commercial or industrial uses - $100.00 and (2) non-commercial uses - $10.00. DO NOT SUBMIT ANY FEE TO THE U.S ARMY, CORPS OF ENGINEERS UNTIL YOU ARE NOTIFIED OF THE REQUIRED AMOUNT. (Note: The Federal filing fee is in addition to any fee required by the State of Michigan).

Please read privacy act and application penalty statement on the instruction sheets.

DRAWINGS MUST ACCOMPANY APPLICATION (see attached check sheet for drawings).

APPLICATIONS NOT FULLY COMPLETED WILL BE RETURNED.

INSTRUCTION SHEETS FOR COMPLETING JOINT CORPS OF ENGINEERS
AND MICHIGAN DEPARTMENT OF NATURAL RESOURCES APPLICATION FORM R4506

APPLICANT MUST COMPLETE ALL ITEMS NUMBERED 1-22

ITEM # 1. Enter the applicants name.

EXAMPLE: George Washington

ITEM # 2. Enter the official mailing address of the applicant.

Number and Street: P.O. Box No.; RR No. etc.

City or Town, State and Zip Code.

Include area code and telephone number(s) where applicant may be reached during ordinary business hours.

ITEM # 3. Enter address of property (if applicable) where project is to take place or address of adjoining property. Give directions to the project site. Use additional sheet if space is not sufficient.

ITEM # 4. Enter Legal Description of upland property where property is located (see tax statement)

EXAMPLE (Metes & Bounds): THAT PART, OF LOT 1210 LYING SW OF A LINE BEG ON E LOT LINE S 32°56 1/2' W 15 FT FROM ITS NE COR, & RUNS N 48°34 1/2' W TO W LINE AT A POINT 14.35' NE'LY OF SW COR, ALSO LOTS 1211 THRU 1214 INC. INCL RIVER FRONT BETW LOT LINES EXT'D.

ITEM # 5. Enter name of Waterway.

EXAMPLE: The St. Clair River

ITEM # 6. Enter the name of subdivision

EXAMPLE: Supervisor Roy T. Gilbert No. 14

ITEM # 7. Enter Lot Number(s).

EXAMPLE: Part of Lot 1210 and all of Lots 1211 thru 1214

ITEM # 8. Enter reason for proposed project, its purpose and intended use.

EXAMPLE: To afford shore protection.

Then also check appropriate box at right of item.

ITEM # 9. Enter a check mark in the "Yes" block if you are the owner of above described property.

If you are not the owner enter a check mark in the "No" block and attach the name and address of owner of record.

ITEM # 10. Enter proposed activity, description, etc.

EXAMPLE: A wood bulkhead will be constructed along an inland canal adjacent to and north of the North Channel of the St. Clair River. The bulkhead will consist of wood plank piling that will extend along the entire width of the property, which is about 80 feet. Approximately 444 cubic yards of sand and topsoil will be trucked in, and will be used as fill behind the proposed structure. The fill material will be placed at a sloping grade from the top of the bulkhead to the grade of the house. The top of the grade will be at an elevation of 578.3'; top of the bulkhead will have an elevation of 577.1'; the water level at the time of application was about 575.0'.

ITEM # 11. EXAMPLE: This proposed project by providing shore protection may reduce pollution, will not impair or destroy the water quality and will not impair or destroy any known natural resource.

ITEM # 12. EXAMPLE: I have considered riprapping, steel bulkhead and gabion bank protection.

ITEM # 13. Enter adjacent property owners mailing address at which owners may be reached.

EXAMPLE: (1) James Barrymore
91466 LaCroix Rd.
Harsens Island, MI. 48028

(2) J. Jones
1413 Edmore
Detroit, MI. 48200

ITEM # 14. Enter name and address of remittor.

ITEM # 15. Enter name, address, and telephone of authorized agent (if applicable).

EXAMPLE: John Doe
1236 Newport
Harsens Island, MI. 48028
Telephone (313) 229-1234

ITEM # 16. Enter date work is expected to commence. EXAMPLE: 1 July 1976

Enter date work is expected to be completed. EXAMPLE: 14 July 1976

ITEM # 17. Enter name, address and telephone of contractor (if applicable)

EXAMPLE: William Doe
Jones Marine Construction
456 Basin
St. Clair Shores, MI. 48199
(313) 987-6543

ITEM # 18. Enter "Yes" or "No" if any portion of the activity is completed. If "Yes," please explain.

EXAMPLE: "Yes". Forty (40) feet of the eighty (80) foot bulkhead was constructed by the previous owner Mr. Johann Rall, 18075 Canterberry Lane, Atlantic City, New Jersey, in 1958. I don't know if Mr. Rall received authorization for the work.

ITEM # 19. Enter what other Governmental authorizations you have requested or received.

EXAMPLE:

Issuing Agency	Type Approval	Identification No.	Date of Application	Date of Approval
Clay Township	Permit	76-14-00	2-25-76	Pending
St. Clair County	Permit	0000-76	2-25-76	3-23-76

ITEM # 20. If "Yes", enter which agency denied approval for the proposed activity described herein.

EXAMPLE: Denied Township approval.

Reason: Must obtain Corps of Engineers and State DNR permits prior to Township approval.

ITEM # 22. Please read carefully before signing. Should you have questions please contact the Corps of Engineers, telephone 313-226-6812.

NOTE: Mail application and filing fee if required, to

Department of Natural Resources
Land Resource Programs Division
Box 30028
Lansing, Michigan 48909

Upon receipt by DNR a copy will be forwarded to the Detroit District, Corps of Engineers.

NOTE: Drawing(s) must accompany the application (see check sheet on reverse side).

DATA REQUIRED BY THE PRIVACY ACT OF 1974
(5 U.S.C. 552a)

TITLE OF FORM: Joint Application for Permits From The State of Michigan, Department of Natural Resources and Department of the Army, Corps of Engineers

PRESCRIBING DIRECTIVE: ER 1145-2-303

1. AUTHORITY

Section 10 River & Harbor Act 1899, Section 103 Marine Protection, Research & Sanctuaries Act of 1972, and Section 404 Federal Water Pollution Control Act

2. PRINCIPAL PURPOSE(S)

Application form for permits authorizing structures and work in or affecting navigable waters of the United States, the discharge of dredged or fill material into navigable waters, and the transportation of dredged material for the purpose of dumping it into ocean waters.

3. ROUTINE USES

Describes the proposed activity, its purpose and intended use, including a description of the type of structures, if any, to be erected on fills, or pile or float-supported platforms, and the type, composition and quantity of materials to be discharged or dumped and means of conveyance.

If the application is made at the Detroit District level, a copy will be furnished the Michigan Department of Natural Resources, conversely if the application is submitted to the Michigan DNR, a copy will be furnished the Detroit District, and subsequently the content is made a matter of public record through issuance of a public notice.

The application is made available to any requesting State or Federal agencies, dealing with the review of the application. The form itself is not made available; only that information which is pertinent to the evaluation of the permit request.

The form (or copies) could be kept on file at the Michigan DNR, Detroit District, Division or OCE level, depending on the details surrounding the case. The information could become a part of any record of a reviewing agency with a need to know; such as U. S. Fish & Wildlife; Environmental Protection Agency; etc.

The application will become part of the record in any litigation action by the Department of Justice or the Michigan Attorney Generals Office involving the work or activity.

4. MANDATORY OR VOLUNTARY DISCLOSURE AND EFFECT ON INDIVIDUAL NOT PROVIDING INFORMATION

The disclosure of information is VOLUNTARY. Incomplete data precludes proper evaluation of the permit application. Without the necessary data (i.e., name, address and phone number), the permit application cannot be processed or a permit subsequently issued.

PENALTY

18 U.S.C. Section 1001 provides that: Whoever, in any manner within the jurisdiction of any department or agency of the United States knowingly and willfully falsifies, conceals, or covers up by any trick, scheme, or device a material fact or makes any false, fictitious or fraudulent statements or representations or makes or uses any false writing or document knowing same to contain any false fictitious or fraudulent statement or entry, shall be fined not more than $10,000 or imprisioned not more than five years, or both.

CHECK SHEET FOR APPLICATION DRAWINGS

a. Have an over-all size of 8 x 10½ inches, including a 1-inch margin for binding along one 8-inch side. (Additional sheets can be used for each view, if desirable).

b. Indicate clearly purposed and existing construction.

c. Be drawn to scale with dimensions.

d. Have scale shown graphically. Example:

e. Have arrows showing the north.

f. Indicate by arrows the direction of current in rivers.

g. Show sufficient water depths to properly represent conditions at the site prior to commencement of activity.

h. Have all water depths and elevations referred to Low Water Datum (L.W.D.) on I.G.L.D. for the Great Lakes or datum reference from U.S.G.S. Quad sheet.

i. Have simple title block in lower right hand corner describing the existing or proposed activity. Name of waterway, county, state, and applicant's name.

j. Have location map stating what map or chart location map was copied from.

k. Show names and addresses of the owners of the adjacent property on both sides, and the relative location of any structures which may exist in front of the adjacent properties. If there are no adjacent structures show existing shorelines.

l. Indicate what structures are existing and what structures are proposed.

m. If structures were authorized by previous Federal/State permit, show the corresponding permit number.

n. Show a typical cross section of structures, dredge cuts and fills (include dimensions and elevations).

o. For bulkheads, show distance along property line fron face of bulkhead to centerline of street or other definable reference point. Where this distance is not the same for both property lines, then show both measurements.

p. Describe the construction material (1) thickness, (2) slope, (3) type (stone, concrete, etc.) and (4) size or weight of riprap material when placing a protective facing on an earth retention structure. Include the total amount (volume) in tons or cubic yards of all fill or dredge material.

q. If your activity involves dredging, it will be necessary to furnish the following information:

(1) Provide a discription of the area in which the dredged material will be placed.

(2) Should the dredged material be placed on-site, please outline the disposal area on the plan view of the drawing.

(3) If the dredged material will be hauled away, please provide a vicinity map showing the location of the upland disposal area.

(4) Dredged material should be placed in such a manner so as to prevent its re-entry into any waterway or wetland. If this is the case, state so.

ENVIRONMENTAL ASSESSMENT

(Project Title)

(Date Prepared)

Prepared by:

____

(Name and Title)

PART I - INTRODUCTION

1. <u>Project Location</u>

Describe the proposed site, general and exact location - maps and photographs as required.

PART II - ENVIRONMENTAL INVENTORY

2. <u>Environmental Setting Without the Action</u>

a. Physical - Geological elements, climate, topography, unique features, air and water quality.

b. Biological - Flora and fauna, zoological elements, rare or endangered species.

c. Cultural - Land use, population density and trends, regional development, transportation systems, cultural patterns, utilities.

d. Ecological relationships - Air and Water pollution, health hazards.

e. Others -

PART III - PROPOSED ACTION

3. <u>Action Description</u>

Describe the proposal by name and specific location and summarize its objectives, purpose and the activities which will ensue if it is adopted. Provide technical data adequate to permit a complete understanding and a careful assessment of environmental impact. Where relevant, maps and diagramatic sketches should be provided.

Identify the probable direct and secondary environmental consequences of the proposed action, activity or project. This shall include commentary on the direct impact on man's health and welfare and his surroundings. Threats to other forms of life and their ecosystems shall be included. (Examples of primary and secondary environmental consequences that should be identified are the primary military aircraft operations and the secondary impact on future land use which may result from such operations.) The direct and indirect effects of the following environmental items will be included in all environmental assessments for applicable actions, activities, and projects. Any of the items that are not applicable for the action, activity or project will still be included and noted as being not applicable.

4. Air Quality

5. Water Quality

6. Land Use - Urbanization or increase density, changes in land use or zoning.

7. Noise - Sound and noise levels

8. Visual Aesthetics

9. Traffic - Railway, automotive, air, water, pipeline, electrical or communications transmissions.

10. Waste Disposal - Solid waste, sewage, other materials.

11. Wildlife

12. Vegetation

13. Historical

14. Others

PART IV - ALTERNATIVES

Describe various alternatives considered, why each was not recommended, and the benefits and detriments of each. Include the alternative of no action.

PART V - CONCLUSIONS

1. This action (will) (will not) have a significant adverse affect on the environment.

2. This action (will) (will not) have a beneficial affect on the environment.

3. The affect of this action (will) (will not) be environmentally controversial.

3.2.6. Other Problems

There are several other minor difficulties connnected to a proposed community erosion protection system: a) liability for end effect damage: b) how to exact payment if the structure and/or the land has eroded before payment is complete; and c) how do the recent tax limitation amendments effect implementation of Act 148.

a) Liability for End Effect Damage.

Any structure placed in the water will have some effect, however minimal, on the wave and current patterns with which it interacts. An erosion control system is designed specificially to interfere with and decrease the effects of the water's action on a designated section of shoreline. The force of the waves and currents is repulsed and deflected by the structure. As the permitting section[1] shows, a permit will be necessary for the proposed projects from both the U.S. Army Corps of Engineers and the Michigan Department of Natural Resources. While the Corps will be primarily concerned with the effect of the structure on navigation,[2] the DNR will be concerned with the effects of the structure on neighboring riparians,[3] and if the end effects are significant, may very well refuse the necessary permit. If an Environmental Impact Statement is necessary under NEPA[4], steps must be taken to mitigate detrimental end effects.

Should the township fail to provide for mitigation of the end effects, it might be liable for the resulting damage. The injured adjacent riparian could and probably would sue a number of defendants. The U.S. Army Corps of

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1 See Section V, supra.

2 33 USC 403.

3 MSA Sec. 13.700(1)-(15); MCLA Sec. 322.709-715; MSA Sec. 11.475(1)-(15); MCLA Sec. 281.951-965.

4 42 USC 5431-4347.

Engineers as a permitting agency under the Rivers and Harbor Act of 1899, as amended[5] and as primary agency under NEPA[6] would or could be responsible for negligently granting a permit. The Michigan DNR would or could be similary liable under their permitting procedures either pursuant to the Great Lakes Submerged Lands Act[7] or the Inland Lake and Streams Act.[8] The township board and supervisor might be responsible for approving and contracing for the offending structure. The designer could be liable for faulty design and/or the contractor for faulty construction of the structure, allegedly constituting the proximate cause of the damage. If any materials are at fault, the suppliers might also be joined as defendants. Lastly the benefited property owners could be responsible, because the damage is a foreseeable consequence of an erosion control structure constructed at their behest.

The problem can and should be addressed in two ways. First, the erosion control structure should be designed and constructed to minimize end effects. Secondly, the total project might include regular beach nourishment of any adversely affected adjacent areas. The cost of construction[9] includes design and maintenance costs. Maintenance is broad enough to encompass beach nourishment. The cost would be part of the assessments levied against the benefited property. Because the adjacent riparians are being damaged more than they would be without the structure they would not be assessed the cost of putting their land in the condition that would have existed without the structure.

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5 See note 2, supra.

6 See note 4, supra.

7 MSA Sec. 13.700(1)(15); MCLA Sec. 322.709-715.

8 MSA Sec. 11.475(1)-(15); MCLA Sec. 281.951-965.

9 MCLA 41.721; MSA Sec. 5.2770(51).

(b) How to Enforce Payment of Assessments Where the Improvement and/or the Benefited Land Has Ceased to Exist Due to Erosion

This problem is not a major one, first, because it is unlikely to happen, and second, because the assessments can be expressed in such a way as to protect the township's right to payment. Erosion control structures are commonly built to protect the land from all except the 200 year event, the storm with the combination of wave height and lake level, likely to occur once in two hundred years. This does not mean that it will not happen in the first year, but only that the structure is high enough and strong enough to cope with lesser storms, if adequately maintained. Even if the 200 year event comes at any time before the structure is paid for, it will be partially effective in preventing erosion. Although the structure itself may need maintenance thereafter, it should not be totally destroyed. So although both the structure and the land may suffer some damage, the damage will be considerably less than that which would have occurred in the absence of the structure. Value will have been received by the benefited land owners and the assessments will have to be paid. The assessment resolution should be worded to make this clear. If the notice provisions of the statute Sections 4[10] and 4a[11] are followed, responsibility of the individual property owners for their assessments will be assured.

Until fully paid the assessments constitute a lien against the benefited property. Consequently no owner can sell or transfer the property without discharging the lien. The lien gives the township security for the investment in the improvement. Only in the unlikely event that the structure fails

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10 MCLA Sec. 41.724; MSA Sec. 5.2770(44).

11 MCLA Sec. 41.724; MSA Sec. 5.2770(54)(a).

miserably as a result of a 200 year event before the assessment is fully paid, and the land is completely eroded away, will the lien be unenforceable. The assessment fees will still be owed, but they cannot be collected through the lien process.

(c) The Effect of Recent Tax Limitation Amendments on P.A. 148 of 1976.

The tax limitation amendments to the Michigan Constitution passed Nov. 7, 1978, and effective Dec. 22, 1978 bring into question the ability of a township to issue bonds or assess the cost of improvements against the benefited properties. For our purposes the operative provisions are the mill limitation section[12] for ad valorem property taxes, the general property, local, and state taxation and spending limitation section,[13] which states in part:

> "Property taxes and other local taxes and state taxation and spending may not be increased above the limitations specified herein without direct voter approval . . . "

and the local government provision.[14]

This latter section contains an exemption for bonds issued before the amendment became effective:

> "The limitations of this section shall not apply to taxes imposed for the payment of principal and interest or other evidence of indebtedness or for payment of assessments on contract obligations in anticipation of which bonds are issued which were authorized prior to the effective date of this amendment."

Clearly assessments to pay for bonds issued before Dec. 22, 1978 are valid. Assessments to meet the principal and interest on bonds issued since that date are not valid "without the approval of a majority of the qualified electors of that unit of Land Government voting thereon."[15]

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12 Article 9 Sec. 6.

13 Article 9 Sec. 25.

14 Article 9 Sec. 31.

15 ibid.

Article 9 Section 6 has a provision exempting special assessments from the provisions of sections 25-34, but also requiring voter approval:

> "The foregoing limitation shall not apply to taxes imposed for the payment of principal and interest on bonds approved by the electors or other evidences of indebtedness approved by the electors or for the payment of assessments or contract obligations in anticipation of which bonds are issued approved by the electors, which taxes may be imposed without limitation as to rate or amount; or subject to the provisions of sections 25 through 34 of this article, to taxes imposed for any other authority, the tax limitations of which are provided by charter or by law."[16]

Subject to voter approval of the special assessment, the township can approve and implement improvements under the act[17] without regard to the tax limitation provisions of Article 9 Sections 6 and 25-34 of the Michigan Constitution of 1963. What constitutes voter approval? Although the amendments are silent on the question, the legislature is authorized to implement the Amendment.[18] In the absence of further amendments to the statute, the voter approval must be that required in the petition section of the act.[19] Signatures of the record owners of at least 51% of the area in the special assessment district are required before the project can be approved and implemented by the township board.

With the recent constitutional amendments, it is doubtful that the township boards will be able to initiate improvements without a petition signed by the record owners of 51% of the subject land. Township attorneys would be well advised to require petitions in all special assessments for improvements under this statute. This reservation would not apply were the township able to assess the benefited properties and stay within the applicable tax limitation provisions.

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16 Article 7 Sec. 6.

17 MCLA 41.722; MSA Sec. 5.2770(52).

18 Article 9 Sec. 34.

19 MCLA Sec. 41.723; MSA Sec. 5.2770(53).

3.3. Economic Considerations

One of the critical considerations when evaluating a community erosion protection system is whether the project is economically feasible. This requires that the cost of the protection system be justified in terms of property value saved from erosion. If the protective structure prevents substantial property losses that would have occurred without it, the project may be economically desirable. The methodology used to determine economic feasibility is discussed in the following section.

One of the reasons for selecting a community protection system as opposed to each property owner undertaking his/her own course of action is economic. First of all, there may be substantial savings from building one large structure instead of many individual structures. The cost per front foot of one large structure should be considerably less, although this will vary with the type of structure chosen. Second, the ability to borrow the necessary funds through municipal bonds may allow many shoreline property owners to afford a protection structure that is very effective in preventing rapid erosion over a long period of time. Whether or not these economic advantages are great enough to justify a community structure depends on many factors which will be discussed in depth below.

A word of caution regarding the economic analysis should be made at the outset. The community erosion protection system is evaluated over a thirty year period. Thus, if the project were to be undertaken next year (1980), for example, the analysis involves making projections through the year 2010. It is obvious that no one can predict property values that far in the future, or how much erosion would occur between now and then. Therefore, the specific values that were determined through analysis should only be viewed as illustrative. As will be seen, the decision of whether to build a community protection structure for the study area chosen will not depend on precise values. The uncertainty problem is one that cannot be avoided. Investment decisions for a 30 year period are made every day. The decision makers acquire the most reliable information available and then hope their estimates are not too far off the mark. This is the approach that was taken in this study. It is hoped that the conclusions are a fair indication of what can be expected from a community erosion protection system.

3.3.1. The investment decision model

To assess the economic value of the community erosion protection system, an investment decision model developed at the Coastal Zone Laboratory was used. A detailed discussion of the model is given in Appendix D and in other sources (Armstrong and DenUyl, 1977). The model was specifically developed to determine the benefits and costs of alternative shoreline protection structures.

The benefit derived from building a protection structure is the loss in property value that is prevented through the substantial reduction in the natural rate of erosion. As erosion takes away land and buildings on the property, the value of the property declines. The way in which property value declines as a shoreline lot is eroded has been determined through consultation with real estate analysts, and is shown in Figure 3.3-1 and Figure 3.3-2.

Figure 3.3-1 depicts the decline in the value of a house on a lakeside lot (if any) as erosion reduces the distance between the house and the bluff. For example, when the distance between the house and the bluff is reduced to 100 feet, a prospective buyer would be concerned that the home

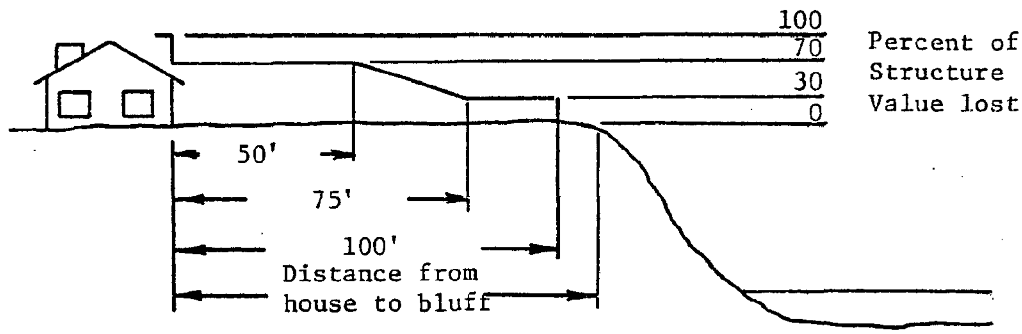

Figure 3.3-1. Percent loss in structure value associated with bluff recession.

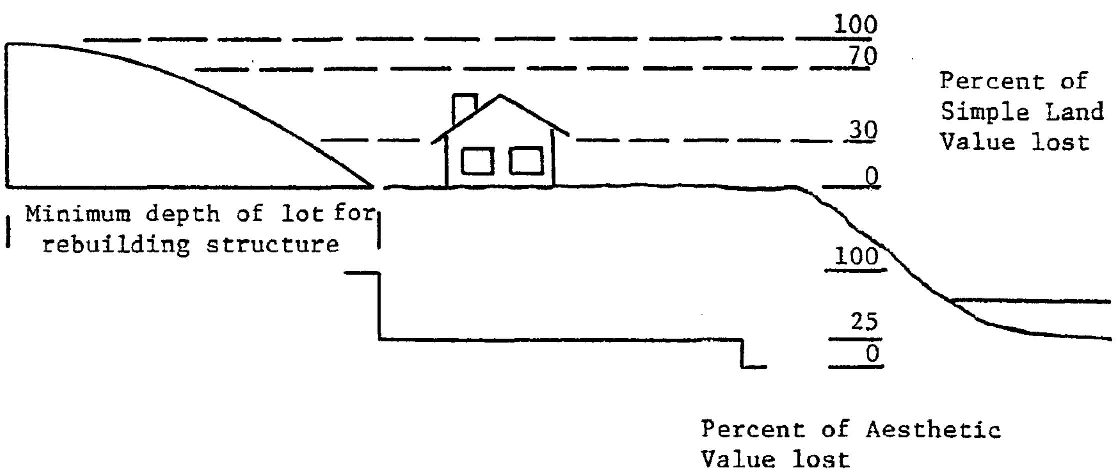

Figure 3.3-2. Percent loss in simple land value and aesthetic value, associated with bluff recession.

could be in jeopardy in the not too distant future. Therefore, the market value of the house would decline by approximately 30 percent. When the distance between the house and the bluff is reduced to 75 feet through erosion losses, the market value will begin to decline at a rapid rate. When only 50 feet separates the house from the bluff, a buyer would not be able to obtain a mortgage from a bank, because the bank would believe that the loan is too risky. By that time 70 percent of the value of the house is lost. The remaining 30 percent is lost when the edge of the bluff reaches the house. The actual distances will vary, depending on the area and the erosion rate. The distances selected for the study area differ from those shown in Figure 3.3-1, and are discussed in the following section.

The other component of the total value of the property is the market value of the lot. Properties bordering the shoreline are considerably more expensive than lots of the same size located away from the shore. This additional value of lakeside lots is separated from total land value for the purposes of the model, and is termed the "aesthetic value". The residual value is referred to as the "simple land value". The way that these values decline as the lot is eroded is shown in Figure 3.3-2. Approximately 25 percent of the aesthetic value is lost when the vegetative cover of the bluff is eroded. The remaining 75 percent of the aesthetic value is not lost until the lot is no longer deep enough to build on. In essence, as long as a house can be located on a lakeside lot, most of that additional value is retained. The simple land value also begins declining when the lot no longer has enough area on which to locate a house.

This distribution of lakeside property value is the basis for determining the benefits of a shoreline protection structure. A protection structure will reduce the rate of erosion that would have occurred in its absence. Therefore, it prevents a decline in property value. For example, suppose a house is currently located 110 feet from the edge of the bluff, and over the next five years erosion will reduce this distance to 95 feet. From the figures it can be determined that 30 percent of the value of the house (termed the "structure value") and 25 percent of the aesthetic value would be lost. If the structure value is $50,000 and the aesthetic value is $25,000 then a protection structure that is effective in preventing this erosion would save $21,250 in lost property value.

To determine whether a protection structure is economically justified the model takes the cost of the structure along with estimates of how many feet of erosion it will prevent over its effective life and compares this with the estimate of property value loss prevented. A discount factor is also applied. If the cost of the structure is $15,000 and is completely effective in preventing erosion over five years, then the protection structure would be economically justified for the example used above. The same procedure applies to a community erosion protection structure. There is simply more property to protect, and a community structure will usually be more effective than individual protection structures. Complications may arise when deciding how to apportion the cost of a community protection structure between the many properties protected (which is discussed below), but this does not influence the determination of whether the protection structure is economically feasible. This discussion, and much of what follows, is based on previous research wherein the investment decision model was developed from data from Berrien County. For details of the model, the reader is referred to Appendix D and Armstrong and DenUyl (1977).

3.3.2. The case study: Lincoln Township

To determine whether the community erosion protection system is economically attractive for the case study area in Lincoln Township, substantial amounts of information had to be acquired. This information was then used as input to the investment decision model. Employing the logic discussed above, the computer output from the model made an economic evaluation for each property and for the community protection structure as a whole. Note that the potential risk of end-effect damage as mentioned in Section 3.2.6 is not considered because it is assumed that the structures have been designed so as to reduce this risk and that the system is maintained.

The case study area consisted of 27 properties for which market values had to be determined. Unfortunately, there was no available information concerning market values so the assessed value (computed for tax purposes) was utilized. In order to determine the current market value from the assessed value, the assessed value is multiplied by two, and then by the state equalizing value of 1.710665. In several cases the assessed value was not current, so an inflation factor of 10 percent per year was applied. Discussions with township officials and information on recent sales of properties in the area suggested that the actual market value might be higher by approximately 30 percent than the figure obtained from these calculations. Therefore a 30 percent markup was applied.

It was also necessary to determine various distances, including the depth of the lot, the distance from the house to the bluff, the front footage of the lot along the shore and other values. This information was acquired from field surveys and aerial photographs. A long term recession rate of 3.667 feet per year based on data from the Michigan Department of Natural Resources was used.

There were several variables which required some degree of judgement. Two of these involve changes in the distance shown in Figure 3.3-1. The initial 30 percent of structure (house) value lost is said to occur at 50 feet, instead of 100 feet as shown in Figure 3.3-1. The distance at which 70 percent of structure value is lost was changed to 20 feet from 50 feet. These distances were reduced in this case study because a very effective, long-lived protection structure will be in place. With such a structure present, the market would not perceive the house to be in imminent danger until the edge of the bluff was relatively close to the house. Individual protection structures have often been so ineffective that the market will discount property values with the bluff farther away from the house. To reflect this advantage of community protection structures, these distances were reduced in the case study.

Another judgemental variable is the rate that lakeside real estate will appreciate over the 30 year study period. It was assumed that it would appreciate 10 percent per year since, even with a lower inflation rate than currently exists, lakeside land is quite scarce and thus will likely increase in value. The benefits and costs are discounted at 10 percent.

There were three community protection structures that were analyzed (a discussion of their engineering characteristics is contained in Section 3.1. and Appendix B). The first alternative was a series of wooden groins extending along the 6000 feet of shoreline in the case study area. The groins are 80 percent renourished every four years, and 60 percent of the groins must be rebuilt every 10 years. The total cost of the structure including renourishment and rebuilding is $4,964,674. It is this sum that will be sold as bonds (25 year maturity) to pay for the structure. The interest rate on the bonds was set at seven and one-half percent. When this interest is included, the total cost of the structure is $11,134,606. The total cost per front foot of shoreline per year is $74.23

Table 3.3-1. Cost evaluation for artificially nourished wooden groins.

I. Construction, mobilization and demobilization costs:

Structure costs	$689,582
Sand Nourishment cost	$489,600
Total Initial costs	$1,188,452

II. Maintenance Costs:

80% renourishment every 4 years	$391,680/renourishment
Total	$1,426,142
Total maintenance for 30 years	$3,776,222

III. Mortgage costs:

Principal mortgage value = $4,964,674
Interest rate = 7.5%
Maturity = 25 years

$$\text{Total Costs} = (P)\frac{i}{1 - \frac{1}{(1+i)^n}}(n)$$

P = principal mortgage amount
i = interest rate
n = length of mortgage in years

Total costs = $11,134,604

IV. Cost breakdown

Total cost = $11,134,604
= 1,855.77 ($/front foot)
= 74.23 ($/year/front foot)

A large stone revetment was another alternative that was examined. There would be maintenance costs equal to two percent of the initial cost of $569,740. The maintenance costs were inflated at a compounded rate of six percent per year over the 30 years. In the results presented below, it was assumed that maintenance costs would be paid as they were required, and would not be part of the initial debt financed by bonds. The total cost per front foot per year of the revetment is $14.52 (Table 3.3-2).

The final alternative community erosion protection structure was an offshore breakwater. Maintenance charges amount to two percent of the initial cost of $673,018, inflated at six percent per year. The total cost per front foot per year for this alternative is $17.16 (Table 3.3-3).

Alternative protection structures have varying rates of effectiveness. Effectiveness is defined to mean the ability to reduce the erosion rate that would occur in the absence of the structure. If the natural long-term erosion rate is four feet per year, and the structure is 75 percent effective, then the long-term erosion rate with the structure is one foot per year. If it is 50 percent effective the erosion rate is two feet per year. The effectiveness of the structure will decline over time as it is subjected to wave energy, ice, and weathering.

To determine the total recession with and without the structure, the effectiveness must be estimated. For this study, staff experts in coastal engineering and geology determined the likely structure effectiveness and how it would vary over the life of the structure. For the nourished groins there was a ten year cycle in effectiveness. At the beginning of the period the structure was 75 percent effective, but after ten years its effectiveness declined to 40 percent. In the beginning of the eleventh year the structure was rebuilt and the effectiveness was again increased to 75 percent.

Table 3.3-2. Cost evaluation for stone revetment and artificial nourishment.

I. Construction, mobilization and demobilization costs:

Structure costs	\$501,340
Nourishment costs	\$68,400
Total Initial costs	\$569,740

II. Maintenance costs:

2%/year of the initial costs inflated at 6% per year for 30 years.

first year	\$11,395
Total (30 years)	\$900,852

III. Mortgage costs:

Principal mortgage value= \$569,740
(yearly maintenance not included in mortgage)

Interest rate = 7.5%
Maturity = 25 years

$$\text{Total costs} = (P)\frac{i}{1-\frac{1}{(1+i)^n}}(n)$$

P = Principal mortgage value
i = Interest rate
n = Length of mortgage in years

Total cost = \$1,277,793

IV. Costs/front foot

Mortgaged Costs	\$1,277,793
Maintenance	\$900,852
Total	\$2,178,654
	363.11 (\$/front foot)
	14.52 (\$/year/front foot)

Table 3.3-3. Cost evaluation for the offshore breakwall and artificial nourishment.

I. Construction, mobilization and demobilization costs:

Structure costs	$495,418
Nourishment costs	$177,600
Total Initial costs	$673,018

II. Maintenance costs:

2%/year of initial cost inflated at 6% per year for 30 years.

first year	$13,460
Total	$1,064,151

III. Mortgage costs:

Principal mortgage value $673,018
(yearly maintenance costs not included in mortgage)
Interest rate = 7.5%
Maturity = 25 years

$$\text{Total costs} = (P)\frac{i}{1 - \frac{1}{(1+i)^n}}(n)$$

P = principal mortgage value
i = interest rate
n = length of mortgage in years

Total costs $1,509,422

IV. Cost/front foot

Mortgaged costs	$1,509,422
Maintenance	$1,064,151
Total	$2,573,573
	428.93 ($/front foot)
	17.16 ($/year/front foot)

The initial effectiveness of the stone revetment is 95 percent and remains at this level for the first nine years. After 20 years its effectiveness has fallen to 40 percent and is 20 percent by the thirtieth year. The offshore breakwater also starts out at 95 percent effectiveness, but declines to 89 percent after ten years. In 20 years it is 69 percent effective and 49 percent effective in 30 years.

3.3.3. The results of the economic analysis

The investment decision model evaluated the economic worth of each of the alternative community erosion protection structures for each of the properties in the case study area and for the entire structure as a whole. The nourished groins would produce very substantial negative benefits and thus will not be considered. The stone revetment yielded positive economic benefits of $34.25 per front foot, or $205,500 over the 6000 feet of protected shoreline. This means that when all the costs and benefits are considered, the economic benefits of the stone revetment exceed the costs over a 30 year period by $205,500. The offshore breakwater is expected to produce benefits of $22.95 per front foot, or $137,700 in total.

The existence of these positive economic benefits notwithstanding, the community erosion protection system is economically infeasible for the case study area in Lincoln Township. It should be emphasized at the outset that these conclusions only hold true for this particular case study area, and in no way reflect upon the possible economic attributes of community erosion protection systems elsewhere. In fact, the lessons learned from this case study should be quite valuable in selecting other potential sites for community structures.

The reason that positive net benefits are obtained for the structure as a whole (see attached computer printouts Appendix E and tables 3.3-4 and 3.3-5) relates to the existence of one property in the study area that would

3.3-4 Results from benefit/cost model of shoreline recession for the stone revetment option.

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY UNIVERSITY OF MICHIGAN VERSION #2 DECEMBER 1978

STONE REVETMENT - 6000 FT STRUCTURE - 25 YEAR BOND
MEAN BENEFITS FOR PROPERTIES IN REACH

NUMBER OF PROPERTIES PROCESSED = 27 TOTAL LENGTH OF SHORELINE = 4563.00

DPTH =	400.000 - DEPTH OF THE LOT (FEET)		L =	148.000 - FRONT FOOTAGE OF LOT IN (FEET)	
FOUN =	0.0 - DISTANCE FROM FOUNDATION TO BLUFF (FEET)		HOME =	70.000 - DEPTH OF THE HOME (FEET)	
RSET =	140.000 - RECCOMENDED SET BACK DISTANCE (FEET)		FSET =	35.000 - SET BACK IN FRONT OF HOME (FEET)	
H =	55.000 - HEIGTH OF THE BLUFF (FEET)		TH =	0.637 - ANGLE OF THE BLUFF (RADIANS)	
TV =	22200.000 - LAKESIDE LAND VALUE ($)		LV =	6660.000 - INLAND LAND VALUE ($)	
SV =	45000.000 - HOME OR STRUCTURE VALUE ($)		RESR =	1.000 - RECESSION RATE MODIFIER	
LRES =	3.667 - LONG TERM RECESSION RATE (FEET/YEAR)		AEST =	15540.000 - ASTHETIC VALUE ($)	
COST =	6000.000 - COST TO MOVE HOME ($)		RI =	0.100 - DISCOUNTING RATE	
REST =	20.000 - REALTORS ESTIMATE OF BANK (FEET)		A =	0.500 - WEIGHTING FACTOR	
MLT1 =	2.500 - WEIGHTING FACTOR		MLT2 =	0.500 - WEIGHTING FACTOR	
T =	30.000 - INVESTMENT HORIZON (YEARS)		PLV =	245.000 - DISTANCE FROM ROAD TO SETBACK (FEET)	
BANK =	23.750 - POINT WHERE MORTGAGE BECOMES UNAVAILABLE		STPL =	50.000 - POINT OF SHARP STRUCTURE VALUE DECLINE	
STPB =	36.875 - 1/2 WAY BETWEEN BANK AND STEPL (FEET)		BASE =	74.335 - LENGTH OF THE BLUFF BASE (FEET)	

INPUT PARAMETERS					OUTPUT PARAMETERS									
AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	14.52	0.950	0	2.50	0.13	0.01	0.01	14.52	14.52	-14.51	41.48	41.48
3.90	.100	14.52	0.950	1	6.40	0.32	3.89	3.90	13.20	27.72	-23.82	3.87	45.35
5.40	.100	14.52	0.950	2	11.80	0.59	19.24	23.14	12.00	39.72	-16.58	19.21	64.56
4.80	.100	14.52	0.950	3	16.60	0.83	26.02	49.15	10.91	50.63	-1.48	25.99	90.55
4.40	.100	14.52	0.950	4	21.00	1.05	30.49	79.64	9.92	60.55	19.10	16.84	107.39
3.90	.100	14.52	0.950	5	24.90	1.25	0.88	80.53	9.02	69.56	10.96	0.86	108.26
3.30	.100	14.52	0.950	6	28.20	1.41	0.96	81.49	8.20	77.76	3.73	-0.96	107.30
2.60	.100	14.52	0.950	7	30.80	1.54	0.01	81.49	7.45	85.21	-3.72	-0.01	107.29
1.90	.100	14.52	0.950	8	32.70	1.64	0.01	81.50	6.77	91.98	-10.48	-0.01	107.28
1.70	.100	14.52	0.950	9	34.40	1.72	0.43	81.93	6.16	98.14	-16.21	0.42	107.70
3.20	.100	14.52	0.900	10	37.60	2.04	1.07	83.00	5.60	103.74	-20.74	1.05	108.74
2.90	.100	14.52	0.850	11	40.50	2.48	12.64	95.63	5.09	108.83	-13.19	12.62	121.36
2.40	.100	14.52	0.800	12	42.90	2.95	0.80	96.44	4.63	113.45	-17.02	0.78	122.15
1.30	.100	14.52	0.750	13	44.20	3.28	0.25	96.69	4.21	117.66	-20.97	0.42	122.57
0.70	.100	14.52	0.700	14	44.90	3.49	-0.02	96.67	3.82	121.48	-24.81	0.23	122.80
1.40	.100	14.52	0.650	15	46.30	3.98	68.58	165.25	3.48	124.96	40.29	69.15	191.94
2.30	.100	14.52	0.600	16	48.60	4.90	-1.08	164.16	3.16	128.12	36.04	-0.01	191.93
2.80	.100	14.52	0.550	17	51.40	6.16	3.47	167.64	2.87	130.99	36.64	-4.97	186.96
2.80	.100	14.52	0.500	18	54.20	7.56	-1.65	165.99	2.61	133.60	32.38	-0.01	186.95
3.30	.100	14.52	0.450	19	57.50	9.38	-5.62	160.37	2.37	135.98	24.39	-0.90	186.05
4.10	.100	14.52	0.400	20	61.60	11.83	0.64	161.01	2.16	138.14	22.87	12.11	198.16
3.90	.100	14.52	0.380	21	65.50	14.25	2.32	163.33	1.96	140.10	23.23	13.59	211.75
4.30	.100	14.52	0.360	22	69.80	17.00	-0.93	162.40	1.78	141.88	20.52	14.98	226.73
4.80	.100	14.52	0.340	23	74.60	20.17	-3.89	158.51	1.62	143.50	15.00	1.15	227.88
5.40	.100	14.52	0.320	24	80.00	23.84	-4.17	154.34	1.47	144.98	9.36	-6.42	221.46
5.40	.100	14.52	0.300	25	85.40	27.62	2.32	156.65	1.34	146.32	10.34	-3.28	218.19
4.90	.100	0.0	0.280	26	90.30	31.15	0.02	156.68	0.0	146.32	10.36	-0.03	218.15
4.60	.100	0.0	0.260	27	94.90	34.56	-0.45	156.23	0.0	146.32	9.91	-0.03	218.12
3.40	.100	0.0	0.240	28	98.30	37.14	33.52	189.74	0.0	146.32	43.42	34.33	252.44
4.40	.100	0.0	0.220	29	102.70	40.57	-8.08	181.66	0.0	146.32	35.34	4.66	257.11
4.20	.100	0.0	0.200	30	106.90	43.93	-1.09	180.57	0.0	146.32	34.25	-0.04	257.07

3.3-5 Results from benefit/cost model of shoreline recession for the offshore breakwater option.

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY UNIVERSITY OF MICHIGAN VERSION #2 DECEMBER 1978

OFFSHORE BREAKWATER - 6000 FT STRUCTURE - 25 YEAR BOND
MEAN BENEFITS FOR PROPERTIES IN REACH

NUMBER OF PROPERTIES PROCESSED = 27 TOTAL LENGTH OF SHORELINE = 4563.00

DPTH =	400.000	- DEPTH OF THE LOT (FEET)	L =	148.000	- FRONT FOOTAGE OF LOT IN (FEET)
FOUN =	0.0	- DISTANCE FROM FOUNDATION TO BLUFF (FEET)	HOME =	70.000	- DEPTH OF THE HOME (FEET)
RSET =	140.000	- RECCOMENDED SET BACK DISTANCE (FEET)	PSET =	35.000	- SET BACK IN FRONT OF HOME (FEET)
H =	55.000	- HEIGTH OF THE BLUFF (FEET)	TH =	0.637	- ANGLE OF THE BLUFF (RADIANS)
TV =	22200.000	- LAKESIDE LAND VALUE ($)	LV =	6660.000	- INLAND LAND VALUE ($)
SV =	45000.000	- HOME OR STRUCTURE VALUE ($)	RESR =	1.000	- RECESSION RATE MODIFIER
LRES =	3.667	- LONG TERM RECESSION RATE (FEET/YEAR)	AEST =	15540.000	- ASTHETIC VALUE ($)
COST =	6000.000	- COST TO MOVE HOME ($)	RI =	0.100	- DISCOUNTING RATE
REST =	20.000	- REALTORS ESTIMATE OF BANK (FEET)	A =	0.500	- WEIGHTING FACTOR
MLT1 =	2.500	- WEIGHTING FACTOR	MLT2 =	0.500	- WEIGHTING FACTOR
T =	30.000	- INVESTMENT HORIZON (YEARS)	PLV =	245.000	- DISTANCE FROM ROAD TO SETBACK (FEET)
BANK =	23.750	- POINT WHERE MORTGAGE BECOMES UNAVAILABLE	STPL =	50.000	- POINT OF SHARP STRUCTURE VALUE DECLINE
STPB =	36.875	- 1/2 WAY BETWEEN BANK AND STEPL (FEET)	BASE =	74.335	- LENGTH OF THE BLUFF BASE (FEET)

INPUT PARAMETERS					OUTPUT PARAMETERS									
AVERAGE ANNUAL *RECESSION* RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE *COST AND* MAINTANCE ($)	PROTECTIVE *STRUCTURE* EFFIC. (%)	YEAR	TOTAL RECESSION *WITHOUT* STRUCTURE (FEET)	TOTAL RECESSION *WITH* STRUCTURE (FEET)	YEARLY *DISC.* BENEFITS ($)	TOTAL *DISC.* BENEFITS ($)	YEARLY *DISC.* COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME *MOVING* BENEFITS ($)	TOTAL HOME *MOVING* BENEFITS ($)
2.50	.100	17.16	0.950	0	2.50	0.13	0.01	0.01	17.16	17.16	-17.15	41.48	41.48
3.90	.100	17.16	0.950	1	6.40	0.32	3.89	3.90	15.60	32.76	-28.86	3.87	45.35
5.40	.100	17.16	0.950	2	11.80	0.59	19.24	23.14	14.18	46.94	-23.80	19.21	64.56
4.80	.100	17.16	0.950	3	16.60	0.83	26.02	49.15	12.89	59.83	-10.68	25.99	90.55
4.40	.100	17.16	0.950	4	21.00	1.05	30.49	79.64	11.72	71.55	8.09	16.84	107.39
3.90	.100	17.16	0.950	5	24.90	1.25	0.88	80.53	10.66	82.21	-1.68	0.86	108.26
3.30	.100	17.16	0.950	6	28.20	1.41	0.96	81.49	9.69	91.90	-10.41	-0.96	107.30
2.60	.100	17.16	0.950	7	30.80	1.54	0.01	81.49	8.81	100.70	-19.21	-0.01	107.29
1.90	.100	17.16	0.930	8	32.70	1.67	0.01	81.50	8.01	108.71	-27.21	-0.01	107.28
1.70	.100	17.16	0.910	9	34.40	1.83	0.43	81.93	7.28	115.98	-34.06	0.42	107.70
3.20	.100	17.16	0.890	10	37.60	2.18	1.07	83.00	6.62	122.60	-39.60	1.05	108.74
2.90	.100	17.16	0.870	11	40.50	2.56	12.64	95.63	6.01	128.62	-32.98	12.62	121.36
2.40	.100	17.16	0.850	12	42.90	2.91	0.80	96.44	5.47	134.08	-37.65	0.78	122.15
1.30	.100	17.16	0.830	13	44.20	3.14	0.42	96.86	4.97	139.05	-42.20	0.42	122.57
0.70	.100	17.16	0.810	14	44.90	3.27	0.08	96.93	4.52	143.57	-46.64	0.23	122.80
1.40	.100	17.16	0.790	15	46.30	3.56	68.81	165.74	4.11	147.68	18.06	69.15	191.94
2.30	.100	17.16	0.770	16	48.60	4.09	-0.62	165.12	3.73	151.42	13.71	-0.01	191.93
2.80	.100	17.16	0.750	17	51.40	4.79	4.14	169.26	3.40	154.81	14.45	-4.97	186.96
2.80	.100	17.16	0.730	18	54.20	5.55	-0.89	168.38	3.09	157.90	10.48	-0.01	186.95
3.30	.100	17.16	0.710	19	57.50	6.51	-0.24	168.14	2.81	160.70	7.44	-0.90	186.05
4.10	.100	17.16	0.690	20	61.60	7.78	10.64	178.78	2.55	163.25	15.52	12.11	198.16
3.90	.100	17.16	0.670	21	65.50	9.06	8.83	187.61	2.32	165.57	22.03	13.59	211.75
4.30	.100	17.16	0.650	22	69.80	10.57	7.99	195.60	2.11	167.68	27.92	14.98	226.73
4.80	.100	17.16	0.630	23	74.60	12.34	7.17	202.77	1.92	169.60	33.17	1.15	227.88
5.40	.100	17.16	0.610	24	80.00	14.45	-3.44	199.33	1.74	171.34	27.99	-6.42	221.46
5.40	.100	17.16	0.590	25	85.40	16.66	-10.57	188.76	1.58	172.92	15.84	-3.28	218.19
4.90	.100	0.0	0.570	26	90.30	18.77	-7.33	181.44	0.0	172.92	8.52	-0.03	218.15
4.60	.100	0.0	0.550	27	94.90	20.84	-22.32	159.12	0.0	172.92	-13.80	-0.03	218.12
3.40	.100	0.0	0.530	28	98.30	22.44	32.95	192.07	0.0	172.92	19.14	34.33	252.44
4.40	.100	0.0	0.510	29	102.70	24.59	4.73	196.80	0.0	172.92	23.87	4.66	257.11
4.20	.100	0.0	0.490	30	106.90	26.74	-0.92	195.88	0.0	172.92	22.95	-0.04	257.07

receive very substantial economic benefits from these protection structures. The property referred to is an apartment complex with a market value estimated to be approximately one million dollars. One set of buildings is only 45 feet from the edge of the bluff, and the other buildings are 95 feet from the bluff. The very high value of the property combined with the buildings' close proximity to the bluff mean that an effective protective structure will yield substantial economic benefits. The model determined that these benefits would be approximately \$4,800 per front foot or \$1,320,000 in total for both the revetment and offshore breakwater. To determine the economic value of the community erosion protection structure over the entire 6000 feet of shoreline, all of the values for each of the properties are averaged together. Since the total value of the revetment for all of the properties is \$205,500. Whereas the total value for the apartments alone is \$1,320,000, many of the other properties must have negative benefits. In a sense then, the one property with the apartments is subsidizing the protection structure for many of the other individual properties. Without the substantial benefits from this one property to pull up the average, the economic worth of the community erosion protection structure would be negative.

It is worthwhile to examine this in more depth. In the case of both the revetment and the offshore breakwater there is only one additional property where the economic benefits of the structure outweigh the costs. This means that 24 of the 27 properties (the apartments are broken into two properties for purposes of computation) in the study area derive negative economic benefits from the protection structures. There are several factors contributing to these negative benefits. First, 12 of the 27 properties, or 44 percent, are vacant lots. In almost any area, the market value of a vacant lot cannot justify the large expenditures required to build a reliable and effective community protection structure. When the lot has a house on it and the erosion moves the bluff back close enough to the house, some structure value is lost. If this occurs with a protection structure present, it is treated as a disbenefit and is subtracted from the other benefits. In the case of these four properties, the disbenefits plus the cost of the structure outweighed the benefits.

It was previously stated that the property with the apartments was implicitly subsidizing the other properties in order for the economic benefits of the community erosion protection structure over the entire study area to be positive. In order for the residents of the study area to adopt the community protection structure, this is exactly what would have to happen. Since all but one of the other properties would not be expected to receive positive economic benefits, if the property owners paid the cost of the protection structure fronting their property, they would be unlikely to agree to undertake such a project. Only if a substantial portion of the cost were paid by the owners of the apartments would most property owners in this study area find it beneficial to vote for the community erosion protection system. There may be cases where it would benefit one or several of the property owners to pay more than the cost of the structure fronting their property. Usually this situation would occur when the net benefits of a community protection structure are much greater than those expected from an individual structure.

These points raise another very crucial issue which has not been discussed. Even if the benefits for a community structure turn out to be positive, it does not imply that such action should be undertaken. There may be other alternatives with much greater benefits that should be considered.

The objective is to select the alternative with the greatest net benefits. For the apartments in the case study, the community protection structure may be the best alternative if the apartment owners only have to pay for the cost of the structure fronting their property. If, in order to induce others to participate in the project the owners would have to pay more than this cost, it might be more economically advantageous to build an individual protection structure in front of their property. Not all alternatives were considered in this analysis, but it is clear that a community erosion protection structure would not be a feasible alternative along this reach.

3.3.4. Criteria for economic feasibility

It is apparent that a community erosion protection system located in the case study area in Lincoln Township would not be economically feasible. In some respects however, the case study area was a very good choice for analyzing community protection systems. It enabled the study team to determine what the characteristics of an area would be where the idea might be economically attractive.

One of the most important characteristics would be an area where the proportion of vacant lots is quite small. As pointed out above, it is difficult to justify the high costs of an effective community protection structure with the benefits accruing to vacant land. Also, the houses cannot be in either imminent danger of falling over the bluff or set so far back from the bluff that erosion is not a problem. It is not crucial that the value of the house be extremely high, although many small cottages might reduce the benefits derived. It is important that the value of the homes as well as their distances from the bluff not vary too widely. This would induce high acceptability on the part of some property owners and opposition from others. The next section discusses this point in depth.

The analysis has also pointed out desirable attributes of community erosion protection structures. It is important that the maintenance costs are not substantial. If they are too high to be paid as they are needed, it would be necessary to include such charges in the initial debt to be bonded. This involves substantial interest costs and raises the ultimate cost of the structure as was the case for the nourished groin system. High maintenance costs that occur throughout the life of the structure are also subject to inflation which may more than quadruple the maintenance costs in the final years as compared to the initial years.

It is also highly desirable that the structure maintain its effectiveness over its life. Of course, the cost of a highly effective structure may be quite high or involve significant maintenance costs which were already shown to be undesirable. So there is a tradeoff involved. The tradeoff being that a highly effective structure will save the disbenefits, but will its cost be greater than the disbenefits it saves. Since these disbenefits can be very significant it may pay to invest initially in a more durable structure.

3.3.5. Allocation of the cost of a community shoreline protection system

The discussion thus far has assumed that the amount each property owner would pay for the cost of the community protection structure depends on the front footage of their property. If the cost is $20 per front foot per year and the front footage of an individual's property is 100 feet, they would pay $2,000 per year. This method may not be the most desirable method of allocating the cost. This section will discuss this problem in depth using a hypothetical example to simplify the explanation. Since this issue is intimately related to legal questions, the reader is also referred to the section dealing with the legal aspects of community erosion protection systems.

Act No. 148 of the Public Acts of 1976 states: " . . . the total amount to be assessed against each parcel of land, which amount shall be the relative portion of the whole sum to be levied against all parcels of land in the special assessment district as the benefit to the parcel of land bears to the total benefits to all parcels of land in the special assessment district."

The act does not specify how the benefits shall be determined. Therefore, this paper will explore several possible methods and examine the effects of each.

<u>3.3.5.1. a method using the investment decision model</u>. Let us first assume that the assessment is based on the benefits of a community structure as determined by the model. Presumably, this would imply that each property owner is assessed that proportion of the cost that he receives in benefits from the project. Suppose the following:

(a) The structure costs $50,000 and is built along a 500-ft reach ($100/linear foot).

(b) Assume that the structure is built at time 0, and that no maintenance is required over its 20-year life. As a result, no discounting of the cost occurs.

(c) The structure protects 4 properties of equal frontage (125 ft). The properties differ, however, with respect to their structure value (one of the residences (B) is a summer cottage approximately 1/2 the value of the others), and the distance between the house and the bluff (one of the permanent residences (D) is set well back from the bluff, but there would be a loss of structure value in the 20-year time frame). The discounted benefits per front foot are given below:

	Property A	Property B	Property C	Property D	Total
Discounted benefits	$145	$95	$120	$105	$465
Percent of total	31.18%	20.43%	25.81%	22.58%	100%
Costs	$124.72	$81.72	$103.24	$90.32	$400
B/C ratio	1.16	1.16	1.16	1.16	--

The results from this hypothetical situation reveal some important insights. First, we have assumed that the project is justified for the community as a whole. That is, the sum of the discounted benefits over the four properties exceed the cost of the community structure. However, this particular structure would not have been justified for property B if the full cost of the structure fronting that property had been paid. When the cost is distributed in proportion to the benefits accruing to each property, the project can be justified for each property so long as the sum of the benefits is greater than the cost for the project. As is evident from the figures, properties A and C are paying in excess of the cost of protecting their respective properties, and are, in a sense, subsidizing part of the cost to B and D. Individually they each receive an equal ratio of benefits to cost under this system.

The implicit subsidization under this method of allocating costs might be objectionable to those paying more than the cost of protection of their property ($100 per front foot). Under current law only the " . . . record owners of 51% of the land area in the . . . assessment district . . ." are required to approve the project. Would we expect all of the property owners to approve this allocation if no special assessment district were available, but these property owners saw the advantage of joint action? If we can show that property owners would voluntarily undertake a similar allocation, then implicit subsidization is not a problem.

It seems apparent from the figures that these four property owners would not undertake such a project if each had to pay the full share of the cost (i.e., $100 per front foot) because the benefits to property owner B are less than $100. Each of the other property owners would be willing to pay $100 per front foot because each receives benefits in excess of that cost. It may be that one or more of the property owners would agree to pay more than their share of the costs so that B would agree to the project. For example, A might offer to pay $110 per front foot so that B would only have to pay $90. Since A's benefit equals $145, A would still significantly benefit from the project, and now that B's cost is less than the expected benefit, B would be likely to approve the project. In reality, actual allocation of the cost would depend upon the relative bargaining strengths of each of the property owners, so there is no reason to expect the same result as we obtained when each payed in proportion to the benefits received. However, it is clear that implicit subsidies would still be likely to result even if participation was voluntary.

The only case in which this result is not likely to occur is if one or more of the property owners could build as beneficial a structure for their own property at less cost than what they would pay for their share of a community project, including any subsidy for other participants. For example, if A could build the structure for less than $124.72 per front foot, and it was as effective as a community structure, it would be more profitable not to participate in the project. Of course, there are usually substantial economies of scale in projects of this type which lower the cost to any individual structure. This situation does bring up the possibility of preferred individual action when the distribution of benefits is significantly different among the potential participants.

3.3.5.2. allocation of costs based on property values. The method of allocating costs of a community shore protection system based on results obtained from the investment decision model has several shortcomings. Most of these relate to uncertainty regarding future rates of erosion and performance of alternative shore protection systems. It is presently not possible to accurately predict rates of bluff recession, and there appears to be a fairly wide variance in both the ability of a structure to protect the bluff, and its expected life. There are, however, advantages when dealing with a community protection system as opposed to individual structures in this regard. Usually a community protective structure will be selected on the basis of its effectiveness over a considerable length of time (e.g., a large rock revetment). Predictions of life and performance of these structures are usually more accurate than for less durable structures which may fail during one large storm. In addition, the long life of community protective structures enables the modeler to have greater reliance on estimates of average rates of erosion over that period. If average rates of recession for an area under consideration have been two feet per year over the past 100 years, the probability that the area will experience recession rates of two feet per year is greater in any 20-year period than in a five-year period. There are problems with using average rates of recession in the model because the net present value (npv) of the benefits is sensitive to the year in which recession occurs. If all of the recession occurred in the last five years of a 20-year period as opposed to the first five years, but the average over 20 years was equal, the npv would be greater in the case where recession was in the first five years.

Given the various uncertainties inherent in the investment decision model, the distribution of the benefits, and hence, the allocation of the costs, may be misrepresented. A more "concrete" approach might be to allocate the costs in proportion to the values of the properties protected.

Since benefits are greatly influenced by the value of property protected, this may seem like an appropriate approach. We will examine the implications of this approach by providing another hypothetical example. The data will be the same as in the previous example, except that we will now specify the value of the properties. To simplify the example, we will assume that the value of A and C are equal to $125,000 and the value of B and D are equal to $100,000.

There are several ways in which the value of two properties could be equal and receive different benefits from a protective structure. In this example we assume that the house on property C is much farther inland from the bluff than is the house on property A. Therefore, A has a more immediate need for protection and accordingly, higher net present value of the benefits. The situation at B is one where there is a very large lot that has a cottage of relatively low value compared to D, for which the greatest value of the property is accounted by the home. Both residences on B and D are an equal distance from the bluff. Even if a large proportion of the structure value of B is lost through recession, a large proportion of the total value is retained because most of the aesthetic and simple land value remains. For D, the loss of structure value is more critical.

To determine the results of allocating the costs on the basis of property value in this example, the following figures are given (including those from the previous table):

	Property A	Property B	Property C	Property D	Total
Discounted benefits	$145	$95	$120	$105	$465
Percent of total	31.18%	20.43%	25.81%	22.58%	100%
Costs (per front ft)	$124.72	$81.72	$103.24	$90.32	$400
B/C ratio	1.16	1.16	1.16	1.16	--
Property value	$125,000	$100,000	$125,000	$100,000	$450,000
Percent of total	27.78%	22.22%	27.78%	22.78%	100%
Costs (per front ft)	$111.12	$88.88	$111.12	$88.88	$400
B/C ratio	1.30	1.06	1.08	1.18	--
Percent Δ in B/C ratio	+12.07%	-8.62%	-6.90%	+1.72%	--

What is immediately apparent from these results is the change in the allocation of the costs and the resulting change in the benefit cost ratio. No longer is the "amount assessed against each parcel of land . . . (in proportion to) . . . the benefit the parcel of land bears to the total benefit to all parcels of land . . ." as the law requires. Property C pays the same proportion of costs as A, even though the benefits to C are less. More serious is the prospect that the benefit cost ratio for one or more properties could be negative if costs are allocated on the basis of property value. The example could be easily altered to demonstrate this possibility without making the numbers unrealistic. A negative benefit cost ratio for any of the properties is not possible using the method of allocating costs in proportion to the benefits as long as the benefit cost ratio for the entire project is greater than one.

One of the problems of using the investment decision model that was discussed above was the uncertainty regarding future recession rates and structure performance. The property value approach does nothing to resolve or improve upon this problem. It would be pure chance that this method resulted in an allocation of costs more closely approximating the benefits than the investment decision model. Since benefits from a protective structure are not solely a function of total property values, there is no logical reason why the property value approach would allocate costs in proportion to the benefits. The only reason why the property value approach might be used is that it is simple and ensures that those owning more valuable property pay a greater percentage of the cost.

<u>3.3.5.3. cost-determined allocation</u>. The simplest approach to determining the allocation of the cost of a community protection system would be to have each property owner pay for the cost of the structure fronting that property. For example, if the cost of the structure per front foot was $100 and a property owner had 125 feet of lake frontage, he would pay $12,500. Another owner with 150 feet would pay $15,000. This method avoids any uncertainty as the the distribution of the benefits, bad feelings about implicit subsidization and the like. Of course, this method implies that costs are equal to benefits in every case, which is not likely to be true. A more serious problem is that a community of shoreline residents would be less likely to adopt a community protection system under this method of allocation unless most property owners perceived benefits in excess of costs. In the case where homes were not in immediate jeopardy, were of relatively low value, or where the value of the lot per front foot was not great, property owners might feel the benefits do not justify the costs and prefer individual approaches.

3.4. Environmental Considerations

The near shore aquatic environment of Lake Michigan is important enough to be considered in the evaluation of any community erosion protection system (CEPS). An evaluation should examine the aquatic and terrestrial ecosystems both prior to, during, and after the construction of the CEPS at both the construction site and the site where nutrient sand is obtained. If the project reaches the implementation phase and, depending on the location of the project (on the beach or in the water), environmental impact statements may have to be prepared for the U.S. Army Corps of Engineers and/or the Michigan Department of Natural Resources.

It should also be noted that these studies are both site and project specific studies. The environmental considerations regarding an offshore breakwater will be much different than a revetment, while a groin system and Headlands Park may have similar characteristics and therefore similar environmental considerations. Because of this, no attempt was made to develop actual environmental impact statements for the possible CEPS presented as examples. Instead a general discussion of the environment along the southeast coast of Lake Michigan and the environmental impact statement process is presented in order to point out areas which may be of major concern in the feasibility analysis of CEPS.

3.4.1. The coastal environment

Water Quality

The local water quality will be subject to temporary deterioration due to construction of protection structures and sand nourishment. Construction activities create a disturbance of sediment which results in the suspension of particles and increased turbidity. The immediate effect of turbidity is to reduce light transmission and, thus, reduce photosynthesis.

The duration of increased levels of turbidity and subsequent lower levels of photosynthetic activity will not persist for a long period because the settling rate of sand particles is high causing the turbidity to drop quickly. This will be most noticeable in the calmer water offshore where wave action does not naturally stir up the sediments.

Another possible effect resulting from the resuspension of sediments during construction or discharge of fill for the headlands and offshore breakwater is the depletion of oxygen because of an increased chemical oxygen demand as organic material is introduced into the water column. The range of values for organic content in silty sand and sandy sediments of Lake Michigan were observed to range from 0.4% to 0.22% of the total composition for sand and 0.16% to 0.71% for silty sand (Lewis and Herdendorf, 1976). These levels of organic content are not expected to cause a significant increase in the demand, but care needs to be taken in the selection of a fill material used for the Headland.

A variety of chemicals can be released from the sediments into the water column during construction. Among those chemicals with potential for release are metals, e.g. Mn, Fe (Sly, 1977), nutrients such as phosphorous (Sly, 1977) and pesticides which are chlorinated hydrocarbons (IWGACPDA, 1975). The composition of the sediments being disturbed determines the level and nature of the chemicals that may be released into the water column. For this reason, because there are no sources to introduce pollutants into the sediments within the study area, degradation of water quality by contamination from released sediment constituents is not expected to by significant.

The impact described above, though short term and localized, will exist for the length of the construction period, which may be weeks. If they become a problem, as indicated by dissolved oxygen and chemical oxygen demand tests, they can be mitigated to a great degree by turbidity curtains and filters.

Littoral Processes

Although the major objective of a CEPS is to reduce the erosion of the natural bluffs and beaches, a project which accomplishes this objective could have a detrimental environmental effect on shoreland properties downdrift of the project. The interruption of the updrift sand caused by a CEPS could, due to complicated interrelationships of near shore energy flux, sediment budget, and transport mechanisms, cause the beaches and bluffs downdrift of the structures to be eroded at a faster rate. This is a definite potential impact which, if it occurs, must be compensated by the design of the structure or mitigated by some sort of action such as artificial nourishment. This has been attempted in this study (See Sec. 3.1 & App. B).

Aquatic Environment

The construction of a CEPS and associated nourishment could cause the destruction of benthic organisms, immobile fish fry, and other fauna directly under the structures or nourishment. The more mobile organisms will move away from the disturbance or in the case of thin layers of nourishment migrate up through the sediments, but most will be lost. The rate at which the communities recover from the disturbance will be dependent on the recolonization rate of each species, and the rate at which the water quality returns to a favorable environment. If the size and composition of the sediment used for nourishment differs greatly from the naturally occurring substrate, it is possible that there could be a change in the species composition of the benthos. Because material used for nourishment will still have grain sizes and composition within the sand class, no change in the community composition is expected.

The most direct effect of construction activities on plankton is that of turbidity and the suspension of sandy sediment. As discussed above the turbidity generated by construction activities tends to inhibit photosynthetic rates within the immediate vicinity of the activity. Fortunately, suspension of particles is of a short duration because large particles such as sand tend to settle quickly and, therefore, will likely have little effect on the phytoplankton community (Herdendorf and Cooper, 1975 or O'Connor and Sherk, 1975).

The zooplankton have not been adequately studied in the nearshore regions of the Great Lakes and, thus, it is difficult to evaluate the effects of CEPS on this community. Studies conducted on the feeding behavior of estuarine copepods, Ascartia tonsa and Eurytemora affinis, indicate that both species are adversely affected by suspended solids of the silt size range as they tend to accidently or purposely (for E. affinis) filter non-nutritious particles (O'Connor and Sherk, 1975). It can be safely assumed that filter feeding zooplankton of the nearshore waters of Lake Michigan within the immediate vicinity of the construction operations would also be adversely affected by the resuspension of silt from the sediments and this effect should endure for as long as construction activities continue.

A CEPS would most directly affect fish species by: 1) the suspension of solids; 2) the possible disturbance of fish feeding areas; and 3) the possible destruction of spawning grounds, eggs, and larvae. The fish most directly affected in terms of spawning is the alewife, which spawns in the spring in sandy and gravelly substrates along the beach at night (Scott and Crossman, 1973). Other fish species, however, may be affected in their feeding and diet by the removal of benthic macro-invertebrates due to the CEPS. The duration of this decrease in food would be as long as the time required for recolonization of the benthic community.

The resuspension of sediments could impair respiration of fishes from entrapment of suspended solids by their gills. This is not expected to be much of a problem due to the depth of water involved and because most of the adult fish will leave the area during construction. But if it were to become a problem, the filter feeding fish species would be the groups most susceptible to this respiratory problem.

Short term non-aquatic impacts associated with the construction of a CEPS can also be expected. These include increased noise and dust levels, possible traffic congestions and general inconveniences. There would be some temporary loss of recreational opportunity during construction of the project, and if the project were large enough an increased demand on harbor facilities because of construction related vessels. These impacts have no residual effects and because they are mainly an inconvenience to the public and not an impact on the environment, they are not expected to be a strong factor, assuming the general public is in favor of the CEPS.

The source area of sand to be used in beach nourishment will be subject to environmental impact and should be included in the environment assessment process to determine the extent and magnitude of possible impact. If this material were to come from a local source, the environmental effects of that action would have to be addressed along with the legal problems associated with the removel of dune sand.

3.4.2. Environmental assessment procedures

There are both federal and state regulations which control the construction of projects within the coastal environment. The legal aspects of these regulations are presented in Section 3.2.5. This section will address the content of environmental assessments as they pertain to a Community Erosion Protection Structure (CEPS).

Not all community erosion protection projects will be required by the permitting agencies to submit an Environmental Impact Statement (EIS) or an Environmental Impact Assessment (EIA). This will be determined by the permitting agencies depending on the complexity of the project and its potential for environmental degradation. In order to cover the major aspects which may have to be addressed, the more complex EIS was chosen for discussion in this phase of the project.

An environmental impact statement must address both the beneficial and adverse impacts of a project on the local environment. In order to determine the impacts, which are defined as changes from the natural case, two areas of concern must be addressed. First, a comprehensive evaluation of the local environment must be made which will define both the existing conditions and expected changes to these conditions that would occur with no structure. Secondly, a detailed description of the expected deviations from the natural trends which are caused by the structure must be made. This information will allow definition of the environmental impacts expected by the project. Table 3.4-1 presents a general list of possible areas of concern which could be addressed by the assessment team evaluating a CEPS (Chicago Lakefront Demonstration Project Phase 2 report, 1977).

Once the impacts are determined, they must be evaluated as to their significance. This should be done in a quantitative manner using test results and standards set up by local, state, and federal regulatory agencies. These evaluations must also address the duration of the impacts. The permanence of certain environmental impacts, such as the loss of irretrievable resources, requires that the long term and short term effects of a project be analyzed. Short term impacts are generally those which are associated with the construction phase of the project or effects which will not last long after completion of the project.

Table 3.4-1. Major areas of concern which should be considered in the development of an Environmental Impact Statement.*

PHYSICAL ENVIRONMENT

(1) Geologic Setting

(2) Atmospheric Setting

(3) Hydrologic Setting

(4) Littoral Setting

(5) Aquatic Ecosystem

(6) Terrestrial Ecosystem

SOCIAL ENVIRONMENT

(1) Privacy

(2) Public Health and Welfare

(3) Recreational Opportunities

(4) Needs of User Populations

(5) Needs of Special Populations

ECONOMIC ENVIRONMENT

(1) Property Values

(2) Resources and Labor

(3) Fiscal Structure and Stability (Public)

(4) Priorities of Public Expenditures

CULTURAL RESOURCES

(1) Historic Preservation Values

(2) Archaeological Preservation Values

(3) Aesthetic Form and Values

* Source: Chicago Lakefront Demonstration Project Phase 2 report December 1977

Once the impacts have been defined and evaluated an assessment of the unavoidable adverse environmental impacts of the project must be made. These are impacts which cannot be avoided by an alternative design or mitigated by some sort of corrective action. All CEPS will have some unavoidable effects which must be quantified and added to the cost when doing the benefit-cost analysis. Some of these will be minor, short term impacts such as turbidity, dust, noise, etc. and will have little effect on the overall benefit or worth of a project. While others may be major impacts such as the destruction of a spawning bed or the loss of the recreational value of the beaches, as in the case of a seawall, and may deem the project unbeneficial even though the benefit-cost ratio is positive.

Finally, an EIS should also recommend alternatives to the proposed CEPS. These should include alternative designs, new zoning ordinances, and "no action" alternatives.

4.0. CONCLUSIONS AND RECOMMENDATIONS

4.1. Conclusions

- From the engineering perspective it is possible to build an effective shoreline protection structure.

- In order to decide between the possible structures, a detailed feasibility study must be conducted. At a minimum this feasibility study should look at the engineering, economics, legal, and environmental aspects of the project.

- P.A. 148 (1976), as it exists, is not sufficient to allow the implementation of a community erosion protection system (CEPS). Specifically, the following problems were discovered:

  1) Due to the unique nature of shoreline erosion the calculation of benefits received cannot be based solely on either the land area or shoreline frontage benefited.
  2) There is no existing mechanism which allows the funding of the required initial feasibility study.
  3) The Act does not address several other problems such as liability for end effects damage, how to enforce payment of assessments when the benefited land has ceased to exist due to erosion, and responsibility with respect to existing structures.
  4) There is no mechanism to account for parcels that already have implemented costly shore erosion control structures.

- A project of this nature will require several permits as outlined in Section 3.2.5.

- A CEPS along this study reach is not economically feasible, because most of the positive net benefits are attributable to a single property.

- Several desirable characteristics needed to make a CEPS more economically attractive were discovered:

  1) The amount of vacant land along a project reach should be a minimum.
  2) The number of land uses within the project reach should be as low as possible. That is, only public and residential, just residential, just commercial, or etc. Mixing of land use types can lead to a single parcel supporting the project when it might not otherwise be economically justified.
  3) Property structures should be located neither too close nor too far from the eroding bluff, and these distances must be determined on a project by project basis. Although there are no hard

rules on what is too close or too far, a few general guidelines can be suggested:

a) structure distances may be mixed, but no more than 10% of the involved structures should exceed the guidelines;
b) a structure may be considered too close to the bluff edge when the structure value cannot be maintained; i.e., when more that 30% of the structure value has already been lost (which is usually equal to 5 times average annual recession rate);
c) a structure may be considered too far if it is located farther back than 45 feet from the edge of the bluff.

4) At present there exists no fair and standardized method for calculating the benefits as required by the Act.

- The economic conclusions apply <u>only</u> for the study reach. They do <u>not</u> apply to other reaches other than to show the necessary characteristics, as outlined above, which would make a CEPS more feasible economically.

- A CEPS which is located in the shallow coastal waters of Southeastern Lake Michigan is expected to have little or no long term environmental impacts and only minor short term impacts. The potential short term impacts expected are:

1) Increased turbidity and a temporary decrease in photosynthesis.
2) The potential destruction of benthic organisms, fish fry and other fauna located under the structure and nourishment.
3) The potential disturbance of fish feeding areas and possible destruction of spawning grounds, eggs and larvae.

NOTE: The effects of these potential localized disturbances on the larger ecosystem have not been determined by study, but they are felt to be acceptable.

- If the concerns raised during this study are resolved, then the economy of scale and increased effectiveness of protection may make a community erosion protection system an attractive alternative to individual actions by each separate property owner.

4.2. Recommendations

- Prior to implementation of a CEPS a detailed engineering feasibility analysis must be conducted and must address, at a minimum, local wave conditions, local climate, beach and bluff geology, and construction material type and costs.

- Act 148 should be readdressed to allow funding of the feasibility analysis, specify a fair and rational mechanism for computing the assessment distribution (Section 3.2.4. discusses a possible mechanism), as well as other problems mentioned in the conclusions.

- As part of the implementation of a CEPS, and in order to properly determine the economic feasibility of a CEPS, the local unit of government must determine the following parameters:

  1) True real estate market values of each parcel protected.
  2) Minimum setback distances.
  3) Cost of proposed alternatives, including estimates of periodic maintenance.
  4) Discounting and bond interest rates, and amortization periods.

- Prior to the implementation of a CEPS the local unit of government must develop a set of reasonable and strong zoning ordinances consistent with local and state coastal zone management plans.

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Appendix A

Site Selection

LIST OF TABLES

A.1.0. SELECTION OF A STUDY SITE

The scope of this study is limited to a small scale that could be administered by a township. At the request of the MDNR Berrien County was chosen as a county with significant erosion problems which might possibly be addressed by Public Act 148.

As determination of a specific site is very subjective, an attempt was made to increase the objectivity in the site selection process through the use of a matrix, matching townships with concrete categories that describe the issues to be addressed. Three issues presented in the work statement are economics, socio-politics, and engineering.

Concensus within the CEPSA workgroup at CZL was that the main driving force for a group to undertake a CEPS would be economic. Two economic indicators (property damage and property value) that came to mind were readily available from the recent Great Lakes Damage Assessment Study (GLDAS). Most importantly the people involved must be incurring enough damage to desire a CEPS. Coastal Zone Laboratory Technical Report No. 112 (the GLDAS Project Report) has such a number expressed in dollar damages per foot of shoreline per year (the study period was 9/1/72-9/1/76).

Due to the possible high cost of a CEPS, a group must have the ability to afford a CEPS. Economic value placed on an area was felt to be roughly approximated by the average tax-assessed value per front foot from the CZL TR-112.

A third value felt to be of lesser importance is the ability of the local government to obtain money. This value was related to the municipal bond rating.

Socio-political indicators were much harder to find objectively. To balance subjectivity, we used a greater variety of indicators giving them individually smaller parameters than the economic indicators. The willingness of people to participate in a CEPS was related to their desire to tax themselves and their concern for coastal erosion problems. The best recent indicator of people's willingness to tax themselves was the percent no vote on the Tisch amendment.

Concern for coastal erosion problems was determined by people's willingness to respond to a self-administered survey form during the 1977 GLDAS. Thus, the percent response from GLDAS was used as an indicator of interest in coastal problems.

A CEPS will probably involve different types of land uses; thus, a township with a greater variety of uses (e.g., residential, commercial, parks, etc.) would be preferred. Land use as determined in GLDAS was used.

Mechanisms for aiding implementation of a CEPS (e.g., zoning ordinances) were considered a plus. Townships without such were given a lower rating in this category because they were farther from implementing a successful CEPS. This value was subjective as time did not allow a thorough study of available mechanisms in each township. Consequently, it was rated lower than the three previous socio-political factors.

The most subjective and lowest rated category under socio-politics was the willingness of local government to assist CEPSA and follow up with a CEPS if CEPSA showed positive results. This was inferred through telephone conversations with local officials.

Engineering design factors were felt to be least important of the three areas. CEPSA would only be able to develop a few alternatives for producing rough-cost estimates of a CEPS. Further design would have to be conducted by an engineering firm with experience in the area. Only two parameters were chosen to influence the site selection. A variety of shore types in the study area could increase design problems; however, this variety should make the design alternatives more generalized, thus a greater number of shore types was preferred for CEPSA sites.

The structure would be better used in an area with a higher erosion rate. We used the volume lost per foot of shoreline as determined in GLDAS (CZL TR-112).

Assigning priorities to the various categories was in itself a subjective task depending upon the considerations we felt needed to be looked at by CEPSA. The total number of "points" allotted to each category was the result of several discussions by lab personnel. A set number of points was allotted to each item. Then a relative importance factor was used to determine the final point allotment (see Table A-1). Note that the point allocation procedure was determined before looking at the raw data for townships. Information from GLDAS and other sources is compiled in Table A-2. This was the "raw" data. Table A-3 is the final selection matrix which shows the result of combining Table A-1 and Table A-2.

As an example, the tax-assessed value per front foot from Table A-2 for Hagar Township is $95.72. This would fit into the TAV sub-element $81.00-$95.99, which has a point allocation of 3. The total points for the Hagar Township TAV is calculated by:

multiplier x sub-element points = total points

(1.3) x (3) = (3.9)

This total point value is inserted in Table 3 for Hagar Township TAV.

Lincoln Township has the most total points. This indicates that Lincoln Township will offer a very good study area which has possibility of implementation. This does not say other townships would not have served as a good study area. Rather, the other areas appear after a brief overview to be less likely to fulfill the intent of the study than Lincoln Township.

Table A-1. Selection Matrix: Point Allocations

Category	Element	Multiplier	Sub-element	Points	Total
Economic	Tax Assessed Value (T.A.V.) $/ft. ave.	1.3	> $186/ft	10	13.0
			171-185	9	11.7
			156-170	8	10.4
			141-155	7	9.1
			126-140	6	7.8
			111-125	5	6.5
			96-110	4	5.2
			81-95	3	3.9
			66-80	2	2.6
			51-65	1	1.3
			< 50	0	0
					max=13.0
	Damages from GLDAS ($/ft)	1.4	> $10/ft/yr	10	14.0
			9	9	12.6
			8	8	11.2
			7	7	9.8
			6	6	8.4
			5	5	7.0
			4	4	5.6
			3	3	4.2
			2	2	2.8
			1	1	1.4
			0	0	0
					max=14.0
	Bond rating	1.1	AAA,AA Rating	5	5.5
			A	4	4.4
			BA	3	3.3
			BBB	2	2.2
			BB	1	1.1
			C	0	0.0
					max=5.5
				total	32.5

(continued)

Table A-1. (continued)

Category	Element	Multiplier	Sub-element	Points	Total
Socio-political	Government Interest Willingness to Assist	1.4	Yes	1	1.4
			No	0	0
	Willingness to Follow up	1.4	Yes	1	1.4
			No	0	0
	% No Vote on Tisch Amend.	1.4	75-100%	4	5.6
			50-74%	3	4.2
			25-49%	2	2.8
			0-24%	1	1.4
	% Complete on SDAP	1.4	75-100%	4	5.6
			50-74%	3	4.2
			25-49%	2	2.8
			0-24%	1	1.4
					max=14.0
	Land Use (from GLDAS)	1.2	# of types		
	Residential		5	5	6.0
	Commercial/Industrial		4	4	4.8
	Utilities/Transportation		3	3	3.6
	Agriculture		2	2	2.4
	Others (e.g. Parks)		1	1	1.2
					max=6.0
	Zoning	1.1	Very Good	5	5.5
			Good	4	4.4
			Fair	3	3.3
			Poor	2	2.2
			Very Poor	1	1.1
			None	0	0
					max=5.5
					25.5

(continued)

Table A-1. (continued)

Category	Element	Multiplier	Sub-element	Points	Total
Engineering	Recession Rate ft/yr(av.)	1.1	> 5.0 ft/yr	5	5.5
			4.0–4.9	4	4.4
			3.0–3.9	3	3.3
			2.0–2.9	2	2.2
			1.0–1.9	1	1.1
			0.0–0.9	0	0
					max=5.5
	Shoretype (from Humphries)	1.2	# of types		
	Warren Dunes		6	4	7.2
	Michiana Bluff: River Variation		5	5	6.0
	Michiana Bluff: Lakeside Variation		4	4	4.8
	St. Joseph Bluff: River Variation		3	3	3.6
	St. Joseph Bluff		2	2	2.4
	Hardert Bluff		1	1	1.2
					max=7.2
			Category total		12.7
			Maximum Total Possible:		70.7 points

Table A-2. Site Statistics.

	Local government interest	Damages $/foot/yr	Zoning ordinances	TAV[a] ($/ft)	Types of Shoreland	Average recession rate ft/yr	Bond[b] rating	% no Tisch	% returned on GLDAS	Land Use types
Hagar	yes yes	6.53	fair	95.72	2	1.50	--	56.8	65	5
Benton	yes ?no	.42	fair	117.45	1	1.50	--	59.7	77	4
St. Joseph (Shoreham)	yes ?	3.74	poor	126.62	2	3.54	--	60.2	66	4
Lincoln	yes yes	14.09	very good	154.31	2	3.67	--	60.3	86	5
Lake	yes no	1.18	poor	175.62	1	1.67	--	59.5	58	4
Chikaming	yes yes	1.18	poor	90.42	4	1.75	--	53.4	64	2
New Buffalo	yes yes	5.16	poor	61.20	2	2.76	--	34.7	54	5

[a] TAV/ft- Tax Assessed Value: dollars per front foot of shoreline

[b] No bond ratings available due to low borrowing totals

Table A-3. Selection Matrix: Final Standing.

	Local government interest	% no on Tisch	% return of GLDAS	Damages $/ft/yr	TAV $/ft	Bond rating[a]	Land use	Zoning ordinances	Shore-type	Average recession rate ft/yr	Total
Hagar	2.8	4.2	4.2	8.4	3.9	--	6.0	3.3	2.4	1.1	36.3
Benton	1.4	4.2	5.6	0	6.5	--	4.8	3.3	1.2	1.1	28.1
St. Joseph	1.4	4.2	4.2	4.2	7.8	--	4.8	2.2	2.4	3.3	34.5
Lincoln	2.8	4.2	5.6	14.0	9.1	--	6.0	5.5	2.4	3.3	52.9
Lake	1.4	4.2	4.2	1.4	11.7	--	4.8	2.2	1.2	1.1	32.2
Chikaming	2.8	4.2	4.2	1.4	3.9	--	2.4	2.2	4.8	1.1	27.0
New Buffalo	2.8	2.8	4.2	7.0	1.3	--	6.0	2.2	2.4	2.2	30.9

[a] No Bonding ratings available due to low borrowing totals.

Appendix B

DESIGN CONSIDERATIONS

APPENDIX B

Design Consideration

Table of Contents

PAGE

LIST OF TABLES

LIST OF FIGURES

B.1.0. Introduction

In order to design any shore protection structure, it is necessary first to obtain some information on the waves that are likely to affect the structure. The waves will be the source of the forces that the structure must be designed to mitigate. As the waves change form from "deepwater" (where the water depth is greater than half the wavelength) conditions to "shallow water" (where the water depth is less than 0.05 of the wavelength) conditions, it is necessary to see how they will change, what they will be like at the structure, and where they will break.

Most available wave data represent deepwater conditions. So, it is necessary to theoretically bring the wave in from deepwater to shore. For an actual design, this procedure is accomplished by creating a "refraction diagram" with or without a computer. The refraction diagram shows how the direction of wave travel changes, how the wave energy distribution changes, and how the wave height and length change as the wave moves closer to shore. However, due to the time and cost required to produce the input data, this procedure is rarely carried out for a preliminary study of this nature. The necessary information can be obtained to a first order approximation by a few simplifying assumptions. First, we assume that Airy's Linear Wave Theory is applicable. This assumption is adequate for engineering purposes and introduces only a small error in the design parameters. Second, it is assumed that the offshore topography can be represented by straight and parallel contours. The offshore area at Lincoln Township is reasonably close to this assumption so that it was felt that only minor errors would result for the general case discussed in this report. However, for design of specific sections of the chosen system, should that occur, it is likely that this assumption could introduce considerable error. Finally, it was assumed that the design parameters could be based on a theoretical "design wave", that is, that particular wave which would represent the significant design forces. However, due to the particular setting of the Great Lakes, it would perhaps be better to base the design parameters on the "wave spectra". Unfortunately, the state of the art of coastal engineering has not progressed far enough to allow this. Therefore, this last assumption is required.

The following calculations were based on several references and these will be given as required below. Note that SPM refers to the Shore Protection Manual published by the Coastal Engineering Research Center (CERC) of the U.S. Army Corps of Engineers in 1973.

B.2.0. General Information

B.2.1. The Design Water Level

Standard practice used by the U.S. Army Corps of Engineers in the Great Lakes is to design the structure based on the 200-year event which is a combination of either the 20-year lake level (the lake level likely to occur once in 20 years) plus the 10-year wave or the 10-year lake level and the 20-year wave (Charles Johnson, North Central Division, NCD of the U.S. Army Corps of Engineers, personal communication). For this study, it was decided to use the 10-year lake level plus the 20-year wave as it was felt that the 20-year wave would be more conservative. A more complete analysis would be necessary during design to determine if this decision were correct.

The design water level (also called the still water level, SWL) which is likely to return once in 10 years includes the long term lake level plus the one-year short-term rise (which accounts for the extra depth caused by storms). These data are available from curves published by the Corps of Engineers in Detroit (1979). Thus, for Lake Michigan, 10 yr long-term lake level = 580.0 ft (IGLD, 1955)

1 yr short-term rise = 1.1 ft

SWL = 581.1 ft (IGLD, 1955)

or a 4.3 feet above low water datum (LWD) of 576.8 ft (IGLD, 1955) for Lake Michigan used on the navigational charts for the Great Lakes. For example, if the chart showed the depth of water 400 feet from shore to be 4.0 feet, the design depth would be,

Chart = 4.0 ft

SWL =+4.3 ft

8.3 ft

B.2.2. The Design Wave

The design wave for this study is the wave likely to occur once in 20 years which will be most significant for design. This type of data is available for the Great Lakes in a recent publication by the Waterways Experiment Station (WES) of the U.S. Army Corps of Engineers (WES, 1976). The data are presented in terms of three sectors. For this study, these three sectors were divided into seven directions based on the orientation of the shoreline at Lincoln Township: N, NNW, NW, WNW, W, WSW, SW. The WES data provided the deep-water wave height, H_o (the subscript o indicates deepwater conditions), and the corresponding period, T. The following table gives these data:

Table B-1. Wave heights and period for waves approaching from seven sectors based on the orientation of the shoreline.

Direction	N	NNW	NW	NW	WNW	W	W	WSW	SW
H_o (ft)	18.7	18.7	18.7	17.1	17.1	17.1	8.5	8.5	8.5
T (sec)	10.5	10.5	10.5	10.0	10.0	10.0	7.15	7.15	7.15

The doubling of data at NW and W was necessary due to the directional uncertainty of the WES data in these directions.

Next, the angle of approach of the wave crest with the shoreline, α_o, was determined and these are given in the following table:

Table B-2. Angle of approach of the wave crest with the shoreline α_o.

Direction	N	NNW	NW	WNW	W	WSW	SW
α_o	62.5^o	40.0^o	17.5^o	5^o	27.5^o	50^o	72.5^o

The shoreline orientation of Lincoln Township was assumed to be 27.5^o east of north. Figure B-1 illustrates α_o and shows how the angle α changes from α_o to α at the shoreline (or how the wave refracts):

Next, a series of parameters is calculated which show how the wave changes in order to find the depth where the wave breaks, d_b, and the height at breaking, H_b. The parameters were calculated at particular ratios of the depth, d, to the deepwater wavelength, L_o, as in standard practice. The parameters d/L (L is the wavelength at depth d) and H/H_o' were obtained from Table C-1 of volume III of the SPM. With these parameters the following data were calculated:

d = depth

L = wavelength at that depth, d

α = the angle the wave crest makes with the shoreline at the depth, d

K_R = refraction coefficient (a measure of the bending of the wave crest)

K_S = shoaling coefficient (a measure of the change in wave height)

H = wave height at that depth

H_o' = theoretical wave height that would produce H if there were no refraction (K_R = 1.000)

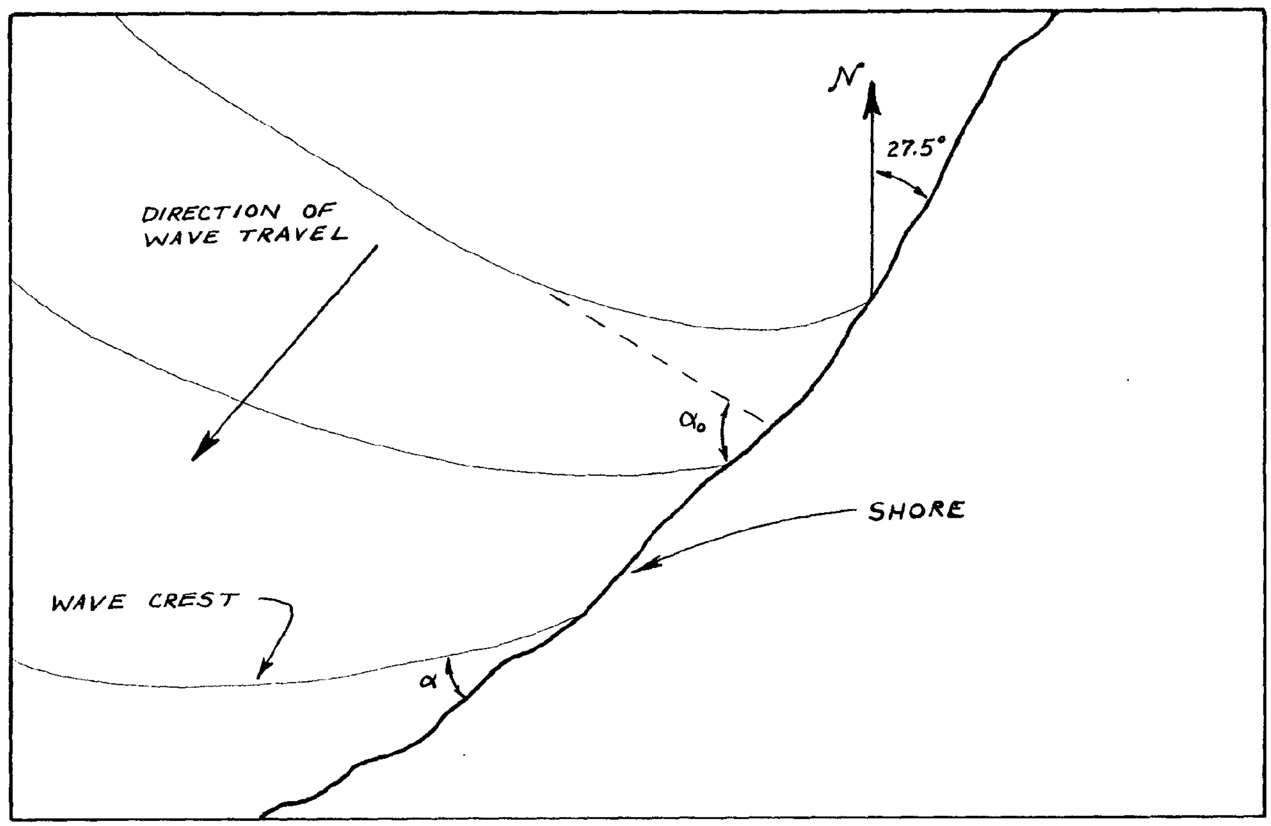


Figure B-1. Wave refraction for various wave crests showing relationship between α_o and α.

$$\left.\begin{array}{l} H_o'/L_o \\ d/H_o \\ d_b/H_o' \\ H_b/H_o' \end{array}\right\}$$ parameters used later to get d_b and H_b.

where

$$L_o = gT^2/2\pi = 5.12T^2$$

$$d = L_o(d/L_o)$$

$$L = d/(d/L)$$

$$\alpha = \sin^{-1}[(L/L_0)\sin\alpha_o]$$

$$K_R = (\cos\alpha_o/\cos\alpha)^{1/2}$$

$$H_o' = H_oK_R$$

$$H = H_oK_R(H/H_o')$$

$$K_s = H/H_o$$

$$d_b/H_o' = [0.106/(H_o'/L_o)]^{0.2}$$

$$H_b/H_o' = [0.031/(H_o'/L_o)]^{0.2}$$

The results of these calculations are presented at the end of this section.

Next, d_b is found by noting where the curve of d/H_o' vs. H_o'/L_o crossed the curve of d_b/H_o' vs. H_o'/L_o. For example, say that the crossing point had the following coordinates:

$$x = d/H_o' = d_b/H_o = 2.56$$

$$y = H_o'/L_o = 0.0240$$

and

$$L_o = 512.$$

Then,

$$H_o' = (H_o'/L_o)L_o = (0.0240)(512) = 12.29$$

and

$$d_b = (d/H_o')H_o' = (2.56)(12.29) = 31.45 \text{ feet}.$$

H_b is found by finding the coordinates of the crossing point of the curves H/H_o' vs. H_o/L_o and H_b/H_o' vs. H_o'/L_o and doing similar calculations as those above. These results are also presented with the wave parameters at the end of this section.

The following table presents a summary of the important wave parameters at breaking:

Table B-3. Summary of important wave parameters.

Direction	α_o	α	H_o	T	L_o	K_R	d_b	H_b
N	62.5	22.5	18.7	10.5	564.5	0.707	18.0	16.0
NNW	40.0	17.4	18.7	10.5	564.5	0.896	21.7	17.1
NW	17.5	8.5	18.7	10.5	564.5	0.982	23.3	18.2
NW	17.5	8.5	17.1	10.0	512.0	0.982	21.2	16.6
WNW	5.0	3.4	17.1	10.0	512.0	0.999	21.5	16.8
W	27.5	12.9	17.1	10.0	512.0	0.954	20.7	16.3
W	27.5	12.9	8.5	7.15	261.8	0.954	10.4	8.2
WSW	50.0	20.4	8.5	7.15	261.8	0.828	9.3	7.3
SW	72.5	22.3	8.5	7.15	261.8	0.570	6.9	5.1

With these data we can now begin the preliminary design calculations. Note that the design wave was not chosen yet. This will depend on the depth of the structure and its determination will be shown with each structure. The design of each structure is discussed separately.

