Erosion of the Cliffs of Outer Cape Cod: Tables and Graphs

by

John M. Zeigler
Herman J. Tasha
Graham Giese

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APPROVED FOR DISTRIBUTION

John M. Hunt, Chairman
Department of Chemistry and Geology
The following tables and graphs place in convenient storage the results of several years of careful surveying and at the same time provide rudimentary interpretation of results by comparing erosion rates. The reader will find listed in the bibliography pertinent published papers which analyze these coastal erosion data in great detail.

The Marindin Surveys

Mr. Henry Marindin, an assistant to the Superintendent of the U. S. Coast and Geodetic Survey, conducted a most interesting and worthwhile series of measurements which allowed him to determine the rates of erosion on the cliffs and beaches of Outer Cape Cod (Marindin, 1889, 1891). These were made from August 1887 through 1889. Lines in Provincetown Harbor were surveyed in 1890. In brief, Marindin established a series of points, 229 in all, approximately 300 meters apart along almost the entire eastern coast of Cape Cod and on around the Provincelands hook (Figures 1-6F). From these points, which he marked in the field by oaken stakes, he published measured distances and elevations over the ground more or less at right angles to the coast. The elevations were established on a mean sea level datum that he derived from tidal observations made at Chatham, in 1887. Marindin located his origins in terms of latitude and longitude but, because of a change in the geodetic grid, it is necessary to correct his origins by subtracting 0.6 second from each of his latitudes in order to plot the points on contemporary charts. This survey, which was carried out under the usual adversities of scrubby vegetation and variable weather, technically was an excellent job. After repeating some of his measurements we fully appreciate Marindin’s difficulties and accomplishments.
Marindin simply compared the new position of the cliff base, or cliff top, or high water line with its position on earlier charts that had been surveyed in 1848, 1856 or 1868. He gives the average rate of erosion along the coast as 3.2 feet per year. Marindin published all of the data concerning the location of the points of origin, the azimuths of the lines and the distances along the lines to cliff tops, cliff bases and water lines. He specifically stated that he hoped that someday someone would repeat his measurements.

Giese and Tasha, using both plane table and transit surveying methods reoccupied 74 of Marindin's points of origin located between Nauset at the south end of the cliffs, and Pilgrim Lake in the Provincelands. They marked each of the relocated points of origin with a concrete post which held a circular brass plate. They found none of Marindin's original oak stakes but in a few places our relocated points matched the descriptions of landmarks as given by Marindin. The average rate of change for the coast was obtained by drawing a line of best fit through all the points which were resurveyed (Figure 8).

Before resurveying Marindin's points we tried determining erosion rates by comparing the position of the coast, based on Marindin's data, with the position of the coast as given on the appropriate maps of the T-series, prepared from aerial photographs in 1940 by the U. S. Coast Geodetic Survey. We found that the rates of coastal changes measured this way were so erratic that the method was useless (Figure 8).

We compared the profiles measured in 1958 and 1959 with the profiles measured in 1879. Where the profiles crossed cliffs we compared the rate of change of the cliff lip and cliff base and used the average of the two. Where the profiles crossed dunes we chose the base of the foredune on the sea side as a point for comparison, supporting this choice where
possible by using mean sea level. Mean sea level itself is a bit complicated to use because these beaches change severely from day to day (Zeigler and Tuttle, 1961), and also because the local mean sea level differs from the Geodetic Sea level of 1929.

The major sources of error in determining rates of coastal change by this manner are failure to re-occupy the exact point of origin of the original survey, short term differential erosion of the cliffs and short term changes in the position of high water or beach level. The coast of Cape Cod has a smooth outline; therefore one might reason that the rate of erosion or accretion does not vary appreciably from place to place over long periods of time and the variation observed from profile to profile consequently is due to one of the above mentioned causes of error.

We assumed that the true rate of coastal change is the average of the values measured by us, and were careful to allow for the fact that coastal change is different from the Province-lands where the coast is accreting, the cliffs where the coast is cutting and the spit where the rate of erosion is much faster. This is illustrated by Figure 8.

We fully recognize the inherent danger of measuring a natural change over a limited period of years and dividing by the number of years to obtain an average. While such a number is probably nearly correct for the inclusive years it may become considerably less accurate if extrapolated for ten times the length of the observed period and even less when extended 100 times. On the other hand the coast of Cape Cod has maintained a smooth outline facing the sea for as long as people have been around to make maps. Until something indicates that the coast has been subjected to more severe sea states or more severe erosion we shall assume that the rates of coastal change presented herein are valid and therefore useful to be used in computations.
Changes along Outer Cape Cod are summarized in Figure 9. The main cliff section facing the sea is being eroded at a rate of approximately 2.5 feet per year. This erosion becomes less to the north and finally a point is reached near Pilgrim Lake where the coast is neither building nor cutting. On to the north of this point the great Provincetown hook of loose sands is developed and its coast is growing into the sea. Erosion rates show that Nauset Spit on the south end of our survey was being driven into the marshes at approximately 5 feet per year but we do not think this is a valid figure. At about the time the surveying was being done Nauset Spit was cut by a series of breakthroughs and coastal adjustments were rapid. We have observed no serious bending of this spit in the years following our survey and therefore we assume Nauset Spit must be retreating at the same rate as the cliffs.

Rate of cliff retreat can also be stated in terms of volume because the topography is known, relief having been measured during the surveying. Inasmuch as this report is concerned only with that part of the Cape north of Nauset Inlet, the volume figures are computed only for this section.

Table 1 presents the erosion rates in terms of cubic yards of sediment delivered to the sea per year for a 25,700 yard long strip of coast undergoing erosion as shown on Figure 9. Inasmuch as the cliffs have retreated about 60 yards in seventy years and the sea has removed a wedge below mean high water, in this case extreme high water is almost exactly at the base of the cliffs, this yearly increment is added also. How much material is made available offshore from the beach is unknown, clearly the volume available is greater than the values given in Table 1.
TABLE 1

Average yearly volume of sediment eroded from Outer Cape Cod between Nauset Coast Guard and Pilgrim Lake.

<table>
<thead>
<tr>
<th>Description</th>
<th>Length (yds)</th>
<th>Av. Cliff Ht. (yds)</th>
<th>Erosion Rate/year</th>
<th>Volume per year (cu. feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cliff Section between Nauset and Highland to the point where Erosion decreases Marindin Stations 54 to 141.</td>
<td>25,700</td>
<td>24.12</td>
<td>0.85</td>
<td>526,850</td>
</tr>
<tr>
<td>Rate of Erosion in the Region from Highland to point where accretion begins Marindin Stations 141-152</td>
<td>3,700</td>
<td>21.64</td>
<td>0.64</td>
<td>55,022</td>
</tr>
<tr>
<td>Material eroded from below sea level since Marindin Survey of 1887-89 between present mean high water and extreme high water 70 years ago.</td>
<td>(Width) 59.50</td>
<td>(Length) 29,400</td>
<td>(Thickness) 6</td>
<td>1,749,320</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Average yearly volume</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Total yearly volume</td>
</tr>
</tbody>
</table>

Total yearly volume of sediment available to maintain beaches and bars 606,862
This work has been supported by the Geography Branch of the Office of Naval Research, Contract Number Nonr 1254 (00), (NR-388-018), and by Nonr 2196 (00).

The writers wish to acknowledge the cooperative spirit of members of the National Park Service at the Cape Cod National Seashore. Their enthusiasm for the work we have been doing is most rewarding. Also, we wish to thank the people in the towns of Provincetown, Truro, Wellfleet, Eastham, Orleans and Chatham for understanding and assistance to our field parties. The nature of this work is such that we must cross property boundaries and drive on beaches and in many other ways depend on local permission in order to complete our tasks. We hope that the results presented here will provide a useful basis for future development of their coastline and in some measure repay them for their tolerance.

Explanation of Tables

Profile Number- that used by Marindin in his report of 1889. Readers will perhaps note that Marindin re-numbered his profiles for his final report so that the profiles were ordered from South to North. Locations of these profiles are correctly plotted on the accompanying charts.

Latitude- Latitudes have been adjusted by subtracting 0.6" from latitudes given by Marindin in accordance with new geodetic grids for all present day charts.

Longitude- Same as that of Marindin.

Azimuth- Geodetic azimuth measure from south through west to south, the same as for Marindin.

Elevations- Based on Woods Hole levelling from various benchmarks some of which were the same ones used by Marindin.