Table B-4. Results of calculations for a wave approaching from the north with an initial height of 18.7 feet.

$H_o' = 18.7$ $\alpha_o = 62.5$ $d_b = 18.0$

$T = 10.5$ $L_o = 564.48$ $H_b = 16.0$

d	d/L_o	d/L	H/H_o' SPM	L	α	K_R	K_S	H	H_o'	H_o'/L_o	d/H_o'	d_b/H_o'	H/H_o'	H_o/H_o'
282.2	0.5	0.5018	0.9905	562.5	62.1	0.994	0.984	18.4	18.6	0.0329	--	1.264	--	0.988
225.8	0.4	0.4050	0.9761	557.5	61.2	0.979	0.955	17.9	18.3	0.0324	--	1.267	--	0.991
169.3	0.3	0.3121	0.9490	542.6	58.5	0.940	0.892	16.7	17.6	0.0311	--	1.278	0.949	0.999
112.9	0.2	0.2251	0.9181	501.5	52.0	0.866	0.795	14.9	16.2	0.0286	6.97	1.299	0.918	1.016
56.4	0.1	0.1410	0.9327	400.3	39.0	0.771	0.719	13.4	14.4	0.0255	3.92	1.329	0.933	1.040
28.2	0.05	0.09416	1.023	299.7	28.1	0.723	0.740	13.8	13.5	0.0240	2.09	1.35	1.023	1.053
5.6	0.01	0.0432	1.435	130.7	11.8	0.687	0.986	18.4	12.8	0.0228	0.44	1.36	1.435	1.064

Table B-5. Results of calculations for a wave approaching from the north northwest with an initial height of 18.7 feet.

H_o = 18.7 α_o = 40.0 d_b = 21.7
T = 10.5 L_o = 564.48 H_b = 17.1

d	d/L_o	d/L	H/H'_o SPM	L	α	K_R	K_S	H	H'_o	H'_o/L_o	d/H'_o	d_b/H'_o	H/H'_o	H_o/H'_o
282.2	0.5	0.5018	0.9905	562.5	39.8	0.999	0.989	18.5	18.7	0.0331	--	1.262	--	0.987
225.8	0.4	0.4050	0.9761	557.5	39.4	0.996	0.972	18.2	18.6	0.0330	--	1.263	--	0.976
169.3	0.3	0.3121	0.9490	542.6	38.2	0.987	0.937	17.5	18.5	0.0327	--	1.265	--	0.989
112.9	0.2	0.2251	0.9181	501.5	34.8	0.966	0.887	16.6	18.1	0.0320	6.25	1.271	0.918	0.994
56.4	0.1	0.1410	0.9327	400.3	27.1	0.928	0.865	16.2	17.3	0.0307	3.25	1.281	0.933	1.002
28.2	0.05	0.09416	1.023	299.7	20.0	0.903	0.924	17.3	16.9	0.0299	1.67	1.288	1.023	1.007
5.6	0.01	0.0432	1.435	130.7	8.6	0.880	1.263	23.6	16.5	0.0292	0.343	1.295	1.435	1.012

Table B-6. Results of calculations for a wave approaching from the northwest with an initial height of 18.7 feet.

$H_o = 18.7$ $\alpha_o = 17.5$ $d_b = 23.3'$

$T = 10.5$ $L_o = 564.48$ $H_b = 18.2'$

d	d/L_o	d/L	H/H'_o SPM	L	α	K_R	K_S	H	H'_o	H'_o/L_o	d/H'_o	d_b/H'_o	H/H'_o	H_o/H'_o
282.2	0.5	0.5018	0.9905	562.5	17.4	0.999	0.990	18.5	18.7	0.0331	--	1.262	--	0.987
25.8	0.4	0.4050	0.9761	557.5	17.3	0.999	0.976	18.2	18.7	0.0331	--	1.262	--	0.976
169.3	0.3	0.3121	0.9490	542.6	16.8	0.998	0.947	17.7	18.7	0.0331	--	1.262	--	0.987
112.9	0.2	0.2251	0.9181	501.5	15.5	0.995	0.913	17.1	18.6	0.0330	6.07	1.263	0.918	0.988
56.4	0.1	0.1410	0.9327	400.3	12.3	0.988	0.922	17.2	18.5	0.0327	3.06	1.265	0.933	0.989
28.2	0.05	0.09416	1.023	299.7	9.2	0.983	1.006	18.8	18.4	0.0326	1.54	1.266	1.023	0.990
5.6	0.01	0.0432	1.435	130.7	4.0	0.978	1.403	26.2	18.3	0.0324	0.309	1.268	1.435	0.991

Table B-7. Results of calculations for a wave approaching from the northwest with an initial height of 17.1 feet.

$H_o = 17.1$ $\alpha_o = 17.5$ $d_b = 21.2'$

$T = 10.0$ $L_o = 512.0$ $H_b = 16.6$

d	d/L_o	d/L	H/H'_o SPM	L	α	K_R	K_S	H	H'_o	H'_o/L_o	d/H'_o	d_b/H'_o	H/H'_o	H_o/H'_o
256	0.5	0.5018	0.9905	510.2	17.4	0.999	0.990	16.9	17.1	.0334	--	1.260	--	.985
204.8	0.4	0.4050	0.9761	505.7	17.3	0.999	.976	16.7	17.1	.0334	--	1.260	--	.985
153.6	0.3	0.3121	0.9490	492.1	16.8	.998	.947	16.2	17.1	.0333	--	1.260	--	.986
102.4	0.2	0.2251	0.9181	454.9	15.5	.995	.913	15.6	17.0	.0332	6.02	1.261	.918	.986
51.2	0.1	0.1410	0.9327	363.1	12.3	.988	.922	15.8	16.9	.0330	3.03	1.263	.933	.988
25.6	0.05	0.09416	1.023	271.9	9.2	.983	1.006	17.2	16.8	.0328	1.52	1.264	1.023	.989
5.1	0.01	0.0432	1.435	118.5	4.0	.978	1.403	24.0	16.7	.0327	.306	1.266	1.435	.990

Table B-8. Results of calculations for a wave approaching from the west northwest with an initial height of 17.1 feet.

$H_o = 17.1$ $\alpha_o = 5$ $d_b = 21.5'$

$T = 10.0$ $L_o = 512.0$ $H_b = 16.8'$

d	d/L_o	d/L	H/H'_o SPM	L	α	K_R	K_S	H	H'_o	H'_o/L_o	d/H'_o	d_b/H'_o	H/H'_o	H_o/H'_o
256	0.5	0.5018	0.9905	510.2	5.0	1.000	.990	16.9	17.1	.0334	--	1.260	--	.985
204.8	0.4	0.4050	0.9761	505.7	4.9	1.000	.976	16.7	17.1	.0334	--	1.260	--	.985
153.6	0.3	0.3121	0.9490	492.1	4.8	1.000	.949	16.2	17.1	.0334	--	1.260	--	.985
102.4	0.2	0.2251	0.9181	454.9	4.4	1.000	.918	15.7	17.1	.0334	5.99	1.260	.918	.985
51.2	0.1	0.1410	0.9327	363.1	3.5	.999	.932	15.9	17.1	.0334	3.00	1.260	.933	.985
25.6	0.05	0.09416	1.023	371.9	2.7	.999	1.022	17.5	17.1	.0334	1.50	1.260	1.023	.985
5.1	0.01	0.0432	1.435	118.5	1.2	.998	1.432	24.5	17.1	.0333	0.30	1.260	1.435	.986

Table B-9. Results of calculations for a wave approaching from the west with an initial height of 17.1 feet.

$H_o = 17.1$ $\alpha_o = 27.5$ $d_b = 20.7$

$T = 10.0$ $L_o = 512.0$ $H_b = 16.3$

d	d/L_o	d/L	H/H'_o SPM	L	α	K_R	K_S	H	H'_o	H'_o/L_o	d/H'_o	d_b/H'_o	H/H'_o	H_o/H'_o
256	0.5	0.5018	0.9905	510.2	27.4	1.000	.990	16.9	17.1	.0334	--	1.260	--	.985
204.8	0.4	0.4050	0.9761	505.7	27.1	.998	.974	16.7	17.1	.0333	--	1.260	--	.986
153.6	0.3	0.3121	0.9490	492.1	26.3	.995	.944	16.1	17.0	.0332	--	1.261	--	.986
102.4	0.2	0.2251	0.9181	454.9	24.2	.986	.905	15.5	16.9	.0329	6.07	1.263	.918	.988
51.2	0.1	0.1410	0.9327	363.1	19.1	.969	.904	15.5	16.6	.0324	3.09	1.268	.933	.991
25.6	0.05	0.09416	1.023	271.9	14.2	.957	.979	16.7	16.4	.0319	1.57	1.271	1.023	.994
5.1	0.01	0.0432	1.435	118.5	6.1	.944	1.355	23.2	16.2	.0315	.317	1.274	1.435	.997

Table B-10. Results of calculations for a wave approaching from the west with an initial height of 8.5 feet.

$H_o = 8.5$ $\alpha_o = 27.5$ $d_b = 10.4'$

$T = 7.15$ $L_o = 261.75$ $H_b = 8.2'$

d	d/L_o	d/L	H/H'_o SPM	L	α	K_R	K_S	H	H'_o	H'_o/L_o	d/H'_o	d_b/H'_o	H/H'_o	H_o/H'_o
130.9	0.5	0.5018	0.9905	260.8	27.4	1.000	.990	8.4	8.5	.0325	--	1.267	--	.991
104.7	0.4	0.4050	0.9761	258.5	27.1	.998	.974	8.3	8.5	.0324	--	1.267	--	.991
78.5	0.3	0.3121	0.9490	251.6	26.3	.995	.944	8.0	8.5	.0323	--	1.263	--	.992
52.3	0.2	0.2251	0.9181	232.6	24.2	.936	.905	7.7	8.4	.0320	6.24	1.270	.918	.994
26.2	0.1	0.1410	0.9327	185.6	19.1	.969	.904	7.7	8.2	.0315	3.18	1.275	.933	.997
13.1	0.05	0.09416	1.023	139.0	14.2	.957	.979	8.3	8.1	.0311	1.61	1.278	1.023	1.000
2.6	0.01	0.0432	1.435	60.6	6.1	.945	1.355	11.5	8.0	.0307	.326	1.281	1.435	1.002

Table B-11. Results of calculations for a wave approaching from the west southwest with an initial height of 8.5 feet.

$H_o = 8.5$ $\alpha_o = 50$ $d_b = 9.3'$

$T = 7.15$ $L_o = 261.75$ $H_b = 7.3'$

d	d/L_o	d/L	H/H'_o SPM	L	α	K_R	K_S	H	H'_o	H'_o/L_o	d/H'_o	d_b/H'_o	H/H'_o	H_o/H'_o
130.9	0.5	0.5018	0.9905	260.8	49.8	.997	.988	8.4	8.5	.0324	--	1.268	--	.991
104.7	0.4	0.4050	0.9761	258.5	49.2	.991	.968	8.2	8.4	.0322	--	1.269	--	.992
78.5	0.3	0.3121	0.9490	251.6	47.4	.975	.925	7.9	8.3	.0317	--	1.273	--	.996
52.3	0.2	0.2251	0.9181	232.6	42.9	.937	.860	7.3	8.0	.0304	--	1.284	.918	1.004
26.2	0.1	0.1410	0.9327	185.6	32.9	.875	.816	6.9	7.4	.0284	3.52	1.301	.933	1.018
13.1	0.05	0.09416	1.023	139.0	24.0	.839	.858	7.3	7.1	.0272	1.84	1.312	1.023	1.026
2.6	0.01	0.0432	1.435	60.6	10.2	.808	1.160	9.9	6.9	.0262	.331	1.322	1.435	1.034

Table B-12. Results of calculations for a wave approaching from the southwest with an initial height of 8.5 feet.

$H'_o = 8.5$ $\alpha_o = 72.5$ $d_b = 6.9'$

$T = 7.15$ $L_o = 261.75$ $H_b = 5.1'$

d	d/L_o	d/L	H/H'_o SPM	L	α	K_R	K_S	H	H'_o	H'_o/L_o	d/H'_o	d_b/H'_o	H/H'_o	H_o/H'_o
130.9	0.5	0.5018	0.9905	260.8	71.9	.983	.973	8.3	8.4	.0319	--	1.271	--	.994
104.7	0.4	0.4050	0.9761	258.5	70.4	.946	.924	7.9	8.0	.0307	--	1.281	--	1.002
78.5	0.3	0.3121	0.9490	251.6	66.5	.868	.823	7.0	7.4	.0282	--	1.303	--	1.019
52.3	0.2	0.2251	0.9181	232.6	57.9	.753	.691	5.9	6.4	.0244	8.18	1.341	.918	1.049
26.2	0.1	0.1410	0.9327	185.6	42.6	.639	.596	5.1	5.4	.0207	4.82	1.386	.933	1.084
13.1	0.05	0.09416	1.023	139.0	30.4	.591	.604	5.1	5.0	.0192	2.61	1.403	1.023	1.101
2.6	0.01	0.0432	1.435	60.6	12.8	.555	.797	6.8	4.7	.0180	.555	1.425	1.435	1.114

B.3.0. The Offshore Breakwater

The discussion of the offshore breakwater is presented in the main report and, so, will not be reproduced here. Only the design calculations are presented.

If the offshore breakwater is placed 400 feet from shore it should be in about 4 feet of water at LWD. Adding the still water level of +4.3', the design depth, d_s, is 8.3 feet.

Now, it is possible to make some calculations to see if the structure would be subject to breaking waves in 8.3 feet of water, but this is not done here (see the calculations for the rubblemound revetment for these types of calculations) because it was felt that it was not only conservative, but also highly probable that waves would break on the structure. Thus, the height of the breaking wave at the structure, H_b^s, is needed. Now,

$$H_b^s = d_s/(\beta - m\tau_p) \qquad \text{(7-4, SPM II, 7-8)}^1$$

where,

$$\beta = d_b/H_b$$

$$\tau_p = X_p/H_b$$

and

$$X_p = (4.0 - 9.25m)H_b \qquad \text{(7-3, SPM II, 7-4)}$$

where

m = bottom slope

so

$$\tau_p = 4.0 - 9.25\,m.$$

---

[1] (7-4, SPM II, 7-8) means formula number 7-4, SPM volume II, page 7-8.

Now,

$m = 0.01$ (1:100)

so

$m\tau_p = (0.01)[4.0 - 9.25(0.01)] = 0.0391.$

and

$H_b^s = (8.3)/(\beta - 0.0391).$

Using this formula and the data from Table B-13 the following table results:

Table B-13. Wave characteristics for waves approaching at various angles, for the offshore breakwater option.

Direction	H_b^s from various directions			
	d_b	H_b	β	H_b^s
N	18.0	16.0	1.125	7.6
NNW	21.7	17.1	1.269	6.7
NW	23.3	18.2	1.280	6.7
NW	21.2	16.6	1.277	6.7
WNW	21.5	16.8	1.280	6.7
W	20.7	16.3	1.270	6.7
W	10.4	8.2	1.268	6.8
WSW	9.3	7.3	1.274	6.7
SW	6.9	5.1	1.353	6.3

Thus, the design breaking wave is 7.6 feet high.

To find the maximum required elevation it is necessary to calculate the runup, R, or the vertical distance above SWL the wave will reach, on the structure. SPM provides information on R in terms of R/H_o' so it is necessary to first find H_o'. Now,

$d/L_o = 8.3/564.5 = 0.0147,$

and from Table C-1, SPM III,

$H/H_o' = 1.313$

so

$H_o' = 7.6/1.313 = 5.45.$

To find R, the parameters H_o/gT^2 and d_s/H_o' must be calculated:

$H_o'/gT^2 = 5.45/(32.2)(10.5)^2 = 0.0015$

$d_s/H_o' = 8.3/5.45 = 1.522.$

The slope of the breakwater is 1:1.5 (to reduce the volume to a minimum and still have a stable structure) , so $\cot\theta = 1.5$. Then,

(Fig. 7-10, SPM II, 7-20)	$R/H_o' = 4.5$
Interpolated value	$R/H_o' = 3.8$
(Fig. 7-11, SPM II, 7-21)	$R/H_o' = 3.3$

Thus, the uncorrected runup, R_u, is

$R_u = 3.8(H_o') = 3.8(5.45) = 20.7'$

Using Fig. 7-13 (SPM II, 7-23) to find the scale correction factor, k = 1.216, the runup on a smooth impermeable slope, R_s, is

$R_s = kR_u = (1.216)(20.7) = 25.2'.$

To find R on a rubble slope:

(Fig. 7-14, SPM II, 7-26) $(R/H_o')_{riprap} = 2.0'$

and the correction is

$$\frac{(R/H_o')_{riprap}}{(R/H_o')_{smooth}} = \frac{2.0}{3.8} = 0.526$$

and

$R = 0.526R_s = (0.526)\ (25.2) = 13.3'.$

Therefore, for no overtopping, the maximum required height is

$$\begin{array}{rl} d_s = & 8.3 \\ +R = & \underline{13.3} \\ & 21.6 \text{ feet above the bottom} \end{array}$$

and the elevation is

$$\begin{array}{rl} SWL = & 581.1 \\ + R = & \underline{13.3} \\ \text{Crest elevation} = & 594.4' \text{ (IGLD, 1955).} \end{array}$$

These calculations were for illustration only. Actually, no overtopping conditions could be accomplished by lowering the height and widening the structure. However, with an offshore breakwater some overtopping can be tolerated and is, in fact, desirable.

Thus, a height of 10.0 feet from the bottom (a crest elevation of 582.8 ft, + 6.0' above LWD, or only 1.7' above SWL) is needed. A structure this low would need to be marked as a navigation hazard to small craft, but reduces the required volume.

However, in order to effectively reduce the wave energy, the structure needs some width. The general standard is three stones wide (Charles Johnson, NCD, personal communication) so the stone size must be calculated.

The stone weight is calculated from the following formula:

$$W = \frac{W_r H_b^3}{K_D (S_r - 1)^3 \cot\theta} \qquad \text{(7-105, SPM II, 7-169)}$$

where

W_r = unit weight, lbs/ft^3 (stone)

S_r = specific gravity of stone

θ = structure slope

K_D = from Table 7-6, SPM II, 7-170

Assuming limestone is used for the armor stone, then

$$W_r = 156 \text{ lbs/ft}^3$$

$$S_r = 2.5$$

$$\cot\theta = 1.5$$

$$K_D = 3.5 \text{ (rough angular stone, 2 units thick)}$$

and

$$W = \frac{(156)(7.6)^3}{(3.5)(2.5 - 1)^3 1.5} = 3{,}865 \text{ lbs} = 1.9 \text{ tons,}$$

and

$$\ell^3 = \frac{3{,}865 \text{ lbs}}{156 \text{ lbs/ft}^3} = 24.8 \text{ ft}^3$$

$$\ell = \text{stone width} = 2.9 \text{ ft.}$$

So far, due to the fact that the breakwater will be in 8.3 feet of water and subject to breaking waves 7.6 feet high, one armor layer is needed on top of the structure constructed of 1.9 ton stone. The lakeward side should be two units thick. the midlayer should be about 5.0 feet thick of 6-12" quarry run and the bed should be 2.0 feet thick and made of gravel less than three inches wide. Side slopes of 33° (1:1.5) were assumed. Assuming equidimensional and 1.9-ton stone for the armor layers and a top width of three stones, the top of the breakwater will be about 9 feet wide and the base 39 feet wide.

In order to calculate the required volumes it is necessary to first know the length and number of breakwaters. A continuous breakwater, while certainly effective at protecting the shoreline, would pose serious problems in terms of the longshore transport and would involve such large volumes of material as to be probably prohibitively expensive. Thus, a series of breakwaters, spaced some distance apart, would be more desirable. The length and spacing of such a system cannot presently be based on solid engineering criteria, but rather, must be based on limited data for similar structures elsewhere.

Based on preliminary results of an experiment at Presque Isle, Pennsylvania, small breakwaters, about 100 feet long, are adequate (Charles Johnson, U.S.C.O.E., personal communication). A second preliminary result of that experiment showed that the length to spacing ratio is a function of the grain size of the sand of the beach to be protected, i.e., the larger the grain size, the larger the spacing. A third, and somewhat related, result indicated that artificial nourishment of the protected beach is very desirable. Thus, a small beach was designed behind the offshore breakwaters proposed here (about 44,400 yd^3 along the 6,000 feet of the study reach). But, due to the realtively fine grain size of the available sand in the Lincoln Township area (onshore or offshore), a relatively narrow spacing of 2 breakwater lengths is suggested. Thus the 100 foot long breakwaters should be spaced about 200 feet apart. This length to spacing ratio will result in 18 structures along the 6,000 feet of the study reach. Table B-14 and Figures B-2 and B-3 present the total required materials, and design sketches.

Table B-14. Material Requirements for the Offshore Breakwater and Beach.

Material	Per structure	Total
Armor stone (1.9 ton)	500 yd^3	9,000 yd^3
Midlayer (6-12")	324 yd^3	5,832 yd^3
Bed ($\leq$3")	254 yd^3	4,572 yd^3
Sand	2,200 yd^3	44,400 yd^3

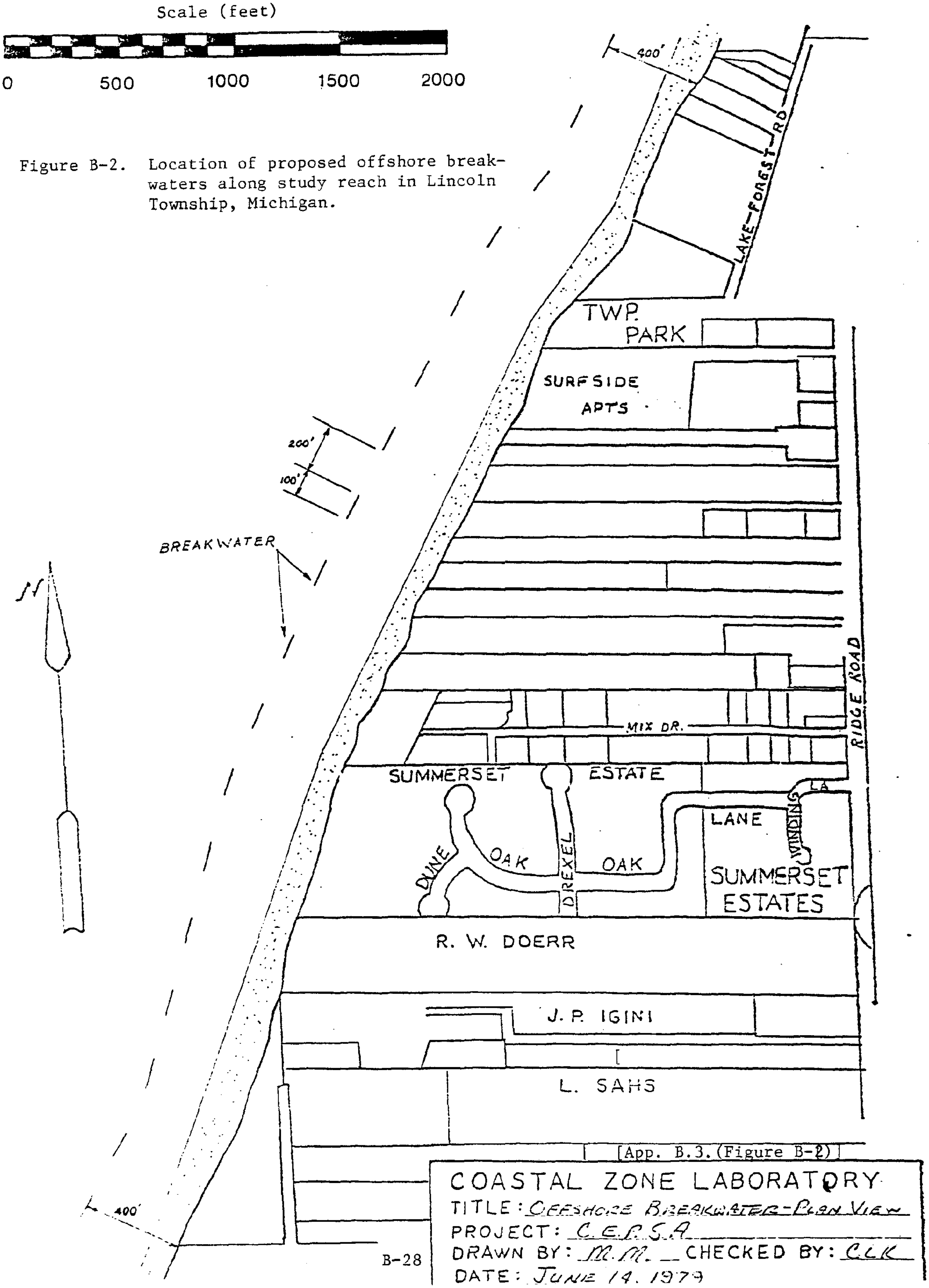


Figure B-2. Location of proposed offshore breakwaters along study reach in Lincoln Township, Michigan.

[App. B.3.(Figure B-2)]

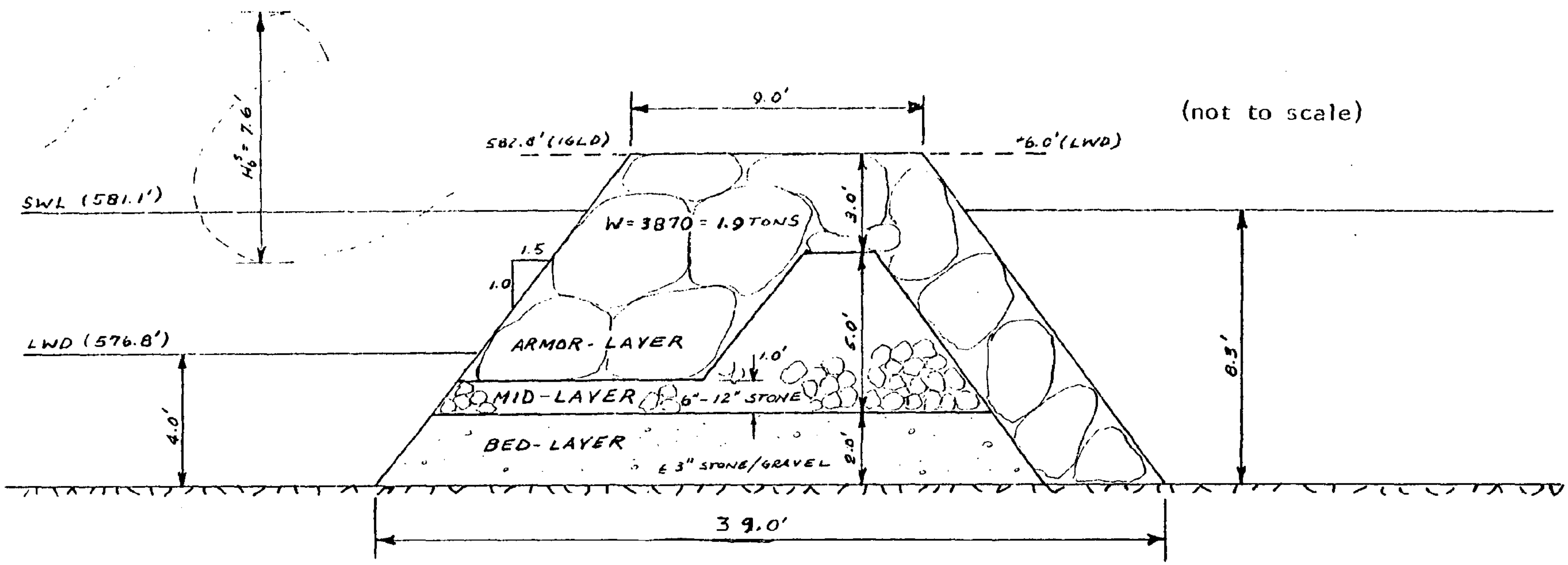
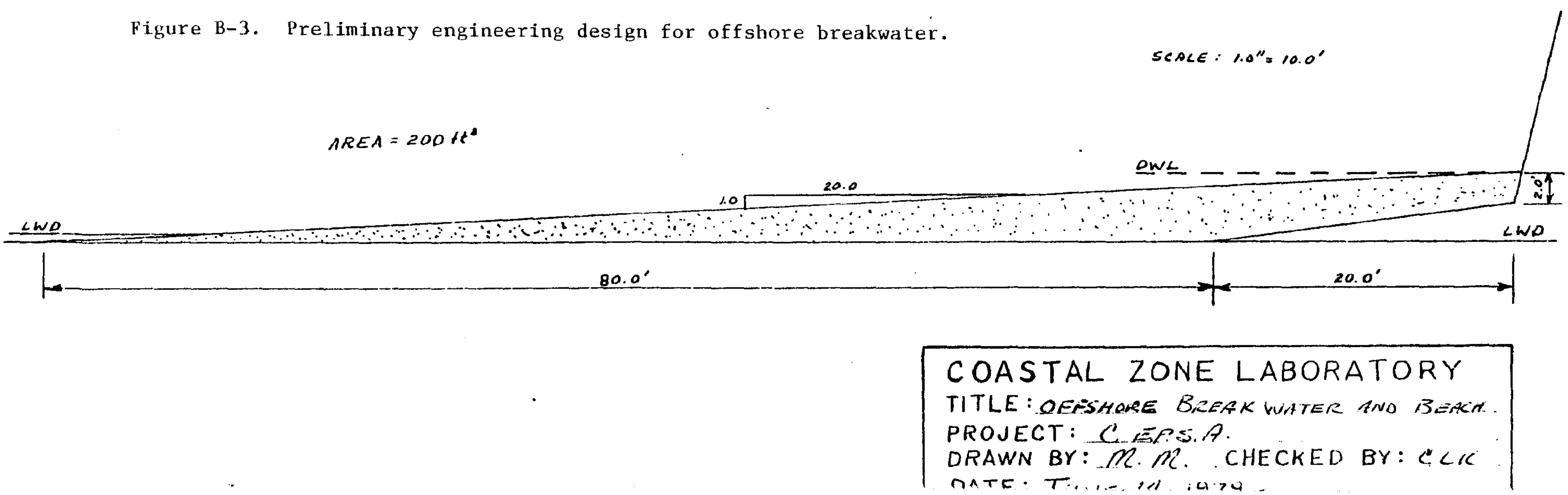


Figure B-3. Preliminary engineering design for offshore breakwater.



B.4.0. Timber Groins

In contrast to the design of the offshore breakwater, there are no well developed formulas or criteria for the design of a groin or groin field. There are, however, certain design parameters that must be determined, viz., groin length, freeboard, depth, and whether or not to artificially nourish the area between the groins. These parameters are usually somewhat arbitrary and based on accepted practice in the area; that is, they are based on what works.

Groin length is, perhaps, the most difficult parameter to establish because it is very dependent on the local coastal process for which the data is usually inadequate. An "effective length" (the wetted length) of 30 feet or less along the Lake Michigan shoreline is considered adequate for single-property lakefronts to provide a protective beach without interrupting significant quantities of the longshore transport. However, as a groin will generally build a beach, or fillet, that stretches along the shoreline for 2-4 times the effective length, short groins are undesirable for a large-scale project because many groins are required and this raises the material and construction costs. Thus, longer groins are desirable for large projects because they tend to interrupt more of the longshore transport thereby creating a larger beach. But they also create a greater potential for damage downdrift. It is a good idea to keep this fact in mind during design.

The effect created by the newly formed fillet is to move the shoreline lakeward (which is particularly important during high-water periods). So the groin needs to be long enough to provide protection during average or high-water periods. Low-water datum would represent the lake level during low water periods, so it was decided that the groin needed to extend to 5 feet landward of the LWD shoreline. Thus, the groin would extend about 140 feet lakeward from the toe of the bluff, or about 120 feet from the April, 1979, shoreline. As d_s is 4.3 feet above LWD, the design depth at the end of the groin will be 4.3 feet.

Freeboard is a term which refers to the height of the groin above the waterline. For instance, a freeboard of 3 feet in 6 feet of water means that the groin stands 9 feet off the bottom and the last 3 feet are above the water. Some freeboard is necessary in order to maintain a fillet, but it must be low enought to allow some sand and water to pass over and continue down the shoreline. Due to the nature of the longshore transport process the groin should have the lowest freeboard farthest from shore. The freeboard can be increased as the groin approaches shore. Generally, the lakewardmost end has a freeboard of 1.5 feet, but, as the proposed groin will be quite long (120 feet from shore), the freeboard has been reduced to 1.0 feet (or +5.3' above LWD) at the end. The freeboard has been staged to 2.0 feet above SWL (+6.3' above LWD) and 4.0 feet above SWL (+9.3' above LWD) at 79 feet and 31 feet from the April, 1979, shore respectively. These distances are not arbitrary, but rather, were based on the initial and expected sand nourishment profiles. The sketch illustrates the relationships expected.

How deep to drive the groin below the bottom is a very important question in terms of the survivability of the structure. Although, again there are no "cookbook" formulas for calculating the depth needed, this parameter would not be difficult to determine by a qualified soils engineer if he knew the nature of the bottom material, the height of the groin above the bottom, and the magnitude of the forces to which the groin would be subjected. Lacking enought data on the nature of the bottom along the study reach, CZL used a "rule-of-thumb" whichstates that the ratio of the groin height above the bottom to the depth of the groin below the bottom should be 1:3. That is, for every foot above the bottom, the groin should be sunk three feet. Thus, at the lakewardmost end of the groin (which is 5.3 feet above the bottom), the timber should be sunk 14.5 - 16.0 feet. The design sketches show the structure depth at slightly less than 3 times the height due to three factors: (1) there will be artificial nourishment which will increase the bottom elevation, (2) the bottom may be well compacted, and (3) a desire to reduce material requirements. During actual design, however, the depth should be carefully determined.

As the end of the groin will be subjected to wave forces which will cause toe scour and reduce the structure effectiveness, toe protection will be necessary. The calculations that follow apply to the lakeward end, but it is recommended that this toe scour protection be used along at least half of the wetted length at SWL. First we must know the wave height. Proceeding as in the section discussing the offshore breakwaters:

$$H_b^s = (4.3/(\beta - 0.0391),$$

which yields Table B-15.

Table B-15. Wave characteristics for waves approaching at various angles, for the timber groin option.

Direction	d_b	H_b	β	H_b^s
N	18.0	16.0	1.125	3.96
NNW	21.7	17.1	1.269	3.50
NW	23.3	18.2	1.280	3.47
NW	21.2	16.6	1.277	3.47
WNW	21.5	16.8	1.280	3.47
W	20.7	16.3	1.270	3.49
W	10.8	8.2	1.268	3.50
WSW	9.3	7.3	1.274	3.48
SW	6.9	5.1	1.353	3.27

Thus, we want to use a height, H, of 3.96 feet. Now, the stone weight W, can be determined by,

$$W = \frac{W_r H^3}{N_s^3 (Sr - 1)^3} \qquad \text{(7-10, SPM II, 7-203)}$$

where,

W = mean weight of individual stones, lbs

W_r = unit weight of rock, lbs/ft^3

H = wave height, ft

S_r = specific gravity of rock

N_s = design stability number (from Fig. 7-99, SPM II, 7-202).

Assuming limestone, as with the rubblemound breakwater:

W_r = 156 lbs/ft^3

S_r = 2.5

H = 3.96.

If a slope of 1:2 is used and depth below SWL, d_i' is 1.0 feet, then entering Fig. 7-99 with $d_i/d_s = 1.0/4.3 = 0.23$, $N_s^3 = 27$, and

$W = [(156)(3.96)^3]/[(27)(2.5 - 1)^3] = 106$ lbs,

or about 10-11 inches wide. The top width of the toe protection, B, 1.0 foot below SWL is 0.4 d_s (Fig. 7-99, SPM II, 7-202), so,

$B = 0.4(4.3) = 1.7$ feet.

The timber sheet piling should be constructed of 2" x 3" sheet piles in a Wakefield pattern (to provide strength and flexibility). The planks should be held together by clinched nails. The wales should be 8" x 10" and held by bolts running from the wale on one side through the planks and wale on the other side and through the pile. There should be four wales, two on each side. The piles should be 12" in diameter and spaced about 10 feet apart on a side, but alternately spaced with the opposing sides (see Fig. 6-58, SPM-II, 6-77). All timber should be pressure-treated with creosote after being cut and drilled.

The design sketch following this section shows the general features of length, depth, and freeboard, but does not show wales, piles, or sheet piles for clarity.

An important feature of all groin construction is to provide a tieback into the bluff. As there will be an artificial beach, it is recommended that a tieback need only go 5 feet into the bluff. Of course, this parameter assumes proper maintenance of the beach and groin.

Although groins create fillets, or beaches, as the protection mechanism, it is often advantageous to artificially nourish these groins at the time of construction as natural processes could take months or years depending on storms and the quantity of material in transport. It has been estimated in several reports (e.g., U.S.Army Corps of Engineers, Detroit District, 1974) that the net transport in this area is to the south at about 100,000 yd^3 per year which is not a large quantity of material. Also, considering the general performance of groins in this area, it could take some time to fill the groin field. Therefore, it is recommended that these groins be artificially nourished in order to provide immediate protection.

For ease of construction, the original nourishment configuration should be as follows: at the toe of the bluff the sand should be about 2 feet higher than the groin and extend 20-25 feet lakeward. From that point, the sand should be on a 1:10 slope until it reaches the level of the bottom or beach. It is expected that the beach will initially adjust to the wave climate so that the slope in front of the toe will be 1: 12 to a height of one foot above the groin at the bluff toe, 1:3 in the swash zone, and 1:30 lakeward. The adjusted beach should, then, extend from the toe of the bluff to the end of the groin (see sketch).

The spacing of the groins is a function of the effective, or wetted, length as mentioned above. However, the effective length varies with lake level as the changing level changes the shoreline position; viz., a lower lake level means a more lakeward shoreline. Thus, for the determination of the effective length and the spacing, the intersection of the SWL (+4.3 feet above LWD, or 581.1 feet above IGLD) and the anticipated resultant profile of the nourishment sand was used resulting in an effective length of 94 feet. The SPM (pg. 5-38, paragraph 5.664) recommends, as a general rule of thumb, that the spacing be "two to three times" the effective length. This spacing allows the most beach buildup without scour problems caused by wave interaction. Thus, the groins should be spaced about 280 feet apart. This spacing will result in 22 groins, each 141 feet long.

Table B-16 presents the quantity requirements for the timber groin option. The sand quantities listed assume sand that is closely matched to the natural beach. During actual design, the borrow sand and the native sand must be analyzed to learn if an overfill is necessary, and if so, how much. This analysis must include an economic analysis of the tradeoffs between the costs of grading the sand to provide more stability and the costs of a greater quantity of sand.

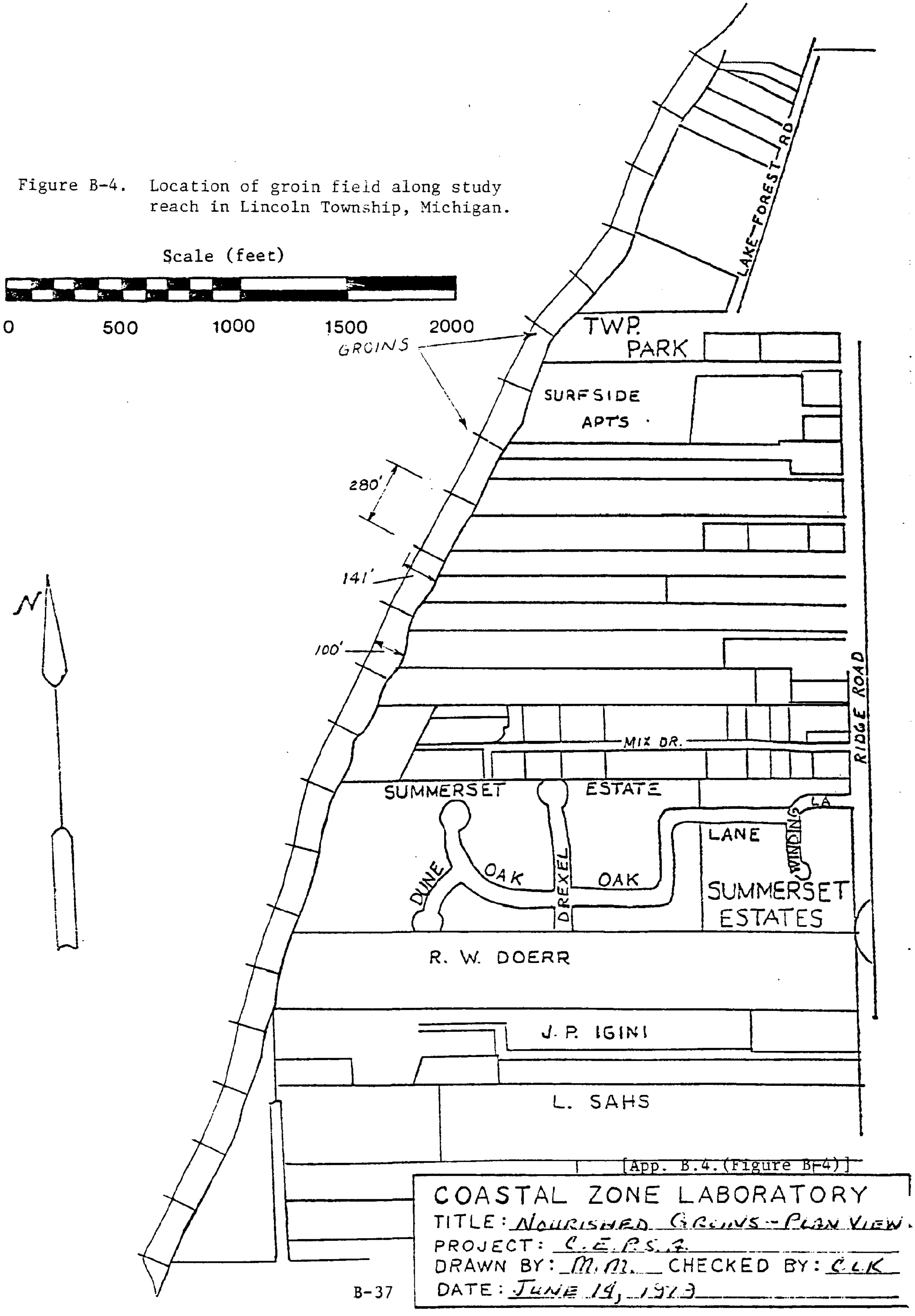
The expected adjustment in the profile should occur in about 1 yr and represents a loss of 21% or 21,300 yd^3. At this rate of loss, the initial quantity of 101,100 yd^3 would be reduced to 31,100 yd^3 in 5 years. Thus, the nourishment will require replacement about every 5 years in the amount of about 70,000 yd^3 (see Figures B-4 and B-5).

Table B-16. Material Requirements for Artificially Nourished Timber Groins.

Material	Specs	Quantity per groin	Quantity total
Timber sheet piling	2" x 8" Wakefield	55,692 B.F.[a]	1,225,224 B.F.
Timber wales	8" x 10"	3,760 B.F.	82,720 B.F.
Timber piles	12" dia.	2,398 L.F.[a]	52,756 L.F.
Sand	-----	4,595 C.Y.[a]	101,100 C.Y.

[a]B.F. = board feet, L.F. = linear feet, and C.Y. = cubic yards

Figure B-4. Location of groin field along study reach in Lincoln Township, Michigan.



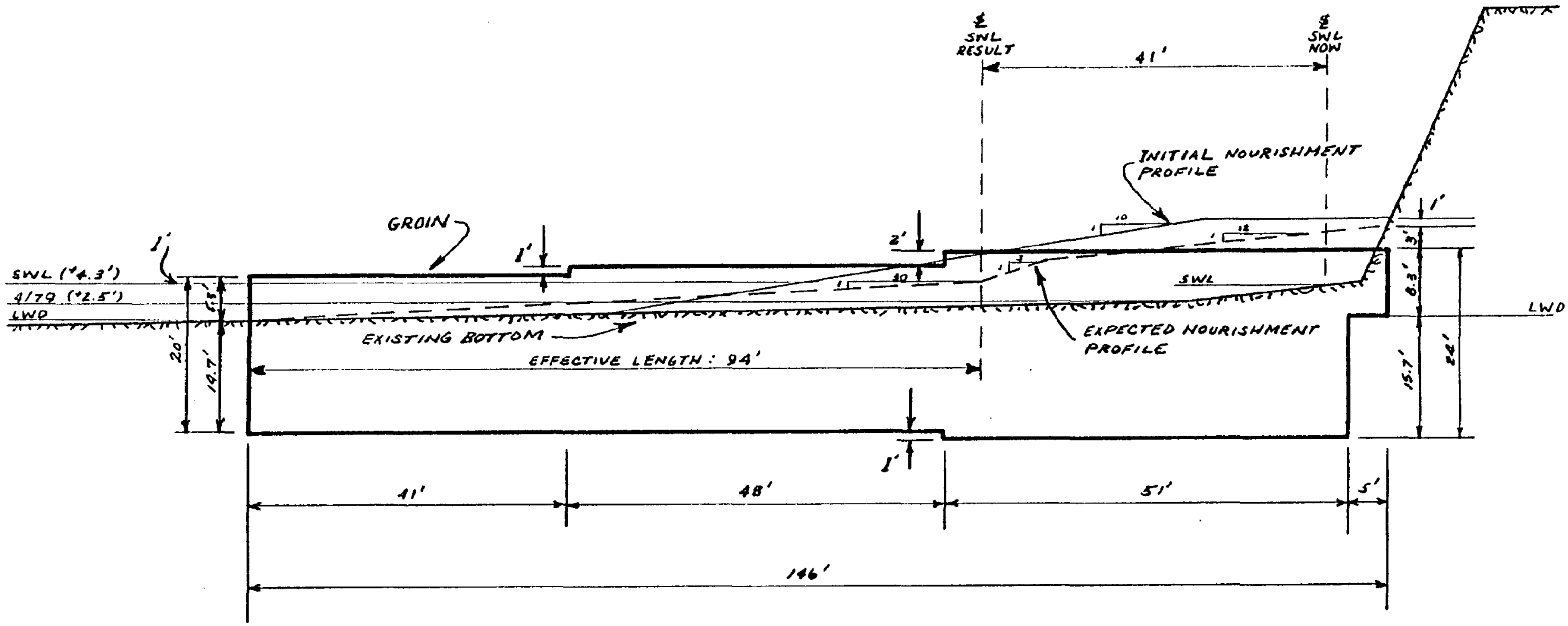


Figure B-5. Proposed engineering design cross section of groin showing groin, existing beach profile, and expected beach profile after artificial nourishment.

COASTAL ZONE LABORATORY
TITLE: TIMBER GROIN
PROJECT: C.E.P.S.A.
DRAWN BY: M.M. CHECKED BY: C.L.K
DATE: JUNE 15, 1979 1"=20'

B.5.0. Rubblemound Revetment

A rubblemound revetment is a very simple to design, yet very effective, shore protection structure. Unfortunately, they usually severely restrict access to the beach. However, for this exercise it will be assumed that an access route (such as a stairway) can be built and a beach has been artificially created lakeward of the structure. This beach will eventually erode thereby exposing the toe of the structure to direct wave attack at a lake level near the SWL. So, as there will probably be some time lag from the time of toe exposure to the time of nourishment, the revetment must be designed for these conditions. If the revetment has a 1:1.5 slope, the toe will be at or very near, to LWD; thus, d_s = 4.3 feet as the SWL is 4.3 feet above LWD.

The next question to answer is whether or not the revetment will be subject to breaking waves (breaking waves expend much greater force than non-breaking waves). From the previous discussion, the design wave was determined to be from the north at 18.7 feet in deepwater and with a period of 10.5 seconds.

Thus,

$H_o = 18.7$ ft, $T = 10.5$s

$\alpha_o = 62.5^o$, $d_s = 4.3$

$d/L_o = 4.3/564 = 0.0076$

Therefore,

$d/L = 0.03506$ (Table C-1, SPM III, C-6)

$H/H_0' = 1.531$

and

$L = d/(d/L) = 4.3/(0.03506) = 123$ ft

$\alpha = \sin^{-1}[(L/L_o)\sin\alpha_o] = \sin^{-1}[(123/564)\sin(62.5)] = 11.2^o$

$K_R = \sqrt{(\cos\alpha_o/\cos\alpha)} = [\cos(62.5)/\cos(11.2)]^{1/2} = 0.686$

$H_o' = H_o K_R = (0.686)(18.7) = 12.8$ ft

$H = H_o'(H/H_o') = (12.8)(1.531) = 19.6$ ft.

Assume the slope, m, is 0.01 (or 1:100) and,

$H_o'/(gT) = (12.8)/[(32.2)(10.5)^2] = 0.0036$

$d_s/gT^2 = (4.3)/[(32.2)(10.5)^2] = 0.00121.$

So,

$H_b/d_s = 0.87$ (Fig. 7-4, SPM II, 7-9)

$H_b = (0.87)(4.3) = 3.7$ ft

$H_b/H_o' = 1.3$ (Fig. 7-3, SPM II, 7-7)

$H_b = (1.3)(12.8) = 16.6$ ft

Then, from Fig. 7-2, SPM II, pg. 7-8.

@$H_b = 3.7$, $H_b/gT^2 = 0.00104$, m = slope of bottom = 0.01

$\alpha = 1.48$

$\beta = d_b/H_b = 0.69$

$x_p = (4.0 - 0.25m)H_b = [4.0 - 9.25(0.01)]3.7 = 14.46$ ft

$(d_b)max = \alpha H_b = (1.48)(3.7) = 5.5$ ft

$(d_b)min = \beta H_b = (0.69)(3.7) = 2.6$ ft

@$H_b = 16.6$ ft, $H_b/gT^2 = 0.00468$

$\alpha = 1.525$

$\beta = d_b/H_b = 0.71$

$X_p = [4.0 - 9.25(0.01)]16.6 = 64.86$ ft

(d_b) max $= \alpha H_b = 25.3$ ft

$(d_b)min = \beta H_b = 11.8$ ft

Now, the distance from the minimum depth of breaking to the structure toe is X'. where

$$X' = [(d_b)_{min} - d_s]/m$$

and the structure will be subject to breaking wave conditions only if X' is less than X_p. Now the minimum $(d_b)_{min}$ is 2.6 ft corresponding to a breaking wave of 3.7 feet. This depth is less than the depth at the structure toe, so the structure is subject to breaking waves. But, to carry out the illustration:

$$X' = (2.6 - 5.3)\ 0.01 = -170$$

or 170 landward of the toe. So,

$$X' < X_p$$

and the structure is subject to breaking wave conditions. Thus, assuming a breaking wave of 3.7 feet, the required stone size is,

$$W = (W_r H_b^3)/[(Sr - 1)^3 \cot\theta K_D] \qquad \text{(7 - 105, SPM II, 7-169)}$$

If limestone is used then,

$$W_r = 156 \text{ lbs/ft}^3$$

$$Sr = 2.5$$

and

$$K_D = 3.5 \qquad \text{(Table 7-6, SPM II, 7-170)}$$

and

$$W = (156)(3.7)^3/(1.5)^3(1.5)(3.5) = 450 \text{ lbs} = 0.23 \text{ ton,}$$

Assuming equidimensional stone of length ℓ:

$$\ell^3 = W/W_r = 450/156 = 2.9 \text{ ft}^3$$

$$\ell = 1.4 \text{ ft.}$$

So, there will be one armor layer, 1.4 ft thick. The midlayer should consist of stones W/10 heavy (45 lbs or 7-10 inches in size about 2.0 feet thick. The bed layer should consist of gravel 3 inches or less in size.)

In order to determine the crest elevation, the runup needs to be calculated. Now,

$H_o' = (3.7)/(1.531) = 2.4$ ft

and

$H_o'/gT^2 = 0.00068$

$d_s/H_o' = 4.3/2.4 = 1.79$

$\cot\theta = 1.5$

$d_s/H_o' = 0.8$: $R/H_o' = 5.4$ (Fig. 7-10, SPM II, 7-20)

Interpolated value: $(R/H_o')_s = 4.2$

$d_s/H_o' = 2.0$: $R/H_o' = 3.9$ (Fig. 7-11, SPM II, 7-21)

Thus, the uncorrected (for scale effects) runup, R_u is,

$R_u = (R/H_o')H_o' = (4.2)(2.4) = 10.1$ ft.

Fig. 7-13, SPM II, pg. 7-23 provides the scale correction factor k = 1.206, and the runup on a smooth impermeable slope, R_s, is

$R_s = kR_u = (1.206)(10.1) = 12.2$ ft.

To correct for the riprap situation Fig. 7-15, SPM II, pg. 7-26 provides runup on a riprap surface, $(R/H_o')_r$ of slope 1:1.5:

$(R/H_o')_r = 2.65.$

So, the correction is

$$\frac{(R/H_o')_r}{(R/H_o')_s} = \frac{2.65}{4.20} = 0.63$$

and

$R = (0.63)R_s = (0.63)(12.2) = 7.7$ ft.

R represents the vertical distance above SWL that the wave will run, so the height above LWD is

576.8 (LWD)
+12.0 (d_s + R)
588.8 ft above IGLD (1955)

The revetment must be built this high as no overtopping can be permitted without compromising the structure.

The protective beach lakeward of the structure should be placed such that it is 1.5 feet above SWL (5.8 ft above LWD) at the structure and extends lakeward on a 1:10 slope until it intersects the bottom. There will likely be heavy losses of this material (even when matched to the native sand) and replacement could occur once every 2-3 years. The volumes of sand given assume no overfill required. The required volumes of material are given in Table B-17 and the design sketch on Figure B-6.

Table B-17. Material Requirements for the Rip-Rap Revetment Option.

Material	Size	Quantity per ft	Quantity total
Armor stone	450 lbs	0.91 C.Y.	5,500 C.Y.
Midlayer	7-10 in	0.89 C.Y.	5,400 C.Y.
Bed layer	$\leq$3 in	1.6 C.Y.	9,700 C.Y.
Sand	---	2.7 C.Y.	16,000 C.Y.

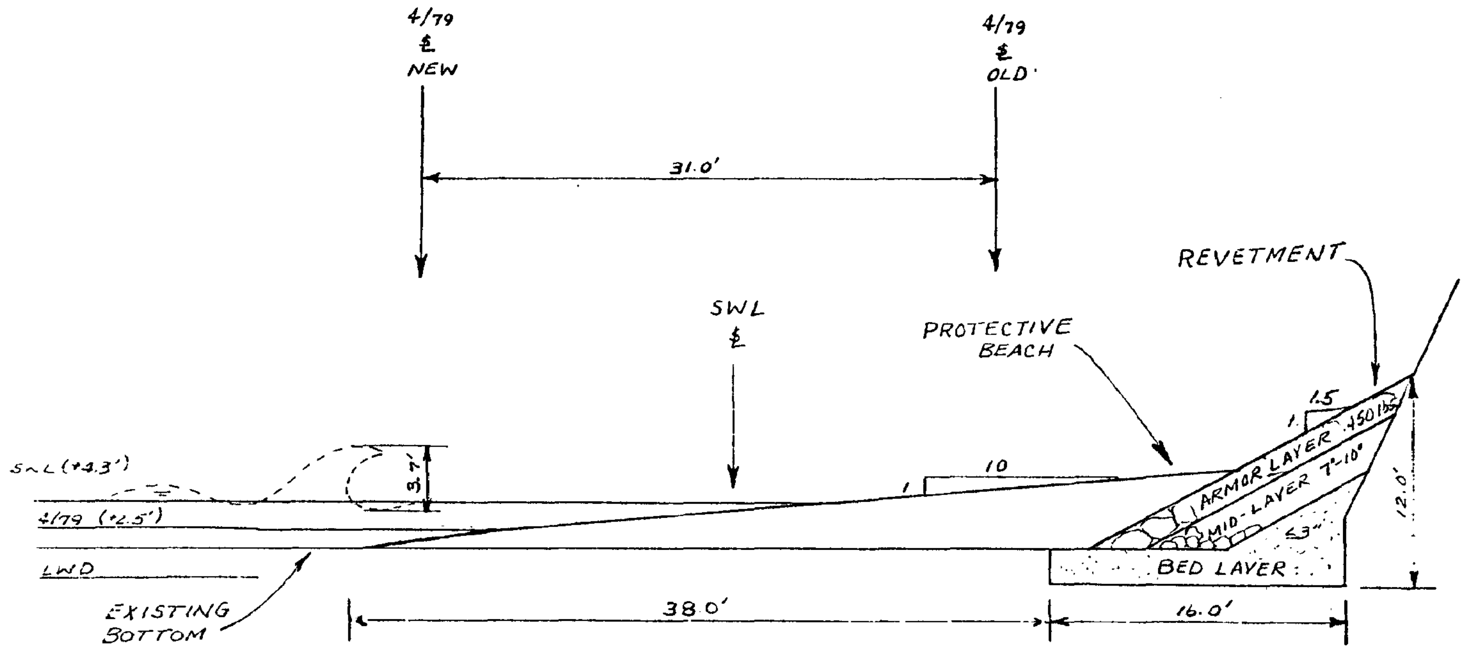


Figure B-6. Preliminary engineering design for stone revetment.

COASTAL ZONE LABORATORY
TITLE: Rip-Rap Revetment
PROJECT: C.E.P.S.A.
DRAWN BY: M.M. CHECKED BY: CLK
DATE: June 14, 1979 1" = 10'

B.6.0. Headland Parks

A novel, but not original concept, is to create shore protection while, at the same time, creating new recreation areas. Headland parks are not a new idea, but their application in the Great Lakes is limited. A modified version of this concept was proposed for Illinois Beach State Park (Tetra Tech., 1978) where the headlands were used simply as small overlooks. However, with due consideration for the longshore transport, a larger headland, suitable for use as a park is technically possible and has been successfully used at Toronto, Canada, although the shoreline conditions are considerably different there.

The headland park (hereinafter referred to as the H.P.) is a complicated structure requiring five integrated concepts: (1) at least three states of rubblemound breakwaters, (2) park fill, (3) nourishment updrift of the H.P., (4) groins downdrift, and (5) nourishment for the groins. It is anticipated that the nourishment would serve two purposes: (1) immediate protection of the adjacent shoreline by creating a beach, and (2) lessening of the impact on the coastal processes. The breakwater is crecentic in shape (see the plan view) to aid in directing the longshore transport onto and along-shore. It is unknown at this time whether such action would occur (although it has been observed elsewhere, e.g., Santa Barbara) so that a monitoring program would be prudent to make certain that the desired effects were occurring. Of course, should the monitoring program ascertain that such was not the case, a sand bypassing plan should be ready for implementation at the earliest signs of a problem.

The H.P. concept, as presented here, involves two headlands. This would be the ideal situation in terms of the length of the study reach, but may not be politically feasible in that only one H.P. could be built. However, as one of the objectives of this study is to provide alternative shore protection methods, the two H.P. concepts will be assumed throughout this section. Aside from the obvious protection an H.P. provides to the shoreline behind it, it also acts like a large groin. Thus, the headlands could be spaced apart a distance equal to about 3 times their length perpendicular to the shoreline. However, as these structures are generally much longer than a groin they can be expected to "trap" more material. The distance chosen considered this, but is rather arbitrary and reflects the desire to provide optimum coverage with two structures.

B.6.1. Rubblemound Breakwater

The rubblemound breakwater will be built in three sections (A, B, and C) which are fully connected into a single unit 900 feet long. Section A, the outermost section will be 400 feet from the LWD shoreline at its farthest point; Section B, the middle section, will be 250 feet from the LWD shoreline at its midpoint; and Section C, the innermost section, will be at the LWD shoreline at its midpoint. The calculations for each section follow.

B.6.1.1. Section A

Section A, at 400 feet from the LWD, will be in water that is 4.0 feet deep below LWD or at a design depth, d_s, of 8.3 feet or 4.3 feet above LWD (see the Section Design Water Level). This is about the same position as the offshore breakwaters and the design is the same, but it may be useful to present the calculations here as well. Thus, assuming the structure is subject to breaking waves, the calculation of the height of the breaking wave, H_b^s, proceeds as follows:

$$H_b^s = d_s/(\beta - m\tau p) \qquad \text{(7-4, SPM II, 7-8)}$$

where

$$\beta = d_b/H_b$$

$$\tau_p = X_p/H_b$$

and

$$X_p = (4.0 - 9.25M)H_b \qquad \text{(7-3, SPM II, 704)}$$

and

m = bottom slope.

So,

$$\tau_p = 4.0 - 9.25m.$$

Now, assuming

m = 0.01 (or 1:100),

then,

$$m\tau_p = (0.01)[(4.0 - 9.25(0.01)] = 0.0391$$

and

$$H_b^s = 8.3/(\beta - 0.0391).$$

Using this formula and the data from Table B-18 the following table results:

Table B-18. Wave characteristics for Section A, d_s = 8.3 feet, and waves approaching at various angles, for the headland park option.

Direction	d_b	H_b	β	H_b^s
N	18.0	16.0	1.125	7.6
NNW	21.7	17.1	1.269	6.7
NW	23.3	18.2	1.280	6.7
NW	21.2	16.6	1.277	6.7
WNW	21.5	16.8	1.280	6.7
W	20.7	16.3	1.270	6.7
W	10.4	8.2	1.268	6.8
WSW	9.3	7.3	1.274	6.7
SW	6.9	5.1	1.353	6.3

Thus, H_b^s is 7.6 feet high. H_b^s is used to find the required armor stone size and the required crest elevation and width.

To find the required crest elevation, it is necessary to calculate the runup, R, or the vertical distance above SWL, the wave will run on the structure. The SPM provides information on R in terms of R/H_o' so it is necessary to first find H_o' . Now,

$$d_s/L_o = 8.3/564.48 = 0.0147,$$

so, from Table C-1, SPM III, pg. C-6,

$$H/H_o' = 1.313.$$

Therefore,

$$H_o' = H_b^s/1.313 = 7.6/1.313 = 5.45.$$

To find R, the parameters H_o'/gT^2 and d_s/H_o' must be calculated:

$$H_o'/gT^2 = 5.45/(32.2)(10.5)^2 = 0.0015$$

$$d_s/H_o' = 8.3/5.45 = 1.522.$$

Assuming the slope of the sides of the breakwater, cotθ, is 1.5 (or 1:1.5), then,

$(@d_s/H_o' = 0.80)$:	$R/H_o' = 4.5$	(Fig. 7-10, SPM II, 7-20)
Interpolated value:	$R/H_o' = 3.8$	
$(@d_s/H_o' = 2.0)$:	$R/H_o' = 3.3$	(Fig. 7-11, SPM II, 7-21)

Thus, the uncorrected runup on a smooth impermeable slope, R_u, (uncorrected for scale effects) is

$$R_u = 3.8(H_o') = 3.8(5.45) = 20.7 \text{ feet}.$$

Next, using Fig. 7-13, SPM II pg. 7-23 to find the scale correction factor, k = 1.216, the corrected runup on a smooth impermeable slope, R_s, is,

$$R_s = kR_u = (1.216)(20.7) = 25.2 \text{ feet}.$$

But, the breakwater is rubblemound, so that a correction needs to be applied to reflect this construction material. From Fig. 7-15, SPM II, pg. 7-26 the value of R/H_o' on a rubble slope of 1:1.5 and uncorrected for scale effects $(R/H_o')_r$ is 2.0 and the correction factor is, then,

$$(R/H_o')_r/(R/H_o')_s = 2.0/3.8 = 0.526.$$

Finally, therefore, the runup, R, is,

$$R = 0.526R_s = (0.526)(25.2) = 13.3 \text{ feet.}$$

Now, remember, R is the vertical distance above the SWL, so the crest elevator is

SWL =	581.1 feet (above IGLD, 1955)
R =	13.3
Crest elevation =	594.4 feet (above IGLD, 1955),

or, the height above the bottom is,

d_s =	8.3 feet
+R =	13.3 feet
Height above bottom =	21.6 feet.

The size of the armor stone is determined by the required weight of the stone which is, in turn, a function of $H_b{}^s$. Thus,

$$W = \frac{W_r H_b{}^3}{K_D(Sr - 1)^3 \cot\Theta} \text{ lbs} \qquad (7\text{-}105, \text{SPM II}, 7\text{-}169)$$

where

W_r = unit weight of stone, lbs/ft^3

Sr = specific gravity of stone

$\cot\Theta = 1.5$

$K_D = 3.5$

so

$$W = \frac{(156)(7.6)^3}{(3.5)(2.5 - 1)^3(1.5)} = 3{,}865 \text{ lbs} = 1.9 \text{ tons.}$$

Assuming equidimensional stone of length, ℓ,

$$\ell^3 = W/W_r = (3{,}865 \text{ lbs})(156 \text{ lbs/ft}^3) = 24.8 \text{ ft}^3$$

so

$$\ell = 2.9 \text{ ft.}$$

The lakeward side of the breakwater should be two units, 5.8 feet, thick while the landward side need be only one unit thick. The crest width should be three stones wide or about 9 feet.

The midlayer stone weight should be about W/25 or 10"-12" in size and about 9.0 feet thick. The bed layer, which acts to prevent scour as well as support, should be constructed of stone $\leq$3" in size and makes up the remaining 6.6 feet.

As Section A will be about 650 feet long, the corresponding volumes are

Armor stone	9,028 C.Y.
Midlayer	8,390 C.Y.
Bed layer	8,580 C.Y.

The landward side needs to be filled in order to create the park. As d_s is 8.3, the fill needs to be at least this high. Now, a four-foot increase, to 12.8 feet, (585.1 feet above IGLD, 1955) brings the park above water and yet creates a low enough slope (1:75) over the 300-foot length of the Section A fill as to be used without difficulty by park goers. If the remaining 8.3 feet is placed on a 1:100 slope it will cover 830 feet of bottom and be suitable for bathing. Thus, the fill required for Section A is 24,600 yd^3.

B.6.1.2 Section B.

The reasoning and calculations for Section B are similar to those for Section A, so are only presented in summary form below:

d_s = 6.8 feet

H_b^s = 6.8/(β - 0.0391)

Table B-19. Wave characteristics for Section B, d_s = 6.8 feet, and waves approaching at various angles, for the headland park option.

Direction	β	H_b^s
N	1.125	6.3
NNW	1.269	5.5
NW	1.280	5.5
NW	1.277	5.5
WNW	1.280	5.5
W	1.270	5.5
W	1.268	5.5
WSW	1.274	5.5
SW	1.353	5.2

So,

H_b^s = 6.3 feet.

d_s/L_o = 6.8/564.48 = 0.0120

H/H_o' = 1.375 (Table C-1, SPM II, C-6)

H_o' = 6.3/1.375 = 4.6'

H_o'/gT^2 = 4.6/(32.2)(10.5)^2 = 0.00129

d_s/H_0' = 6.8/4.6 = 1.48

cotθ = 1.5

(@d_s/H_o' = 0.8): R/H_o' ≈ 4.7 (Fig. 7-10, SPM II, 7-20)

Interpolated value: R/H_o' ≈ 4.1

(@d_s/H_o' = 2.0): R/H_o' ≈ 3.6 (Fig. 7-11, SPM II, 7-21)

R_u = (4.1)(4.6) = 18.9

k ≈ 1.206 (Fig. 7-13, SPM II, 7-23)

$R_s = kR_u = (1.206)(18.9) = 22.8$ feet

$(R/H_o')_r = 1.85$

$(R/H_o')_r/(R/H_o')_s = 1.85/4.1 = 0.45$

$R = 0.45R_s = (0.45)(22.8) = 10.3$ feet

SWL = 581.1 feet (above IGLD, 1955)

R = $\underline{10.3}$

591.4 feet (above IGLD, 1955)

or

$d_s = 6.8$

R = $\underline{10.3}$

17.1 feet above the bottom

$$W = \frac{(156)(6.3)^3}{(3.5)(2.5 - 1)^3(1.5)} = 2{,}200 \text{ lbs} = 1.1 \text{ tons}$$

$\ell^3 = (2{,}200)/(156) = 14.1 \text{ ft}^3$

$\ell = 2.4$ ft

Fill depth = 10.8 feet = 585.1 feet above IGLD, 1955

Length of fill above SWL = 500 feet

Slope above SWL = 1:125

Length of fill below SWL = 680 feet

Table B-20. Material Requirements for Section B.

Armor stone	1,562 C.Y.
Midlayer	1,366 C.Y.
Bed layer	1,647 C.Y.
Fill	37,500 C.Y.

B.6.1.3 Section C.

Section C follows similarly to Sections A and B.

d_s = 4.3 feet

$H_b^s = 4.3/(\beta - 0.0391)$

Table B-21. Wave characteristics for Section C, d_s = 4.3 feet, and waves approaching at various angles, for the headland park option.

Direction	β	H_b^s
N	1.125	4.0
NNW	1.269	3.5
NW	1.280	3.5
NW	1.277	3.5
WNW	1.280	3.5
W	1.270	3.5
W	1.268	3.5
WSW	1.274	3.5
SW	1.353	3.3

So,

H_b^s = 4.0 feet

d_s/L_o = 4.3/564.48 = 0.0076

H/H_o' = 1.531 (Table C-1, SPM II, C-6)

H_o' = 4.0/1.531 = 2.61

$H_o'/gT^2 = 2.61/(32.2)(10.5)^2 = 0.00075$

d_s/H_o' = 4.3/2.65 = 1.62

$\cot\theta$ = 1.5

(@d_s/H_o' = 0.8): R/H_o' = 5.4 (Fig. 7-10, SPM II, 7-20)

Interpolated value: R/H_o' = 4.8

(@d_s/H_o' = 2.0): R/H_o' = 3.85 (Fig. 7-11, SPM II, 7-21)

R_u = (4.8)(2.6) = 12.5

$k = 1.206$ (Fig. 7-13, SPM II, 7-21)

$R_s = kR_u = (1.206)(12.5) = 15.1$ feet

$(R/H_o')_r = 2.3$ (Fig. 7-15, SPM II, 7-26)

$(R/H_o')_r/(R/H_o')_s = 2.3/4.8 = 0.48$

$R = 0.48R_s = (0.48)(15.1) = 7.2$ feet

SWL = 581.1 feet (above IGLD, 1955)

or

$d_s = 4.3$

$R = \underline{7.2}$

11.5 above the bottom

$$W = \frac{(156)(4.0)^3}{(3.5)(2.5 - 1)^3(1.5)} = 560 \text{ lbs}$$

$\ell^3 = (560)/(156) = 3.6 \text{ ft}^3$

$\ell = 1.5$ ft.

Fill depth = 8.3 feet = 581.1 feet above IGLD, 1955

Length of fill above SWL = 750 feet

Slope above SWL = 1:190

Length of fill below SWL = 430 feet

Table B-22. Material Requirements for Section C.

Armor Stone	427 C.Y
Midlayer	373 C.Y.
Bed layer	528 C.Y.
Fill	10,500 C.Y.

B.6.2 Timber Groins

Groins will have the same design as described under the Timber Groins section. The results per groin are summarized below including the nourishment (fill) requirements.

Table B-23. Material requirements for timber groins.

Material	Quantity
Timber sheet piling (2" x 8", wakefield)	55,692 B.F.
Timber wales (8" x 10")	3,760 B.F.
Timber piles (12" dia)	2,398 L.F.
Fill	4,600 C.Y.

B.6.3 Other Fill

Other fill is required to ensure immediate protection in the amount of 38,800 yd^3 per H.P. Table B-24 summarizes the results of these calculations, and Figures B-7, B-8 and B-9 show the design drawings.

Table B-24. Material Requirements for the Park Headlands Option.

Structure	Quantity per structure	Total quantity
Breakwater		
Section A		
Armor (1.9 tons)	9,028 C.Y.[a]	18,056 C.Y.
Midlayer (10"-12")	8,011 C.Y.	16,022 C.Y.
Bed layer (≤3")	8,580 C.Y.	17,160 C.Y.
Fill	24,600 C.Y.	49,200 C.Y.
Section B		
Armor (1.1 tons)	1,562 C.Y.	3,124 C.Y.
Midlayer (10"-12")	1,366 C.Y.	2,732 C.Y.
Bed layer (≤3")	1,647 C.Y.	3,294 C.Y.
Fill	37,500 C.Y.	75,000 C.Y.

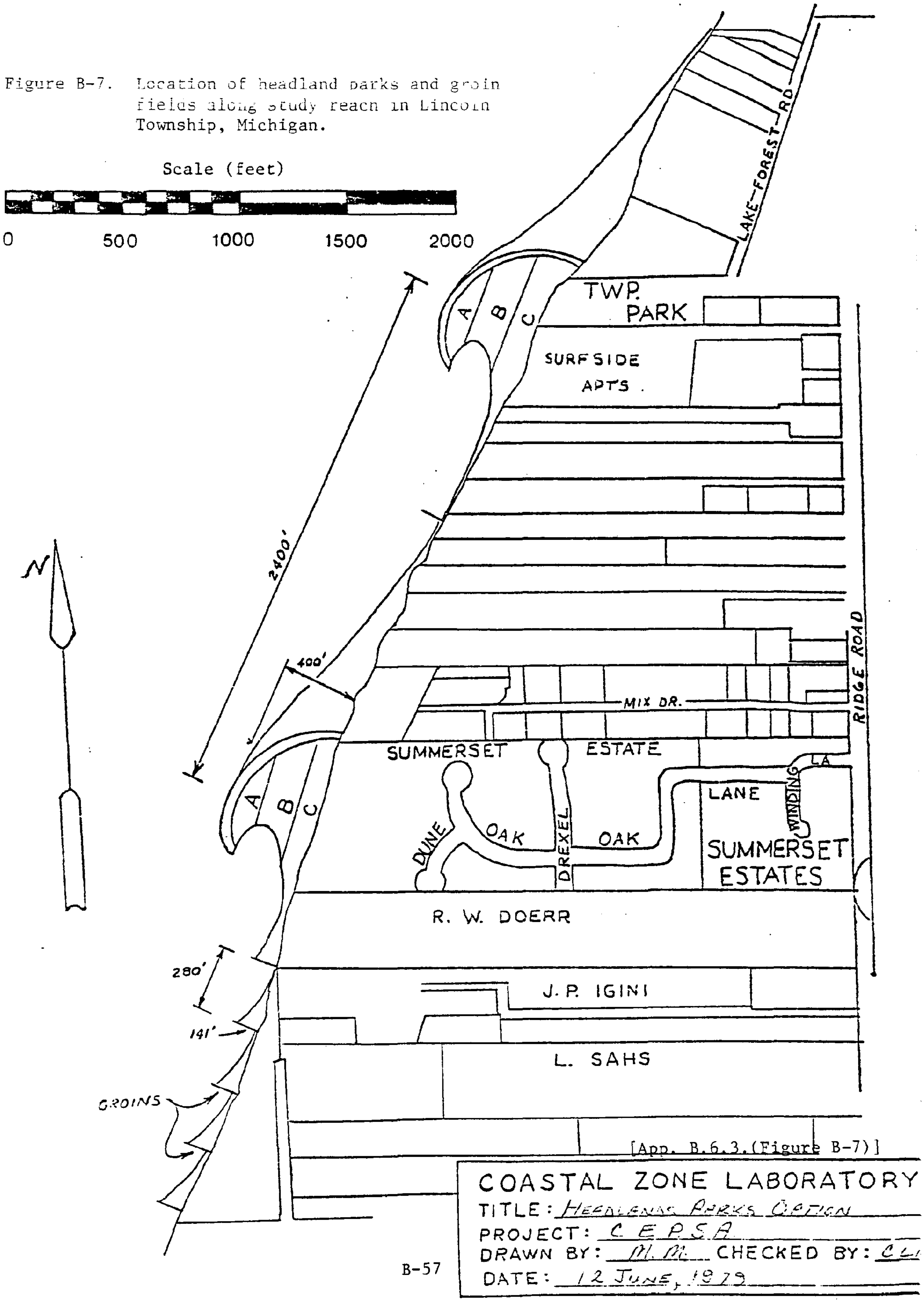
continued

Table B-24 Continued.

Structure	Quantity per structure	Total quantity
Section C		
Armor (560 lbs)	427 C.Y.	854 C.Y.
Midlayer (7"-10")	373 C.Y.	746 C.Y.
Bed layer ($\leq$3")	528 C.Y.	1,056 C.Y.
Fill	10,500 C.Y.	21,000 C.Y.
Groin		
Timber sheet piling (2" x 8" wakefield)	55,692 B.F.[a]	334,152 B.F.
Timber wales (8" x 10")	3,760 B.F.	22,560 B.F.
Timber piles (12" dia)	2,398 L.F.[a]	14,388 L.F.
Fill	4,600 C.Y.	27,600 C.Y.
Other fill	38,800 C.Y.	77,600 C.Y.

[a]C.Y. = cubic yards, B.F. = board feet, and L.F. = linear feet.

Figure B-7. Location of headland parks and groin fields along study reach in Lincoln Township, Michigan.



[App. B.6.3.(Figure B-7)]

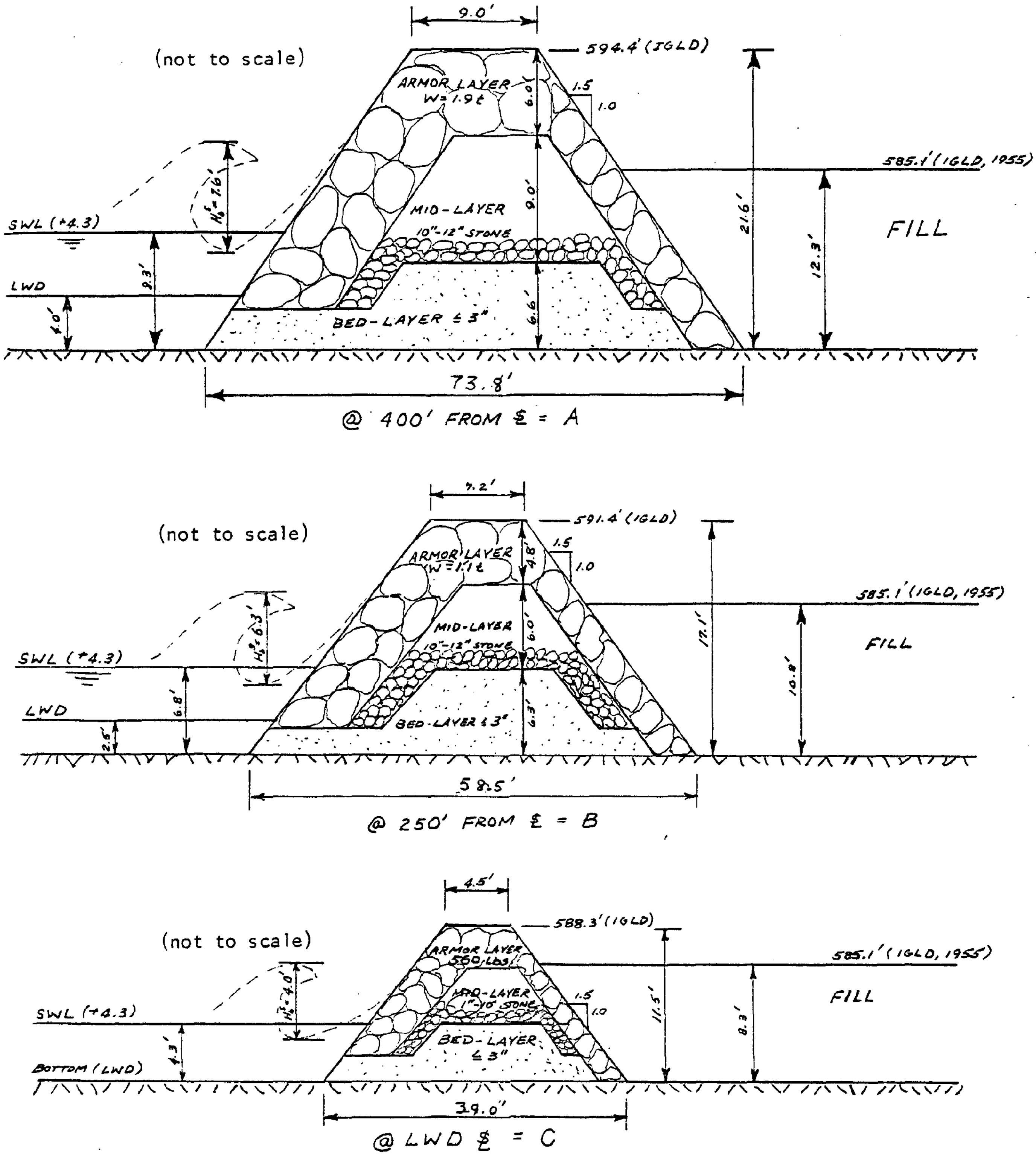


Figure B-8.

Proposed engineering design cross section of headland park through Sections A, B, and C. See Figure B-7.

COASTAL ZONE LABORATORY
TITLE: ______________________
PROJECT: ______________________
DRAWN BY: ________ CHECKED BY: ________
DATE: ______________________

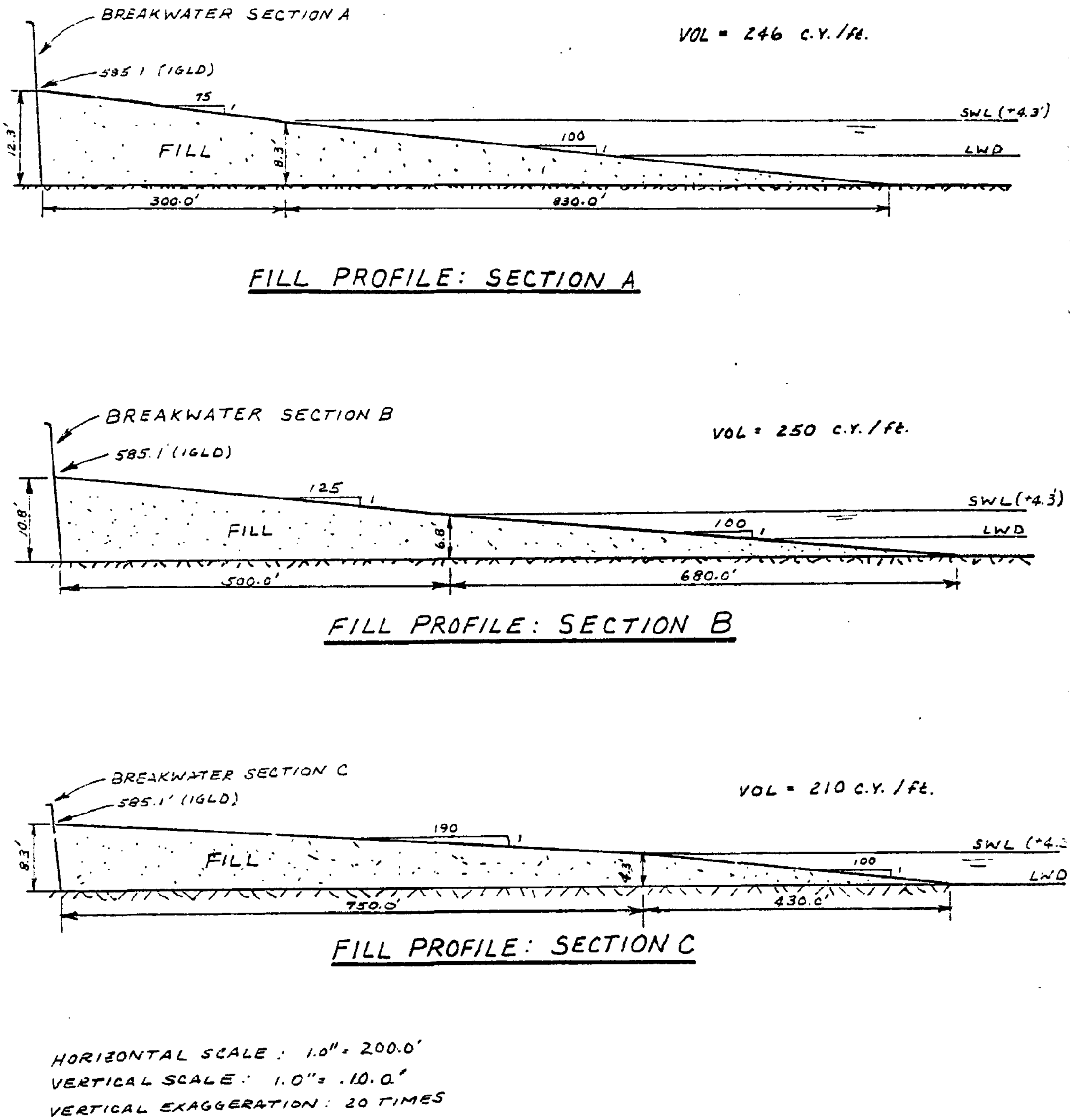


Figure B-9. Proposed engineering design cross sections of headland park beach nourishment profiles for Sections A, B, and C. See Figure B-7.

COASTAL ZONE LABORATORY
TITLE: Park Fill Profiles - Headland
PROJECT: C.E.P.S.A
DRAWN BY: M. M. CHECKED BY:
DATE: June 12, 197

Appendix C

Michigan Public Act

CERTAIN PUBLIC IMPROVEMENTS BY TOWNSHIPS

Act 188, 1954, p 453; imd eff May 5.

(Title as amended by Pub Acts 1974, No. 143, imd eff June 5.)

AN ACT to provide for the making of certain public improvements by townships; to provide for [paying for the same by the issuance of bonds; to provide for the levying of taxes; to provide for] assessing the whole or a part of the cost ♦ [of public improvements] against property benefited; and to provide for the issuance of bonds in anticipation of the collection of such special assessments, and for the obligation of the township thereon.

The People of the State of Michigan enact:

§ 5.2770(51) Improvements; power to make; bonds; special assessments; cost components.] SEC. 1. The township board shall have the power to make the hereinafter named improvements [to provide for the payment thereof by the issuance of bonds as set forth in section 15] and to determine that the whole or any part of the cost ♦ [of the improvements] shall be defrayed by special assessments against the property especially benefited thereby. The cost of engineering services, all expenses incident to the proceedings for the making of the improvement and the financing thereof, and not to exceed 1 year's interest on any bonds to be issued hereunder, shall be deemed to be a part of the cost of the improvement. (MCL §41.721.)

History. As amended by Pub Acts 1974, No. 143, imd eff June 5.

Digest reference. See Callaghan's Mich Dig, Local Improvements and Assessments, §1 et seq.

Textbook references. See Callaghan's Mich Civ Jur, Townships §73; McQuillin Mun Corp (3rd Ed) §§37.01 et seq., 38.01 et seq.

§ 5.2770(52) Improvements which may be made; approval required relative to improvements of certain highways.] SEC. 2. The following improvements may be made under this act: (1) The construction and maintenance of [storm or sanitary] sewers [or combined storm and sanitary sewers]; (2) the construction of water mains; (3) the improvements of public highways by grading, graveling, paving, curbing, or draining the same or constructing driveway approaches or sidewalks thereon; (4) the maintenance and improvement of parks or the trimming and spraying of trees; (5) the installation of elevated structures for foot travel over highways in the township; and (6) the collection of garbage and rubbish. ◆ [A] highway under the jurisdiction of either the state highway commissioner or the board of county road commissioners shall [not] be improved under the provisions of this act without the written approval of the state highway commissioner or the board of county road commissioners. As a condition to the granting of such approval, the state highway commissioner or the board of county road commissioners may require that all engineering with respect to [the] improvement be performed by, and that all construction including the awarding of contracts therefor in connection with [the] improvement be under the supervision of and in accordance with the specifications of, the state highway commissioner or the board of county road commissioners and that the cost of [the] engineering and supervision be paid to the state highway commissioner or the board of county road commissioners from the funds of the special assessment district. (MCL §41.722.)

History. As amended by Pub Acts 1958, No. 163, eff September 13; 1964, No. 30, imd eff May 1; 1966, No. 116, imd eff June 22; 1974, No. 143, imd eff June 5.

Digest reference. See Callaghan's Mich Dig, Local Improvements and Assessments, §1 et seq.

§ 5.2770(53) Petition; requisite signatures; determination of record owners; supplementing petition.] SEC. 3. No improvement shall be made hereunder unless a petition shall be filed with the township board, signed as follows: (a) In case of highway improvements, by the record owners of lands whose frontage constitutes at least 65% of the total frontage upon the highway improvements; and (b) in case of water mains or sewers, by record owners of lands constituting at least 51% of the total land area in the special assessment district as finally thereafter established by the township board. [In any township with a population in excess of 5,000, after notification by mail to the owners of lands whose names appear on the latest tax roll, no petition shall be required for water mains or sewers and the township board may exercise the powers granted by this act on its own initiative in accordance with the provisions of this act, except as they relate to a petition or action with reference thereto, but no such improvement shall be made without petition if the record owners of land constituting more than 20% of the total land area in the special assessment district file their written objections thereto with the township board at or prior to the hearing described in section 4 of this act.] Record owners shall be determined as of the records in the register of deeds' office on the day of the filing of the petition, [or in case written objections are filed as above provided, then on the day of the hearing]. In determining the sufficiency of the petition, [lands not subject to special assessment and] lands within public highway and alleys shall not be included [in computing frontage or assessment district area]. Any filed petition may be supplemented as to signatures by the filing of an additional signed copy or copies thereof, and in such case the validity of the signatures thereon shall be determined by said records on the day of filing the supplemental petition. (MCL §41.723.)

History. As amended by Pub Acts 1957, No. 187, imd eff June 4; 1961, No. 143, eff September 8.

Digest reference. See Callaghan's Mich Dig, Local Improvements and Assessments, §§16, 17.

§ 5.2770(54) Preparation of plans and estimate of cost; tentative designation of assessment district; hearing of objections; addition of property or increase in cost; notice to railroad companies.] SEC. 4. Upon receipt of ♦ a petition, [or upon determination of the township board if a petition is not required by this act or any other applicable act,] the township board, if it desires to proceed on the petition, shall cause to be prepared by a registered engineer, plans showing the improvement and the location thereof and an estimate of the cost thereof. Upon receipt of such plans and estimate, the township board shall order the same to be filed with the township clerk, and if it shall desire to proceed further with the improvement it shall by resolution tentatively declare its intention to make [the] improvement and tentatively designate the special assessment district against which the cost of [the] improvement [or a designated part thereof] is to be assessed. The township board shall then fix a time and place when and where it will meet and hear any objections to the petition, [if a petition is required,] to the improvement and to the special assessment district therefor, and shall cause notice of [the] hearing to be given by the publication thereof twice prior to [the] hearing in a newspaper circulating in the township, the first publication to be at least 10 days prior to the time of the hearing. [In addition the notice required by section 4a shall be given. The] notice shall state that the plans and estimates are on file with the township clerk for public examination and shall contain a description of the proposed special assessment district. At the time of such hearing, or any adjournment thereof which may be without further notice, the township board shall hear any objections to the petition, [if a petition is required,] to the improvement and to the special assessment district, and may revise, correct, amend, or change the plans, estimate of cost ♦ or special assessment district. ♦ Property shall [not] be added to the district nor any increase in the estimate of cost in excess of 10% of the original estimate of cost shall be made unless notice be given as above provided, or by personal service upon the owners of the property in the entire proposed special assessment district and a hearing afforded to [the] owners. [Where a petition is required] if property ♦ [is] added to the special assessment district and the original petition [is] insufficient because of [the] added property, then a supplemental petition shall be filed containing additional names. Railroad companies shall file with the secretary of state a paper stating the name and post office address of the person upon whom may be served notice of any proceedings under this act, and when [the] paper has been so filed, notice in addition to the notice by publication shall be given to [the] person by registered mail, or personally, within 5 days after the first publication of [the] notice. An affidavit of [the] service shall be filed by the township board with the proof of publication of [the] notice. (MCL §41.724.)

History. As amended by Pub Acts 1974, No. 143, imd eff June 5.

Digest reference. See Callaghan's Mich Dig, Local Improvements and Assessments, §24 et seq.

§ 5.2770(54a) Notice of hearings.] Sec. 4a. (1) Where special assessments are made against property, notice of hearings in the special assessment proceedings shall be given as provided in this section in addition to any notice of the hearings to be given by publication or posting as required elsewhere in this act.

Persons to receive notice; mailing.] (2) Notice of hearings in special assessment proceedings shall be given to each owner of, or party in interest in property to be assessed, whose name appears upon the last township tax assessment records, by mailing by first class mail addressed to the owner or party at the address shown on the tax records, at least 10 days before the date of the hearing. The last township tax assessment records means the last assessment roll for ad valorem tax purposes which was reviewed by the township board of review, as supplemented by any subsequent changes in the names or the addresses of the owners or parties listed thereon.

Claimants to property interests; filing of name and address; entry on records.] (3) Where a person claims an interest in real property whose name and correct address do not appear upon the last township tax assessment records, he shall be obligated to file immediately the name and address with the township supervisor. This requirement shall be deemed effective *only for* the purpose of establishing a record of the names and addresses of those persons entitled to notice of hearings in special assessment proceedings. It shall be the duty of the supervisor to immediately enter on the tax assessment records any changes in the names and addresses of owners or parties in interest filed with him and at all times to keep the tax assessment records current and complete and available for public inspection.

Reliance on tax assessment records; declaration as to method of giving notice.] (4) A township officer whose duty is to give notice of hearings in special assessment proceedings may rely upon the last township tax assessment records in giving notice of hearing by mail. The method of giving notice by mail as provided in this section is declared to be the method that is reasonably certain to inform those to be assessed of the special assessment proceedings.

Failure to give notice; effect; invalidity of assessment; reassessment.] (5) Failure to give notice as required in this section shall not invalidate an entire assessment roll but only the assessment on property affected by the lack of notice. A special assessment shall not be declared invalid as to any property if the owner or the party in interest thereof actually received notice, waived notice, or paid any part of the assessment. If an assessment is declared void by court decree or judgment, a reassessment against the property may be made.

Validation of hearings.] (6) Notwithstanding the lack of a statute providing for the mailing of notice of hearings, a special assessment hearing heretofore held is validated insofar as any notice of hearing is concerned, if notice was given by mail to the owners or parties in interest whose names appeared at the time of mailing on the last township tax assessment records. Any such special assessment hearing is validated as to any owner or party in interest who acutally [sic] received notice of hearing, waived the notice, or paid any part of the special assessment. (MCL §41.724a.)

History. Added by Pub Acts 1974, No. 143, imd eff June 5.

§ 5.2770(55) Township board desiring to proceed with improvement, resolution; attacking sufficiency of petition; making of special assessment roll, contents.] SEC. 5. After the hearing provided for in the preceding section, if the township board then desires to proceed with the improvement, it shall by resolution determine to make the same and shall approve the plans and estimate of cost as originally presented or as revised, corrected, amended, or changed, and shall also determine the sufficiency of the petition for the improvement **[**where a petition is required**]**. After **[**the**]** determination **[**where a petition is required**]**, the sufficiency of the petition shall not thereafter be subject to attack except in an action brought in a court of competent jurisdiction within 30 days after the adoption of the resolution determining such sufficiency. The township board after finally determining the special assessment district shall direct the supervisor to make a special assessment roll in which shall be entered and described all the parcels of land to be assessed, with the names of the respective owners thereof, if known, and the total amount to be assessed against each parcel of land, which amount shall be the relative portion of the whole sum to be levied against all parcels of land in the special assessment district as the benefit to **[**the**]** parcel of land bears to the total benefit to all parcels of land in the special assessment district. When the supervisor ♦ **[**completes**]** the assessment roll, he shall affix thereto his certificate stating that it was made pursuant to a resolution of the township board adopted on a specified date, and that in making **[**the**]** assessment roll he has according to his best judgment conformed in all respects to the directions contained in such resolution and the statutes of ♦ **[**this**]** state ♦. (MCL §41.725.)

History. As amended by Pub Acts 1974, No. 143, imd eff June 5.

1-10. [Reserved for use in future supplementation.]

11. Assessment. Where trial court found, and record supported finding, that location and shape of lot were considered in assessing benefits for sanitary sewer, and court further found, on facts, that front foot method of assessment for benefits was fair and equitable, such finding was held not to be clearly erroneous, this section not precluding use of front foot method of assessment. Spear v. Township of Fenton, 17 Mich App 682.

Digest reference. See Callaghan's Mich Dig, Local Improvements and Assessments, §§16 et seq., 69 et seq.