Profile Dates- Dates given for both surveys, and last date of recovery, i.e. whether the measurements could be re-located or not.

Note: Much detail is not stored in this report, such as the surveyors descriptions of each origin, photographs of the origin and profile and details of field surveying. This information is stored in the original field notes in Woods Hole.


Zeigler, J. M., Tuttle, S. D., Giese, Graham, and Tasha, Herman - Residence Time of Sand on Beaches and Bars of Outer Cape Cod.
The Following Information is on File in Drawer 13, Room 101, Old Main, Woods Hole Oceanographic Institution:

1. Manila Folder with contents indexed on outside, namely:
   
   A. Folder containing computations and pertinent data, plus, indexes of photographs of origin points.
   
   B. Complete xerox copies of Marindin's Original Report.
   
   C. Deck of information cards made by G. Giese which give survey dates, and reference to Field Note Books, Profile data for 187 and 188 are on pages 129-135 of the beach profile notebook for 1962.
   
2. Four field notebooks with original levelling information and station descriptions labelled I, II, III, IV.

3. Sheets from which blue cover tables were made.

4. Envelope containing aerial photographs on which all Marindin origin points were located.

5. Original plane table sheets in rolls.

6. Large scale plots of the profiles.

7. Multilith master sheets of this report.

8. All bench mark information, of which there is considerable.
Figure 1. Index chart of Cape Cod showing approximate positions of profiles.
Figure 2. Exact positions of profiles 43 through 59.
Figure 3. Exact positions of profiles 63 through 72 and 87 through 92.
Figure 4. Exact positions of profiles 93 through 121
Figure 5. Exact positions of profiles 141 through 157.
Figure 6. Exact positions of profiles 158 through 166.
Figure 7. Exact positions of profiles 187 and 188.
Figure 8. Erosion rates, east side of Cape Cod based on re-survey of profiles established in 1889.
Figure 9. Rates of erosion and derivation of average rate.
<table>
<thead>
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</tr>
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<td>69° 56' 23.3&quot;</td>
<td>258° 52'</td>
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<td>7.78</td>
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<td>69° 56' 23.3&quot;</td>
<td>258° 52'</td>
<td>57</td>
<td>7.89</td>
<td>Top of Mon.</td>
</tr>
<tr>
<td>41° 48' 57.7&quot;</td>
<td>69° 56' 23.3&quot;</td>
<td>258° 52'</td>
<td>130</td>
<td>10.98</td>
<td>Top of berm</td>
</tr>
<tr>
<td>41° 48' 57.7&quot;</td>
<td>69° 56' 23.3&quot;</td>
<td>258° 52'</td>
<td>146</td>
<td>8.69</td>
<td>High tide mark</td>
</tr>
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<td>41° 48' 57.7&quot;</td>
<td>69° 56' 23.3&quot;</td>
<td>258° 52'</td>
<td>200</td>
<td>0.32</td>
<td></td>
</tr>
</tbody>
</table>

Profile date: 10/9/56
Monument lost: 9/17/57
Average loss/yr: 4.0' (11' contour)

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<th></th>
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</thead>
<tbody>
<tr>
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</tr>
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<td>69° 56' 23.3&quot;</td>
<td>258° 52'</td>
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<td>8.03</td>
<td>Top of Mon.</td>
</tr>
<tr>
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<td>69° 56' 23.3&quot;</td>
<td>258° 52'</td>
<td>105</td>
<td>11.86</td>
<td>Top of berm</td>
</tr>
<tr>
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<td>69° 56' 23.3&quot;</td>
<td>258° 52'</td>
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<td>69° 56' 23.3&quot;</td>
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<td>170</td>
<td>2.10</td>
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</tr>
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Profile date: 10/9/56
Monument lost: 9/17/57
Average loss/yr: 4.9' (11' contour)
Lat. 41° 49' 35.5"
Long. 69° 56' 35.1"
Az. 258° 52'

Dist. Elev. Remarks

0 5.99 Top of Mon.
0 5.35
140 11.51
194 10.33
223 13.65
243 17.08
306 25.32
336 29.19 Bluff Station
360 14.69 Foot of Bluff
393 10.79
404 9.96 High tide mark