§ 5.2770(56) Special assessment roll; filing, review and hearing of objections; confirmation, conclusiveness of assessments after confirmation.] SEC. 6. When ♦ **[**a**]** special assessment roll ♦ **[**is**]** reported by the supervisor to the township board ♦ **[**it**]** shall be filed in the office of the township clerk. Before confirming **[**the**]** assessment roll the township board shall appoint a time and place when it will meet and review the same and hear any objections thereto, and shall cause notice of [the] hearing and the filing of [the] assessment roll to be published twice prior to [the] hearing in a newspaper circulating in the township, the first publication to be at least 10 days before [the] hearing [in addition to the notice required by section 4a. The] hearing may be adjourned from time to time without further notice. ♦ [A] person objecting to the assessment roll shall file his objection thereto in writing with the township clerk before the close of [the] hearing or within such further time as the township board may grant. After [the] hearing the township board [at the same or subsequent meeting] may confirm the special assessment roll as reported to it by the supervisor or as amended or corrected by it, or may refer it back to the supervisor for revision, or may annul it and direct a new roll to be made. When a special assessment roll ♦ [is] confirmed the township clerk shall endorse thereon the date of the confirmation. After [the] confirmation of [sic] the special assessment roll and all assessments thereon shall be final and conclusive unless attacked in a court of competent jurisdiction within 30 days after the date of confirmation. (MCL §41.726.)

History. As amended by Pub Acts 1974, No. 143, imd eff June 5.

Digest reference. See Callaghan's Mich Dig, Local Improvements and Assessments, §§69 et seq., 107 et seq.

§ 5.2770(57) Installment payment of assessments.] SEC. 7. Upon the confirmation of ♦ [a] special assessment roll, the township board may provide that the same shall be payable in 1 or more approximately equal annual installments, not exceeding 10 in the case of highway improvements and not exceeding 30 in the case of water and sewer improvements. The amount of each installment, if more than 1, need not be extended upon the special assessment roll until after confirmation. The first installment of a special assessment shall be due on or before [the] time after confirmation as the township board shall fix, and the several subsequent installments shall be due at intervals of 12 months from the due date of the first installment or from such other date as the township board shall fix [sic] All unpaid installments prior to their transfer to the township tax roll as hereinafter provided shall bear interest, payable annually on each installment due date, at a rate to be set by the township board, not exceeding [8%] per annum, from such date as shall be fixed by the township board. Future due installments of an assessment against any parcel of land may be paid to the township treasurer at any time in full, with interest accrued to the due date of the next installment. If ♦ [an] installment of a special assessment is not paid when due, then the same shall be deemed to be delinquent and there shall be collected thereon, in addition to interest as above provided, a penalty at the rate of ♦ [not more than] 1% for each month, or fraction thereof, that the same remains unpaid before being reported to the township board for reassessment upon the township tax roll. (MCL §41.727.)

History. As amended by Pub Acts 1957, No. 187, imd eff June 4; 1974, No. 143, imd eff June 5.

Digest reference. See Callaghan's Mich Dig, Local Improvements and Assessments, §87.

§ 5.2770(58) Special assessments to constitute lien.] SEC. 8. All special assessments contained in any special assessment roll, including any part thereof deferred as to payment, shall from the date of confirmation of such roll, constitute a lien upon the respective parcels of land assessed. Such lien shall be of the same character and effect as the lien created for township taxes and shall include accrued interest and penalties. No judgment or decree or any act of the township board vacating a special assessment shall destroy or impair the lien of the township upon the premises assessed for such amount of the assessment as may be equitably charged against the same, or as by a regular mode of proceeding might be lawfully assessed thereon. (MCL §41.728.)

Digest reference. See Callaghan's Mich Dig, Local Improvements and Assessments, §88.

§ 5.2770(59) Collection of assessments; delinquent assessments.] SEC. 9. When any special assessment roll shall be confirmed the township board shall direct the assessments made therein to be collected. The township clerk shall thereupon deliver to the township treasurer such special assessment roll, to which he shall attach his warrant commanding the township treasurer to collect the assessments therein in accordance with the directions of the township board in respect thereto. Said warrant shall further require the township treasurer on the 1st day of September following the date when any such assessments or any part thereof have become due to submit to the township board a sworn statement setting forth the names of the persons delinquent, if known, a description of the parcels of land upon which there are delinquent assessments and the amount of such delinquency, including accrued interest and penalties computed to September 1 of such year. Upon receiving such special assessment roll and warrant the treasurer shall proceed to collect the several amounts assessed therein as the same shall become due. (MCL §41.729.)

Digest reference. See Callaghan's Mich Dig, Local Improvements and Assessments, §91 et seq.

§ 5.2770(60) Reassessment of delinquent assessments.] SEC. 10. In case the treasurer shall, as above provided, report as delinquent any assessment or part thereof, the township board shall certify the same to the supervisor, who shall reassess on the annual township tax roll of such year in a column headed "special assessments" the sum so delinquent, with interest and penalties to September 1 of such year, and an additional penalty of 6% of the total amount. Thereafter the statutes relating to township taxes shall be applicable to such reassessments. (MCL §41.730.)

Digest reference. See Callaghan's Mich Dig, Local Improvements and Assessments, §82.

§ 5.2770(61) Division of property after having been assessed, apportionment of uncollected amounts.] SEC. 11. Should any parcel of land be divided after a special assessment thereon has been confirmed, and before the collection thereof, the township board may require the supervisor to apportion the uncollected amounts between the several divisions thereof and the report of such apportionment when confirmed by the township board shall be conclusive upon all parties: Provided, That if the interested parties do not agree in writing to such apportionment, then before such confirmation notice of hearing shall be given to all the interested parties, either by personal service or by publication as above provided in case of an original assessment roll. (MCL §41.731.)

Digest reference. See Callaghan's Mich Dig, Local Improvements and Assessments, §62 et seq.

§ 5.2770(62) Assessments insufficient or more than sufficient to pay for improvement.] SEC. 12. Should the assessments in any special assessment roll prove insufficient for any reason, including the noncollection thereof, to pay for the improvement for which they were made or to pay the principal and interest on the bonds issued in anticipation of the collection thereof, then the township board shall make additional pro rata assessments to supply the deficiency, but the total amount assessed against any parcel of land shall not exceed the value of the benefits received from the improvement. Should the total amount collected on assessments prove larger than necessary by more than 5% of the original roll, then the surplus shall be prorated among the properties assessed in accordance with the amount assessed against each and applied toward the payment of the next township tax levied against such properties, respectively, or if there be no such tax then it shall be refunded to the persons who are the respective record owners of the properties on the date of the passage of the resolution ordering such refund. Any such surplus of 5% or less may be paid into the township contingent funds disposed of as above provided. (MCL §41.732.)

Digest reference. See Callaghan's Mich Dig, Local Improvements and Assessments, §§82 et seq., 122 et seq.

§ 5.2770(63) Invalidity of assessment, new assessment; application of payment made on invalid assessment.] SEC. 13. Whenever any special assessment shall, in the opinion of the township board, be invalid by reason of irregularities or informalities in the proceedings, or if any court of competent jurisdiction shall adjudge such assessment to be illegal, the township board shall, whether the improvement has been made or not, whether any part of the assessment has been paid or not, have power to proceed from the last step at which the proceedings were legal and cause a new assessment to be made for the same purpose for which the former assessment was made. All proceedings on such reassessment and for the collection thereof shall be conducted in the same manner as provided for the original assessment, and whenever an assessment or any part thereof levied upon any premises has been so set aside, if the same has been paid and not refunded, the payment so made shall be applied upon the reassessment. (MCL §41.733.)

Digest reference. See Callaghan's Mich Dig, Local Improvements and Assessments, §97 et seq.

§ 5.2770(64) Agreement to pay assessment by corporation whose land is exempt.] SEC. 14. The governing body of any public or private corporation whose lands are exempt by law may, by resolution, agree to pay the special assessments against such lands, and in such case the assessment, including all the installments thereof, shall be a valid claim against such corporation. (MCL §41.734.)

§ 5.2770(64a) Townships paying part of assessments on corner lots.] SEC. 14a. The governing body of any township, by resolution, may agree to pay up to 1/3 of the cost of the special assessment levied against any platted corner lot for the payment of public improvements authorized under the provisions of this act. (MCL §41.734a.)

History. Added by Pub Acts 1959, No. 196, eff March 19, 1960.

§ 5.2770(65) Issuance of bonds in anticipation of collection of assessments.] SEC. 15. The township board may borrow money and issue the bonds of the township therefor in anticipation of the collection of special assessments to defray [all or any part of] the cost of any improvement made under this act after the special assessment roll therefor shall have been confirmed. Such bonds shall not exceed the amount of the special assessments in anticipation of the collection of which they are issued, and shall bear interest at a rate not exceeding ♦ [the maximum rate permitted by Act No. 202 of the Public Acts of 1943, as amended, being sections 131.1 to 138.2 of the Michigan Compiled Laws]. Collections on special assessments to the extent the same are pledged for the payment of bonds shall be set aside in a special fund for the payment of such bonds. ♦ Bonds may be issued in anticipation of the collection of special assessments levied in respect to [1] or more public improvements, but no special assessment district shall be compelled to pay the obligation of any other special assessment district. The township board may pledge the full faith and credit of the township for the prompt payment of the principal of and interest on the bonds authorized herein, as the same shall become due[, in which event the township may levy a tax on all taxable property in the township for the payment of principal and interest on the bonds without limitation as to rate or amount and in addition to all other taxes which the township may be authorized to levy. The issuance of bonds under this section shall be subject to Act No. 202 of the Public Acts of 1943, as amended, being sections 131.1 to 138.2 of the Michigan Compiled Laws]. Bonds issued hereunder shall be executed by the supervisor and township clerk and the interest coupons to be attached thereto shall be executed by [the] officials causing their facsimile signatures to be affixed thereto. (MCL §41.735.)

History. As amended by Pub Acts 1974, No. 143, imd eff June 5.

Statutory reference. Act No. 202 of 1943, above referred to, is §5.3188(1) et seq., infra.

Digest references. See Callaghan's Mich Dig, Municipal and Public Bonds, §1 et seq.; Townships, §39.

§ 5.2770(65a) Alternate method of defraying cost of improvement.] SEC. 15a. The township board as an alternate method of defraying the cost of any improvement made under the provisions of this act, after the special assessment roll therefor shall have been confirmed, may pay the cost of the improvement from the township improvement revolving fund. The amount shall not exceed the amount the board anticipates will be collected by the special assessments. The amount so advanced by the township shall bear interest at a rate not exceeding 5% per annum. (MCL §41.735a.)

History. Added by Pub Acts 1956, No. 109, eff August 11.

Digest reference. See Callaghan's Mich Dig, Local Improvements and Assessments, §14.

§ 5.2770(65b) Township improvement revolving fund; creation; transfers between such fund and township general fund.] SEC. 15b. The township board of any township by resolution may create and designate a fund to be known as the township improvement revolving fund and thereafter may transfer to such fund from the general fund of the township in any one year an amount not exceeding 2 mills of the state equalized valuation of the real and personal property in the township and thereafter may each year transfer from the general fund to the township improvement revolving fund until such fund shall be equal to 5 mills of the state equalized valuation of the real and personal property in the township. All interest charges collected shall become a part of such fund and the township board may transfer from the township improvement revolving fund to the general fund such sum or sums and at such time or times as in the judgment of the board should be transferred. (MCL §41.735b.)

History. Added by Pub Acts 1956, No. 109, eff August 11.

1-10. [Reserved for use in future supplementation.]

11. Credits exceeding limitations. Money credited to the township improvement revolving fund in violation of the limitations contained in act authorizing establishment of funds may be considered by the county tax allocation board as being credited to the general fund. Op Atty Gen, January 9, 1958, No. 3162.

12. Transfers to and from fund. The amount of money lawfully deposited in and standing to the credit of revolving fund lies within the discretion of township board, and county tax allocation board may not reduce millage requests for operating expenses of township based thereon. Op Atty Gen, January 9, 1958, No. 3162.

13. Statement. Annual budget submitted to the county tax allocation board pursuant to §7.69 must include a statement of all estimated township expenditures and revenues, and statement of township expenditures and revenues during the preceding two years, if submitted at request of county tax allocation board must show transfers between general fund and township improvement revolving fund. Op Atty Gen, January 9, 1958, No. 3162.

Digest references. See Callaghan's Mich Dig, Local Improvements and Assessments, §14; Townships, §54.

§ 5.2770(65c) Special assessments against certain property specially benefitted; procedure; inapplicability of statutes.] SEC. 15c. The township board may determine that the whole or any part of an obligation of the township assessed or contracted for pursuant to Act No. 342 of the Public Acts of 1939, as amended, being sections 46.171 to 46.187 of the Michigan Compiled Laws; Act No. 185 of the Public Acts of 1957, as amended, being sections 123.731 to 123.786 of the Michigan Compiled Laws; Act No. 40 of the Public Acts of 1956, as amended, being sections 280.1 to 280.623 of the Michigan Compiled Laws; and Act No. 233 of the Public Acts of 1955, as amended, being sections 124.281 to 124.294 of the Michigan Compiled Laws, shall be defrayed by special assessments against the property specially benefited thereby and in such case, the special assessments may be levied and collected in accordance with this act except as herein provided. The requirements of section 3 with respect to requiring a petition and section 4 with respect to the hearing therein required shall not apply to any special assessments levied and collected in accordance with this section and the above described acts. (MCL §41.735c.)

History. Added by Pub Acts 1974, No. 143, imd eff June 5.

Statutory references. Act No. 342 of 1939, above referred to, is §5.2767(1) et seq., supra; Act No. 185 of 1957 is §5.570(1) et seq., supra; Act No. 40 of 1956 is §11.1001 et seq., infra; Act No. 233 of 1955 is §5.2769(51) et seq., supra.

§ 5.2770(66) Townships which may exercise powers granted.] SEC. 16. The powers herein granted may be exercised by any township ♦ and shall be in addition to the powers granted by any other statute. (MCL §41.736.)

History. As amended by Pub Acts 1961, No. 14, imd eff May 9.

§ 5.2770(67) Applicability of act.] SEC. 17. The provisions of this act shall not apply to any obligations issued or assessments levied except in accordance with the provisions of this act after the effective date thereof, and shall not validate any proceedings or action taken by any township prior to the effective date of this act. (MCL §41.737.)

§ **5.2770(52) Improvements which may be made.]** SEC. 2. [(1)] The following improvements may be made under this act:

[(a)] The construction and maintenance of storm or sanitary sewers or combined storm and sanitary sewers.

[(b)] The construction of water mains.

[(c)] The improvements of public highways by grading, graveling, paving, curbing, or draining the same or constructing driveway approaches or sidewalks thereon.

[(d)] The maintenance and improvement of parks or the trimming and spraying of trees.

[(e)] The installation of elevated structures for foot travel over highways in the township. ♦

[(f)] The collection of garbage and rubbish.

[(g) The construction, maintenance, or improvement of bicycle paths parallel to public highways.

(h) The construction, maintenance, repair, or improvement of erosion control structures or dikes.]

Approval as to certain highway improvements; conditions for granting.] [(2)] A highway under the jurisdiction of either the [department of] state ♦ [highways and transportation] or the board of county road commissioners shall not be improved under ♦ this act without the written approval of the ♦ [department of state highways and transportation] or the board of county road commissioners. As a condition to the granting of such approval, the [department of] state ♦ [highways and transportation] or the board of county road commissioners may require that all engineering with respect to the improvement be performed by, and that all construction including the awarding of contracts therefor in connection with the improvement be under the supervision of and in accordance with the specifications of, the [department of] state ♦ [highways and transportation] or the board of county road commissioners and that the cost of the engineering and supervision be paid to the [department of] state ♦ [highways and transportation] or the board of county road commissioners from the funds of the special assessment district.

History.
As amended by Pub Acts 1976, No. 148, imd eff June 16.

Administrative rules.
R 28.1707 [pedestrian overpass, right-of-way].

Analysis of New Notes.

Administrative rules.

§ **5.2770(53) Petitions, requisite signatures.]** SEC. 3. [(1) An] ♦ improvement shall [not] be made hereunder unless a petition shall be filed with the township board, signed as follows:

Highway improvements.] (a) In case of highway improvements, by the record owners of lands whose frontage constitutes ♦ [not less than 51%] of the total frontage upon the highway improvements. ♦ [In a township after notification by mail to the owners of land whose names appear on the latest tax roll, a petition shall not be required for highway improvements and the board may exercise the powers granted by this act on its own initiative in accordance with this act, except as they relate to a petition or action with reference thereto, but an improvement shall not be made without petition if the record owners of land constituting 20% of the total frontage upon the highway improvements file their written objections thereto with the township board at or before the hearing described in section 4.]

Water mains and sewers; erosion control structures; dikes.] (b) In case of water mains or sewers, [or erosion control structures or dikes,] by record owners of lands constituting at least 51% of the total land area in the special assessment district as finally thereafter established by the township board. In ♦ [a] township with a population in excess of [2,000], after notification by mail to the owners of lands whose names appear on the latest tax roll, ♦ [a] petition shall [not] be required for water mains or sewers [or erosion control structures or dikes] and the township board may exercise the powers granted by this act on its own initiative in accordance with ♦ this act, except as they relate to a petition or action with reference thereto, but ♦ [an] improvement shall [not] be made without petition if the record owners of land constituting more than 20% of the total land area in the special assessment district file their written objections thereto with the township board at or ♦ [before] the hearing described in section 4 of this act.

Determination of record owners; supplementing petitions.] [(2)] Record owners shall be determined as of the records in the register of deeds' office on the day of the filing of the petition, or in case written objections are filed as above provided, then on the day of the hearing. In determining the sufficiency of the petition, lands not subject to special assessment and lands within public highway and alleys shall not be included in computing frontage or assessment district area. Any filed petition may be supplemented as to signatures by the filing of an additional signed copy or copies thereof, and in [that] case the validity of the signatures thereon shall be determined by [the] records on the day of filing the supplemental petition.

History.
As amended by Pub Acts 1976, No. 113, imd eff May 14, No. 148, imd eff June 16, No. 332, imd eff December 15.

Although this section was three times amended at the 1976 session of the legislature, only the last amendment is herein set out, as under the rule of Detroit United Railway v. Barnes Paper Co., 172 Mich 586, the last amendment was controlling.

§ 5.2770(57) Installment payment of assessments.]

Analysis of New Notes.

16. Interest on special assessments.

16. Interest on special assessments.
In the absence of a clear expression of legislative intent, a local governmental unit may not charge a full year's interest on special assessments due in the future, but may only charge such interest that may have accrued at the time of payment. Op Atty Gen, April 7, 1978, No. 5289.

§ **5.2770(59a) Hardship deferment of total or partial payment of assessment.]** SEC. 9a. (1) An owner of property who by reason of hardship is unable to contribute to the cost of an assessment for an improvement authorized in section 2(1)(a), (b), (c), (g), or (h) may have the assessment deferred by application to the assessing officer. Upon receipt of evidence of hardship, the township may defer partial or total payment of the assessment.

Ordinance; deferred assessment as lien on property.] (2) The township board of trustees may enact an ordinance to define hardship and to permit deferred or partial payment of an assessment pursuant to this section. As a condition of granting the deferred or partial payment of an assessment, the township board shall require that any deferred assessment will constitute a recorded lien against the property.

(MCL §41.729a.)

History.
Added by Pub Acts 1976, No. 148, imd eff June 16.

Appendix D

COMPUTERIZED VERSION OF THE BENEFIT-COST MODEL OF SHORELINE PROTECTION SYSTEMS

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

D.1.0. INTRODUCTION

Shoreline erosion is a fact of life which most property owners on the Great Lakes must face or literally lose the land on which they live. To combat the problems of severe shoreline erosion most property owners turn to some sort of shoreline protection structure (SPS). There is a host of shoreline protection systems which may be grouped as offshore floating or fixed structures, beach protection structures, beach replenishment techniques, and bluff stabilization techniques. Within each class, there are several and sometimes hundreds of systems or designs, most of which have not been tested enough to know their longterm efficiency and stability. Along with this, the large variability in cost of materials and labor to install a shoreline protection structure must be added. Given this wide variety of structures and possibilities it becomes almost impossible for one to evaluate and rank all of them. In order to allow the property owner or engineer to evaluate this problem, an economic model of net benefits derived from shoreline protection structures has been prepared.

This paper presents a computerized version of the Benefit-Cost model of shoreline protection systems, developed by the Coastal Zone Laboratory. The purpose of the paper is to:

(a) Present the basic logic of the model.

(b) Present the layout of the computer program and sample runs of the model.

(c) Present an initial sensitivity analysis of the model.

D.2.0. THE BENEFIT-COST MODEL

D.2.1. Basic Concepts

The model developed by the Coastal Zone Laboratory is based on the idea that the protection of a home from damage and the prevention of bluff recession are imputed benefits of putting in a shoreline protection structure. Yearly benefits and costs converted to their present value are combined to get the accumulated net benefit of putting in a shoreline protection structure (SPS). Thus, at the time the SPS is built, there are usually no benefits, but the initial costs of building the structure are still present.

The benefit-cost model is based on the perceived market value of the property. It is important that the concept of market decision making be distinguished from other approaches to economic efficiency. The market is an average of individual values which may differ from the personal value placed by a particular shoreline owner on his property. For example, a family may have owned a cottage on the lake for three generations. The value of that property to the present owner is probably much higher than the market value. Such subjective values are very important and may be the deciding factor in determining how much is invested in shoreline protection. The model, however, is based on the market value because it is very hard to put a quantitative number to an individual's values regarding his shoreline.

It is assumed that each shoreline property owner is seeking to maximize the return on his investment in shoreline property. With this assumption, the amount of money that an individual should be investing in a shoreline protection system will be defined so that the property value saved by the structure justifies the cost of building it.

In order to explain the major elements of the Benefit-Cost Model, a typical shoreline property will be used as an example (Figure D-1). The lot is 300 feet deep with 100 feet of front footage. The home is located 120 feet from the edge of the bluff. The total value of the property is $70,000, of which $30,000 makes up the simple land value and $40,000 the structure value. The aesthetic value is assumed to be the difference between the simple land value of the lakeside property and the simple land value of a comparable property off the lake. For this case, the inland land value is $15,000 making the aesthetic value $15,000. Another piece of information necessary is the height and angle of the bluff. Our test property has a bluff height of 18 feet at an angle of 45 degrees. The other values necessary to run the model are listed in Table D-1. These values are usually more general, applying to a group or reach of properties.

D.2.2. Property Losses and Imputed Benefits

The manner in which property value declines as the bluff recedes was found to be somewhat irregular. Instead of a constant loss of value as the bluff recedes, large steps or jumps in property values occurred as the bluff reached various depths. This is due to three major components of shoreline property value.

(a) The simple land value which is the value of the lot independent of its lakeside location.

(b) The aesthetic value is the additional value of the lot due to its lakeside location.

Figure D-1. Typical shoreline property which will be used to explain the Benefit-Cost Model.

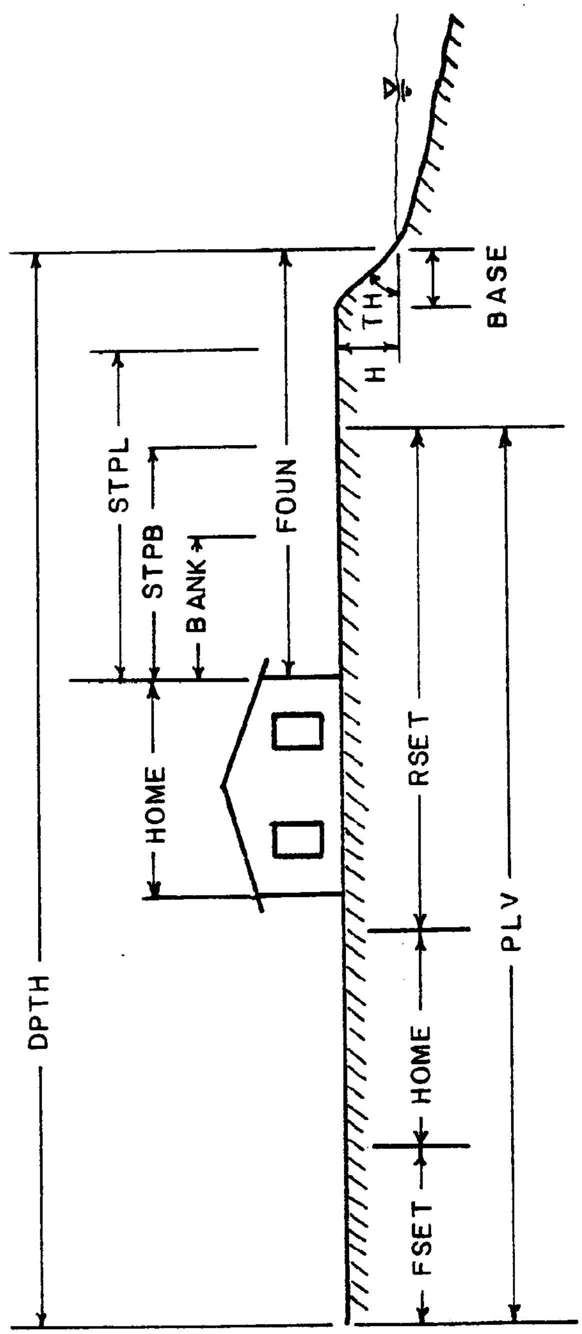


Table D-1. Tabulated results.

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY UNIVERSITY OF MICHIGAN VERSION #2 DECEMBER 1978

TEST RUN VARIABLE EFFECTIVENESS AND RECESSION RATE (NO REBUILD)

DPTH = 300.000 - DEPTH OF THE LOT (FEET)
FOUN = 120.000 - DISTANCE FROM FOUNDATION TO BLUFF (FEET)
RSET = 140.000 - RECOMMENDED SET BACK DISTANCE (FEET)
H = 18.000 - HEIGTH OF THE BLUFF (FEET)
LV = 30000.000 - LAKESIDE LAND VALUE ($)
SV = 40000.000 - HOME OR STRUCTURE VALUE ($)
LRES = 3.000 - LONG TERM RECESSION RATE (FEET/YEAR)
COST = 5000.000 - COST TO MOVE HOME ($)
REST = 35.000 - REALTORS ESTIMATE OF BANK (FEET)
MLT1 = 5.000 - WEIGHTING FACTOR
T = 30.000 - INVESTMENT HORIZON (YEARS)
BANK = 40.000 - DISTANCE WHERE BANK WILL NO LONGER GRANT
STPB = 55.500 - 1/2 WAY BETWEEN BANK AND STPPL (FEET)

L = 100.000 - FRONT FOOTAGE OF LOT IN (FEET)
HOME = 60.000 - DEPTH OF THE HOME (FEET)
FSPT = 50.000 - SET BACK IN FRONT OF HOME (FEET)
TH = 0.780 - ANGLE OF THE BLUFF (RADIANS)
LV = 15000.000 - INLAND LAND VALUE ($)
RESR = 1.000 - RECESSION RATE MODIFIER
AEST = 15000.000 - ASTHETIC VALUE ($)
DT = 0.120 - DISCOUNTING RATE
A = 0.500 - WEIGHTING FACTOR
MLT2 = 0.500 - WEIGHTING FACTOR
PLV = 250.000 - DISTANCE FROM ROAD TO SETBACK (FEET)
STPL = 91.000 - POINT OF SHARP DECLINE IN STRUCTURE VALU
BASE = 13.195 - LENGTH OF THE BLUFF BASE (FEET)

INPUT PARAMETERS					OUTPUT PARAMETERS								
AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENFITS ($)	TOTAL DISC. BENFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENFITS ($)	YEARLY HOME MOVING BENFITS ($)	TOTAL HOME MOVING BENFITS ($)
2.50	.100	250.00	1.000	0	2.50	0.0	0.0	0.0	250.00	250.00	-250.00	-60.00	-60.00
3.50	.100	0.0	0.980	1	6.40	0.08	0.0	0.0	0.0	250.00	-250.00	0.0	-60.00
5.10	.100	0.0	0.970	2	11.80	0.24	0.0	0.0	0.0	250.00	-250.00	0.0	-60.00
[illegible]	.100	0.0	0.950	3	16.60	0.48	0.0	0.0	0.0	250.00	-250.00	0.0	-60.00
4.40	.100	0.0	0.940	4	21.20	0.74	38.38	38.38	0.0	250.00	-211.62	-38.38	-98.38
3.50	.100	0.0	0.920	5	24.90	1.06	0.0	38.38	0.0	250.00	-211.62	0.0	-98.38
3.30	.100	0.0	0.900	6	28.20	1.39	0.0	38.38	0.0	250.00	-211.62	0.0	-98.38
2.60	.100	0.0	0.890	7	30.80	1.67	116.36	154.74	0.0	250.00	-95.26	116.36	17.98
1.90	.100	0.0	0.870	8	32.70	1.92	0.0	154.74	0.0	250.00	-95.26	0.0	17.98
1.70	.100	0.0	0.850	9	34.40	2.17	0.0	154.74	0.0	250.00	-95.26	0.0	17.98
3.20	.100	0.0	0.830	10	37.60	2.69	0.0	154.74	0.0	250.00	-95.26	0.0	17.98
2.90	.100	0.0	0.820	11	40.50	3.21	0.0	154.74	0.0	250.00	-95.26	0.0	17.98
2.40	.100	0.0	0.815	12	42.90	3.56	0.0	154.74	0.0	250.00	-95.26	0.0	17.98
1.30	.100	0.0	0.790	13	44.20	3.94	0.0	154.74	0.0	250.00	-95.26	0.0	17.98
0.70	.100	0.0	0.770	14	44.90	4.10	0.0	154.74	0.0	250.00	-95.26	0.0	17.98
1.40	.100	0.0	0.760	15	46.10	4.43	0.0	154.74	0.0	250.00	-95.26	0.0	17.98
2.30	.100	0.0	0.740	16	48.60	5.03	0.0	154.74	0.0	250.00	-95.26	0.0	17.98
2.80	.100	0.0	0.730	17	51.40	5.79	91.10	245.84	0.0	250.00	-4.16	-91.10	-73.13
2.80	.100	0.0	0.710	18	54.20	6.59	0.03	245.87	0.0	250.00	-4.13	-0.03	-73.16
3.30	.100	0.0	0.690	19	57.50	7.62	14.77	260.65	0.0	250.00	10.65	14.63	-58.53
4.10	.100	0.0	0.680	20	61.60	8.94	19.48	280.53	0.0	250.00	30.53	19.59	-38.94
3.90	.100	0.0	0.660	21	65.50	10.26	18.53	299.16	0.0	250.00	49.16	18.25	-20.69
4.30	.100	0.0	0.650	22	69.80	11.77	20.24	319.39	0.0	250.00	69.39	19.70	-0.99
4.50	.100	0.0	0.630	23	74.60	13.54	22.26	341.65	0.0	250.00	91.65	21.52	20.52
5.40	.100	0.0	0.610	24	80.90	15.65	24.09	366.34	0.0	250.00	115.34	23.68	44.21
5.40	.100	0.0	0.600	25	85.40	17.81	0.60	365.94	0.0	250.00	115.94	-0.59	43.61
[illegible]	.100	0.0	0.540	26	90.10	19.87	-25.21	341.73	0.0	250.00	91.73	-0.61	43.00
4.30	.100	0.0	0.560	27	[illegible]	21.85	0.64	342.37	0.0	250.00	92.37	-0.64	42.36
3.40	.100	0.0	[illegible]	28	[illegible]	23.47	0.51	342.87	0.0	250.00	92.87	-0.51	41.86
4.40	.100	0.0	[illegible]	29	102.70	25.49	0.70	343.57	0.0	250.00	93.57	-78.97	-37.12
4.20	.100	0.0	0.520	30	106.60	27.50	0.71	344.27	0.0	250.00	94.27	-0.71	-37.82

(c) The structure value which includes the house, if present, and any related structures (sheds, garage, etc.).

Simple Land Value

According to surveys done in the Benton Harbor area, there will be no loss in simple land value until the lot becomes too small to build on. This point (coded PLV in the computer model) is a summation of the minimum set back from the lot line on the landward side of the house (coded FSET) plus the thickness of the home (coded HOME), plus the recommended setback distance from the bluff (coded RSET). Figure D-2 shows how the point PLV is determined and how the simple land value decreases as a function of bluff recession. The recommended setback limit is the minimum number of feet that a property owner may build a new home from the edge of the bluff as established by the Michigan Department of Natural Resources. Under Public Act 245, this applies only to undeveloped property in designated high risk erosion areas.

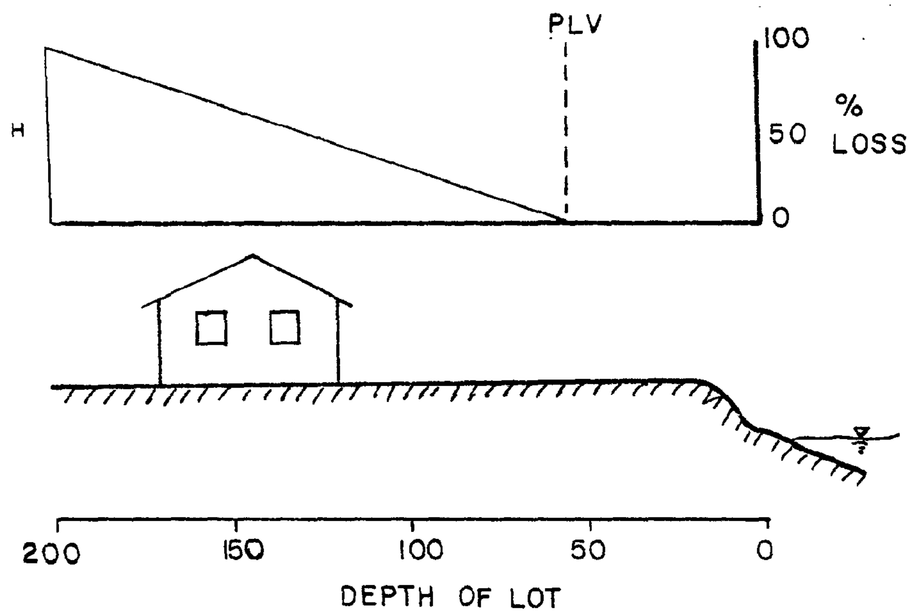
The decline in property value as the bluff recedes beyond the point PLV is not a linear function. It is more truly represented as the area under the line in Figure D-2. If the distance PLV and the simple land value are known, the value of H is calculated as follows:

Simple land value = Area = 1/2 x PLV x H

H = (Simple land value) x 2 / PLV

The model interprets the area of the trapezoid which is lost in year "i" as the simple land value lost. It should be noted that this is the cumulative loss for years 0 to "i", not the benefit gained in year "i". This point will become important later in the report when the present value of benefits gained each year is calculated.

Figure D-2. Percent of inland land value lost as a result of bluff recession.



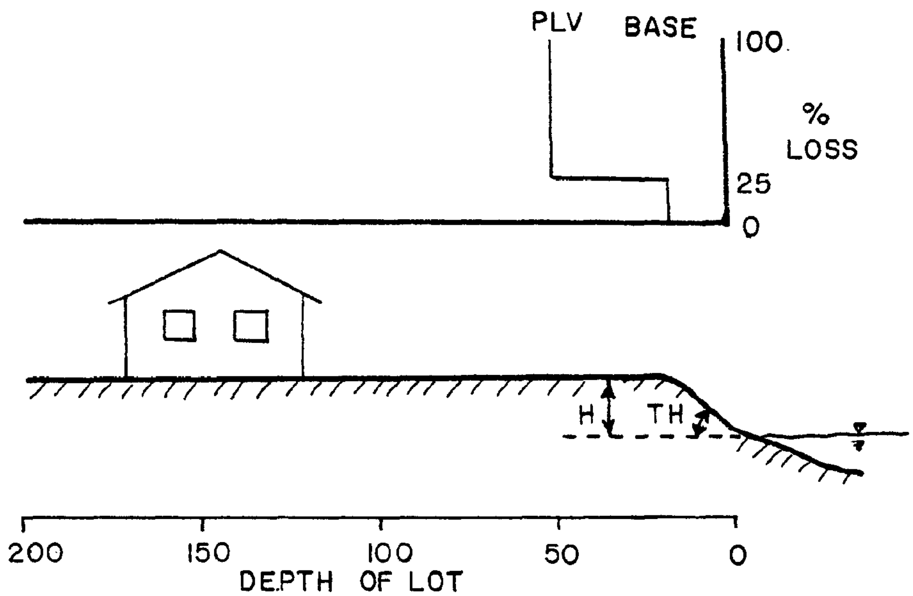
Aesthetic Value

The aesthetic value is defined by the model as the difference between the total land value and simple land value. In other words, the value of a lot due to its lakeside location. The aesthetic value was separated from the simple land value because of the major differences in the way that damages are alloted as the bluff recedes.

Losses in aesthetic value were found to be a two step function of bluff recession (Figure D-3). The first step, attributed to erosion of the vegetative cover of the bluff, was found to be 25% of the aesthetic value of the lot. Because the point where the vegetative cover is lost is a function of the type of vegetation, soil type, soil structure, slope of bluff, stability of the bluff and a host of other terms, it became almost impossible for the model to quantify the point in time when this happened. It was decided that going to this detail was beyond the accuracy of the model because it did not determine the amount of the losses, just the year in which the loss was incurred. Thus, it was decided to define this point as the point in time when the initial base of the bluff has been eroded.

The 75% of aesthetic value remaining is not lost until the depth of the lot has been eroded to the point where a house can no longer be built on the lot. At this time the remaining aesthetic value is lost immediately. There is one exception to this, that is when a house exists on a lot already too shallow to allow the owner to rebuild that home. In this case, the second 75% of aesthetic value is not lost till the bluff recedes to the edge of the present home.

Figure D-3. Distribution of aesthetic value as the bluff recedes.



Structure Value

Of the three components, changes in structure value were found to be the most sensitive to erosion. Any loss in structure value can be attributed to a fear of damage to or loss of the structure as perceived by the prospective buyers.

The rate of structure value decline is not evenly distributed between the edge of the bluff and the house. At the critical distance (termed STPL by the model), fear of damage to the house becomes a factor and the structure value will decline approximately 30% (Figure D-4). As erosion continues to decrease the distance between the house and bluff, there will be no further decline in property value until the point STPB is reached. STPB is defined as a point half the way between the critical distance (STPL) and BANK, the point where a bank will no longer grant a mortgage on the house. At this point, there will be a further gradual decline in structure value as bluff recession continues. When the distance from the house to the bluff reaches BANK the house can no longer be sold if a mortgage is required, and 70% of the structure value has been lost. The remaining 30% of value is not lost until the bluff recedes to the foundation of the house.

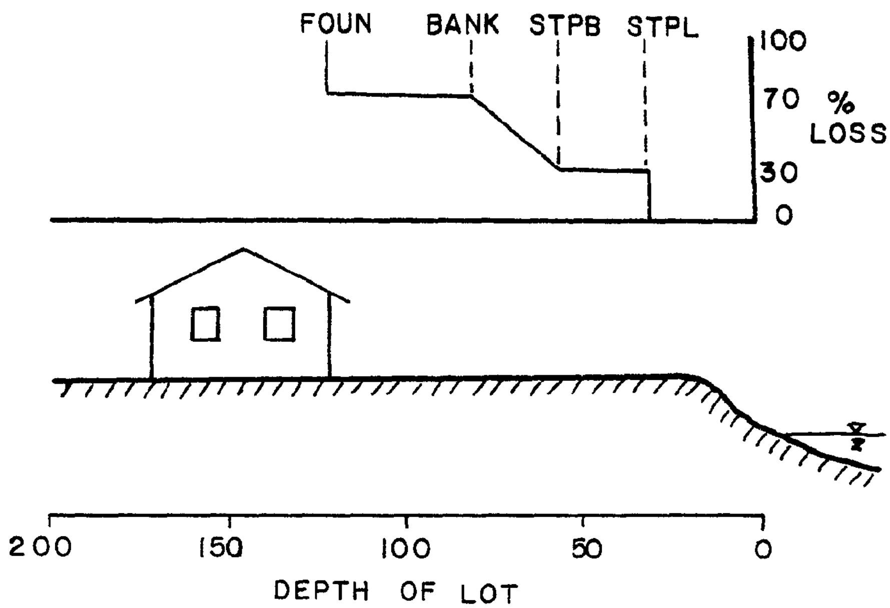
The equation proposed for calculating the distance BANK is:

$$BANK = (A \times REST) + (1 + MLT2) \times MLT1 \times RSET$$

REST = Realtor estimate of BANK
MLT2 = Uncertainty weighting to realtor estimates
RSET = Long term recession rate
MLT1 = Curve fitting factor
A = Weighting factor

Values MLT2, MLT1 and A were determined from surveys of realtors located in Berrien County.

Figure D-4. Percent of structure value lost as a function of bluff recession.



D.2.3. Alternatives to Shoreline Protection Structures

An alternative to building a shoreline protection structure is to move the house inland. This, of course, requires that the lot be deep enough to allow the home to be moved a distance great enough to justify the expenditure. There are essentially two reasons for this alternative. First, the cost of moving a home is competitive with a well constructed shoreline protection structure. Second, there will be no risk of erosion for many years, provided the home is moved back far enough.

The benefits to be gained from moving the home are calculated in the same manner as previously explained for structure value, simple land value and aesthetic value. There is, though, one major exception. Previously, an imputed benefit was defined as a loss in property value which was avoided by building a structure. In this case no shoreline protection structure is being built, and thus no losses being avoided, except for structure value losses which have been avoided by moving the home. So, for the home moving option, an imputed benefit can only be gained by avoiding structure value losses. All other losses, aesthetic value and simple land value, are actual losses to the property value and must be subtracted from any imputed benefits gained.

D.3.0. MODEL STABILITY

D.3.1. Sensitivity Analysis of Input Parameters

In order to determine how sensitive the model is to the many parameters which must be input, a sensitivity analysis was made. This was done by varying each parameter, one at a time, by -20%, -10%, 0, +10%, and +20%. The results of the runs for each offset, in the form of net benefit versus time, were plotted on the same graph. The test property previously described was used for these runs.

There has also been a concern as to the benefits gained by a long term expensive structure, 30 year expected life; and a short term, low cost structure, 5 year expected life, which will be rebuilt at the end of those five years. The structures were assumed to have a linearly decreasing effectiveness from 100% to 50% over the life of the structure.

A third concern was the effect of the recession rate. Technology at this time does not allow us to predict accurately long term recession rates, but it is known that they would be a function of the lake level, storm frequency and storm duration. With this it was decided to assume that there was a direct relationship between the yearly mean lake level and recession rate. To do this, the elevation of 575 feet was taken as 0.0 feet/year recession and each foot of water level elevation above this point was assumed to indicate an increase in recession of 1 foot/year. The previous 30 years of lake level data from 1948 to 1978 on Lake Michigan were used to obtain the recession rate curve for our tests.

The results have been separated into four sections: structure value, aesthetic value, simple land value, and general parameters. Figures D-5, D-6 and Tables D-1, D-2 present the results of the test property.

Structure Value

Results of the structure value analysis are presented in Figures 1-14 Appendix DB. These show that the model is relatively insensitive to the values which go into calculating BANK. They only have an effect for a

Figure D-5. Net benefits versus time generated by a structure with a variable effectiveness, variable recession rate and a structure life of 30 years.

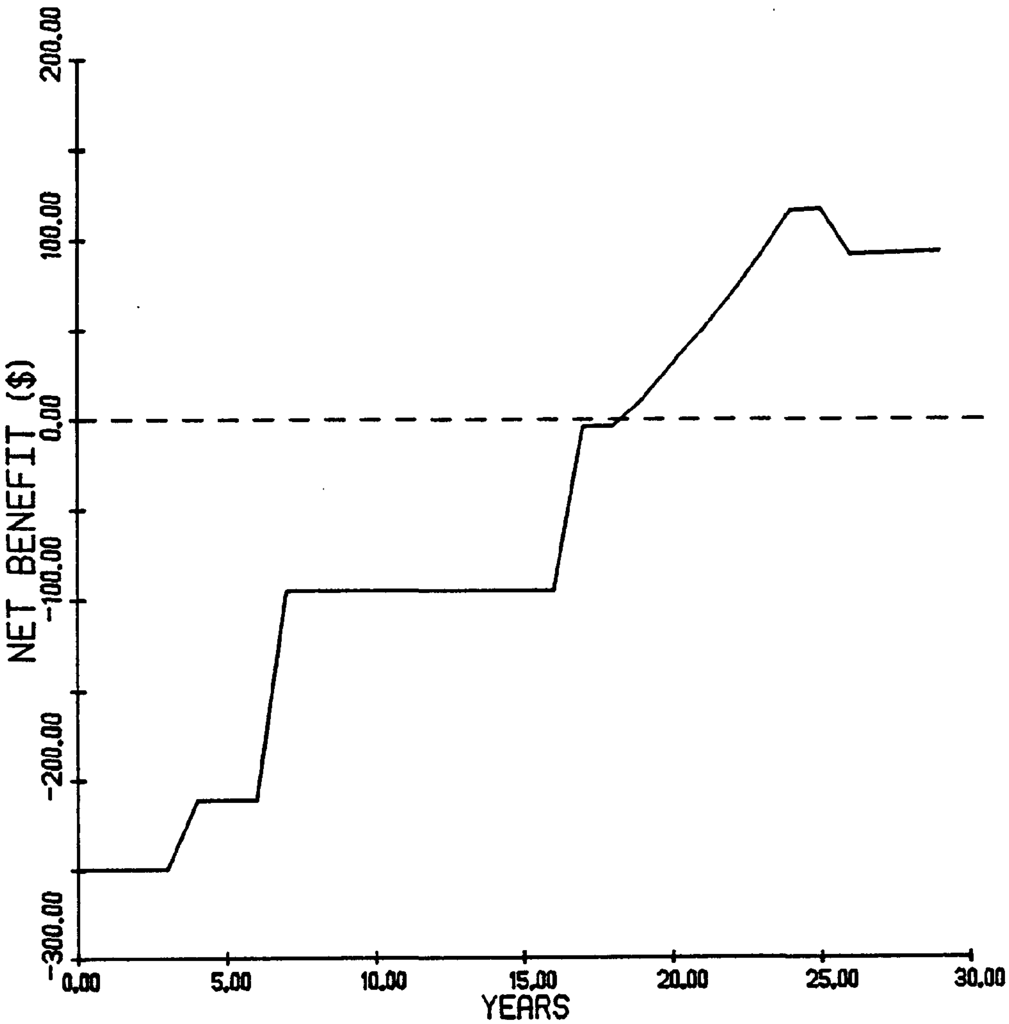


Figure D-6. Net benefits versus time generated by a structure with a variable effectiveness, variable recession rate and a structure life of 5 years. The structure is rebuilt every 5 years.

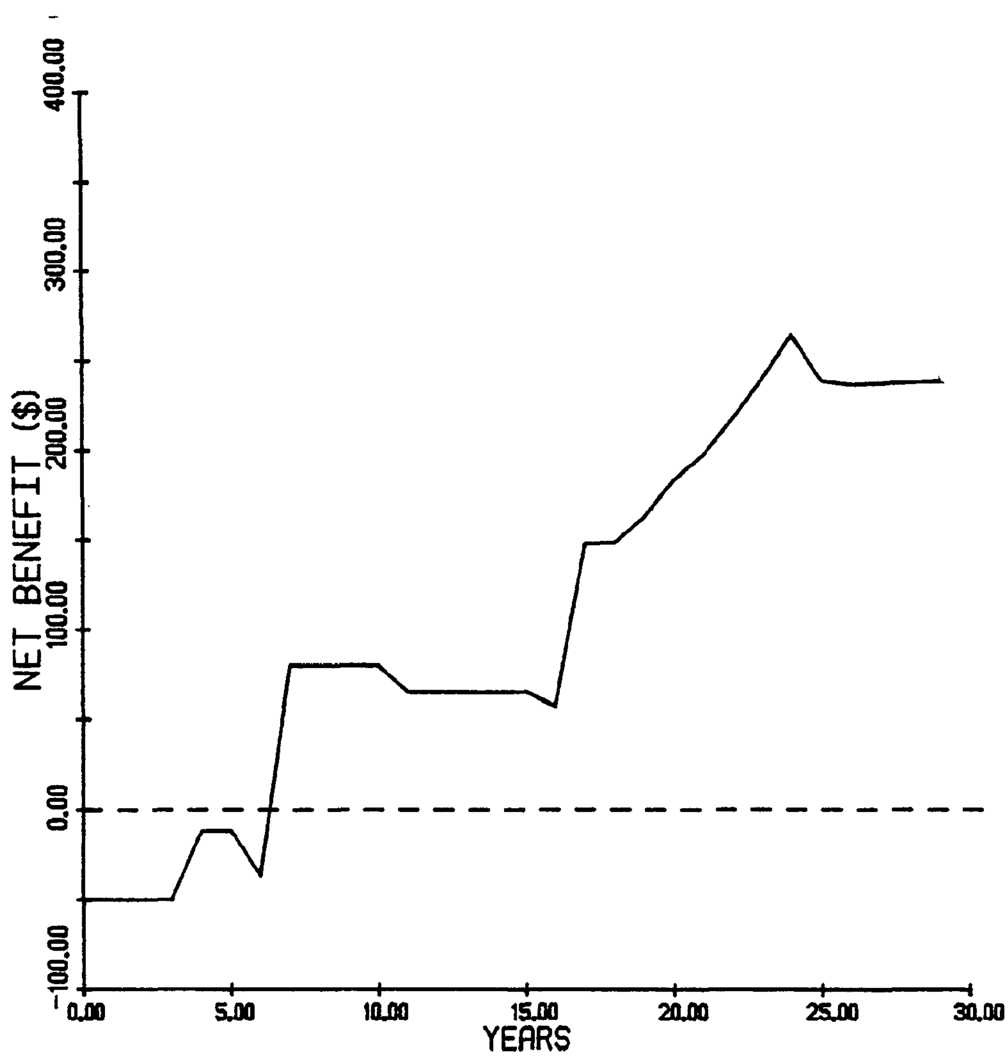


Table D-2.

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COASTAL ZONE LABORATORY UNIVERSITY OF MICHIGAN VERSION #2 DECEMBER 1978

TEST RUN VARIABLE EFFECTIVENESS AND RECESSION RATE (REBUILD EVERY 5 YEARS)

DPTH =	100.000	- DEPTH OF THE LOT (FEET)
FOUN =	120.000	- DISTANCE FROM FOUNDATION TO BLUFF (FEET)
RSET =	140.000	- RECOMMENDED SET BACK DISTANCE (FEET)
H =	19.000	- HEIGHT OF THE BLUFF (FEET)
LV =	30000.000	- LAKESIDE LAND VALUE ($)
SV =	40000.000	- HOME OR STRUCTURE VALUE ($)
LRES =	3.000	- LONG TERM RECESSION RATE (FEET/YEAR)
COST =	5000.000	- COST TO MOVE HOME ($)
[illegible]	35.000	- ENGINEERS ESTIMATE OF BANK (FEET)
WLT1 =	5.000	- WEIGHTING FACTOR
Y =	30.000	- INVESTMENT HORIZON (YEARS)
BANK =	45.000	- DISTANCE WHERE BANK WILL NO LONGER GRANT
STPB =	55.500	- 1/2 WAY BETWEEN BANK AND STEPL (FEET)
L =	100.000	- FRONT FOOTAGE OF LOT IN (FEET)
HOMD =	60.000	- DEPTH OF THE HOME (FEET)
FSET =	50.000	- SET BACK IN FRONT OF HOME (FEET)
TH =	0.780	- ANGLE OF THE BLUFF (RADIANS)
LV =	15000.000	- INLAND LAND VALUE ($)
RESR =	1.000	- RECESSION RATE MODIFIER
AEST =	15000.000	- ASTHETIC VALUE ($)
RI =	0.120	- DISCOUNTING RATE
A =	0.500	- WEIGHTING FACTOR
WLT2 =	0.500	- WEIGHTING FACTOR
PLV =	250.000	- DISTANCE FROM ROAD TO SETBACK (FEET)
STPL =	91.000	- POINT OF SHARP DECLINE IN STRUCTURE VALU
BASE =	18.195	- LENGTH OF THE BLUFF BASE (FEET)

INPUT PARAMETERS / OUTPUT PARAMETERS

AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTENANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENFITS ($)	TOTAL DISC. BENFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENFITS ($)	YEARLY HOME MOVING BENFITS ($)	TOTAL HOME MOVING BENFITS ($)
2.50	.100	50.00	1.000	0	2.50	0.0	0.0	0.0	50.00	50.00	-50.00	-60.00	-60.00
3.90	.100	0.0	0.900	1	6.40	0.39	0.0	0.0	0.0	50.00	-50.00	0.0	-60.00
5.40	.100	0.0	0.800	2	11.80	1.47	0.0	0.0	0.0	50.00	-50.00	0.0	-60.00
4.80	.100	0.0	0.700	3	16.60	2.91	0.0	0.0	0.0	50.00	-50.00	0.0	-60.00
4.40	.100	0.0	0.600	4	21.00	4.67	38.38	38.38	0.0	50.00	-11.62	-38.38	-98.38
3.90	.100	0.0	0.500	5	24.90	6.62	0.0	38.38	0.0	50.00	-11.62	0.0	-98.38
3.30	.100	50.00	1.000	6	28.20	6.62	0.0	38.38	25.33	75.33	-36.95	0.0	-98.38
2.60	.100	0.0	0.900	7	30.80	6.98	116.36	154.74	0.0	75.33	79.41	116.36	17.98
1.90	.100	0.0	0.800	8	32.70	7.26	0.0	154.74	0.0	75.33	79.41	0.0	17.98
1.70	.100	0.0	0.700	9	34.40	7.77	0.0	154.74	0.0	75.33	79.41	0.0	17.98
3.20	.100	0.0	0.600	10	37.60	9.05	0.0	154.74	0.0	75.33	79.41	0.0	17.98
2.90	.100	50.00	1.000	11	40.50	9.05	0.0	154.74	14.37	89.71	65.03	0.0	17.98
2.40	.100	0.0	0.900	12	42.90	9.25	0.0	154.74	0.0	89.71	65.03	0.0	17.98
1.30	.100	0.0	0.800	13	44.20	9.55	0.0	154.74	0.0	89.71	65.03	0.0	17.98
0.70	.100	0.0	0.700	14	44.90	9.76	0.0	154.74	0.0	89.71	65.03	0.0	17.98
1.40	.100	0.0	0.600	15	46.30	10.32	0.0	154.74	0.0	89.71	65.03	0.0	17.98
2.30	.100	50.00	1.000	16	48.60	10.32	0.0	154.74	8.16	97.86	56.88	0.0	17.98
2.80	.100	0.0	0.900	17	51.40	10.60	91.10	245.84	0.0	97.86	147.98	-91.10	-73.13
2.80	.100	0.0	0.800	18	54.20	11.16	0.03	245.87	0.0	97.86	148.01	-0.03	-73.16
3.30	.100	0.0	0.700	19	57.50	12.15	14.77	260.65	0.0	97.86	162.79	14.63	-58.53
4.10	.100	0.0	0.600	20	61.60	13.79	19.88	280.53	0.0	97.86	182.67	19.59	-38.94
3.90	.100	50.00	1.000	21	65.50	13.79	18.63	299.16	4.63	102.49	196.67	18.25	-20.69
4.30	.100	0.0	0.900	22	69.80	14.22	20.24	319.39	0.0	102.49	216.90	19.70	-0.99
4.80	.100	0.0	0.800	23	74.60	15.18	22.26	341.65	0.0	102.49	239.16	21.52	20.52
5.40	.100	0.0	0.700	24	80.00	16.80	24.69	366.34	0.0	102.49	263.85	23.68	44.21
5.40	.100	0.0	0.600	25	85.40	18.96	-25.69	340.65	0.0	102.49	238.16	-0.59	43.61
4.90	.100	50.00	1.000	26	90.30	18.96	0.61	341.26	2.63	105.12	236.14	-0.61	43.00
4.50	.100	0.0	0.900	27	94.80	19.42	0.64	341.90	0.0	105.12	236.78	-0.64	42.36
4.40	.100	0.0	0.800	28	99.20	20.10	0.51	342.40	0.0	105.12	237.29	-0.51	41.86
4.50	.100	0.0	0.700	29	103.70	21.42	0.70	343.10	0.0	105.12	237.99	-78.97	-37.12
[illegible]	.100	0.0	0.600	30	106.60	23.10	0.71	343.80	0.0	105.12	238.69	-0.71	-37.82

short period of time, after which the net benefit is completely insensitive to BANK. There is, however, a large change in the net benefits for small changes in STPL and FOUN (the distance between the bluff on foundation of the house). It was found that STPL was less sensitive the longer the structure was in, say 20-30 years, but would change the results drastically if you were only looking at 0-10 years. The parameter FOUN has a major effect over the total time period.

Aesthetic Value

The height of the bluff "H" and the angle of the bluff "TH" have only a small effect on the benefits and only for a small time period. Outside of this 2 or 3 year period the model was found to be insensitive to change in the size and shape of the bluff (Figures DB-15 through DB-18 Appendix DB). The second step in the aesthetic value is controlled by the length PLV. Figures DB-19 through DB-26 in Appendix DB show that the parameters which make up the distance PLV have a major effect on <u>when</u> the benefits from the value are gained, but little long term effect on the <u>amount</u> of the benefit.

Simple Land Value

An analysis of the parameters which are used to calculate the simple land value benefits are presented in Figures DB-19 through DB-26 Appendix DB. Because the parameters, FSET, MONE, RSET, are used in both the simple land value and aesthetic value calculation, one must be careful to only look at those portions of the graphs which make up the simple land value benefits (see Figures D-5 and D-6).

Because of the depth of the test lot used, very little of the simple land value was lost, and thus a small inputed benefit gained. This caused the model to be relatively insensitive to the simple land value parameters. This will be the case any time you have a deep lot, but if you are working with a shallow lot the model may be very sensitive to simple land value and must be tested for sensitivity.

General Parameters

The general parameters are those which effect all benefit calculations. These parameters, total land value "TV", simple land value "LV", structure value "SV", and present value depreciation rate "RI", are presented in Figures DB-27 through DB-34 Appendix DB. It was found that these were the only parameters which had a major change in the amount of the benefits gained, while not significantly effecting when the benefits are accrued.

The parameters Total land value (TV), Simple land Value (SV), and Structure Value (SV) apply a relatively constant offset to the net benefit curve with time, while the Discounting Rate (RI) has an increasing effect on the benefits as the investment horizon increases. Because of this, the discounting rate was found to have the largest long term effect on the benefits gained by a SPS.

If one were to rank all the parameters as to their importance in controlling the net benefits it would break down as follows:

(1) Long term effects (20+ years)
- RI
- FOUN
- DPTH
- STPL
- SV & TV & LV

(2) Interim effects (10-20 years)
- DPTH
- FOUN
- PSET
- HOME
- FSET

(3) Short term effects (0-10 years)
FOUN
STPL
DPTH
RSET
H & TH

(4) Overall effects
FOUN
DPTH
STPL
RSET
RI
HOME
FSET
SV & TV & LV
H & TH

D.3.2. Effects of Recession Rates and Structure Effectiveness

To look at the effects of structure effectiveness on net benefits, a set of runs were made at different constant and variable structure effectiveness. The constant percent effectiveness and mean percent effectiveness were plotted versus the net benefits gained for an investment horizon of 5, 10, 15, 20, and 25 years. The picture was also varied by looking at the effects of constant and varied recession rates, and a long term 30 year life, and short term 5 year life, structures. The short term structure was rebuilt every 5 years. These graphs are presented in Figures DC-1 through DC-8 Appendix DC.

A comparison of the results obtained at constant and variable recession rates indicates that the model is very sensitive to when the recession occurs over the investment horizon. A comparison of the 10 year and 15 year benefits on Figures DC-1 and DC-2 Appendix DC shows that the dip in recession rate caused a decrease in the 15 year benefits as compared to the 10 year benefits. In order not to bias the results the constant recession rate is the average of the variable recession rate curve.

The more dramatic fact which shows up on these graphs is that the net benefits do not necessarily go up for a given increase in structure effectiveness. If one looks at Figures DC-4 and DC-8, the most realistic cases, it can be seen that a structure of 65% effectiveness will have about the same benefits after 25 years as a structure of higher effectiveness. Given that the technology exists to build structures at different effectivenesses, these graphs could be used to optimize the structure selection process.

D.4.0. SUMMARY AND CONCLUSIONS

The Benefit-Cost Model does provide a logical way of assessing the benefits which could be gained by putting in a shoreline protection system as long as the user recognizes its drawbacks and limitations.

First, the model was designed around surveys done in the Berrien County, Michigan area. The results received from the studies reflect the market values and individual values of this area and may not be general to most other high erosion areas. Because of this the user must check the validity of the erosion induced damage curves in the area where he plans to apply the model.

A second limitation to the model is the inability at this time to predict long term recession rates. This does not mean the model should not be used, but does mean that the user must keep in mind the recession rate curve he put into the model and what the consequences will be if the actual recession is different than predicted. An estimate of the possible consequences can be made by selecting a set of recession rate curves and running each through the model.

Finally, the user must address himself to the accuracy of the input parameters. It was found that the magnitude of certain parameters makes a big difference in the final net benefit for a given investment horizon. Because of this, the user must select the investment horizon in which he is interested and adjust his data collection efforts to reflect the relative importance of the input parameters.

Even with these limitations the model can be used as an investment decision tool in an area where trial and error has been the major deciding factor. The model now allows the user to compare the benefits which will be gained from a variety of types and sizes of structures. It is also hoped that further work on the limitations of the model will continue so that the model will become more accurate in predicting benefits and more generally applicable.

Appendix DA

Model Calculations

MODEL CALCULATIONS

Real Estate Value Appreciation

Value = Value + (Value x Interest Rate)

Recession Rate

(1) Total Recession

TRESR = TRESR + Yearly Recession

(2) Structure Recession

Value= Yearly Recession x Structure Effectiveness

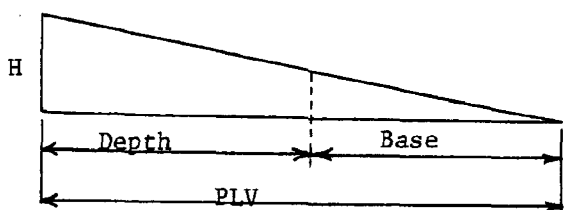
SRESR = SRESR + (Yearly Recession - Value)

SRESR = cumulative recession with structure

Value = yearly recession with structure

Simple Land Value Benefit

Height = (2 x simple land value)/PLV



SUMSLV = 1/2 Base [(H/PLV) x Base]

SUMSLV = cumulative Simple Land Value benefit

Structure Value Benefit

If found < STPL and Found > Step B

Value = 0.3 x Structure Value

If FOUND < STPB and FOUND > BANK

dist = STPB - FOUND
slope = 0.4/(STPB - BANK)
value = [(slope x dist) + 0.3] x structure value

If FOUND < BANK and FOUND > 0

Value = 0.7 x Structure Value

If FOUND < 0

Value = Structure Value

Aesthetic Land Value Benefit

Aesthetic Value = Total Land Value - Simple Land Value

If total lot depth < PLV

value = 0.25 x aesthetic value
If Found < 0.0   Value = Aesthetic Value

If total lot depth > PLV

If (recession total ≥ Base)   Value = 0.25 Ass. Value
If (depth > PLV)   Value = Ass. Value

Base = height of bluff/Tan(angle of bluff)

Appendix DB

Output Showing the Effects of Varying Model Parameters on the Net Benefits Generated by a Structure

LIST OF FIGURES

Figure DB-1. The effects of different long term recession rates "LRES" on the net benefits generated by a structure with variable effectiveness and recession rates and with a structure life of 30 years.

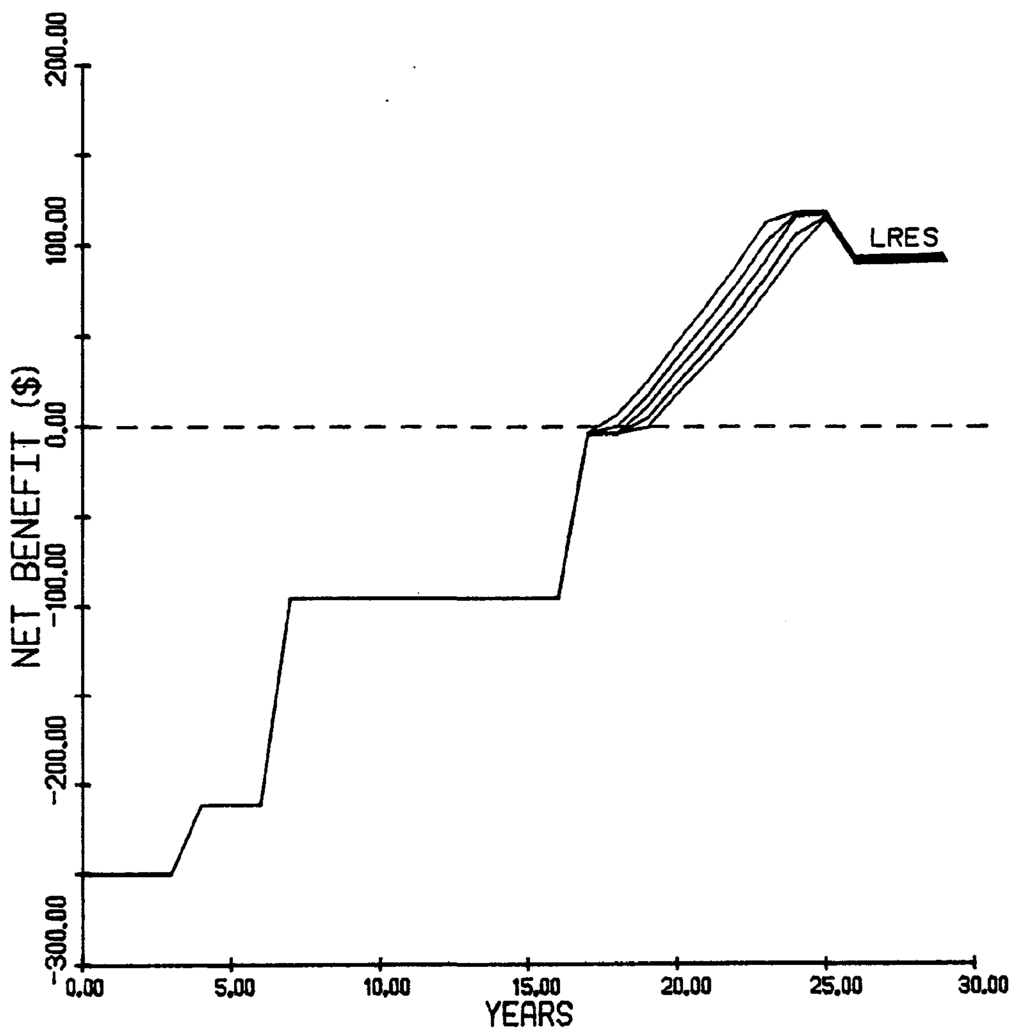


Figure DB-2. The effects of different long term recession rates "LRES" on the net benefits generated by a structure with variable effectiveness and recession rates and a structure life of 5 years. The structure is rebuilt every 5 years.

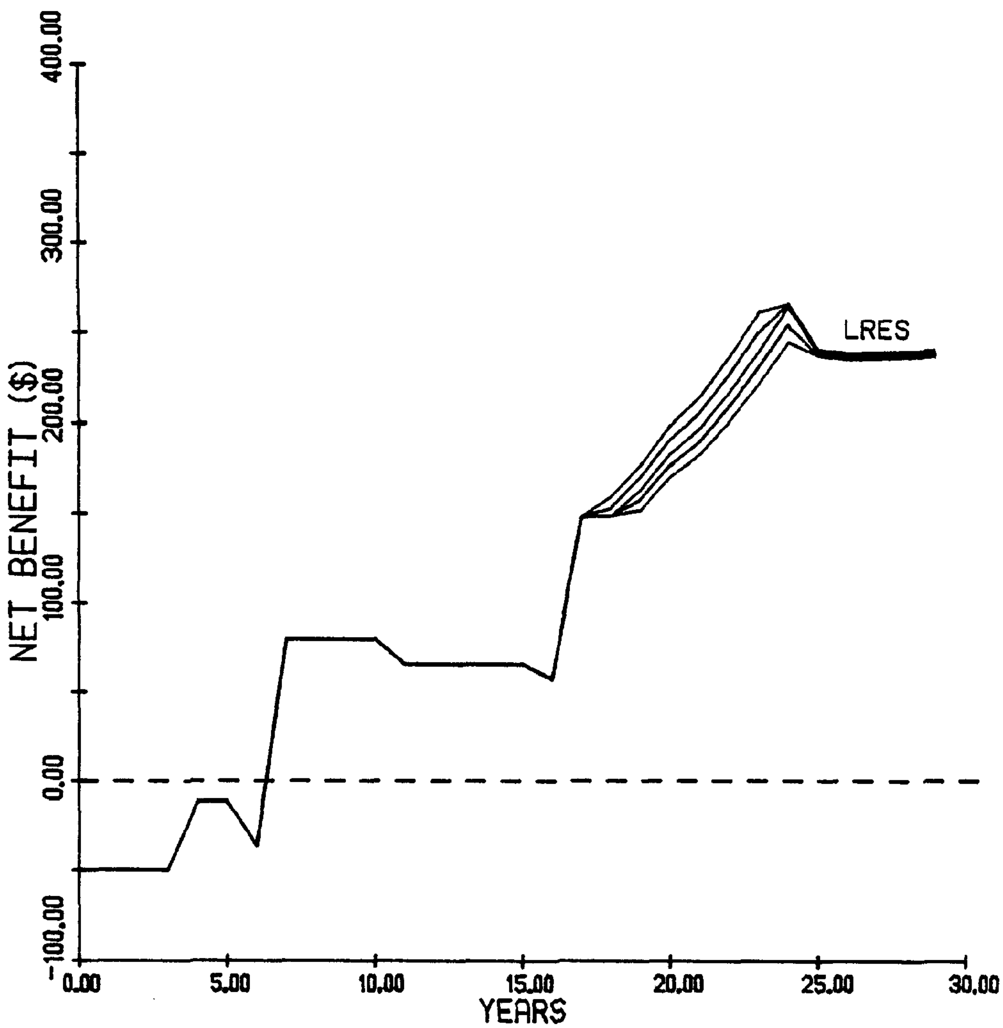


Figure DB-3. The effects of varying the parameter "REST", realtor estimates of BANK, on the net benefits generated by a structure with variable effectiveness and recession rates and a structure life of 30 years.

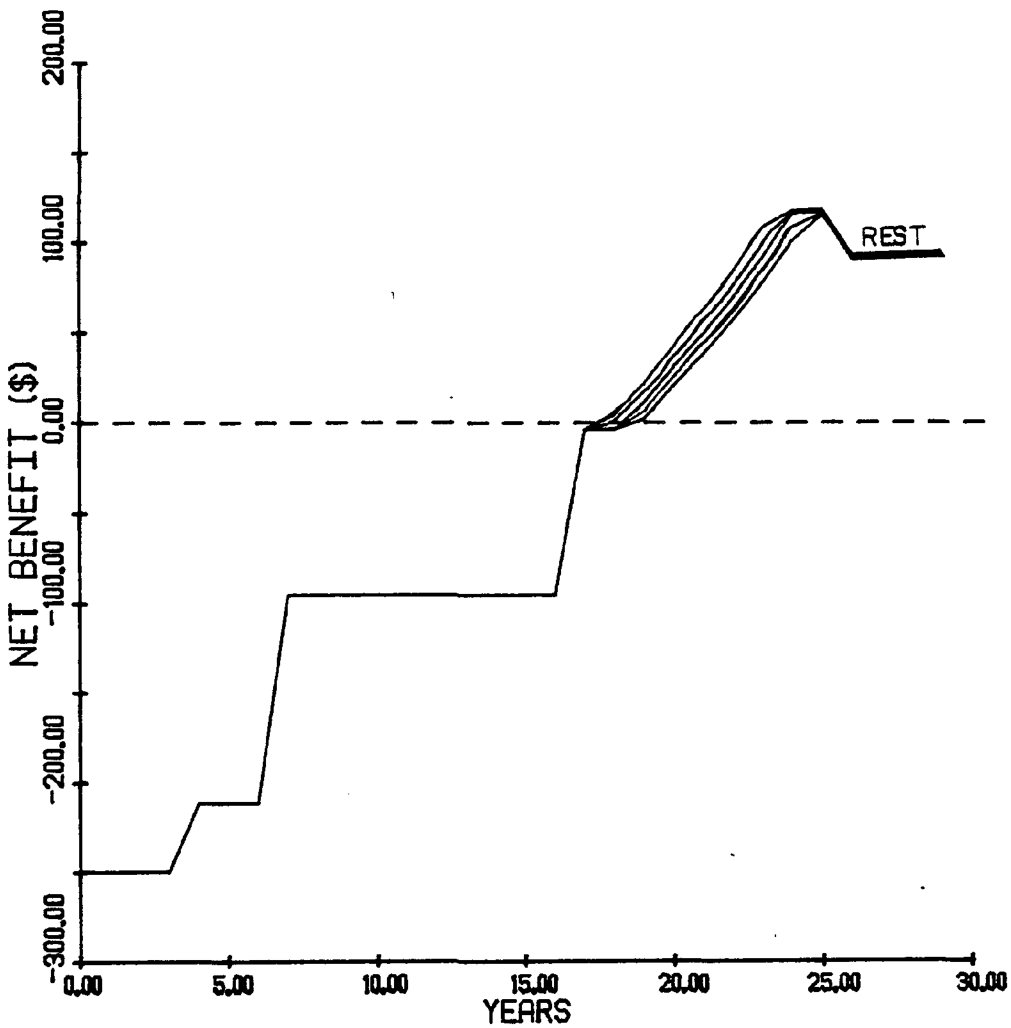


Figure DB-4. The effects of varying the parameter "REST", realtor estimates of BANK, on the net benefits generated by a structure with variable effectiveness and recession rates and a structure life of 5 years. The structure is rebuilt every 5 years.

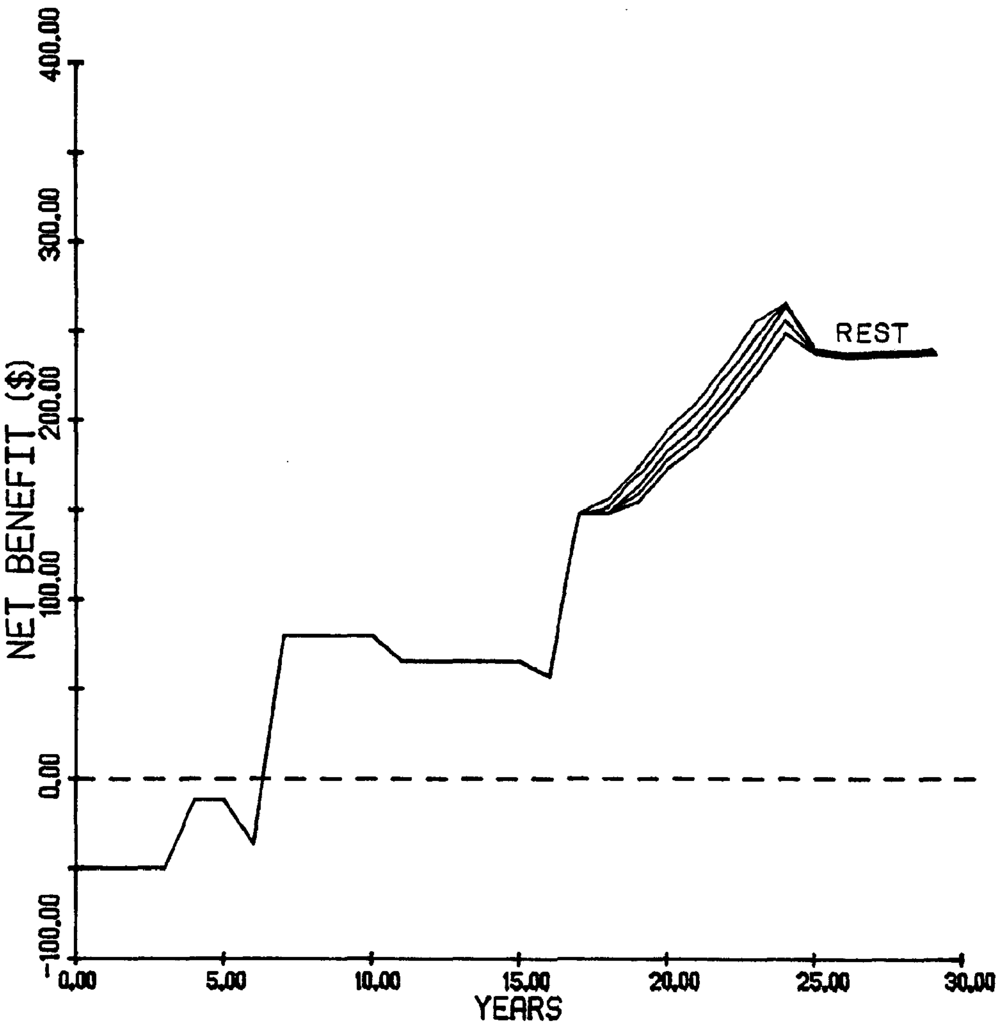


Figure DB-5. The effects of varying the weighting factos "A", on the net benefits generated by a structure with variable effectiveness and recession rates and a structure life of 30 years.

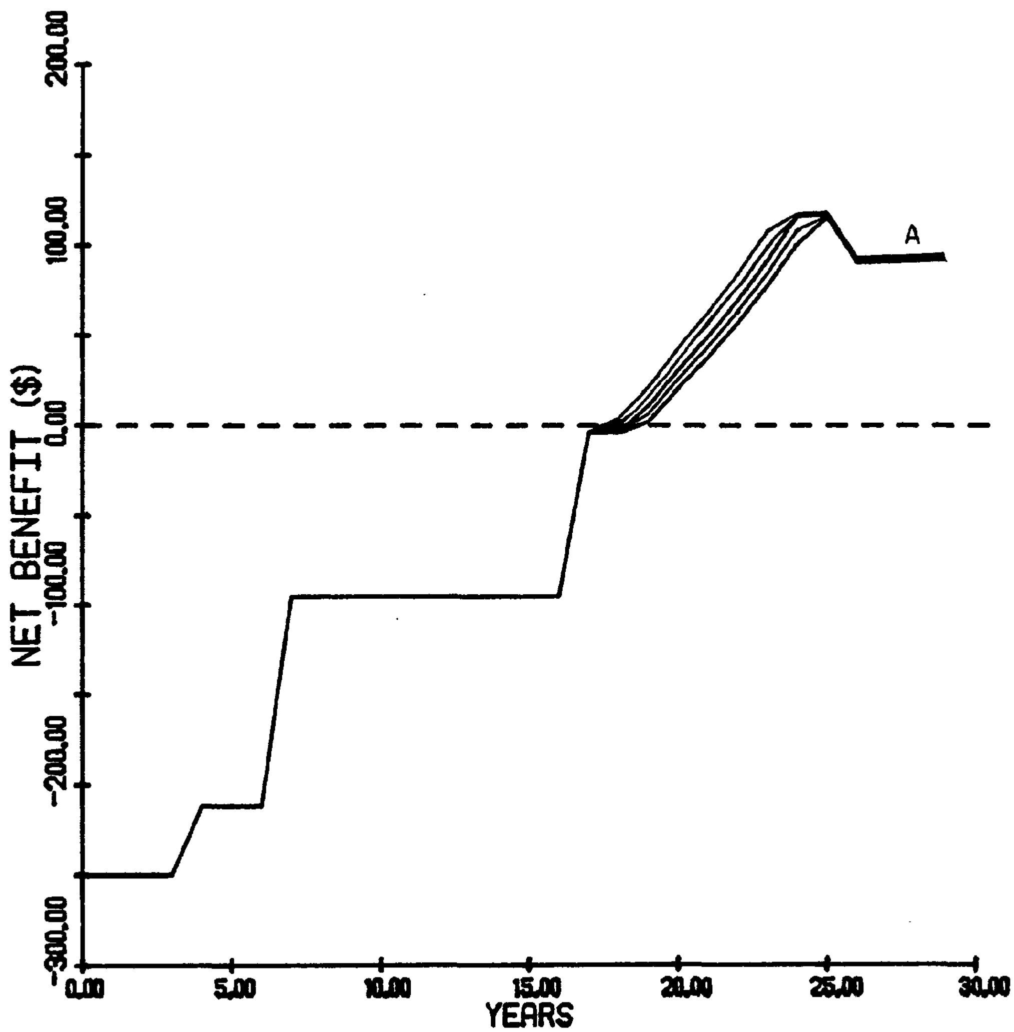


Figure DB-6. The effects of varying the weighting factor "A", on the net benefits generated by a structure with variable effectiveness and recession rates and a structure life of 5 years. The structure is rebuilt every 5 years.

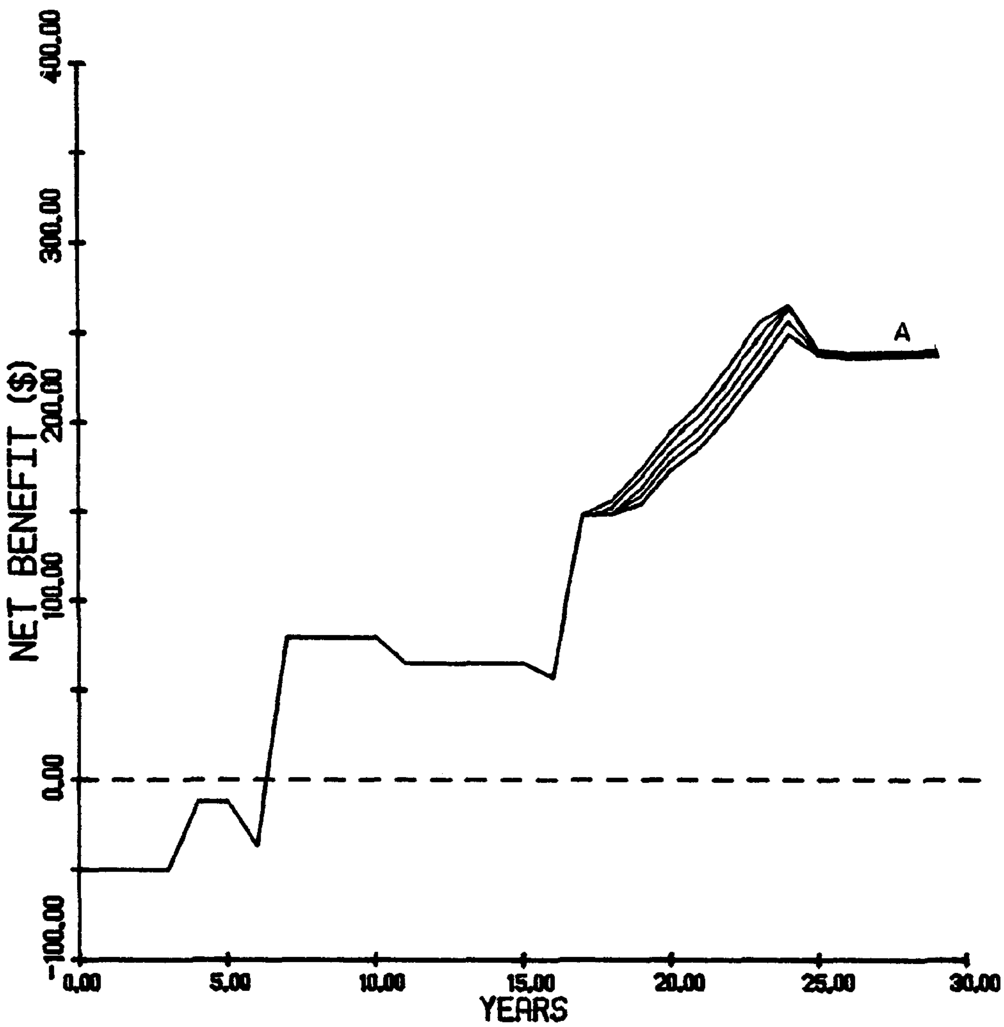


Figure DB-7. The effects of varying the weighting factor "MLT1", on the net benefits generated by a structure with variable effectiveness and recession rates and a structure life of 30 years.

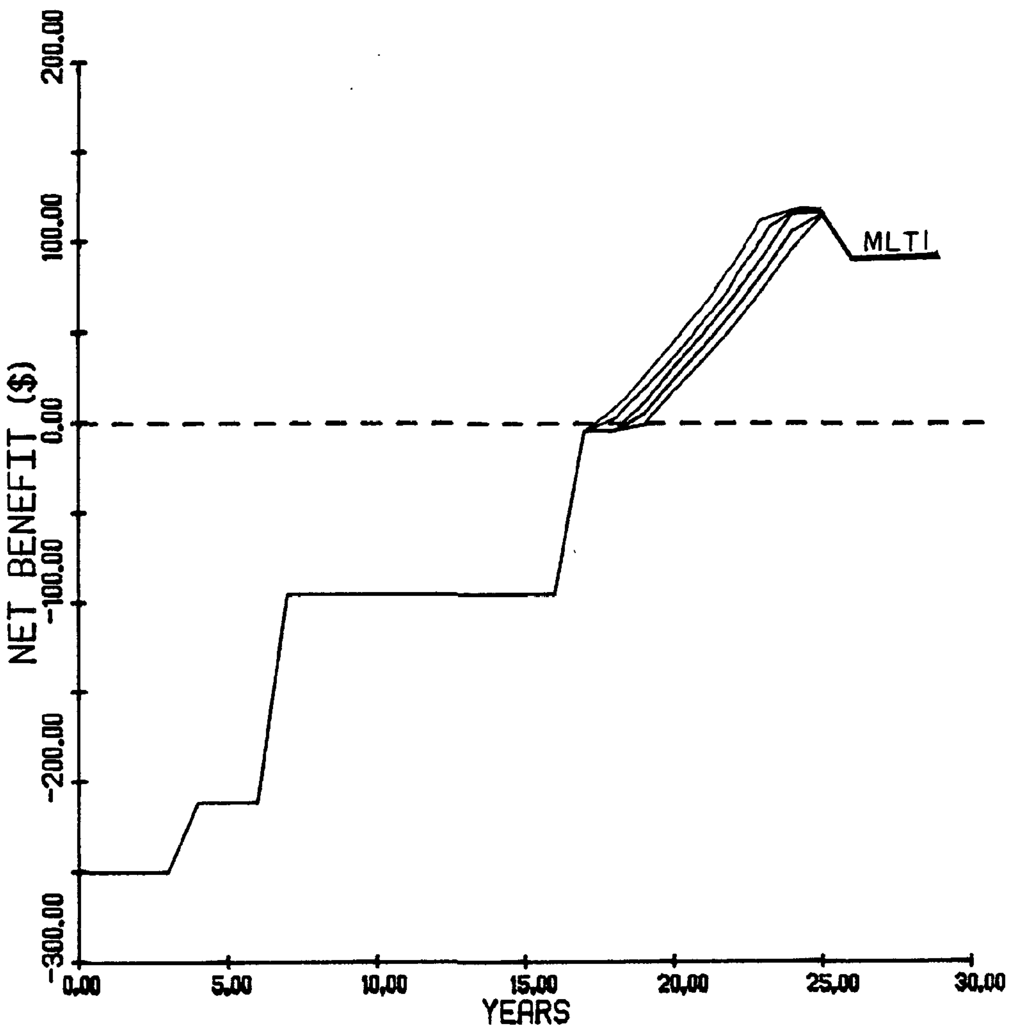


Figure DB-8. The effects of varying the weighting factor "MLT1", on the net benefits generated by a structure with variable effectiveness and recession rates and a structure life of 5 years. The structure is rebuilt every 5 years.

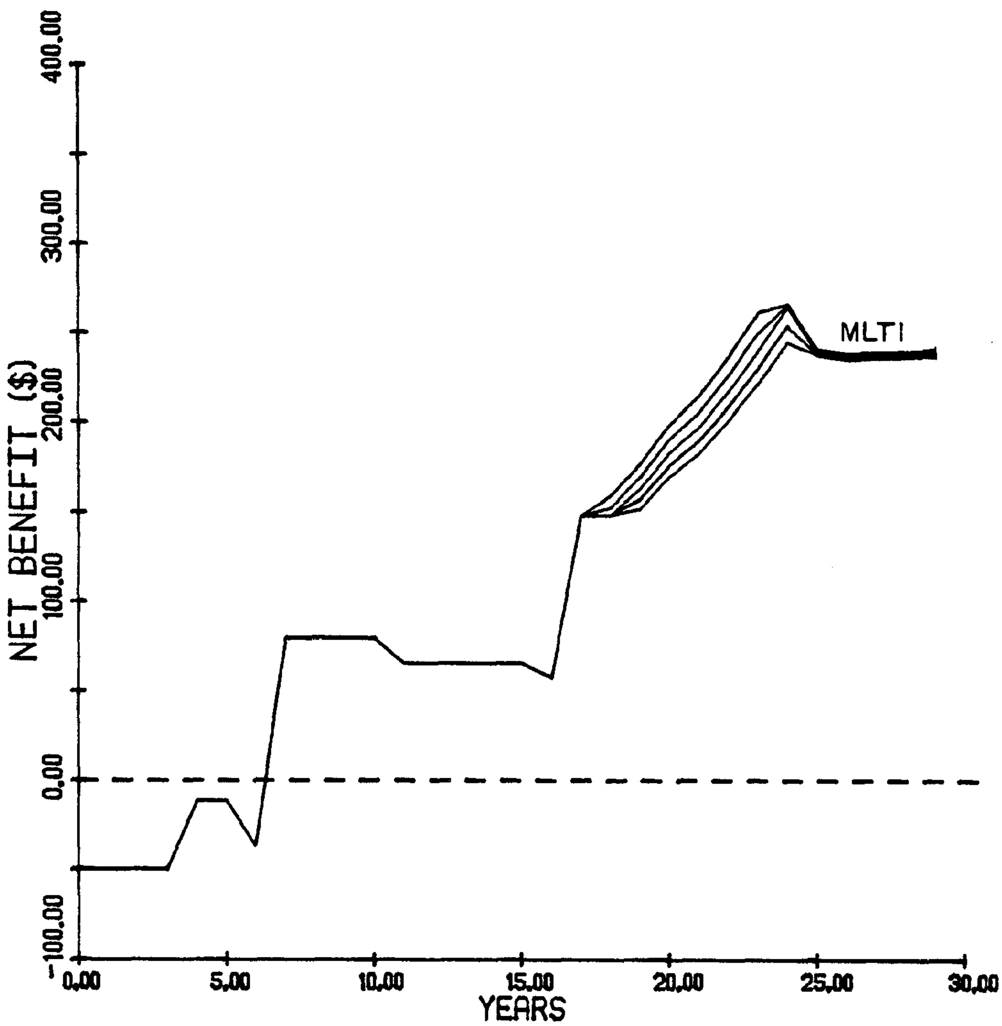


Figure DB-9. The effects of varying the weighting factor "MLT2", on the net benefits generated by a structure with variable effectiveness and recession rates and a structure life of 30 years.

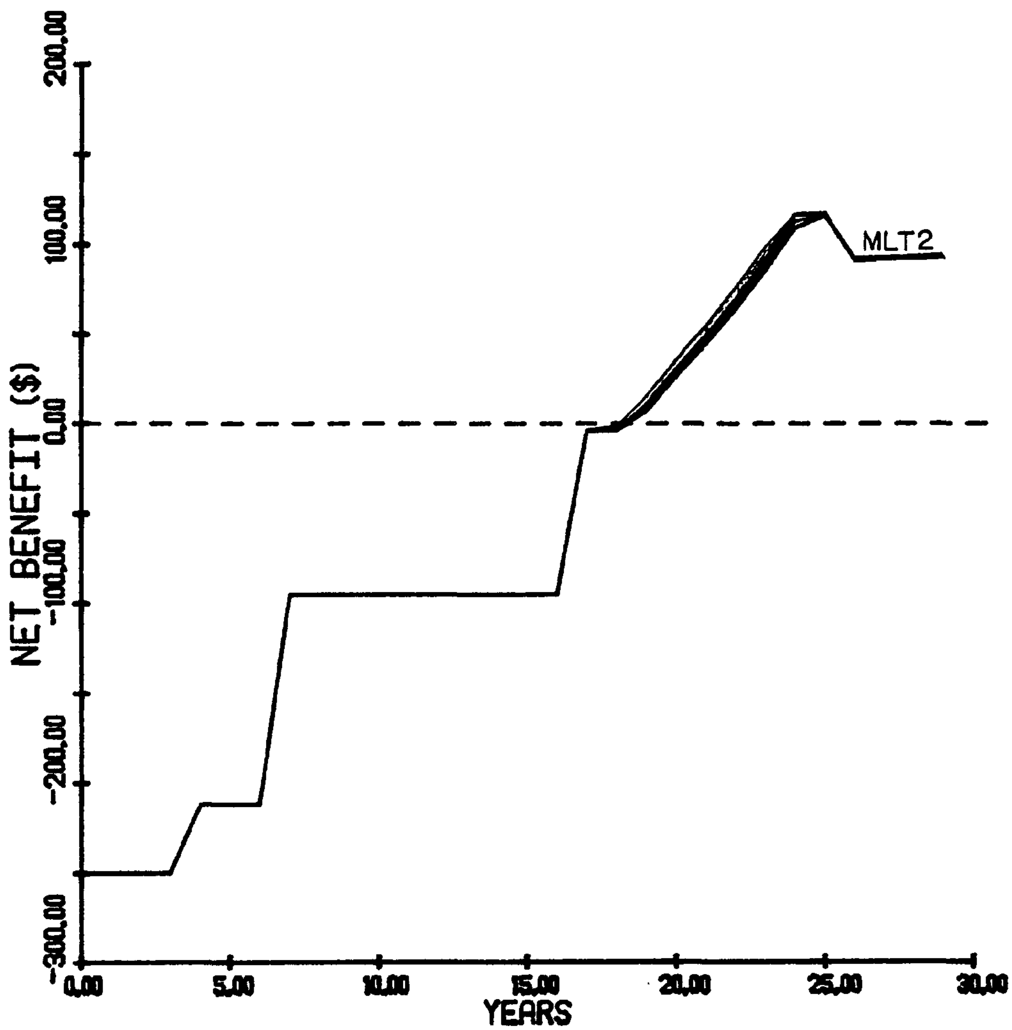


Figure DB-10. The effects of varying the weighting factor "MLT2", on the net benefits generated by a structure with variable effectiveness and recession rates and a structure life of 5 years. The structure is rebuilt every 5 years.

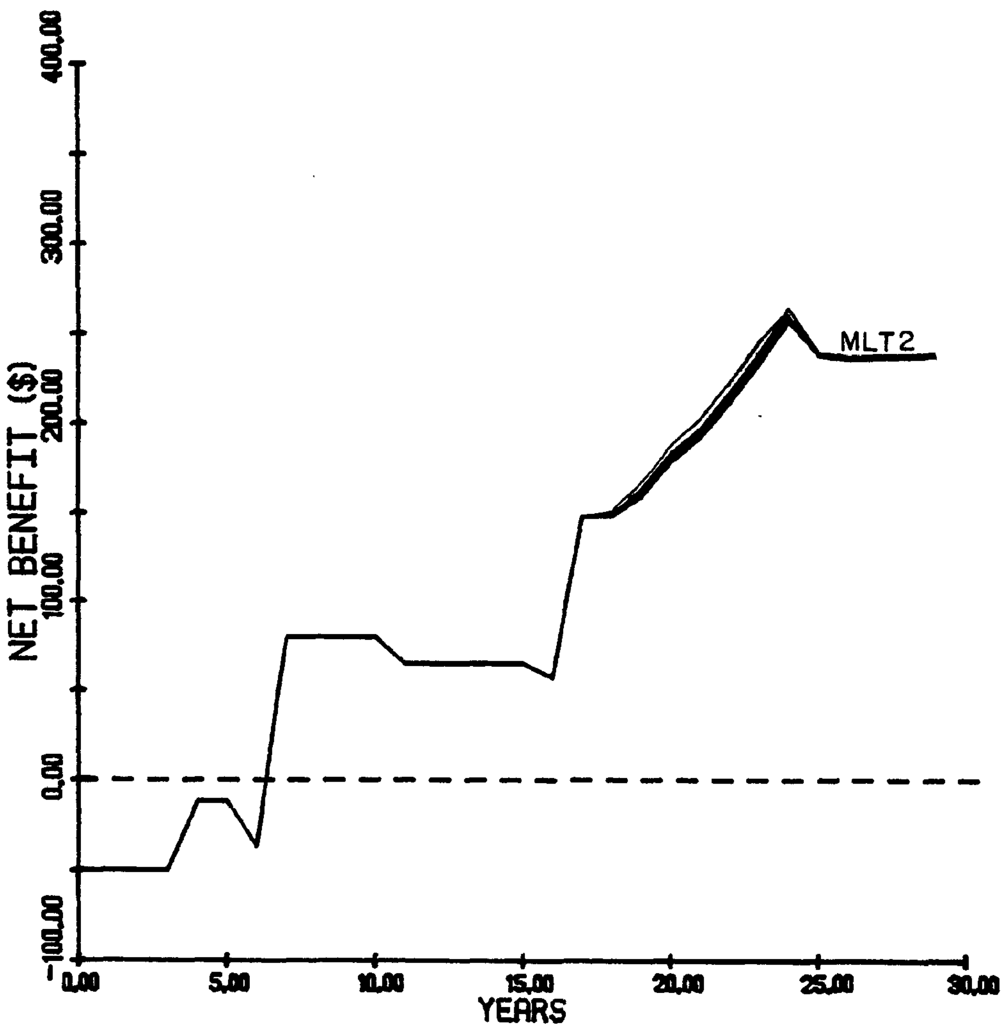


Figure DB-11. The effects of varying the parameter "STPL", the point where there is a sharp decline in the structure value, on the net benefits generated by a structure with variable effectiveness, variable recession rate and a structure life of 30 years.