Profile date: 10/9/56
Average loss/yr: 5.0' Berm

Lat. 41° 49' 54.1"
Long. 69° 56' 38.1"
Az. 258° 52'

Dist. Elev. Remarks

0 9.74 Top of Mon.
0 8.00
84 13.53
138 13.71
236 26.51 Top of dune
243 20.50 Foot of dune
265 12.42 High tide mark

Profile date: 10/9/56
Average loss/yr: 4.1' (15' contour)
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<td>117</td>
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<td>153</td>
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<td>187</td>
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<td>345</td>
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<td>356</td>
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Profile date: 10/11/56

Average loss/yr: 4.0' Dune foot

---

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<td>88</td>
<td>16.38</td>
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<td>19.07</td>
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<td>163</td>
<td>22.29</td>
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<tr>
<td>205</td>
<td>27.12</td>
<td>Bluff Station</td>
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<tr>
<td>232</td>
<td>13.09</td>
<td>Foot of Bluff</td>
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<td>297</td>
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<td>375</td>
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(Profile date 10/11/56)

Average loss/yr: 3.7' Dune foot

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<td>232</td>
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<td>374</td>
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Profile Date: 10/11/56

Average loss/yr: 3.4' Bluff Foot
Lat. 41° 50' 50.8"
Long. 69° 56' 53.4"
Az. 258° 52'

Dist. Elev. Remarks

0 32.31 Top of Mon.
0 31.86
32 27.19
109 27.52
169 37.08
204 32.92
211 30.24 Bluff Station
225 13.63 Foot of Bluff

Profile date: 10/11/56
Average loss/yr: 3.3 Bluff Foot

Lat. 41° 51' 00.2"
Long. 69° 56' 58.0"
Az. 258° 52'

Dist. Elev. Remarks

0 54.24 Top of Mon.
0 53.55
9 52.47
50 54.48
214 52.07
235 49.15
253 48.64
257 47.45
298 42.93
322 42.17 Bluff Station
361 12.22 Foot of Bluff

Profile date: 10/15/56
Average loss/yr: 3.3 Bluff Foot

Lat. 41° 51' 09.4"
Long. 69° 57' 04.2"
Az. 258° 52'

Dist. Elev. Remarks

0 54.06 Top of Mon.
0 53.28
257 62.81
347 65.93
391 67.73
415 68.58
516 56.38
567 57.83
631 52.29 Bluff Station
682 11.29 Foot of Bluff

Profile date: 10/15/56
Average loss/yr: 1.5 Bluff Foot

* Marindin's report
Gives the longitude as:
69° 56' 04.2"
This is assumed an error
because this point falls
approx. 2/3 mile offshore.
<table>
<thead>
<tr>
<th>Lat.</th>
<th>41° 51' 19.3&quot;</th>
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<tbody>
<tr>
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<td>Az.</td>
<td>258° 52'</td>
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**Dist. Elev. Remarks**

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<td>431</td>
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Profile date: 10/15/56

Average loss/yr: 0.4 Bluff Foot

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<tr>
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<td>69° 57' 03.4&quot;</td>
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<tr>
<td>Az.</td>
<td>258° 52'</td>
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**Dist. Elev. Remarks**

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<th>Remarks</th>
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<tr>
<td>68</td>
<td>14.81</td>
<td>Foot of Bluff</td>
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</table>

Profile date: 10/15/56

Station lost (over edge of bluff) 9/17/57

Average loss/yr: 2.1 Bluff Foot

---

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<td>Az.</td>
<td>256° 13'</td>
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**Dist. Elev. Remarks**

<table>
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<th>Dist.</th>
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<td>76.69</td>
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<td>137</td>
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Profile date: 8/17/56

Average loss/yr: 1.9 Bluff

Average loss/yr: 2.9 Foot

2.4 Average

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<td>Az.</td>
<td>256° 06'</td>
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</tbody>
</table>

**Dist. Elev. Remarks**

<table>
<thead>
<tr>
<th>Dist.</th>
<th>Elev.</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>75.76</td>
<td>Top of Mon.</td>
</tr>
<tr>
<td>0</td>
<td>73.86</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>74.31</td>
<td></td>
</tr>
<tr>
<td>57</td>
<td>74.96</td>
<td>Bluff Station</td>
</tr>
<tr>
<td>132</td>
<td>11.52</td>
<td>Foot of Bluff</td>
</tr>
</tbody>
</table>