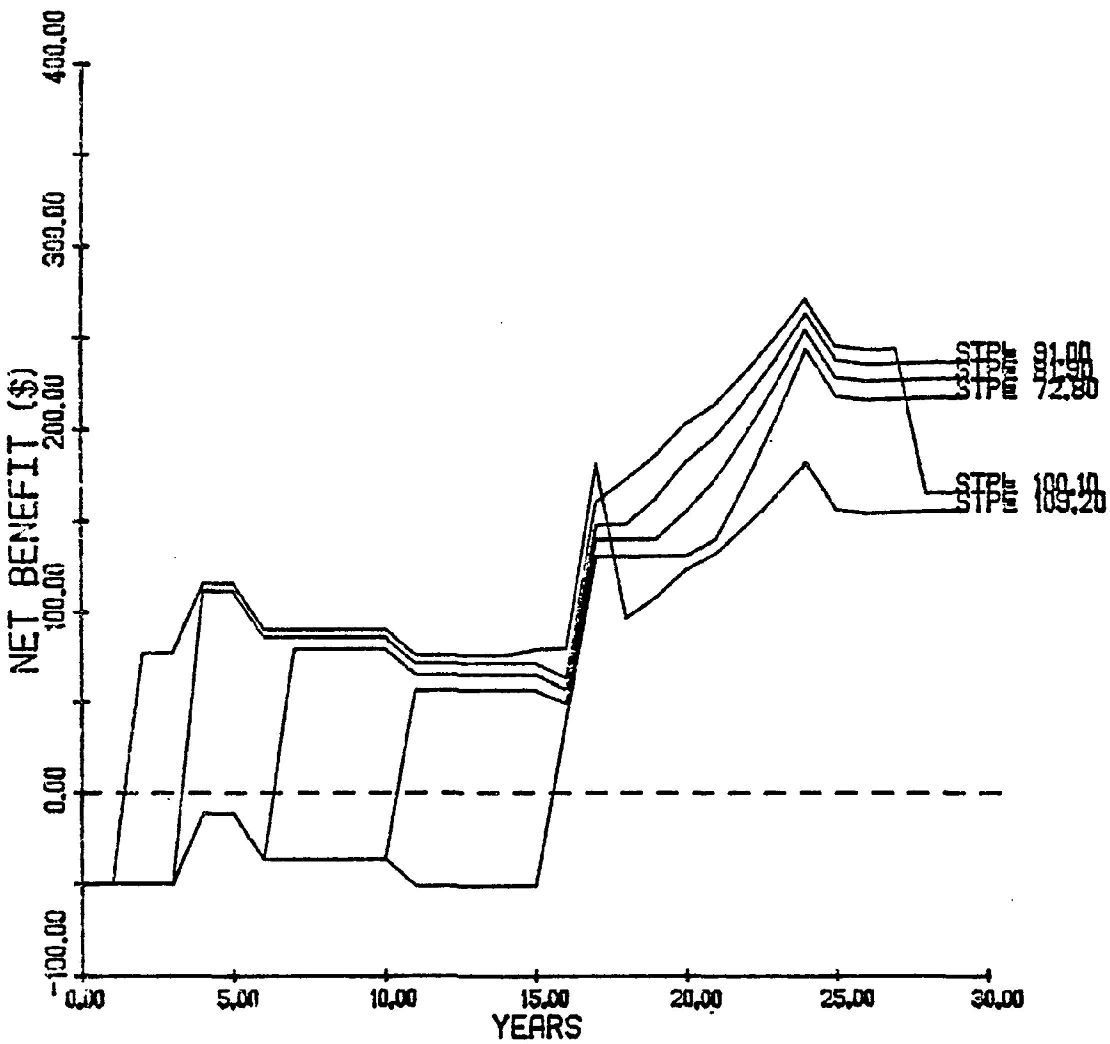


Figure DB-12. The effects of varying the parameter "STPL", the point where there is a sharp decline in the structure value, on the net benefits generated by a structure with variable effectiveness, variable recession rate and a structure life of 5 years. The structure is rebuilt every 5 years.

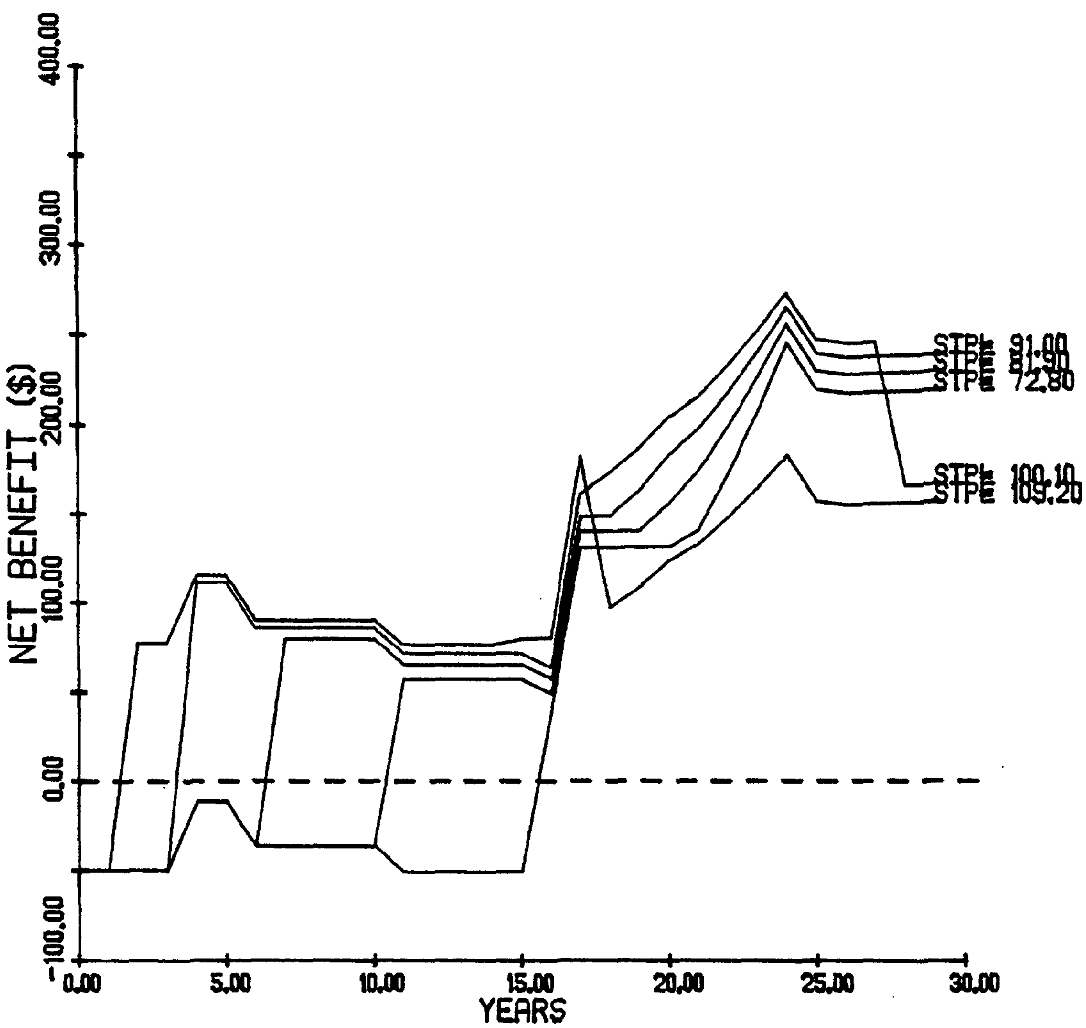


Figure DB-13. The effects of varying the parameter "FOUN", the distance from the home to the bluff, on the net benefits generated by a structure with a variable effectiveness, variable recession rate and a structure life of 30 years.

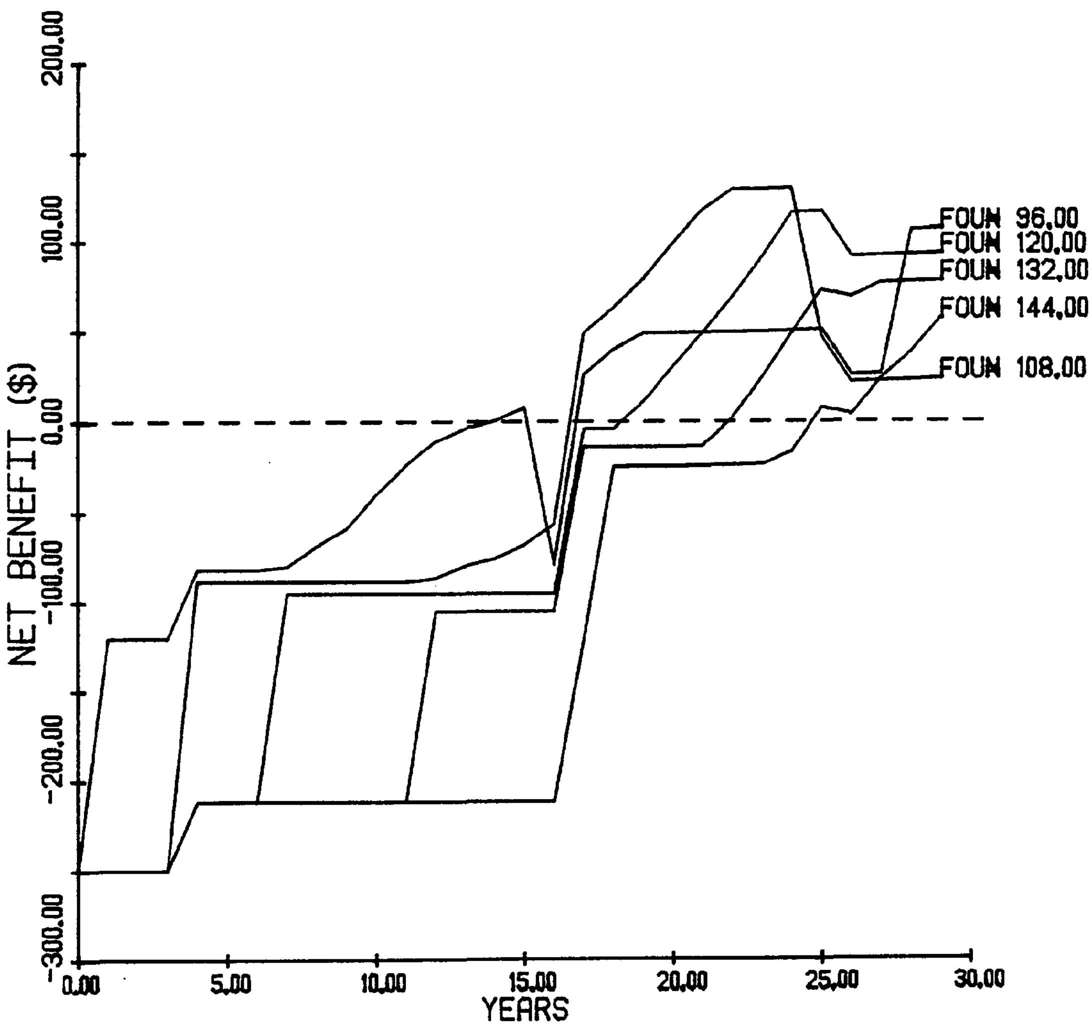


Figure DB-14. The effects of varying the parameter "FOUN", the distance from the home to the bluff, on the net benefits generated by a structure with a variable effectiveness, variable recession rate and a structure life of 5 years. The structure is rebuilt every 5 years.

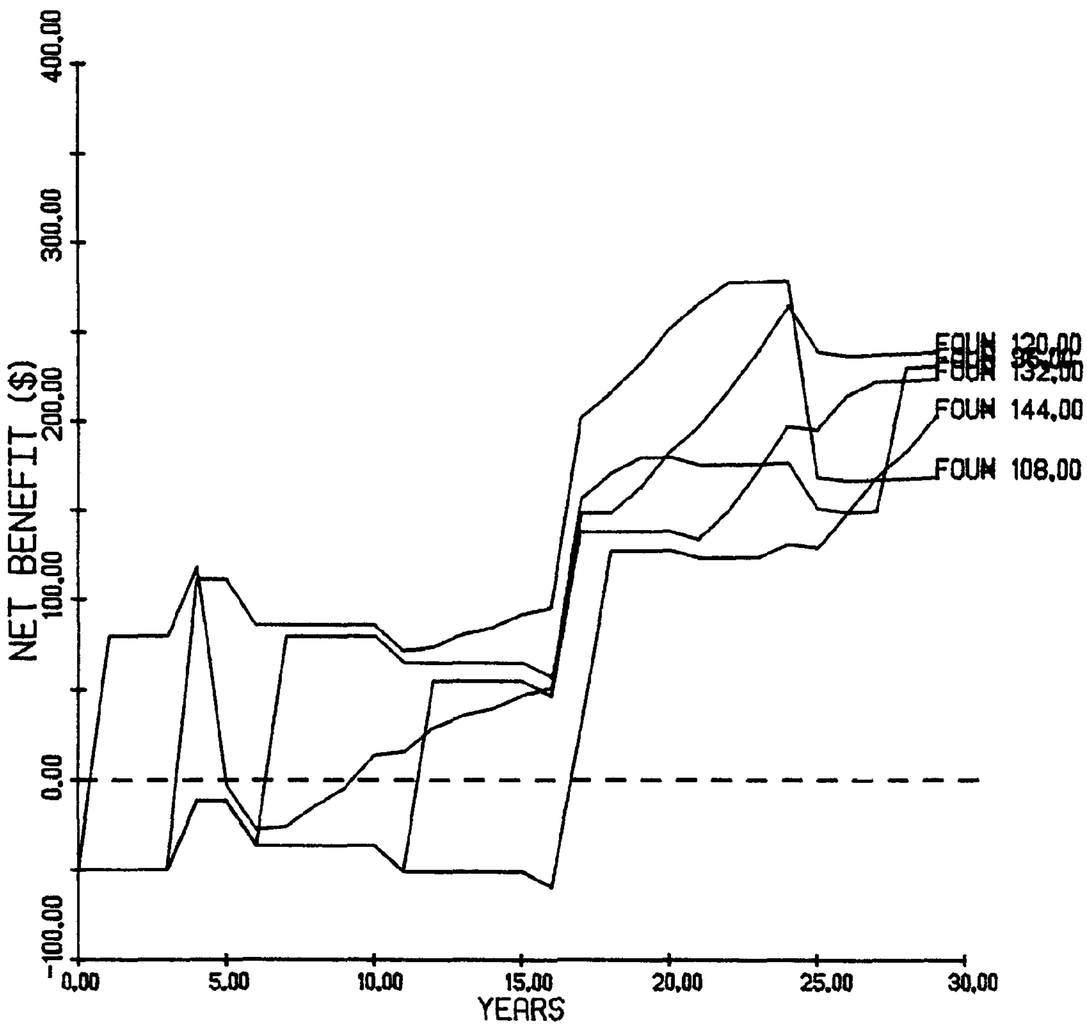


Figure DB-15. The effects of varying the parameter "H", the height of the bluff, on the net benefits generated by a structure with a variable effectiveness, variable recession rate and a structure life of 30 years.

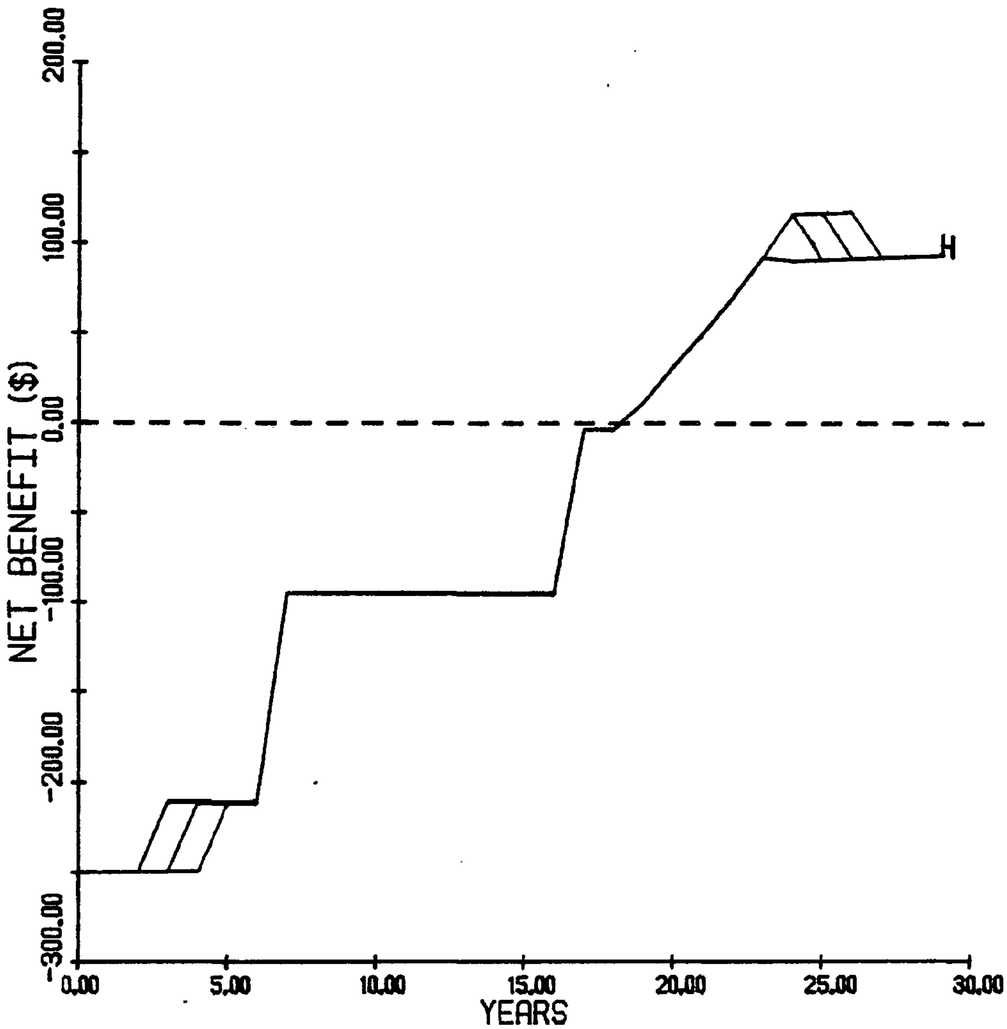


Figure DB-16. The effects of varying the parameter "H", the height of the bluff, on the net benefits generated by a structure with a variable effectiveness, variable recession rate and a structure life of 5 years. The structure is rebuilt every 5 years.

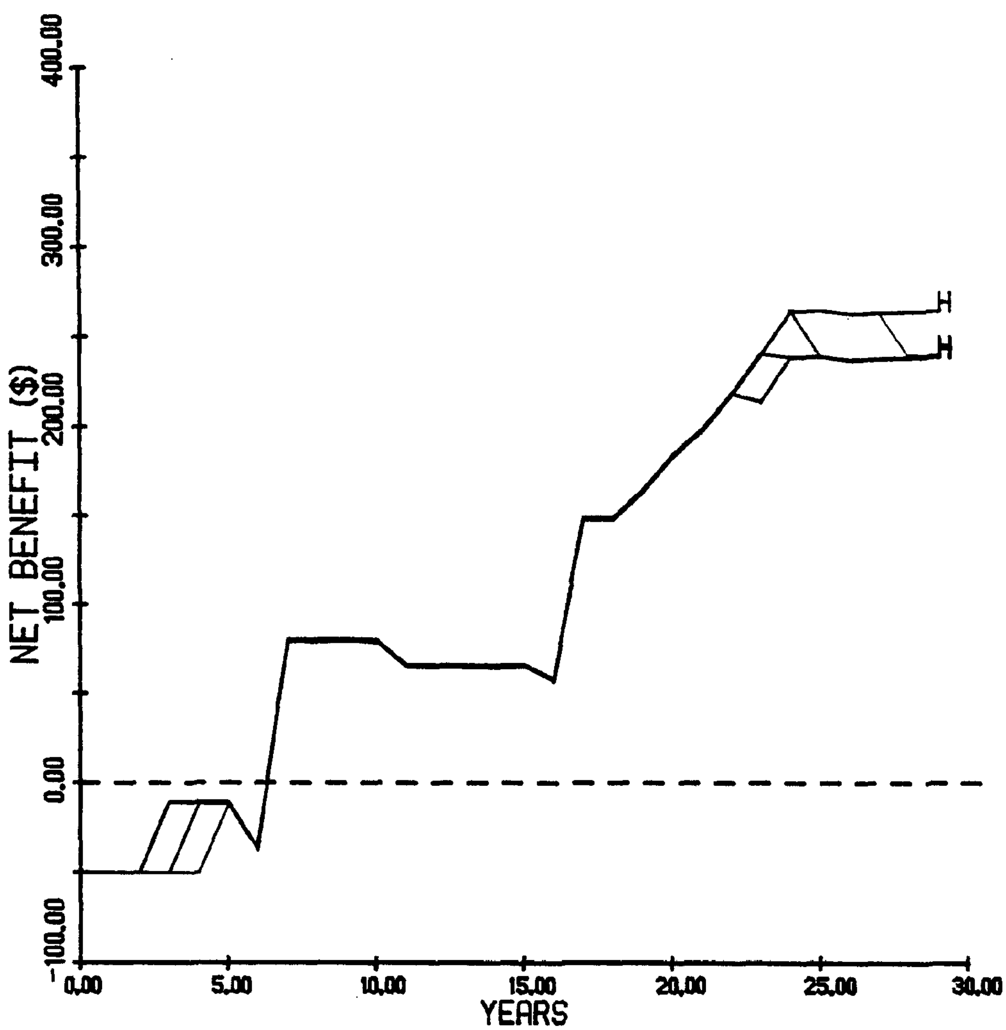


Figure DB-17. The effects of varying the parameter "TH", the angle of the bluff, on the net benefits generated by a structure with a variable effectiveness, variable recession rate and a structure life of 30 years.

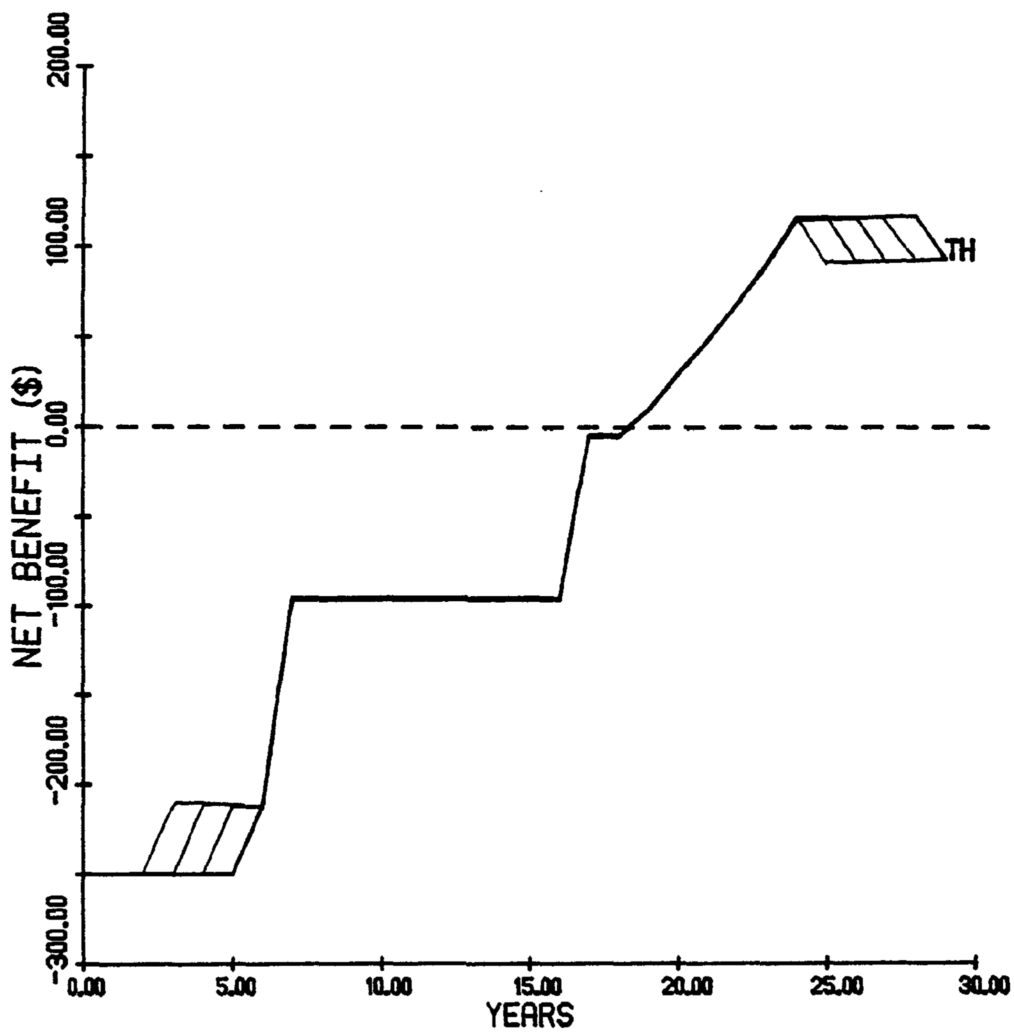


Figure DB-18. The effects of varying the parameter "TH", the angle of the bluff, on the net benefits generated by a structure with a variable effectiveness, variable recession rate and a structure life of 5 years. The structure is rebuilt every 5 years.

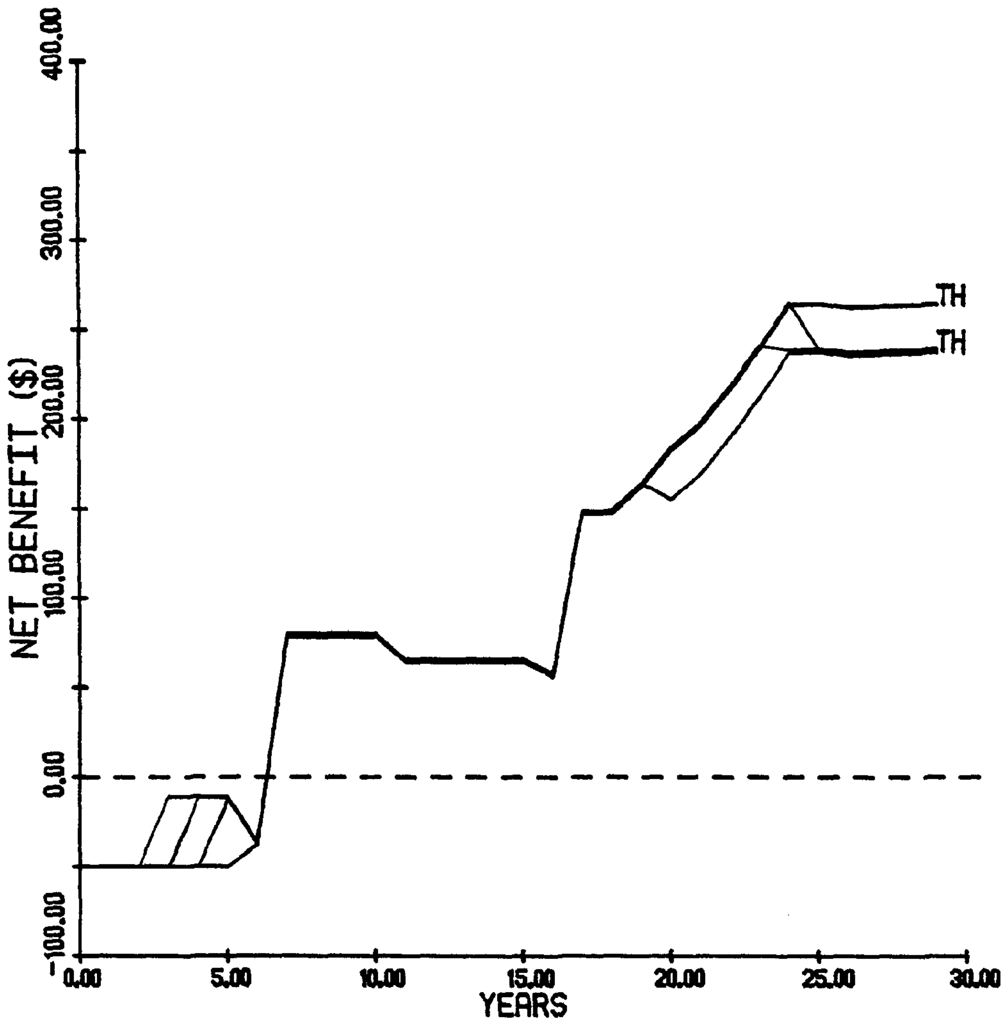


Figure DB-19. The effects of varying the parameter "FSET", the setback distance from the road to the house, on the net benefits generated by a structure with a variable effectiveness, variable recession rate and a structure life of 30 years.

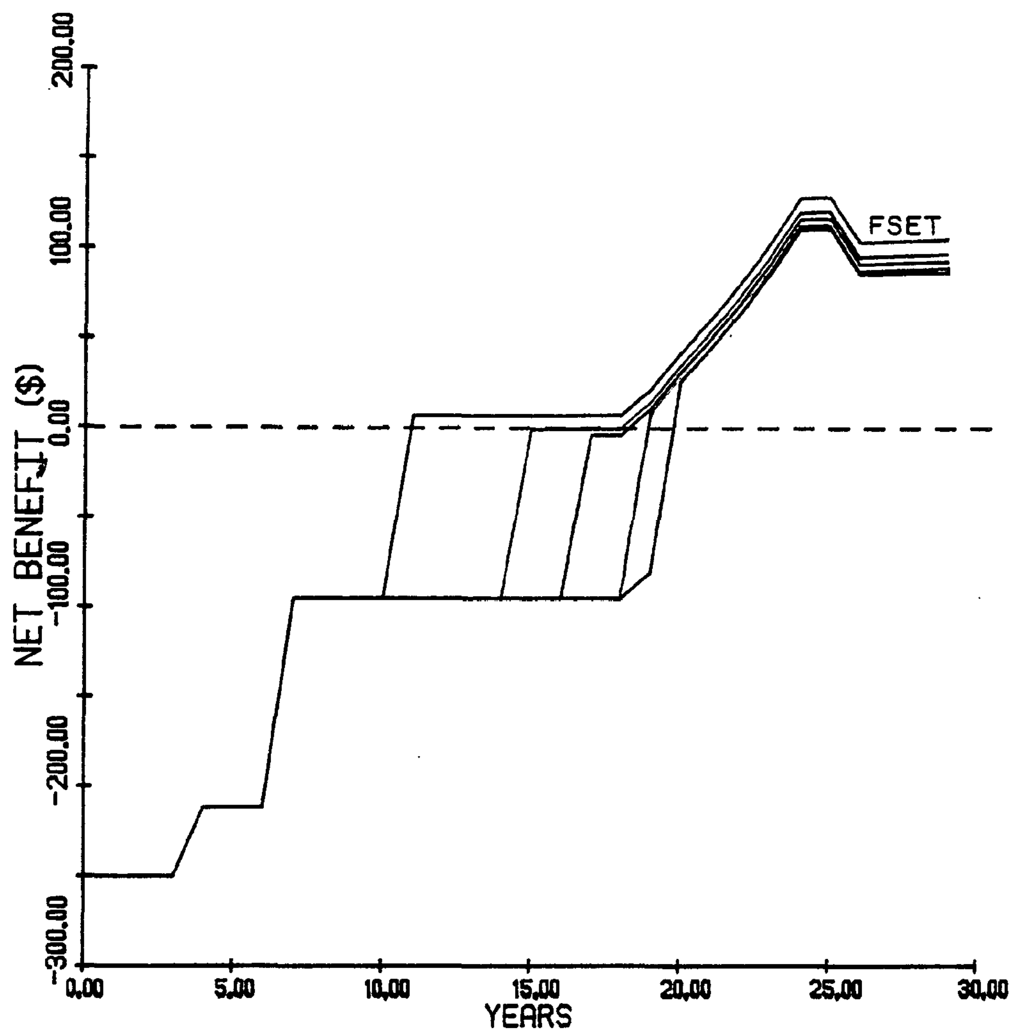


Figure DB-20. The effects of varying the parameter "FSET", the setback distance from the road to the house, on the net benefits generated by a structure with a variable effectiveness, variable recession rate and a structure life of 5 years. The structure is rebuilt every 5 years.

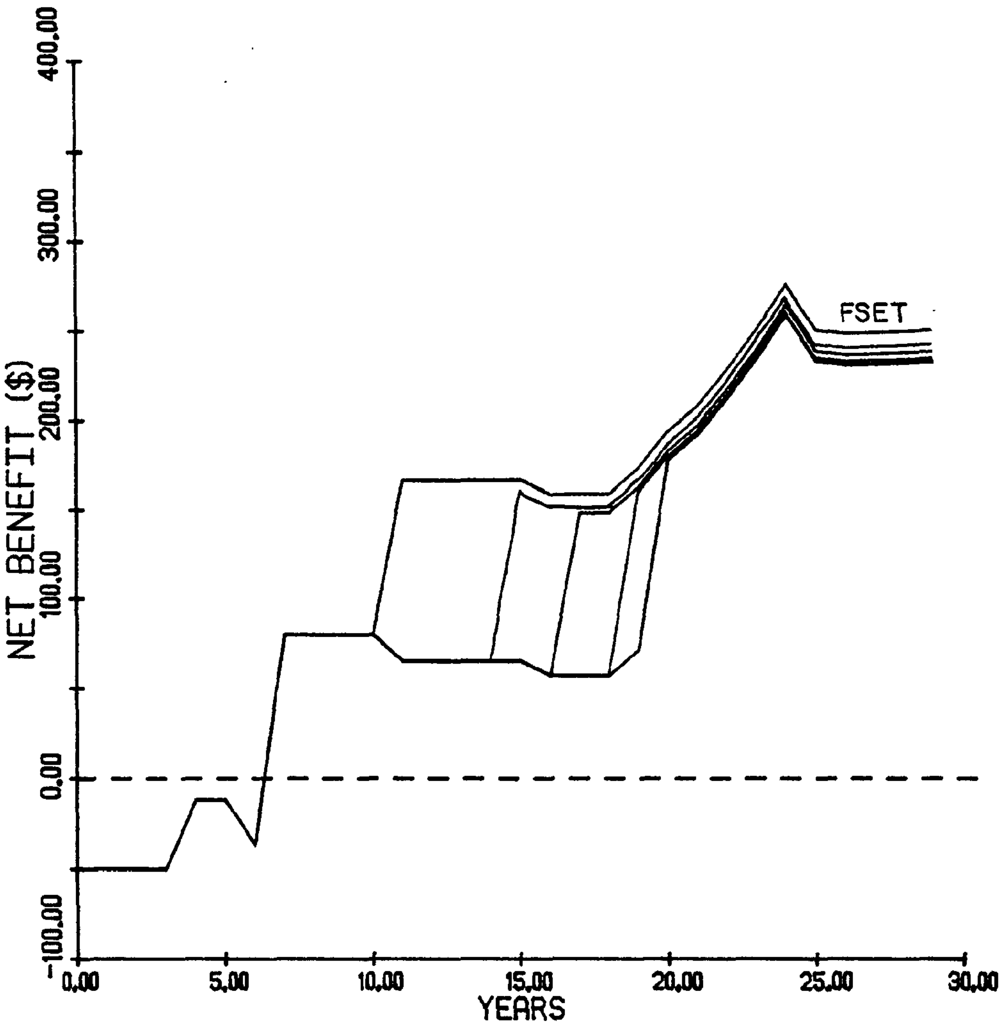


Figure DB-21. The effects of varying the parameter "HOME", the thickness of the home, on the net benefits generated by a structure with a variable effectiveness, variable recession rate and a structure life of 30 years.

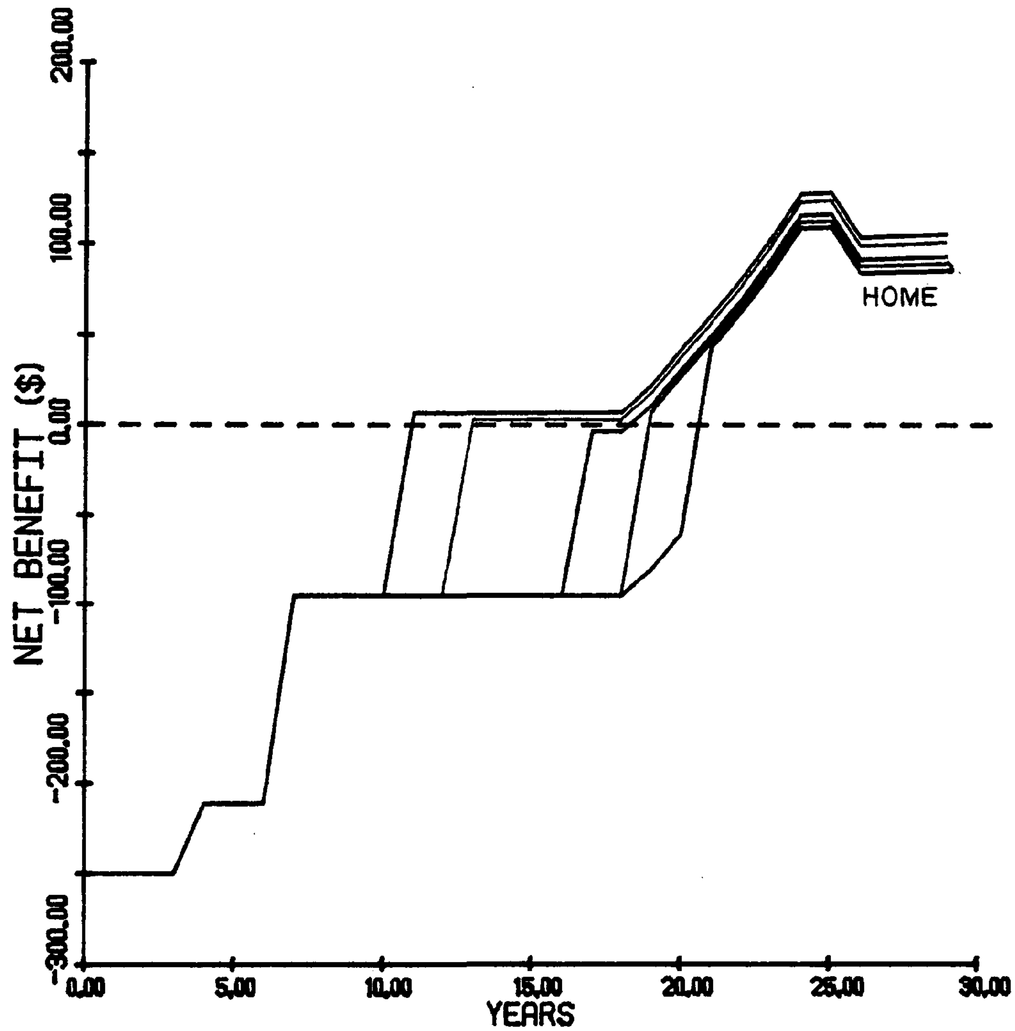


Figure DB-22. The effects of varying the parameter "HOME", the thickness of the home, on the net benefits generated by a structure with a variable effectiveness, variable recession rate and a structure life of 5 years. The structure is rebuilt every 5 years.

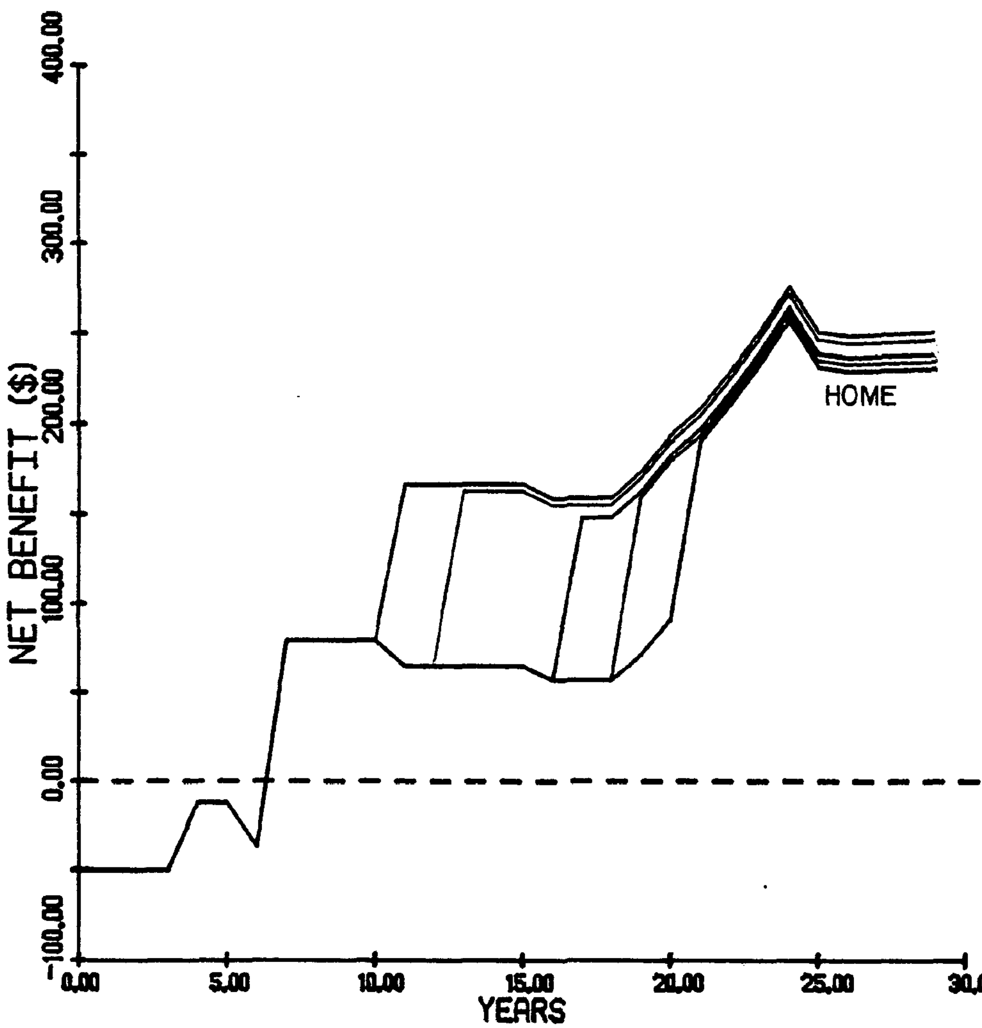


Figure DB-23. The effects of varying the parameter "FSET", the recommended setback distance from the house to the bluff, on the net benefits generated by a structure with a variable effectiveness, variable recession rate and a structure life of 30 years.

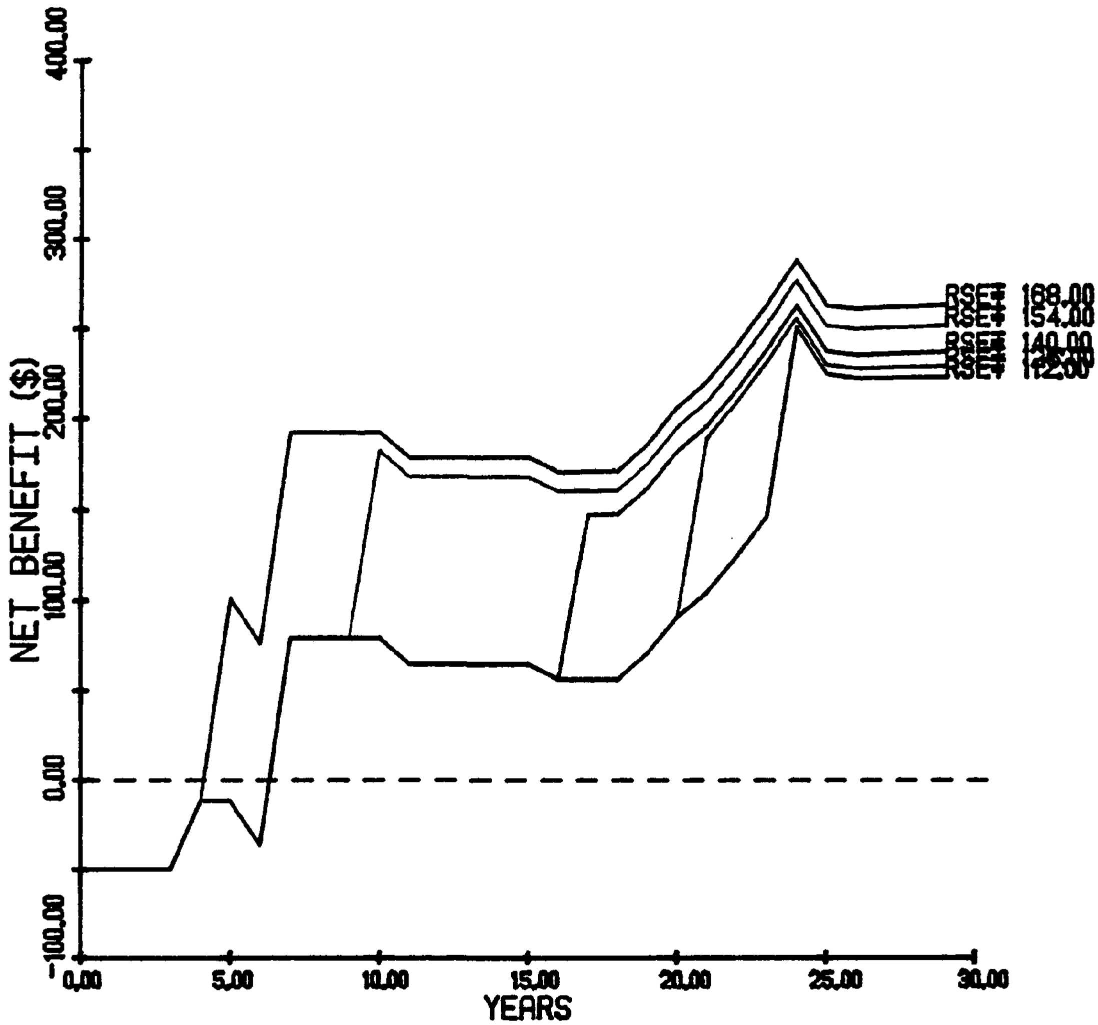


Figure DB-24. The effects of varying the parameter "FSET", the recommended setback distance from the house to the bluff, on the net benefits generated by a structure with a variable effectiveness, variable recession rate and a structure life of 5 years. The structure is rebuilt every 5 years.

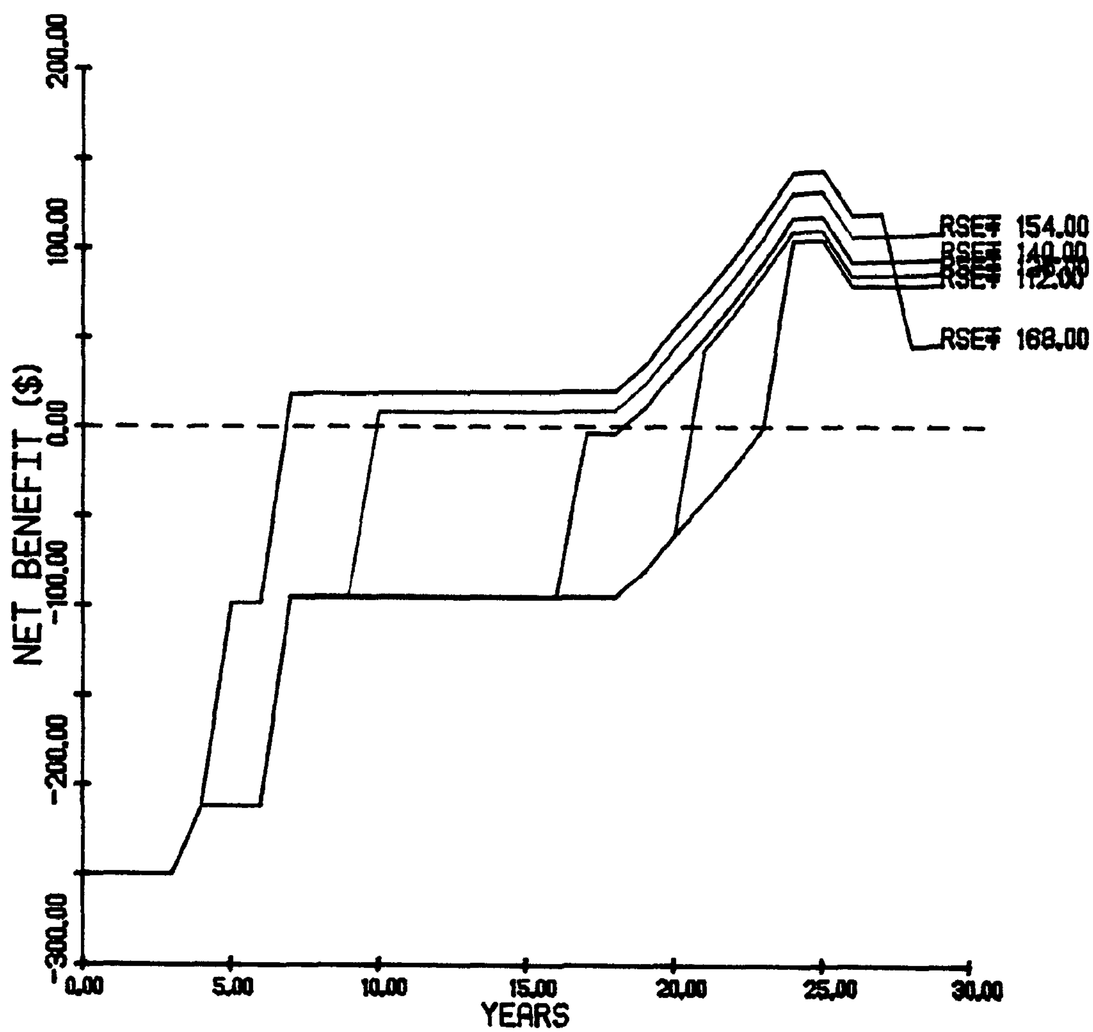


Figure DB-25. The effects of varying the parameter "DPTH", the depth of the lot, on the net benefits generated by a structure with a variable effectiveness, variable recession rate and a structure life of 30 years.

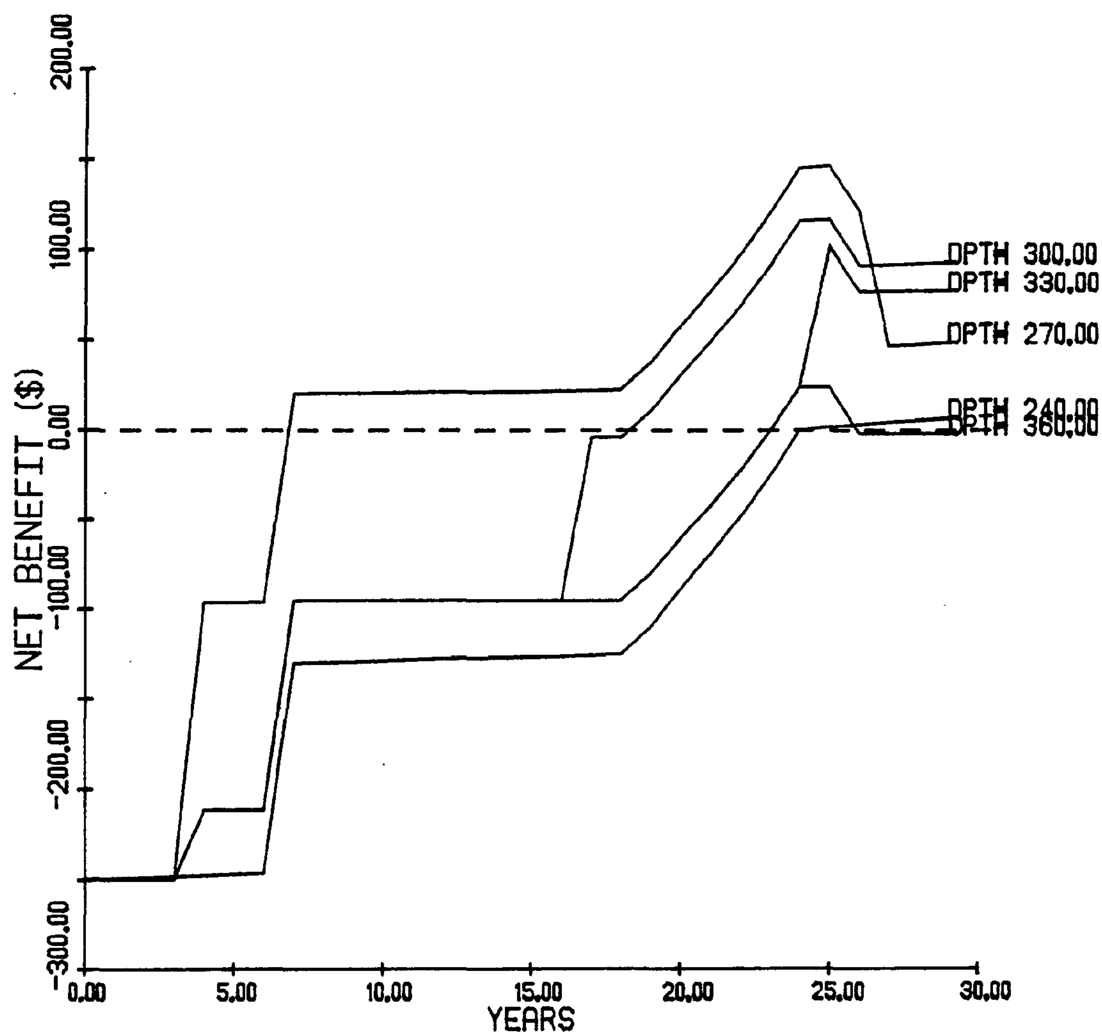


Figure DB-26. The effects of varying the parameter "DPTH", the depth of the lot, on the net benefits generated by a structure with a variable effectiveness, variable recession rate and a structure life of 5 years. The structure is rebuilt every 5 years.

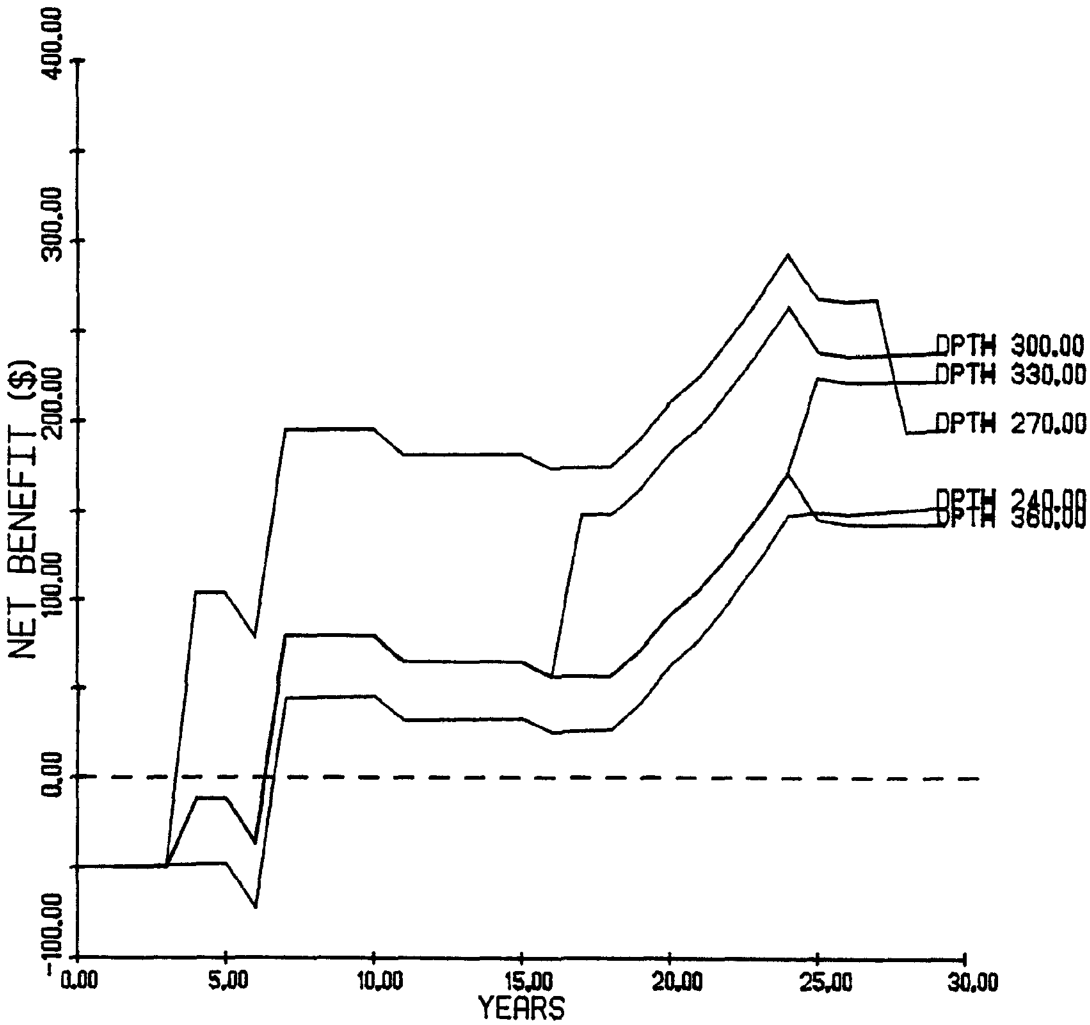


Figure DB-27. The effects of varying the parameter "TV", the total property value, on the net benefits generated by a structure with a variable effectiveness, variable recession rate and a structure life of 30 years.

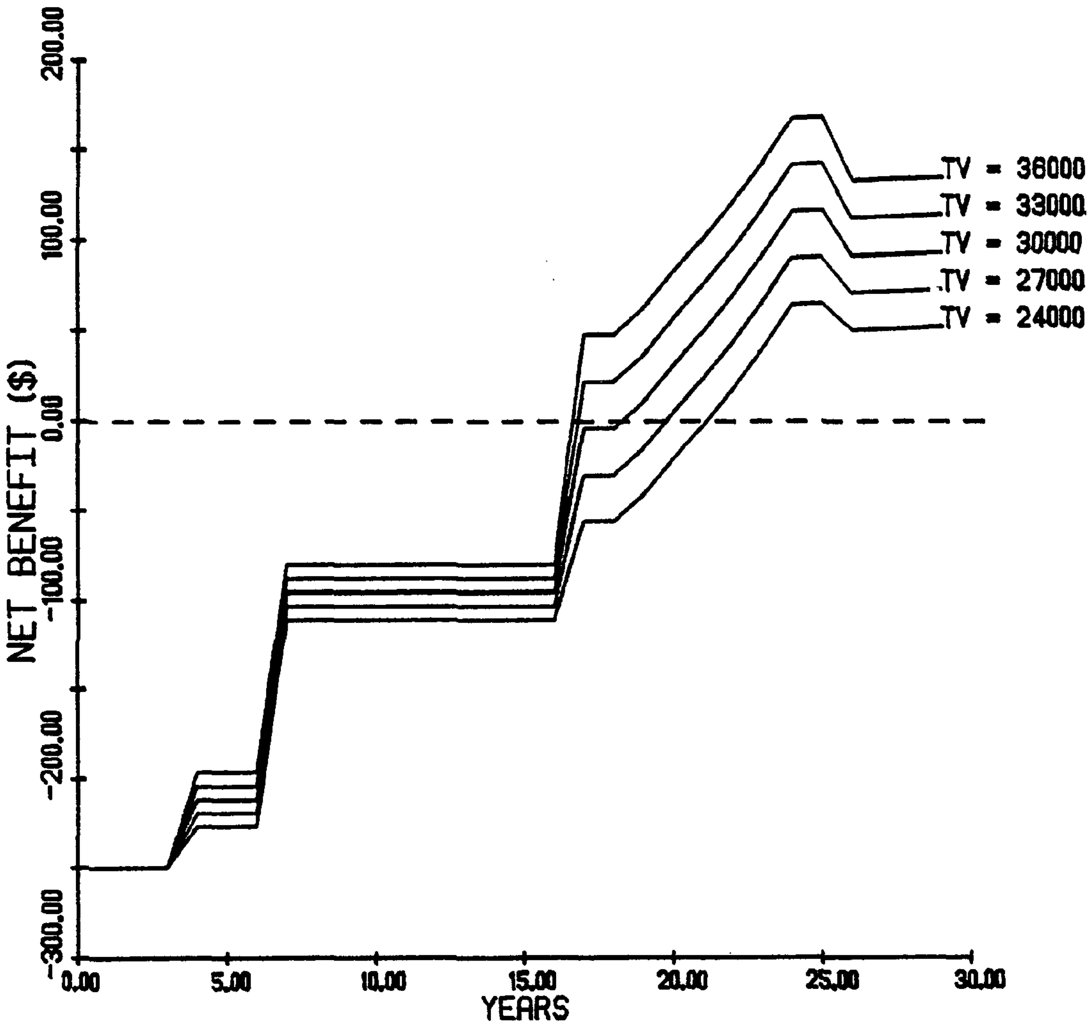


Figure DB-28. The effects of varying the parameter "TV", the total property value, on the net benefits generated by a structure with a variable effectiveness, variable recession rate and a structure life of 5 years. The structure is rebuilt every 5 years.

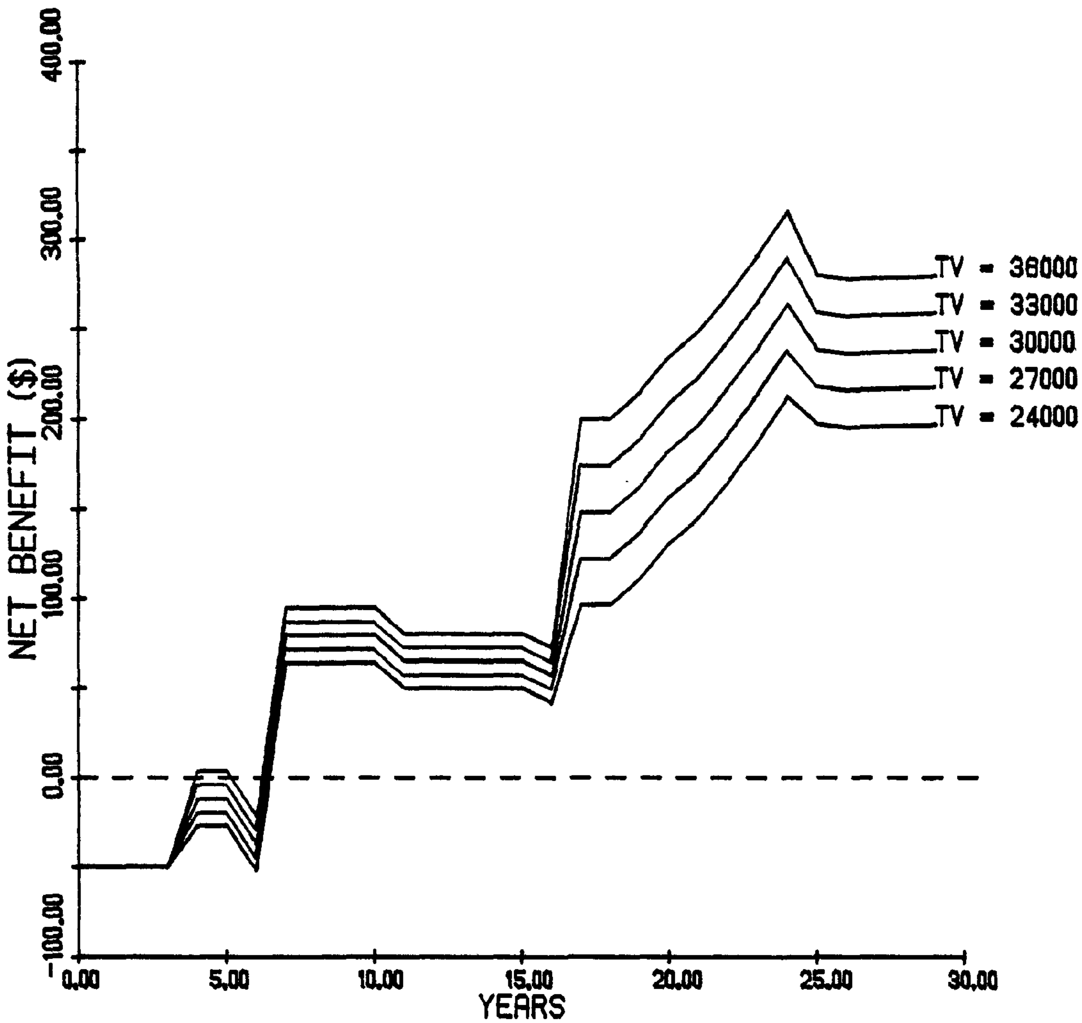


Figure DB-29. The effects of varying the parameter "LV", the inland land value, on the net benefits generated by a structure with a variable effectiveness, variable recession rate and a structure life of 30 years.

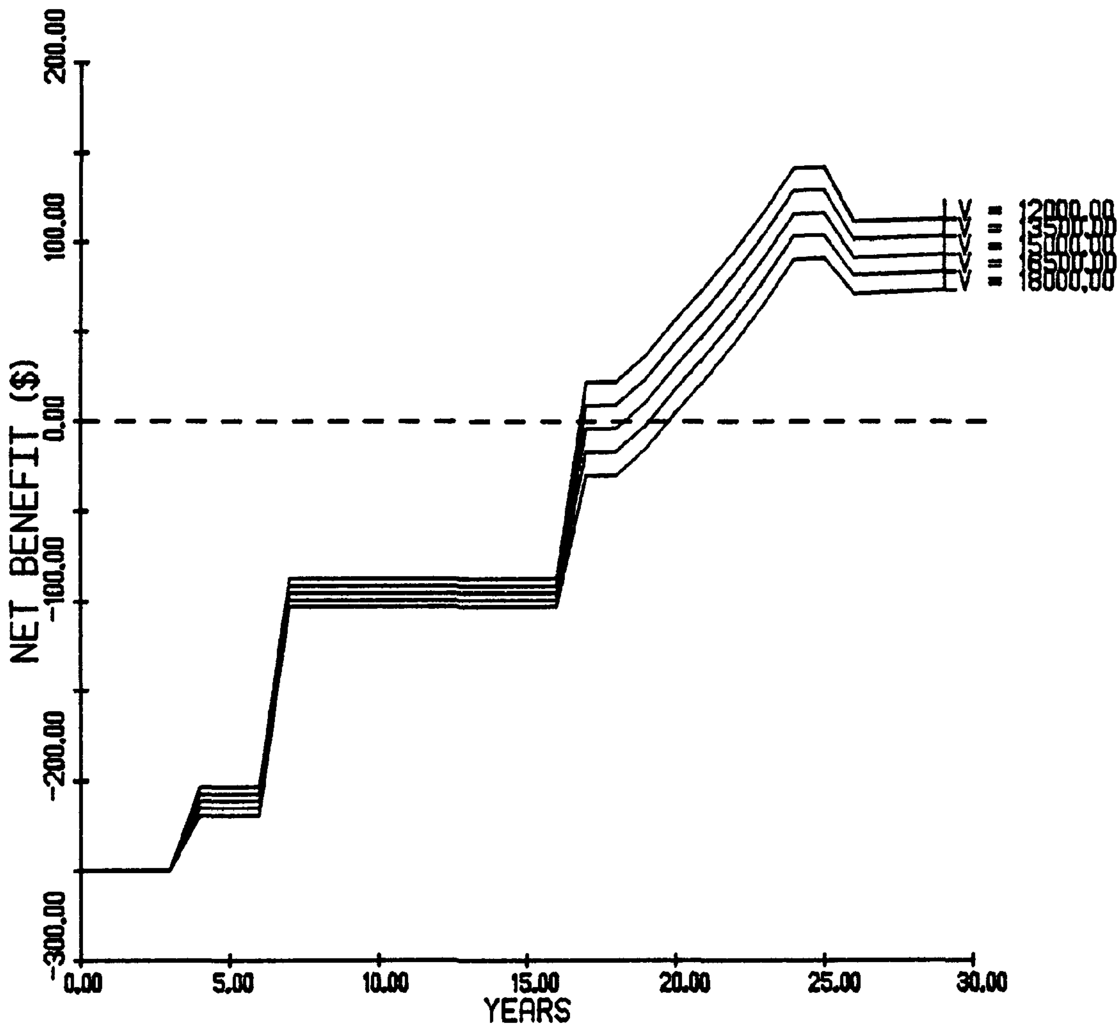


Figure DB-30. The effects of varying the parameter "LV", the inland land value, on the net benefits generated by a structure with a variable effectiveness, variable recession rate and a structure life of 5 years. The structure is rebuilt every 5 years.

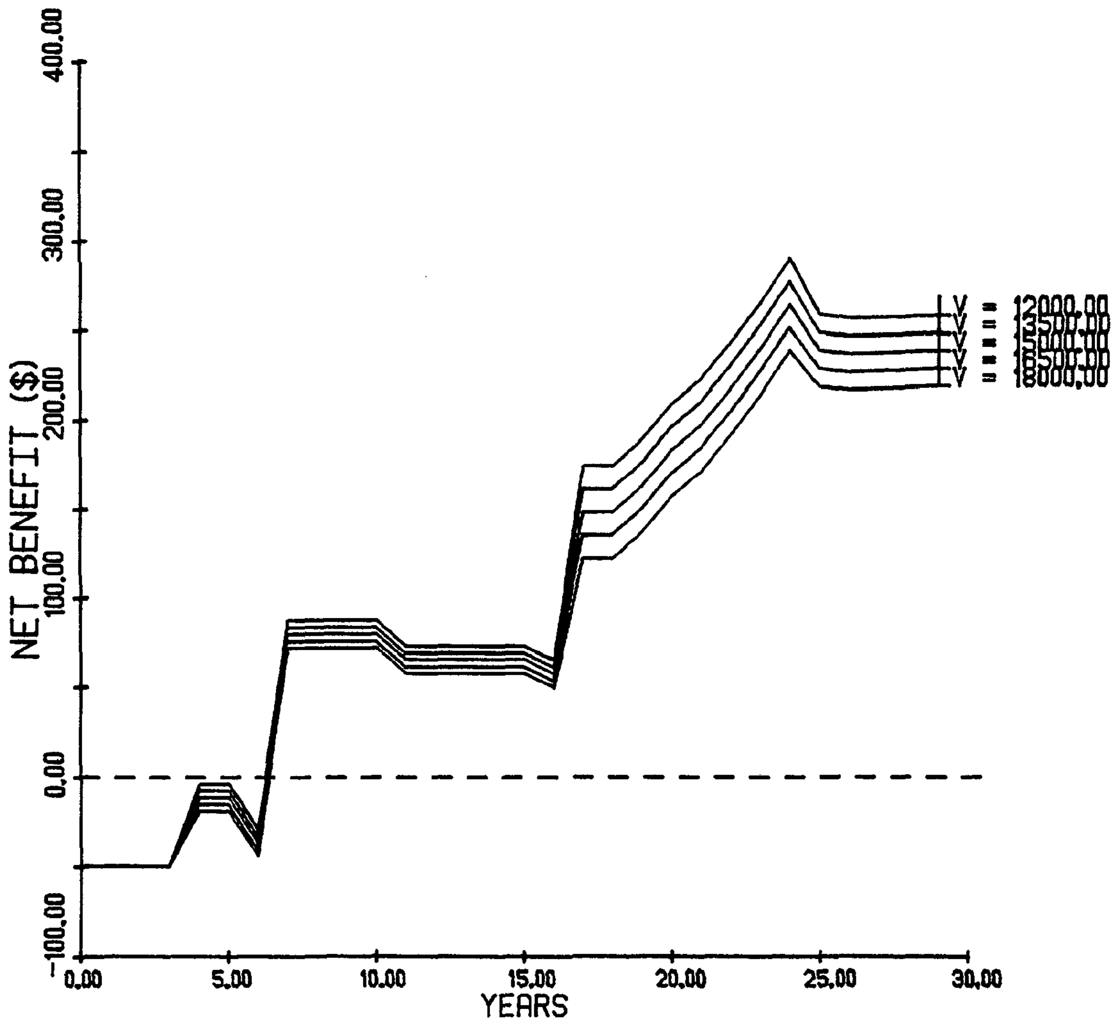


Figure DB-31. The effects of varying the parameter "SV", the structure value, on the net benefits generated by a structure with a variable effectiveness, variable recession rate and a structure life of 30 years.

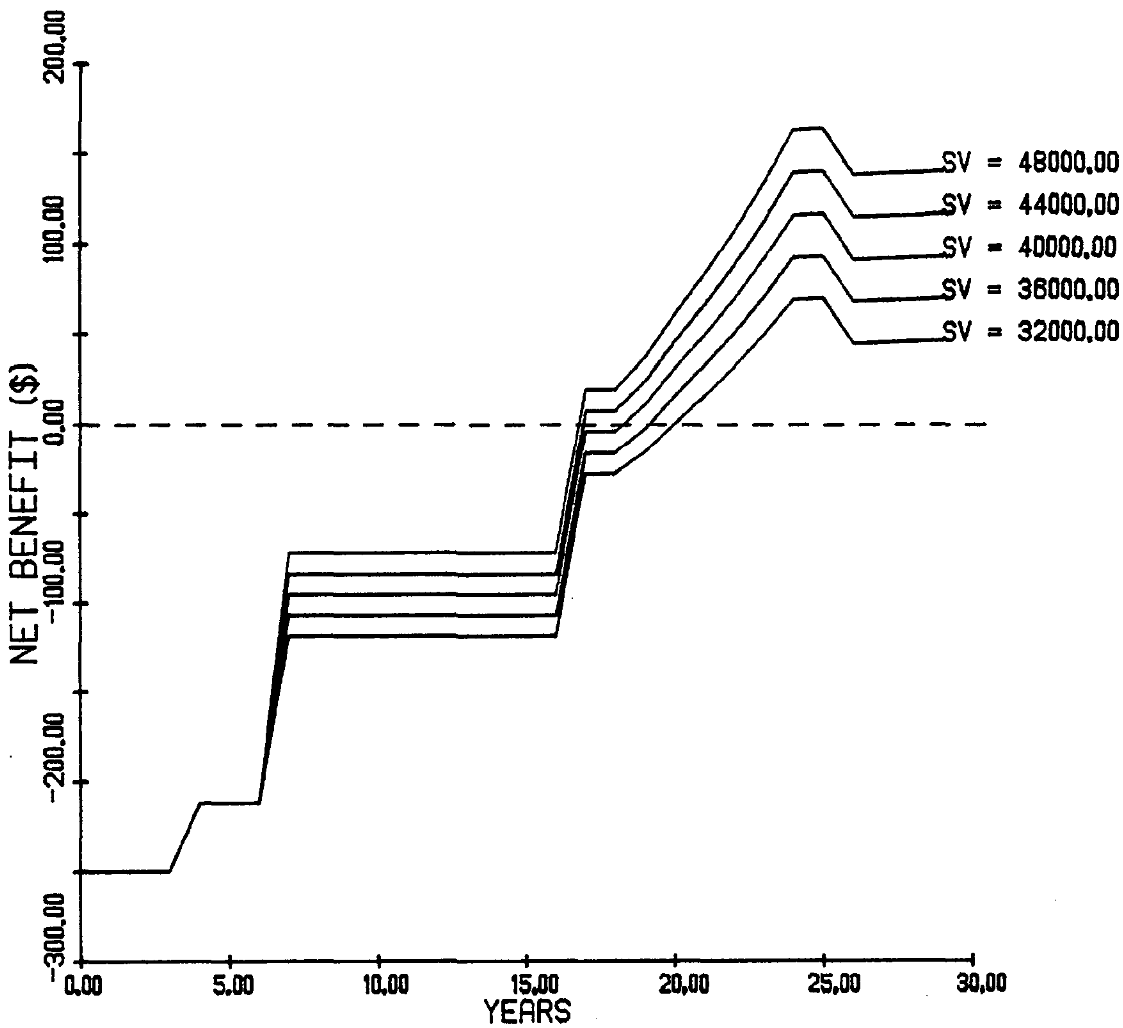


Figure DB-32. The effects of varying the parameter "SV", the structure value, on the net benefits generated by a structure with a variable effectiveness, variable recession rate and a structure life of 5 years. The structure is rebuilt every 5 years.

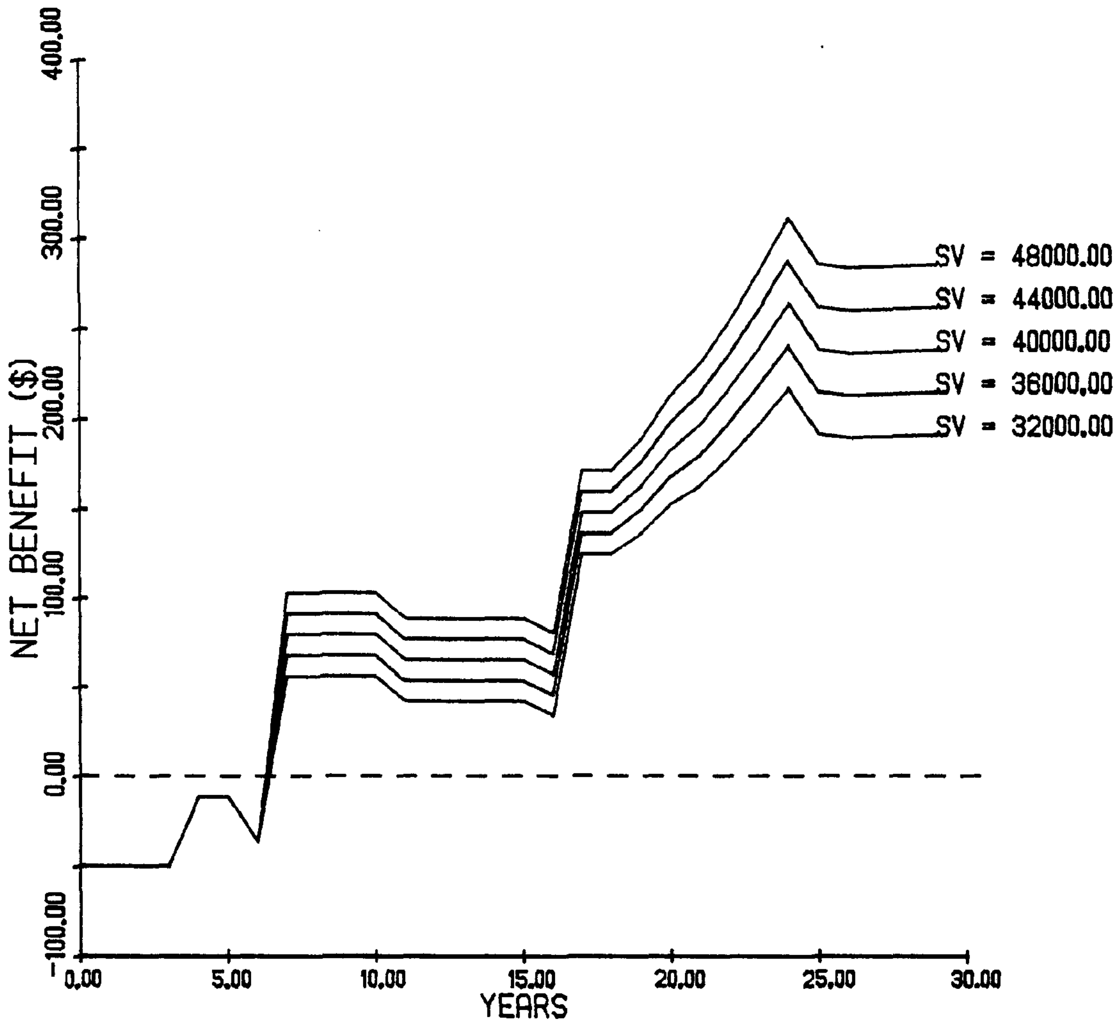


Figure DB-33. The effects of varying the parameter "RI", the discounting rate, on the net benefits generated by a structure with a variable effectiveness, variable recession rate and a structure life of 30 years.

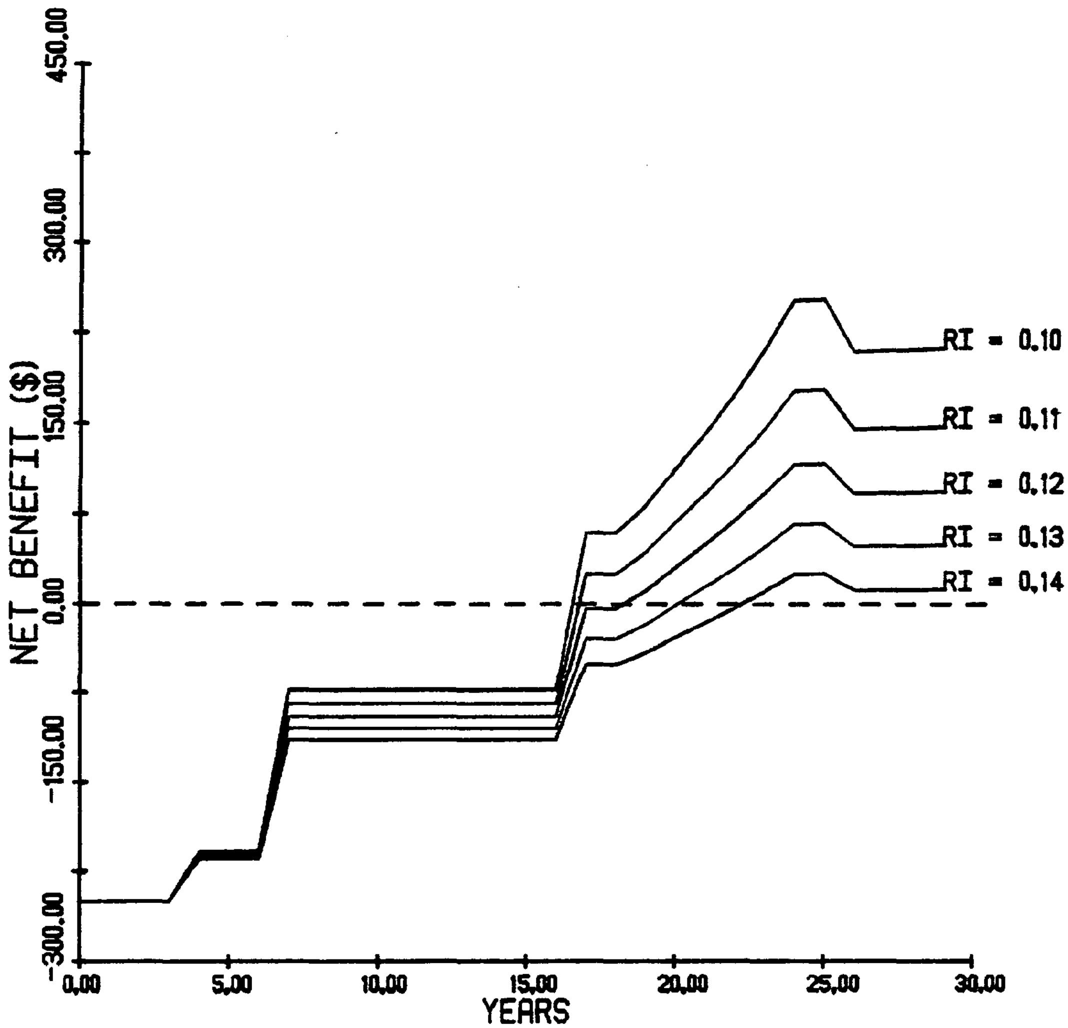
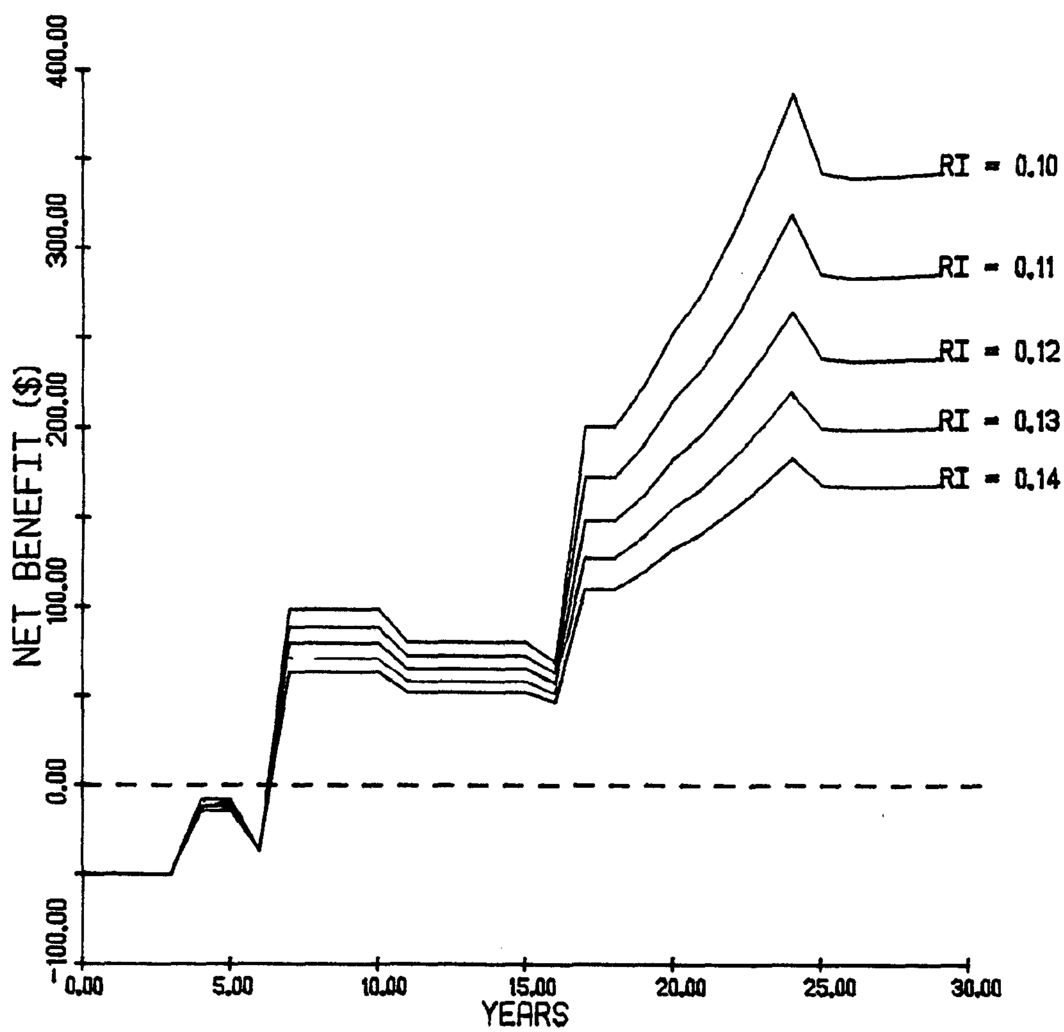


Figure DB-34. The effects of varying the parameter "RI", the discounting rate, on the net benefits generated by a structure with a variable effectiveness, variable recession rate and a structure life of 5 years. The structure is rebuilt every 5 years.



Appendix DC

Output Showing the Effects of Net
Benefits Generated by a Structure

LIST OF FIGURES

Figure DC-1. The effects of structure effectiveness on the net benefits generated by a structure with a constant effectiveness, constant recession and a structure life of 30 years.

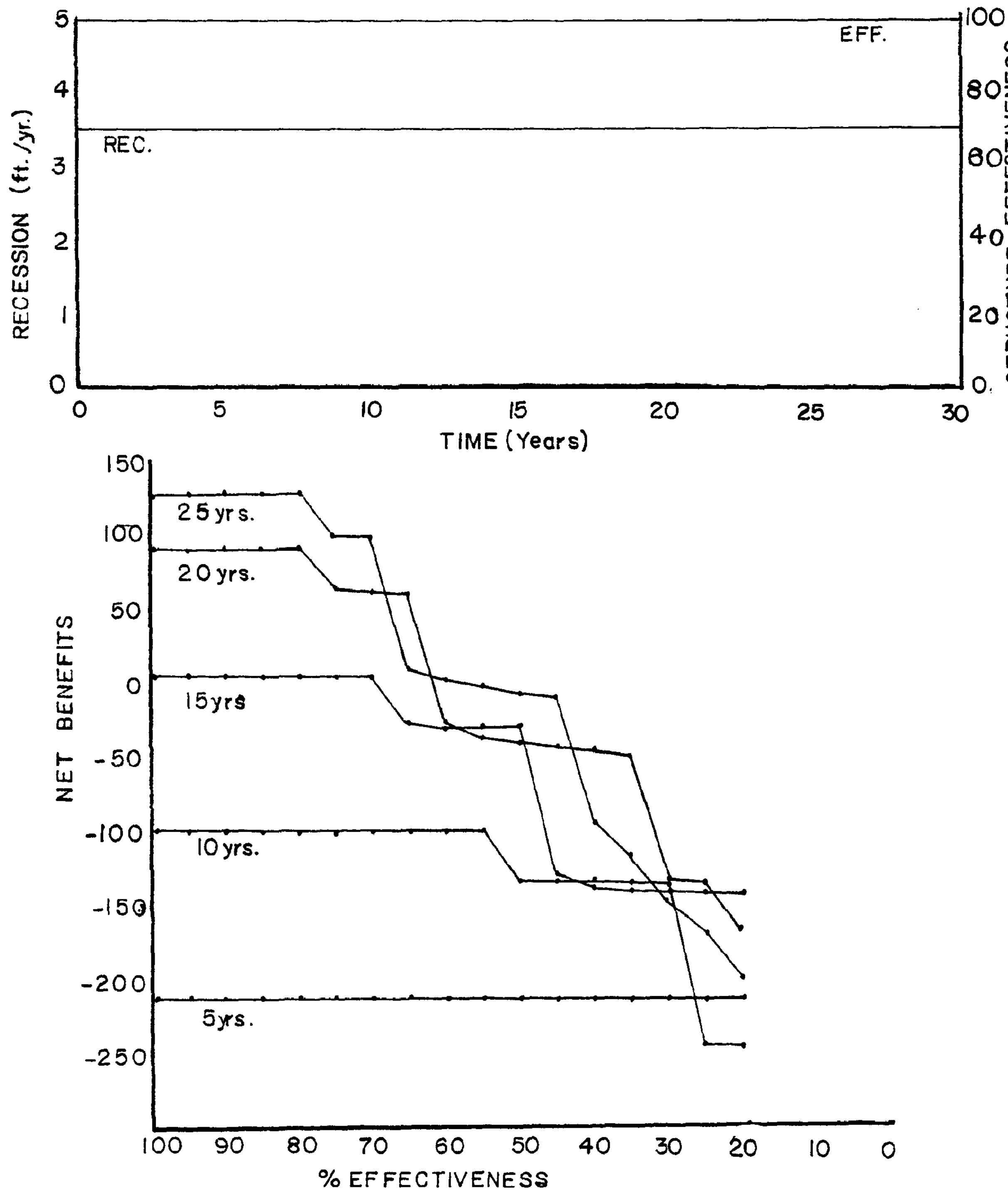
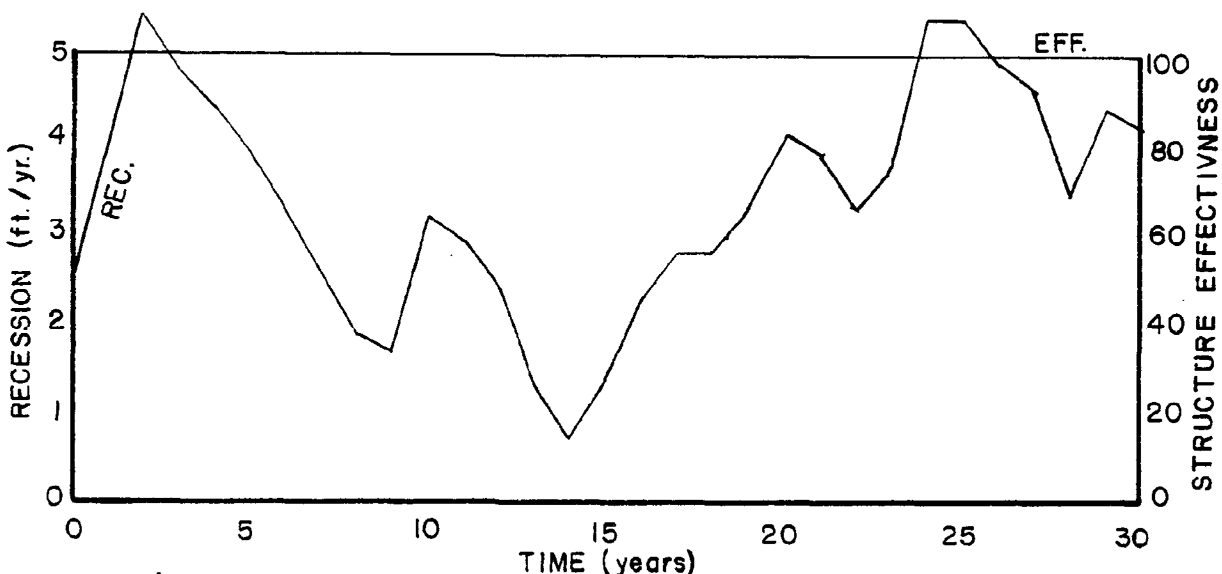


Figure DC-2. The effects of structure effectiveness on the net benefits generated by a structure with a constant effectiveness, variable recession rate and a structure life of 30 years.



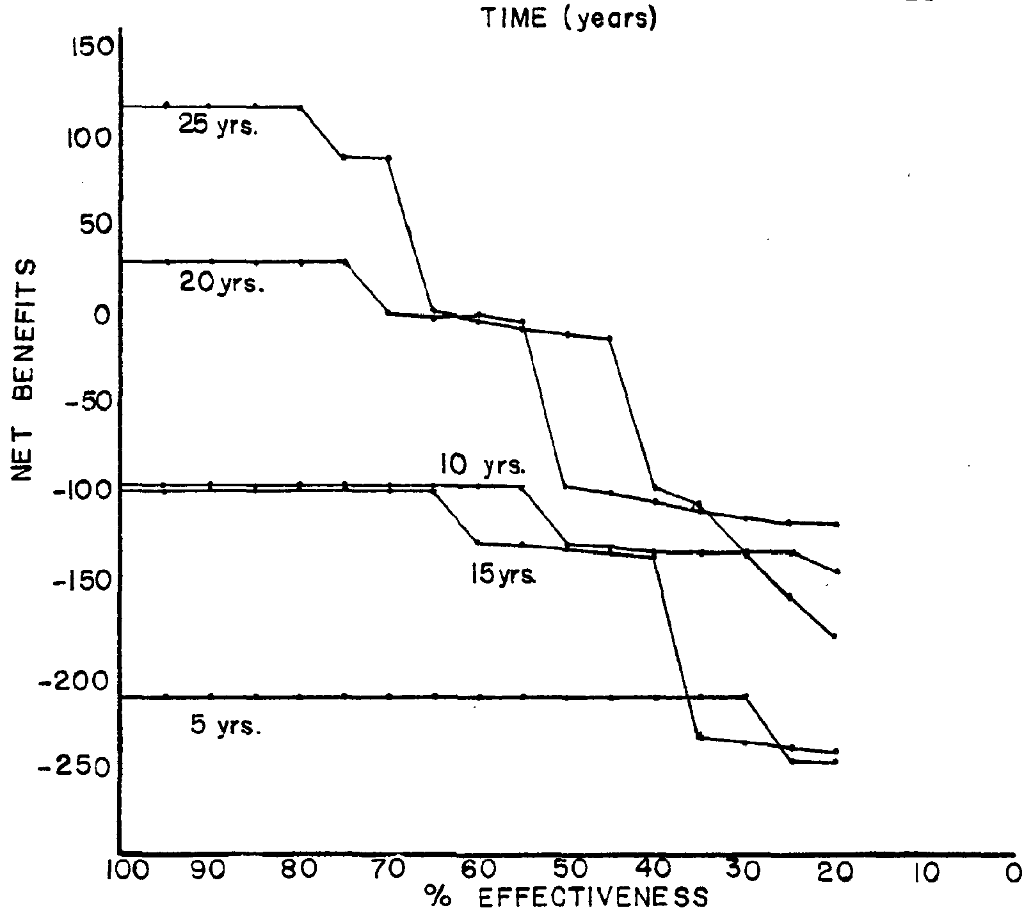


Figure DC-3. The effects of structure effectiveness on the net benefits generated by a structure with a variable effectiveness, constant recession rate and a structure life of 30 years.

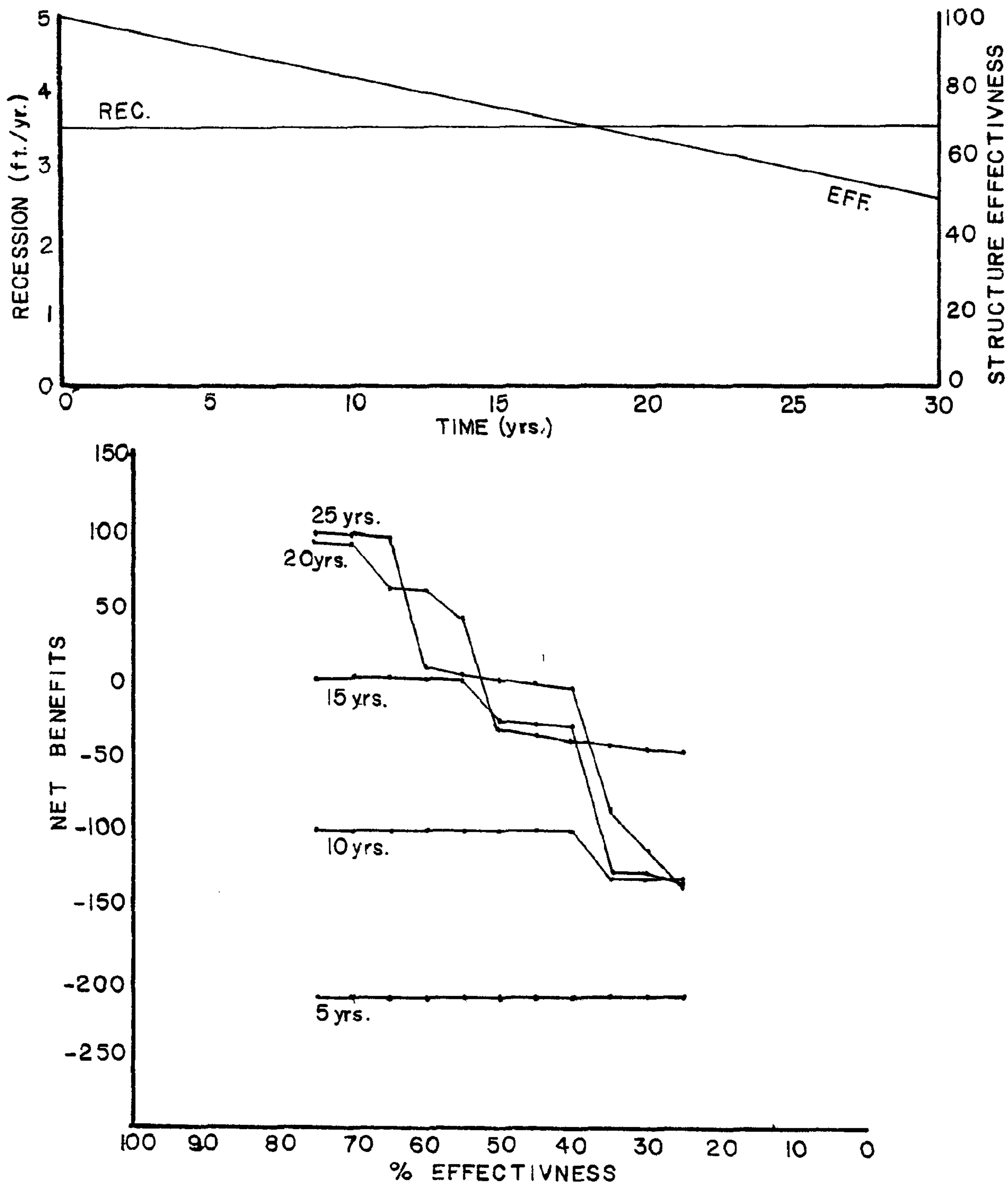


Figure DC-4. The effects of structure effectiveness on the net benefits generated by a structure with a variable effectiveness, variable recession rate and a structure life of 30 years.

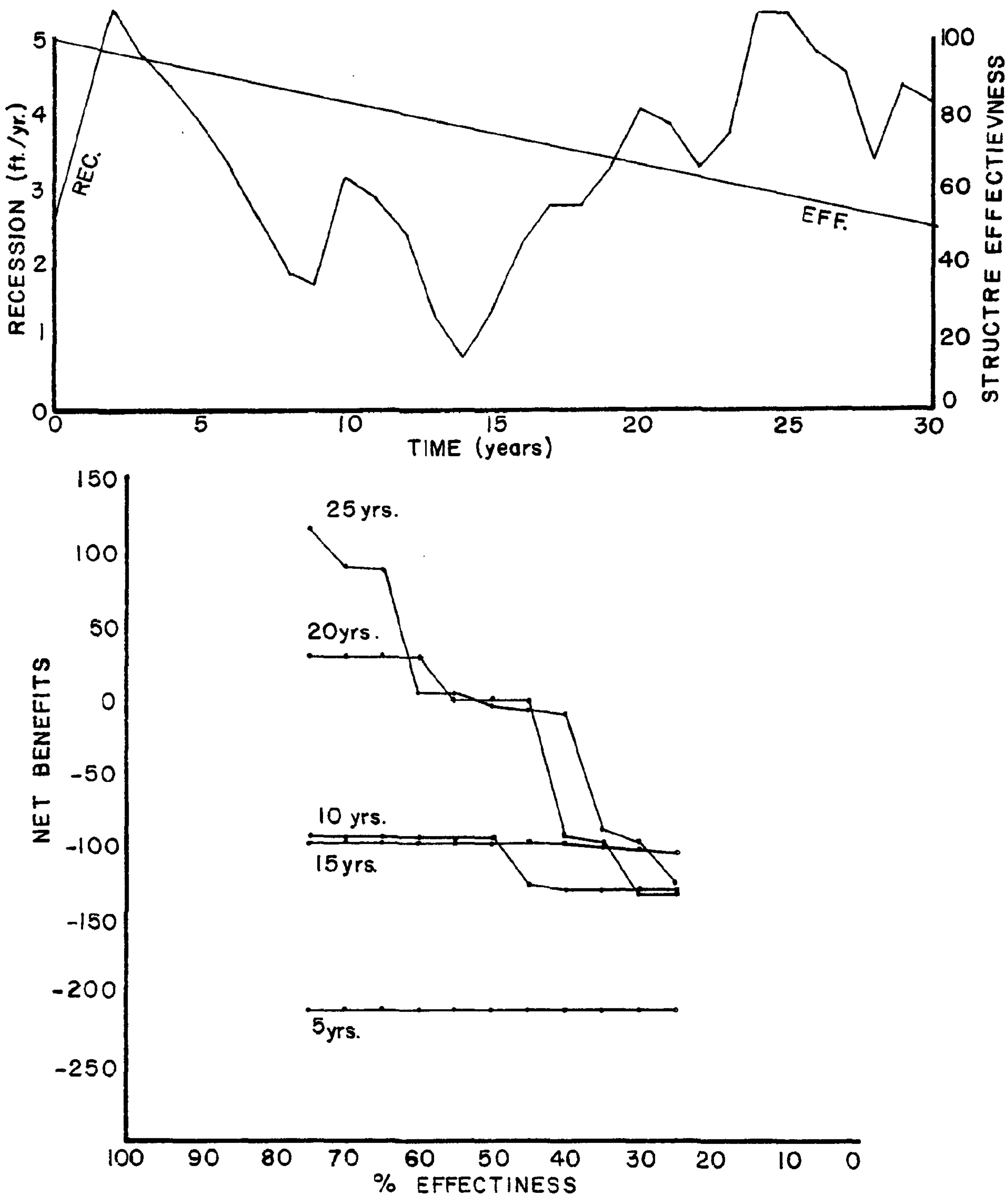


Figure DC-5. The effects of structure effectiveness on the net benefits generated by a structure with a constant effectiveness, constant recession rate and a structure life of 5 years. The structure is rebuilt every 5 years.

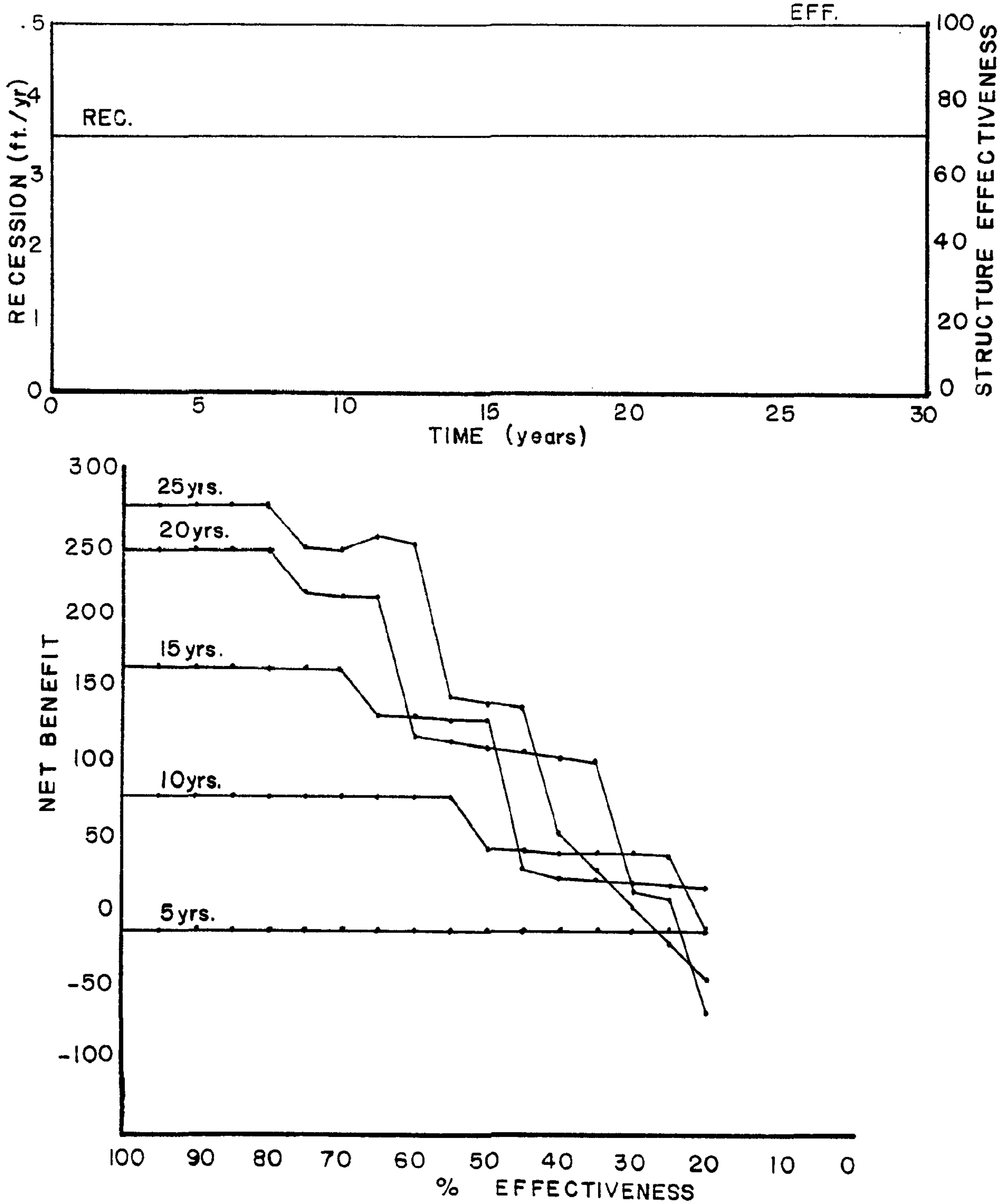
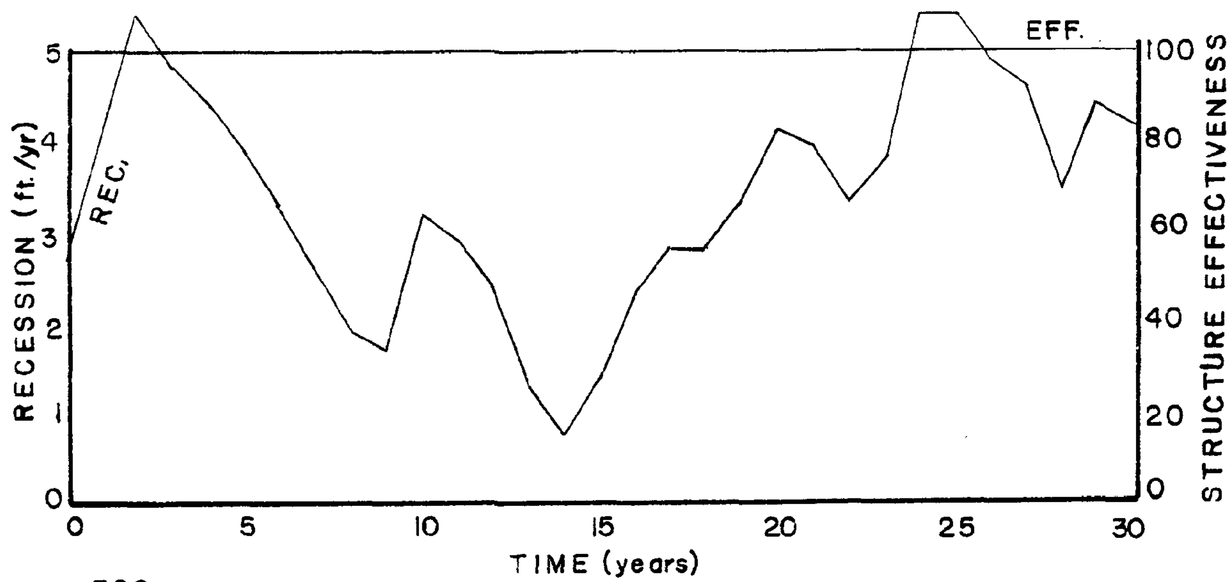


Figure DC-6. The effects of structure effectiveness on the net benefits generated by a structure with a constant effectiveness, variable recession rate and a structure life of 5 years. The structure is rebuilt every 5 years.



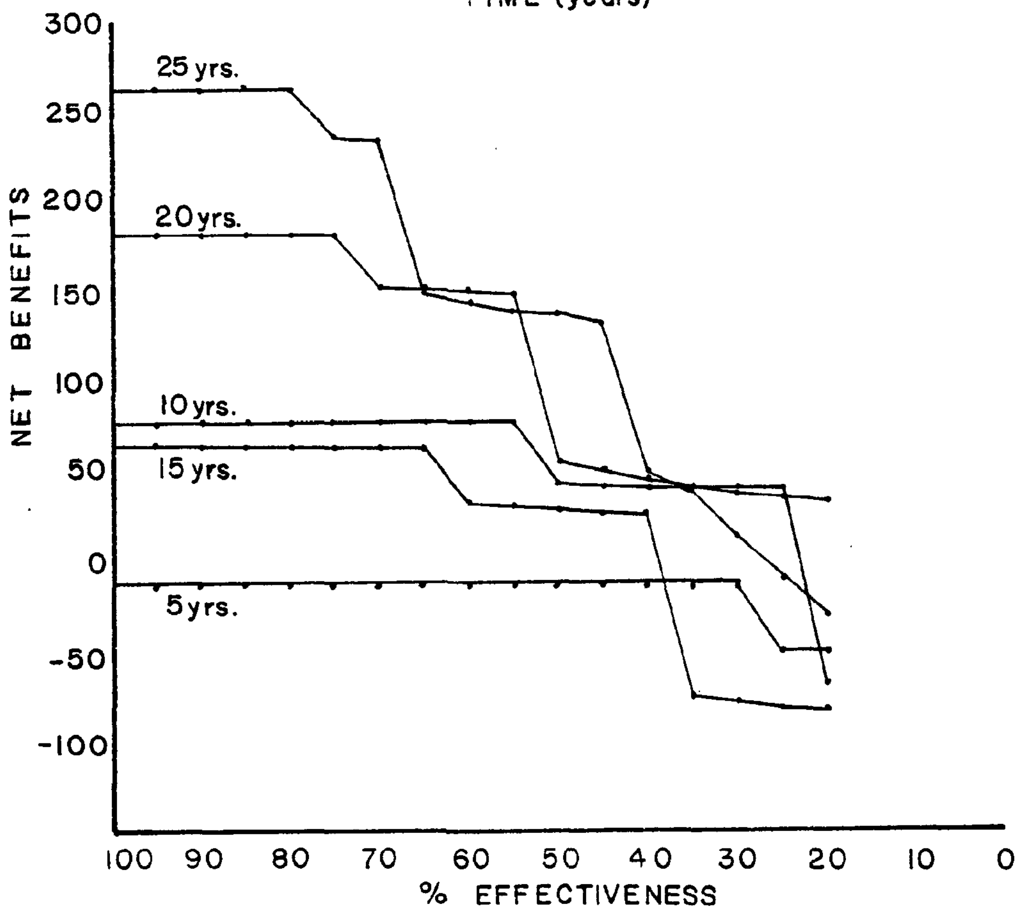


Figure DC-7. The effects of structure effectiveness on the net benefits generated by a structure with a variable effectiveness, constant recession rate and a structure life of 5 years. The structure is rebuilt every 5 years.

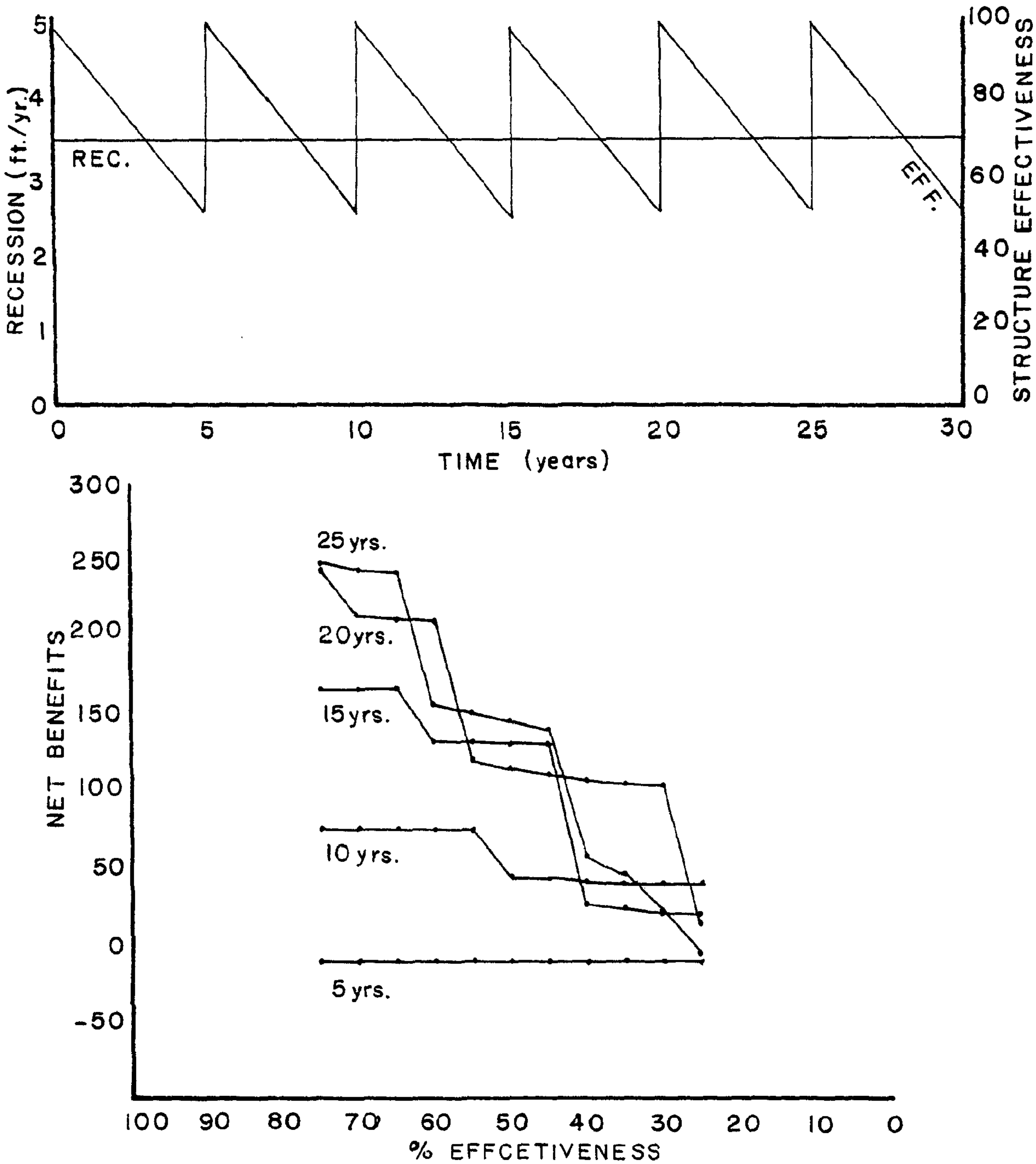
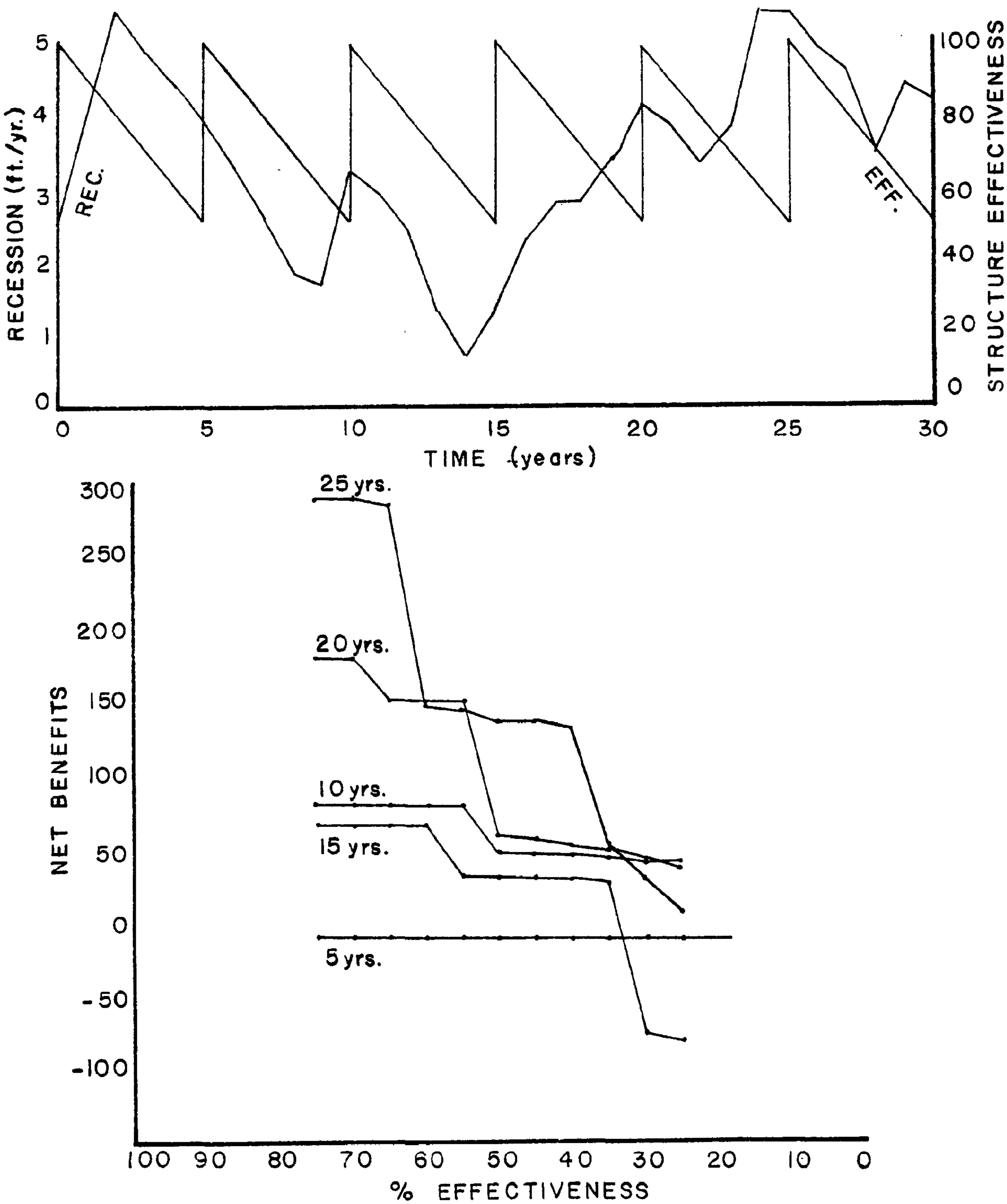


Figure DC-8. The effects of structure effectiveness on the net benefits generated by a structure with a variable effectiveness, variable recession rate and a structure life of 5 years. The structure is rebuilt every 5 years.



Appendix E

Output from Benefit/Cost Model for Stone Revetment and Offshore Breakwater Cases

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY   UNIVERSITY OF MICHIGAN   VERSION #2 DECEMBER 1978

STONE REVETMENT - 6000 FT STRUCTURE - 25 YEAR BOND
C2L-10   COBLE   (SM28)
NUMBER OF PROPERTIES PROCESSED = 1   TOTAL LENGTH OF SHORELINE = 49.00

DPTH =	300.000	DEPTH OF THE LOT (FEET)	L =	49.000	FRONT FOOTAGE OF LOT IN (FEET)
FOUN =	0.0	DISTANCE FROM FOUNDATION TO BLUFF (FEET)	HOME =	0.0	DEPTH OF THE HOME (FEET)
BSET =	140.000	RECCOMENDED SET BACK DISTANCE (FEET)	FSET =	35.000	SET BACK IN FRONT OF HOME (FEET)
H =	35.000	HEIGTH OF THE BLUFF (FEET)	TH =	1.047	ANGLE OF THE BLUFF (RADIANS)
TV =	7500.000	LAKESIDE LAND VALUE ($)	LV =	2250.000	INLAND LAND VALUE ($)
SV =	0.0	HOME OR STRUCTURE VALUE ($)	RESR =	1.000	RECESSION RATE MODIFIER
LRES =	3.667	LONG TERM RECESSION RATE (FEET/YEAR)	AEST =	5250.000	ASTHETIC VALUE ($)
COST =	6000.000	COST TO MOVE HOME ($)	RI =	0.100	DISCOUNTING RATE
REST =	20.000	REALTORS ESTIMATE OF BANK (FEET)	A =	0.500	WEIGHTING FACTOR
MLT1 =	2.500	WEIGHTING FACTOR	MLT2 =	0.500	WEIGHTING FACTOR
T =	30.000	INVESTMENT HORIZON (YEARS)	PLV =	175.000	DISTANCE FROM ROAD TO SETBACK (FEET)
BANK =	23.750	POINT WHERE MORTGAGE BECOMES UNAVAILABLE	STPL =	50.000	POINT OF SHARP STRUCTURE VALUE DECLINE
STPB =	36.875	1/2 WAY BETWEEN BANK AND STEPL (FEET)	BASE =	20.784	LENGTH OF THE BLUFF BASE (FEET)

INPUT PARAMETERS   OUTPUT PARAMETERS

AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	14.52	0.950	0	2.50	0.13	0.0	0.0	14.52	14.52	-14.52	-122.45	-122.45
3.90	.100	14.52	0.950	1	6.40	0.32	0.0	0.0	13.20	27.72	-27.72	0.0	-122.45
5.40	.100	14.52	0.950	2	11.80	0.59	0.0	0.0	12.00	39.72	-39.72	0.0	-122.45
4.80	.100	14.52	0.950	3	16.60	0.83	0.0	0.0	10.91	50.63	-50.63	0.0	-122.45
4.40	.100	14.52	0.950	4	21.00	1.05	29.46	29.46	9.92	60.55	-31.08	-29.46	-151.91
3.90	.100	14.52	0.950	5	24.90	1.25	0.0	29.46	9.02	69.56	-40.10	0.0	-151.91
3.30	.100	14.52	0.950	6	28.20	1.41	0.0	29.46	8.20	77.76	-48.29	0.0	-151.91
2.60	.100	14.52	0.950	7	30.80	1.54	0.0	29.46	7.45	85.21	-55.75	0.0	-151.91
1.90	.100	14.52	0.950	8	32.70	1.64	0.0	29.46	6.77	91.98	-62.52	0.0	-151.91
1.70	.100	14.52	0.950	9	34.40	1.72	0.0	29.46	6.16	98.14	-68.68	0.0	-151.91
3.20	.100	14.52	0.900	10	37.60	2.04	0.0	29.46	5.60	103.74	-74.27	0.0	-151.91
2.90	.100	14.52	0.850	11	40.50	2.48	0.0	29.46	5.09	108.83	-79.36	0.0	-151.91
2.40	.100	14.52	0.800	12	42.90	2.96	0.0	29.46	4.63	113.46	-83.99	0.0	-151.91
1.30	.100	14.52	0.750	13	44.20	3.28	0.0	29.46	4.21	117.66	-88.20	0.0	-151.91
0.70	.100	14.52	0.700	14	44.90	3.49	0.0	29.46	3.82	121.48	-92.02	0.0	-151.91
1.40	.100	14.52	0.650	15	46.30	3.98	0.0	29.46	3.48	124.96	-95.50	0.0	-151.91
2.30	.100	14.52	0.600	16	48.60	4.90	0.0	29.46	3.16	128.12	-98.66	0.0	-151.91
2.80	.100	14.52	0.550	17	51.40	6.16	0.0	29.46	2.87	130.99	-101.53	0.0	-151.91
2.80	.100	14.52	0.500	18	54.20	7.56	0.0	29.46	2.61	133.60	-104.14	0.0	-151.91
3.30	.100	14.52	0.450	19	57.50	9.38	0.0	29.46	2.37	135.98	-106.51	0.0	-151.91
4.10	.100	14.52	0.400	20	61.60	11.84	0.0	29.46	2.16	138.14	-108.67	0.0	-151.91
3.90	.100	14.52	0.380	21	65.50	14.25	0.0	29.46	1.96	140.10	-110.64	0.0	-151.91
4.30	.100	14.52	0.360	22	69.80	17.00	0.0	29.46	1.78	141.88	-112.42	0.0	-151.91
4.80	.100	14.52	0.340	23	74.60	20.17	0.0	29.46	1.62	143.50	-114.04	0.0	-151.91
5.40	.100	14.52	0.320	24	80.00	23.84	-29.46	-0.00	1.47	144.98	-144.98	0.0	-151.91
5.40	.100	14.52	0.300	25	85.40	27.62	0.0	-0.00	1.34	146.32	-146.32	0.0	-151.91
4.90	.100	0.0	0.280	26	90.30	31.15	0.0	-0.00	0.0	146.32	-146.32	0.0	-151.91
4.60	.100	0.0	0.260	27	94.90	34.56	0.0	-0.00	0.0	146.32	-146.32	0.0	-151.91
3.40	.100	0.0	0.240	28	98.30	37.14	0.0	-0.00	0.0	146.32	-146.32	0.0	-151.91
4.40	.100	0.0	0.220	29	102.70	40.57	0.0	-0.00	0.0	146.32	-146.32	0.0	-151.91
4.20	.100	0.0	0.200	30	106.90	43.93	0.0	-0.00	0.0	146.32	-146.32	0.0	-151.91

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY UNIVERSITY OF MICHIGAN VERSION #2 DECEMBER 1978

STONE REVETMENT - 6000 FT STRUCTURE - 25 YEAR BOND
CZL-20 LAUER (929)
NUMBER OF PROPERTIES PROCESSED = 1 TOTAL LENGTH OF SHORELINE = 50.00

DPTH =	200.000	DEPTH OF THE LOT (FEET)	L =	50.000	FRONT FOOTAGE OF LOT IN (FEET)
FOUN =	0.0	DISTANCE FROM FOUNDATION TO BLUFF (FEET)	HOME =	0.0	DEPTH OF THE HOME (FEET)
RSET =	140.000	RECCOMENDED SET BACK DISTANCE (FEET)	FSET =	35.000	SET BACK IN FRONT OF HOME (FEET)
H =	36.000	HEIGTH OF THE BLUFF (FEET)	TH =	1.047	ANGLE OF THE BLUFF (RADIANS)
TV =	7500.000	LAKESIDE LAND VALUE ($)	LV =	2250.000	INLAND LAND VALUE ($)
SV =	0.0	HOME OR STRUCTURE VALUE ($)	RESR =	1.000	RECESSION RATE MODIFIER
LRES =	3.667	LONG TERM RECESSION RATE (FEET/YEAR)	AEST =	5250.000	ASTHETIC VALUE ($)
COST =	6000.000	COST TO MOVE HOME ($)	RI =	0.100	DISCOUNTING RATE
REST =	20.000	REALTORS ESTIMATE OF BANK (FEET)	A =	0.500	WEIGHTING FACTOR
MLT1 =	2.500	WEIGHTING FACTOR	MLT2 =	0.500	WEIGHTING FACTOR
T =	30.000	INVESTMENT HORIZON (YEARS)	PLV =	175.000	DISTANCE FROM ROAD TO SETBACK (FEET)
BANK =	23.750	POINT WHERE MORTGAGE BECOMES UNAVAILABLE	STPL =	50.000	POINT OF SHARP STRUCTURE VALUE DECLINE
STPB =	35.875	1/2 WAY BETWEEN BANK AND STEPL (FEET)	BASE =	20.794	LENGTH OF THE BLUFF BASE (FEET)

INPUT PARAMETERS / OUTPUT PARAMETERS

AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	14.52	0.950	0	2.50	0.13	0.0	0.0	14.52	14.52	-14.52	-120.00	-120.00
3.90	.100	14.52	0.950	1	6.40	0.32	0.0	0.0	13.20	27.72	-27.72	0.0	-120.00
5.40	.100	14.52	0.950	2	11.80	0.59	0.0	0.0	12.00	39.72	-39.72	0.0	-120.00
4.80	.100	14.52	0.950	3	16.60	0.83	0.0	0.0	10.91	50.63	-50.63	0.0	-120.00
4.40	.100	14.52	0.950	4	21.00	1.05	28.88	28.88	9.92	60.55	-31.67	-28.88	-148.88
3.90	.100	14.52	0.950	5	24.90	1.25	0.0	28.88	9.02	69.56	-40.69	0.0	-148.88
3.30	.100	14.52	0.950	6	28.20	1.41	86.64	115.52	8.20	77.76	37.76	-86.64	-235.52
2.60	.100	14.52	0.950	7	30.80	1.54	0.04	115.55	7.45	85.21	30.35	-0.04	-235.55
1.90	.100	14.52	0.950	8	32.70	1.64	0.04	115.60	6.77	91.98	23.61	-0.04	-235.60
1.70	.100	14.52	0.950	9	34.40	1.72	0.05	115.64	6.16	98.14	17.50	-0.05	-235.64
3.20	.100	14.52	0.900	10	37.60	2.04	0.11	115.76	5.60	103.74	12.02	-0.11	-235.76
2.90	.100	14.52	0.850	11	40.50	2.48	0.13	115.89	5.09	108.83	7.06	-0.13	-235.89
2.40	.100	14.52	0.800	12	42.90	2.96	0.13	116.02	4.63	113.46	2.56	-0.13	-236.02
1.30	.100	14.52	0.750	13	44.20	3.28	0.08	116.10	4.21	117.66	-1.56	-0.08	-236.10
0.70	.100	14.52	0.700	14	44.90	3.49	0.04	116.14	3.82	121.48	-5.34	-0.04	-236.14
1.40	.100	14.52	0.650	15	46.30	3.98	0.09	116.23	3.48	124.96	-8.73	-0.09	-236.23
2.30	.100	14.52	0.600	16	48.60	4.90	0.17	116.40	3.16	128.12	-11.72	-0.17	-236.40
2.80	.100	14.52	0.550	17	51.40	6.16	0.23	116.63	2.87	130.99	-14.37	-0.23	-236.63
2.80	.100	14.52	0.500	18	54.20	7.56	0.25	116.88	2.61	133.60	-16.73	-0.25	-236.88
3.30	.100	14.52	0.450	19	57.50	9.38	0.33	117.21	2.37	135.98	-18.77	-0.33	-237.21
4.10	.100	14.52	0.400	20	61.60	11.84	0.46	117.67	2.16	138.14	-20.47	-0.46	-237.67
3.90	.100	14.52	0.380	21	65.50	14.25	0.49	118.15	1.96	140.10	-21.95	-0.49	-238.15
4.30	.100	14.52	0.360	22	69.80	17.00	0.59	118.74	1.78	141.88	-23.14	-0.59	-238.74
4.80	.100	14.52	0.340	23	74.60	20.17	0.73	119.48	1.62	143.50	-24.03	-0.73	-239.48
5.40	.100	14.52	0.320	24	80.00	23.84	-27.96	91.51	1.47	144.98	-53.46	-0.91	-240.39
5.40	.100	14.52	0.300	25	85.40	27.62	-85.63	5.88	1.34	146.32	-140.43	-1.01	-241.40
4.90	.100	0.0	0.280	26	90.30	31.15	0.95	6.83	0.0	146.32	-139.49	-1.00	-242.39
4.60	.100	0.0	0.260	27	94.90	34.56	0.92	7.75	0.0	146.32	-138.57	-1.01	-243.40
3.40	.100	0.0	0.240	28	98.30	37.14	0.70	8.45	0.0	146.32	-137.87	-0.79	-244.18
4.40	.100	0.0	0.220	29	102.70	40.57	0.92	9.37	0.0	146.32	-136.95	-1.07	-245.26
4.20	.100	0.0	0.200	30	106.90	43.93	0.90	10.26	0.0	146.32	-136.06	-1.08	-246.34

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY UNIVERSITY OF MICHIGAN VERSION #2 DECEMBER 1978

STONE REVETMENT - 6000 FT STRUCTURE - 25 YEAR BOND
CZL-30 MC ROBERTS (9M18)
NUMBER OF PROPERTIES PROCESSED = 1 TOTAL LENGTH OF SHORELINE = 100.00

DPTH =	335.000	DEPTH OF THE LOT (FEET)
FOUN =	0.0	DISTANCE FROM FOUNDATION TO BLUFF (FEET)
RSET =	140.000	RECCOMENDED SET BACK DISTANCE (FEET)
H =	36.000	HEIGTH OF THE BLUFF (FEET)
TV =	15000.000	LAKESIDE LAND VALUE ($)
SV =	0.0	HOME OR STRUCTURE VALUE ($)
LRES =	3.667	LONG TERM RECESSION RATE (FEET/YEAR)
COST =	6000.000	COST TO MOVE HOME ($)
REST =	20.000	REALTORS ESTIMATE OF BANK (FEET)
HLT1 =	2.500	WEIGHTING FACTOR
T =	30.000	INVESTMENT HORIZON (YEARS)
BANK =	23.750	POINT WHERE MORTGAGE BECOMES UNAVAILABLE
STPB =	36.875	1/2 WAY BETWEEN BANK AND STEPL (FEET)
L =	100.000	FRONT FOOTAGE OF LOT IN (FEET)
HOME =	0.0	DEPTH OF THE HOME (FEET)
FSET =	35.000	SET BACK IN FRONT OF HOME (FEET)
TH =	1.047	ANGLE OF THE BLUFF (RADIANS)
LV =	4500.000	INLAND LAND VALUE ($)
RESR =	1.000	RECESSION RATE MODIFIER
AEST =	10500.000	ASTHETIC VALUE ($)
RI =	0.100	DISCOUNTING RATE
A =	0.500	WEIGHTING FACTOR
HLT2 =	0.500	WEIGHTING FACTOR
PLV =	175.000	DISTANCE FROM ROAD TO SETBACK (FEET)
STPL =	50.000	POINT OF SHARP STRUCTURE VALUE DECLINE
BASE =	20.784	LENGTH OF THE BLUFF BASE (FEET)

INPUT PARAMETERS — OUTPUT PARAMETERS

AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YR##	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	14.52	0.950	0	2.50	0.13	0.0	0.0	14.52	14.52	-14.52	-60.00	-60.00
3.90	.100	14.52	0.950	1	6.40	0.32	0.0	0.0	13.20	27.72	-27.72	0.0	-60.00
5.40	.100	14.52	0.950	2	11.80	0.59	0.0	0.0	12.00	39.72	-39.72	0.0	-60.00
4.80	.100	14.52	0.950	3	16.60	0.83	0.0	0.0	10.91	50.63	-50.63	0.0	-60.00
4.40	.100	14.52	0.950	4	21.00	1.05	28.88	28.88	9.92	60.55	-31.67	-28.88	-88.88
3.90	.100	14.52	0.950	5	24.90	1.25	0.0	28.88	9.02	69.56	-40.69	0.0	-88.88
3.30	.100	14.52	0.950	6	28.20	1.41	0.0	28.88	8.20	77.76	-48.88	0.0	-88.88
2.60	.100	14.52	0.950	7	30.80	1.54	0.0	28.88	7.45	85.21	-56.33	0.0	-88.88
1.90	.100	14.52	0.950	8	32.70	1.64	0.0	28.88	6.77	91.98	-63.11	0.0	-88.88
1.70	.100	14.52	0.950	9	34.40	1.72	0.0	28.88	6.16	98.14	-69.27	0.0	-88.88
3.20	.100	14.52	0.900	10	37.60	2.04	0.0	28.88	5.60	103.74	-74.86	0.0	-88.88
2.90	.100	14.52	0.850	11	40.50	2.48	0.0	28.88	5.09	108.83	-79.95	0.0	-88.88
2.40	.100	14.52	0.800	12	42.90	2.96	0.0	28.88	4.63	113.46	-84.58	0.0	-88.88
1.30	.100	14.52	0.750	13	44.20	3.28	0.0	28.88	4.21	117.66	-88.79	0.0	-88.88
0.70	.100	14.52	0.700	14	44.90	3.49	0.0	28.88	3.82	121.48	-92.61	0.0	-88.88
1.40	.100	14.52	0.650	15	46.30	3.98	0.0	28.88	3.48	124.96	-96.09	0.0	-88.88
2.30	.100	14.52	0.600	16	48.60	4.90	0.0	28.88	3.16	128.12	-99.25	0.0	-88.88
2.80	.100	14.52	0.550	17	51.40	6.16	0.0	28.88	2.87	130.99	-102.12	0.0	-88.88
2.80	.100	14.52	0.500	18	54.20	7.56	0.0	28.88	2.61	133.60	-104.73	0.0	-88.88
3.30	.100	14.52	0.450	19	57.50	9.38	0.0	28.88	2.37	135.98	-107.10	0.0	-88.88
4.10	.100	14.52	0.400	20	61.60	11.84	0.0	28.88	2.16	138.14	-109.26	0.0	-88.88
3.90	.100	14.52	0.380	21	65.50	14.25	0.0	28.88	1.96	140.10	-111.22	0.0	-88.88
4.30	.100	14.52	0.360	22	69.80	17.00	0.0	28.88	1.78	141.88	-113.01	0.0	-88.88
4.80	.100	14.52	0.340	23	74.60	20.17	0.0	28.88	1.62	143.50	-114.63	0.0	-88.88
5.40	.100	14.52	0.320	24	80.00	23.84	-28.88	-0.00	1.47	144.98	-144.98	0.0	-88.88
5.40	.100	14.52	0.300	25	85.40	27.62	0.0	-0.00	1.34	146.32	-146.32	0.0	-88.88
4.90	.100	0.0	0.280	26	90.30	31.15	0.0	-0.00	0.0	146.32	-146.32	0.0	-88.88
4.60	.100	0.0	0.260	27	94.90	34.56	0.0	-0.00	0.0	146.32	-146.32	0.0	-88.88
3.40	.100	0.0	0.240	28	98.30	37.14	0.0	-0.00	0.0	146.32	-146.32	0.0	-88.88
4.40	.100	0.0	0.220	29	102.70	40.57	0.0	-0.00	0.0	146.32	-146.32	0.0	-88.88
4.20	.100	0.0	0.200	30	106.90	43.93	0.0	-0.00	0.0	146.32	-146.32	0.0	-88.88

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY UNIVERSITY OF MICHIGAN VERSION #2 DECEMBER 1978

STONE REVETMENT - ECCO PT STRUCTURE - 25 YEAR BOND
CZL-40 SBSANC (9K19)
NUMBER OF PROPERTIES PROCESSED = 1 TOTAL LENGTH OF SHORELINE = 100.00

DPTH = 392.000 - DEPTH OF THE LOT (FEET)	L = 100.000 - FRONT FOOTAGE OF LOT IN (FEET)		
FOUN = 20.000 - DISTANCE FROM FOUNDATION TO BLUFF (FEET)	HOME = 50.000 - DEPTH OF THE HOME (FEET)		
RSET = 140.000 - RECCOMENDED SET BACK DISTANCE (FEET)	PSET = 35.000 - SET BACK IN FRONT OF HOME (FEET)		
H = 36.000 - HEIGTH OF THE BLUFF (FEET)	TH = 1.047 - ANGLE OF THE BLUFF (RADIANS)		
TV = 15000.000 - LAKESIDE LAND VALUE ($)	LV = 4500.000 - INLAND LAND VALUE ($)		
SV = 32411.000 - HOME OR STRUCTURE VALUE ($)	RESR = 1.000 - RECESSION RATE MODIFIER		
LRES = 3.667 - LONG TERM RECESSION RATE (FEET/YEAR)	AEST = 10500.000 - ASTHETIC VALUE ($)		
COST = 6000.000 - COST TO MOVE HOME ($)	RT = 0.100 - DISCOUNTING RATE		
REST = 20.000 - REALTORS ESTIMATE OF BANK (FEET)	A = 0.500 - WEIGHTING FACTOR		
MLT1 = 2.500 - WEIGHTING FACTOR	MLT2 = 0.500 - WEIGHTING FACTOR		
T = 30.000 - INVESTMENT HORIZON (YEARS)	PLV = 225.000 - DISTANCE FROM ROAD TO SETBACK (FEET)		
BANK = 23.750 - POINT WHERE MORTGAGE BECOMES UNAVAILABLE	STPL = 50.000 - POINT OF SHARP STRUCTURE VALUE DECLINE		
STPB = 35.875 - 1/2 WAY BETWEEN BANK AND STEPL (FEET)	BASE = 20.784 - LENGTH OF THE BLUFF BASE (FEET)		

INPUT PARAMETERS					OUTPUT PARAMETERS									
AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	14.52	0.950	0	2.50	0.13	0.0	0.0	14.52	14.52	-14.52	189.56	189.56
3.90	.100	14.52	0.950	1	6.40	0.32	0.0	0.0	13.20	27.72	-27.72	0.0	189.56
5.40	.100	14.52	0.950	2	11.80	0.59	0.0	0.0	12.00	39.72	-39.72	0.0	189.56
4.80	.100	14.52	0.950	3	16.60	0.83	0.0	0.0	10.91	50.63	-50.63	0.0	189.56
4.40	.100	14.52	0.950	4	21.00	1.05	135.83	135.83	9.92	60.55	75.29	78.08	267.65
3.90	.100	14.52	0.950	5	24.90	1.25	0.0	135.83	9.02	69.56	66.27	0.0	267.65
3.30	.100	14.52	0.950	6	28.20	1.41	0.0	135.83	8.20	77.76	58.07	0.0	267.65
2.60	.100	14.52	0.950	7	30.80	1.54	0.0	135.83	7.45	85.21	50.62	0.0	267.65
1.90	.100	14.52	0.950	8	32.70	1.64	0.0	135.83	6.77	91.98	43.85	0.0	267.65
1.70	.100	14.52	0.950	9	34.40	1.72	0.0	135.83	6.16	98.14	37.69	0.0	267.65
3.20	.100	14.52	0.900	10	37.60	2.04	0.0	135.83	5.60	103.74	32.09	0.0	267.65
2.90	.100	14.52	0.850	11	40.50	2.48	0.0	135.83	5.09	108.83	27.00	0.0	267.65
2.40	.100	14.52	0.800	12	42.90	2.96	0.0	135.83	4.63	113.46	22.38	0.0	267.65
1.30	.100	14.52	0.750	13	44.20	3.28	0.0	135.83	4.21	117.66	18.17	0.0	267.65
0.70	.100	14.52	0.700	14	44.90	3.49	0.0	135.83	3.82	121.48	14.35	0.0	267.65
1.40	.100	14.52	0.650	15	46.30	3.98	0.0	135.83	3.48	124.96	10.87	0.0	267.65
2.30	.100	14.52	0.600	16	48.60	4.90	0.0	135.83	3.16	128.12	7.71	0.0	267.65
2.80	.100	14.52	0.550	17	51.40	6.16	0.0	135.83	2.87	130.99	4.84	0.0	267.65
2.80	.100	14.52	0.500	18	54.20	7.56	0.0	135.83	2.61	133.60	2.23	0.0	267.65
3.30	.100	14.52	0.450	19	57.50	9.38	0.0	135.83	2.37	135.98	-0.15	0.0	267.65
4.10	.100	14.52	0.400	20	61.60	11.84	0.0	135.83	2.16	138.14	-2.31	0.0	267.65
3.90	.100	14.52	0.380	21	65.50	14.25	0.0	135.83	1.96	140.10	-4.27	0.0	267.65
4.30	.100	14.52	0.360	22	69.80	17.00	0.0	135.83	1.78	141.88	-6.05	0.0	267.65
4.80	.100	14.52	0.340	23	74.60	20.17	-106.96	28.87	1.62	143.50	-114.63	0.0	267.65
5.40	.100	14.52	0.320	24	80.00	23.84	-28.88	-0.00	1.47	144.98	-144.98	0.0	267.65
5.40	.100	14.52	0.300	25	85.40	27.62	0.0	-0.00	1.34	146.32	-146.32	0.0	267.65
4.90	.100	0.0	0.280	26	90.30	31.15	0.0	-0.00	0.0	146.32	-146.32	0.0	267.65
4.60	.100	0.0	0.260	27	94.90	34.56	0.0	-0.00	0.0	146.32	-146.32	0.0	267.65
3.40	.100	0.0	0.240	28	98.30	37.14	0.0	-0.00	0.0	146.32	-146.32	0.0	267.65
4.40	.100	0.0	0.220	29	102.70	40.57	0.0	-0.00	0.0	146.32	-146.32	0.0	267.65
4.20	.100	0.0	0.200	30	106.90	43.93	0.0	-0.00	0.0	146.32	-146.32	0.0	267.65

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY   UNIVERSITY OF MICHIGAN   VERSION #2 DECEMBER 1978

STONE REVETMENT - 6000 FT STRUCTURE - 25 YEAR BOND
CZL-50   COLLINS   (9H1)
NUMBER OF PROPERTIES PROCESSED = 1   TOTAL LENGTH OF SHORELINE = 110.00

DPTH =	398.000 - DEPTH OF THE LOT (FEET)		L =	110.000 - FRONT FOOTAGE OF LOT IN (FEET)	
FOUN =	40.000 - DISTANCE FROM FOUNDATION TO BLUFF (FEET)		HOME =	60.000 - DEPTH OF THE HOME (FEET)	
BSET =	140.000 - RECCOMENDED SET BACK DISTANCE (FEET)		FSET =	35.000 - SET BACK IN FRONT OF HOME (FEET)	
H =	36.000 - HEIGTH OF THE BLUFF (FEET)		TH =	1.047 - ANGLE OF THE BLUFF (RADIANS)	
TV =	16500.000 - LAKESIDE LAND VALUE ($)		LV =	4950.000 - INLAND LAND VALUE ($)	
SV =	26360.000 - HOME OR STRUCTURE VALUE ($)		RESR =	1.000 - RECESSION RATE MODIFIER	
LRES =	3.667 - LONG TERM RECESSION RATE (FEET/YEAR)		AEST =	11550.000 - ASTHETIC VALUE ($)	
COST =	6000.000 - COST TO MOVE HOME ($)		RI =	0.100 - DISCOUNTING RATE	
REST =	20.000 - REALTORS ESTIMATE OF BANK (FEET)		A =	0.500 - WEIGHTING FACTOR	
MLT1 =	2.500 - WEIGHTING FACTOR		MLT2 =	0.500 - WEIGHTING FACTOR	
T =	30.000 - INVESTMENT HORIZON (YEARS)		PLV =	235.000 - DISTANCE FROM ROAD TO SETBACK (FEET)	
BANK =	23.750 - POINT WHERE MORTGAGE BECOMES UNAVAILABLE		STPL =	50.000 - POINT OF SHARP STRUCTURE VALUE DECLINE	
STPB =	36.875 - 1/2 WAY BETWEEN BANK AND STEPL (FEET)		BASE =	20.784 - LENGTH OF THE BLUFF BASE (FEET)	

INPUT PARAMETERS   OUTPUT PARAMETERS

AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	14.52	0.950	0	2.50	0.13	0.0	0.0	14.52	14.52	-14.52	24.53	24.53
3.90	.100	14.52	0.950	1	6.40	0.32	26.31	26.31	13.20	27.72	-1.41	26.31	50.84
5.40	.100	14.52	0.950	2	11.80	0.59	43.38	69.69	12.00	39.72	29.97	43.38	94.23
4.80	.100	14.52	0.950	3	16.60	0.83	35.75	105.44	10.91	50.63	54.81	35.75	129.97
4.40	.100	14.52	0.950	4	21.00	1.05	28.88	134.32	9.92	60.55	73.77	-28.88	101.10
3.90	.100	14.52	0.950	5	24.90	1.25	0.0	134.32	9.02	69.56	64.75	0.0	101.10
3.30	.100	14.52	0.950	6	28.20	1.41	0.0	134.32	8.20	77.76	56.56	0.0	101.10
2.60	.100	14.52	0.950	7	30.80	1.54	0.0	134.32	7.45	85.21	49.11	0.0	101.10
1.90	.100	14.52	0.950	8	32.70	1.64	0.0	134.32	6.77	91.98	42.33	0.0	101.10
1.70	.100	14.52	0.950	9	34.40	1.72	0.0	134.32	6.16	98.14	36.17	0.0	101.10
3.20	.100	14.52	0.900	10	37.60	2.04	0.0	134.32	5.60	103.74	30.58	0.0	101.10
2.90	.100	14.52	0.850	11	40.50	2.48	79.08	213.40	5.09	108.83	104.57	79.08	180.18
2.40	.100	14.52	0.800	12	42.90	2.96	0.0	213.40	4.63	113.46	99.94	0.0	180.18
1.30	.100	14.52	0.750	13	44.20	3.28	-1.25	212.15	4.21	117.66	94.49	0.0	180.18
0.70	.100	14.52	0.700	14	44.90	3.49	-1.69	210.46	3.82	121.48	88.98	0.0	180.18
1.40	.100	14.52	0.650	15	46.30	3.98	-3.94	206.53	3.48	124.96	81.57	0.0	180.18
2.30	.100	14.52	0.600	16	48.60	4.90	-7.39	199.14	3.16	128.12	71.01	0.0	180.18
2.80	.100	14.52	0.550	17	51.40	6.16	-10.12	189.01	2.87	130.99	58.02	0.0	180.18
2.80	.100	14.52	0.500	18	54.20	7.56	-11.25	177.77	2.61	133.60	44.16	0.0	180.18
3.30	.100	14.52	0.450	19	57.50	9.38	-14.58	163.18	2.37	135.98	27.21	0.0	180.18
4.10	.100	14.52	0.400	20	61.60	11.84	-19.76	143.42	2.16	138.14	5.28	0.0	180.18
3.90	.100	14.52	0.380	21	65.50	14.25	-19.43	124.00	1.96	140.10	-16.10	0.0	180.18
4.30	.100	14.52	0.360	22	69.80	17.00	-16.04	107.95	1.78	141.88	-33.93	0.0	180.18
4.80	.100	14.52	0.340	23	74.60	20.17	0.0	107.95	1.62	143.50	-35.55	0.0	180.18
5.40	.100	14.52	0.320	24	80.00	23.84	-28.88	79.08	1.47	144.98	-65.90	0.0	180.18
5.40	.100	14.52	0.300	25	85.40	27.62	0.0	79.08	1.34	146.32	-67.24	0.0	180.18
4.90	.100	0.0	0.280	26	90.30	31.15	0.0	79.08	0.0	146.32	-67.24	0.0	180.18
4.60	.100	0.0	0.260	27	94.90	34.56	0.0	79.08	0.0	146.32	-67.24	0.0	180.18
3.40	.100	0.0	0.240	28	98.30	37.14	0.0	79.08	0.0	146.32	-67.24	0.0	180.18
4.40	.100	0.0	0.220	29	102.70	40.57	-79.08	-0.00	0.0	146.32	-146.32	0.0	180.18
4.20	.100	0.0	0.200	30	106.90	43.93	0.0	-0.00	0.0	146.32	-146.32	0.0	180.18

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY UNIVERSITY OF MICHIGAN VERSION #2 DECEMBER 1978

STONE REVETMENT - 6000 FT STRUCTURE - 25 YEAR BOND
CZL-60 PETRIDGE (SM2)
NUMBER OF PROPERTIES PROCESSED = 1 TOTAL LENGTH OF SHORELINE = 750.00

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DPTH =    470.000 - DEPTH OF THE LOT (FEET)                       L    =    750.000 - FRONT FOOTAGE OF LOT IN (FEET)
FOUN =     40.000 - DISTANCE FROM FOUNDATION TO BLUFF (FEET)      HOME =     60.000 - DEPTH OF THE HOME (FEET)
HSET =    140.000 - RECCOMENDED SET BACK DISTANCE (FEET)          FSET =     35.000 - SET BACK IN FRONT OF HOME (FEET)
H    =     35.000 - HEIGTH OF THE BLUFF (FEET)                    TH   =      1.047 - ANGLE OF THE BLUFF (RADIANS)
TV   =100000.000 - LAKESIDE LAND VALUE ($)                        LV   =  30000.000 - INLAND LAND VALUE ($)
SV   =100000.000 - HOME OR STRUCTURE VALUE ($)                    RESR =      1.000 - RECESSION RATE MODIFIER
LRES =      3.667 - LONG TERM RECESSION RATE (FEET/YEAR)          AEST =  70000.000 - ASTHETIC VALUE ($)
COST =   6000.000 - COST TO MOVE HOME ($)                         RI   =      0.100 - DISCOUNTING RATE
REST =     20.000 - REALTORS ESTIMATE OF BANK (FEET)              A    =      0.500 - WEIGHTING FACTOR
MLT1 =      2.500 - WEIGHTING FACTOR                              MLT2 =      0.500 - WEIGHTING FACTOR
T    =     30.000 - INVESTMENT HORIZON (YEARS)                    PLV  =    235.000 - DISTANCE FROM ROAD TO SETBACK (FEET)
BANK =     23.750 - POINT WHERE MORTGAGE BECOMES UNAVAILABLE      STPL =     50.000 - POINT OF SHARP STRUCTURE VALUE DECLINE
STPB =     36.875 - 1/2 WAY BETWEEN BANK AND STEPL (FEET)         BASE =     20.784 - LENGTH OF THE BLUFF BASE (FEET)
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INPUT PARAMETERS					OUTPUT PARAMETERS									
AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	14.52	0.950	0	2.50	0.13	0.0	0.0	14.52	14.52	-14.52	36.00	36.00
3.90	.100	14.52	0.950	1	6.40	0.32	14.64	14.64	13.20	27.72	-13.08	14.64	50.64
5.40	.100	14.52	0.950	2	11.80	0.59	24.14	38.78	12.00	39.72	-0.94	24.14	74.78
4.80	.100	14.52	0.950	3	16.60	0.83	19.89	58.67	10.91	50.63	8.04	19.89	94.67
4.40	.100	14.52	0.950	4	21.00	1.05	25.67	84.33	9.92	60.55	23.79	-25.67	69.00
3.90	.100	14.52	0.950	5	24.90	1.25	0.0	84.33	9.02	69.56	14.77	0.0	69.00
3.30	.100	14.52	0.950	6	28.20	1.41	0.0	84.33	8.20	77.76	6.57	0.0	69.00
2.60	.100	14.52	0.950	7	30.80	1.54	0.0	84.33	7.45	85.21	-0.88	0.0	69.00
1.90	.100	14.52	0.950	8	32.70	1.64	0.0	84.33	6.77	91.98	-7.65	0.0	69.00
1.70	.100	14.52	0.950	9	34.40	1.72	0.0	84.33	6.16	98.14	-13.81	0.0	69.00
3.20	.100	14.52	0.900	10	37.60	2.04	0.0	84.33	5.60	103.74	-19.41	0.0	69.00
2.90	.100	14.52	0.850	11	40.50	2.48	44.00	128.33	5.09	108.83	19.51	44.00	113.00
2.40	.100	14.52	0.800	12	42.90	2.96	0.0	128.33	4.63	113.46	14.88	0.0	113.00
1.30	.100	14.52	0.750	13	44.20	3.28	-0.69	127.64	4.21	117.66	9.98	0.0	113.00
0.70	.100	14.52	0.700	14	44.90	3.49	-0.94	126.70	3.82	121.48	5.22	0.0	113.00
1.40	.100	14.52	0.650	15	46.30	3.98	-2.19	124.51	3.48	124.96	-0.45	0.0	113.00
2.30	.100	14.52	0.600	16	48.60	4.90	-4.11	120.40	3.16	128.12	-7.72	0.0	113.00
2.80	.100	14.52	0.550	17	51.40	6.16	-5.63	114.77	2.87	130.99	-16.23	0.0	113.00
2.80	.100	14.52	0.500	18	54.20	7.56	-6.26	108.51	2.61	133.60	-25.10	0.0	113.00
3.30	.100	14.52	0.450	19	57.50	9.38	-8.11	100.40	2.37	135.98	-35.58	0.0	113.00
4.10	.100	14.52	0.400	20	61.60	11.84	-11.00	89.40	2.16	138.14	-48.74	0.0	113.00
3.90	.100	14.52	0.380	21	65.50	14.25	-10.81	78.59	1.96	140.10	-61.51	0.0	113.00
4.30	.100	14.52	0.360	22	69.80	17.00	-8.93	69.67	1.78	141.88	-72.22	0.0	113.00
4.80	.100	14.52	0.340	23	74.60	20.17	0.0	69.67	1.62	143.50	-73.84	0.0	113.00
5.40	.100	14.52	0.320	24	80.00	23.84	-25.67	44.00	1.47	144.98	-100.98	0.0	113.00
5.40	.100	14.52	0.300	25	85.40	27.62	0.0	44.00	1.34	146.32	-102.32	0.0	113.00
4.90	.100	0.0	0.280	26	90.30	31.15	0.0	44.00	0.0	146.32	-102.32	0.0	113.00
4.60	.100	0.0	0.260	27	94.90	34.56	0.0	44.00	0.0	146.32	-102.32	0.0	113.00
3.40	.100	0.0	0.240	28	98.30	37.14	0.0	44.00	0.0	146.32	-102.32	0.0	113.00
4.40	.100	0.0	0.220	29	102.70	40.57	-44.00	-0.00	0.0	146.32	-146.32	0.0	113.00
4.20	.100	0.0	0.200	30	106.90	43.93	0.0	-0.00	0.0	146.32	-146.32	0.0	113.00

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY UNIVERSITY OF MICHIGAN VERSION #2 DECEMBER 1978

STONE REVETMENT - 6000 FT STRUCTURE - 25 YEAR BOND
CZL-70 TOWNSHIP PARK (16M1)
NUMBER OF PROPERTIES PROCESSED = 1 TOTAL LENGTH OF SHORELINE = 165.00

DPTH =	400.000	- DEPTH OF THE LOT (FEET)	L =	165.000	- FRONT FOOTAGE OF LOT IN (FEET)
FOUN =	0.0	- DISTANCE FROM FOUNDATION TO BLUFF (FEET)	HOME =	0.0	- DEPTH OF THE HOME (FEET)
BSET =	140.000	- RECCOMENDED SET BACK DISTANCE (FEET)	FSET =	35.000	- SET BACK IN FRONT OF HOME (FEET)
H =	38.000	- HEIGTH OF THE BLUFF (FEET)	TH =	0.489	- ANGLE OF THE BLUFF (RADIANS)
TV =	25000.000	- LAKESIDE LAND VALUE ($)	LV =	7500.000	- INLAND LAND VALUE ($)
SV =	0.0	- HOME OR STRUCTURE VALUE ($)	RESR =	1.000	- RECESSION RATE MODIFIER
LRES =	3.667	- LONG TERM RECESSION RATE (FEET/YEAR)	AEST =	17500.000	- ASTHETIC VALUE ($)
COST =	6000.000	- COST TO MOVE HOME ($)	RI =	0.100	- DISCOUNTING RATE
REST =	20.000	- REALTORS ESTIMATE OF BANK (FEET)	A =	0.500	- WEIGHTING FACTOR
MLT1 =	2.500	- WEIGHTING FACTOR	MLT2 =	0.500	- WEIGHTING FACTOR
T =	30.000	- INVESTMENT HORIZON (YEARS)	PLV =	175.000	- DISTANCE FROM ROAD TO SETBACK (FEET)
BANK =	23.750	- POINT WHERE MORTGAGE BECOMES UNAVAILABLE	STPL =	50.000	- POINT OF SHARP STRUCTURE VALUE DECLINE
STPB =	36.875	- 1/2 WAY BETWEEN BANK AND STEPL (FEET)	BASE =	71.466	- LENGTH OF THE BLUFF BASE (FEET)

INPUT PARAMETERS OUTPUT PARAMETERS

AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	14.52	0.950	0	2.50	0.13	0.0	0.0	14.52	14.52	-14.52	-36.36	-36.36
3.90	.100	14.52	0.950	1	6.40	0.32	0.0	0.0	13.20	27.72	-27.72	0.0	-36.36
5.40	.100	14.52	0.950	2	11.80	0.59	0.0	0.0	12.00	39.72	-39.72	0.0	-36.36
4.80	.100	14.52	0.950	3	16.60	0.83	0.0	0.0	10.91	50.63	-50.63	0.0	-36.36
4.40	.100	14.52	0.950	4	21.00	1.05	0.0	0.0	9.92	60.55	-60.55	0.0	-36.36
3.90	.100	14.52	0.950	5	24.90	1.25	0.0	0.0	9.02	69.56	-69.56	0.0	-36.36
3.30	.100	14.52	0.950	6	28.20	1.41	0.0	0.0	8.20	77.76	-77.76	0.0	-36.36
2.60	.100	14.52	0.950	7	30.80	1.54	0.0	0.0	7.45	85.21	-85.21	0.0	-36.36
1.90	.100	14.52	0.950	8	32.70	1.64	0.0	0.0	6.77	91.98	-91.98	0.0	-36.36
1.70	.100	14.52	0.950	9	34.40	1.72	0.0	0.0	6.16	98.14	-98.14	0.0	-36.36
3.20	.100	14.52	0.900	10	37.60	2.04	0.0	0.0	5.60	103.74	-103.74	0.0	-36.36
2.90	.100	14.52	0.850	11	40.50	2.48	0.0	0.0	5.09	108.83	-108.83	0.0	-36.36
2.40	.100	14.52	0.800	12	42.90	2.96	0.0	0.0	4.63	113.46	-113.46	0.0	-36.36
1.30	.100	14.52	0.750	13	44.20	3.28	0.0	0.0	4.21	117.66	-117.66	0.0	-36.36
0.70	.100	14.52	0.700	14	44.90	3.49	0.0	0.0	3.82	121.48	-121.48	0.0	-36.36
1.40	.100	14.52	0.650	15	46.30	3.98	0.0	0.0	3.48	124.96	-124.96	0.0	-36.36
2.30	.100	14.52	0.600	16	48.60	4.90	0.0	0.0	3.16	128.12	-128.12	0.0	-36.36
2.80	.100	14.52	0.550	17	51.40	6.16	0.0	0.0	2.87	130.99	-130.99	0.0	-36.36
2.80	.100	14.52	0.500	18	54.20	7.56	0.0	0.0	2.61	133.60	-133.60	0.0	-36.36
3.30	.100	14.52	0.450	19	57.50	9.38	0.0	0.0	2.37	135.98	-135.98	0.0	-36.36
4.10	.100	14.52	0.400	20	61.60	11.84	0.0	0.0	2.16	138.14	-138.14	0.0	-36.36
3.90	.100	14.52	0.380	21	65.50	14.25	0.0	0.0	1.96	140.10	-140.10	0.0	-36.36
4.30	.100	14.52	0.360	22	69.80	17.00	0.0	0.0	1.78	141.88	-141.88	0.0	-36.36
4.80	.100	14.52	0.340	23	74.60	20.17	29.17	29.17	1.62	143.50	-114.34	-29.17	-65.53
5.40	.100	14.52	0.320	24	80.00	23.84	0.0	29.17	1.47	144.98	-115.81	0.0	-65.53
5.40	.100	14.52	0.300	25	85.40	27.62	0.0	29.17	1.34	146.32	-117.15	0.0	-65.53
4.90	.100	0.0	0.280	26	90.30	31.15	0.0	29.17	0.0	146.32	-117.15	0.0	-65.53
4.60	.100	0.0	0.260	27	94.90	34.56	0.0	29.17	0.0	146.32	-117.15	0.0	-65.53
3.40	.100	0.0	0.240	28	98.30	37.14	0.0	29.17	0.0	146.32	-117.15	0.0	-65.53
4.40	.100	0.0	0.220	29	102.70	40.57	0.0	29.17	0.0	146.32	-117.15	0.0	-65.53
4.20	.100	0.0	0.200	30	106.90	43.93	0.0	29.17	0.0	146.32	-117.15	0.0	-65.53

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY UNIVERSITY OF MICHIGAN VERSION #2 DECEMBER 1978

STONE REVETMENT - 6000 FT STRUCTURE - 25 YEAR BOND
CZL-80.1 SURFSIDE APARTMENTS - NORTH BUILDING (1682)
NUMBER OF PROPERTIES PROCESSED = 1 TOTAL LENGTH OF SHORELINE = 137.00

DPTH =	350.000 - DEPTH OF THE LOT (FEET)	L =	137.000 - FRONT FOOTAGE OF LOT IN (FEET)
FOUN =	45.000 - DISTANCE FROM FOUNDATION TO BLUFF (FEET)	HOME =	90.000 - DEPTH OF THE HOME (FEET)
RSET =	140.000 - RECCOMENDED SET BACK DISTANCE (FEET)	PSET =	35.000 - SET BACK IN FRONT OF HOME (FEET)
H =	42.000 - HEIGTH OF THE BLUFF (FEET)	TH =	0.489 - ANGLE OF THE BLUFF (RADIANS)
TV =	25610.000 - LAKESIDE LAND VALUE ($)	LV =	7683.000 - INLAND LAND VALUE ($)
SV =	475000.000 - HOME OR STRUCTURE VALUE ($)	RESR =	1.000 - RECESSION RATE MODIFIER
LRES =	3.667 - LONG TERM RECESSION RATE (FEET/YEAR)	AEST =	17927.000 - ASTHETIC VALUE ($)
COST =	6000.000 - COST TO MOVE HOME ($)	RT =	0.100 - DISCOUNTING RATE
REST =	20.000 - REALTORS ESTIMATE OF BANK (FEET)	A =	0.500 - WEIGHTING FACTOR
MLT1 =	2.500 - WEIGHTING FACTOR	MLT2 =	0.500 - WEIGHTING FACTOR
T =	30.000 - INVESTMENT HORIZON (YEARS)	PLV =	265.000 - DISTANCE FROM ROAD TO SETBACK (FEET)
BANK =	23.750 - POINT WHERE MORTGAGE BECOMES UNAVAILABLE	STPL =	50.000 - POINT OF SHARP STRUCTURE VALUE DECLINE
STPB =	36.875 - 1/2 WAY BETWEEN BANK AND STEPL (FEET)	BASE =	78.989 - LENGTH OF THE BLUFF BASE (FEET)

INPUT PARAMETERS					OUTPUT PARAMETERS								
AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	14.52	0.950	0	2.50	0.13	0.0	0.0	14.52	14.52	-14.52	1100.36	1100.36
3.90	.100	14.52	0.950	1	6.40	0.32	0.0	0.0	13.20	27.72	-27.72	0.0	1100.36
5.40	.100	14.52	0.950	2	11.80	0.59	427.16	427.16	12.00	39.72	387.44	427.16	1527.53
4.80	.100	14.52	0.950	3	16.60	0.83	557.92	985.08	10.91	50.63	934.45	557.92	2085.44
4.40	.100	14.52	0.950	4	21.00	1.05	511.42	1496.50	9.92	60.55	1435.96	511.42	2596.87
3.90	.100	14.52	0.950	5	24.90	1.25	29.05	1525.55	9.02	69.56	1455.99	29.05	2625.91
3.30	.100	14.52	0.950	6	28.20	1.41	0.0	1525.55	8.20	77.76	1447.79	0.0	2625.91
2.60	.100	14.52	0.950	7	30.80	1.54	0.0	1525.55	7.45	85.21	1440.34	0.0	2625.91
1.90	.100	14.52	0.950	8	32.70	1.64	0.0	1525.55	6.77	91.98	1433.56	0.0	2625.91
1.70	.100	14.52	0.950	9	34.40	1.72	0.0	1525.55	6.16	98.14	1427.41	0.0	2625.91
3.20	.100	14.52	0.900	10	37.60	2.04	0.0	1525.55	5.60	103.74	1421.81	0.0	2625.91
2.90	.100	14.52	0.850	11	40.50	2.48	0.0	1525.55	5.09	108.83	1416.72	0.0	2625.91
2.40	.100	14.52	0.800	12	42.90	2.96	0.0	1525.55	4.63	113.46	1412.09	0.0	2625.91
1.30	.100	14.52	0.750	13	44.20	3.28	0.0	1525.55	4.21	117.66	1407.89	0.0	2625.91
0.70	.100	14.52	0.700	14	44.90	3.49	0.0	1525.55	3.82	121.48	1404.06	0.0	2625.91
1.40	.100	14.52	0.650	15	46.30	3.98	1144.17	2669.71	3.48	124.96	2544.75	1144.17	3770.08
2.30	.100	14.52	0.600	16	48.60	4.90	0.0	2669.71	3.16	128.12	2541.59	0.0	3770.08
2.80	.100	14.52	0.550	17	51.40	6.16	0.0	2669.71	2.87	130.99	2538.72	0.0	3770.08
2.80	.100	14.52	0.500	18	54.20	7.56	0.0	2669.71	2.61	133.60	2536.11	0.0	3770.08
3.30	.100	14.52	0.450	19	57.50	9.38	-145.30	2524.41	2.37	135.98	2388.44	0.0	3770.08
4.10	.100	14.52	0.400	20	61.60	11.84	-285.94	2238.48	2.16	138.14	2100.34	0.0	3770.08
3.90	.100	14.52	0.380	21	65.50	14.25	-281.05	1957.43	1.96	140.10	1817.33	0.0	3770.08
4.30	.100	14.52	0.360	22	69.80	17.00	-319.87	1637.56	1.78	141.88	1495.67	0.0	3770.08
4.80	.100	14.52	0.340	23	74.60	20.17	-368.23	1269.33	1.62	143.50	1125.83	0.0	3770.08
5.40	.100	14.52	0.320	24	80.00	23.84	-89.19	1180.14	1.47	144.98	1035.16	-35.99	3734.09
5.40	.100	14.52	0.300	25	85.40	27.62	107.96	1288.10	1.34	146.32	1141.78	-107.96	3626.14
4.90	.100	0.0	0.280	26	90.30	31.15	0.02	1288.12	0.0	146.32	1141.80	-0.02	3626.11
4.60	.100	0.0	0.260	27	94.90	34.56	0.06	1288.18	0.0	146.32	1141.86	-0.06	3626.05
3.40	.100	0.0	0.240	28	98.30	37.14	0.07	1288.25	0.0	146.32	1141.93	-0.07	3625.98
4.40	.100	0.0	0.220	29	102.70	40.57	0.12	1288.37	0.0	146.32	1142.05	-0.12	3625.86
4.20	.100	0.0	0.200	30	106.90	43.93	0.15	1288.52	0.0	146.32	1142.20	-0.15	3625.72

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY UNIVERSITY OF MICHIGAN VERSION #2 DECEMBER 1978

STONE REVETMENT - 6000 FT STRUCTURE - 25 YEAR BOND
CZL-80.2 SURFSIDE APPARTMENTS - SOUTH BUILDING (16M2)
NUMBER OF PROPERTIES PROCESSED = 1 TOTAL LENGTH OF SHORELINE = 138.00

DPTH =	350.000 - DEPTH OF THE LOT (FEET)		L =	138.000 - FRONT FOOTAGE OF LOT IN (FEET)	
FOUN =	95.000 - DISTANCE FROM FOUNDATION TO BLUFF (FEET)		HOME =	0.0 - DEPTH OF THE HOME (FEET)	
RSET =	140.000 - RECCOMENDED SET BACK DISTANCE (FEET)		FSET =	35.000 - SET BACK IN FRONT OF HOME (FEET)	
H =	42.000 - HEIGTH OF THE BLUFF (FEET)		TH =	0.489 - ANGLE OF THE BLUFF (RADIANS)	
TV =	25610.000 - LAKESIDE LAND VALUE ($)		LV =	7683.000 - INLAND LAND VALUE ($)	
SV =	475030.000 - HOME OR STRUCTURE VALUE ($)		RRSR =	1.000 - RECESSION RATE MODIFIER	
LRES =	3.667 - LONG TERM RECESSION RATE (FEET/YEAR)		AEST =	17927.000 - ASTHETIC VALUE ($)	
COST =	6000.000 - COST TO MOVE HOME ($)		RI =	0.100 - DISCOUNTING RATE	
REST =	23.000 - REALTORS ESTIMATE OF BANK (FEET)		A =	0.500 - WEIGHTING FACTOR	
MLT1 =	2.500 - WEIGHTING FACTOR		MLT2 =	0.500 - WEIGHTING FACTOR	
T =	30.000 - INVESTMENT HORIZON (YEARS)		PLV =	175.000 - DISTANCE FROM ROAD TO SETBACK (FEET)	
BANK =	23.750 - POINT WHERE MORTGAGE BECOMES UNAVAILABLE		STPL =	50.000 - POINT OF SHARP STRUCTURE VALUE DECLINE	
STPU =	36.875 - 1/2 WAY BETWEEN BANK AND STEPL (FEET)		BASE =	78.989 - LENGTH OF THE BLUFF BASE (FEET)	

INPUT PARAMETERS					OUTPUT PARAMETERS								
AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	14.52	0.950	0	2.50	0.13	0.0	0.0	14.52	14.52	-14.52	-43.48	-43.48
3.90	.100	14.52	0.950	1	6.40	0.32	0.0	0.0	13.20	27.72	-27.72	0.0	-43.48
5.40	.100	14.52	0.950	2	11.80	0.59	0.0	0.0	12.00	39.72	-39.72	0.0	-43.48
4.80	.100	14.52	0.950	3	16.60	0.83	0.0	0.0	10.91	50.63	-50.63	0.0	-43.48
4.40	.100	14.52	0.950	4	21.00	1.05	0.0	0.0	9.92	60.55	-60.55	0.0	-43.48
3.90	.100	14.52	0.950	5	24.90	1.25	0.0	0.0	9.02	69.56	-69.56	0.0	-43.48
3.30	.100	14.52	0.950	6	28.20	1.41	0.0	0.0	8.20	77.76	-77.76	0.0	-43.48
2.60	.100	14.52	0.950	7	30.80	1.54	0.0	0.0	7.45	85.21	-85.21	0.0	-43.48
1.90	.100	14.52	0.950	8	32.70	1.64	0.0	0.0	6.77	91.98	-91.98	0.0	-43.48
1.70	.100	14.52	0.950	9	34.40	1.72	0.0	0.0	6.16	98.14	-98.14	0.0	-43.48
3.20	.100	14.52	0.900	10	37.60	2.04	0.0	0.0	5.60	103.74	-103.74	0.0	-43.48
2.90	.100	14.52	0.850	11	40.50	2.48	0.0	0.0	5.09	108.83	-108.83	0.0	-43.48
2.40	.100	14.52	0.800	12	42.90	2.96	0.0	0.0	4.63	113.46	-113.46	0.0	-43.48
1.30	.100	14.52	0.750	13	44.20	3.28	0.0	0.0	4.21	117.66	-117.66	0.0	-43.48
0.70	.100	14.52	0.700	14	44.90	3.49	0.0	0.0	3.82	121.48	-121.48	0.0	-43.48
1.40	.100	14.52	0.650	15	46.30	3.98	1135.87	1135.87	3.48	124.96	1010.91	1135.87	1092.40
2.30	.100	14.52	0.600	16	48.60	4.90	0.0	1135.87	3.16	128.12	1007.75	0.0	1092.40
2.80	.100	14.52	0.550	17	51.40	6.16	0.0	1135.87	2.87	130.99	1004.88	0.0	1092.40
2.80	.100	14.52	0.500	18	54.20	7.56	0.0	1135.87	2.61	133.60	1002.27	0.0	1092.40
3.30	.100	14.52	0.450	19	57.50	9.38	0.0	1135.87	2.37	135.98	999.90	0.0	1092.40
4.10	.100	14.52	0.400	20	61.60	11.84	400.97	1536.85	2.16	138.14	1398.71	400.97	1493.37
3.90	.100	14.52	0.380	21	65.50	14.25	450.02	1986.87	1.96	140.10	1846.77	450.02	1943.40
4.30	.100	14.52	0.360	22	69.80	17.00	496.18	2483.06	1.78	141.88	2341.17	496.18	2439.58
4.80	.100	14.52	0.340	23	74.60	20.17	167.32	2650.38	1.62	143.50	2506.87	167.32	2606.90
5.40	.100	14.52	0.320	24	80.00	23.84	35.72	2686.10	1.47	144.98	2541.12	-35.72	2571.18
5.40	.100	14.52	0.300	25	85.40	27.62	0.0	2686.10	1.34	146.32	2539.78	0.0	2571.18
4.90	.100	0.0	0.280	26	90.30	31.15	0.0	2686.10	0.0	146.32	2539.78	0.0	2571.18
4.60	.100	0.0	0.260	27	94.90	34.56	0.0	2686.10	0.0	146.32	2539.78	0.0	2571.18
3.40	.100	0.0	0.240	28	98.30	37.14	1135.88	3821.98	0.0	146.32	3675.66	1135.88	3707.06
4.40	.100	0.0	0.220	29	102.70	40.57	0.0	3821.98	0.0	146.32	3675.66	0.0	3707.06
4.20	.100	0.0	0.200	30	106.90	43.93	0.0	3821.98	0.0	146.32	3675.66	0.0	3707.06

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY UNIVERSITY OF MICHIGAN VERSION #2 DECEMBER 1978

STONE REVETMENT - 6000 FT STRUCTURE - 25 YEAR BOND
CZL-90 ATWELL (16M3.2)
NUMBER OF PROPERTIES PROCESSED = 1 TOTAL LENGTH OF SHORELINE = 50.00

DPTH = 1267.000 - DEPTH OF THE LOT (FEET)
FOUN = 900.000 - DISTANCE FROM FOUNDATION TO BLUFF (FEET)
RSET = 140.000 - RECOMMENDED SET BACK DISTANCE (FEET)
H = 42.000 - HEIGTH OF THE BLUFF (FEET)
TV = 7500.000 - LAKESIDE LAND VALUE ($)
SV = 60030.000 - HOME OR STRUCTURE VALUE ($)
LRES = 3.667 - LONG TERM RECESSION RATE (FEET/YEAR)
COST = 6000.000 - COST TO MOVE HOME ($)
BEST = 20.000 - REALTORS ESTIMATE OF BANK (FEET)
MLT1 = 2.500 - WEIGHTING FACTOR
T = 30.000 - INVESTMENT HORIZON (YEARS)
BANK = 23.750 - POINT WHERE MORTGAGE BECOMES UNAVAILABLE
STPB = 36.875 - 1/2 WAY BETWEEN BANK AND STEPL (FEET)

L = 50.000 - FRONT FOOTAGE OF LOT IN (FEET)
HOME = 40.000 - DEPTH OF THE HOME (FEET)
PSET = 35.000 - SET BACK IN FRONT OF HOME (FEET)
TH = 0.489 - ANGLE OF THE BLUFF (RADIANS)
LV = 2250.000 - INLAND LAND VALUE ($)
RESR = 1.000 - RECESSION RATE MODIFIER
AEST = 5250.000 - ASTHETIC VALUE ($)
RI = 0.100 - DISCOUNTING RATE
A = 0.500 - WEIGHTING FACTOR
MLT2 = 0.500 - WEIGHTING FACTOR
PLV = 215.000 - DISTANCE FROM ROAD TO SETBACK (FEET)
STPL = 50.000 - POINT OF SHARP STRUCTURE VALUE DECLINE
BASE = 78.989 - LENGTH OF THE BLUFF BASE (FEET)

INPUT PARAMETERS							OUTPUT PARAMETERS						
AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	14.52	0.950	0	2.50	0.13	0.0	0.0	14.52	14.52	-14.52	-120.00	-120.00
3.90	.100	14.52	0.950	1	6.40	0.32	0.0	0.0	13.20	27.72	-27.72	0.0	-120.00
5.40	.100	14.52	0.950	2	11.80	0.59	0.0	0.0	12.00	39.72	-39.72	0.0	-120.00
4.80	.100	14.52	0.950	3	16.60	0.83	0.0	0.0	10.91	50.63	-50.63	0.0	-120.00
4.40	.100	14.52	0.950	4	21.00	1.05	0.0	0.0	9.92	60.55	-60.55	0.0	-120.00
3.90	.100	14.52	0.950	5	24.90	1.25	0.0	0.0	9.02	69.56	-69.56	0.0	-120.00
3.30	.100	14.52	0.950	6	28.20	1.41	0.0	0.0	8.20	77.76	-77.76	0.0	-120.00
2.60	.100	14.52	0.950	7	30.80	1.54	0.0	0.0	7.45	85.21	-85.21	0.0	-120.00
1.90	.100	14.52	0.950	8	32.70	1.64	0.0	0.0	6.77	91.98	-91.98	0.0	-120.00
1.70	.100	14.52	0.950	9	34.40	1.72	0.0	0.0	6.16	98.14	-98.14	0.0	-120.00
3.20	.100	14.52	0.900	10	37.60	2.04	0.0	0.0	5.60	103.74	-103.74	0.0	-120.00
2.90	.100	14.52	0.850	11	40.50	2.48	0.0	0.0	5.09	108.83	-108.83	0.0	-120.00
2.40	.100	14.52	0.800	12	42.90	2.96	0.0	0.0	4.63	113.46	-113.46	0.0	-120.00
1.30	.100	14.52	0.750	13	44.20	3.28	0.0	0.0	4.21	117.66	-117.66	0.0	-120.00
0.70	.100	14.52	0.700	14	44.90	3.49	0.0	0.0	3.82	121.48	-121.48	0.0	-120.00
1.40	.100	14.52	0.650	15	46.30	3.98	0.0	0.0	3.48	124.96	-124.96	0.0	-120.00
2.30	.100	14.52	0.600	16	48.60	4.90	0.0	0.0	3.16	128.12	-128.12	0.0	-120.00
2.80	.100	14.52	0.550	17	51.40	6.16	0.0	0.0	2.87	130.99	-130.99	0.0	-120.00
2.80	.100	14.52	0.500	18	54.20	7.56	0.0	0.0	2.61	133.60	-133.60	0.0	-120.00
3.30	.100	14.52	0.450	19	57.50	9.38	0.0	0.0	2.37	135.98	-135.98	0.0	-120.00
4.10	.100	14.52	0.400	20	61.60	11.84	0.0	0.0	2.16	138.14	-138.14	0.0	-120.00
3.90	.100	14.52	0.380	21	65.50	14.25	0.0	0.0	1.96	140.10	-140.10	0.0	-120.00
4.30	.100	14.52	0.360	22	69.80	17.00	0.0	0.0	1.78	141.88	-141.88	0.0	-120.00
4.80	.100	14.52	0.340	23	74.60	20.17	0.0	0.0	1.62	143.50	-143.50	0.0	-120.00
5.40	.100	14.52	0.320	24	80.00	23.84	28.88	28.88	1.47	144.98	-116.10	-28.88	-148.88
5.40	.100	14.52	0.300	25	85.40	27.62	0.0	28.88	1.34	146.32	-117.44	0.0	-148.88
4.90	.100	0.0	0.280	26	90.30	31.15	0.0	28.88	0.0	146.32	-117.44	0.0	-148.88
4.60	.100	0.0	0.260	27	94.90	34.56	0.0	28.88	0.0	146.32	-117.44	0.0	-148.88
3.40	.100	0.0	0.240	28	98.30	37.14	0.0	28.88	0.0	146.32	-117.44	0.0	-148.88
4.40	.100	0.0	0.220	29	102.70	40.57	0.0	28.88	0.0	146.32	-117.44	0.0	-148.88
4.20	.100	0.0	0.200	30	106.90	43.93	0.0	28.88	0.0	146.32	-117.44	0.0	-148.88

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY UNIVERSITY OF MICHIGAN VERSION #2 DECEMBER 1978

STONE REVETMENT - ECCO P1 STRUCTURE - 25 YEAR BOND
CZL-100 DELMASIAFI (16M3.3)
NUMBER OF PROPERTIES PROCESSED = 1 TOTAL LENGTH OF SHORELINE = 70.00

DPTH =	1305.000	- DEPTH OF THE LOT (FEET)	L =	70.000	- FRONT FOOTAGE OF LOT IN (FEET)
FOUN =	0.0	- DISTANCE FROM FOUNDATION TO BLUFF (FEET)	HOME =	0.0	- DEPTH OF THE HOME (FEET)
RSET =	140.000	- RECCOMENDED SET BACK DISTANCE (FEET)	FSET =	35.000	- SET BACK IN FRONT OF HOME (FEET)
H =	42.000	- HEIGTH OF THE BLUFF (FEET)	TH =	0.489	- ANGLE OF THE BLUFF (RADIANS)
TV =	10500.000	- LAKESIDE LAND VALUE ($)	LV =	3150.000	- INLAND LAND VALUE ($)
SV =	0.0	- HOME OR STRUCTURE VALUE ($)	RESR =	1.000	- RECESSION RATE MODIFIER
LRES =	3.667	- LONG TERM RECESSION RATE (FEET/YEAR)	AEST =	7350.000	- ASTHETIC VALUE ($)
COST =	6000.000	- COST TO MOVE HOME ($)	BI =	0.100	- DISCCUNTING RATE
REST =	20.000	- REALTORS ESTIMATE OF BANK (FEET)	A =	0.500	- WEIGHTING FACTOR
MLT1 =	2.500	- WEIGHTING FACTOR	MLT2 =	0.500	- WEIGHTING FACTOR
T =	30.000	- INVESTMENT HORIZON (YEARS)	PLV =	175.000	- DISTANCE FROM ROAD TO SETBACK (FEET)
BANK =	23.750	- POINT WHERE MORTGAGE BECOMES UNAVAILABLE	STPL =	50.000	- POINT OF SHARP STRUCTURE VALUE DECLINE
STPB =	35.875	- 1/2 WAY BETWEEN BANK AND STEPL (FEET)	BASE =	78.989	- LENGTH OF THE BLUFF BASE (FEET)

INPUT PARAMETERS					OUTPUT PARAMETERS								
AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	14.52	0.950	0	2.50	0.13	0.0	0.0	14.52	14.52	-14.52	-85.71	-85.71
3.90	.100	14.52	0.950	1	6.40	0.32	0.0	0.0	13.20	27.72	-27.72	0.0	-85.71
5.40	.100	14.52	0.950	2	11.80	0.59	0.0	0.0	12.00	39.72	-39.72	0.0	-85.71
4.80	.100	14.52	0.950	3	16.60	0.83	0.0	0.0	10.91	50.63	-50.63	0.0	-85.71
4.40	.100	14.52	0.950	4	21.00	1.05	0.0	0.0	9.92	60.55	-60.55	0.0	-85.71
3.90	.100	14.52	0.950	5	24.90	1.25	0.0	0.0	9.02	69.56	-69.56	0.0	-85.71
3.30	.100	14.52	0.950	6	28.20	1.41	0.0	0.0	8.20	77.76	-77.76	0.0	-85.71
2.60	.100	14.52	0.950	7	30.80	1.54	0.0	0.0	7.45	85.21	-85.21	0.0	-85.71
1.90	.100	14.52	0.950	8	32.70	1.64	0.0	0.0	6.77	91.98	-91.98	0.0	-85.71
1.70	.100	14.52	0.950	9	34.40	1.72	0.0	0.0	6.16	98.14	-98.14	0.0	-85.71
3.20	.100	14.52	0.900	10	37.60	2.04	0.0	0.0	5.60	103.74	-103.74	0.0	-85.71
2.90	.100	14.52	0.850	11	40.50	2.48	0.0	0.0	5.09	108.83	-108.83	0.0	-85.71
2.40	.100	14.52	0.800	12	42.90	2.96	0.0	0.0	4.63	113.46	-113.46	0.0	-85.71
1.30	.100	14.52	0.750	13	44.20	3.28	0.0	0.0	4.21	117.66	-117.66	0.0	-85.71
0.70	.100	14.52	0.700	14	44.90	3.49	0.0	0.0	3.82	121.48	-121.48	0.0	-85.71
1.40	.100	14.52	0.650	15	46.30	3.98	0.0	0.0	3.48	124.96	-124.96	0.0	-85.71
2.30	.100	14.52	0.600	16	48.60	4.90	0.0	0.0	3.16	128.12	-128.12	0.0	-85.71
2.80	.100	14.52	0.550	17	51.40	6.16	0.0	0.0	2.87	130.99	-130.99	0.0	-85.71
2.80	.100	14.52	0.500	18	54.20	7.56	0.0	0.0	2.61	133.60	-133.60	0.0	-85.71
3.30	.100	14.52	0.450	19	57.50	9.38	0.0	0.0	2.37	135.98	-135.98	0.0	-85.71
4.10	.100	14.52	0.400	20	61.60	11.84	0.0	0.0	2.16	138.14	-138.14	0.0	-85.71
3.90	.100	14.52	0.380	21	65.50	14.25	0.0	0.0	1.96	140.10	-140.10	0.0	-85.71
4.30	.100	14.52	0.360	22	69.80	17.00	0.0	0.0	1.78	141.88	-141.88	0.0	-85.71
4.80	.100	14.52	0.340	23	74.60	20.17	0.0	0.0	1.62	143.50	-143.50	0.0	-85.71
5.40	.100	14.52	0.320	24	80.00	23.84	28.88	28.88	1.47	144.98	-116.10	-28.88	-114.59
5.40	.100	14.52	0.300	25	85.40	27.62	0.0	28.88	1.34	146.32	-117.44	0.0	-114.59
4.90	.100	0.0	0.280	26	90.30	31.15	0.0	28.88	0.0	146.32	-117.44	0.0	-114.59
4.60	.100	0.0	0.260	27	94.90	34.56	0.0	28.88	0.0	146.32	-117.44	0.0	-114.59
3.40	.100	0.0	0.240	28	98.30	37.14	0.0	28.88	0.0	146.32	-117.44	0.0	-114.59
4.40	.100	0.0	0.220	29	102.70	40.57	0.0	28.88	0.0	146.32	-117.44	0.0	-114.59
4.20	.100	0.0	0.200	30	106.90	43.93	0.0	28.88	0.0	146.32	-117.44	0.0	-114.59

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY UNIVERSITY OF MICHIGAN VERSION #2 DECEMBER 1978

STONE REVETMENT - 6000 FT STRUCTURE - 25 YEAR BOND
CZL-101 DELMARIANI (16M4)
NUMBER OF PROPERTIES PROCESSED = 1 TOTAL LENGTH OF SHORELINE = 165.00

DPTH = 1200.000	DEPTH OF THE LOT (FEET)	L = 165.000	FRONT FOOTAGE OF LOT IN (FEET)
FOUN = 900.000	DISTANCE FROM FOUNDATION TO BLUFF (FEET)	HOME = 50.000	DEPTH OF THE HOME (FEET)
RSET = 140.000	RECCOMENDED SET BACK DISTANCE (FEET)	PSET = 35.000	SET BACK IN FRONT OF HOME (FEET)
H = 42.000	HEIGTH OF THE BLUFF (FEET)	TH = 0.489	ANGLE OF THE BLUFF (RADIANS)
TV = 24750.000	LAKESIDE LAND VALUE ($)	LV = 7425.000	INLAND LAND VALUE ($)
SV = 65000.000	HOME OR STRUCTURE VALUE ($)	RESR = 1.000	RECESSION RATE MODIFIER
LRES = 3.667	LONG TERM RECESSION RATE (FEET/YEAR)	AEST = 17325.000	ASTHETIC VALUE ($)
COST = 6000.000	COST TO MOVE HOME ($)	RI = 0.100	DISCOUNTING RATE
REST = 20.000	REALTORS ESTIMATE OF BANK (FEET)	A = 0.500	WEIGHTING FACTOR
MLT1 = 2.500	WEIGHTING FACTOR	MLT2 = 0.500	WEIGHTING FACTOR
T = 30.000	INVESTMENT HORIZON (YEARS)	PLV = 225.000	DISTANCE FROM ROAD TO SETBACK (FEET)
BANK = 23.750	POINT WHERE MORTGAGE BECOMES UNAVAILABLE	STPL = 50.000	POINT OF SHARP STRUCTURE VALUE DECLINE
STPB = 36.875	1/2 WAY BETWEEN BANK AND STEPL (FEET)	BASE = 78.989	LENGTH OF THE BLUFF BASE (FEET)

INPUT PARAMETERS / OUTPUT PARAMETERS

AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	14.52	0.950	0	2.50	0.13	0.0	0.0	14.52	14.52	-14.52	-36.36	-36.36
3.90	.100	14.52	0.950	1	6.40	0.32	0.0	0.0	13.20	27.72	-27.72	0.0	-36.36
5.40	.100	14.52	0.950	2	11.80	0.59	0.0	0.0	12.00	39.72	-39.72	0.0	-36.36
4.80	.100	14.52	0.950	3	16.60	0.83	0.0	0.0	10.91	50.63	-50.63	0.0	-36.36
4.40	.100	14.52	0.950	4	21.00	1.05	0.0	0.0	9.92	60.55	-60.55	0.0	-36.36
3.90	.100	14.52	0.950	5	24.90	1.25	0.0	0.0	9.02	69.56	-69.56	0.0	-36.36
3.30	.100	14.52	0.950	6	28.20	1.41	0.0	0.0	8.20	77.76	-77.76	0.0	-36.36
2.60	.100	14.52	0.950	7	30.80	1.54	0.0	0.0	7.45	85.21	-85.21	0.0	-36.36
1.90	.100	14.52	0.950	8	32.70	1.64	0.0	0.0	6.77	91.98	-91.98	0.0	-36.36
1.70	.100	14.52	0.950	9	34.40	1.72	0.0	0.0	6.16	98.14	-98.14	0.0	-36.36
3.20	.100	14.52	0.900	10	37.60	2.04	0.0	0.0	5.60	103.74	-103.74	0.0	-36.36
2.90	.100	14.52	0.850	11	40.50	2.48	0.0	0.0	5.09	108.83	-108.83	0.0	-36.36
2.40	.100	14.52	0.800	12	42.90	2.96	0.0	0.0	4.63	113.46	-113.46	0.0	-36.36
1.30	.100	14.52	0.750	13	44.20	3.28	0.0	0.0	4.21	117.66	-117.66	0.0	-36.36
0.70	.100	14.52	0.700	14	44.90	3.49	0.0	0.0	3.82	121.48	-121.48	0.0	-36.36
1.40	.100	14.52	0.650	15	46.30	3.98	0.0	0.0	3.48	124.96	-124.96	0.0	-36.36
2.30	.100	14.52	0.600	16	48.60	4.90	0.0	0.0	3.16	128.12	-128.12	0.0	-36.36
2.80	.100	14.52	0.550	17	51.40	6.16	0.0	0.0	2.87	130.99	-130.99	0.0	-36.36
2.80	.100	14.52	0.500	18	54.20	7.56	0.0	0.0	2.61	133.60	-133.60	0.0	-36.36
3.30	.100	14.52	0.450	19	57.50	9.38	0.0	0.0	2.37	135.98	-135.98	0.0	-36.36
4.10	.100	14.52	0.400	20	61.60	11.84	0.0	0.0	2.16	138.14	-138.14	0.0	-36.36
3.90	.100	14.52	0.380	21	65.50	14.25	0.0	0.0	1.96	140.10	-140.10	0.0	-36.36
4.30	.100	14.52	0.360	22	69.80	17.00	0.0	0.0	1.78	141.88	-141.88	0.0	-36.36
4.80	.100	14.52	0.340	23	74.60	20.17	0.0	0.0	1.62	143.50	-143.50	0.0	-36.36
5.40	.100	14.52	0.320	24	80.00	23.84	28.88	28.88	1.47	144.98	-116.10	-28.88	-65.24
5.40	.100	14.52	0.300	25	85.40	27.62	0.0	28.88	1.34	146.32	-117.44	0.0	-65.24
4.90	.100	0.0	0.280	26	90.30	31.15	0.0	28.88	0.0	146.32	-117.44	0.0	-65.24
4.60	.100	0.0	0.260	27	94.90	34.56	0.0	28.88	0.0	146.32	-117.44	0.0	-65.24
3.40	.100	0.0	0.240	28	98.30	37.14	0.0	28.88	0.0	146.32	-117.44	0.0	-65.24
4.40	.100	0.0	0.220	29	102.70	40.57	0.0	28.88	0.0	146.32	-117.44	0.0	-65.24
4.20	.100	0.0	0.200	30	106.90	43.93	0.0	28.88	0.0	146.32	-117.44	0.0	-65.24

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY UNIVERSITY OF MICHIGAN VERSION #2 DECEMBER 1978

STONE REVETMENT - ECCO FT STRUCTURE - 25 YEAR BOND
CZL-110 PHELPS (16M5.5)
NUMBER OF PROPERTIES PROCESSED = 1 TOTAL LENGTH OF SHORELINE = 125.00

DPTH = 730.000 - DEPTH OF THE LOT (FEET)		L = 125.000 - FRONT FOOTAGE OF LOT IN (FEET)	
FOUN = 600.000 - DISTANCE FROM FOUNDATION TO BLUFF (FEET)		HOME = 40.000 - DEPTH OF THE HOME (FEET)	
RSET = 140.000 - RECCOMENDED SET BACK DISTANCE (FEET)		PSET = 35.000 - SET BACK IN FRONT OF HOME (FEET)	
H = 42.000 - HEIGTH OF THE BLUFF (FEET)		TH = 0.489 - ANGLE OF THE BLUFF (RADIANS)	
TV = 18750.000 - LAKESIDE LAND VALUE ($)		LV = 5625.000 - INLAND LAND VALUE ($)	
SV = 63750.000 - HOME OR STRUCTURE VALUE ($)		RESR = 1.000 - RECESSION RATE MODIFIER	
LRES = 3.667 - LONG TERM RECESSION RATE (FEET/YEAR)		AEST = 13125.000 - ASTHETIC VALUE ($)	
COST = 6000.000 - COST TO MOVE HOME ($)		RI = 0.100 - DISCOUNTING RATE	
REST = 20.000 - REALTORS ESTIMATE OF FARK (FEET)		A = 0.500 - WEIGHTING FACTOR	
MLT1 = 2.500 - WEIGHTING FACTOR		MLT2 = 0.500 - WEIGHTING FACTOR	
T = 30.000 - INVESTMENT HORIZON (YEARS)		PLV = 215.000 - DISTANCE FROM ROAD TO SETBACK (FEET)	
BANK = 23.750 - POINT WHERE MORTGAGE BECOMES UNAVAILABLE		STPL = 50.000 - POINT OF SHARP STRUCTURE VALUE DECLINE	
STPB = 36.875 - 1/2 WAY BETWEEN BANK AND STEPL (FEET)		BASE = 79.989 - LENGTH OF THE BLUFF BASE (FEET)	

INPUT PARAMETERS | OUTPUT PARAMETERS

AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	14.52	0.950	0	2.50	0.13	0.0	0.0	14.52	14.52	-14.52	-48.00	-48.00
3.90	.100	14.52	0.950	1	6.40	0.32	0.0	0.0	13.20	27.72	-27.72	0.0	-48.00
5.40	.100	14.52	0.950	2	11.80	0.59	0.0	0.0	12.00	39.72	-39.72	0.0	-48.00
4.80	.100	14.52	0.950	3	16.60	0.83	0.0	0.0	10.91	50.63	-50.63	0.0	-48.00
4.40	.100	14.52	0.950	4	21.00	1.05	0.0	0.0	9.92	60.55	-60.55	0.0	-48.00
3.90	.100	14.52	0.950	5	24.90	1.25	0.0	0.0	9.02	69.56	-69.56	0.0	-48.00
3.30	.100	14.52	0.950	6	28.20	1.41	0.0	0.0	8.20	77.76	-77.76	0.0	-48.00
2.60	.100	14.52	0.950	7	30.80	1.54	0.0	0.0	7.45	85.21	-85.21	0.0	-48.00
1.90	.100	14.52	0.950	8	32.70	1.64	0.0	0.0	6.77	91.98	-91.98	0.0	-48.00
1.70	.100	14.52	0.950	9	34.40	1.72	0.0	0.0	6.16	98.14	-98.14	0.0	-48.00
3.20	.100	14.52	0.900	10	37.60	2.04	0.0	0.0	5.60	103.74	-103.74	0.0	-48.00
2.90	.100	14.52	0.850	11	40.50	2.48	0.0	0.0	5.09	108.83	-108.83	0.0	-48.00
2.40	.100	14.52	0.800	12	42.90	2.96	0.0	0.0	4.63	113.46	-113.46	0.0	-48.00
1.30	.100	14.52	0.750	13	44.20	3.28	0.0	0.0	4.21	117.66	-117.66	0.0	-48.00
0.70	.100	14.52	0.700	14	44.90	3.49	0.0	0.0	3.82	121.48	-121.48	0.0	-48.00
1.40	.100	14.52	0.650	15	46.30	3.98	0.0	0.0	3.48	124.96	-124.96	0.0	-48.00
2.30	.100	14.52	0.600	16	48.60	4.90	0.0	0.0	3.16	128.12	-128.12	0.0	-48.00
2.80	.100	14.52	0.550	17	51.40	6.16	0.0	0.0	2.87	130.99	-130.99	0.0	-48.00
2.80	.100	14.52	0.500	18	54.20	7.56	0.0	0.0	2.61	133.60	-133.60	0.0	-48.00
3.30	.100	14.52	0.450	19	57.50	9.38	0.0	0.0	2.37	135.98	-135.98	0.0	-48.00
4.10	.100	14.52	0.400	20	61.60	11.84	0.0	0.0	2.16	138.14	-138.14	0.0	-48.00
3.90	.100	14.52	0.380	21	65.50	14.25	0.0	0.0	1.96	140.10	-140.10	0.0	-48.00
4.30	.100	14.52	0.360	22	69.80	17.00	0.0	0.0	1.78	141.88	-141.88	0.0	-48.00
4.80	.100	14.52	0.340	23	74.60	20.17	0.0	0.0	1.62	143.50	-143.50	0.0	-48.00
5.40	.100	14.52	0.320	24	80.00	23.84	28.88	28.88	1.47	144.98	-116.10	-28.88	-76.88
5.40	.100	14.52	0.300	25	85.40	27.62	0.0	28.88	1.34	146.32	-117.44	0.0	-76.88
4.90	.100	0.0	0.280	26	90.30	31.15	0.0	28.88	0.0	146.32	-117.44	0.0	-76.88
4.60	.100	0.0	0.260	27	94.90	34.56	0.0	28.88	0.0	146.32	-117.44	0.0	-76.88
3.40	.100	0.0	0.240	28	98.30	37.14	0.0	28.88	0.0	146.32	-117.44	0.0	-76.88
4.40	.100	0.0	0.220	29	102.70	40.57	0.0	28.88	0.0	146.32	-117.44	0.0	-76.88
4.20	.100	0.0	0.200	30	106.90	43.93	0.0	28.88	0.0	146.32	-117.44	0.0	-76.88

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY UNIVERSITY OF MICHIGAN VERSION #2 DECEMBER 1978

STONE REVETMENT - 6000 FT STRUCTURE - 25 YEAR BOND
CZL-120 SEPE (1EM6.3)
NUMBER OF PROPERTIES PROCESSED = 1 TOTAL LENGTH OF SHORELINE = 143.00

DPTH =	1353.000	- DEPTH OF THE LOT (FEET)	L =	143.000	- FRONT FOOTAGE OF LOT IN (FEET)
FOUN =	900.000	- DISTANCE FROM FOUNDATION TO BLUFF (FEET)	HOME =	40.000	- DEPTH OF THE HOME (FEET)
RSET =	140.000	- RECCOMENDED SET BACK DISTANCE (FEET)	FSET =	35.000	- SET BACK IN FRONT OF HOME (FEET)
H =	42.000	- HEIGTH OF THE BLUFF (FEET)	TH =	0.489	- ANGLE OF THE BLUFF (RADIANS)
TV =	30000.000	- LAKESIDE LAND VALUE ($)	LV =	3000.000	- INLAND LAND VALUE ($)
SV =	50000.000	- HOME OR STRUCTURE VALUE ($)	RESR =	1.000	- RECESSION RATE MODIFIER
LRES =	3.667	- LONG TERM RECESSION RATE (FEET/YEAR)	AEST =	27000.000	- ASTHETIC VALUE ($)
COST =	6000.000	- COST TO MOVE HOME ($)	RI =	0.100	- DISCOUNTING RATE
REST =	20.000	- REALTORS ESTIMATE OF BANK (FEET)	A =	0.500	- WEIGHTING FACTOR
MLT1 =	2.500	- WEIGHTING FACTOR	MLT2 =	0.500	- WEIGHTING FACTOR
T =	30.000	- INVESTMENT HORIZON (YEARS)	PLV =	215.000	- DISTANCE FROM ROAD TO SETBACK (FEET)
BANK =	23.750	- POINT WHERE MORTGAGE BECOMES UNAVAILABLE	STPL =	50.000	- POINT OF SHARP STRUCTURE VALUE DECLINE
STPB =	36.875	- 1/2 WAY BETWEEN BANK AND STEPL (FEET)	BASE =	78.989	- LENGTH OF THE BLUFF BASE (FEET)

INPUT PARAMETERS					OUTPUT PARAMETERS								
AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	14.52	0.950	0	2.50	0.13	0.0	0.0	14.52	14.52	-14.52	-41.96	-41.96
3.90	.100	14.52	0.950	1	6.40	0.32	0.0	0.0	13.20	27.72	-27.72	0.0	-41.96
5.40	.100	14.52	0.950	2	11.80	0.59	0.0	0.0	12.00	39.72	-39.72	0.0	-41.96
4.80	.100	14.52	0.950	3	16.60	0.83	0.0	0.0	10.91	50.63	-50.63	0.0	-41.96
4.40	.100	14.52	0.950	4	21.00	1.05	0.0	0.0	9.92	60.55	-60.55	0.0	-41.96
3.90	.100	14.52	0.950	5	24.90	1.25	0.0	0.0	9.02	69.56	-69.56	0.0	-41.96
3.30	.100	14.52	0.950	6	28.20	1.41	0.0	0.0	8.20	77.76	-77.76	0.0	-41.96
2.60	.100	14.52	0.950	7	30.80	1.54	0.0	0.0	7.45	85.21	-85.21	0.0	-41.96
1.90	.100	14.52	0.950	8	32.70	1.64	0.0	0.0	6.77	91.98	-91.98	0.0	-41.96
1.70	.100	14.52	0.950	9	34.40	1.72	0.0	0.0	6.16	98.14	-98.14	0.0	-41.96
3.20	.100	14.52	0.900	10	37.60	2.04	0.0	0.0	5.60	103.74	-103.74	0.0	-41.96
2.90	.100	14.52	0.850	11	40.50	2.48	0.0	0.0	5.09	108.83	-108.83	0.0	-41.96
2.40	.100	14.52	0.800	12	42.90	2.96	0.0	0.0	4.63	113.46	-113.46	0.0	-41.96
1.30	.100	14.52	0.750	13	44.20	3.28	0.0	0.0	4.21	117.66	-117.66	0.0	-41.96
0.70	.100	14.52	0.700	14	44.90	3.49	0.0	0.0	3.82	121.48	-121.48	0.0	-41.96
1.40	.100	14.52	0.650	15	46.30	3.98	0.0	0.0	3.48	124.96	-124.96	0.0	-41.96
2.30	.100	14.52	0.600	16	48.60	4.90	0.0	0.0	3.16	128.12	-128.12	0.0	-41.96
2.80	.100	14.52	0.550	17	51.40	6.16	0.0	0.0	2.87	130.99	-130.99	0.0	-41.96
2.80	.100	14.52	0.500	18	54.20	7.56	0.0	0.0	2.61	133.60	-133.60	0.0	-41.96
3.30	.100	14.52	0.450	19	57.50	9.38	0.0	0.0	2.37	135.98	-135.98	0.0	-41.96
4.10	.100	14.52	0.400	20	61.60	11.84	0.0	0.0	2.16	138.14	-138.14	0.0	-41.96
3.90	.100	14.52	0.380	21	65.50	14.25	0.0	0.0	1.96	140.10	-140.10	0.0	-41.96
4.30	.100	14.52	0.360	22	69.80	17.00	0.0	0.0	1.78	141.88	-141.88	0.0	-41.96
4.80	.100	14.52	0.340	23	74.60	20.17	0.0	0.0	1.62	143.50	-143.50	0.0	-41.96
5.40	.100	14.52	0.320	24	80.00	23.84	51.92	51.92	1.47	144.98	-93.06	-51.92	-93.88
5.40	.100	14.52	0.300	25	85.40	27.62	0.0	51.92	1.34	146.32	-94.40	0.0	-93.88
4.90	.100	0.0	0.280	26	90.30	31.15	0.0	51.92	0.0	146.32	-94.40	0.0	-93.88
4.60	.100	0.0	0.260	27	94.90	34.56	0.0	51.92	0.0	146.32	-94.40	0.0	-93.88
3.40	.100	0.0	0.240	28	98.30	37.14	0.0	51.92	0.0	146.32	-94.40	0.0	-93.88
4.40	.100	0.0	0.220	29	102.70	40.57	0.0	51.92	0.0	146.32	-94.40	0.0	-93.88
4.20	.100	0.0	0.200	30	106.90	43.93	0.0	51.92	0.0	146.32	-94.40	0.0	-93.88

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY UNIVERSITY OF MICHIGAN VERSION #2 DECEMBER 1978

STONE REVETMENT - 6000 FT STRUCTURE - 25 YEAR BOND
CZL-130 LATZ (1686.2)
NUMBER OF PROPERTIES PROCESSED = 1 TOTAL LENGTH OF SHORELINE = 100.00

DPTH = 1025.000 - DEPTH OF THE LOT (FEET)
FCON = 15.000 - DISTANCE FROM FOUNDATION TO BLUFF (FEET)
RSET = 140.000 - RECCOMENDED SET BACK DISTANCE (FEET)
H = 43.000 - HEIGTH OF THE BLUFF (FEET)
TV = 25000.000 - LAKESIDE LAND VALUE ($)
SV = 55000.000 - HOME OR STRUCTURE VALUE ($)
LRES = 3.667 - LONG TERM RECESSION RATE (FEET/YEAR)
COST = 6000.000 - COST TO MOVE HOME ($)
REST = 20.000 - REALTORS ESTIMATE OF BANK (FEET)
MLT1 = 2.500 - WEIGHTING FACTOR
T = 30.000 - INVESTMENT HORIZON (YEARS)
BANK = 23.750 - POINT WHERE MORTGAGE BECOMES UNAVAILABLE
STPB = 36.875 - 1/2 WAY BETWEEN BANK AND STEPL (FEET)

L = 100.000 - FRONT FOOTAGE OF LOT IN (FEET)
HOME = 60.000 - DEPTH OF THE HOME (FEET)
FSET = 35.000 - SET BACK IN FRONT OF HOME (FEET)
TH = 0.755 - ANGLE OF THE BLUFF (RADIANS)
LV = 7500.000 - INLAND LAND VALUE ($)
RESR = 1.000 - RECESSION RATE MODIFIER
AEST = 17500.000 - ASTHETIC VALUE ($)
RI = 0.100 - DISCOUNTING RATE
A = 0.500 - WEIGHTING FACTOR
MLT2 = 0.500 - WEIGHTING FACTOR
PLV = 235.000 - DISTANCE FROM ROAD TO SETBACK (FEET)
STPL = 50.000 - POINT OF SHARP STRUCTURE VALUE DECLINE
BASE = 51.021 - LENGTH OF THE BLUFF BASE (FEET)

INPUT PARAMETERS | OUTPUT PARAMETERS

AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	14.52	0.950	0	2.50	0.13	0.0	0.0	14.52	14.52	-14.52	363.50	363.50
3.90	.100	14.52	0.950	1	6.40	0.32	0.0	0.0	13.20	27.72	-27.72	0.0	363.50
5.40	.100	14.52	0.950	2	11.80	0.59	0.0	0.0	12.00	39.72	-39.72	0.0	363.50
4.80	.100	14.52	0.950	3	16.60	0.83	181.50	181.50	10.91	50.63	130.87	181.50	545.00
4.40	.100	14.52	0.950	4	21.00	1.05	0.0	181.50	9.92	60.55	120.95	0.0	545.00
3.90	.100	14.52	0.950	5	24.90	1.25	0.0	181.50	9.02	69.56	111.94	0.0	545.00
3.30	.100	14.52	0.950	6	28.20	1.41	0.0	181.50	8.20	77.76	103.74	0.0	545.00
2.60	.100	14.52	0.950	7	30.80	1.54	0.0	181.50	7.45	85.21	96.29	0.0	545.00
1.90	.100	14.52	0.950	8	32.70	1.64	0.0	181.50	6.77	91.98	89.52	0.0	545.00
1.70	.100	14.52	0.950	9	34.40	1.72	0.0	181.50	6.16	98.14	83.36	0.0	545.00
3.20	.100	14.52	0.900	10	37.60	2.04	0.0	181.50	5.60	103.74	77.76	0.0	545.00
2.90	.100	14.52	0.850	11	40.50	2.48	0.0	181.50	5.09	108.83	72.67	0.0	545.00
2.40	.100	14.52	0.800	12	42.90	2.96	0.0	181.50	4.63	113.46	68.05	0.0	545.00
1.30	.100	14.52	0.750	13	44.20	3.28	0.0	181.50	4.21	117.66	63.84	0.0	545.00
0.70	.100	14.52	0.700	14	44.90	3.49	0.0	181.50	3.82	121.48	60.02	0.0	545.00
1.40	.100	14.52	0.650	15	46.30	3.98	0.0	181.50	3.48	124.96	56.54	0.0	545.00
2.30	.100	14.52	0.600	16	48.60	4.90	0.0	181.50	3.16	128.12	53.38	0.0	545.00
2.80	.100	14.52	0.550	17	51.40	6.16	48.13	229.63	2.87	130.99	98.63	-48.13	496.87
2.80	.100	14.52	0.500	18	54.20	7.56	0.0	229.63	2.61	133.60	96.02	0.0	496.87
3.30	.100	14.52	0.450	19	57.50	9.38	0.0	229.63	2.37	135.98	93.65	0.0	496.87
4.10	.100	14.52	0.400	20	61.60	11.84	0.0	229.63	2.16	138.14	91.49	0.0	496.87
3.90	.100	14.52	0.380	21	65.50	14.25	0.0	229.63	1.96	140.10	89.53	0.0	496.87
4.30	.100	14.52	0.360	22	69.80	17.00	-181.50	48.12	1.78	141.88	-93.76	0.0	496.87
4.80	.100	14.52	0.340	23	74.60	20.17	0.0	48.12	1.62	143.50	-95.38	0.0	496.87
5.40	.100	14.52	0.320	24	80.00	23.84	0.0	48.12	1.47	144.98	-96.85	0.0	496.87
5.40	.100	14.52	0.300	25	85.40	27.62	0.0	48.12	1.34	146.32	-98.19	0.0	496.87
4.90	.100	0.0	0.280	26	90.30	31.15	0.0	48.12	0.0	146.32	-98.19	0.0	496.87
4.60	.100	0.0	0.260	27	94.90	34.56	0.0	48.12	0.0	146.32	-98.19	0.0	496.87
3.40	.100	0.0	0.240	28	98.30	37.14	0.0	48.12	0.0	146.32	-98.19	0.0	496.87
4.40	.100	0.0	0.220	29	102.70	40.57	0.0	48.12	0.0	146.32	-98.19	0.0	496.87
4.20	.100	0.0	0.200	30	106.90	43.93	0.0	48.12	0.0	146.32	-98.19	0.0	496.87

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY UNIVERSITY OF MICHIGAN VERSION #2 DECEMBER 1978

STONE REVETMENT - 6000 FT STRUCTURE - 25 YEAR BOND
CZL-140 ANGEIOS (16M7)
NUMBER OF PROPERTIES PROCESSED = 1 TOTAL LENGTH OF SHORELINE = 125.00

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DPTH =  1350.000 - DEPTH OF THE LOT (FEET)                        L    =   125.000 - FRONT FOOTAGE OF LOT IN (FEET)
FOUN =     0.0   - DISTANCE FROM FOUNDATION TO BLUFF (FEET)       HOME =     0.0   - DEPTH OF THE HOME (FEET)
RSET =   140.000 - RECCOMENDED SET BACK DISTANCE (FEET)           PSET =    35.000 - SET BACK IN FRONT OF HOME (FEET)
H    =    48.000 - HEIGTH OF THE BLUFF (FEET)                     TH   =     0.755 - ANGLE OF THE BLUFF (RADIANS)
TV   = 25000.000 - LAKESIDE LAND VALUE ($)                        LV   =  7500.000 - INLAND LAND VALUE ($)
SV   =     0.0   - HOME OR STRUCTURE VALUE ($)                    RESR =     1.000 - RECESSION RATE MODIFIER
LRES =     3.667 - LONG TERM RECESSION RATE (FEET/YEAR)           AEST = 17500.000 - ASTHETIC VALUE ($)
COST =  6000.000 - COST TO MOVE HOME ($)                          RI   =     0.100 - DISCOUNTING RATE
REST =    20.000 - REALTORS ESTIMATE OF BANK (FEET)               A    =     0.500 - WEIGHTING FACTOR
MLT1 =     2.500 - WEIGHTING FACTOR                               MLT2 =     0.500 - WEIGHTING FACTOR
T    =    30.000 - INVESTMENT HORIZON (YEARS)                     PLV  =   175.000 - DISTANCE FROM ROAD TO SETBACK (FEET)
BANK =    23.750 - POINT WHERE MORTGAGE BECOMES UNAVAILABLE       STPL =    50.000 - POINT OF SHARP STRUCTURE VALUE DECLINE
STPD =    36.875 - 1/2 WAY BETWEEN BANK AND STEPL (FEET)          BASE =    51.021 - LENGTH OF THE BLUFF BASE (FEET)
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INPUT PARAMETERS					OUTPUT PARAMETERS									
AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	14.52	0.950	0	2.50	0.13	0.0	0.0	14.52	14.52	-14.52	-48.00	-48.00
3.90	.100	14.52	0.950	1	6.40	0.32	0.0	0.0	13.20	27.72	-27.72	0.0	-48.00
5.40	.100	14.52	0.950	2	11.80	0.59	0.0	0.0	12.00	39.72	-39.72	0.0	-48.00
4.80	.100	14.52	0.950	3	16.60	0.83	0.0	0.0	10.91	50.63	-50.63	0.0	-48.00
4.40	.100	14.52	0.950	4	21.00	1.05	0.0	0.0	9.92	60.55	-60.55	0.0	-48.00
3.90	.100	14.52	0.950	5	24.90	1.25	0.0	0.0	9.02	69.56	-69.56	0.0	-48.00
3.30	.100	14.52	0.950	6	28.20	1.41	0.0	0.0	8.20	77.76	-77.76	0.0	-48.00
2.60	.100	14.52	0.950	7	30.80	1.54	0.0	0.0	7.45	85.21	-85.21	0.0	-48.00
1.90	.100	14.52	0.950	8	32.70	1.64	0.0	0.0	6.77	91.98	-91.98	0.0	-48.00
1.70	.100	14.52	0.950	9	34.40	1.72	0.0	0.0	6.16	98.14	-98.14	0.0	-48.00
3.20	.100	14.52	0.900	10	37.60	2.04	0.0	0.0	5.60	103.74	-103.74	0.0	-48.00
2.90	.100	14.52	0.850	11	40.50	2.48	0.0	0.0	5.09	108.83	-108.83	0.0	-48.00
2.40	.100	14.52	0.800	12	42.90	2.96	0.0	0.0	4.63	113.46	-113.46	0.0	-48.00
1.30	.100	14.52	0.750	13	44.20	3.28	0.0	0.0	4.21	117.66	-117.66	0.0	-48.00
0.70	.100	14.52	0.700	14	44.90	3.49	0.0	0.0	3.82	121.48	-121.48	0.0	-48.00
1.40	.100	14.52	0.650	15	46.30	3.98	0.0	0.0	3.48	124.96	-124.96	0.0	-48.00
2.30	.100	14.52	0.600	16	48.60	4.90	0.0	0.0	3.16	128.12	-128.12	0.0	-48.00
2.80	.100	14.52	0.550	17	51.40	6.16	38.50	38.50	2.87	130.99	-92.49	-38.50	-86.50
2.80	.100	14.52	0.500	18	54.20	7.56	0.0	38.50	2.61	133.60	-95.10	0.0	-86.50
3.30	.100	14.52	0.450	19	57.50	9.38	0.0	38.50	2.37	135.98	-97.48	0.0	-86.50
4.10	.100	14.52	0.400	20	61.60	11.84	0.0	38.50	2.16	138.14	-99.64	0.0	-86.50
3.90	.100	14.52	0.380	21	65.50	14.25	0.0	38.50	1.96	140.10	-101.60	0.0	-86.50
4.30	.100	14.52	0.360	22	69.80	17.00	0.0	38.50	1.78	141.88	-103.38	0.0	-86.50
4.80	.100	14.52	0.340	23	74.60	20.17	0.0	38.50	1.62	143.50	-105.00	0.0	-86.50
5.40	.100	14.52	0.320	24	80.00	23.84	0.0	38.50	1.47	144.98	-106.48	0.0	-86.50
5.40	.100	14.52	0.300	25	85.40	27.62	0.0	38.50	1.34	146.32	-107.82	0.0	-86.50
4.90	.100	0.0	0.280	26	90.30	31.15	0.0	38.50	0.0	146.32	-107.82	0.0	-86.50
4.60	.100	0.0	0.260	27	94.90	34.56	0.0	38.50	0.0	146.32	-107.82	0.0	-86.50
3.40	.100	0.0	0.240	28	98.30	37.14	0.0	38.50	0.0	146.32	-107.82	0.0	-86.50
4.40	.100	0.0	0.220	29	102.70	40.57	0.0	38.50	0.0	146.32	-107.82	0.0	-86.50
4.20	.100	0.0	0.200	30	106.90	43.93	0.0	38.50	0.0	146.32	-107.82	0.0	-86.50

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY UNIVERSITY OF MICHIGAN VERSION #2 DECEMBER 1978

STONE REVETMENT - 6000 FT STRUCTURE - 25 YEAR BOND
CZL-150 DELMAFIANI (16M55)
NUMBER OF PROPERTIES PROCESSED = 1 TOTAL LENGTH OF SHORELINE = 162.00

DPTH =	1410.000 - DEPTH OF THE LOT (FEET)	L =	162.000 - FRONT FOOTAGE OF LOT IN (FEET)
FOUN =	0.0 - DISTANCE FROM FOUNDATION TO BLUFF (FEET)	HOME =	0.0 - DEPTH OF THE HOME (FEET)
RSET =	140.000 - RECCOMENDED SET BACK DISTANCE (FEET)	PSET =	35.000 - SET BACK IN FRONT OF HOME (FEET)
H =	49.000 - HEIGTH OF THE BLUFF (FEET)	TH =	0.755 - ANGLE OF THE BLUFF (RADIANS)
TV =	30000.000 - LAKESIDE LAND VALUE ($)	LV =	9000.000 - INLAND LAND VALUE ($)
SV =	0.0 - HOME OR STRUCTURE VALUE ($)	RESP =	1.000 - RECESSION RATE MODIFIER
LRES =	3.667 - LONG TERM RECESSION RATE (FEET/YEAR)	AEST =	21000.000 - ASTHETIC VALUE ($)
COST =	6000.000 - COST TO MOVE HOME ($)	RI =	0.100 - DISCOUNTING RATE
REST =	20.000 - REALTORS ESTIMATE OF BANK (FEET)	A =	0.500 - WEIGHTING FACTOR
MLT1 =	2.500 - WEIGHTING FACTOR	MLT2 =	0.500 - WEIGHTING FACTOR
T =	30.000 - INVESTMENT HORIZON (YEARS)	PLV =	175.000 - DISTANCE FROM ROAD TO SETBACK (FEET)
BANK =	23.750 - POINT WHERE MORTGAGE BECOMES UNAVAILABLE	STPL =	50.000 - POINT OF SHARP STRUCTURE VALUE DECLINE
STPU =	36.875 - 1/2 WAY BETWEEN BANK AND STEPL (FEET)	BASE =	51.021 - LENGTH OF THE BLUFF BASE (FEET)

INPUT PARAMETERS | OUTPUT PARAMETERS

AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	14.52	0.950	0	2.50	0.13	0.0	0.0	14.52	14.52	-14.52	-37.04	-37.04
3.90	.100	14.52	0.950	1	6.40	0.32	0.0	0.0	13.20	27.72	-27.72	0.0	-37.04
5.40	.100	14.52	0.950	2	11.80	0.59	0.0	0.0	12.00	39.72	-39.72	0.0	-37.04
4.80	.100	14.52	0.950	3	16.60	0.83	0.0	0.0	10.91	50.63	-50.63	0.0	-37.04
4.40	.100	14.52	0.950	4	21.00	1.05	0.0	0.0	9.92	60.55	-60.55	0.0	-37.04
3.90	.100	14.52	0.950	5	24.90	1.25	0.0	0.0	9.02	69.56	-69.56	0.0	-37.04
3.30	.100	14.52	0.950	6	28.20	1.41	0.0	0.0	8.20	77.76	-77.76	0.0	-37.04
2.60	.100	14.52	0.950	7	30.80	1.54	0.0	0.0	7.45	85.21	-85.21	0.0	-37.04
1.90	.100	14.52	0.950	8	32.70	1.64	0.0	0.0	6.77	91.98	-91.98	0.0	-37.04
1.70	.100	14.52	0.950	9	34.40	1.72	0.0	0.0	6.16	98.14	-98.14	0.0	-37.04
3.20	.100	14.52	0.900	10	37.60	2.04	0.0	0.0	5.60	103.74	-103.74	0.0	-37.04
2.90	.100	14.52	0.850	11	40.50	2.48	0.0	0.0	5.09	108.83	-108.83	0.0	-37.04
2.40	.100	14.52	0.800	12	42.90	2.96	0.0	0.0	4.63	113.46	-113.46	0.0	-37.04
1.30	.100	14.52	0.750	13	44.20	3.28	0.0	0.0	4.21	117.66	-117.66	0.0	-37.04
0.70	.100	14.52	0.700	14	44.90	3.49	0.0	0.0	3.82	121.48	-121.48	0.0	-37.04
1.40	.100	14.52	0.650	15	46.30	3.98	0.0	0.0	3.48	124.96	-124.96	0.0	-37.04
2.30	.100	14.52	0.600	16	48.60	4.90	0.0	0.0	3.16	128.12	-128.12	0.0	-37.04
2.80	.100	14.52	0.550	17	51.40	6.16	35.65	35.65	2.87	130.99	-95.34	-35.65	-72.69
2.80	.100	14.52	0.500	18	54.20	7.56	0.0	35.65	2.61	133.60	-97.96	0.0	-72.69
3.30	.100	14.52	0.450	19	57.50	9.38	0.0	35.65	2.37	135.98	-100.33	0.0	-72.69
4.10	.100	14.52	0.400	20	61.60	11.84	0.0	35.65	2.16	138.14	-102.49	0.0	-72.69
3.90	.100	14.52	0.380	21	65.50	14.25	0.0	35.65	1.96	140.10	-104.45	0.0	-72.69
4.30	.100	14.52	0.360	22	69.80	17.00	0.0	35.65	1.78	141.88	-106.23	0.0	-72.69
4.80	.100	14.52	0.340	23	74.60	20.17	0.0	35.65	1.62	143.50	-107.86	0.0	-72.69
5.40	.100	14.52	0.320	24	80.00	23.84	0.0	35.65	1.47	144.98	-109.33	0.0	-72.69
5.40	.100	14.52	0.300	25	85.40	27.62	0.0	35.65	1.34	146.32	-110.67	0.0	-72.69
4.90	.100	0.0	0.280	26	90.30	31.15	0.0	35.65	0.0	146.32	-110.67	0.0	-72.69
4.60	.100	0.0	0.260	27	94.90	34.56	0.0	35.65	0.0	146.32	-110.67	0.0	-72.69
3.40	.100	0.0	0.240	28	98.30	37.14	0.0	35.65	0.0	146.32	-110.67	0.0	-72.69
4.40	.100	0.0	0.220	29	102.70	40.57	0.0	35.65	0.0	146.32	-110.67	0.0	-72.69
4.20	.100	0.0	0.200	30	106.90	43.93	0.0	35.65	0.0	146.32	-110.67	0.0	-72.69

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY UNIVERSITY OF MICHIGAN VERSION #2 DECEMBER 1978

STONE REVETMENT - 6000 FT STRUCTURE - 25 YEAR BOND
C2L-160 MORPHCS (16M56)
NUMBER OF PROPERTIES PROCESSED = 1 TOTAL LENGTH OF SHORELINE = 165.00

DPTH = 1200.000 - DEPTH OF THE LOT (FEET)		L = 165.000 - FRONT FOOTAGE OF LOT IN (FEET)	
FOUN = 150.000 - DISTANCE FROM FOUNDATION TO BLUFF (FEET)		HOME = 60.000 - DEPTH OF THE HOME (FEET)	
RSET = 140.000 - RECCOMENDED SET BACK DISTANCE (FEET)		FSET = 35.000 - SET BACK IN FRONT OF HOME (FEET)	
H = 48.000 - HEIGTH OF THE BLUFF (FEET)		TH = 0.755 - ANGLE OF THE BLUFF (RADIANS)	
TV = 30000.000 - LAKESIDE LAND VALUE ($)		LV = 9000.000 - INLAND LAND VALUE ($)	
SV = 65000.000 - HOME OR STRUCTURE VALUE ($)		RESR = 1.000 - RECESSION RATE MODIFIER	
LRES = 3.667 - LONG TERM RECESSION RATE (FEET/YEAR)		AEST = 21000.000 - ASTHETIC VALUE ($)	
COST = 6000.000 - COST TO MOVE HOME ($)		RI = 0.100 - DISCOUNTING RATE	
REST = 20.000 - REALTORS ESTIMATE OF BANK (FEET)		A = 0.500 - WEIGHTING FACTOR	
MLT1 = 2.500 - WEIGHTING FACTOR		MLT2 = 0.500 - WEIGHTING FACTOR	
T = 30.000 - INVESTMENT HORIZON (YEARS)		PLV = 235.000 - DISTANCE FROM ROAD TO SETBACK (FEET)	
BANK = 23.750 - POINT WHERE MORTGAGE BECOMES UNAVAILABLE		STPL = 50.000 - POINT OF SHARP STRUCTURE VALUE DECLINE	
STPB = 36.875 - 1/2 WAY BETWEEN BANK AND STEPL (FEET)		BASE = 51.021 - LENGTH OF THE BLUFF BASE (FEET)	

INPUT PARAMETERS / OUTPUT PARAMETERS

AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	14.52	0.950	0	2.50	0.13	0.0	0.0	14.52	14.52	-14.52	-36.36	-36.36
3.90	.100	14.52	0.950	1	6.40	0.32	0.0	0.0	13.20	27.72	-27.72	0.0	-36.36
5.40	.100	14.52	0.950	2	11.80	0.59	0.0	0.0	12.00	39.72	-39.72	0.0	-36.36
4.80	.100	14.52	0.950	3	16.60	0.83	0.0	0.0	10.91	50.63	-50.63	0.0	-36.36
4.40	.100	14.52	0.950	4	21.00	1.05	0.0	0.0	9.92	60.55	-60.55	0.0	-36.36
3.90	.100	14.52	0.950	5	24.90	1.25	0.0	0.0	9.02	69.56	-69.56	0.0	-36.36
3.30	.100	14.52	0.950	6	28.20	1.41	0.0	0.0	8.20	77.76	-77.76	0.0	-36.36
2.60	.100	14.52	0.950	7	30.80	1.54	0.0	0.0	7.45	85.21	-85.21	0.0	-36.36
1.90	.100	14.52	0.950	8	32.70	1.64	0.0	0.0	6.77	91.98	-91.98	0.0	-36.36
1.70	.100	14.52	0.950	9	34.40	1.72	0.0	0.0	6.16	98.14	-98.14	0.0	-36.36
3.20	.100	14.52	0.900	10	37.60	2.04	0.0	0.0	5.60	103.74	-103.74	0.0	-36.36
2.90	.100	14.52	0.850	11	40.50	2.48	0.0	0.0	5.09	108.83	-108.83	0.0	-36.36
2.40	.100	14.52	0.800	12	42.90	2.96	0.0	0.0	4.63	113.46	-113.46	0.0	-36.36
1.30	.100	14.52	0.750	13	44.20	3.28	0.0	0.0	4.21	117.66	-117.66	0.0	-36.36
0.70	.100	14.52	0.700	14	44.90	3.49	0.0	0.0	3.82	121.48	-121.48	0.0	-36.36
1.40	.100	14.52	0.650	15	46.30	3.98	0.0	0.0	3.48	124.96	-124.96	0.0	-36.36
2.30	.100	14.52	0.600	16	48.60	4.90	0.0	0.0	3.16	128.12	-128.12	0.0	-36.36
2.80	.100	14.52	0.550	17	51.40	6.16	35.00	35.00	2.87	130.99	-95.99	-35.00	-71.36
2.80	.100	14.52	0.500	18	54.20	7.56	0.0	35.00	2.61	133.60	-98.60	0.0	-71.36
3.30	.100	14.52	0.450	19	57.50	9.38	0.0	35.00	2.37	135.98	-100.98	0.0	-71.36
4.10	.100	14.52	0.400	20	61.60	11.84	0.0	35.00	2.16	138.14	-103.14	0.0	-71.36
3.90	.100	14.52	0.380	21	65.50	14.25	0.0	35.00	1.96	140.10	-105.10	0.0	-71.36
4.30	.100	14.52	0.360	22	69.80	17.00	0.0	35.00	1.78	141.88	-106.88	0.0	-71.36
4.80	.100	14.52	0.340	23	74.60	20.17	0.0	35.00	1.62	143.50	-108.50	0.0	-71.36
5.40	.100	14.52	0.320	24	80.00	23.84	0.0	35.00	1.47	144.98	-109.98	0.0	-71.36
5.40	.100	14.52	0.300	25	85.40	27.62	0.0	35.00	1.34	146.32	-111.32	0.0	-71.36
4.90	.100	0.0	0.280	26	90.30	31.15	0.0	35.00	0.0	146.32	-111.32	0.0	-71.36
4.60	.100	0.0	0.260	27	94.90	34.56	0.0	35.00	0.0	146.32	-111.32	0.0	-71.36
3.40	.100	0.0	0.240	28	98.30	37.14	0.0	35.00	0.0	146.32	-111.32	0.0	-71.36
4.40	.100	0.0	0.220	29	102.70	40.57	130.00	165.00	0.0	146.32	18.68	130.00	58.64
4.20	.100	0.0	0.200	30	106.90	43.93	0.0	165.00	0.0	146.32	18.68	0.0	58.64

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY UNIVERSITY OF MICHIGAN VERSION #2 DECEMBER 1978

STONE REVETMENT - 6000 FT STRUCTURE - 25 YEAR BOND
CZL-180 MANASZAK (16MB.5)
NUMBER OF PROPERTIES PROCESSED = 1 TOTAL LENGTH OF SHORELINE = 40.00

DPTH =	345.000 - DEPTH OF THE LOT (FEET)	L =	40.000 - FRONT FOOTAGE OF LOT IN (FEET)
FOUN =	20.000 - DISTANCE FROM FOUNDATION TO BLUFF (FEET)	HOME =	50.000 - DEPTH OF THE HOME (FEET)
RSET =	140.000 - RECCOMENDED SET BACK DISTANCE (FEET)	FSET =	35.000 - SET BACK IN FRONT OF HOME (FEET)
H =	43.000 - HEIGTH OF THE BLUFF (FEET)	TH =	0.755 - ANGLE OF THE BLUFF (RADIANS)
TV =	7500.000 - LAKESIDE LAND VALUE ($)	LV =	2250.000 - INLAND LAND VALUE ($)
SV =	37500.000 - HOME OR STRUCTURE VALUE ($)	RESR =	1.000 - RECESSION RATE MODIFIER
LRES =	3.667 - LONG TERM RECESSION RATE (FEET/YEAR)	AEST =	5250.000 - ASTHETIC VALUE ($)
COST =	6000.000 - COST TO MOVE HOME ($)	RI =	0.100 - DISCOUNTING RATE
REST =	20.000 - REALTORS ESTIMATE OF BANK (FEET)	A =	0.500 - WEIGHTING FACTOR
MLT1 =	2.500 - WEIGHTING FACTOR	MLT2 =	0.500 - WEIGHTING FACTOR
T =	30.000 - INVESTMENT HORIZON (YEARS)	PLV =	225.000 - DISTANCE FROM ROAD TO SETBACK (FEET)
BANK =	23.750 - POINT WHERE MORTGAGE BECOMES UNAVAILABLE	STPL =	50.000 - POINT OF SHARP STRUCTURE VALUE DECLINE
STPD =	36.875 - 1/2 WAY BETWEEN BANK AND STEPL (FEET)	BASE =	51.021 - LENGTH OF THE BLUFF BASE (FEET)

INPUT PARAMETERS | OUTPUT PARAMETERS

AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	14.52	0.950	0	2.50	0.13	0.0	0.0	14.52	14.52	-14.52	571.87	571.87
3.90	.100	14.52	0.950	1	6.40	0.32	0.0	0.0	13.20	27.72	-27.72	0.0	571.87
5.40	.100	14.52	0.950	2	11.80	0.59	0.0	0.0	12.00	39.72	-39.72	0.0	571.87
4.80	.100	14.52	0.950	3	16.60	0.83	0.0	0.0	10.91	50.63	-50.63	0.0	571.87
4.40	.100	14.52	0.950	4	21.00	1.05	309.38	309.38	9.92	60.55	248.83	309.38	881.25
3.90	.100	14.52	0.950	5	24.90	1.25	0.0	309.38	9.02	69.56	239.81	0.0	881.25
3.30	.100	14.52	0.950	6	28.20	1.41	0.0	309.38	8.20	77.76	231.62	0.0	881.25
2.60	.100	14.52	0.950	7	30.80	1.54	0.0	309.38	7.45	85.21	224.17	0.0	881.25
1.90	.100	14.52	0.950	8	32.70	1.64	0.0	309.38	6.77	91.98	217.39	0.0	881.25
1.70	.100	14.52	0.950	9	34.40	1.72	0.0	309.38	6.16	98.14	211.23	0.0	881.25
3.20	.100	14.52	0.900	10	37.60	2.04	0.0	309.38	5.60	103.74	205.64	0.0	881.25
2.90	.100	14.52	0.850	11	40.50	2.48	0.0	309.38	5.09	108.83	200.55	0.0	881.25
2.40	.100	14.52	0.800	12	42.90	2.96	0.0	309.38	4.63	113.46	195.92	0.0	881.25
1.30	.100	14.52	0.750	13	44.20	3.28	0.0	309.38	4.21	117.66	191.71	0.0	881.25
0.70	.100	14.52	0.700	14	44.90	3.49	0.0	309.38	3.82	121.48	187.89	0.0	881.25
1.40	.100	14.52	0.650	15	46.30	3.98	0.0	309.38	3.48	124.96	184.42	0.0	881.25
2.30	.100	14.52	0.600	16	48.60	4.90	0.0	309.38	3.16	128.12	181.26	0.0	881.25
2.80	.100	14.52	0.550	17	51.40	6.16	36.09	345.47	2.87	130.99	214.48	-36.09	845.16
2.80	.100	14.52	0.500	18	54.20	7.56	0.0	345.47	2.61	133.60	211.86	0.0	845.16
3.30	.100	14.52	0.450	19	57.50	9.38	0.0	345.47	2.37	135.98	209.49	0.0	845.16
4.10	.100	14.52	0.400	20	61.60	11.84	0.0	345.47	2.16	138.14	207.33	0.0	845.16
3.90	.100	14.52	0.380	21	65.50	14.25	0.0	345.47	1.96	140.10	205.37	0.0	845.16
4.30	.100	14.52	0.360	22	69.80	17.00	0.0	345.47	1.78	141.88	203.59	0.0	845.16
4.80	.100	14.52	0.340	23	74.60	20.17	-309.38	36.09	1.62	143.50	-107.41	0.0	845.16
5.40	.100	14.52	0.320	24	80.00	23.84	0.0	36.09	1.47	144.98	-108.89	0.0	845.16
5.40	.100	14.52	0.300	25	85.40	27.62	0.0	36.09	1.34	146.32	-110.23	0.0	845.16
4.90	.100	0.0	0.280	26	90.30	31.15	0.0	36.09	0.0	146.32	-110.23	0.0	845.16
4.60	.100	0.0	0.260	27	94.90	34.56	0.0	36.09	0.0	146.32	-110.23	0.0	845.16
3.40	.100	0.0	0.240	28	98.30	37.14	0.0	36.09	0.0	146.32	-110.23	0.0	845.16
4.40	.100	0.0	0.220	29	102.70	40.57	0.0	36.09	0.0	146.32	-110.23	0.0	845.16
4.20	.100	0.0	0.200	30	106.90	43.93	0.0	36.09	0.0	146.32	-110.23	0.0	845.16

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY UNIVERSITY OF MICHIGAN VERSION #2 DECEMBER 1978

STONE REVETMENT - 6000 FT STRUCTURE - 25 YEAR BOND
CZL-190 ANTONICIII (1688.12)
NUMBER OF PROPERTIES PROCESSED = 1 TOTAL LENGTH OF SHORELINE = 75.00

DPTH =	287.000	- DEPTH OF THE LOT (FEET)	L =	75.000	- FRONT FOOTAGE OF LOT IN (FEET)
FOUN =	0.0	- DISTANCE FROM FOUNDATION TO BLUFF (FEET)	HOME =	0.0	- DEPTH OF THE HOME (FEET)
RSET =	140.000	- RECCOMENDED SET BACK DISTANCE (FEET)	FSET =	35.000	- SET BACK IN FRONT OF HOME (FEET)
H =	41.000	- HEIGTH OF THE BLUFF (FEET)	TH =	0.620	- ANGLE OF THE BLUFF (RADIANS)
TV =	11250.000	- LAKESIDE LAND VALUE ($)	LV =	3375.000	- INLAND LAND VALUE ($)
SV =	0.0	- HOME OR STRUCTURE VALUE ($)	RESR =	1.000	- RECESSION RATE MODIFIER
LRES =	3.667	- LONG TERM RECESSION RATE (FEET/YEAR)	AEST =	7875.000	- ASTHETIC VALUE ($)
COST =	6000.000	- COST TO MOVE HOME ($)	RI =	0.100	- DISCOUNTING RATE
REST =	20.000	- REALTORS ESTIMATE OF BANK (FEET)	A =	0.500	- WEIGHTING FACTOR
MLT1 =	2.500	- WEIGHTING FACTOR	MLT2 =	0.500	- WEIGHTING FACTOR
T =	30.000	- INVESTMENT HORIZON (YEARS)	PLV =	175.000	- DISTANCE FROM ROAD TO SETBACK (FEET)
BANK =	23.750	- POINT WHERE MORTGAGE BECOMES UNAVAILABLE	STPL =	50.000	- POINT OF SHARP STRUCTURE VALUE DECLINE
STPB =	36.875	- 1/2 WAY BETWEEN BANK AND STPL (FEET)	BASE =	57.479	- LENGTH OF THE BLUFF BASE (FEET)

INPUT PARAMETERS					OUTPUT PARAMETERS									
AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	14.52	0.950	0	2.50	0.11	0.0	0.0	14.52	14.52	-14.52	-80.00	-80.00
3.90	.100	14.52	0.950	1	6.40	0.32	0.0	0.0	13.20	27.72	-27.72	0.0	-80.00
5.40	.100	14.52	0.950	2	11.80	0.59	0.0	0.0	12.00	39.72	-39.72	0.0	-80.00
4.80	.100	14.52	0.950	3	16.60	0.83	0.0	0.0	10.91	50.63	-50.63	0.0	-80.00
4.40	.100	14.52	0.950	4	21.00	1.05	0.0	0.0	9.92	60.55	-60.55	0.0	-80.00
3.90	.100	14.52	0.950	5	24.90	1.25	0.0	0.0	9.02	69.56	-69.56	0.0	-80.00
3.30	.100	14.52	0.950	6	28.20	1.41	0.0	0.0	8.20	77.76	-77.76	0.0	-80.00
2.60	.100	14.52	0.950	7	30.80	1.54	0.0	0.0	7.45	85.21	-85.21	0.0	-80.00
1.90	.100	14.52	0.950	8	32.70	1.64	0.0	0.0	6.77	91.98	-91.98	0.0	-80.00
1.70	.100	14.52	0.950	9	34.40	1.72	0.0	0.0	6.16	98.14	-98.14	0.0	-80.00
3.20	.100	14.52	0.900	10	37.60	2.04	0.0	0.0	5.60	103.74	-103.74	0.0	-80.00
2.90	.100	14.52	0.850	11	40.50	2.48	0.0	0.0	5.09	108.83	-108.83	0.0	-80.00
2.40	.100	14.52	0.800	12	42.90	2.96	0.0	0.0	4.63	113.46	-113.46	0.0	-80.00
1.30	.100	14.52	0.750	13	44.20	3.28	0.0	0.0	4.21	117.66	-117.66	0.0	-80.00
0.70	.100	14.52	0.700	14	44.90	3.49	0.0	0.0	3.82	121.48	-121.48	0.0	-80.00
1.40	.100	14.52	0.650	15	46.30	3.98	0.0	0.0	3.48	124.96	-124.96	0.0	-80.00
2.30	.100	14.52	0.600	16	48.60	4.90	0.0	0.0	3.16	128.12	-128.12	0.0	-80.00
2.80	.100	14.52	0.550	17	51.40	6.16	0.0	0.0	2.87	130.99	-130.99	0.0	-80.00
2.80	.100	14.52	0.500	18	54.20	7.56	0.0	0.0	2.61	133.60	-133.60	0.0	-80.00
3.30	.100	14.52	0.450	19	57.50	9.38	28.88	28.88	2.37	135.98	-107.10	-28.88	-108.88
4.10	.100	14.52	0.400	20	61.60	11.84	0.0	28.88	2.16	138.14	-109.26	0.0	-108.88
3.90	.100	14.52	0.380	21	65.50	14.25	0.0	28.88	1.96	140.10	-111.22	0.0	-108.88
4.30	.100	14.52	0.360	22	69.80	17.00	0.0	28.88	1.78	141.88	-113.01	0.0	-108.88
4.80	.100	14.52	0.340	23	74.60	20.17	0.0	28.88	1.62	143.50	-114.63	0.0	-108.88
5.40	.100	14.52	0.320	24	80.00	23.84	0.0	28.88	1.47	144.98	-116.10	0.0	-108.88
5.40	.100	14.52	0.300	25	85.40	27.62	0.0	28.88	1.34	146.32	-117.44	0.0	-108.88
4.90	.100	0.0	0.280	26	90.30	31.15	0.0	28.88	0.0	146.32	-117.44	0.0	-108.88
4.60	.100	0.0	0.260	27	94.90	34.56	0.0	28.88	0.0	146.32	-117.44	0.0	-108.88
3.40	.100	0.0	0.240	28	98.30	37.14	0.0	28.88	0.0	146.32	-117.44	0.0	-108.88
4.40	.100	0.0	0.220	29	102.70	40.57	0.0	28.88	0.0	146.32	-117.44	0.0	-108.88
4.20	.100	0.0	0.200	30	106.90	43.93	0.0	28.88	0.0	146.32	-117.44	0.0	-108.88

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY UNIVERSITY OF MICHIGAN VERSION #2 DECEMBER 1978

STONE REVETMENT - 6000 FT STRUCTURE - 25 YEAR BOND
CZL-200 O BRIEN (16M8.14)
NUMBER OF PROPERTIES PROCESSED = 1 TOTAL LENGTH OF SHORELINE = 65.00

DPTH = 347.000 - DEPTH OF THE LOT (FEET)
POUN = 40.000 - DISTANCE FROM FOUNDATION TO BLUFF (FEET)
RSET = 140.000 - RECCOMENDED SET BACK DISTANCE (FEET)
H = 41.000 - HEIGTH OF THE BLUFF (FEET)
TV = 9750.000 - LAKESIDE LAND VALUE ($)
SV = 35000.000 - HOME OR STRUCTURE VALUE ($)
LRES = 3.667 - LONG TERM RECESSION RATE (FEET/YEAR)
COST = 6000.000 - COST TO MOVE HOME ($)
REST = 20.000 - REALTORS ESTIMATE OF BANK (FEET)
MLT1 = 2.500 - WEIGHTING FACTOR
T = 30.000 - INVESTMENT HORIZON (YEARS)
BANK = 23.750 - POINT WHERE MORTGAGE BECOMES UNAVAILABLE
STPB = 36.875 - 1/2 WAY BETWEEN BANK AND STEPL (FEET)

L = 65.000 - FRONT FOOTAGE OF LOT IN (FEET)
HOME = 40.000 - DEPTH OF THE HOME (FEET)
FSET = 35.000 - SET BACK IN FRONT OF HOME (FEET)
TH = 0.620 - ANGLE OF THE BLUFF (RADIANS)
LV = 2925.000 - INLAND LAND VALUE ($)
RESR = 1.000 - RECESSION RATE MODIFIER
AEST = 6825.000 - ASTHETIC VALUE ($)
RI = 0.100 - DISCOUNTING RATE
A = 0.500 - WEIGHTING FACTOR
MLT2 = 0.500 - WEIGHTING FACTOR
PLV = 215.000 - DISTANCE FROM ROAD TO SETBACK (FEET)
STPL = 50.000 - POINT OF SHARP STRUCTURE VALUE DECLINE
BASE = 57.479 - LENGTH OF THE BLUFF BASE (FEET)

INPUT PARAMETERS					OUTPUT PARAMETERS									
AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	14.52	0.950	0	2.50	0.13	0.0	0.0	14.52	14.52	-14.52	85.38	85.38
3.90	.100	14.52	0.950	1	6.40	0.32	59.12	59.12	13.20	27.72	31.40	59.12	144.50
5.40	.100	14.52	0.950	2	11.80	0.59	97.48	156.60	12.00	39.72	116.88	97.48	241.98
4.80	.100	14.52	0.950	3	16.60	0.83	80.33	236.92	10.91	50.63	186.29	80.33	322.31
4.40	.100	14.52	0.950	4	21.00	1.05	0.0	236.92	9.92	60.55	176.38	0.0	322.31
3.90	.100	14.52	0.950	5	24.90	1.25	0.0	236.92	9.02	69.56	167.36	0.0	322.31
3.30	.100	14.52	0.950	6	28.20	1.41	0.0	236.92	8.20	77.76	159.16	0.0	322.31
2.60	.100	14.52	0.950	7	30.80	1.54	0.0	236.92	7.45	85.21	151.71	0.0	322.31
1.90	.100	14.52	0.950	8	32.70	1.64	0.0	236.92	6.77	91.98	144.94	0.0	322.31
1.70	.100	14.52	0.950	9	34.40	1.72	0.0	236.92	6.16	98.14	138.78	0.0	322.31
3.20	.100	14.52	0.900	10	37.60	2.04	0.0	236.92	5.60	103.74	133.18	0.0	322.31
2.90	.100	14.52	0.850	11	40.50	2.48	177.69	414.62	5.09	108.83	305.79	177.69	500.00
2.40	.100	14.52	0.800	12	42.90	2.96	0.0	414.62	4.63	113.46	301.16	0.0	500.00
1.30	.100	14.52	0.750	13	44.20	3.28	-2.80	411.82	4.21	117.66	294.16	0.0	500.00
0.70	.100	14.52	0.700	14	44.90	3.49	-3.79	408.03	3.82	121.48	286.54	0.0	500.00
1.40	.100	14.52	0.650	15	46.30	3.98	-8.85	399.18	3.48	124.96	274.22	0.0	500.00
2.30	.100	14.52	0.600	16	48.60	4.90	-16.61	382.57	3.16	128.12	254.45	0.0	500.00
2.80	.100	14.52	0.550	17	51.40	6.16	-22.75	359.83	2.87	130.99	228.83	0.0	500.00
2.80	.100	14.52	0.500	18	54.20	7.56	-25.27	334.56	2.61	133.60	200.95	0.0	500.00
3.30	.100	14.52	0.450	19	57.50	9.38	-3.89	330.67	2.37	135.98	194.69	-28.88	471.13
4.10	.100	14.52	0.400	20	61.60	11.84	-44.41	286.26	2.16	138.14	148.12	0.0	471.13
3.90	.100	14.52	0.380	21	65.50	14.25	-43.65	242.61	1.96	140.10	102.51	0.0	471.13
4.30	.100	14.52	0.360	22	69.80	17.00	-36.05	206.57	1.78	141.88	64.68	0.0	471.13
4.80	.100	14.52	0.340	23	74.60	20.17	0.0	206.57	1.62	143.50	63.06	0.0	471.13
5.40	.100	14.52	0.320	24	80.00	23.84	0.0	206.57	1.47	144.98	61.59	0.0	471.13
5.40	.100	14.52	0.300	25	85.40	27.62	0.0	206.57	1.34	146.32	60.25	0.0	471.13
4.90	.100	0.0	0.280	26	90.30	31.15	0.0	206.57	0.0	146.32	60.25	0.0	471.13
4.60	.100	0.0	0.260	27	94.90	34.56	0.0	206.57	0.0	146.32	60.25	0.0	471.13
3.40	.100	0.0	0.240	28	98.30	37.14	0.0	206.57	0.0	146.32	60.25	0.0	471.13
4.40	.100	0.0	0.220	29	102.70	40.57	-177.69	28.87	0.0	146.32	-117.45	0.0	471.13
4.20	.100	0.0	0.200	30	106.90	43.93	0.0	28.87	0.0	146.32	-117.45	0.0	471.13

BENEFIT/COST MCDEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY UNIVERSITY OF MICHIGAN VERSION #2 DECEMBER 1978

STONE REVETMENT - ECCO PT STRUCTURE - 25 YEAR BOND
CZL-210 SUMMERSET ESTATES (LOTS 21-27)
NUMBER OF PROPERTIES PROCESSED = 1 TOTAL LENGTH OF SHORELINE = 700.00

DPTH =	75.000 - DEPTH OF THE LOT (FEET)		L =	700.000 - FRONT FOOTAGE OF LOT IN (FEET)	
FOUN =	0.0 - DISTANCE FROM FOUNDATION TO BLUFF (FEET)		HOME =	0.0 - DEPTH OF THE HOME (FEET)	
RSET =	140.000 - RECCOMENDED SET BACK DISTANCE (FEET)		PSET =	35.000 - SET BACK IN FRONT OF HOME (FEET)	
H =	41.000 - HEIGTH OF THE BLUFF (FEET)		TH =	0.620 - ANGLE OF THE BLUFF (RADIANS)	
TV =	5000.000 - LAKESIDE LAND VALUE ($)		LV =	1500.000 - INLAND LAND VALUE ($)	
SV =	0.0 - HOME OR STRUCTURE VALUE ($)		RESR =	1.000 - RECESSION RATE MODIFIER	
LRES =	3.667 - LONG TERM RECESSION RATE (FEET/YEAR)		AEST =	3500.000 - ASTHETIC VALUE ($)	
COST =	6000.000 - COST TO MOVE HOME ($)		RI =	0.100 - DISCOUNTING RATE	
REST =	20.000 - REALTORS ESTIMATE OF BANK (FEET)		A =	0.500 - WEIGHTING FACTOR	
MLT1 =	2.500 - WEIGHTING FACTOR		MLT2 =	0.500 - WEIGHTING FACTOR	
T =	30.000 - INVESTMENT HORIZON (YEARS)		PLV =	175.000 - DISTANCE FROM ROAD TO SETBACK (FEET)	
BANK =	23.750 - POINT WHERE MORTGAGE BECOMES UNAVAILABLE		STPL =	50.000 - POINT OF SHARP STRUCTURE VALUE DECLINE	
STPB =	36.875 - 1/2 WAY BETWEEN BANK AND STEPL (FEET)		BASE =	57.479 - LENGTH OF THE BLUFF BASE (FEET)	

INPUT PARAMETERS OUTPUT PARAMETERS

AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	14.52	0.950	0	2.50	0.13	0.04	0.04	14.52	14.52	-14.48	-14.88	-14.88
3.90	.100	14.52	0.950	1	6.40	0.32	0.06	0.10	13.20	27.72	-27.62	-0.06	-14.94
5.40	.100	14.52	0.950	2	11.80	0.59	0.09	0.18	12.00	39.72	-39.54	-0.09	-15.03
4.80	.100	14.52	0.950	3	16.60	0.83	0.08	0.26	10.91	50.63	-50.37	-0.08	-15.12
4.40	.100	14.52	0.950	4	21.00	1.05	0.08	0.34	9.92	60.55	-60.21	-0.08	-15.20
3.90	.100	14.52	0.950	5	24.90	1.25	0.07	0.41	9.02	69.56	-69.15	-0.07	-15.27
3.30	.100	14.52	0.950	6	28.20	1.41	0.06	0.47	8.20	77.76	-77.29	-0.06	-15.34
2.60	.100	14.52	0.950	7	30.80	1.54	0.05	0.52	7.45	85.21	-84.69	-0.05	-15.39
1.90	.100	14.52	0.950	8	32.70	1.64	0.04	0.56	6.77	91.98	-91.42	-0.04	-15.43
1.70	.100	14.52	0.950	9	34.40	1.72	0.03	0.59	6.16	98.14	-97.55	-0.03	-15.46
3.20	.100	14.52	0.900	10	37.60	2.04	0.06	0.66	5.60	103.74	-103.08	-0.07	-15.53
2.90	.100	14.52	0.850	11	40.50	2.48	0.06	0.71	5.09	108.83	-108.12	-0.06	-15.59
2.40	.100	14.52	0.800	12	42.90	2.96	0.04	0.76	4.63	113.46	-112.70	-0.05	-15.64
1.30	.100	14.52	0.750	13	44.20	3.28	0.02	0.78	4.21	117.66	-116.88	-0.03	-15.67
0.70	.100	14.52	0.700	14	44.90	3.49	0.01	0.79	3.82	121.48	-120.69	-0.02	-15.69
1.40	.100	14.52	0.650	15	46.30	3.98	0.02	0.82	3.48	124.96	-124.15	-0.03	-15.72
2.30	.100	14.52	0.600	16	48.60	4.90	0.04	0.85	3.16	128.12	-127.27	-0.05	-15.77
2.80	.100	14.52	0.550	17	51.40	6.16	0.04	0.90	2.87	130.99	-130.10	-0.06	-15.84
2.80	.100	14.52	0.500	18	54.20	7.56	0.04	0.94	2.61	133.60	-132.67	-0.07	-15.90
3.30	.100	14.52	0.450	19	57.50	9.38	0.05	0.99	2.37	135.98	-134.99	-0.08	-15.98
4.10	.100	14.52	0.400	20	61.60	11.84	0.06	1.05	2.16	138.14	-137.09	-0.10	-16.08
3.90	.100	14.52	0.380	21	65.50	14.25	0.06	1.10	1.96	140.10	-139.00	-0.10	-16.18
4.30	.100	14.52	0.360	22	69.80	17.00	0.06	1.17	1.78	141.88	-140.72	-0.11	-16.29
4.80	.100	14.52	0.340	23	74.60	20.17	0.07	1.23	1.62	143.50	-142.27	-0.13	-16.42
5.40	.100	14.52	0.320	24	80.00	23.84	0.08	1.31	1.47	144.98	-143.67	-0.15	-16.57
5.40	.100	14.52	0.300	25	85.40	27.62	0.08	1.39	1.34	146.32	-144.93	-0.15	-16.72
4.90	.100	0.0	0.280	26	90.30	31.15	0.07	1.46	0.0	146.32	-144.86	-0.14	-16.86
4.60	.100	0.0	0.260	27	94.90	34.56	0.07	1.53	0.0	146.32	-144.79	-0.14	-17.00
3.40	.100	0.0	0.240	28	98.30	37.14	0.05	1.58	0.0	146.32	-144.74	-0.10	-17.10
4.40	.100	0.0	0.220	29	102.70	40.57	0.06	1.64	0.0	146.32	-144.68	-0.14	-17.23
4.20	.100	0.0	0.200	30	106.90	43.93	0.06	1.70	0.0	146.32	-144.62	-0.13	-17.37

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY   UNIVERSITY OF MICHIGAN   VERSION #2 DECEMBER 1978

STONE REVETMENT - 6000 FT STRUCTURE - 25 YEAR BOND
CZL-220   DOEBF   (16810)
NUMBER OF PROPERTIES PROCESSED = 1   TOTAL LENGTH OF SHORELINE = 346.00

DPTH =	2000.000	- DEPTH OF THE LOT (FEET)	L =	346.000	- FRONT FOOTAGE OF LOT IN (FEET)
FOUN =	0.0	- DISTANCE FROM FOUNDATION TO BLUFF (FEET)	HOME =	0.0	- DEPTH OF THE HOME (FEET)
BSET =	140.000	- RECCOMENDED SET BACK DISTANCE (FEET)	PSET =	35.000	- SET BACK IN FRONT OF HOME (FEET)
H =	55.000	- HEIGTH OF THE BLUFF (FEET)	TH =	0.637	- ANGLE OF THE BLUFF (RADIANS)
TV =	52000.000	- LAKESIDE LAND VALUE ($)	LV =	15600.000	- INLAND LAND VALUE ($)
SV =	0.0	- HOME OR STRUCTURE VALUE ($)	RESR =	1.000	- RECESSION RATE MODIFIER
LRES =	3.667	- LONG TERM RECESSION RATE (FEET/YEAR)	AEST =	36400.000	- ASTHETIC VALUE ($)
COST =	6000.000	- COST TO MOVE HOME ($)	RI =	0.100	- DISCOUNTING RATE
REST =	20.000	- REALTORS ESTIMATE OF BANK (FEET)	A =	0.500	- WEIGHTING FACTOR
MLT1 =	2.500	- WEIGHTING FACTOR	MLT2 =	0.500	- WEIGHTING FACTOR
T =	30.000	- INVESTMENT HORIZON (YEARS)	PLV =	175.000	- DISTANCE FROM ROAD TO SETBACK (FEET)
BANK =	23.750	- POINT WHERE MORTGAGE BECOMES UNAVAILABLE	STPL =	50.000	- POINT OF SHARP STRUCTURE VALUE DECLINE
STPB =	36.875	- 1/2 WAY BETWEEN BANK AND STEPL (FEET)	BASE =	74.335	- LENGTH OF THE BLUFF BASE (FEET)

INPUT PARAMETERS   OUTPUT PARAMETERS

AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	14.52	0.950	0	2.50	0.13	0.0	0.0	14.52	14.52	-14.52	-17.34	-17.34
3.90	.100	14.52	0.950	1	6.40	0.32	0.0	0.0	13.20	27.72	-27.72	0.0	-17.34
5.40	.100	14.52	0.950	2	11.80	0.59	0.0	0.0	12.00	39.72	-39.72	0.0	-17.34
4.80	.100	14.52	0.950	3	16.60	0.83	0.0	0.0	10.91	50.63	-50.63	0.0	-17.34
4.40	.100	14.52	0.950	4	21.00	1.05	0.0	0.0	9.92	60.55	-60.55	0.0	-17.34
3.90	.100	14.52	0.950	5	24.90	1.25	0.0	0.0	9.02	69.56	-69.56	0.0	-17.34
3.30	.100	14.52	0.950	6	28.20	1.41	0.0	0.0	8.20	77.76	-77.76	0.0	-17.34
2.60	.100	14.52	0.950	7	30.80	1.54	0.0	0.0	7.45	85.21	-85.21	0.0	-17.34
1.90	.100	14.52	0.950	8	32.70	1.64	0.0	0.0	6.77	91.98	-91.98	0.0	-17.34
1.70	.100	14.52	0.950	9	34.40	1.72	0.0	0.0	6.16	98.14	-98.14	0.0	-17.34
3.20	.100	14.52	0.900	10	37.60	2.04	0.0	0.0	5.60	103.74	-103.74	0.0	-17.34
2.90	.100	14.52	0.850	11	40.50	2.48	0.0	0.0	5.09	108.83	-108.83	0.0	-17.34
2.40	.100	14.52	0.800	12	42.90	2.96	0.0	0.0	4.63	113.46	-113.46	0.0	-17.34
1.30	.100	14.52	0.750	13	44.20	3.28	0.0	0.0	4.21	117.66	-117.66	0.0	-17.34
0.70	.100	14.52	0.700	14	44.90	3.49	0.0	0.0	3.82	121.48	-121.48	0.0	-17.34
1.40	.100	14.52	0.650	15	46.30	3.98	0.0	0.0	3.48	124.96	-124.96	0.0	-17.34
2.30	.100	14.52	0.600	16	48.60	4.90	0.0	0.0	3.16	128.12	-128.12	0.0	-17.34
2.80	.100	14.52	0.550	17	51.40	6.16	0.0	0.0	2.87	130.99	-130.99	0.0	-17.34
2.80	.100	14.52	0.500	18	54.20	7.56	0.0	0.0	2.61	133.60	-133.60	0.0	-17.34
3.30	.100	14.52	0.450	19	57.50	9.38	0.0	0.0	2.37	135.98	-135.98	0.0	-17.34
4.10	.100	14.52	0.400	20	61.60	11.84	0.0	0.0	2.16	138.14	-138.14	0.0	-17.34
3.90	.100	14.52	0.380	21	65.50	14.25	0.0	0.0	1.96	140.10	-140.10	0.0	-17.34
4.30	.100	14.52	0.360	22	69.80	17.00	0.0	0.0	1.78	141.88	-141.88	0.0	-17.34
4.80	.100	14.52	0.340	23	74.60	20.17	28.93	28.93	1.62	143.50	-114.57	-28.93	-46.27
5.40	.100	14.52	0.320	24	80.00	23.84	0.0	28.93	1.47	144.98	-116.05	0.0	-46.27
5.40	.100	14.52	0.300	25	85.40	27.62	0.0	28.93	1.34	146.32	-117.39	0.0	-46.27
4.90	.100	0.0	0.280	26	90.30	31.15	0.0	28.93	0.0	146.32	-117.39	0.0	-46.27
4.60	.100	0.0	0.260	27	94.90	34.56	0.0	28.93	0.0	146.32	-117.39	0.0	-46.27
3.40	.100	0.0	0.240	28	98.30	37.14	0.0	28.93	0.0	146.32	-117.39	0.0	-46.27
4.40	.100	0.0	0.220	29	102.70	40.57	0.0	28.93	0.0	146.32	-117.39	0.0	-46.27
4.20	.100	0.0	0.200	30	106.90	43.93	0.0	28.93	0.0	146.32	-117.39	0.0	-46.27

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY UNIVERSITY OF MICHIGAN VERSION #2 DECEMBER 1978

STONE REVETMENT - 6000 FT STRUCTURE - 25 YEAR BOND
CZL-230 PIONEER DEVELOPMENT CORP. (16M11)
NUMBER OF PROPERTIES PROCESSED = 1 TOTAL LENGTH OF SHORELINE = 285.00

DPTH = 1100.000 - DEPTH OF THE LOT (FEET)	L = 285.000 - FRONT FOOTAGE OF LOT IN (FEET)
FOUN = 70.000 - DISTANCE FROM FOUNDATION TO BLUFF (FEET)	HOME = 60.000 - DEPTH OF THE HOME (FEET)
RSET = 140.000 - RECCOMENDED SET BACK DISTANCE (FEET)	FSET = 35.000 - SET BACK IN FRONT OF HOME (FEET)
H = 55.000 - HEIGTH OF THE BLUFF (FEET)	TH = 0.637 - ANGLE OF THE BLUFF (RADIANS)
TV = 40000.000 - LAKESIDE LAND VALUE ($)	LV = 12000.000 - INLAND LAND VALUE ($)
SV = 45000.000 - HOME OR STRUCTURE VALUE ($)	RESR = 1.000 - RECESSION RATE MODIFIER
LRES = 3.667 - LONG TERM RECESSION RATE (FEET/YEAR)	AEST = 28000.000 - ASTHETIC VALUE ($)
COST = 6000.000 - COST TO MOVE HOME ($)	RI = 0.100 - DISCOUNTING RATE
REST = 20.000 - REALTORS ESTIMATE OF BANK (FEET)	A = 0.500 - WEIGHTING FACTOR
MLT1 = 2.500 - WEIGHTING FACTOR	MLT2 = 0.500 - WEIGHTING FACTOR
T = 30.000 - INVESTMENT HORIZON (YEARS)	PLV = 235.000 - DISTANCE FROM ROAD TO SETBACK (FEET)
BANK = 21.750 - POINT WHERE MORTGAGE BECOMES UNAVAILABLE	STPL = 50.000 - POINT OF SHARP STRUCTURE VALUE DECLINE
STPB = 36.875 - 1/2 WAY BETWEEN BANK AND STEPL (FEET)	BASE = 74.335 - LENGTH OF THE BLUFF BASE (FEET)

INPUT PARAMETERS					OUTPUT PARAMETERS								
AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	14.52	0.950	0	2.50	0.13	0.0	0.0	14.52	14.52	-14.52	-21.05	-21.05
3.90	.100	14.52	0.950	1	6.40	0.32	0.0	0.0	13.20	27.72	-27.72	0.0	-21.05
5.40	.100	14.52	0.950	2	11.80	0.59	0.0	0.0	12.00	39.72	-39.72	0.0	-21.05
4.80	.100	14.52	0.950	3	16.60	0.83	0.0	0.0	10.91	50.63	-50.63	0.0	-21.05
4.40	.100	14.52	0.950	4	21.00	1.05	52.11	52.11	9.92	60.55	-8.44	52.11	31.05
3.90	.100	14.52	0.950	5	24.90	1.25	0.0	52.11	9.02	69.56	-17.46	0.0	31.05
3.30	.100	14.52	0.950	6	28.20	1.41	0.0	52.11	8.20	77.76	-25.65	0.0	31.05
2.60	.100	14.52	0.950	7	30.80	1.54	0.0	52.11	7.45	85.21	-33.10	0.0	31.05
1.90	.100	14.52	0.950	8	32.70	1.64	0.0	52.11	6.77	91.98	-39.88	0.0	31.05
1.70	.100	14.52	0.950	9	34.40	1.72	6.75	58.85	6.16	98.14	-39.29	6.75	37.80
3.20	.100	14.52	0.900	10	37.60	2.04	16.94	75.79	5.60	103.74	-27.95	16.94	54.74
2.90	.100	14.52	0.850	11	40.50	2.48	15.35	91.14	5.09	108.83	-17.69	15.35	70.09
2.40	.100	14.52	0.800	12	42.90	2.96	12.70	103.85	4.63	113.46	-9.61	12.70	82.79
1.30	.100	14.52	0.750	13	44.20	3.28	6.88	110.73	4.21	117.66	-6.93	6.88	89.68
0.70	.100	14.52	0.700	14	44.90	3.49	3.71	114.43	3.82	121.48	-7.05	3.71	93.38
1.40	.100	14.52	0.650	15	46.30	3.98	7.15	121.58	3.48	124.96	-3.38	7.15	100.53
2.30	.100	14.52	0.600	16	48.60	4.90	0.0	121.58	3.16	128.12	-6.54	0.0	100.53
2.80	.100	14.52	0.550	17	51.40	6.16	0.0	121.58	2.87	130.99	-9.41	0.0	100.53
2.80	.100	14.52	0.500	18	54.20	7.56	0.0	121.58	2.61	133.60	-12.03	0.0	100.53
3.30	.100	14.52	0.450	19	57.50	9.38	0.0	121.58	2.37	135.98	-14.40	0.0	100.53
4.10	.100	14.52	0.400	20	61.60	11.84	0.0	121.58	2.16	138.14	-16.56	0.0	100.53
3.90	.100	14.52	0.380	21	65.50	14.25	0.0	121.58	1.96	140.10	-18.52	0.0	100.53
4.30	.100	14.52	0.360	22	69.80	17.00	0.0	121.58	1.78	141.88	-20.30	0.0	100.53
4.80	.100	14.52	0.340	23	74.60	20.17	27.02	148.60	1.62	143.50	5.09	25.09	125.61
5.40	.100	14.52	0.320	24	80.00	23.84	0.0	148.60	1.47	144.98	3.62	0.0	125.61
5.40	.100	14.52	0.300	25	85.40	27.62	0.0	148.60	1.34	146.32	2.28	0.0	125.61
4.90	.100	0.0	0.280	26	90.30	31.15	0.0	148.60	0.0	146.32	2.28	0.0	125.61
4.60	.100	0.0	0.260	27	94.90	34.56	-7.58	141.02	0.0	146.32	-5.30	0.0	125.61
3.40	.100	0.0	0.240	28	98.30	37.14	-13.68	127.34	0.0	146.32	-18.98	0.0	125.61
4.40	.100	0.0	0.220	29	102.70	40.57	-18.17	109.17	0.0	146.32	-37.15	0.0	125.61
4.20	.100	0.0	0.200	30	106.90	43.93	-17.79	91.39	0.0	146.32	-54.93	0.0	125.61

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY   UNIVERSITY OF MICHIGAN   VERSION #2 DECEMBER 1978

STONE REVETMENT - 6000 FT STRUCTURE - 25 YEAR BOND
CZL-240   KLEIMAN   (MW-1,2,3,4)
NUMBER OF PROPERTIES PROCESSED = 1   TOTAL LENGTH OF SHORELINE = 100.00

DPTH = 307.000 - DEPTH OF THE LOT (FEET)
FOUN = 3.0 - DISTANCE FROM FOUNDATION TO BLUFF (FEET)
RSET = 140.000 - RECCOMENDED SET BACK DISTANCE (FEET)
H = 55.000 - HEIGTH OF THE BLUFF (FEET)
TV = 15000.000 - LAKESIDE LAND VALUE ($)
SV = 0.0 - HOME OR STRUCTURE VALUE ($)
LRES = 3.667 - LONG TERM RECESSION RATE (FEET/YEAR)
COST = 6000.000 - COST TO MOVE HOME ($)
REST = 20.000 - REALTORS ESTIMATE OF BANK (FEET)
MLT1 = 2.500 - WEIGHTING FACTOR
T = 30.000 - INVESTMENT HORIZON (YEARS)
BANK = 23.750 - POINT WHERE MORTGAGE BECOMES UNAVAILABLE
STPB = 35.875 - 1/2 WAY BETWEEN BANK AND STEPL (FEET)

L = 100.000 - FRONT FOOTAGE OF LOT IN (FEET)
HOME = 0.0 - DEPTH OF THE HOME (FEET)
PSET = 35.000 - SET BACK IN FRONT OF HOME (FEET)
TH = 0.637 - ANGLE OF THE BLUFF (RADIANS)
LV = 4500.000 - INLAND LAND VALUE ($)
RESR = 1.000 - RECESSION RATE MODIFIER
AEST = 10500.000 - ASTHETIC VALUE ($)
RI = 0.100 - DISCOUNTING RATE
A = 0.500 - WEIGHTING FACTOR
MLT2 = 0.500 - WEIGHTING FACTOR
PLV = 175.000 - DISTANCE FROM ROAD TO SETBACK (FEET)
STPL = 50.000 - POINT OF SHARP STRUCTURE VALUE DECLINE
BASE = 74.335 - LENGTH OF THE BLUFF BASE (FEET)

INPUT PARAMETERS   OUTPUT PARAMETERS

AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	14.52	0.950	0	2.50	0.13	0.0	0.0	14.52	14.52	-14.52	-60.00	-60.00
3.90	.100	14.52	0.950	1	6.40	0.32	0.0	0.0	13.20	27.72	-27.72	0.0	-60.00
5.40	.100	14.52	0.950	2	11.80	0.59	0.0	0.0	12.00	39.72	-39.72	0.0	-60.00
4.80	.100	14.52	0.950	3	16.60	0.83	0.0	0.0	10.91	50.63	-50.63	0.0	-60.00
4.40	.100	14.52	0.950	4	21.00	1.05	0.0	0.0	9.92	60.55	-60.55	0.0	-60.00
3.90	.100	14.52	0.950	5	24.90	1.25	0.0	0.0	9.02	69.56	-69.56	0.0	-60.00
3.30	.100	14.52	0.950	6	28.20	1.41	0.0	0.0	8.20	77.76	-77.76	0.0	-60.00
2.60	.100	14.52	0.950	7	30.80	1.54	0.0	0.0	7.45	85.21	-85.21	0.0	-60.00
1.90	.100	14.52	0.950	8	32.70	1.64	0.0	0.0	6.77	91.98	-91.98	0.0	-60.00
1.70	.100	14.52	0.950	9	34.40	1.72	0.0	0.0	6.16	98.14	-98.14	0.0	-60.00
3.20	.100	14.52	0.900	10	37.60	2.04	0.0	0.0	5.60	103.74	-103.74	0.0	-60.00
2.90	.100	14.52	0.850	11	40.50	2.48	0.0	0.0	5.09	108.83	-108.83	0.0	-60.00
2.40	.100	14.52	0.800	12	42.90	2.96	0.0	0.0	4.63	113.46	-113.46	0.0	-60.00
1.30	.100	14.52	0.750	13	44.20	3.28	0.0	0.0	4.21	117.66	-117.66	0.0	-60.00
0.70	.100	14.52	0.700	14	44.90	3.49	0.0	0.0	3.82	121.48	-121.48	0.0	-60.00
1.40	.100	14.52	0.650	15	46.30	3.98	0.0	0.0	3.48	124.96	-124.96	0.0	-60.00
2.30	.100	14.52	0.600	16	48.60	4.90	0.0	0.0	3.16	128.12	-128.12	0.0	-60.00
2.80	.100	14.52	0.550	17	51.40	6.16	0.0	0.0	2.87	130.99	-130.99	0.0	-60.00
2.80	.100	14.52	0.500	18	54.20	7.56	0.0	0.0	2.61	133.60	-133.60	0.0	-60.00
3.30	.100	14.52	0.450	19	57.50	9.38	0.0	0.0	2.37	135.98	-135.98	0.0	-60.00
4.10	.100	14.52	0.400	20	61.60	11.84	0.0	0.0	2.16	138.14	-138.14	0.0	-60.00
3.90	.100	14.52	0.380	21	65.50	14.25	0.0	0.0	1.96	140.10	-140.10	0.0	-60.00
4.30	.100	14.52	0.360	22	69.80	17.00	0.0	0.0	1.78	141.88	-141.88	0.0	-60.00
4.80	.100	14.52	0.340	23	74.60	20.17	28.88	28.88	1.62	143.50	-114.63	-28.88	-88.88
5.40	.100	14.52	0.320	24	80.00	23.84	0.0	28.88	1.47	144.98	-116.10	0.0	-88.88
5.40	.100	14.52	0.300	25	85.40	27.62	0.0	28.88	1.34	146.32	-117.44	0.0	-88.88
4.90	.100	0.0	0.280	26	90.30	31.15	0.0	28.88	0.0	146.32	-117.44	0.0	-88.88
4.60	.100	0.0	0.260	27	94.90	34.56	0.0	28.88	0.0	146.32	-117.44	0.0	-88.88
3.40	.100	0.0	0.240	28	98.30	37.14	0.0	28.88	0.0	146.32	-117.44	0.0	-88.88
4.40	.100	0.0	0.220	29	102.70	40.57	0.0	28.88	0.0	146.32	-117.44	0.0	-88.88
4.20	.100	0.0	0.200	30	106.90	43.93	0.0	28.88	0.0	146.32	-117.44	0.0	-88.88

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY UNIVERSITY OF MICHIGAN VERSION #2 DECEMBER 1978

STONE REVETMENT - ECCO FT STRUCTURE - 25 YEAR BOND
CZL-241 KLEINMAN (MW-1,2,3,4)
NUMBER OF PROPERTIES PROCESSED = 1 TOTAL LENGTH OF SHORELINE = 100.00

DPTH =	325.000	- DEPTH OF THE LOT (FEET)	L =	100.000	- FRONT FOOTAGE OF LOT IN (FEET)
FOUN =	0.0	- DISTANCE FROM FOUNDATION TO BLUFF (FEET)	HOME =	0.0	- DEPTH OF THE HOME (FEET)
RSET =	140.000	- RECCOMENDED SET BACK DISTANCE (FEET)	FSET =	35.000	- SET BACK IN FRONT OF HOME (FEET)
H =	55.000	- HEIGTH OF THE BLUFF (FEET)	TH =	0.637	- ANGLE OF THE BLUFF (RADIANS)
TV =	15000.000	- LAKESIDE LAND VALUE ($)	LV =	4500.000	- INLAND LAND VALUE ($)
SV =	0.0	- HOME OR STRUCTURE VALUE ($)	RESR =	1.000	- RECESSION RATE MODIFIER
LRES =	3.667	- LONG TERM RECESSION RATE (FEET/YEAR)	AEST =	10500.000	- ASTHETIC VALUE ($)
COST =	6000.000	- COST TO MOVE HOME ($)	RI =	0.100	- DISCOUNTING RATE
REST =	20.000	- REALTORS ESTIMATE OF BANK (FEET)	A =	0.500	- WEIGHTING FACTOR
MLT1 =	2.500	- WEIGHTING FACTOR	MLT2 =	0.500	- WEIGHTING FACTOR
T =	30.000	- INVESTMENT HORIZON (YEARS)	PLV =	175.000	- DISTANCE FROM ROAD TO SETBACK (FEET)
BANK =	23.750	- POINT WHERE MORTGAGE BECOMES UNAVAILABLE	STPL =	50.000	- POINT OF SHARP STRUCTURE VALUE DECLINE
STPB =	36.875	- 1/2 WAY BETWEEN BANK AND STEPL (FEET)	BASE =	74.335	- LENGTH OF THE BLUFF BASE (FEET)

INPUT PARAMETERS | OUTPUT PARAMETERS

AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	14.52	0.950	0	2.50	0.13	0.0	0.0	14.52	14.52	-14.52	-60.00	-60.00
3.90	.100	14.52	0.950	1	6.40	0.32	0.0	0.0	13.20	27.72	-27.72	0.0	-60.00
5.40	.100	14.52	0.950	2	11.80	0.59	0.0	0.0	12.00	39.72	-39.72	0.0	-60.00
4.80	.100	14.52	0.950	3	16.60	0.83	0.0	0.0	10.91	50.63	-50.63	0.0	-60.00
4.40	.100	14.52	0.950	4	21.00	1.05	0.0	0.0	9.92	60.55	-60.55	0.0	-60.00
3.90	.100	14.52	0.950	5	24.90	1.25	0.0	0.0	9.02	69.56	-69.56	0.0	-60.00
3.30	.100	14.52	0.950	6	28.20	1.41	0.0	0.0	8.20	77.76	-77.76	0.0	-60.00
2.60	.100	14.52	0.950	7	30.80	1.54	0.0	0.0	7.45	85.21	-85.21	0.0	-60.00
1.90	.100	14.52	0.950	8	32.70	1.64	0.0	0.0	6.77	91.98	-91.98	0.0	-60.00
1.70	.100	14.52	0.950	9	34.40	1.72	0.0	0.0	6.16	98.14	-98.14	0.0	-60.00
3.20	.100	14.52	0.900	10	37.60	2.04	0.0	0.0	5.60	103.74	-103.74	0.0	-60.00
2.90	.100	14.52	0.850	11	40.50	2.48	0.0	0.0	5.09	108.83	-108.83	0.0	-60.00
2.40	.100	14.52	0.800	12	42.90	2.96	0.0	0.0	4.63	113.46	-113.46	0.0	-60.00
1.30	.100	14.52	0.750	13	44.20	3.28	0.0	0.0	4.21	117.66	-117.66	0.0	-60.00
0.70	.100	14.52	0.700	14	44.90	3.49	0.0	0.0	3.82	121.48	-121.48	0.0	-60.00
1.40	.100	14.52	0.650	15	46.30	3.98	0.0	0.0	3.48	124.96	-124.96	0.0	-60.00
2.30	.100	14.52	0.600	16	48.60	4.90	0.0	0.0	3.16	128.12	-128.12	0.0	-60.00
2.80	.100	14.52	0.550	17	51.40	6.16	0.0	0.0	2.87	130.99	-130.99	0.0	-60.00
2.80	.100	14.52	0.500	18	54.20	7.56	0.0	0.0	2.61	133.60	-133.60	0.0	-60.00
3.30	.100	14.52	0.450	19	57.50	9.38	0.0	0.0	2.37	135.98	-135.98	0.0	-60.00
4.10	.100	14.52	0.400	20	61.60	11.84	0.0	0.0	2.16	138.14	-138.14	0.0	-60.00
3.90	.100	14.52	0.380	21	65.50	14.25	0.0	0.0	1.96	140.10	-140.10	0.0	-60.00
4.30	.100	14.52	0.360	22	69.80	17.00	0.0	0.0	1.78	141.88	-141.88	0.0	-60.00
4.80	.100	14.52	0.340	23	74.60	20.17	28.88	28.88	1.62	143.50	-114.63	-28.88	-88.88
5.40	.100	14.52	0.320	24	80.00	23.84	0.0	28.88	1.47	144.98	-116.10	0.0	-88.88
5.40	.100	14.52	0.300	25	85.40	27.62	0.0	28.88	1.34	146.32	-117.44	0.0	-88.88
4.90	.100	0.0	0.280	26	90.30	31.15	0.0	28.88	0.0	146.32	-117.44	0.0	-88.88
4.60	.100	0.0	0.260	27	94.90	34.56	0.0	28.88	0.0	146.32	-117.44	0.0	-88.88
3.40	.100	0.0	0.240	28	98.30	37.14	0.0	28.88	0.0	146.32	-117.44	0.0	-88.88
4.40	.100	0.0	0.220	29	102.70	40.57	0.0	28.88	0.0	146.32	-117.44	0.0	-88.88
4.20	.100	0.0	0.200	30	106.90	43.93	0.0	28.88	0.0	146.32	-117.44	0.0	-88.88

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY UNIVERSITY OF MICHIGAN VERSION #2 DECEMBER 1978

STONE REVETMENT - 6000 FT STRUCTURE - 25 YEAR BOND
CZL-250 MAZKECTIS (MW-5,6)
NUMBER OF PROPERTIES PROCESSED = 1 TOTAL LENGTH OF SHORELINE = 148.00

DPTH = 400.000 - DEPTH OF THE LOT (FEET)
FOUN = 0.0 - DISTANCE FROM FOUNDATION TO BLUFF (FEET)
RSET = 140.000 - RECCOMENDED SET BACK DISTANCE (FEET)
H = 55.000 - HEIGTH OF THE BLUFF (FEET)
TV = 22200.000 - LAKESIDE LAND VALUE ($)
SV = 45000.000 - HOME OR STRUCTURE VALUE ($)
LRES = 3.667 - LONG TERM RECESSION RATE (FEET/YEAR)
COST = 6000.000 - COST TO MOVE HOME ($)
REST = 20.000 - REALTORS ESTIMATE OF BANK (FEET)
MLT1 = 2.500 - WEIGHTING FACTOR
T = 30.000 - INVESTMENT HORIZON (YEARS)
BANK = 23.750 - POINT WHERE MORTGAGE BECOMES UNAVAILABLE
STPB = 36.875 - 1/2 WAY BETWEEN BANK AND STEPL (FEET)

L = 148.000 - FRONT FOOTAGE OF LOT IN (FEET)
HOME = 70.000 - DEPTH OF THE HOME (FEET)
PSET = 35.000 - SET BACK IN FRONT OF HOME (FEET)
TH = 0.637 - ANGLE OF THE BLUFF (RADIANS)
LV = 6660.000 - INLAND LAND VALUE ($)
RESR = 1.000 - RECESSION RATE MODIFIER
AEST = 15540.000 - ASTHETIC VALUE ($)
RI = 0.100 - DISCOUNTING RATE
A = 0.500 - WEIGHTING FACTOR
MLT2 = 0.500 - WEIGHTING FACTOR
PLV = 245.000 - DISTANCE FROM ROAD TO SETBACK (FEET)
STPL = 50.000 - POINT OF SHARP STRUCTURE VALUE DECLINE
BASE = 74.335 - LENGTH OF THE BLUFF BASE (FEET)

INPUT PARAMETERS					OUTPUT PARAMETERS									
AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. ($)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	14.52	0.950	0	2.50	0.13	0.0	0.0	14.52	14.52	-14.52	293.92	293.92
5.90	.100	14.52	0.950	1	6.40	0.32	0.0	0.0	13.20	27.72	-27.72	0.0	293.92
5.40	.100	14.52	0.950	2	11.80	0.59	0.0	0.0	12.00	39.72	-39.72	0.0	293.92
4.80	.100	14.52	0.950	3	16.60	0.83	0.0	0.0	10.91	50.63	-50.63	0.0	293.92
4.40	.100	14.52	0.950	4	21.00	1.05	0.0	0.0	9.92	60.55	-60.55	0.0	293.92
3.90	.100	14.52	0.950	5	24.90	1.25	0.0	0.0	9.02	69.56	-69.56	0.0	293.92
3.30	.100	14.52	0.950	6	28.20	1.41	0.0	0.0	8.20	77.76	-77.76	0.0	293.92
2.60	.100	14.52	0.950	7	30.80	1.54	0.0	0.0	7.45	85.21	-85.21	0.0	293.92
1.90	.100	14.52	0.950	8	32.70	1.64	0.0	0.0	6.77	91.98	-91.98	0.0	293.92
1.70	.100	14.52	0.950	9	34.40	1.72	0.0	0.0	6.16	98.14	-98.14	0.0	293.92
3.20	.100	14.52	0.900	10	37.60	2.04	0.0	0.0	5.60	103.74	-103.74	0.0	293.92
2.90	.100	14.52	0.850	11	40.50	2.48	0.0	0.0	5.09	108.83	-108.83	0.0	293.92
2.40	.100	14.52	0.800	12	42.90	2.96	0.0	0.0	4.63	113.46	-113.46	0.0	293.92
1.30	.100	14.52	0.750	13	44.20	3.28	0.0	0.0	4.21	117.66	-117.66	0.0	293.92
0.70	.100	14.52	0.700	14	44.90	3.49	0.0	0.0	3.82	121.48	-121.48	0.0	293.92
1.40	.100	14.52	0.650	15	46.30	3.98	0.0	0.0	3.48	124.96	-124.96	0.0	293.92
2.30	.100	14.52	0.600	16	48.60	4.90	0.0	0.0	3.16	128.12	-128.12	0.0	293.92
2.80	.100	14.52	0.550	17	51.40	6.16	0.0	0.0	2.87	130.99	-130.99	0.0	293.92
2.80	.100	14.52	0.500	18	54.20	7.56	0.0	0.0	2.61	133.60	-133.60	0.0	293.92
3.30	.100	14.52	0.450	19	57.50	9.38	0.0	0.0	2.37	135.98	-135.98	0.0	293.92
4.10	.100	14.52	0.400	20	61.60	11.84	0.0	0.0	2.16	138.14	-138.14	0.0	293.92
3.90	.100	14.52	0.380	21	65.50	14.25	0.0	0.0	1.96	140.10	-140.10	0.0	293.92
4.30	.100	14.52	0.360	22	69.80	17.00	0.0	0.0	1.78	141.88	-141.88	0.0	293.92
4.80	.100	14.52	0.340	23	74.60	20.17	28.88	28.88	1.62	143.50	-114.63	-28.88	265.04
5.40	.100	14.52	0.320	24	80.00	23.84	0.0	28.88	1.47	144.98	-116.10	0.0	265.04
5.40	.100	14.52	0.300	25	85.40	27.62	0.0	28.88	1.34	146.32	-117.44	0.0	265.04
4.90	.100	0.0	0.280	26	90.30	31.15	0.0	28.88	0.0	146.32	-117.44	0.0	265.04
4.60	.100	0.0	0.260	27	94.90	34.56	0.0	28.88	0.0	146.32	-117.44	0.0	265.04
3.40	.100	0.0	0.240	28	98.30	37.14	0.0	28.88	0.0	146.32	-117.44	0.0	265.04
4.40	.100	0.0	0.220	29	102.70	40.57	0.0	28.88	0.0	146.32	-117.44	0.0	265.04
4.20	.100	0.0	0.200	30	106.90	43.93	0.0	28.88	0.0	146.32	-117.44	0.0	265.04

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY UNIVERSITY OF MICHIGAN VERSION #2 DECEMBER 1978

STONE REVETMENT - 6000 FT STRUCTURE - 25 YEAR BOND
MEAN BENEFITS FOR PROPERTIES IN REACH

NUMBER OF PROPERTIES PROCESSED = 27 TOTAL LENGTH OF SHORELINE = 4563.00

DPTH = 400.000 - DEPTH OF THE LOT (FEET)	L = 148.000 - FRONT FOOTAGE OF LOT IN (FEET)
FOUN = 0.0 - DISTANCE FROM FOUNDATION TO BLUFF (FEET)	HOME = 70.000 - DEPTH OF THE HOME (FEET)
RSET = 140.000 - RECCOMENDED SET BACK DISTANCE (FEET)	FSET = 35.000 - SET BACK IN FRONT OF HOME (FEET)
H = 55.000 - HEIGTH OF THE BLUFF (FEET)	TH = 0.637 - ANGLE OF THE BLUFF (RADIANS)
TV = 22200.000 - LAKESIDE LAND VALUE ($)	LV = 6660.000 - INLAND LAND VALUE ($)
SV = 45000.000 - HOME OR STRUCTURE VALUE ($)	RESF = 1.000 - RECESSION RATE MODIFIER
LRES = 3.667 - LONG TERM RECESSION RATE (FEET/YEAR)	AEST = 15540.000 - ASTHETIC VALUE ($)
COST = 6000.000 - COST TO MOVE HOME ($)	RI = 0.100 - DISCOUNTING RATE
REST = 20.000 - REALTORS ESTIMATE OF FARM (FEET)	A = 0.500 - WEIGHTING FACTOR
MLT1 = 2.500 - WEIGHTING FACTOR	MLT2 = 0.500 - WEIGHTING FACTOR
T = 30.000 - INVESTMENT HORIZON (YEARS)	PLV = 245.000 - DISTANCE FROM ROAD TO SETBACK (FEET)
BANK = 23.750 - POINT WHERE MORTGAGE BECOMES UNAVAILABLE	STPL = 50.000 - POINT OF SHARP STRUCTURE VALUE DECLINE
STPD = 36.875 - 1/2 WAY BETWEEN BANK AND STEPL (FEET)	BASE = 74.335 - LENGTH OF THE BLUFF BASE (FEET)

INPUT PARAMETERS					OUTPUT PARAMETERS									
AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	14.52	0.950	0	2.50	0.13	0.01	0.01	14.52	14.52	-14.51	41.48	41.48
3.90	.100	14.52	0.950	1	6.40	0.32	3.89	3.90	13.20	27.72	-23.82	3.87	45.35
5.40	.100	14.52	0.950	2	11.80	0.59	19.24	23.14	12.00	39.72	-16.58	19.21	64.56
4.80	.100	14.52	0.950	3	16.60	0.83	26.02	49.15	10.91	50.63	-1.48	25.99	90.55
4.40	.100	14.52	0.950	4	21.00	1.05	30.49	79.64	9.92	60.55	19.10	16.84	107.39
3.90	.100	14.52	0.950	5	24.90	1.25	0.88	80.53	9.02	69.56	10.96	0.86	108.26
3.30	.100	14.52	0.950	6	28.20	1.41	0.96	81.49	8.20	77.76	3.73	-0.96	107.30
2.60	.100	14.52	0.950	7	30.80	1.54	0.01	81.49	7.45	85.21	-3.72	-0.01	107.29
1.90	.100	14.52	0.950	8	32.70	1.64	0.01	81.50	6.77	91.98	-10.48	-0.01	107.28
1.70	.100	14.52	0.950	9	34.40	1.72	0.43	81.93	6.16	98.14	-16.21	0.42	107.70
3.20	.100	14.52	0.900	10	37.60	2.04	1.07	83.00	5.60	103.74	-20.74	1.05	108.74
2.90	.100	14.52	0.850	11	40.50	2.48	12.64	95.63	5.09	108.83	-13.19	12.62	121.36
2.40	.100	14.52	0.800	12	42.90	2.95	0.80	96.44	4.63	113.45	-17.02	0.78	122.15
1.30	.100	14.52	0.750	13	44.20	3.28	0.25	96.69	4.21	117.66	-20.97	0.42	122.57
0.70	.100	14.52	0.700	14	44.90	3.49	-0.02	96.67	3.82	121.48	-24.81	0.23	122.80
1.40	.100	14.52	0.650	15	46.30	3.98	68.58	165.25	3.48	124.96	40.29	69.15	191.94
2.30	.100	14.52	0.600	16	48.60	4.90	-1.08	164.16	3.16	128.12	36.04	-0.01	191.93
2.80	.100	14.52	0.550	17	51.40	6.16	3.47	167.64	2.87	130.99	36.64	-4.97	186.96
2.80	.100	14.52	0.500	18	54.20	7.56	-1.65	165.99	2.61	133.60	32.38	-0.01	186.95
3.30	.100	14.52	0.450	19	57.50	9.38	-5.62	160.37	2.37	135.98	24.39	-0.90	186.05
4.10	.100	14.52	0.400	20	61.60	11.83	0.64	161.01	2.16	138.14	22.87	12.11	198.16
3.90	.100	14.52	0.380	21	65.50	14.25	2.32	163.33	1.96	140.10	23.23	13.59	211.75
4.30	.100	14.52	0.360	22	69.80	17.00	-0.93	162.40	1.78	141.88	20.52	14.98	226.73
4.80	.100	14.52	0.340	23	74.60	20.17	-3.89	158.51	1.62	143.50	15.00	1.15	227.88
5.40	.100	14.52	0.320	24	80.00	23.84	-4.17	154.34	1.47	144.98	9.36	-6.42	221.46
5.40	.100	14.52	0.300	25	85.40	27.62	2.32	156.65	1.34	146.32	10.34	-3.28	218.19
4.90	.100	0.0	0.280	26	90.30	31.15	0.02	156.68	0.0	146.32	10.36	-0.03	218.15
4.60	.100	0.0	0.260	27	94.90	34.56	-0.45	156.23	0.0	146.32	9.91	-0.03	218.12
3.40	.100	0.0	0.240	28	98.30	37.14	33.52	189.74	0.0	146.32	43.42	34.33	252.44
4.40	.100	0.0	0.220	29	102.70	40.57	-8.08	181.66	0.0	146.32	35.34	4.66	257.11
4.20	.100	0.0	0.200	30	106.90	43.93	-1.09	180.57	0.0	146.32	34.25	-0.04	257.07

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY UNIVERSITY OF MICHIGAN VERSION #2 DECEMBER 1978

OFFSHORE BREAKWATER - 6000 FT STRUCTURE - 25 YEAR BOND
CZL- 10 COBLE (SP28)
NUMBER OF PROPERTIES PROCESSED = 1 TOTAL LENGTH OF SHORELINE = 49.00

DPTH =	363.000 - DEPTH OF THE LOT (FEET)	L =	49.000 - FRONT FOOTAGE OF LOT IN (FEET)
FOUN =	0.0 - DISTANCE FROM FOUNDATION TO BLUFF (FEET)	HOME =	0.0 - DEPTH OF THE HOME (FEET)
RSET =	140.000 - RECCOMENDED SET BACK DISTANCE (FEET)	PSET =	35.000 - SET BACK IN FRONT OF HOME (FEET)
H =	35.000 - HEIGTH OF THE BLUFF (FEET)	TH =	1.047 - ANGLE OF THE BLUFF (RADIANS)
LV =	7500.000 - LAKESIDE LAND VALUE ($)	LV =	2250.000 - INLAND LAND VALUE ($)
SV =	0.0 - HOME OR STRUCTURE VALUE ($)	RESR =	1.000 - RECESSION RATE MODIFIER
LRES =	3.667 - LONG TERM RECESSION RATE (FEET/YEAR)	AEST =	5250.000 - ASTHETIC VALUE ($)
COST =	6000.000 - COST TO MOVE HOME ($)	RI =	0.100 - DISCOUNTING RATE
REST =	20.000 - REALTORS ESTIMATE OF BANK (FEET)	A =	0.500 - WEIGHTING FACTOR
MLT1 =	2.500 - WEIGHTING FACTOR	MLT2 =	0.500 - WEIGHTING FACTOR
T =	30.000 - INVESTMENT HORIZON (YEARS)	PLV =	175.000 - DISTANCE FROM ROAD TO SETBACK (FEET)
BANK =	23.750 - POINT WHERE MORTGAGE BECOMES UNAVAILABLE	STPL =	50.000 - POINT OF SHARP STRUCTURE VALUE DECLINE
STPB =	36.875 - 1/2 WAY BETWEEN BANK AND STEPL (FEET)	BASE =	20.784 - LENGTH OF THE BLUFF BASE (FEET)

INPUT PARAMETERS / OUTPUT PARAMETERS

AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. ($)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	17.16	0.950	0	2.50	0.13	0.0	0.0	17.16	17.16	-17.16	-122.45	-122.45
3.90	.100	17.16	0.950	1	6.40	0.32	0.0	0.0	15.60	32.76	-32.76	0.0	-122.45
5.40	.100	17.16	0.950	2	11.80	0.59	0.0	0.0	14.18	46.94	-46.94	0.0	-122.45
4.80	.100	17.16	0.950	3	16.60	0.83	0.0	0.0	12.89	59.83	-59.83	0.0	-122.45
4.40	.100	17.16	0.950	4	21.00	1.05	29.46	29.46	11.72	71.55	-42.09	-29.46	-151.91
3.90	.100	17.16	0.950	5	24.90	1.25	0.0	29.46	10.66	82.21	-52.75	0.0	-151.91
3.30	.100	17.16	0.950	6	28.20	1.41	0.0	29.46	9.69	91.90	-62.43	0.0	-151.91
2.60	.100	17.16	0.950	7	30.80	1.54	0.0	29.46	8.81	100.70	-71.24	0.0	-151.91
1.90	.100	17.16	0.930	8	32.70	1.67	0.0	29.46	8.01	108.71	-79.24	0.0	-151.91
1.70	.100	17.16	0.910	9	34.40	1.83	0.0	29.46	7.28	115.99	-86.52	0.0	-151.91
3.20	.100	17.16	0.890	10	37.60	2.18	0.0	29.46	6.62	122.60	-93.14	0.0	-151.91
2.90	.100	17.16	0.870	11	40.50	2.56	0.0	29.46	6.01	128.62	-99.15	0.0	-151.91
2.40	.100	17.16	0.850	12	42.90	2.92	0.0	29.46	5.47	134.08	-104.62	0.0	-151.91
1.30	.100	17.16	0.830	13	44.20	3.14	0.0	29.46	4.97	139.05	-109.59	0.0	-151.91
0.70	.100	17.16	0.810	14	44.90	3.27	0.0	29.46	4.52	143.57	-114.11	0.0	-151.91
1.40	.100	17.16	0.790	15	46.30	3.56	0.0	29.46	4.11	147.68	-118.22	0.0	-151.91
2.30	.100	17.16	0.770	16	48.60	4.09	0.0	29.46	3.73	151.42	-121.95	0.0	-151.91
2.80	.100	17.16	0.750	17	51.40	4.79	0.0	29.46	3.40	154.81	-125.35	0.0	-151.91
2.80	.100	17.16	0.730	18	54.20	5.55	0.0	29.46	3.09	157.90	-128.43	0.0	-151.91
3.30	.100	17.16	0.710	19	57.50	6.51	0.0	29.46	2.81	160.70	-131.24	0.0	-151.91
4.10	.100	17.16	0.690	20	61.60	7.78	0.0	29.46	2.55	163.25	-133.79	0.0	-151.91
3.90	.100	17.16	0.670	21	65.50	9.06	0.0	29.46	2.32	165.57	-136.11	0.0	-151.91
4.30	.100	17.16	0.650	22	69.80	10.57	0.0	29.46	2.11	167.68	-138.22	0.0	-151.91
4.80	.100	17.16	0.630	23	74.60	12.34	0.0	29.46	1.92	169.60	-140.13	0.0	-151.91
5.40	.100	17.16	0.610	24	80.00	14.45	0.0	29.46	1.74	171.34	-141.87	0.0	-151.91
5.40	.100	17.16	0.590	25	85.40	16.66	0.0	29.46	1.58	172.92	-143.46	0.0	-151.91
4.90	.100	0.0	0.570	26	90.30	18.77	0.0	29.46	0.0	172.92	-143.46	0.0	-151.91
4.60	.100	0.0	0.550	27	94.90	20.84	-29.46	-0.00	0.0	172.92	-172.92	0.0	-151.91
3.40	.100	0.0	0.530	28	98.30	22.44	0.0	-0.00	0.0	172.92	-172.92	0.0	-151.91
4.40	.100	0.0	0.510	29	102.70	24.59	0.0	-0.00	0.0	172.92	-172.92	0.0	-151.91
4.20	.100	0.0	0.490	30	106.90	26.74	0.0	-0.00	0.0	172.92	-172.92	0.0	-151.91

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY UNIVERSITY OF MICHIGAN VERSION #2 DECEMBER 1978

OFFSHORE BREAKWATER - 6000 FT STRUCTURE - 25 YEAR BOND
CZL-20 LAUFR (SPS)
NUMBER OF PROPERTIES PROCESSED = 1 TOTAL LENGTH OF SHORELINE = 50.00

DPTH =	200.000 - DEPTH OF THE LOT (FEET)	L =	50.000 -	FRONT FOOTAGE OF LOT IN (FEET)
FOUN =	0.0 - DISTANCE FROM FOUNDATION TO BLUFF (FEET)	HOME =	0.0 -	DEPTH OF THE HOME (FEET)
RSET =	140.000 - RECCOMENDED SET BACK DISTANCE (FEET)	FSET =	35.000 -	SET BACK IN FRONT OF HOME (FEET)
H =	36.000 - HEIGTH OF THE BLUFF (FEET)	TH =	1.047 -	ANGLE OF THE BLUFF (RADIANS)
TV =	7500.000 - LAKESIDE LAND VALUE ($)	LV =	2250.000 -	INLAND LAND VALUE ($)
SV =	0.0 - HOME OR STRUCTURE VALUE ($)	RESR =	1.000 -	RECESSION RATE MODIFIER
LRES =	3.667 - LONG TERM RECESSION RATE (FEET/YEAR)	AEST =	5250.000 -	ASTHETIC VALUE ($)
COST =	6000.000 - COST TO MOVE HOME ($)	RI =	0.100 -	DISCOUNTING RATE
REST =	23.000 - REALTORS ESTIMATE OF BANK (FEET)	A =	0.500 -	WEIGHTING FACTOR
MLT1 =	2.500 - WEIGHTING FACTOR	MLT2 =	0.500 -	WEIGHTING FACTOR
T =	30.000 - INVESTMENT HORIZON (YEARS)	PLV =	175.000 -	DISTANCE FROM ROAD TO SETBACK (FEET)
BANK =	23.750 - POINT WHERE MORTGAGE BECOMES UNAVAILABLE	STPL =	50.000 -	POINT OF SHARP STRUCTURE VALUE DECLINE
STPB =	36.875 - 1/2 WAY BETWEEN BANK AND STEEL (FEET)	BASF =	20.794 -	LENGTH OF THE BLUFF BASE (FEET)

INPUT PARAMETERS					OUTPUT PARAMETERS								
AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	17.16	0.950	0	2.50	0.13	0.0	0.0	17.16	17.16	-17.16	-120.00	-120.00
3.90	.100	17.16	0.950	1	6.40	0.32	0.0	0.0	15.60	32.76	-32.76	0.0	-120.00
5.40	.100	17.16	0.950	2	11.80	0.59	0.0	0.0	14.18	46.94	-46.94	0.0	-120.00
4.80	.100	17.16	0.950	3	16.60	0.83	0.0	0.0	12.89	59.83	-59.83	0.0	-120.00
4.40	.100	17.16	0.950	4	21.00	1.05	28.88	28.88	11.72	71.55	-42.68	-28.88	-148.88
3.90	.100	17.16	0.950	5	24.90	1.25	0.0	28.88	10.66	82.21	-53.33	0.0	-148.88
3.30	.100	17.16	0.950	6	28.20	1.41	86.64	115.52	9.69	91.90	23.62	-86.64	-235.52
2.60	.100	17.16	0.950	7	30.80	1.54	0.04	115.55	8.81	100.70	14.85	-0.04	-235.55
1.90	.100	17.16	0.930	8	32.70	1.67	0.04	115.60	8.01	108.71	6.89	-0.04	-235.60
1.73	.100	17.16	0.910	9	34.40	1.83	0.05	115.64	7.28	115.99	-0.34	-0.05	-235.64
3.20	.100	17.16	0.890	10	37.60	2.18	0.11	115.76	6.62	122.60	-6.84	-0.11	-235.76
2.90	.100	17.16	0.870	11	40.50	2.56	0.13	115.89	6.01	128.62	-12.73	-0.13	-235.89
2.40	.100	17.16	0.850	12	42.90	2.92	0.13	116.02	5.47	134.08	-18.07	-0.13	-236.02
1.30	.100	17.16	0.830	13	44.20	3.14	0.08	116.10	4.97	139.05	-22.96	-0.08	-236.10
0.70	.100	17.16	0.810	14	44.90	3.27	0.04	116.14	4.52	143.57	-27.43	-0.04	-236.14
1.40	.100	17.16	0.790	15	46.30	3.56	0.09	116.23	4.11	147.68	-31.45	-0.09	-236.23
2.30	.100	17.16	0.770	16	48.60	4.09	0.17	116.40	3.73	151.42	-35.01	-0.17	-236.40
2.80	.100	17.16	0.750	17	51.40	4.79	0.23	116.63	3.40	154.81	-38.18	-0.23	-236.63
2.80	.100	17.16	0.730	18	54.20	5.55	0.25	116.88	3.09	157.90	-41.02	-0.25	-236.88
3.30	.100	17.16	0.710	19	57.50	6.51	0.33	117.21	2.81	160.70	-43.50	-0.33	-237.21
4.10	.100	17.16	0.690	20	61.60	7.78	0.46	117.67	2.55	163.25	-45.59	-0.46	-237.67
3.90	.100	17.16	0.670	21	65.50	9.06	0.49	118.15	2.32	165.57	-47.42	-0.49	-238.15
4.30	.100	17.16	0.650	22	69.80	10.57	0.59	118.74	2.11	167.68	-48.94	-0.59	-238.74
4.80	.100	17.16	0.630	23	74.60	12.34	0.73	119.48	1.92	169.60	-50.12	-0.73	-239.48
5.40	.100	17.16	0.610	24	80.00	14.45	0.91	120.39	1.74	171.34	-50.95	-0.91	-240.39
5.40	.100	17.16	0.590	25	85.40	16.66	1.01	121.40	1.58	172.92	-51.53	-1.01	-241.40
4.90	.100	0.0	0.570	26	90.30	18.77	1.00	122.39	0.0	172.92	-50.53	-1.00	-242.39
4.60	.100	0.0	0.550	27	94.90	20.84	-27.87	94.52	0.0	172.92	-78.40	-1.01	-243.40
3.40	.100	0.0	0.530	28	98.30	22.44	0.79	95.31	0.0	172.92	-77.61	-0.79	-244.18
4.40	.100	0.0	0.510	29	102.70	24.59	1.07	96.38	0.0	172.92	-76.54	-1.07	-245.26
4.20	.100	0.0	0.490	30	106.90	26.74	-85.55	10.84	0.0	172.92	-162.09	-1.08	-246.34

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY UNIVERSITY OF MICHIGAN VERSION #2 DECEMBER 1978

OFFSHORE BREAKWATER - 6000 FT STRUCTURE - 25 YEAR BOND
CZL-30 MC ROBERTS (9M18)
NUMBER OF PROPERTIES PROCESSED = 1 TOTAL LENGTH OF SHORELINE = 100.00

DPTH =	335.000 - DEPTH OF THE LOT (FEET)	L =	100.000 - FRONT FOOTAGE OF LOT IN (FEET)
POUH =	0.0 - DISTANCE FROM FOUNDATION TO BLUFF (FEET)	HOME =	0.0 - DEPTH OF THE HOME (FEET)
RSET =	140.000 - RECCOMENDED SET BACK DISTANCE (FEET)	PSET =	35.000 - SET BACK IN FRONT OF HOME (FEET)
H =	35.000 - HEIGTH OF THE BLUFF (FEET)	TH =	1.047 - ANGLE OF THE BLUFF (RADIANS)
TV =	15000.000 - LAKESIDE LAND VALUE ($)	LV =	4500.000 - INLAND LAND VALUE ($)
SV =	0.0 - HOME OR STRUCTURE VALUE ($)	RESR =	1.000 - RECESSION RATE MODIFIER
LRES =	3.667 - LONG TERM RECESSION RATE (FEET/YEAR)	AEST =	10500.000 - ASTHETIC VALUE ($)
COST =	6000.000 - COST TO MOVE HOME ($)	RI =	0.100 - DISCOUNTING RATE
REST =	20.000 - REALTORS ESTIMATE OF BANK (FEET)	A =	0.500 - WEIGHTING FACTOR
WLT1 =	2.500 - WEIGHTING FACTOR	WLT2 =	0.500 - WEIGHTING FACTOR
T =	30.000 - INVESTMENT HORIZON (YEARS)	PLV =	175.000 - DISTANCE FROM ROAD TO SETBACK (FEET)
BANK =	23.750 - POINT WHERE MORTGAGE BECOMES UNAVAILABLE	STPL =	50.000 - POINT OF SHARP STRUCTURE VALUE DECLINE
STPB =	36.875 - 1/2 WAY BETWEEN BANK AND STEPL (FEET)	BASE =	20.784 - LENGTH OF THE BLUFF BASE (FEET)

INPUT PARAMETERS OUTPUT PARAMETERS

AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	17.16	0.950	0	2.50	0.13	0.0	0.0	17.16	17.16	-17.16	-60.00	-60.00
3.90	.100	17.16	0.950	1	6.40	0.32	0.0	0.0	15.60	32.76	-32.76	0.0	-60.00
5.40	.100	17.16	0.950	2	11.80	0.59	0.0	0.0	14.18	46.94	-46.94	0.0	-60.00
4.80	.100	17.16	0.950	3	16.60	0.83	0.0	0.0	12.89	59.83	-59.83	0.0	-60.00
4.40	.100	17.16	0.950	4	21.00	1.05	28.88	28.88	11.72	71.55	-42.68	-28.88	-88.88
3.90	.100	17.16	0.950	5	24.90	1.25	0.0	28.88	10.66	82.21	-53.33	0.0	-88.88
3.30	.100	17.16	0.950	6	28.20	1.41	0.0	28.88	9.69	91.90	-63.02	0.0	-88.88
2.60	.100	17.16	0.950	7	30.80	1.54	0.0	28.88	8.81	100.70	-71.83	0.0	-88.88
1.90	.100	17.16	0.930	8	32.70	1.67	0.0	28.88	8.01	108.71	-79.83	0.0	-88.88
1.70	.100	17.16	0.910	9	34.40	1.83	0.0	28.88	7.28	115.99	-87.11	0.0	-88.88
3.20	.100	17.16	0.890	10	37.60	2.18	0.0	28.88	6.62	122.60	-93.73	0.0	-88.88
2.90	.100	17.16	0.870	11	40.50	2.56	0.0	28.88	6.01	128.62	-99.74	0.0	-88.88
2.40	.100	17.16	0.850	12	42.90	2.92	0.0	28.88	5.47	134.08	-105.21	0.0	-88.88
1.30	.100	17.16	0.830	13	44.20	3.14	0.0	28.88	4.97	139.05	-110.18	0.0	-88.88
0.70	.100	17.16	0.810	14	44.90	3.27	0.0	28.88	4.52	143.57	-114.70	0.0	-88.88
1.40	.100	17.16	0.790	15	46.30	3.56	0.0	28.88	4.11	147.68	-118.81	0.0	-88.88
2.30	.100	17.16	0.770	16	48.60	4.09	0.0	28.88	3.73	151.42	-122.54	0.0	-88.88
2.80	.100	17.16	0.750	17	51.40	4.79	0.0	28.88	3.40	154.81	-125.94	0.0	-88.88
2.80	.100	17.16	0.730	18	54.20	5.55	0.0	28.88	3.09	157.90	-129.02	0.0	-88.88
3.30	.100	17.16	0.710	19	57.50	6.51	0.0	28.88	2.81	160.70	-131.83	0.0	-88.88
4.10	.100	17.16	0.690	20	61.60	7.78	0.0	28.88	2.55	163.25	-134.38	0.0	-88.88
3.90	.100	17.16	0.670	21	65.50	9.06	0.0	28.88	2.32	165.57	-136.70	0.0	-88.88
4.30	.100	17.16	0.650	22	69.80	10.57	0.0	28.88	2.11	167.68	-138.81	0.0	-88.88
4.80	.100	17.16	0.630	23	74.60	12.34	0.0	28.88	1.92	169.60	-140.72	0.0	-88.88
5.40	.100	17.16	0.610	24	80.00	14.45	0.0	28.88	1.74	171.34	-142.46	0.0	-88.88
5.40	.100	17.16	0.590	25	85.40	16.66	0.0	28.88	1.58	172.92	-144.05	0.0	-88.88
4.90	.100	0.0	0.570	26	90.30	18.77	0.0	28.88	0.0	172.92	-144.05	0.0	-88.88
4.60	.100	0.0	0.550	27	94.90	20.84	-28.88	-0.00	0.0	172.92	-172.92	0.0	-88.88
3.40	.100	0.0	0.530	28	98.30	22.44	0.0	-0.00	0.0	172.92	-172.92	0.0	-88.88
4.40	.100	0.0	0.510	29	102.70	24.59	0.0	-0.00	0.0	172.92	-172.92	0.0	-88.88
4.20	.100	0.0	0.490	30	106.90	26.74	0.0	-0.00	0.0	172.92	-172.92	0.0	-88.88

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY   UNIVERSITY OF MICHIGAN   VERSION #2 DECEMBER 1978

OFFSHORE BREAKWATER - 6000 FT STRUCTURE - 25 YEAR BOND
CZL-40   SESANC   (SM19)
NUMBER OF PROPERTIES PROCESSED = 1   TOTAL LENGTH OF SHORELINE = 100.00

DPTH = 332.000 - DEPTH OF THE LOT (FEET)
FOUN = 20.000 - DISTANCE FROM FOUNDATION TO BLUFF (FEET)
RSET = 140.000 - RECCOMENDED SET BACK DISTANCE (FEET)
H = 35.000 - HEIGTH OF THE BLUFF (FEET)
TV = 15000.000 - LAKESIDE LAND VALUE ($)
SV = 32411.000 - HOME OR STRUCTURE VALUE ($)
LRES = 3.667 - LONG TERM RECESSION RATE (FEET/YEAR)
COST = 6000.000 - COST TO MOVE HOME ($)
REST = 25.000 - REALTORS ESTIMATE OF BANK (FEET)
MLT1 = 2.500 - WEIGHTING FACTOR
T = 30.000 - INVESTMENT HORIZON (YEARS)
BANK = 23.750 - POINT WHERE MORTGAGE BECOMES UNAVAILABLE
STPU = 36.875 - 1/2 WAY BETWEEN BANK AND STEPL (FEET)

L = 100.000 - FRONT FOOTAGE OF LOT IN (FEET)
HOME = 50.000 - DEPTH OF THE HOME (FEET)
PSET = 35.000 - SET BACK IN FRONT OF HOME (FEET)
TH = 1.047 - ANGLE OF THE BLUFF (RADIANS)
LV = 4500.000 - INLAND LAND VALUE ($)
RESR = 1.000 - RECESSION RATE MODIFIER
AEST = 10500.000 - ASTHETIC VALUE ($)
RI = 0.100 - DISCOUNTING RATE
A = 0.500 - WEIGHTING FACTOR
MLT2 = 0.500 - WEIGHTING FACTOR
PLV = 225.000 - DISTANCE FROM ROAD TO SETBACK (FEET)
STPL = 50.000 - POINT OF SHARP STRUCTURE VALUE DECLINE
BASE = 20.784 - LENGTH OF THE BLUFF BASE (FEET)

INPUT PARAMETERS					OUTPUT PARAMETERS									
AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	17.16	0.950	0	2.50	0.13	0.0	0.0	17.16	17.16	-17.16	189.56	189.56
3.90	.100	17.16	0.950	1	6.40	0.32	0.0	0.0	15.60	32.76	-32.76	0.0	189.56
5.40	.100	17.16	0.950	2	11.80	0.59	0.0	0.0	14.18	46.94	-46.94	0.0	189.56
4.80	.100	17.16	0.950	3	16.60	0.83	0.0	0.0	12.89	59.83	-59.83	0.0	189.56
4.40	.100	17.16	0.950	4	21.00	1.05	135.83	135.83	11.72	71.55	64.28	78.08	267.65
3.90	.100	17.16	0.950	5	24.90	1.25	0.0	135.83	10.66	82.21	53.62	0.0	267.65
3.30	.100	17.16	0.950	6	28.20	1.41	0.0	135.83	9.69	91.90	43.94	0.0	267.65
2.60	.100	17.16	0.950	7	30.80	1.54	0.0	135.83	8.81	100.70	35.13	0.0	267.65
1.90	.100	17.16	0.930	8	32.70	1.67	0.0	135.83	8.01	108.71	27.12	0.0	267.65
1.70	.100	17.16	0.910	9	34.40	1.83	0.0	135.83	7.28	115.99	19.85	0.0	267.65
3.20	.100	17.16	0.890	10	37.60	2.18	0.0	135.83	6.62	122.60	13.23	0.0	267.65
2.90	.100	17.16	0.870	11	40.50	2.56	0.0	135.83	6.01	128.62	7.22	0.0	267.65
2.40	.100	17.16	0.850	12	42.90	2.92	0.0	135.83	5.47	134.08	1.75	0.0	267.65
1.30	.100	17.16	0.830	13	44.20	3.14	0.0	135.83	4.97	139.05	-3.22	0.0	267.65
0.70	.100	17.16	0.810	14	44.90	3.27	0.0	135.83	4.52	143.57	-7.74	0.0	267.65
1.40	.100	17.16	0.790	15	46.30	3.56	0.0	135.83	4.11	147.68	-11.85	0.0	267.65
2.30	.100	17.16	0.770	16	48.60	4.09	0.0	135.83	3.73	151.42	-15.58	0.0	267.65
2.80	.100	17.16	0.750	17	51.40	4.79	0.0	135.83	3.40	154.81	-18.98	0.0	267.65
2.80	.100	17.16	0.730	18	54.20	5.55	0.0	135.83	3.09	157.90	-22.07	0.0	267.65
3.30	.100	17.16	0.710	19	57.50	6.51	0.0	135.83	2.81	160.70	-24.87	0.0	267.65
4.10	.100	17.16	0.690	20	61.60	7.78	0.0	135.83	2.55	163.25	-27.42	0.0	267.65
3.90	.100	17.16	0.670	21	65.50	9.06	0.0	135.83	2.32	165.57	-29.74	0.0	267.65
4.30	.100	17.16	0.650	22	69.80	10.57	0.0	135.83	2.11	167.68	-31.85	0.0	267.65
4.80	.100	17.16	0.630	23	74.60	12.34	0.0	135.83	1.92	169.60	-33.76	0.0	267.65
5.40	.100	17.16	0.610	24	80.00	14.45	0.0	135.83	1.74	171.34	-35.51	0.0	267.65
5.40	.100	17.16	0.590	25	85.40	16.66	0.0	135.83	1.58	172.92	-37.09	0.0	267.65
4.90	.100	0.0	0.570	26	90.30	18.77	0.0	135.83	0.0	172.92	-37.09	0.0	267.65
4.60	.100	0.0	0.550	27	94.90	20.84	-135.83	-0.00	0.0	172.92	-172.92	0.0	267.65
3.40	.100	0.0	0.530	28	98.30	22.44	0.0	-0.00	0.0	172.92	-172.92	0.0	267.65
4.40	.100	0.0	0.510	29	102.70	24.59	0.0	-0.00	0.0	172.92	-172.92	0.0	267.65
4.20	.100	0.0	0.490	30	106.90	26.74	0.0	-0.00	0.0	172.92	-172.92	0.0	267.65

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY UNIVERSITY OF MICHIGAN VERSION #2 DECEMBER 1978

OFFSHORE BREAKWATER - 6000 FT STRUCTURE - 25 YEAR BOND
CZL-50 COLLINS (SM1)
NUMBER OF PROPERTIES PROCESSED = 1 TOTAL LENGTH OF SHORELINE = 110.00

DPTH =	338.000	- DEPTH OF THE LOT (FEET)	L =	110.000	- FRONT FOOTAGE OF LOT IN (FEET)
FOUN =	40.000	- DISTANCE FROM FOUNDATION TO BLUFF (FEET)	HOME =	60.000	- DEPTH OF THE HOME (FEET)
RSET =	140.000	- RECCOMENDED SET BACK DISTANCE (FEET)	FSET =	35.000	- SET BACK IN FRONT OF HOME (FEET)
H =	36.000	- HEIGTH OF THE BLUFF (FEET)	TH =	1.047	- ANGLE OF THE BLUFF (RADIANS)
TV =	16500.000	- LAKESIDE LAND VALUE ($)	LV =	4950.000	- INLAND LAND VALUE ($)
SV =	26360.000	- HOME OR STRUCTURE VALUE ($)	RESR =	1.000	- RECESSION RATE MODIFIER
LRES =	3.667	- LONG TERM RECESSION RATE (FEET/YEAR)	AEST =	11550.000	- ASTHETIC VALUE ($)
COST =	6000.000	- COST TO MOVE HOME ($)	RI =	0.100	- DISCOUNTING RATE
REST =	20.000	- REALTORS ESTIMATE OF BANK (FEET)	A =	0.500	- WEIGHTING FACTOR
MLT1 =	2.500	- WEIGHTING FACTOR	MLT2 =	0.500	- WEIGHTING FACTOR
T =	30.000	- INVESTMENT HORIZON (YEARS)	PLV =	235.000	- DISTANCE FROM ROAD TO SETBACK (FEET)
BANK =	23.750	- POINT WHERE MORTGAGE BECOMES UNAVAILABLE	STPL =	50.000	- POINT OF SHARP STRUCTURE VALUE DECLINE
STPB =	36.875	- 1/2 WAY BETWEEN BANK AND STPL (FEET)	BASE =	20.784	- LENGTH OF THE BLUFF BASE (FEET)

INPUT PARAMETERS — OUTPUT PARAMETERS

AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	17.16	0.950	0	2.50	0.13	0.0	0.0	17.16	17.16	-17.16	24.53	24.53
3.90	.100	17.16	0.950	1	6.40	0.32	26.31	26.31	15.60	32.76	-6.45	26.31	50.84
5.40	.100	17.16	0.950	2	11.80	0.59	43.38	69.69	14.18	46.94	22.75	43.38	94.23
4.80	.100	17.16	0.950	3	16.60	0.83	35.75	105.44	12.89	59.83	45.61	35.75	129.97
4.40	.100	17.16	0.950	4	21.00	1.05	28.88	134.32	11.72	71.55	62.76	-28.88	101.10
3.90	.100	17.16	0.950	5	24.90	1.25	0.0	134.32	10.66	82.21	52.11	0.0	101.10
3.30	.100	17.16	0.950	6	28.20	1.41	0.0	134.32	9.69	91.90	42.42	0.0	101.10
2.60	.100	17.16	0.950	7	30.80	1.54	0.0	134.32	8.81	100.70	33.61	0.0	101.10
1.90	.100	17.16	0.930	8	32.70	1.67	0.0	134.32	8.01	108.71	25.61	0.0	101.10
1.70	.100	17.16	0.910	9	34.40	1.83	0.0	134.32	7.28	115.99	18.33	0.0	101.10
3.20	.100	17.16	0.890	10	37.60	2.18	0.0	134.32	6.62	122.60	11.71	0.0	101.10
2.90	.100	17.16	0.870	11	40.50	2.56	79.08	213.40	6.01	128.62	84.78	79.08	180.18
2.40	.100	17.16	0.850	12	42.90	2.92	0.0	213.40	5.47	134.08	79.31	0.0	180.18
1.30	.100	17.16	0.830	13	44.20	3.14	-0.09	213.31	4.97	139.05	74.25	0.0	180.18
0.70	.100	17.16	0.810	14	44.90	3.27	-1.07	212.24	4.52	143.57	68.67	0.0	180.18
1.40	.100	17.16	0.790	15	46.30	3.56	-2.36	209.88	4.11	147.68	62.20	0.0	180.18
2.30	.100	17.16	0.770	16	48.60	4.09	-4.25	205.63	3.73	151.42	54.21	0.0	180.18
2.80	.100	17.16	0.750	17	51.40	4.79	-5.62	200.00	3.40	154.81	45.19	0.0	180.18
2.80	.100	17.16	0.730	18	54.20	5.55	-6.07	193.93	3.09	157.90	36.03	0.0	180.18
3.30	.100	17.16	0.710	19	57.50	6.51	-7.69	186.24	2.81	160.70	25.54	0.0	180.18
4.10	.100	17.16	0.690	20	61.60	7.78	-10.21	176.03	2.55	163.25	12.78	0.0	180.18
3.90	.100	17.16	0.670	21	65.50	9.06	-10.34	165.69	2.32	165.57	0.12	0.0	180.18
4.30	.100	17.16	0.650	22	69.80	10.57	-12.09	153.60	2.11	167.68	-14.08	0.0	180.18
4.80	.100	17.16	0.630	23	74.60	12.34	-14.27	139.33	1.92	169.60	-30.26	0.0	180.18
5.40	.100	17.16	0.610	24	80.00	14.45	-16.92	122.41	1.74	171.34	-48.92	0.0	180.18
5.40	.100	17.16	0.590	25	85.40	16.66	-14.46	107.95	1.58	172.92	-64.97	0.0	180.18
4.90	.100	0.0	0.570	26	90.30	18.77	0.0	107.95	0.0	172.92	-64.97	0.0	180.18
4.60	.100	0.0	0.550	27	94.90	20.84	-28.88	79.08	0.0	172.92	-93.84	0.0	180.18
3.40	.100	0.0	0.530	28	98.30	22.44	0.0	79.08	0.0	172.92	-93.84	0.0	180.18
4.40	.100	0.0	0.510	29	102.70	24.59	0.0	79.08	0.0	172.92	-93.84	0.0	180.18
4.20	.100	0.0	0.490	30	106.90	26.74	0.0	79.08	0.0	172.92	-93.84	0.0	180.18

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY UNIVERSITY OF MICHIGAN VERSION #2 DECEMBER 1978

OFFSHORE BREAKWATER - 6000 FT STRUCTURE - 25 YEAR BOND
CZL-60 FETRIEGE (9M2)
NUMBER OF PROPERTIES PROCESSED = 1 TOTAL LENGTH OF SHORELINE = 750.00

DPTH = 470.000 - DEPTH OF THE LOT (FEET)	L = 750.000 - FRONT FOOTAGE OF LOT IN (FEET)
FOUN = 43.000 - DISTANCE FROM FOUNDATION TO BLUFF (FEET)	HOME = 60.000 - DEPTH OF THE HOME (FEET)
RSET = 140.000 - RECCOMENDED SET BACK DISTANCE (FEET)	FSET = 35.000 - SET BACK IN FRONT OF HOME (FEET)
H = 36.000 - HEIGTH OF THE BLUFF (FEET)	TH = 1.047 - ANGLE OF THE BLUFF (RADIANS)
TV =100000.000 - LAKESIDE LAND VALUE ($)	LV = 30000.000 - INLAND LAND VALUE ($)
SV =100000.000 - HOME OR STRUCTURE VALUE ($)	RESR = 1.000 - RECESSION RATE MODIFIER
LRES = 3.667 - LONG TERM RECESSION RATE (FEET/YEAR)	AEST = 70000.000 - ASTHETIC VALUE ($)
COST = 6000.000 - COST TO MOVE HOME ($)	RI = 0.100 - DISCOUNTING RATE
REST = 20.000 - REALTORS ESTIMATE OF BANK (FEET)	A = 0.500 - WEIGHTING FACTOR
MLT1 = 2.500 - WEIGHTING FACTOR	MLT2 = 0.500 - WEIGHTING FACTOR
T = 30.000 - INVESTMENT HORIZON (YEARS)	PLV = 235.000 - DISTANCE FROM ROAD TO SETBACK (FEET)
BANK = 23.750 - POINT WHERE MORTGAGE BECOMES UNAVAILABLE	STPL = 50.000 - POINT OF SHARP STRUCTURE VALUE DECLINE
STPB = 36.875 - 1/2 WAY BETWEEN BANK AND STEPL (FEET)	BASE = 20.784 - LENGTH OF THE BLUFF BASE (FEET)

INPUT PARAMETERS					OUTPUT PARAMETERS									
AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	17.16	0.950	0	2.50	0.13	0.0	0.0	17.16	17.16	-17.16	36.00	36.00
3.90	.100	17.16	0.950	1	6.40	0.32	14.64	14.64	15.60	32.76	-18.12	14.64	50.64
5.40	.100	17.16	0.950	2	11.80	0.59	24.14	38.78	14.18	46.94	-8.17	24.14	74.78
4.80	.100	17.16	0.950	3	16.60	0.83	19.89	58.67	12.89	59.83	-1.17	19.89	94.67
4.40	.100	17.16	0.950	4	21.00	1.05	25.67	84.33	11.72	71.55	12.78	-25.67	69.00
3.90	.100	17.16	0.950	5	24.90	1.25	0.0	84.33	10.66	82.21	2.12	0.0	69.00
3.30	.100	17.16	0.950	6	28.20	1.41	0.0	84.33	9.69	91.90	-7.56	0.0	69.00
2.60	.100	17.16	0.950	7	30.80	1.54	0.0	84.33	8.81	100.70	-16.37	0.0	69.00
1.90	.100	17.16	0.930	8	32.70	1.67	0.0	84.33	8.01	108.71	-24.37	0.0	69.00
1.70	.100	17.16	0.910	9	34.40	1.83	0.0	84.33	7.28	115.99	-31.65	0.0	69.00
3.20	.100	17.16	0.890	10	37.60	2.18	0.0	84.33	6.62	122.60	-38.27	0.0	69.00
2.90	.100	17.16	0.870	11	40.50	2.56	44.00	128.33	6.01	128.62	-0.28	44.00	113.00
2.40	.100	17.16	0.850	12	42.90	2.92	0.0	128.33	5.47	134.08	-5.75	0.0	113.00
1.30	.100	17.16	0.830	13	44.20	3.14	-0.05	128.28	4.97	139.05	-10.77	0.0	113.00
0.70	.100	17.16	0.810	14	44.90	3.27	-0.59	127.69	4.52	143.57	-15.88	0.0	113.00
1.40	.100	17.16	0.790	15	46.30	3.56	-1.31	126.38	4.11	147.68	-21.31	0.0	113.00
2.30	.100	17.16	0.770	16	48.60	4.09	-2.36	124.01	3.73	151.42	-27.40	0.0	113.00
2.80	.100	17.16	0.750	17	51.40	4.79	-3.13	120.88	3.40	154.81	-33.93	0.0	113.00
2.80	.100	17.16	0.730	18	54.20	5.55	-3.38	117.50	3.09	157.90	-40.39	0.0	113.00
3.30	.100	17.16	0.710	19	57.50	6.51	-4.28	113.23	2.81	160.70	-47.48	0.0	113.00
4.10	.100	17.16	0.690	20	61.60	7.78	-5.68	107.54	2.55	163.25	-55.71	0.0	113.00
3.90	.100	17.16	0.670	21	65.50	9.06	-5.75	101.79	2.32	165.57	-63.78	0.0	113.00
4.30	.100	17.16	0.650	22	69.80	10.57	-6.73	95.06	2.11	167.68	-72.62	0.0	113.00
4.80	.100	17.16	0.630	23	74.60	12.34	-7.94	87.13	1.92	169.60	-82.47	0.0	113.00
5.40	.100	17.16	0.610	24	80.00	14.45	-9.41	77.71	1.74	171.34	-93.63	0.0	113.00
5.40	.100	17.16	0.590	25	85.40	16.66	-8.05	69.67	1.58	172.92	-103.26	0.0	113.00
4.90	.100	0.0	0.570	26	90.30	18.77	0.0	69.67	0.0	172.92	-103.26	0.0	113.00
4.60	.100	0.0	0.550	27	94.90	20.84	-25.67	44.00	0.0	172.92	-128.92	0.0	113.00
3.40	.100	0.0	0.530	28	98.30	22.44	0.0	44.00	0.0	172.92	-128.92	0.0	113.00
4.40	.100	0.0	0.510	29	102.70	24.59	0.0	44.00	0.0	172.92	-128.92	0.0	113.00
4.20	.100	0.0	0.490	30	106.90	26.74	0.0	44.00	0.0	172.92	-128.92	0.0	113.00

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY UNIVERSITY OF MICHIGAN VERSION #2 DECEMBER 1978

OFFSHORE BREAKWATER - 6000 FT STRUCTURE - 25 YEAR BOND
CZL-70 TOWNSHIP FEEK (16N1)
NUMBER OF PROPERTIES PROCESSED = 1 TOTAL LENGTH OF SHORELINE = 165.00

DPTH =	400.000	- DEPTH OF THE LOT (FEET)
FOUN =	0.0	- DISTANCE FROM FOUNDATION TO BLUFF (FEET)
RSET =	140.000	- RECCOMENDED SET BACK DISTANCE (FEET)
H =	38.000	- HEIGTH OF THE BLUFF (FEET)
TV =	25000.000	- LAKESIDE LAND VALUE ($)
SV =	0.0	- HOME OR STRUCTURE VALUE ($)
LRES =	3.667	- LONG TERM RECESSION RATE (FEET/YEAR)
COST =	6000.000	- COST TO MOVE HOME ($)
REST =	20.000	- REALTORS ESTIMATE OF BANK (FEET)
WLT1 =	2.500	- WEIGHTING FACTOR
T =	30.000	- INVESTMENT HORIZON (YEARS)
BANK =	23.750	- POINT WHERE MORTGAGE BECOMES UNAVAILABLE
STPB =	35.875	- 1/2 WAY BETWEEN BANK AND STEPL (FEET)
L =	165.000	- FRONT FOOTAGE OF LOT IN (FEET)
HOME =	0.0	- DEPTH OF THE HOME (FEET)
PSET =	35.000	- SET BACK IN FRONT OF HOME (FEET)
TH =	0.489	- ANGLE OF THE BLUFF (RADIANS)
LV =	7500.000	- INLAND LAND VALUE ($)
RESR =	1.000	- RECESSION RATE MODIFIER
AEST =	17500.000	- ASTHETIC VALUE ($)
RI =	0.100	- DISCOUNTING RATE
A =	0.500	- WEIGHTING FACTOR
WLT2 =	0.500	- WEIGHTING FACTOR
PLV =	175.000	- DISTANCE FROM ROAD TO SETBACK (FEET)
STPL =	50.000	- POINT OF SHARP STRUCTURE VALUE DECLINE
BASE =	71.466	- LENGTH OF THE BLUFF BASE (FEET)

INPUT PARAMETERS | OUTPUT PARAMETERS

AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	17.16	0.950	0	2.50	0.13	0.0	0.0	17.16	17.16	-17.16	-36.36	-36.36
3.90	.100	17.16	0.950	1	6.40	0.32	0.0	0.0	15.60	32.76	-32.76	0.0	-36.36
5.40	.100	17.16	0.950	2	11.80	0.59	0.0	0.0	14.18	46.94	-46.94	0.0	-36.36
4.80	.100	17.16	0.950	3	16.60	0.83	0.0	0.0	12.89	59.83	-59.83	0.0	-36.36
4.40	.100	17.16	0.950	4	21.00	1.05	0.0	0.0	11.72	71.55	-71.55	0.0	-36.36
3.90	.100	17.16	0.950	5	24.90	1.25	0.0	0.0	10.66	82.21	-82.21	0.0	-36.36
3.30	.100	17.16	0.950	6	28.20	1.41	0.0	0.0	9.69	91.90	-91.90	0.0	-36.36
2.60	.100	17.16	0.950	7	30.80	1.54	0.0	0.0	8.81	100.70	-100.70	0.0	-36.36
1.90	.100	17.16	0.930	8	32.70	1.67	0.0	0.0	8.01	108.71	-108.71	0.0	-36.36
1.70	.100	17.16	0.910	9	34.40	1.83	0.0	0.0	7.28	115.99	-115.99	0.0	-36.36
3.20	.100	17.16	0.890	10	37.60	2.18	0.0	0.0	6.62	122.60	-122.60	0.0	-36.36
2.90	.100	17.16	0.870	11	40.50	2.56	0.0	0.0	6.01	128.62	-128.62	0.0	-36.36
2.40	.100	17.16	0.850	12	42.90	2.92	0.0	0.0	5.47	134.08	-134.08	0.0	-36.36
1.30	.100	17.16	0.830	13	44.20	3.14	0.0	0.0	4.97	139.05	-139.05	0.0	-36.36
0.70	.100	17.16	0.810	14	44.90	3.27	0.0	0.0	4.52	143.57	-143.57	0.0	-36.36
1.40	.100	17.16	0.790	15	46.30	3.56	0.0	0.0	4.11	147.68	-147.68	0.0	-36.36
2.30	.100	17.16	0.770	16	48.60	4.09	0.0	0.0	3.73	151.42	-151.42	0.0	-36.36
2.80	.100	17.16	0.750	17	51.40	4.79	0.0	0.0	3.40	154.81	-154.81	0.0	-36.36
2.80	.100	17.16	0.730	18	54.20	5.55	0.0	0.0	3.09	157.90	-157.90	0.0	-36.36
3.30	.100	17.16	0.710	19	57.50	6.51	0.0	0.0	2.81	160.70	-160.70	0.0	-36.36
4.10	.100	17.16	0.690	20	61.60	7.78	0.0	0.0	2.55	163.25	-163.25	0.0	-36.36
3.90	.100	17.16	0.670	21	65.50	9.06	0.0	0.0	2.32	165.57	-165.57	0.0	-36.36
4.30	.100	17.16	0.650	22	69.80	10.57	0.0	0.0	2.11	167.68	-167.68	0.0	-36.36
4.80	.100	17.16	0.630	23	74.60	12.34	29.17	29.17	1.92	169.60	-140.43	-29.17	-65.53
5.40	.100	17.16	0.610	24	80.00	14.45	0.0	29.17	1.74	171.34	-142.17	0.0	-65.53
5.40	.100	17.16	0.590	25	85.40	16.66	0.0	29.17	1.58	172.92	-143.76	0.0	-65.53
4.90	.100	0.0	0.570	26	90.30	18.77	0.0	29.17	0.0	172.92	-143.76	0.0	-65.53
4.60	.100	0.0	0.550	27	94.90	20.84	0.0	29.17	0.0	172.92	-143.76	0.0	-65.53
3.40	.100	0.0	0.530	28	98.30	22.44	0.0	29.17	0.0	172.92	-143.76	0.0	-65.53
4.40	.100	0.0	0.510	29	102.70	24.59	0.0	29.17	0.0	172.92	-143.76	0.0	-65.53
4.20	.100	0.0	0.490	30	106.90	26.74	0.0	29.17	0.0	172.92	-143.76	0.0	-65.53

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY   UNIVERSITY OF MICHIGAN   VERSION #2 DECEMBER 1978

OFFSHORE BREAKWATER - 6000 FT STRUCTURE - 25 YEAR BOND
CZL-80.1   SURFSIDE APARTMENTS - NORTH BUILDING (16M2)
NUMBER OF PROPERTIES PROCESSED = 1   TOTAL LENGTH OF SHORELINE = 137.00

DPTH = 350.000	- DEPTH OF THE LOT (FEET)	L = 137.000 - FRONT FOOTAGE OF LOT IN (FEET)
FOUN = 45.000	- DISTANCE FROM FOUNDATION TO BLUFF (FEET)	HOME = 90.000 - DEPTH OF THE HOME (FEET)
RSET = 140.000	- RECCOMENDED SET BACK DISTANCE (FEET)	PSET = 35.000 - SET BACK IN FRONT OF HOME (FEET)
H = 42.000	- HEIGTH OF THE BLUFF (FEET)	TH = 0.489 - ANGLE OF THE BLUFF (RADIANS)
TV = 25610.000	- LAKESIDE LAND VALUE ($)	LV = 7683.000 - INLAND LAND VALUE ($)
SV =475000.000	- HOME OR STRUCTURE VALUE ($)	RESR = 1.000 - RECESSION RATE MODIFIER
LRES = 3.667	- LONG TERM RECESSION RATE (FEET/YEAR)	AEST = 17927.000 - ASTHETIC VALUE ($)
COST = 6000.000	- COST TO MOVE HOME ($)	RI = 0.100 - DISCOUNTING RATE
REST = 20.000	- REALTORS ESTIMATE OF BANK (FEET)	A = 0.500 - WEIGHTING FACTOR
ALT1 = 2.500	- WEIGHTING FACTOR	ALT2 = 0.500 - WEIGHTING FACTOR
T = 30.000	- INVESTMENT HORIZON (YEARS)	PLV = 265.000 - DISTANCE FROM ROAD TO SETBACK (FEET)
BANK = 23.750	- POINT WHERE MORTGAGE BECOMES UNAVAILABLE	STPL = 50.000 - POINT OF SHARP STRUCTURE VALUE DECLINE
STPB = 36.875	- 1/2 WAY BETWEEN BANK AND STEPL (FEET)	BASE = 78.989 - LENGTH OF THE BLUFF BASE (FEET)

INPUT PARAMETERS   OUTPUT PARAMETERS

AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	17.16	0.950	0	2.50	0.13	0.0	0.0	17.16	17.16	-17.16	1100.36	1100.36
3.90	.100	17.16	0.950	1	6.40	0.32	0.0	0.0	15.60	32.76	-32.76	0.0	1100.36
5.40	.100	17.16	0.950	2	11.80	0.59	427.16	427.16	14.18	46.94	380.22	427.16	1527.53
4.80	.100	17.16	0.950	3	16.60	0.83	557.92	985.08	12.89	59.83	925.24	557.92	2085.44
4.40	.100	17.16	0.950	4	21.00	1.05	511.42	1496.50	11.72	71.55	1424.95	511.42	2596.87
3.90	.100	17.16	0.950	5	24.90	1.25	29.05	1525.55	10.66	82.21	1443.34	29.05	2625.91
3.30	.100	17.16	0.950	6	28.20	1.41	0.0	1525.55	9.69	91.90	1433.65	0.0	2625.91
2.60	.100	17.16	0.950	7	30.80	1.54	0.0	1525.55	8.81	100.70	1424.85	0.0	2625.91
1.90	.100	17.16	0.930	8	32.70	1.67	0.0	1525.55	8.01	108.71	1416.84	0.0	2625.91
1.70	.100	17.16	0.910	9	34.40	1.83	0.0	1525.55	7.28	115.99	1409.56	0.0	2625.91
3.20	.100	17.16	0.890	10	37.60	2.18	0.0	1525.55	6.62	122.60	1402.95	0.0	2625.91
2.90	.100	17.16	0.870	11	40.50	2.56	0.0	1525.55	6.01	128.62	1396.93	0.0	2625.91
2.40	.100	17.16	0.850	12	42.90	2.92	0.0	1525.55	5.47	134.08	1391.46	0.0	2625.91
1.30	.100	17.16	0.830	13	44.20	3.14	0.0	1525.55	4.97	139.05	1386.49	0.0	2625.91
0.70	.100	17.16	0.810	14	44.90	3.27	0.0	1525.55	4.52	143.57	1381.98	0.0	2625.91
1.40	.100	17.16	0.790	15	46.30	3.56	1144.17	2669.71	4.11	147.68	2522.03	1144.17	3770.08
2.30	.100	17.16	0.770	16	48.60	4.09	0.0	2669.71	3.73	151.42	2518.30	0.0	3770.08
2.80	.100	17.16	0.750	17	51.40	4.79	0.0	2669.71	3.40	154.81	2514.90	0.0	3770.08
2.80	.100	17.16	0.730	18	54.20	5.55	0.0	2669.71	3.09	157.90	2511.82	0.0	3770.08
3.30	.100	17.16	0.710	19	57.50	6.51	0.0	2669.71	2.81	160.70	2509.01	0.0	3770.08
4.10	.100	17.16	0.690	20	61.60	7.78	0.0	2669.71	2.55	163.25	2506.46	0.0	3770.08
3.90	.100	17.16	0.670	21	65.50	9.06	-109.04	2560.68	2.32	165.57	2395.11	0.0	3770.08
4.30	.100	17.16	0.650	22	69.80	10.57	-174.93	2385.75	2.11	167.68	2218.07	0.0	3770.08
4.80	.100	17.16	0.630	23	74.60	12.34	-206.43	2179.31	1.92	169.60	2009.72	0.0	3770.08
5.40	.100	17.16	0.610	24	80.00	14.45	-208.80	1970.51	1.74	171.34	1799.17	-35.99	3734.09
5.40	.100	17.16	0.590	25	85.40	16.66	-149.38	1821.13	1.58	172.92	1648.21	-107.96	3626.14
4.90	.100	0.0	0.570	26	90.30	18.77	-244.88	1576.25	0.0	172.92	1403.33	-0.02	3626.11
4.60	.100	0.0	0.550	27	94.90	20.84	-240.54	1335.71	0.0	172.92	1162.79	-0.06	3626.05
3.40	.100	0.0	0.530	28	98.30	22.44	-47.46	1288.25	0.0	172.92	1115.33	-0.07	3625.98
4.40	.100	0.0	0.510	29	102.70	24.59	0.12	1288.37	0.0	172.92	1115.45	-0.12	3625.86
4.20	.100	0.0	0.490	30	106.90	26.74	0.15	1288.51	0.0	172.92	1115.59	-0.15	3625.72

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY UNIVERSITY OF MICHIGAN VERSION #2 DECEMBER 1978

OFFSHORE BREAKWATER - 6000 FT STRUCTURE - 25 YEAR BOND
CZL-80.2 SURFSIDE APPARTMENTS - SOUTH BUILDING (16M2)
NUMBER OF PROPERTIES PROCESSED = 1 TOTAL LENGTH OF SHORELINE = 138.00

DPTH =	350.000	- DEPTH OF THE LOT (FEET)	L =	138.000	- FRONT FOOTAGE OF LOT IN (FEET)
FOUN =	95.000	- DISTANCE FROM FOUNDATION TC BLUFF (FEET)	HOME =	0.0	- DEPTH OF THE HOME (FEET)
BSET =	140.000	- RECCOMENDED SET BACK DISTANCE (FEET)	FSET =	35.000	- SET BACK IN FRONT OF HOME (FEET)
H =	42.000	- HEIGTH OF THE BLUFF (FEET)	TH =	0.489	- ANGLE OF THE BLUFF (RADIANS)
TV =	25610.000	- LAKESIDE LAND VALUE ($)	LV =	7683.000	- INLAND LAND VALUE ($)
SV =	475000.000	- HOME OR STRUCTURE VALUE ($)	RESR =	1.000	- RECESSION RATE MODIFIER
LRES =	3.667	- LONG TERM RECESSION RATE (FEET/YEAR)	AEST =	17927.000	- ASTHETIC VALUE ($)
COST =	6000.000	- COST TO MOVE HOME ($)	RI =	0.100	- DISCOUNTING RATE
REST =	23.000	- REALTORS ESTIMATE OF BANK (FEET)	A =	0.500	- WEIGHTING FACTOR
MLT1 =	2.500	- WEIGHTING FACTOR	MLT2 =	0.500	- WEIGHTING FACTOR
T =	30.000	- INVESTMENT HORIZON (YEARS)	PLV =	175.000	- DISTANCE FROM ROAD TO SETBACK (FEET)
BANK =	23.750	- POINT WHERE MORTGAGE BECOMES UNAVAILABLE	STPL =	50.000	- POINT OF SHARP STRUCTURE VALUE DECLINE
STPB =	36.875	- 1/2 WAY BETWEEN BANK AND STEPL (FEET)	BASE =	78.989	- LENGTH OF THE BLUFF BASE (FEET)

INPUT PARAMETERS / OUTPUT PARAMETERS

AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE ($)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. ($)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	17.16	0.950	0	2.50	0.13	0.0	0.0	17.16	17.16	-17.16	-43.48	-43.48
3.90	.100	17.16	0.950	1	6.40	0.32	0.0	0.0	15.60	32.76	-32.76	0.0	-43.48
5.40	.100	17.16	0.950	2	11.80	0.59	0.0	0.0	14.18	46.94	-46.94	0.0	-43.48
4.80	.100	17.16	0.950	3	16.60	0.83	0.0	0.0	12.89	59.83	-59.83	0.0	-43.48
4.40	.100	17.16	0.950	4	21.00	1.05	0.0	0.0	11.72	71.55	-71.55	0.0	-43.48
3.90	.100	17.16	0.950	5	24.90	1.25	0.0	0.0	10.66	82.21	-82.21	0.0	-43.48
3.30	.100	17.16	0.950	6	28.20	1.41	0.0	0.0	9.69	91.90	-91.90	0.0	-43.48
2.60	.100	17.16	0.950	7	30.80	1.54	0.0	0.0	8.81	100.70	-100.70	0.0	-43.48
1.90	.100	17.16	0.930	8	32.70	1.67	0.0	0.0	8.01	108.71	-108.71	0.0	-43.48
1.70	.100	17.16	0.910	9	34.40	1.83	0.0	0.0	7.28	115.99	-115.99	0.0	-43.48
3.20	.100	17.16	0.890	10	37.60	2.18	0.0	0.0	6.62	122.60	-122.60	0.0	-43.48
2.90	.100	17.16	0.870	11	40.50	2.56	0.0	0.0	6.01	128.62	-128.62	0.0	-43.48
2.40	.100	17.16	0.850	12	42.90	2.92	0.0	0.0	5.47	134.08	-134.08	0.0	-43.48
1.30	.100	17.16	0.830	13	44.20	3.14	0.0	0.0	4.97	139.05	-139.05	0.0	-43.48
0.70	.100	17.16	0.810	14	44.90	3.27	0.0	0.0	4.52	143.57	-143.57	0.0	-43.48
1.40	.100	17.16	0.790	15	46.30	3.56	1135.87	1135.87	4.11	147.68	988.19	1135.87	1092.40
2.30	.100	17.16	0.770	16	48.60	4.09	0.0	1135.87	3.73	151.42	984.46	0.0	1092.40
2.80	.100	17.16	0.750	17	51.40	4.79	0.0	1135.87	3.40	154.81	981.06	0.0	1092.40
2.80	.100	17.16	0.730	18	54.20	5.55	0.0	1135.87	3.09	157.90	977.98	0.0	1092.40
3.30	.100	17.16	0.710	19	57.50	6.51	0.0	1135.87	2.81	160.70	975.17	0.0	1092.40
4.10	.100	17.16	0.690	20	61.60	7.78	400.97	1536.85	2.55	163.25	1373.60	400.97	1493.37
3.90	.100	17.16	0.670	21	65.50	9.06	450.02	1986.87	2.32	165.57	1821.30	450.02	1943.40
4.30	.100	17.16	0.650	22	69.80	10.57	496.18	2483.06	2.11	167.68	2315.38	496.18	2439.58
4.80	.100	17.16	0.630	23	74.60	12.34	167.32	2650.38	1.92	169.60	2480.78	167.32	2606.90
5.40	.100	17.16	0.610	24	80.00	14.45	35.72	2686.10	1.74	171.34	2514.76	-35.72	2571.18
5.40	.100	17.16	0.590	25	85.40	16.66	0.0	2686.10	1.58	172.92	2513.18	0.0	2571.18
4.90	.100	0.0	0.570	26	90.30	18.77	0.0	2686.10	0.0	172.92	2513.18	0.0	2571.18
4.60	.100	0.0	0.550	27	94.90	20.84	0.0	2686.10	0.0	172.92	2513.18	0.0	2571.18
3.40	.100	0.0	0.530	28	98.30	22.44	1135.88	3821.98	0.0	172.92	3649.06	1135.88	3707.06
4.40	.100	0.0	0.510	29	102.70	24.59	0.0	3821.98	0.0	172.92	3649.06	0.0	3707.06
4.20	.100	0.0	0.490	30	106.90	26.74	0.0	3821.98	0.0	172.92	3649.06	0.0	3707.06

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY UNIVERSITY OF MICHIGAN VERSION #2 DECEMBER 1978

OFFSHORE BREAKWATER - 6000 FT STRUCTURE - 25 YEAR BOND
CZL-90 ATWELL (16M3.2)
NUMBER OF PROPERTIES PROCESSED = 1 TOTAL LENGTH OF SHORELINE = 50.00

DPTH = 1267.000 - DEPTH OF THE LOT (FEET)
FOUN = 900.000 - DISTANCE FROM FOUNDATION TO BLUFF (FEET)
RSET = 140.000 - RECCOMENDED SET BACK DISTANCE (FEET)
H = 42.000 - HEIGTH OF THE BLUFF (FEET)
TV = 7500.000 - LAKESIDE LAND VALUE ($)
SV = 60000.000 - HOME OR STRUCTURE VALUE ($)
LRES = 3.667 - LONG TERM RECESSION RATE (FEET/YEAR)
COST = 6000.000 - COST TO MOVE HOME ($)
REST = 20.000 - REALTORS ESTIMATE OF BANK (FEET)
MLT1 = 2.500 - WEIGHTING FACTOR
T = 30.000 - INVESTMENT HORIZON (YEARS)
BANK = 23.750 - POINT WHERE MORTGAGE BECOMES UNAVAILABLE
STPB = 36.875 - 1/2 WAY BETWEEN BANK AND STEPL (FEET)

L = 50.000 - FRONT FOOTAGE OF LOT IN (FEET)
HOME = 40.000 - DEPTH OF THE HOME (FEET)
FSET = 35.000 - SET BACK IN FRONT OF HOME (FEET)
TH = 0.489 - ANGLE OF THE BLUFF (RADIANS)
LV = 2250.000 - INLAND LAND VALUE ($)
RESR = 1.000 - RECESSION RATE MODIFIER
AEST = 5250.000 - ASTHETIC VALUE ($)
RI = 0.100 - DISCOUNTING RATE
A = 0.500 - WEIGHTING FACTOR
MLT2 = 0.500 - WEIGHTING FACTOR
PLV = 215.000 - DISTANCE FROM ROAD TO SETBACK (FEET)
STPL = 50.000 - POINT OF SHARP STRUCTURE VALUE DECLINE
BASE = 78.969 - LENGTH OF THE BLUFF BASE (FEET)

INPUT PARAMETERS					OUTPUT PARAMETERS									
AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	17.16	0.950	0	2.50	0.13	0.0	0.0	17.16	17.16	-17.16	-120.00	-120.00
3.90	.100	17.16	0.950	1	6.40	0.32	0.0	0.0	15.60	32.76	-32.76	0.0	-120.00
5.40	.100	17.16	0.950	2	11.80	0.59	0.0	0.0	14.18	46.94	-46.94	0.0	-120.00
4.80	.100	17.16	0.950	3	16.60	0.83	0.0	0.0	12.89	59.83	-59.83	0.0	-120.00
4.40	.100	17.16	0.950	4	21.00	1.05	0.0	0.0	11.72	71.55	-71.55	0.0	-120.00
3.90	.100	17.16	0.950	5	24.90	1.25	0.0	0.0	10.66	82.21	-82.21	0.0	-120.00
3.30	.100	17.16	0.950	6	28.20	1.41	0.0	0.0	9.69	91.90	-91.90	0.0	-120.00
2.60	.100	17.16	0.950	7	30.80	1.54	0.0	0.0	8.81	100.70	-100.70	0.0	-120.00
1.90	.100	17.16	0.930	8	32.70	1.67	0.0	0.0	8.01	108.71	-108.71	0.0	-120.00
1.70	.100	17.16	0.910	9	34.40	1.83	0.0	0.0	7.28	115.99	-115.99	0.0	-120.00
3.20	.100	17.16	0.890	10	37.60	2.18	0.0	0.0	6.62	122.60	-122.60	0.0	-120.00
2.90	.100	17.16	0.870	11	40.50	2.56	0.0	0.0	6.01	128.62	-128.62	0.0	-120.00
2.40	.100	17.16	0.850	12	42.90	2.92	0.0	0.0	5.47	134.08	-134.08	0.0	-120.00
1.30	.100	17.16	0.830	13	44.20	3.14	0.0	0.0	4.97	139.05	-139.05	0.0	-120.00
0.70	.100	17.16	0.810	14	44.90	3.27	0.0	0.0	4.52	143.57	-143.57	0.0	-120.00
1.40	.100	17.16	0.790	15	46.30	3.56	0.0	0.0	4.11	147.68	-147.68	0.0	-120.00
2.30	.100	17.16	0.770	16	48.60	4.09	0.0	0.0	3.73	151.42	-151.42	0.0	-120.00
2.80	.100	17.16	0.750	17	51.40	4.79	0.0	0.0	3.40	154.81	-154.81	0.0	-120.00
2.80	.100	17.16	0.730	18	54.20	5.55	0.0	0.0	3.09	157.90	-157.90	0.0	-120.00
3.30	.100	17.16	0.710	19	57.50	6.51	0.0	0.0	2.81	160.70	-160.70	0.0	-120.00
4.10	.100	17.16	0.690	20	61.60	7.78	0.0	0.0	2.55	163.25	-163.25	0.0	-120.00
3.90	.100	17.16	0.670	21	65.50	9.06	0.0	0.0	2.32	165.57	-165.57	0.0	-120.00
4.30	.100	17.16	0.650	22	69.80	10.57	0.0	0.0	2.11	167.68	-167.68	0.0	-120.00
4.80	.100	17.16	0.630	23	74.60	12.34	0.0	0.0	1.92	169.60	-169.60	0.0	-120.00
5.40	.100	17.16	0.610	24	80.00	14.45	28.88	28.88	1.74	171.34	-142.46	-28.88	-148.88
5.40	.100	17.16	0.590	25	85.40	16.66	0.0	28.88	1.58	172.92	-144.05	0.0	-148.88
4.90	.100	0.0	0.570	26	90.30	18.77	0.0	28.88	0.0	172.92	-144.05	0.0	-148.88
4.60	.100	0.0	0.550	27	94.90	20.84	0.0	28.88	0.0	172.92	-144.05	0.0	-148.88
3.40	.100	0.0	0.530	28	98.30	22.44	0.0	28.88	0.0	172.92	-144.05	0.0	-148.88
4.40	.100	0.0	0.510	29	102.70	24.59	0.0	28.88	0.0	172.92	-144.05	0.0	-148.88
4.20	.100	0.0	0.490	30	106.90	26.74	0.0	28.88	0.0	172.92	-144.05	0.0	-148.88

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY   UNIVERSITY OF MICHIGAN   VERSION #2 DECEMBER 1978

OFFSHORE BREAKWATER - 6000 FT STRUCTURE - 25 YEAR BOND
CZL-100   DELMARIANI   (16M3.3)
NUMBER OF PROPERTIES PROCESSED = 1   TOTAL LENGTH OF SHORELINE = 70.00

DPTH =	1305.000	- DEPTH OF THE LOT (FEET)	L =	70.000	- FRONT FOOTAGE OF LOT IN (FEET)
FOUN =	0.0	- DISTANCE FROM FOUNDATION TO BLUFF (FEET)	HOME =	0.0	- DEPTH OF THE HOME (FEET)
BSET =	140.000	- RECCOMENDED SET BACK DISTANCE (FEET)	FSET =	35.000	- SET BACK IN FRONT OF HOME (FEET)
H =	42.000	- HEIGTH OF THE BLUFF (FEET)	TH =	0.489	- ANGLE OF THE BLUFF (RADIANS)
TV =	10500.000	- LAKESIDE LAND VALUE ($)	LV =	3150.000	- INLAND LAND VALUE ($)
SV =	0.0	- HOME OR STRUCTURE VALUE ($)	RESR =	1.000	- RECESSION RATE MODIFIER
LRES =	3.667	- LONG TERM RECESSION RATE (FEET/YEAR)	AEST =	7350.000	- ASTHETIC VALUE ($)
COST =	6000.000	- COST TO MOVE HOME ($)	RI =	0.100	- DISCOUNTING RATE
REST =	20.000	- REALTORS ESTIMATE OF BANK (FEET)	A =	0.500	- WEIGHTING FACTOR
MLT1 =	2.500	- WEIGHTING FACTOR	MLT2 =	0.500	- WEIGHTING FACTOR
T =	30.000	- INVESTMENT HORIZON (YEARS)	PLV =	175.000	- DISTANCE FROM ROAD TO SETBACK (FEET)
BANK =	23.750	- POINT WHERE MORTGAGE BECOMES UNAVAILABLE	STPL =	50.000	- POINT OF SHARP STRUCTURE VALUE DECLINE
STPB =	36.875	- 1/2 WAY BETWEEN BANK AND STEPL (FEET)	BASE =	78.989	- LENGTH OF THE BLUFF BASE (FEET)

INPUT PARAMETERS   OUTPUT PARAMETERS

AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	17.16	0.950	0	2.50	0.13	0.0	0.0	17.16	17.16	-17.16	-85.71	-85.71
3.90	.100	17.16	0.950	1	6.40	0.32	0.0	0.0	15.60	32.76	-32.76	0.0	-85.71
5.40	.100	17.16	0.950	2	11.80	0.59	0.0	0.0	14.18	46.94	-46.94	0.0	-85.71
4.80	.100	17.16	0.950	3	16.60	0.83	0.0	0.0	12.89	59.83	-59.83	0.0	-85.71
4.40	.100	17.16	0.950	4	21.00	1.05	0.0	0.0	11.72	71.55	-71.55	0.0	-85.71
3.90	.100	17.16	0.950	5	24.90	1.25	0.0	0.0	10.66	82.21	-82.21	0.0	-85.71
3.30	.100	17.16	0.950	6	28.20	1.41	0.0	0.0	9.69	91.90	-91.90	0.0	-85.71
2.60	.100	17.16	0.950	7	30.80	1.54	0.0	0.0	8.81	100.70	-100.70	0.0	-85.71
1.90	.100	17.16	0.930	8	32.70	1.67	0.0	0.0	8.01	108.71	-108.71	0.0	-85.71
1.70	.100	17.16	0.910	9	34.40	1.83	0.0	0.0	7.28	115.99	-115.99	0.0	-85.71
3.20	.100	17.16	0.890	10	37.60	2.18	0.0	0.0	6.62	122.60	-122.60	0.0	-85.71
2.90	.100	17.16	0.870	11	40.50	2.56	0.0	0.0	6.01	128.62	-128.62	0.0	-85.71
2.40	.100	17.16	0.850	12	42.90	2.92	0.0	0.0	5.47	134.08	-134.08	0.0	-85.71
1.30	.100	17.16	0.830	13	44.20	3.14	0.0	0.0	4.97	139.05	-139.05	0.0	-85.71
0.70	.100	17.16	0.810	14	44.90	3.27	0.0	0.0	4.52	143.57	-143.57	0.0	-85.71
1.40	.100	17.16	0.790	15	46.30	3.56	0.0	0.0	4.11	147.68	-147.68	0.0	-85.71
2.30	.100	17.16	0.770	16	48.60	4.09	0.0	0.0	3.73	151.42	-151.42	0.0	-85.71
2.80	.100	17.16	0.750	17	51.40	4.79	0.0	0.0	3.40	154.81	-154.81	0.0	-85.71
2.80	.100	17.16	0.730	18	54.20	5.55	0.0	0.0	3.09	157.90	-157.90	0.0	-85.71
3.30	.100	17.16	0.710	19	57.50	6.51	0.0	0.0	2.81	160.70	-160.70	0.0	-85.71
4.10	.100	17.16	0.690	20	61.60	7.78	0.0	0.0	2.55	163.25	-163.25	0.0	-85.71
3.90	.100	17.16	0.670	21	65.50	9.06	0.0	0.0	2.32	165.57	-165.57	0.0	-85.71
4.30	.100	17.16	0.650	22	69.80	10.57	0.0	0.0	2.11	167.68	-167.68	0.0	-85.71
4.80	.100	17.16	0.630	23	74.60	12.34	0.0	0.0	1.92	169.60	-169.60	0.0	-85.71
5.40	.100	17.16	0.610	24	80.00	14.45	28.88	28.88	1.74	171.34	-142.46	-28.88	-114.59
5.40	.100	17.16	0.590	25	85.40	16.66	0.0	28.88	1.58	172.92	-144.05	0.0	-114.59
4.90	.100	0.0	0.570	26	90.30	18.77	0.0	28.88	0.0	172.92	-144.05	0.0	-114.59
4.60	.100	0.0	0.550	27	94.90	20.84	0.0	28.88	0.0	172.92	-144.05	0.0	-114.59
3.40	.100	0.0	0.530	28	98.30	22.44	0.0	28.88	0.0	172.92	-144.05	0.0	-114.59
4.40	.100	0.0	0.510	29	102.70	24.59	0.0	28.88	0.0	172.92	-144.05	0.0	-114.59
4.20	.100	0.0	0.490	30	106.90	26.74	0.0	28.88	0.0	172.92	-144.05	0.0	-114.59

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY UNIVERSITY OF MICHIGAN VERSION #2 DECEMBER 1978

OFFSHORE BREAKWATER - 6000 FT STRUCTURE - 25 YEAR BOND
CZL-101 DELMAFIANI (16M4)
NUMBER OF PROPERTIES PROCESSED = 1 TOTAL LENGTH OF SHORELINE = 165.00

DPTH =	1200.000	DEPTH OF THE LOT (FEET)
FOUN =	900.000	DISTANCE FROM FOUNDATION TO BLUFF (FEET)
RSET =	140.000	RECCOMENDED SET BACK DISTANCE (FEET)
H =	42.000	HEIGTH OF THE BLUFF (FEET)
TV =	24750.000	LAKESIDE LAND VALUE ($)
SV =	65000.000	HOME OR STRUCTURE VALUE ($)
LRES =	3.667	LONG TERM RECESSION RATE (FEET/YEAR)
COST =	6000.000	COST TO MOVE HOME ($)
REST =	20.000	REALTORS ESTIMATE OF EARN (FEET)
MLT1 =	2.500	WEIGHTING FACTOR
T =	30.000	INVESTMENT HORIZON (YEARS)
BANK =	23.750	POINT WHERE MORTGAGE BECOMES UNAVAILABLE
STPB =	36.875	1/2 WAY BETWEEN BANK AND STEPL (FEET)

L =	165.000	FRONT FOOTAGE OF LOT IN (FEET)
HOME =	50.000	DEPTH OF THE HOME (FEET)
FSET =	35.000	SET BACK IN FRONT OF HOME (FEET)
TH =	0.489	ANGLE OF THE BLUFF (RADIANS)
LV =	7425.000	INLAND LAND VALUE ($)
RESR =	1.000	RECESSION RATE MODIFIER
AEST =	17325.000	ASTHETIC VALUE ($)
RI =	0.100	DISCOUNTING RATE
A =	0.500	WEIGHTING FACTOR
MLT2 =	0.500	WEIGHTING FACTOR
PLV =	225.000	DISTANCE FROM ROAD TO SETBACK (FEET)
STPL =	50.000	POINT OF SHARP STRUCTURE VALUE DECLINE
BASE =	78.989	LENGTH OF THE BLUFF BASE (FEET)

INPUT PARAMETERS — OUTPUT PARAMETERS

AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	17.16	0.950	0	2.50	0.13	0.0	0.0	17.16	17.16	-17.16	-36.36	-36.36
3.90	.100	17.16	0.950	1	6.40	0.32	0.0	0.0	15.60	32.76	-32.76	0.0	-36.36
5.40	.100	17.16	0.950	2	11.80	0.59	0.0	0.0	14.18	46.94	-46.94	0.0	-36.36
4.80	.100	17.16	0.950	3	16.60	0.83	0.0	0.0	12.89	59.83	-59.83	0.0	-36.36
4.40	.100	17.16	0.950	4	21.00	1.05	0.0	0.0	11.72	71.55	-71.55	0.0	-36.36
3.90	.100	17.16	0.950	5	24.90	1.25	0.0	0.0	10.66	82.21	-82.21	0.0	-36.36
3.30	.100	17.16	0.950	6	28.20	1.41	0.0	0.0	9.69	91.90	-91.90	0.0	-36.36
2.60	.100	17.16	0.950	7	30.80	1.54	0.0	0.0	8.81	100.70	-100.70	0.0	-36.36
1.90	.100	17.16	0.930	8	32.70	1.67	0.0	0.0	8.01	108.71	-108.71	0.0	-36.36
1.70	.100	17.16	0.910	9	34.40	1.83	0.0	0.0	7.28	115.99	-115.99	0.0	-36.36
3.20	.100	17.16	0.890	10	37.60	2.18	0.0	0.0	6.62	122.60	-122.60	0.0	-36.36
2.90	.100	17.16	0.870	11	40.50	2.56	0.0	0.0	6.01	128.62	-128.62	0.0	-36.36
2.40	.100	17.16	0.850	12	42.90	2.92	0.0	0.0	5.47	134.08	-134.08	0.0	-36.36
1.30	.100	17.16	0.830	13	44.20	3.14	0.0	0.0	4.97	139.05	-139.05	0.0	-36.36
0.70	.100	17.16	0.810	14	44.90	3.27	0.0	0.0	4.52	143.57	-143.57	0.0	-36.36
1.40	.100	17.16	0.790	15	46.30	3.56	0.0	0.0	4.11	147.68	-147.68	0.0	-36.36
2.30	.100	17.16	0.770	16	48.60	4.09	0.0	0.0	3.73	151.42	-151.42	0.0	-36.36
2.80	.100	17.16	0.750	17	51.40	4.79	0.0	0.0	3.40	154.81	-154.81	0.0	-36.36
2.80	.100	17.16	0.730	18	54.20	5.55	0.0	0.0	3.09	157.90	-157.90	0.0	-36.36
3.30	.100	17.16	0.710	19	57.50	6.51	0.0	0.0	2.81	160.70	-160.70	0.0	-36.36
4.10	.100	17.16	0.690	20	61.60	7.78	0.0	0.0	2.55	163.25	-163.25	0.0	-36.36
3.90	.100	17.16	0.670	21	65.50	9.06	0.0	0.0	2.32	165.57	-165.57	0.0	-36.36
4.30	.100	17.16	0.650	22	69.80	10.57	0.0	0.0	2.11	167.68	-167.68	0.0	-36.36
4.80	.100	17.16	0.630	23	74.60	12.34	0.0	0.0	1.92	169.60	-169.60	0.0	-36.36
5.40	.100	17.16	0.610	24	80.00	14.45	28.88	28.88	1.74	171.34	-142.46	-28.88	-65.24
5.40	.100	17.16	0.590	25	85.40	16.66	0.0	28.88	1.58	172.92	-144.05	0.0	-65.24
4.90	.100	0.0	0.570	26	90.30	18.77	0.0	28.88	0.0	172.92	-144.05	0.0	-65.24
4.60	.100	0.0	0.550	27	94.90	20.84	0.0	28.88	0.0	172.92	-144.05	0.0	-65.24
3.40	.100	0.0	0.530	28	98.30	22.44	0.0	28.88	0.0	172.92	-144.05	0.0	-65.24
4.40	.100	0.0	0.510	29	102.70	24.59	0.0	28.88	0.0	172.92	-144.05	0.0	-65.24
4.20	.100	0.0	0.490	30	106.90	26.74	0.0	28.88	0.0	172.92	-144.05	0.0	-65.24

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY UNIVERSITY OF MICHIGAN VERSION #2 DECEMBER 1978

OFFSHORE BREAKWATER - 6000 FT STRUCTURE - 25 YEAR BOND
CZL-110 PHELPS (16M5.5)
NUMBER OF PROPERTIES PROCESSED = 1 TOTAL LENGTH OF SHORELINE = 125.00

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DPTH =    738.000 - DEPTH OF THE LOT (FEET)                      L    =    125.000 - FRONT FOOTAGE OF LOT IN (FEET)
FOUN =    600.000 - DISTANCE FROM FOUNDATION TO BLUFF (FEET)     HOME =     40.000 - DEPTH OF THE HOME (FEET)
RSET =    140.000 - RECCOMENDED SET BACK DISTANCE (FEET)         FSET =     35.000 - SET BACK IN FRONT OF HOME (FEET)
H    =     42.000 - HEIGTH OF THE BLUFF (FEET)                   TH   =      0.489 - ANGLE OF THE BLUFF (RADIANS)
TV   =  18750.000 - LAKESIDE LAND VALUE ($)                      LV   =   5625.000 - INLAND LAND VALUE ($)
SV   =  63750.000 - HOME OR STRUCTURE VALUE ($)                  RESR =      1.000 - RECESSION RATE MODIFIER
LRES =      3.667 - LONG TERM RECESSION RATE (FEET/YEAR)         AEST =  13125.000 - ASTHETIC VALUE ($)
COST =   6000.000 - COST TO MOVE HOME ($)                        RI   =      0.100 - DISCOUNTING RATE
REST =     23.000 - REALTORS ESTIMATE OF BANK (FEET)             A    =      0.500 - WEIGHTING FACTOR
MLT1 =      2.500 - WEIGHTING FACTOR                             MLT2 =      0.500 - WEIGHTING FACTOR
T    =     30.000 - INVESTMENT HORIZON (YEARS)                   PLV  =    215.000 - DISTANCE FROM ROAD TO SETBACK (FEET)
BANK =     23.750 - POINT WHERE MORTGAGE BECOMES UNAVAILABLE     STPL =     50.000 - POINT OF SHARP STRUCTURE VALUE DECLINE
STPD =     36.875 - 1/2 WAY BETWEEN BANK AND STPL (FEET)         BASE =     78.989 - LENGTH OF THE BLUFF BASE (FEET)
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INPUT PARAMETERS					OUTPUT PARAMETERS									
AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	17.16	0.950	0	2.50	0.13	0.0	0.0	17.16	17.16	-17.16	-48.00	-48.00
3.90	.100	17.16	0.950	1	6.40	0.32	0.0	0.0	15.60	32.76	-32.76	0.0	-48.00
5.40	.100	17.16	0.950	2	11.80	0.59	0.0	0.0	14.18	46.94	-46.94	0.0	-48.00
4.80	.100	17.16	0.950	3	16.60	0.83	0.0	0.0	12.89	59.83	-59.83	0.0	-48.00
4.40	.100	17.16	0.950	4	21.00	1.05	0.0	0.0	11.72	71.55	-71.55	0.0	-48.00
3.90	.100	17.16	0.950	5	24.90	1.25	0.0	0.0	10.66	82.21	-82.21	0.0	-48.00
3.30	.100	17.16	0.950	6	28.20	1.41	0.0	0.0	9.69	91.90	-91.90	0.0	-48.00
2.60	.100	17.16	0.950	7	30.80	1.54	0.0	0.0	8.81	100.70	-100.70	0.0	-48.00
1.90	.100	17.16	0.930	8	32.70	1.67	0.0	0.0	8.01	108.71	-108.71	0.0	-48.00
1.70	.100	17.16	0.910	9	34.40	1.83	0.0	0.0	7.28	115.99	-115.99	0.0	-48.00
3.20	.100	17.16	0.890	10	37.60	2.18	0.0	0.0	6.62	122.60	-122.60	0.0	-48.00
2.90	.100	17.16	0.870	11	40.50	2.56	0.0	0.0	6.01	128.62	-128.62	0.0	-48.00
2.40	.100	17.16	0.850	12	42.90	2.92	0.0	0.0	5.47	134.08	-134.08	0.0	-48.00
1.50	.100	17.16	0.830	13	44.20	3.14	0.0	0.0	4.97	139.05	-139.05	0.0	-48.00
0.70	.100	17.16	0.810	14	44.90	3.27	0.0	0.0	4.52	143.57	-143.57	0.0	-48.00
1.40	.100	17.16	0.790	15	46.30	3.56	0.0	0.0	4.11	147.68	-147.68	0.0	-48.00
2.30	.100	17.16	0.770	16	48.60	4.09	0.0	0.0	3.73	151.42	-151.42	0.0	-48.00
2.80	.100	17.16	0.750	17	51.40	4.79	0.0	0.0	3.40	154.81	-154.81	0.0	-48.00
2.80	.100	17.16	0.730	18	54.20	5.55	0.0	0.0	3.09	157.90	-157.90	0.0	-48.00
3.30	.100	17.16	0.710	19	57.50	6.51	0.0	0.0	2.81	160.70	-160.70	0.0	-48.00
4.10	.100	17.16	0.690	20	61.60	7.78	0.0	0.0	2.55	163.25	-163.25	0.0	-48.00
3.90	.100	17.16	0.670	21	65.50	9.06	0.0	0.0	2.32	165.57	-165.57	0.0	-48.00
4.30	.100	17.16	0.650	22	69.80	10.57	0.0	0.0	2.11	167.68	-167.68	0.0	-48.00
4.80	.100	17.16	0.630	23	74.60	12.34	0.0	0.0	1.92	169.60	-169.60	0.0	-48.00
5.40	.100	17.16	0.610	24	80.00	14.45	28.88	28.88	1.74	171.34	-142.46	-28.88	-76.88
5.40	.100	17.16	0.590	25	85.40	16.66	0.0	28.88	1.58	172.92	-144.05	0.0	-76.88
4.90	.100	0.0	0.570	26	90.30	18.77	0.0	28.88	0.0	172.92	-144.05	0.0	-76.88
4.60	.100	0.0	0.550	27	94.90	20.84	0.0	28.88	0.0	172.92	-144.05	0.0	-76.88
3.40	.100	0.0	0.530	28	98.30	22.44	0.0	28.88	0.0	172.92	-144.05	0.0	-76.88
4.40	.100	0.0	0.510	29	102.70	24.59	0.0	28.88	0.0	172.92	-144.05	0.0	-76.88
4.20	.100	0.0	0.490	30	106.90	26.74	0.0	28.88	0.0	172.92	-144.05	0.0	-76.88

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY UNIVERSITY OF MICHIGAN VERSION #2 DECEMBER 1978

OFFSHORE BREAKWATER - 6000 FT STRUCTURE - 25 YEAR BOND
CZL-120 SEPE (16M6.3)
NUMBER OF PROPERTIES PROCESSED = 1 TOTAL LENGTH OF SHORELINE = 143.00

DPTH = 1359.000 - DEPTH OF THE LOT (FEET)			L = 143.000 - FRONT FOOTAGE OF LOT IN (FEET)	
FOUN = 900.000 - DISTANCE FROM FOUNDATION TC BLUFF (FEET)			HOME = 40.000 - DEPTH OF THE HOME (FEET)	
RSET = 140.000 - RECCOMENDED SET BACK DISTANCE (FEET)			PSET = 35.000 - SET BACK IN FRONT OF HOME (FEET)	
H = 42.000 - HEIGTH OF THE BLUFF (FEET)			TH = 0.489 - ANGLE OF THE BLUFF (RADIANS)	
TV = 30000.000 - LAKESIDE LAND VALUE ($)			LV = 3000.000 - INLAND LAND VALUE ($)	
SV = 50000.000 - HOME OR STRUCTURE VALUE ($)			RESR = 1.000 - RECESSION RATE MODIFIER	
LRES = 3.667 - LONG TERM RECESSION RATE (FEET/YEAR)			AEST = 27000.000 - ASTHETIC VALUE ($)	
COST = 6000.000 - COST TO MOVE HOME ($)			RI = 0.100 - DISCOUNTING RATE	
REST = 20.000 - REALTORS ESTIMATE OF BANK (FEET)			A = 0.500 - WEIGHTING FACTOR	
MLT1 = 2.500 - WEIGHTING FACTOR			MLT2 = 0.500 - WEIGHTING FACTOR	
T = 30.000 - INVESTMENT HORIZON (YEARS)			PLV = 215.000 - DISTANCE FROM ROAD TO SETBACK (FEET)	
BANK = 23.750 - POINT WHERE MORTGAGE BECOMES UNAVAILABLE			STPL = 50.000 - POINT OF SHARP STRUCTURE VALUE DECLINE	
STPB = 36.875 - 1/2 WAY BETWEEN BANK AND STEPL (FEET)			BASE = 78.989 - LENGTH OF THE BLUFF BASE (FEET)	

INPUT PARAMETERS / OUTPUT PARAMETERS

AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	17.16	0.950	0	2.50	0.13	0.0	0.0	17.16	17.16	-17.16	-41.96	-41.96
3.90	.100	17.16	0.950	1	6.40	0.32	0.0	0.0	15.60	32.76	-32.76	0.0	-41.96
5.40	.100	17.16	0.950	2	11.80	0.59	0.0	0.0	14.18	46.94	-46.94	0.0	-41.96
4.80	.100	17.16	0.950	3	16.60	0.83	0.0	0.0	12.89	59.83	-59.83	0.0	-41.96
4.40	.100	17.16	0.950	4	21.00	1.05	0.0	0.0	11.72	71.55	-71.55	0.0	-41.96
3.90	.100	17.16	0.950	5	24.90	1.25	0.0	0.0	10.66	82.21	-82.21	0.0	-41.96
3.30	.100	17.16	0.950	6	28.20	1.41	0.0	0.0	9.69	91.90	-91.90	0.0	-41.96
2.60	.100	17.16	0.950	7	30.80	1.54	0.0	0.0	8.81	100.70	-100.70	0.0	-41.96
1.90	.100	17.16	0.930	8	32.70	1.67	0.0	0.0	8.01	108.71	-108.71	0.0	-41.96
1.70	.100	17.16	0.910	9	34.40	1.83	0.0	0.0	7.28	115.99	-115.99	0.0	-41.96
3.20	.100	17.16	0.890	10	37.60	2.18	0.0	0.0	6.62	122.60	-122.60	0.0	-41.96
2.90	.100	17.16	0.870	11	40.50	2.56	0.0	0.0	6.01	128.62	-128.62	0.0	-41.96
2.40	.100	17.16	0.850	12	42.90	2.92	0.0	0.0	5.47	134.08	-134.08	0.0	-41.96
1.30	.100	17.16	0.830	13	44.20	3.14	0.0	0.0	4.97	139.05	-139.05	0.0	-41.96
0.70	.100	17.16	0.810	14	44.90	3.27	0.0	0.0	4.52	143.57	-143.57	0.0	-41.96
1.40	.100	17.16	0.790	15	46.30	3.56	0.0	0.0	4.11	147.68	-147.68	0.0	-41.96
2.30	.100	17.16	0.770	16	48.60	4.09	0.0	0.0	3.73	151.42	-151.42	0.0	-41.96
2.80	.100	17.16	0.750	17	51.40	4.79	0.0	0.0	3.40	154.81	-154.81	0.0	-41.96
2.80	.100	17.16	0.730	18	54.20	5.55	0.0	0.0	3.09	157.90	-157.90	0.0	-41.96
3.30	.100	17.16	0.710	19	57.50	6.51	0.0	0.0	2.81	160.70	-160.70	0.0	-41.96
4.10	.100	17.16	0.690	20	61.60	7.78	0.0	0.0	2.55	163.25	-163.25	0.0	-41.96
3.90	.100	17.16	0.670	21	65.50	9.06	0.0	0.0	2.32	165.57	-165.57	0.0	-41.96
4.30	.100	17.16	0.650	22	69.80	10.57	0.0	0.0	2.11	167.68	-167.68	0.0	-41.96
4.80	.100	17.16	0.630	23	74.60	12.34	0.0	0.0	1.92	169.60	-169.60	0.0	-41.96
5.40	.100	17.16	0.610	24	80.00	14.45	51.92	51.92	1.74	171.34	-119.42	-51.92	-93.88
5.40	.100	17.16	0.590	25	85.40	16.66	0.0	51.92	1.58	172.92	-121.00	0.0	-93.88
4.90	.100	0.0	0.570	26	90.30	18.77	0.0	51.92	0.0	172.92	-121.00	0.0	-93.88
4.60	.100	0.0	0.550	27	94.90	20.84	0.0	51.92	0.0	172.92	-121.00	0.0	-93.88
3.40	.100	0.0	0.530	28	98.30	22.44	0.0	51.92	0.0	172.92	-121.00	0.0	-93.88
4.40	.100	0.0	0.510	29	102.70	24.59	0.0	51.92	0.0	172.92	-121.00	0.0	-93.88
4.20	.100	0.0	0.490	30	106.90	26.74	0.0	51.92	0.0	172.92	-121.00	0.0	-93.88

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY UNIVERSITY OF MICHIGAN VERSION #2 DECEMBER 1978

OFFSHORE BREAKWATER - 6000 FT STRUCTURE - 25 YEAR BOND
C2L-130 LAT7 (1686.2)
NUMBER OF PROPERTIES PROCESSED = 1 TOTAL LENGTH OF SHORELINE = 100.00

DPTH = 1025.000 - DEPTH OF THE LOT (FEET)		L = 100.000 - FRONT FOOTAGE OF LOT IN (FEET)	
FOUN = 15.000 - DISTANCE FROM FOUNDATION TO BLUFF (FEET)		HOME = 60.000 - DEPTH OF THE HOME (FEET)	
RSET = 140.000 - RECCOMENDED SET BACK DISTANCE (FEET)		PSET = 35.000 - SET BACK IN FRONT OF HOME (FEET)	
H = 43.000 - HEIGTH OF THE BLUFF (FEET)		TH = 0.755 - ANGLE OF THE BLUFF (RADIANS)	
TV = 25000.000 - LAKESIDE LAND VALUE ($)		LV = 7500.000 - INLAND LAND VALUE ($)	
SV = 55000.000 - HOME OR STRUCTURE VALUE ($)		RESR = 1.000 - RECESSION RATE MODIFIER	
LRES = 3.667 - LONG TERM RECESSION RATE (FEET/YEAR)		AEST = 17500.000 - ASTHETIC VALUE ($)	
COST = 5000.000 - COST TO MOVE HOME ($)		RI = 0.100 - DISCOUNTING RATE	
REST = 20.000 - REALTORS ESTIMATE OF BANK (FEET)		A = 0.500 - WEIGHTING FACTOR	
MLT1 = 2.500 - WEIGHTING FACTOR		MLT2 = 0.500 - WEIGHTING FACTOR	
T = 30.000 - INVESTMENT HORIZON (YEARS)		PLV = 235.000 - DISTANCE FROM ROAD TO SETBACK (FEET)	
BANK = 23.750 - POINT WHERE MORTGAGE BECOMES UNAVAILABLE		STPL = 50.000 - POINT OF SHARP STRUCTURE VALUE DECLINE	
STPB = 36.875 - 1/2 WAY BETWEEN BANK AND STEPL (FEET)		BASE = 51.021 - LENGTH OF THE BLUFF BASE (FEET)	

INPUT PARAMETERS | OUTPUT PARAMETERS

AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	17.16	0.950	0	2.50	0.13	0.0	0.0	17.16	17.16	-17.16	363.50	363.50
3.90	.100	17.16	0.950	1	6.40	0.32	0.0	0.0	15.60	32.76	-32.76	0.0	363.50
5.40	.100	17.16	0.950	2	11.80	0.59	0.0	0.0	14.18	46.94	-46.94	0.0	363.50
4.80	.100	17.16	0.950	3	16.60	0.83	181.50	181.50	12.89	59.83	121.67	181.50	545.00
4.40	.100	17.16	0.950	4	21.00	1.05	0.0	181.50	11.72	71.55	109.95	0.0	545.00
3.90	.100	17.16	0.950	5	24.90	1.25	0.0	181.50	10.66	82.21	99.29	0.0	545.00
3.30	.100	17.16	0.950	6	28.20	1.41	0.0	181.50	9.69	91.90	89.60	0.0	545.00
2.60	.100	17.16	0.950	7	30.80	1.54	0.0	181.50	8.81	100.70	80.80	0.0	545.00
1.90	.100	17.16	0.930	8	32.70	1.67	0.0	181.50	8.01	108.71	72.79	0.0	545.00
1.70	.100	17.16	0.910	9	34.40	1.83	0.0	181.50	7.28	115.99	65.52	0.0	545.00
3.20	.100	17.16	0.890	10	37.60	2.18	0.0	181.50	6.62	122.60	58.90	0.0	545.00
2.90	.100	17.16	0.870	11	40.50	2.56	0.0	181.50	6.01	128.62	52.88	0.0	545.00
2.40	.100	17.16	0.850	12	42.90	2.92	0.0	181.50	5.47	134.08	47.42	0.0	545.00
1.30	.100	17.16	0.830	13	44.20	3.14	0.0	181.50	4.97	139.05	42.45	0.0	545.00
0.70	.100	17.16	0.810	14	44.90	3.27	0.0	181.50	4.52	143.57	37.93	0.0	545.00
1.40	.100	17.16	0.790	15	46.30	3.56	0.0	181.50	4.11	147.68	33.82	0.0	545.00
2.30	.100	17.16	0.770	16	48.60	4.09	0.0	181.50	3.73	151.42	30.09	0.0	545.00
2.80	.100	17.16	0.750	17	51.40	4.79	48.13	229.63	3.40	154.81	74.82	-48.13	496.87
2.80	.100	17.16	0.730	18	54.20	5.55	0.0	229.63	3.09	157.90	71.73	0.0	496.87
3.30	.100	17.16	0.710	19	57.50	6.51	0.0	229.63	2.81	160.70	68.92	0.0	496.87
4.10	.100	17.16	0.690	20	61.60	7.78	0.0	229.63	2.55	163.25	66.37	0.0	496.87
3.90	.100	17.16	0.670	21	65.50	9.06	0.0	229.63	2.32	165.57	64.05	0.0	496.87
4.30	.100	17.16	0.650	22	69.80	10.57	0.0	229.63	2.11	167.68	61.95	0.0	496.87
4.80	.100	17.16	0.630	23	74.60	12.34	0.0	229.63	1.92	169.60	60.03	0.0	496.87
5.40	.100	17.16	0.610	24	80.00	14.45	0.0	229.63	1.74	171.34	58.29	0.0	496.87
5.40	.100	17.16	0.590	25	85.40	16.66	-181.50	48.12	1.58	172.92	-124.80	0.0	496.87
4.90	.100	0.0	0.570	26	90.30	18.77	0.0	48.12	0.0	172.92	-124.80	0.0	496.87
4.60	.100	0.0	0.550	27	94.90	20.84	0.0	48.12	0.0	172.92	-124.80	0.0	496.87
3.40	.100	0.0	0.530	28	98.30	22.44	0.0	48.12	0.0	172.92	-124.80	0.0	496.87
4.40	.100	0.0	0.510	29	102.70	24.59	0.0	48.12	0.0	172.92	-124.80	0.0	496.87
4.20	.100	0.0	0.490	30	106.90	26.74	0.0	48.12	0.0	172.92	-124.80	0.0	496.87

BENEFIT/COST MODEL OF SHORFLINE PROCESSES
COSTAL ZONE LABORATORY UNIVERSITY OF MICHIGAN VERSION #2 DECEMBER 1978

OFFSHORE BREAKWATER - 6000 FT STRUCTURE - 25 YEAR BOND
C2L-140 ANGEICS (16M7)
NUMBER OF PROPERTIES PROCESSED = 1 TOTAL LENGTH OF SHORELINE = 125.00

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DPTH =  1350.000 - DEPTH OF THE LOT (FEET)                    L    =    125.000 - FRONT FOOTAGE OF LOT IN (FEET)
POUN =     0.0   - DISTANCE FROM FOUNDATION TO BLUFF (FEET)   HOME =      0.0   - DEPTH OF THE HOME (FEET)
RSET =   140.000 - RECCOMENDED SET BACK DISTANCE (FEET)       PSET =     35.000 - SET BACK IN FRONT OF HOME (FEET)
H    =    43.000 - HEIGTH OF THE BLUFF (FEET)                 TH   =      0.755 - ANGLE OF THE BLUFF (RADIANS)
TV   = 25000.000 - LAKESIDE LAND VALUE ($)                    LV   =   7500.000 - INLAND LAND VALUE ($)
SV   =     0.0   - HOME OR STRUCTURE VALUE ($)                RESR =      1.000 - RECESSION RATE MODIFIER
LRES =     3.667 - LONG TERM RECESSION RATE (FEET/YEAR)       AEST =  17500.000 - ASTHETIC VALUE ($)
COST =  6000.000 - COST TO MOVE HOME ($)                      RI   =      0.100 - DISCOUNTING RATE
REST =    20.000 - REALTORS ESTIMATE OF BANK (FEET)           A    =      0.500 - WEIGHTING FACTOR
WLT1 =     2.500 - WEIGHTING FACTOR                           WLT2 =      0.500 - WEIGHTING FACTOR
T    =    30.000 - INVESTMENT HORIZON (YEARS)                 PLV  =    175.000 - DISTANCE FROM ROAD TO SETBACK (FEET)
BANK =    23.750 - POINT WHERE MORTGAGE BECOMES UNAVAILABLE   STPL =     50.000 - POINT OF SHARP STRUCTURE VALUE DECLINE
STPB =    36.875 - 1/2 WAY BETWEEN BANK AND STEPL (FEET)      BASE =     51.021 - LENGTH OF THE BLUFF BASE (FEET)
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INPUT PARAMETERS | OUTPUT PARAMETERS

AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	17.16	0.950	0	2.50	0.13	0.0	0.0	17.16	17.16	-17.16	-48.00	-48.00
3.90	.100	17.16	0.950	1	6.40	0.32	0.0	0.0	15.60	32.76	-32.76	0.0	-48.00
5.40	.100	17.16	0.950	2	11.80	0.59	0.0	0.0	14.18	46.94	-46.94	0.0	-48.00
4.80	.100	17.16	0.950	3	16.60	0.83	0.0	0.0	12.89	59.83	-59.83	0.0	-48.00
4.40	.100	17.16	0.950	4	21.00	1.05	0.0	0.0	11.72	71.55	-71.55	0.0	-48.00
3.90	.100	17.16	0.950	5	24.90	1.25	0.0	0.0	10.66	82.21	-82.21	0.0	-48.00
3.30	.100	17.16	0.950	6	28.20	1.41	0.0	0.0	9.69	91.90	-91.90	0.0	-48.00
2.60	.100	17.16	0.950	7	30.80	1.54	0.0	0.0	8.81	100.70	-100.70	0.0	-48.00
1.90	.100	17.16	0.930	8	32.70	1.67	0.0	0.0	8.01	108.71	-108.71	0.0	-48.00
1.70	.100	17.16	0.910	9	34.40	1.83	0.0	0.0	7.28	115.99	-115.99	0.0	-48.00
3.20	.100	17.16	0.890	10	37.60	2.18	0.0	0.0	6.62	122.60	-122.60	0.0	-48.00
2.90	.100	17.16	0.870	11	40.50	2.56	0.0	0.0	6.01	128.62	-128.62	0.0	-48.00
2.40	.100	17.16	0.850	12	42.90	2.92	0.0	0.0	5.47	134.08	-134.08	0.0	-48.00
1.30	.100	17.16	0.830	13	44.20	3.14	0.0	0.0	4.97	139.05	-139.05	0.0	-48.00
0.70	.100	17.16	0.810	14	44.90	3.27	0.0	0.0	4.52	143.57	-143.57	0.0	-48.00
1.40	.100	17.16	0.790	15	46.30	3.56	0.0	0.0	4.11	147.68	-147.68	0.0	-48.00
2.30	.100	17.16	0.770	16	48.60	4.09	0.0	0.0	3.73	151.42	-151.42	0.0	-48.00
2.80	.100	17.16	0.750	17	51.40	4.79	38.50	38.50	3.40	154.81	-116.31	-38.50	-86.50
2.80	.100	17.16	0.730	18	54.20	5.55	0.0	38.50	3.09	157.90	-119.40	0.0	-86.50
3.30	.100	17.16	0.710	19	57.50	6.51	0.0	38.50	2.81	160.70	-122.20	0.0	-86.50
4.10	.100	17.16	0.690	20	61.60	7.78	0.0	38.50	2.55	163.25	-124.75	0.0	-86.50
3.90	.100	17.16	0.670	21	65.50	9.06	0.0	38.50	2.32	165.57	-127.07	0.0	-86.50
4.30	.100	17.16	0.650	22	69.80	10.57	0.0	38.50	2.11	167.68	-129.18	0.0	-86.50
4.80	.100	17.16	0.630	23	74.60	12.34	0.0	38.50	1.92	169.60	-131.10	0.0	-86.50
5.40	.100	17.16	0.610	24	80.00	14.45	0.0	38.50	1.74	171.34	-132.84	0.0	-86.50
5.40	.100	17.16	0.590	25	85.40	16.66	0.0	38.50	1.58	172.92	-134.42	0.0	-86.50
4.90	.100	0.0	0.570	26	90.30	18.77	0.0	38.50	0.0	172.92	-134.42	0.0	-86.50
4.60	.100	0.0	0.550	27	94.90	20.84	0.0	38.50	0.0	172.92	-134.42	0.0	-86.50
3.40	.100	0.0	0.530	28	98.30	22.44	0.0	38.50	0.0	172.92	-134.42	0.0	-86.50
4.40	.100	0.0	0.510	29	102.70	24.59	0.0	38.50	0.0	172.92	-134.42	0.0	-86.50
4.20	.100	0.0	0.490	30	106.90	26.74	0.0	38.50	0.0	172.92	-134.42	0.0	-86.50

BENEFIT/COST MODEL OF SHORELINE PROCESSES

COSTAL ZONE LABORATORY UNIVERSITY OF MICHIGAN VERSION #2 DECEMBER 1978

OFFSHORE BREAKWATER - 6000 FT STRUCTURE - 25 YEAR BOND

CZL-150 DELEABTAAI (16M55)

NUMBER OF PROPERTIES PROCESSED = 1 TOTAL LENGTH OF SHORELINE = 162.00

DPTH =	1410.000	DEPTH OF THE LOT (FEET)	L =	162.000	FRONT FOOTAGE OF LOT IN (FEET)
FOUN =	3.0	DISTANCE FROM FOUNDATION TO BLUFF (FEET)	HOME =	0.0	DEPTH OF THE HOME (FEET)
BSET =	143.000	RECCOMENDED SET BACK DISTANCE (FEET)	PSET =	35.000	SET BACK IN FRONT OF HOME (FEET)
H =	48.000	HEIGTH OF THE BLUFF (FEET)	TH =	0.755	ANGLE OF THE BLUFF (RADIANS)
TV =	30000.000	LAKESIDE LAND VALUE ($)	LV =	9000.000	INLAND LAND VALUE ($)
SV =	0.0	HOME OR STRUCTURE VALUE ($)	RESR =	1.000	RECESSION RATE MODIFIER
LRES =	3.667	LONG TERM RECESSION RATE (FEET/YEAR)	AEST =	21000.000	ASTHETIC VALUE ($)
CCST =	6000.000	COST TO MOVE HOME ($)	√ RI =	0.100	DISCOUNTING RATE
REST =	20.000	REALTORS ESTIMATE OF BANK (FEET)	A =	0.500	WEIGHTING FACTOR
MLT1 =	2.500	WEIGHTING FACTOR	MLT2 =	0.500	WEIGHTING FACTOR
T =	30.000	INVESTMENT HORIZON (YEARS)	PLV =	175.000	DISTANCE FROM ROAD TO SETBACK (FEET)
√BANK =	23.750	POINT WHERE MORTGAGE BECOMES UNAVAILABLE	√ STPL =	50.000	POINT OF SHARP STRUCTURE VALUE DECLINE
STPB =	36.875	1/2 WAY BETWEEN BANK AND STEPL (FEET)	BASE =	51.021	LENGTH OF THE BLUFF BASE (FEET)

INPUT PARAMETERS — OUTPUT PARAMETERS

AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	17.16	0.950	0	2.50	0.13	0.0	0.0	17.16	17.16	-17.16	-37.04	-37.04
3.90	.100	17.16	0.950	1	6.40	0.32	0.0	0.0	15.60	32.76	-32.76	0.0	-37.04
5.40	.100	17.16	0.950	2	11.80	0.59	0.0	0.0	14.18	46.94	-46.94	0.0	-37.04
4.80	.100	17.16	0.950	3	16.60	0.83	0.0	0.0	12.89	59.83	-59.83	0.0	-37.04
4.40	.100	17.16	0.950	4	21.00	1.05	0.0	0.0	11.72	71.55	-71.55	0.0	-37.04
3.90	.100	17.16	0.950	5	24.90	1.25	0.0	0.0	10.66	82.21	-82.21	0.0	-37.04
3.30	.100	17.16	0.950	6	28.20	1.41	0.0	0.0	9.69	91.90	-91.90	0.0	-37.04
2.60	.100	17.16	0.950	7	30.80	1.54	0.0	0.0	8.81	100.70	-100.70	0.0	-37.04
1.90	.100	17.16	0.930	8	32.70	1.67	0.0	0.0	8.01	108.71	-108.71	0.0	-37.04
1.70	.100	17.16	0.910	9	34.40	1.83	0.0	0.0	7.28	115.99	-115.99	0.0	-37.04
3.20	.100	17.16	0.890	10	37.60	2.18	0.0	0.0	6.62	122.60	-122.60	0.0	-37.04
2.90	.100	17.16	0.870	11	40.50	2.56	0.0	0.0	6.01	128.62	-128.62	0.0	-37.04
2.40	.100	17.16	0.850	12	42.90	2.92	0.0	0.0	5.47	134.08	-134.08	0.0	-37.04
1.30	.100	17.16	0.830	13	44.20	3.14	0.0	0.0	4.97	139.05	-139.05	0.0	-37.04
0.70	.100	17.16	0.810	14	44.90	3.27	0.0	0.0	4.52	143.57	-143.57	0.0	-37.04
1.40	.100	17.16	0.790	15	46.30	3.56	0.0	0.0	4.11	147.68	-147.68	0.0	-37.04
2.30	.100	17.16	0.770	16	48.60	4.09	0.0	0.0	3.73	151.42	-151.42	0.0	-37.04
2.80	.100	17.16	0.750	17	51.40	4.79	35.65	35.65	3.40	154.81	-119.16	-35.65	-72.69
2.80	.100	17.16	0.730	18	54.20	5.55	0.0	35.65	3.09	157.90	-122.25	0.0	-72.69
3.30	.100	17.16	0.710	19	57.50	6.51	0.0	35.65	2.81	160.70	-125.05	0.0	-72.69
4.10	.100	17.16	0.690	20	61.60	7.78	0.0	35.65	2.55	163.25	-127.60	0.0	-72.69
3.90	.100	17.16	0.670	21	65.50	9.06	0.0	35.65	2.32	165.57	-129.92	0.0	-72.69
4.30	.100	17.16	0.650	22	69.80	10.57	0.0	35.65	2.11	167.68	-132.03	0.0	-72.69
4.80	.100	17.16	0.630	23	74.60	12.34	0.0	35.65	1.92	169.60	-133.95	0.0	-72.69
5.40	.100	17.16	0.610	24	80.00	14.45	0.0	35.65	1.74	171.34	-135.69	0.0	-72.69
5.40	.100	17.16	0.590	25	85.40	16.66	0.0	35.65	1.58	172.92	-137.27	0.0	-72.69
4.90	.100	0.0	0.570	26	90.30	18.77	0.0	35.65	0.0	172.92	-137.27	0.0	-72.69
4.60	.100	0.0	0.550	27	94.90	20.84	0.0	35.65	0.0	172.92	-137.27	0.0	-72.69
3.40	.100	0.0	0.530	28	98.30	22.44	0.0	35.65	0.0	172.92	-137.27	0.0	-72.69
4.40	.100	0.0	0.510	29	102.70	24.59	0.0	35.65	0.0	172.92	-137.27	0.0	-72.69
4.20	.100	0.0	0.490	30	106.90	26.74	0.0	35.65	0.0	172.92	-137.27	0.0	-72.69

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY UNIVERSITY OF MICHIGAN VERSION #2 DECEMBER 1978

OFFSHORE BREAKWATER - 6000 FT STRUCTURE - 25 YEAR BOND
CZL-160 MORPHCS (16M56)
NUMBER OF PROPERTIES PROCESSED = 1 TOTAL LENGTH OF SHORELINE = 165.00

DPTH =	1200.000	- DEPTH OF THE LOT (FEET)	L =	165.000	- FRONT FOOTAGE OF LOT IN (FEET)
FOUN =	150.000	- DISTANCE FROM FOUNDATION TO BLUFF (FEET)	HOME =	60.000	- DEPTH OF THE HOME (FEET)
RSET =	140.000	- RECCOMENDED SET BACK DISTANCE (FEET)	FSET =	35.000	- SET BACK IN FRONT OF HOME (FEET)
H =	48.000	- HEIGTH OF THE BLUFF (FEET)	TH =	0.755	- ANGLE OF THE BLUFF (RADIANS)
TV =	30000.000	- LAKESIDE LAND VALUE ($)	LV =	9000.000	- INLAND LAND VALUE ($)
SV =	65000.000	- HOME OR STRUCTURE VALUE ($)	RESR =	1.000	- RECESSION RATE MODIFIER
LRES =	3.667	- LONG TERM RECESSION RATE (FEET/YEAR)	AEST =	21000.000	- ASTHETIC VALUE ($)
COST =	6000.000	- COST TO MOVE HOME ($)	RI =	0.100	- DISCOUNTING RATE
REST =	20.000	- REALTORS ESTIMATE OF BANK (FEET)	A =	0.500	- WEIGHTING FACTOR
MLT1 =	2.500	- WEIGHTING FACTOR	MLT2 =	0.500	- WEIGHTING FACTOR
T =	30.000	- INVESTMENT HORIZON (YEARS)	PLV =	235.000	- DISTANCE FROM ROAD TO SETBACK (FEET)
BANK =	23.750	- POINT WHERE MORTGAGE BECOMES UNAVAILABLE	STPL =	50.000	- POINT OF SHARP STRUCTURE VALUE DECLINE
STPB =	36.875	- 1/2 WAY BETWEEN BANK AND STEPL (FEET)	BASE =	51.021	- LENGTH OF THE BLUFF BASE (FEET)

INPUT PARAMETERS — OUTPUT PARAMETERS

AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	17.16	0.950	0	2.50	0.13	0.0	0.0	17.16	17.16	-17.16	-36.36	-36.36
3.90	.100	17.16	0.950	1	6.40	0.32	0.0	0.0	15.60	32.76	-32.76	0.0	-36.36
5.40	.100	17.16	0.950	2	11.80	0.59	0.0	0.0	14.18	46.94	-46.94	0.0	-36.36
4.80	.100	17.16	0.950	3	16.60	0.83	0.0	0.0	12.89	59.83	-59.83	0.0	-36.36
4.40	.100	17.16	0.950	4	21.00	1.05	0.0	0.0	11.72	71.55	-71.55	0.0	-36.36
3.90	.100	17.16	0.950	5	24.90	1.25	0.0	0.0	10.66	82.21	-82.21	0.0	-36.36
3.30	.100	17.16	0.950	6	28.20	1.41	0.0	0.0	9.69	91.90	-91.90	0.0	-36.36
2.60	.100	17.16	0.950	7	30.80	1.54	0.0	0.0	8.81	100.70	-100.70	0.0	-36.36
1.90	.100	17.16	0.930	8	32.70	1.67	0.0	0.0	8.01	108.71	-108.71	0.0	-36.36
1.70	.100	17.16	0.910	9	34.40	1.83	0.0	0.0	7.28	115.99	-115.99	0.0	-36.36
3.20	.100	17.16	0.890	10	37.60	2.18	0.0	0.0	6.62	122.60	-122.60	0.0	-36.36
2.90	.100	17.16	0.870	11	40.50	2.56	0.0	0.0	6.01	128.62	-128.62	0.0	-36.36
2.40	.100	17.16	0.850	12	42.90	2.92	0.0	0.0	5.47	134.08	-134.08	0.0	-36.36
1.30	.100	17.16	0.830	13	44.20	3.14	0.0	0.0	4.97	139.05	-139.05	0.0	-36.36
0.70	.100	17.16	0.810	14	44.90	3.27	0.0	0.0	4.52	143.57	-143.57	0.0	-36.36
1.40	.100	17.16	0.790	15	46.30	3.56	0.0	0.0	4.11	147.68	-147.68	0.0	-36.36
2.30	.100	17.16	0.770	16	48.60	4.09	0.0	0.0	3.73	151.42	-151.42	0.0	-36.36
2.80	.100	17.16	0.750	17	51.40	4.79	35.00	35.00	3.40	154.81	-119.81	-35.00	-71.36
2.80	.100	17.16	0.730	18	54.20	5.55	0.0	35.00	3.09	157.90	-122.90	0.0	-71.36
3.30	.100	17.16	0.710	19	57.50	6.51	0.0	35.00	2.81	160.70	-125.70	0.0	-71.36
4.10	.100	17.16	0.690	20	61.60	7.78	0.0	35.00	2.55	163.25	-128.25	0.0	-71.36
3.90	.100	17.16	0.670	21	65.50	9.06	0.0	35.00	2.32	165.57	-130.57	0.0	-71.36
4.30	.100	17.16	0.650	22	69.80	10.57	0.0	35.00	2.11	167.68	-132.68	0.0	-71.36
4.80	.100	17.16	0.630	23	74.60	12.34	0.0	35.00	1.92	169.60	-134.60	0.0	-71.36
5.40	.100	17.16	0.610	24	80.00	14.45	0.0	35.00	1.74	171.34	-136.34	0.0	-71.36
5.40	.100	17.16	0.590	25	85.40	16.66	0.0	35.00	1.58	172.92	-137.92	0.0	-71.36
4.90	.100	0.0	0.570	26	90.30	18.77	0.0	35.00	0.0	172.92	-137.92	0.0	-71.36
4.60	.100	0.0	0.550	27	94.90	20.84	0.0	35.00	0.0	172.92	-137.92	0.0	-71.36
3.40	.100	0.0	0.530	28	98.30	22.44	0.0	35.00	0.0	172.92	-137.92	0.0	-71.36
4.40	.100	0.0	0.510	29	102.70	24.59	130.00	165.00	0.0	172.92	-7.92	130.00	58.64
4.20	.100	0.0	0.490	30	106.90	26.74	0.0	165.00	0.0	172.92	-7.92	0.0	58.64

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY UNIVERSITY OF MICHIGAN VERSION #2 DECEMBER 1978

OFFSHORE BREAKWATER - 6000 FT STRUCTURE - 25 YEAR BOND
CZL-180 MANASZAK (1688.5)
NUMBER OF PROPERTIES PROCESSED = 1 TOTAL LENGTH OF SHORELINE = 40.00

DPTH =	345.000 - DEPTH OF THE LOT (FEET)		L =	40.000 - FRONT FOOTAGE OF LOT IN (FEET)	
FOUN =	23.000 - DISTANCE FROM FOUNDATION TO BLUFF (FEET)		HOME =	50.000 - DEPTH OF THE HOME (FEET)	
BSET =	140.000 - RECCOMENDED SET BACK DISTANCE (FEET)		PSET =	35.000 - SET BACK IN FRONT OF HOME (FEET)	
H =	43.000 - HEIGTH OF THE BLUFF (FEET)		TH =	0.755 - ANGLE OF THE BLUFF (RADIANS)	
TV =	7503.000 - LAKESIDE LAND VALUE ($)		LV =	2250.000 - INLAND LAND VALUE ($)	
SV =	37500.000 - HOME OR STRUCTURE VALUE ($)		RESP =	1.000 - RECESSION RATE MODIFIER	
LRES =	3.667 - LONG TERM RECESSION RATE (FEET/YEAR)		AEST =	5250.000 - ASTHETIC VALUE ($)	
COST =	6000.000 - COST TO MOVE HOME ($)		RI =	0.100 - DISCOUNTING RATE	
REST =	20.000 - REALTORS ESTIMATE OF BANK (FEET)		A =	0.500 - WEIGHTING FACTOR	
WLT1 =	2.500 - WEIGHTING FACTOR		WLT2 =	0.500 - WEIGHTING FACTOR	
T =	30.000 - INVESTMENT HORIZON (YEARS)		PLV =	225.000 - DISTANCE FROM ROAD TO SETBACK (FEET)	
BANK =	23.750 - POINT WHERE MORTGAGE BECOMES UNAVAILABLE		STPL =	50.000 - POINT OF SHARP STRUCTURE VALUE DECLINE	
STPB =	35.875 - 1/2 WAY BETWEEN BANK AND STEPL (FEET)		BASE =	51.021 - LENGTH OF THE BLUFF BASE (FEET)	

INPUT PARAMETERS					OUTPUT PARAMETERS									
AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	17.16	0.950	0	2.50	0.13	0.0	0.0	17.16	17.16	-17.16	571.87	571.87
3.90	.100	17.16	0.950	1	6.40	0.32	0.0	0.0	15.60	32.76	-32.76	0.0	571.87
5.40	.100	17.16	0.950	2	11.80	0.59	0.0	0.0	14.18	46.94	-46.94	0.0	571.87
4.80	.100	17.16	0.950	3	16.60	0.83	0.0	0.0	12.89	59.83	-59.83	0.0	571.87
4.40	.100	17.16	0.950	4	21.00	1.05	309.38	309.38	11.72	71.55	237.82	309.38	881.25
3.90	.100	17.16	0.950	5	24.90	1.25	0.0	309.38	10.66	82.21	227.17	0.0	881.25
3.30	.100	17.16	0.950	6	28.20	1.41	0.0	309.38	9.69	91.90	217.48	0.0	881.25
2.60	.100	17.16	0.950	7	30.80	1.54	0.0	309.38	8.81	100.70	208.67	0.0	881.25
1.90	.100	17.16	0.930	8	32.70	1.67	0.0	309.38	8.01	108.71	200.67	0.0	881.25
1.70	.100	17.16	0.910	9	34.40	1.83	0.0	309.38	7.28	115.99	193.39	0.0	881.25
3.20	.100	17.16	0.890	10	37.60	2.18	0.0	309.38	6.62	122.60	186.77	0.0	881.25
2.90	.100	17.16	0.870	11	40.50	2.56	0.0	309.38	6.01	128.62	180.76	0.0	881.25
2.40	.100	17.16	0.850	12	42.90	2.92	0.0	309.38	5.47	134.08	175.29	0.0	881.25
1.30	.100	17.16	0.830	13	44.20	3.14	0.0	309.38	4.97	139.05	170.32	0.0	881.25
0.70	.100	17.16	0.810	14	44.90	3.27	0.0	309.38	4.52	143.57	165.80	0.0	881.25
1.40	.100	17.16	0.790	15	46.30	3.56	0.0	309.38	4.11	147.68	161.70	0.0	881.25
2.30	.100	17.16	0.770	16	48.60	4.09	0.0	309.38	3.73	151.42	157.96	0.0	881.25
2.80	.100	17.16	0.750	17	51.40	4.79	36.09	345.47	3.40	154.81	190.66	-36.09	845.16
2.80	.100	17.16	0.730	18	54.20	5.55	0.0	345.47	3.09	157.90	187.57	0.0	845.16
3.30	.100	17.16	0.710	19	57.50	6.51	0.0	345.47	2.81	160.70	184.77	0.0	845.16
4.10	.100	17.16	0.690	20	61.60	7.78	0.0	345.47	2.55	163.25	182.22	0.0	845.16
3.90	.100	17.16	0.670	21	65.50	9.06	0.0	345.47	2.32	165.57	179.90	0.0	845.16
4.30	.100	17.16	0.650	22	69.80	10.57	0.0	345.47	2.11	167.68	177.79	0.0	845.16
4.80	.100	17.16	0.630	23	74.60	12.34	0.0	345.47	1.92	169.60	175.87	0.0	845.16
5.40	.100	17.16	0.610	24	80.00	14.45	0.0	345.47	1.74	171.34	174.13	0.0	845.16
5.40	.100	17.16	0.590	25	85.40	16.66	0.0	345.47	1.58	172.92	172.55	0.0	845.16
4.90	.100	0.0	0.570	26	90.30	18.77	0.0	345.47	0.0	172.92	172.55	0.0	845.16
4.60	.100	0.0	0.550	27	94.90	20.84	-309.38	36.09	0.0	172.92	-136.83	0.0	845.16
3.40	.100	0.0	0.530	28	98.30	22.44	0.0	36.09	0.0	172.92	-136.83	0.0	845.16
4.40	.100	0.0	0.510	29	102.70	24.59	0.0	36.09	0.0	172.92	-136.83	0.0	845.16
4.20	.100	0.0	0.490	30	106.90	26.74	0.0	36.09	0.0	172.92	-136.83	0.0	845.16

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY UNIVERSITY OF MICHIGAN VERSION #2 DECEMBER 1978

OFFSHORE BREAKWATER - 6000 FT STRUCTURE - 25 YEAR BOND
CZL-190 ANTONIOLLI (1688.12)
NUMBER OF PROPERTIES PROCESSED = 1 TOTAL LENGTH OF SHORELINE = 75.00

DPTH = 287.000	DEPTH OF THE LOT (FEET)	L =	75.000	FRONT FOOTAGE OF LOT IN (FEET)
FOUN = 0.0	DISTANCE FROM FOUNDATION TO BLUFF (FEET)	HOMP =	0.0	DEPTH OF THE HOME (FEET)
RSET = 140.000	RECCOMENDED SET BACK DISTANCE (FEET)	FSET =	35.000	SET BACK IN FRONT OF HOME (FEET)
H = 41.000	HEIGTH OF THE BLUFF (FEET)	TH =	0.620	ANGLE OF THE BLUFF (RADIANS)
TV = 11250.000	LAKESIDE LAND VALUE ($)	LV =	3375.000	INLAND LAND VALUE ($)
SV = 0.0	HOME OR STRUCTURE VALUE ($)	RESR =	1.000	RECESSION RATE MODIFIER
LRES = 3.667	LONG TERM RECESSION RATE (FEET/YEAR)	AEST =	7875.000	ASTHETIC VALUE ($)
COST = 6000.000	COST TO MOVE HOME ($)	RI =	0.100	DISCOUNTING RATE
REST = 20.000	REALTORS ESTIMATE OF BANK (FEET)	A =	0.500	WEIGHTING FACTOR
MLT1 = 2.500	WEIGHTING FACTOR	MLT2 =	0.500	WEIGHTING FACTOR
T = 30.000	INVESTMENT HORIZON (YEARS)	PLV =	175.000	DISTANCE FROM ROAD TO SETBACK (FEET)
BANK = 23.750	POINT WHERE MORTGAGE BECOMES UNAVAILABLE	STPL =	50.000	POINT OF SHARP STRUCTURE VALUE DECLINE
STPB = 36.875	1/2 WAY BETWEEN BANK AND STEPL (FEET)	BASE =	57.479	LENGTH OF THE BLUFF BASE (FEET)

INPUT PARAMETERS							OUTPUT PARAMETERS							
AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	17.16	0.950	0	2.50	0.13	0.0	0.0	17.16	17.16	-17.16	-80.00	-80.00
3.90	.100	17.16	0.950	1	6.40	0.32	0.0	0.0	15.60	32.76	-32.76	0.0	-80.00
5.40	.100	17.16	0.950	2	11.80	0.59	0.0	0.0	14.18	46.94	-46.94	0.0	-80.00
4.80	.100	17.16	0.950	3	16.60	0.83	0.0	0.0	12.89	59.83	-59.83	0.0	-80.00
4.40	.100	17.16	0.950	4	21.00	1.05	0.0	0.0	11.72	71.55	-71.55	0.0	-80.00
3.90	.100	17.16	0.950	5	24.90	1.25	0.0	0.0	10.66	82.21	-82.21	0.0	-80.00
3.30	.100	17.16	0.950	6	28.20	1.41	0.0	0.0	9.69	91.90	-91.90	0.0	-80.00
2.60	.100	17.16	0.950	7	30.80	1.54	0.0	0.0	8.81	100.70	-100.70	0.0	-80.00
1.90	.100	17.16	0.930	8	32.70	1.67	0.0	0.0	8.01	108.71	-108.71	0.0	-80.00
1.70	.100	17.16	0.910	9	34.40	1.83	0.0	0.0	7.28	115.99	-115.99	0.0	-80.00
3.20	.100	17.16	0.890	10	37.60	2.18	0.0	0.0	6.62	122.60	-122.60	0.0	-80.00
2.90	.100	17.16	0.870	11	40.50	2.56	0.0	0.0	6.01	128.62	-128.62	0.0	-80.00
2.40	.100	17.16	0.850	12	42.90	2.92	0.0	0.0	5.47	134.08	-134.08	0.0	-80.00
1.30	.100	17.16	0.830	13	44.20	3.14	0.0	0.0	4.97	139.05	-139.05	0.0	-80.00
0.70	.100	17.16	0.810	14	44.90	3.27	0.0	0.0	4.52	143.57	-143.57	0.0	-80.00
1.40	.100	17.16	0.790	15	46.30	3.56	0.0	0.0	4.11	147.68	-147.68	0.0	-80.00
2.30	.100	17.16	0.770	16	48.60	4.09	0.0	0.0	3.73	151.42	-151.42	0.0	-80.00
2.80	.100	17.16	0.750	17	51.40	4.79	0.0	0.0	3.40	154.81	-154.81	0.0	-80.00
2.80	.100	17.16	0.730	18	54.20	5.55	0.0	0.0	3.09	157.90	-157.90	0.0	-80.00
3.30	.100	17.16	0.710	19	57.50	6.51	28.88	28.88	2.81	160.70	-131.83	-28.88	-108.88
4.10	.100	17.16	0.690	20	61.60	7.78	0.0	28.88	2.55	163.25	-134.38	0.0	-108.88
3.90	.100	17.16	0.670	21	65.50	9.06	0.0	28.88	2.32	165.57	-136.70	0.0	-108.88
4.30	.100	17.16	0.650	22	69.80	10.57	0.0	28.88	2.11	167.68	-138.80	0.0	-108.88
4.80	.100	17.16	0.630	23	74.60	12.34	0.0	28.88	1.92	169.60	-140.72	0.0	-108.88
5.40	.100	17.16	0.610	24	80.00	14.45	0.0	28.88	1.74	171.34	-142.46	0.0	-108.88
5.40	.100	17.16	0.590	25	85.40	16.66	0.0	28.88	1.58	172.92	-144.05	0.0	-108.88
4.90	.100	0.0	0.570	26	90.30	18.77	0.0	28.88	0.0	172.92	-144.05	0.0	-108.88
4.60	.100	0.0	0.550	27	94.90	20.84	0.0	28.88	0.0	172.92	-144.05	0.0	-108.88
3.40	.100	0.0	0.530	28	98.30	22.44	0.0	28.88	0.0	172.92	-144.05	0.0	-108.88
4.40	.100	0.0	0.510	29	102.70	24.59	0.0	28.88	0.0	172.92	-144.05	0.0	-108.88
4.20	.100	0.0	0.490	30	106.90	26.74	0.0	28.88	0.0	172.92	-144.05	0.0	-108.88

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY UNIVERSITY OF MICHIGAN VERSION #2 DECEMBER 1978

OFFSHORE BREAKWATER - 6000 FT STRUCTURE - 25 YEAR BOND
CZL-200 0 BRIFN (16MB.14)
NUMBER OF PROPERTIES PROCESSED = 1 TOTAL LENGTH OF SHORELINE = 65.00

DPTH =	347.000	- DEPTH OF THE LOT (FEET)	L =	65.000	- FRONT FOOTAGE OF LOT IN (FEET)
FOUN =	40.000	- DISTANCE FROM FOUNDATION TO BLUFF (FEET)	HOME =	40.000	- DEPTH OF THE HOME (FEET)
RSET =	140.000	- RECCOMENDED SET BACK DISTANCE (FEET)	FSET =	35.000	- SET BACK IN FRONT OF HOME (FEET)
H =	41.000	- HEIGTH OF THE BLUFF (FEET)	TH =	0.620	- ANGLE OF THE BLUFF (RADIANS)
TV =	9750.000	- LAKESIDE LAND VALUE ($)	LV =	2925.000	- INLAND LAND VALUE ($)
SV =	35000.000	- HOME OR STRUCTURE VALUE ($)	RESR =	1.000	- RECESSION RATE MODIFIER
LRES =	3.667	- LONG TERM RECESSION RATE (FEET/YEAR)	AEST =	6825.000	- ASTHETIC VALUE ($)
COST =	6000.000	- COST TO MOVE HOME ($)	RI =	0.100	- DISCOUNTING RATE
REST =	20.000	- REALTORS ESTIMATE OF BANK (FEET)	A =	0.500	- WEIGHTING FACTOR
MLT1 =	2.500	- WEIGHTING FACTOR	MLT2 =	0.500	- WEIGHTING FACTOR
T =	30.000	- INVESTMENT HORIZON (YEARS)	PLV =	215.000	- DISTANCE FROM ROAD TO SETBACK (FEET)
BANK =	23.750	- POINT WHERE MORTGAGE BECOMES UNAVAILABLE	STPL =	50.000	- POINT OF SHARP STRUCTURE VALUE DECLINE
STPB =	36.875	- 1/2 WAY BETWEEN BANK AND STEPL (FEET)	BASE =	57.479	- LENGTH OF THE BLUFF BASE (FEET)

INPUT PARAMETERS | OUTPUT PARAMETERS

AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	17.16	0.950	0	2.50	0.13	0.0	0.0	17.16	17.16	-17.16	85.38	85.38
3.90	.100	17.16	0.950	1	6.40	0.32	59.12	59.12	15.60	32.76	26.36	59.12	144.50
5.40	.100	17.16	0.950	2	11.80	0.59	97.48	156.60	14.18	46.94	109.65	97.48	241.98
4.80	.100	17.16	0.950	3	16.60	0.83	80.33	236.92	12.89	59.83	177.09	80.33	322.31
4.40	.100	17.16	0.950	4	21.00	1.05	0.0	236.92	11.72	71.55	165.37	0.0	322.31
3.90	.100	17.16	0.950	5	24.90	1.25	0.0	236.92	10.66	82.21	154.71	0.0	322.31
3.30	.100	17.16	0.950	6	28.20	1.41	0.0	236.92	9.69	91.90	145.03	0.0	322.31
2.60	.100	17.16	0.950	7	30.80	1.54	0.0	236.92	8.81	100.70	136.22	0.0	322.31
1.90	.100	17.16	0.930	8	32.70	1.67	0.0	236.92	8.01	108.71	128.22	0.0	322.31
1.70	.100	17.16	0.910	9	34.40	1.83	0.0	236.92	7.28	115.99	120.94	0.0	322.31
3.20	.100	17.16	0.890	10	37.60	2.18	0.0	236.92	6.62	122.60	114.32	0.0	322.31
2.90	.100	17.16	0.870	11	40.50	2.56	177.69	414.62	6.01	128.62	286.00	177.69	500.00
2.40	.100	17.16	0.850	12	42.90	2.92	0.0	414.62	5.47	134.08	280.53	0.0	500.00
1.30	.100	17.16	0.830	13	44.20	3.14	-0.20	414.42	4.97	139.05	275.36	0.0	500.00
0.70	.100	17.16	0.810	14	44.90	3.27	-2.40	412.01	4.52	143.57	268.44	0.0	500.00
1.40	.100	17.16	0.790	15	46.30	3.56	-5.31	406.71	4.11	147.68	259.03	0.0	500.00
2.30	.100	17.16	0.770	16	48.60	4.09	-9.55	397.16	3.73	151.42	245.74	0.0	500.00
2.80	.100	17.16	0.750	17	51.40	4.79	-12.64	384.52	3.40	154.81	229.71	0.0	500.00
2.80	.100	17.16	0.730	18	54.20	5.55	-13.65	370.87	3.09	157.90	212.98	0.0	500.00
3.30	.100	17.16	0.710	19	57.50	6.51	11.60	382.47	2.81	160.70	221.77	-28.88	471.13
4.10	.100	17.16	0.690	20	61.60	7.78	-22.94	359.53	2.55	163.25	196.28	0.0	471.13
3.90	.100	17.16	0.670	21	65.50	9.06	-23.23	336.30	2.32	165.57	170.73	0.0	471.13
4.30	.100	17.16	0.650	22	69.80	10.57	-27.17	309.13	2.11	167.68	141.45	0.0	471.13
4.80	.100	17.16	0.630	23	74.60	12.34	-32.06	277.07	1.92	169.60	107.47	0.0	471.13
5.40	.100	17.16	0.610	24	80.00	14.45	-38.02	239.06	1.74	171.34	67.72	0.0	471.13
5.40	.100	17.16	0.590	25	85.40	16.66	-32.49	206.56	1.58	172.92	33.64	0.0	471.13
4.90	.100	0.0	0.570	26	90.30	18.77	0.0	206.56	0.0	172.92	33.64	0.0	471.13
4.60	.100	0.0	0.550	27	94.90	20.84	0.0	206.56	0.0	172.92	33.64	0.0	471.13
3.40	.100	0.0	0.530	28	98.30	22.44	0.0	206.56	0.0	172.92	33.64	0.0	471.13
4.40	.100	0.0	0.510	29	102.70	24.59	0.0	206.56	0.0	172.92	33.64	0.0	471.13
4.20	.100	0.0	0.490	30	106.90	26.74	0.0	206.56	0.0	172.92	33.64	0.0	471.13

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORTORY UNIVERSITY OF MICHIGAN VERSION #2 DECEMBER 1978

OFFSHORE BREAKWATER - 6000 FT STRUCTURE - 25 YEAR BOND
CZL-210 SUMMERSET ESTATES (LOTS 21-27)
NUMBER OF PROPERTIES PROCESSED = 1 TOTAL LENGTH OF SHORELINE = 700.00

DPTH =	75.000	- DEPTH OF THE LOT (FEET)	L =	700.000	- FRONT FOOTAGE OF LOT IN (FEET)
FOUN =	0.0	- DISTANCE FROM FOUNDATION TO BLUFF (FEET)	HOME =	0.0	- DEPTH OF THE HOME (FEET)
RSET =	140.000	- RECCOMENDED SET BACK DISTANCE (FEET)	PSET =	35.000	- SET BACK IN FRONT OF HOME (FEET)
H =	41.000	- HEIGTH OF THE BLUFF (FEET)	TH =	0.620	- ANGLE OF THE BLUFF (RADIANS)
TV =	5000.000	- LAKESIDE LAND VALUE ($)	LV =	1500.000	- INLAND LAND VALUE ($)
SV =	0.0	- HOME OR STRUCTURE VALUE ($)	RESR =	1.000	- RECESSION RATE MODIFIER
LRES =	3.667	- LONG TERM RECESSION RATE (FEET/YEAR)	AEST =	3500.000	- ASTHETIC VALUE ($)
COST =	6000.000	- COST TO MOVE HOME ($)	RI =	0.100	- DISCOUNTING RATE
REST =	20.000	- REALTORS ESTIMATE OF BANK (FEET)	A =	0.500	- WEIGHTING FACTOR
MLT1 =	2.500	- WEIGHTING FACTOR	MLT2 =	0.500	- WEIGHTING FACTOR
T =	30.000	- INVESTMENT HORIZON (YEARS)	PLV =	175.000	- DISTANCE FROM ROAD TO SETBACK (FEET)
BANK =	23.750	- POINT WHERE MORTGAGE BECOMES UNAVAILABLE	STPL =	50.000	- POINT OF SHARP STRUCTURE VALUE DECLINE
STPB =	36.875	- 1/2 WAY BETWEEN BANK AND STEPL (FEET)	BASE =	57.479	- LENGTH OF THE BLUFF BASE (FEET)

INPUT PARAMETERS / OUTPUT PARAMETERS

AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	17.16	0.950	0	2.50	0.13	0.04	0.04	17.16	17.16	-17.12	-14.88	-14.88
3.90	.100	17.16	0.950	1	6.40	0.32	0.06	0.10	15.60	32.76	-32.66	-0.06	-14.94
5.40	.100	17.16	0.950	2	11.80	0.59	0.09	0.18	14.18	46.94	-46.76	-0.09	-15.03
4.80	.100	17.16	0.950	3	16.60	0.83	0.08	0.26	12.89	59.83	-59.57	-0.08	-15.12
4.40	.100	17.16	0.950	4	21.00	1.05	0.08	0.34	11.72	71.55	-71.21	-0.08	-15.20
3.90	.100	17.16	0.950	5	24.90	1.25	0.07	0.41	10.66	82.21	-81.80	-0.07	-15.27
3.30	.100	17.16	0.950	6	28.20	1.41	0.06	0.47	9.69	91.90	-91.42	-0.06	-15.34
2.60	.100	17.16	0.950	7	30.80	1.54	0.05	0.52	8.81	100.70	-100.18	-0.05	-15.39
1.90	.100	17.16	0.930	8	32.70	1.67	0.04	0.56	8.01	108.71	-108.15	-0.04	-15.43
1.70	.100	17.16	0.910	9	34.40	1.83	0.03	0.59	7.28	115.99	-115.39	-0.03	-15.46
3.20	.100	17.16	0.890	10	37.60	2.18	0.06	0.65	6.62	122.60	-121.95	-0.07	-15.53
2.90	.100	17.16	0.870	11	40.50	2.56	0.06	0.71	6.01	128.62	-127.91	-0.06	-15.59
2.40	.100	17.16	0.850	12	42.90	2.92	0.05	0.76	5.47	134.08	-133.33	-0.05	-15.64
1.30	.100	17.16	0.830	13	44.20	3.14	0.03	0.78	4.97	139.05	-138.27	-0.03	-15.67
0.70	.100	17.16	0.810	14	44.90	3.27	0.01	0.80	4.52	143.57	-142.78	-0.02	-15.69
1.40	.100	17.16	0.790	15	46.30	3.56	0.03	0.82	4.11	147.68	-146.86	-0.03	-15.72
2.30	.100	17.16	0.770	16	48.60	4.09	0.04	0.87	3.73	151.42	-150.55	-0.05	-15.77
2.80	.100	17.16	0.750	17	51.40	4.79	0.05	0.92	3.40	154.81	-153.89	-0.06	-15.84
2.80	.100	17.16	0.730	18	54.20	5.55	0.05	0.97	3.09	157.90	-156.92	-0.07	-15.90
3.30	.100	17.16	0.710	19	57.50	6.51	0.06	1.04	2.81	160.70	-159.67	-0.08	-15.98
4.10	.100	17.16	0.690	20	61.60	7.78	0.08	1.12	2.55	163.25	-162.14	-0.10	-16.08
3.90	.100	17.16	0.670	21	65.50	9.06	0.08	1.19	2.32	165.57	-164.38	-0.10	-16.18
4.30	.100	17.16	0.650	22	69.80	10.57	0.09	1.28	2.11	167.68	-166.40	-0.11	-16.29
4.80	.100	17.16	0.630	23	74.60	12.34	0.10	1.37	1.92	169.60	-168.22	-0.13	-16.42
5.40	.100	17.16	0.610	24	80.00	14.45	0.11	1.49	1.74	171.34	-169.85	-0.15	-16.57
5.40	.100	17.16	0.590	25	85.40	16.66	0.11	1.60	1.58	172.92	-171.32	-0.15	-16.72
4.90	.100	0.0	0.570	26	90.30	18.77	0.10	1.70	0.0	172.92	-171.22	-0.14	-16.86
4.60	.100	0.0	0.550	27	94.90	20.84	0.10	1.80	0.0	172.92	-171.12	-0.14	-17.00
3.40	.100	0.0	0.530	28	98.30	22.44	0.07	1.87	0.0	172.92	-171.05	-0.10	-17.10
4.40	.100	0.0	0.510	29	102.70	24.59	0.09	1.97	0.0	172.92	-170.95	-0.14	-17.23
4.20	.100	0.0	0.490	30	106.90	26.74	0.09	2.06	0.0	172.92	-170.86	-0.13	-17.37

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY UNIVERSITY OF MICHIGAN VERSION #2 DECEMBER 1978

OFFSHORE BREAKWATER - 6000 FT STRUCTURE - 25 YEAR BOND
CZL-220 DOEBR (16N10)
NUMBER OF PROPERTIES PROCESSED = 1 TOTAL LENGTH OF SHORELINE = 346.00

DPTH = 2000.000 - DEPTH OF THE LOT (FEET)		L = 346.000 - FRONT FOOTAGE OF LOT IN (FEET)
FOUN = 0.0 - DISTANCE FROM FOUNDATION TO BLUFF (FEET)		HOME = 0.0 - DEPTH OF THE HOME (FEET)
USET = 140.000 - RECCOMENDED SET BACK DISTANCE (FEET)		FSET = 35.000 - SET BACK IN FRONT OF HOME (FEET)
H = 55.000 - HEIGTH OF THE BLUFF (FEET)		TH = 0.637 - ANGLE OF THE BLUFF (RADIANS)
TV = 52000.000 - LAKESIDE LAND VALUE ($)		LV = 15600.000 - INLAND LAND VALUE ($)
SV = 0.0 - HOME OR STRUCTURE VALUE ($)		RESR = 1.000 - RECESSION RATE MODIFIER
LRES = 3.667 - LONG TERM RECESSION RATE (FEET/YEAR)		AEST = 36400.000 - ASTHETIC VALUE ($)
COST = 6000.000 - COST TO MOVE HOME ($)		RI = 0.100 - DISCOUNTING RATE
REST = 20.000 - REALTORS ESTIMATE OF BANK (FEET)		A = 0.500 - WEIGHTING FACTOR
WLT1 = 2.500 - WEIGHTING FACTOR		WLT2 = 0.500 - WEIGHTING FACTOR
T = 30.000 - INVESTMENT HORIZON (YEARS)		PLV = 175.000 - DISTANCE FROM ROAD TO SETBACK (FEET)
BANK = 23.750 - POINT WHERE MORTGAGE BECOMES UNAVAILABLE		STPL = 50.000 - POINT OF SHARP STRUCTURE VALUE DECLINE
STPU = 36.875 - 1/2 WAY BETWEEN BANK AND STEPL (FEET)		BASE = 74.335 - LENGTH OF THE BLUFF BASE (FEET)

INPUT PARAMETERS | OUTPUT PARAMETERS

AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	17.16	0.950	0	2.50	0.13	0.0	0.0	17.16	17.16	-17.16	-17.34	-17.34
5.90	.100	17.16	0.950	1	6.40	0.32	0.0	0.0	15.60	32.76	-32.76	0.0	-17.34
5.40	.100	17.16	0.950	2	11.80	0.59	0.0	0.0	14.18	46.94	-46.94	0.0	-17.34
4.80	.100	17.16	0.950	3	16.60	0.83	0.0	0.0	12.89	59.83	-59.83	0.0	-17.34
4.40	.100	17.16	0.950	4	21.00	1.05	0.0	0.0	11.72	71.55	-71.55	0.0	-17.34
3.90	.100	17.16	0.950	5	24.90	1.25	0.0	0.0	10.66	82.21	-82.21	0.0	-17.34
3.30	.100	17.16	0.950	6	28.20	1.41	0.0	0.0	9.69	91.90	-91.90	0.0	-17.34
2.60	.100	17.16	0.950	7	30.80	1.54	0.0	0.0	8.81	100.70	-100.70	0.0	-17.34
1.90	.100	17.16	0.930	8	32.70	1.67	0.0	0.0	8.01	108.71	-108.71	0.0	-17.34
1.70	.100	17.16	0.910	9	34.40	1.83	0.0	0.0	7.28	115.99	-115.99	0.0	-17.34
3.20	.100	17.16	0.890	10	37.60	2.18	0.0	0.0	6.62	122.60	-122.60	0.0	-17.34
2.90	.100	17.16	0.870	11	40.50	2.56	0.0	0.0	6.01	128.62	-128.62	0.0	-17.34
2.40	.100	17.16	0.850	12	42.90	2.92	0.0	0.0	5.47	134.08	-134.08	0.0	-17.34
1.30	.100	17.16	0.830	13	44.20	3.14	0.0	0.0	4.97	139.05	-139.05	0.0	-17.34
0.70	.100	17.16	0.810	14	44.90	3.27	0.0	0.0	4.52	143.57	-143.57	0.0	-17.34
1.40	.100	17.16	0.790	15	46.30	3.56	0.0	0.0	4.11	147.68	-147.68	0.0	-17.34
2.30	.100	17.16	0.770	16	48.60	4.09	0.0	0.0	3.73	151.42	-151.42	0.0	-17.34
2.80	.100	17.16	0.750	17	51.40	4.79	0.0	0.0	3.40	154.81	-154.81	0.0	-17.34
2.80	.100	17.16	0.730	18	54.20	5.55	0.0	0.0	3.09	157.90	-157.90	0.0	-17.34
3.30	.100	17.16	0.710	19	57.50	6.51	0.0	0.0	2.81	160.70	-160.70	0.0	-17.34
4.10	.100	17.16	0.690	20	61.60	7.78	0.0	0.0	2.55	163.25	-163.25	0.0	-17.34
3.90	.100	17.16	0.670	21	65.50	9.06	0.0	0.0	2.32	165.57	-165.57	0.0	-17.34
4.30	.100	17.16	0.650	22	69.80	10.57	0.0	0.0	2.11	167.68	-167.68	0.0	-17.34
4.80	.100	17.16	0.630	23	74.60	12.34	28.93	28.93	1.92	169.60	-140.67	-28.93	-46.27
5.40	.100	17.16	0.610	24	80.00	14.45	0.0	28.93	1.74	171.34	-142.41	0.0	-46.27
5.40	.100	17.16	0.590	25	85.40	16.66	0.0	28.93	1.58	172.92	-143.99	0.0	-46.27
4.90	.100	0.0	0.570	26	90.30	18.77	0.0	28.93	0.0	172.92	-143.99	0.0	-46.27
4.60	.100	0.0	0.550	27	94.90	20.84	0.0	28.93	0.0	172.92	-143.99	0.0	-46.27
3.40	.100	0.0	0.530	28	98.30	22.44	0.0	28.93	0.0	172.92	-143.99	0.0	-46.27
4.40	.100	0.0	0.510	29	102.70	24.59	0.0	28.93	0.0	172.92	-143.99	0.0	-46.27
4.20	.100	0.0	0.490	30	106.90	26.74	0.0	28.93	0.0	172.92	-143.99	0.0	-46.27

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY UNIVERSITY OF MICHIGAN VERSION #2 DECEMBER 1978

OFFSHORE BREAKWATER - 6000 FT STRUCTURE - 25 YEAR BOND
CZL-230 PIONEER DEVELOPMENT CORP. (16M11)
NUMBER OF PROPERTIES PROCESSED = 1 TOTAL LENGTH OF SHORELINE = 285.00

DPTH =	1100.000 - DEPTH OF THE LOT (FEET)	L =	285.000 - FRONT FOOTAGE OF LOT IN (FEET)
FOUN =	70.000 - DISTANCE FROM FOUNDATION TO BLUFF (FEET)	HOME =	60.000 - DEPTH OF THE HOME (FEET)
RSET =	140.000 - RECCOMENDED SET BACK DISTANCE (FEET)	FSET =	35.000 - SET BACK IN FRONT OF HOME (FEET)
H =	55.000 - HEIGTH OF THE BLUFF (FEET)	TH =	0.637 - ANGLE OF THE BLUFF (RADIANS)
TV =	40000.000 - LAKESIDE LAND VALUE ($)	LV =	12000.000 - INLAND LAND VALUE ($)
SV =	45000.000 - HOME OR STRUCTURE VALUE ($)	RESR =	1.000 - RECESSION RATE MODIFIER
LRES =	3.667 - LONG TERM RECESSION RATE (FEET/YEAR)	AEST =	28000.000 - ASTHETIC VALUE ($)
COST =	6000.000 - COST TO MOVE HOME ($)	RI =	0.100 - DISCOUNTING RATE
REST =	20.000 - REALTORS ESTIMATE OF BANK (FEET)	A =	0.500 - WEIGHTING FACTOR
MLT1 =	2.500 - WEIGHTING FACTOR	MLT2 =	0.500 - WEIGHTING FACTOR
T =	30.000 - INVESTMENT HORIZON (YEARS)	PLV =	235.000 - DISTANCE FROM ROAD TO SETBACK (FEET)
BANK =	23.750 - POINT WHERE MORTGAGE BECOMES UNAVAILABLE	STPL =	50.000 - POINT OF SHARP STRUCTURE VALUE DECLINE
STPB =	36.875 - 1/2 WAY BETWEEN BANK AND STEEL (FEET)	BASE =	74.335 - LENGTH OF THE BLUFF BASE (FEET)

INPUT PARAMETERS					OUTPUT PARAMETERS									
AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	17.16	0.950	0	2.50	0.13	0.0	0.0	17.16	17.16	-17.16	-21.05	-21.05
3.90	.100	17.16	0.950	1	6.40	0.32	0.0	0.0	15.60	32.76	-32.76	0.0	-21.05
5.40	.100	17.16	0.950	2	11.80	0.59	0.0	0.0	14.18	46.94	-46.94	0.0	-21.05
4.80	.100	17.16	0.950	3	16.60	0.83	0.0	0.0	12.89	59.83	-59.83	0.0	-21.05
4.40	.100	17.16	0.950	4	21.00	1.05	52.11	52.11	11.72	71.55	-19.45	52.11	31.05
3.90	.100	17.16	0.950	5	24.90	1.25	0.0	52.11	10.66	82.21	-30.10	0.0	31.05
3.30	.100	17.16	0.950	6	28.20	1.41	0.0	52.11	9.69	91.90	-39.79	0.0	31.05
2.60	.100	17.16	0.950	7	30.80	1.54	0.0	52.11	8.81	100.70	-48.60	0.0	31.05
1.90	.100	17.16	0.930	8	32.70	1.67	0.0	52.11	8.01	108.71	-56.60	0.0	31.05
1.70	.100	17.16	0.910	9	34.40	1.83	6.75	58.85	7.28	115.99	-57.13	6.75	37.80
3.20	.100	17.16	0.890	10	37.60	2.18	16.94	75.79	6.62	122.60	-46.81	16.94	54.74
2.90	.100	17.16	0.870	11	40.50	2.56	15.35	91.14	6.01	128.62	-37.47	15.35	70.09
2.40	.100	17.16	0.850	12	42.90	2.92	12.70	103.85	5.47	134.08	-30.24	12.70	82.79
1.30	.100	17.16	0.830	13	44.20	3.14	6.88	110.73	4.97	139.05	-28.33	6.88	89.68
0.70	.100	17.16	0.810	14	44.90	3.27	3.71	114.43	4.52	143.57	-29.14	3.71	93.38
1.40	.100	17.16	0.790	15	46.30	3.56	7.15	121.58	4.11	147.68	-26.10	7.15	100.53
2.30	.100	17.16	0.770	16	48.60	4.09	0.0	121.58	3.73	151.42	-29.84	0.0	100.53
2.80	.100	17.16	0.750	17	51.40	4.79	0.0	121.58	3.40	154.81	-33.23	0.0	100.53
2.80	.100	17.16	0.730	18	54.20	5.55	0.0	121.58	3.09	157.90	-36.32	0.0	100.53
3.30	.100	17.16	0.710	19	57.50	6.51	0.0	121.58	2.81	160.70	-39.12	0.0	100.53
4.10	.100	17.16	0.690	20	61.60	7.78	0.0	121.58	2.55	163.25	-41.67	0.0	100.53
3.90	.100	17.16	0.670	21	65.50	9.06	0.0	121.58	2.32	165.57	-43.99	0.0	100.53
4.30	.100	17.16	0.650	22	69.80	10.57	0.0	121.58	2.11	167.68	-46.10	0.0	100.53
4.80	.100	17.16	0.630	23	74.60	12.34	79.12	200.70	1.92	169.60	31.11	25.09	125.61
5.40	.100	17.16	0.610	24	80.00	14.45	0.0	200.70	1.74	171.34	29.36	0.0	125.61
5.40	.100	17.16	0.590	25	85.40	16.66	0.0	200.70	1.58	172.92	27.78	0.0	125.61
4.90	.100	0.0	0.570	26	90.30	18.77	0.0	200.70	0.0	172.92	27.78	0.0	125.61
4.60	.100	0.0	0.550	27	94.90	20.84	-52.11	148.60	0.0	172.92	-24.33	0.0	125.61
3.40	.100	0.0	0.530	28	98.30	22.44	0.0	148.60	0.0	172.92	-24.33	0.0	125.61
4.40	.100	0.0	0.510	29	102.70	24.59	0.0	148.60	0.0	172.92	-24.33	0.0	125.61
4.20	.100	0.0	0.490	30	106.90	26.74	0.0	148.60	0.0	172.92	-24.33	0.0	125.61

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY   UNIVERSITY OF MICHIGAN   VERSION #2 DECEMBER 1978

OFFSHORE BREAKWATER - 6000 FT STRUCTURE - 25 YEAR BOND
CZL-240   KLEINPAB   (MW-1,2,3,4)
NUMBER OF PROPERTIES PROCESSED = 1   TOTAL LENGTH OF SHORELINE = 100.00

DPTH =	307.000	- DEPTH OF THE LOT (FEET)
FOUN =	0.0	- DISTANCE FROM FOUNDATION TO BLUFF (FEET)
BSET =	140.000	- RECCOMENDED SET BACK DISTANCE (FEET)
H =	55.000	- HEIGTH OF THE BLUFF (FEET)
TV =	15000.000	- LAKESIDE LAND VALUE ($)
SV =	0.0	- HOME OR STRUCTURE VALUE ($)
LRES =	3.667	- LONG TERM RECESSION RATE (FEET/YEAR)
COST =	6000.000	- COST TO MOVE HOME ($)
REST =	20.000	- REALTORS ESTIMATE OF RANK (FEET)
MLT1 =	2.500	- WEIGHTING FACTOR
T =	30.000	- INVESTMENT HORIZON (YEARS)
BANK =	23.750	- POINT WHERE MORTGAGE BECOMES UNAVAILABLE
STPB =	36.875	- 1/2 WAY BETWEEN BANK AND STEPL (FEET)
L =	100.000	- FRONT FOOTAGE OF LOT IN (FEET)
HOME =	0.0	- DEPTH OF THE HOME (FEET)
FSET =	35.000	- SET BACK IN FRONT OF HOME (FEET)
TH =	0.637	- ANGLE OF THE BLUFF (RADIANS)
LV =	4500.000	- INLAND LAND VALUE ($)
RESR =	1.000	- RECESSION RATE MODIFIER
AEST =	10500.000	- ASTHETIC VALUE ($)
RT =	0.100	- DISCOUNTING RATE
A =	0.500	- WEIGHTING FACTOR
MLT2 =	0.500	- WEIGHTING FACTOR
PLV =	175.000	- DISTANCE FROM ROAD TO SETBACK (FEET)
STPL =	50.000	- POINT OF SHARP STRUCTURE VALUE DECLINE
BASE =	74.335	- LENGTH OF THE BLUFF BASE (FEET)

INPUT PARAMETERS / OUTPUT PARAMETERS

AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	17.16	0.950	0	2.50	0.13	0.0	0.0	17.16	17.16	-17.16	-60.00	-60.00
3.90	.100	17.16	0.950	1	6.40	0.32	0.0	0.0	15.60	32.76	-32.76	0.0	-60.00
5.40	.100	17.16	0.950	2	11.80	0.59	0.0	0.0	14.18	46.94	-46.94	0.0	-60.00
4.80	.100	17.16	0.950	3	16.60	0.83	0.0	0.0	12.89	59.83	-59.83	0.0	-60.00
4.40	.100	17.16	0.950	4	21.00	1.05	0.0	0.0	11.72	71.55	-71.55	0.0	-60.00
3.90	.100	17.16	0.950	5	24.90	1.25	0.0	0.0	10.66	82.21	-82.21	0.0	-60.00
3.30	.100	17.16	0.950	6	28.20	1.41	0.0	0.0	9.69	91.90	-91.90	0.0	-60.00
2.60	.100	17.16	0.950	7	30.80	1.54	0.0	0.0	8.81	100.70	-100.70	0.0	-60.00
1.90	.100	17.16	0.930	8	32.70	1.67	0.0	0.0	8.01	108.71	-108.71	0.0	-60.00
1.70	.100	17.16	0.910	9	34.40	1.83	0.0	0.0	7.28	115.99	-115.99	0.0	-60.00
3.20	.100	17.16	0.890	10	37.60	2.18	0.0	0.0	6.62	122.60	-122.60	0.0	-60.00
2.90	.100	17.16	0.870	11	40.50	2.56	0.0	0.0	6.01	128.62	-128.62	0.0	-60.00
2.40	.100	17.16	0.850	12	42.90	2.92	0.0	0.0	5.47	134.08	-134.08	0.0	-60.00
1.30	.100	17.16	0.830	13	44.20	3.14	0.0	0.0	4.97	139.05	-139.05	0.0	-60.00
0.70	.100	17.16	0.810	14	44.90	3.27	0.0	0.0	4.52	143.57	-143.57	0.0	-60.00
1.40	.100	17.16	0.790	15	46.30	3.56	0.0	0.0	4.11	147.68	-147.68	0.0	-60.00
2.30	.100	17.16	0.770	16	48.60	4.09	0.0	0.0	3.73	151.42	-151.42	0.0	-60.00
2.80	.100	17.16	0.750	17	51.40	4.79	0.0	0.0	3.40	154.81	-154.81	0.0	-60.00
2.80	.100	17.16	0.730	18	54.20	5.55	0.0	0.0	3.09	157.90	-157.90	0.0	-60.00
3.30	.100	17.16	0.710	19	57.50	6.51	0.0	0.0	2.81	160.70	-160.70	0.0	-60.00
4.10	.100	17.16	0.690	20	61.60	7.78	0.0	0.0	2.55	163.25	-163.25	0.0	-60.00
3.90	.100	17.16	0.670	21	65.50	9.06	0.0	0.0	2.32	165.57	-165.57	0.0	-60.00
4.30	.100	17.16	0.650	22	69.80	10.57	0.0	0.0	2.11	167.68	-167.68	0.0	-60.00
4.80	.100	17.16	0.630	23	74.60	12.34	28.88	28.88	1.92	169.60	-140.72	-28.88	-88.88
5.40	.100	17.16	0.610	24	80.00	14.45	0.0	28.88	1.74	171.34	-142.46	0.0	-88.88
5.40	.100	17.16	0.590	25	85.40	16.66	0.0	28.88	1.58	172.92	-144.05	0.0	-88.88
4.90	.100	0.0	0.570	26	90.30	18.77	0.0	28.88	0.0	172.92	-144.05	0.0	-88.88
4.60	.100	0.0	0.550	27	94.90	20.84	0.0	28.88	0.0	172.92	-144.05	0.0	-88.88
3.40	.100	0.0	0.530	28	98.30	22.44	0.0	28.88	0.0	172.92	-144.05	0.0	-88.88
4.40	.100	0.0	0.510	29	102.70	24.59	0.0	28.88	0.0	172.92	-144.05	0.0	-88.88
4.20	.100	0.0	0.490	30	106.90	26.74	0.0	28.88	0.0	172.92	-144.05	0.0	-88.88

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY UNIVERSITY OF MICHIGAN VERSION #2 DECEMBER 1978

OFFSHORE BREAKWATER - 6000 FT STRUCTURE - 25 YEAR BOND
CZL-241 KLEINMAN (MW-1,2,3,4)
NUMBER OF PROPERTIES PROCESSED = 1 TOTAL LENGTH OF SHORELINE = 100.00

DPTH =	325.000	- DEPTH OF THE LOT (FEET)
FOUN =	0.0	- DISTANCE FROM FOUNDATION TO BLUFF (FEET)
RSET =	140.000	- RECCOMENDED SET BACK DISTANCE (FEET)
H =	55.000	- HEIGTH OF THE BLUFF (FEET)
TV =	15000.000	- LAKESIDE LAND VALUE ($)
SV =	0.0	- HOME OR STRUCTURE VALUE ($)
LRES =	3.667	- LONG TERM RECESSION RATE (FEET/YEAR)
COST =	6000.000	- COST TO MOVE HOME ($)
REST =	20.000	- REALTORS ESTIMATE OF BANK (FEET)
MLT1 =	2.500	- WEIGHTING FACTOR
T =	30.000	- INVESTMENT HORIZON (YEARS)
BANK =	23.750	- POINT WHERE MORTGAGE BECOMES UNAVAILABLE
STPB =	36.875	- 1/2 WAY BETWEEN BANK AND STEPL (FEET)
L =	100.000	- FRONT FOOTAGE OF LOT IN (FEET)
HOME =	0.0	- DEPTH OF THE HOME (FEET)
PSET =	35.000	- SET BACK IN FRONT OF HOME (FEET)
TH =	0.637	- ANGLE OF THE BLUFF (RADIANS)
LV =	4500.000	- INLAND LAND VALUE ($)
RESR =	1.000	- RECESSION RATE MODIFIER
AEST =	10500.000	- ASTHETIC VALUE ($)
RI =	0.100	- DISCOUNTING RATE
A =	0.500	- WEIGHTING FACTOR
MLT2 =	0.500	- WEIGHTING FACTOR
PLV =	175.000	- DISTANCE FROM ROAD TO SETBACK (FEET)
STPL =	50.000	- POINT OF SHARP STRUCTURE VALUE DECLINE
BASE =	74.335	- LENGTH OF THE BLUFF BASE (FEET)

INPUT PARAMETERS / OUTPUT PARAMETERS

AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	17.16	0.950	0	2.50	0.13	0.0	0.0	17.16	17.16	-17.16	-60.00	-60.00
3.90	.100	17.16	0.950	1	6.40	0.32	0.0	0.0	15.60	32.76	-32.76	0.0	-60.00
5.40	.100	17.16	0.950	2	11.80	0.59	0.0	0.0	14.18	46.94	-46.94	0.0	-60.00
4.80	.100	17.16	0.950	3	16.60	0.83	0.0	0.0	12.89	59.83	-59.83	0.0	-60.00
4.40	.100	17.16	0.950	4	21.00	1.05	0.0	0.0	11.72	71.55	-71.55	0.0	-60.00
3.90	.100	17.16	0.950	5	24.90	1.25	0.0	0.0	10.66	82.21	-82.21	0.0	-60.00
3.30	.100	17.16	0.950	6	28.20	1.41	0.0	0.0	9.69	91.90	-91.90	0.0	-60.00
2.60	.100	17.16	0.950	7	30.80	1.54	0.0	0.0	8.81	100.70	-100.70	0.0	-60.00
1.90	.100	17.16	0.930	8	32.70	1.67	0.0	0.0	8.01	108.71	-108.71	0.0	-60.00
1.70	.100	17.16	0.910	9	34.40	1.83	0.0	0.0	7.28	115.99	-115.99	0.0	-60.00
3.20	.100	17.16	0.890	10	37.60	2.18	0.0	0.0	6.62	122.60	-122.60	0.0	-60.00
2.90	.100	17.16	0.870	11	40.50	2.56	0.0	0.0	6.01	128.62	-128.62	0.0	-60.00
2.40	.100	17.16	0.850	12	42.90	2.92	0.0	0.0	5.47	134.08	-134.08	0.0	-60.00
1.30	.100	17.16	0.830	13	44.20	3.14	0.0	0.0	4.97	139.05	-139.05	0.0	-60.00
0.70	.100	17.16	0.810	14	44.90	3.27	0.0	0.0	4.52	143.57	-143.57	0.0	-60.00
1.40	.100	17.16	0.790	15	46.30	3.56	0.0	0.0	4.11	147.68	-147.68	0.0	-60.00
2.30	.100	17.16	0.770	16	48.60	4.09	0.0	0.0	3.73	151.42	-151.42	0.0	-60.00
2.80	.100	17.16	0.750	17	51.40	4.79	0.0	0.0	3.40	154.81	-154.81	0.0	-60.00
2.80	.100	17.16	0.730	18	54.20	5.55	0.0	0.0	3.09	157.90	-157.90	0.0	-60.00
3.30	.100	17.16	0.710	19	57.50	6.51	0.0	0.0	2.81	160.70	-160.70	0.0	-60.00
4.10	.100	17.16	0.690	20	61.60	7.78	0.0	0.0	2.55	163.25	-163.25	0.0	-60.00
3.90	.100	17.16	0.670	21	65.50	9.06	0.0	0.0	2.32	165.57	-165.57	0.0	-60.00
4.30	.100	17.16	0.650	22	69.80	10.57	0.0	0.0	2.11	167.68	-167.68	0.0	-60.00
4.80	.100	17.16	0.630	23	74.60	12.34	28.88	28.88	1.92	169.60	-140.72	-28.88	-88.88
5.40	.100	17.16	0.610	24	80.00	14.45	0.0	28.88	1.74	171.34	-142.46	0.0	-88.88
5.40	.100	17.16	0.590	25	85.40	16.66	0.0	28.88	1.58	172.92	-144.05	0.0	-88.88
4.90	.100	0.0	0.570	26	90.30	18.77	0.0	28.88	0.0	172.92	-144.05	0.0	-88.88
4.60	.100	0.0	0.550	27	94.90	20.84	0.0	28.88	0.0	172.92	-144.05	0.0	-88.88
3.40	.100	0.0	0.530	28	98.30	22.44	0.0	28.88	0.0	172.92	-144.05	0.0	-88.88
4.40	.100	0.0	0.510	29	102.70	24.59	0.0	28.88	0.0	172.92	-144.05	0.0	-88.88
4.20	.100	0.0	0.490	30	106.90	26.74	0.0	28.88	0.0	172.92	-144.05	0.0	-88.88

BENEFIT/COST MODEL OF SHORELINE PROCESSES

COSTAL ZONE LABCRTORY   UNIVERSITY OF MICHIGAN   VERSION #2 DECEMBER 1978

OFFSHORE BREAKWATER - 6000 FT STRUCTURE - 25 YEAR BOND

CZL-250   MAZKECTIS   (MN-5,6)

NUMBER OF PROPERTIES PROCESSED = 1   TOTAL LENGTH OF SHORELINE = 148.00

DPTH =	400.000	DEPTH OF THE LOT (FEET)	L =	148.000	FRONT FOOTAGE OF LOT IN (FEET)
FOUN =	0.0	DISTANCE FROM FOUNDATION TO BLUFF (FEET)	HOME =	70.000	DEPTH OF THE HOME (FEET)
RSET =	140.000	RECCOMENDED SET BACK DISTANCE (FEET)	FSET =	35.000	SET BACK IN FRONT OF HOME (FEET)
H =	55.000	HEIGTH OF THE BLUFF (FEET)	TH =	0.637	ANGLE OF THE BLUFF (RADIANS)
TV =	22200.000	LAKESIDE LAND VALUE ($)	LV =	6660.000	INLAND LAND VALUE ($)
SV =	45000.000	HOME OR STRUCTURE VALUE ($)	RESR =	1.000	RECESSION RATE MODIFIER
LRES =	3.667	LONG TERM RECESSION RATE (FEET/YEAR)	AEST =	15540.000	ASTHETIC VALUE ($)
COST =	6000.000	COST TO MOVE HOME ($)	RI =	0.100	DISCOUNTING RATE
REST =	20.000	REALTORS ESTIMATE OF BANK (FEET)	A =	0.500	WEIGHTING FACTOR
MLT1 =	2.500	WEIGHTING FACTOR	MLT2 =	0.500	WEIGHTING FACTOR
T =	30.000	INVESTMENT HORIZON (YEARS)	PLV =	245.000	DISTANCE FROM ROAD TO SETBACK (FEET)
BANK =	23.750	POINT WHERE MORTGAGE BECOMES UNAVAILABLE	STPL =	50.000	POINT OF SHARP STRUCTURE VALUE DECLINE
STPB =	36.875	1/2 WAY BETWEEN BANK AND STEPL (FEET)	BASE =	74.335	LENGTH OF THE BLUFF BASE (FEET)

INPUT PARAMETERS / OUTPUT PARAMETERS

AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	17.16	0.950	0	2.50	0.13	0.0	0.0	17.16	17.16	-17.16	293.92	293.92
3.90	.100	17.16	0.950	1	6.40	0.32	0.0	0.0	15.60	32.76	-32.76	0.0	293.92
5.40	.100	17.16	0.950	2	11.80	0.59	0.0	0.0	14.18	46.94	-46.94	0.0	293.92
4.80	.100	17.16	0.950	3	16.60	0.83	0.0	0.0	12.89	59.83	-59.83	0.0	293.92
4.40	.100	17.16	0.950	4	21.00	1.05	0.0	0.0	11.72	71.55	-71.55	0.0	293.92
3.90	.100	17.16	0.950	5	24.90	1.25	0.0	0.0	10.66	82.21	-82.21	0.0	293.92
3.30	.100	17.16	0.950	6	28.20	1.41	0.0	0.0	9.69	91.90	-91.90	0.0	293.92
2.00	.100	17.16	0.950	7	30.80	1.54	0.0	0.0	8.81	100.70	-100.70	0.0	293.92
1.90	.100	17.16	0.930	8	32.70	1.67	0.0	0.0	8.01	108.71	-108.71	0.0	293.92
1.70	.100	17.16	0.910	9	34.40	1.83	0.0	0.0	7.28	115.99	-115.99	0.0	293.92
3.20	.100	17.16	0.890	10	37.60	2.18	0.0	0.0	6.62	122.60	-122.60	0.0	293.92
2.90	.100	17.16	0.870	11	40.50	2.56	0.0	0.0	6.01	128.62	-128.62	0.0	293.92
2.40	.100	17.16	0.850	12	42.90	2.92	0.0	0.0	5.47	134.08	-134.08	0.0	293.92
1.30	.100	17.16	0.830	13	44.20	3.14	0.0	0.0	4.97	139.05	-139.05	0.0	293.92
0.70	.100	17.16	0.810	14	44.90	3.27	0.0	0.0	4.52	143.57	-143.57	0.0	293.92
1.40	.100	17.16	0.790	15	46.30	3.56	0.0	0.0	4.11	147.68	-147.68	0.0	293.92
2.30	.100	17.16	0.770	16	48.60	4.09	0.0	0.0	3.73	151.42	-151.42	0.0	293.92
2.80	.100	17.16	0.750	17	51.40	4.79	0.0	0.0	3.40	154.81	-154.81	0.0	293.92
2.80	.100	17.16	0.730	18	54.20	5.55	0.0	0.0	3.09	157.90	-157.90	0.0	293.92
3.30	.100	17.16	0.710	19	57.50	6.51	0.0	0.0	2.81	160.70	-160.70	0.0	293.92
4.10	.100	17.16	0.690	20	61.60	7.78	0.0	0.0	2.55	163.25	-163.25	0.0	293.92
3.90	.100	17.16	0.670	21	65.50	9.06	0.0	0.0	2.32	165.57	-165.57	0.0	293.92
4.30	.100	17.16	0.650	22	69.80	10.57	0.0	0.0	2.11	167.68	-167.68	0.0	293.92
4.80	.100	17.16	0.630	23	74.60	12.34	28.88	28.88	1.92	169.60	-140.72	-28.88	265.04
5.40	.100	17.16	0.610	24	80.00	14.45	0.0	28.88	1.74	171.34	-142.46	0.0	265.04
5.40	.100	17.16	0.590	25	85.40	16.66	0.0	28.88	1.58	172.92	-144.05	0.0	265.04
4.90	.100	0.0	0.570	26	90.30	18.77	0.0	28.88	0.0	172.92	-144.05	0.0	265.04
4.00	.100	0.0	0.550	27	94.90	20.84	0.0	28.88	0.0	172.92	-144.05	0.0	265.04
3.40	.100	0.0	0.530	28	98.30	22.44	0.0	28.88	0.0	172.92	-144.05	0.0	265.04
4.40	.100	0.0	0.510	29	102.70	24.59	0.0	28.88	0.0	172.92	-144.05	0.0	265.04
4.20	.100	0.0	0.490	30	106.90	26.74	0.0	28.88	0.0	172.92	-144.05	0.0	265.04

BENEFIT/COST MODEL OF SHORELINE PROCESSES
COSTAL ZONE LABORATORY UNIVERSITY OF MICHIGAN VERSION #2 DECEMBER 1978

OFFSHORE BREAKWATER - 6000 FT STRUCTURE - 25 YEAR BOND
MEAN BENEFITS FOR PROPERTIES IN REACH

NUMBER OF PROPERTIES PROCESSED = 27 TOTAL LENGTH OF SHORELINE = 4563.00

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DPTH =    400.000 - DEPTH OF THE LOT (FEET)                      L    =    148.000 - FRONT FOOTAGE OF LOT IN (FEET)
FOUN =      0.0   - DISTANCE FROM FOUNDATION TO BLUFF (FEET)     HOME =     70.000 - DEPTH OF THE HOME (FEET)
RSET =    140.000 - RECCOMENDED SET BACK DISTANCE (FEET)         PSET =     35.000 - SET BACK IN FRONT OF HOME (FEET)
H    =     55.000 - HEIGTH OF THE BLUFF (FEET)                   TH   =      0.637 - ANGLE OF THE BLUFF (RADIANS)
TV   =  22200.000 - LAKESIDE LAND VALUE ($)                      LV   =   6660.000 - INLAND LAND VALUE ($)
SV   =  45000.000 - HOME OR STRUCTURE VALUE ($)                  RRSR =      1.000 - RECESSION RATE MODIFIER
LRES =      3.667 - LONG TERM RECESSION RATE (FEET/YEAR)         AEST =  15540.000 - ASTHETIC VALUE ($)
COST =   6000.000 - COST TO MOVE HOME ($)                        RI   =      0.100 - DISCOUNTING RATE
REST =     20.000 - REALTORS ESTIMATE OF BANK (FEET)             A    =      0.500 - WEIGHTING FACTOR
MLT1 =      2.500 - WEIGHTING FACTOR                             MLT2 =      0.500 - WEIGHTING FACTOR
T    =     30.000 - INVESTMENT HORIZON (YEARS)                   PLV  =    245.000 - DISTANCE FROM ROAD TO SETBACK (FEET)
BANK =     23.750 - POINT WHERE MORTGAGE BECOMES UNAVAILABLE     STPL =     50.000 - POINT OF SHARP STRUCTURE VALUE DECLINE
STPB =     36.875 - 1/2 WAY BETWEEN BANK AND STEPL (FEET)        BASE =     74.335 - LENGTH OF THE BLUFF BASE (FEET)
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INPUT PARAMETERS | OUTPUT PARAMETERS

AVERAGE ANNUAL RECESSION RATE (FT/YR)	REAL ESTATE APPREC. RATE (%)	PROTECTIVE STRUCTURE COST AND MAINTANCE ($)	PROTECTIVE STRUCTURE EFFIC. (%)	YEAR	TOTAL RECESSION WITHOUT STRUCTURE (FEET)	TOTAL RECESSION WITH STRUCTURE (FEET)	YEARLY DISC. BENEFITS ($)	TOTAL DISC. BENEFITS ($)	YEARLY DISC. COST ($)	TOTAL DISC. COST ($)	DISC. NET BENEFITS ($)	YEARLY HOME MOVING BENEFITS ($)	TOTAL HOME MOVING BENEFITS ($)
2.50	.100	17.16	0.950	0	2.50	0.13	0.01	0.01	17.16	17.16	-17.15	41.48	41.48
3.90	.100	17.16	0.950	1	6.40	0.32	3.89	3.90	15.60	32.76	-28.86	3.87	45.35
5.40	.100	17.16	0.950	2	11.80	0.59	19.24	23.14	14.18	46.94	-23.80	19.21	64.56
4.80	.100	17.16	0.950	3	16.60	0.83	26.02	49.15	12.89	59.83	-10.68	25.99	90.55
4.40	.100	17.16	0.950	4	21.00	1.05	30.49	79.64	11.72	71.55	8.09	16.84	107.39
3.90	.100	17.16	0.950	5	24.90	1.25	0.88	80.53	10.66	82.21	-1.68	0.86	108.26
3.30	.100	17.16	0.950	6	28.20	1.41	0.96	81.49	9.69	91.90	-10.41	-0.96	107.30
2.60	.100	17.16	0.950	7	30.80	1.54	0.01	81.49	8.81	100.70	-19.21	-0.01	107.29
1.90	.100	17.16	0.930	8	32.70	1.67	0.01	81.50	8.01	108.71	-27.21	-0.01	107.28
1.70	.100	17.16	0.910	9	34.40	1.83	0.43	81.93	7.28	115.98	-34.06	0.42	107.70
3.20	.100	17.16	0.890	10	37.60	2.18	1.07	83.00	6.62	122.60	-39.60	1.05	108.74
2.90	.100	17.16	0.870	11	40.50	2.56	12.64	95.63	6.01	128.62	-32.98	12.62	121.36
2.40	.100	17.16	0.850	12	42.90	2.91	0.80	96.44	5.47	134.08	-37.65	0.78	122.15
1.30	.100	17.16	0.830	13	44.20	3.14	0.42	96.86	4.97	139.05	-42.20	0.42	122.57
0.70	.100	17.16	0.810	14	44.90	3.27	0.08	96.93	4.52	143.57	-46.64	0.23	122.80
1.40	.100	17.16	0.790	15	46.30	3.56	68.81	165.74	4.11	147.68	18.06	69.15	191.94
2.30	.100	17.16	0.770	16	48.60	4.09	-0.62	165.12	3.73	151.42	13.71	-0.01	191.93
2.80	.100	17.16	0.750	17	51.40	4.79	4.14	169.26	3.40	154.81	14.45	-4.97	186.96
2.80	.100	17.16	0.730	18	54.20	5.55	-0.89	168.38	3.09	157.90	10.48	-0.01	186.95
3.30	.100	17.16	0.710	19	57.50	6.51	-0.24	168.14	2.81	160.70	7.44	-0.90	186.05
4.10	.100	17.16	0.690	20	61.60	7.78	10.64	178.78	2.55	163.25	15.52	12.11	198.16
3.90	.100	17.16	0.670	21	65.50	9.06	8.83	187.61	2.32	165.57	22.03	13.59	211.75
4.30	.100	17.16	0.650	22	69.80	10.57	7.99	195.60	2.11	167.68	27.92	14.98	226.73
4.80	.100	17.16	0.630	23	74.60	12.34	7.17	202.77	1.92	169.60	33.17	1.15	227.88
5.40	.100	17.16	0.610	24	80.00	14.45	-3.44	199.33	1.74	171.34	27.99	-6.42	221.46
5.40	.100	17.16	0.590	25	85.40	16.66	-10.57	188.76	1.58	172.92	15.84	-3.28	218:19
4.90	.100	0.0	0.570	26	90.30	18.77	-7.33	181.44	0.0	172.92	8.52	-0.03	218.15
4.60	.100	0.0	0.550	27	94.90	20.84	-22.32	159.12	0.0	172.92	-13.80	-0.03	218.12
3.40	.100	0.0	0.530	28	98.30	22.44	32.95	192.07	0.0	172.92	19.14	34.33	252.44
4.40	.100	0.0	0.510	29	102.70	24.59	4.73	196.80	0.0	172.92	23.87	4.66	257.11
4.20	.100	0.0	0.490	30	106.90	26.74	-0.92	195.88	0.0	172.92	22.95	-0.04	257.07