Profile date: 8/17/56

Average loss/yr: 2.0 Bluff

Average loss/yr: 2.4 Foot

2.2 Average
Lat.  41°  52'  24.9"
Long.  69°  57'  23.7"
Az.   256° 10'

Dist. Elev. Remarks

0  75.60 Top of Mon.
  0  74.84
 29  73.56
 49  72.88 W. side of road cut
 64  73.10 E. side of road cut
 99  73.39 Bluff Station
164 13.76 Foot of Bluff

Profile date:  8/17/56

Average loss/yr:  2.3 Bluff
Average loss/yr:  3.1 Foot

  2.7 Average

Lat.  41°  52'  34.2"
Long.  69°  57'  26.8"
Az.   256° 07'

Dist. Elev. Remarks

0  73.73 Top of Mon.
  0  73.00
 17  72.64 W. side of road cut
 36  72.31 E. side of road cut
 79  73.14 Bluff Station
154 14.82 Foot of Bluff

Profile date:  8/17/56

Average loss/yr:  1.6 Bluff
Average loss/yr:  3.4 Foot

  2.5 Average

Lat.  41°  52'  52.6"
Long.  69°  57'  34.6"
Az.   256° 14'

Dist. Elev. Remarks

0  71.56 Top of Mon.
  0  69.87
  73  73.21
116  72.79 W. side of road
145  73.93
229  69.04 Bluff Station
308 11.32 Foot of Bluff

Profile date:  8/17/56

Average loss/yr:  2.4 Bluff
Average loss/yr:  3.0 Foot

  2.7 Average

Lat.  41°  53'  02.5"
Long.  69°  57'  37.5"
Az.   256° 10'

Dist. Elev. Remarks

0  68.49 Top of Mon.
  0  67.16
  42  66.39
  54  67.34
132  67.01
172  71.34
217  72.54 Bluff Station
304 13.34 Foot of Bluff

Profile date:  8/17/56

Average loss/yr:  2.6 Bluff
Average loss/yr:  2.8 Foot

  2.7 Average
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>41°</td>
<td>69°</td>
<td>256°</td>
<td>0</td>
<td>Top of Mon.</td>
</tr>
<tr>
<td>53'</td>
<td>57'</td>
<td>07'</td>
<td>76.61</td>
<td></td>
</tr>
</tbody>
</table>

Profile date: 8/17/56
Average loss/yr: 2.6 Bluff
Average loss/yr: 2.8 Foot
2.7 Average

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
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<tbody>
<tr>
<td>41°</td>
<td>69°</td>
<td>253°</td>
<td>0</td>
<td>Top of Mon.</td>
</tr>
<tr>
<td>53'</td>
<td>57'</td>
<td>03'</td>
<td>61.34</td>
<td></td>
</tr>
</tbody>
</table>

Profile date: 8/17/56
Monument lost: 3/17/59
Average loss/yr: 3.4 Bluff
Average loss/yr: 3.0 Foot
3.1 Average

<table>
<thead>
<tr>
<th></th>
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<tr>
<td>41°</td>
<td>69°</td>
<td>256°</td>
<td>0</td>
<td>Top of Mon.</td>
</tr>
<tr>
<td>53'</td>
<td>57'</td>
<td>03'</td>
<td>51.82</td>
<td></td>
</tr>
</tbody>
</table>

Profile date: 8/17/56
Average loss/yr: 3.4 Bluff
Average loss/yr: 3.7 Foot
3.6 Average

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>41°</td>
<td>69°</td>
<td>253°</td>
<td>0</td>
<td>Top of Mon.</td>
</tr>
<tr>
<td>55'</td>
<td>58'</td>
<td>27'</td>
<td>43.07</td>
<td></td>
</tr>
</tbody>
</table>

Profile date: 8/1/57
Average loss/yr: 3.1 Bluff
Average loss/yr: 3.0 Foot
3.0 Average
Lat.  41° 55'  21.2"
Long.  69° 58'  39.5"
Az.   253°  31'

Dist. Elev. Remarks

0  66.23  Top of Mon.
0  65.72
188  63.57
325  63.38
478  55.68
506  55.35
541  51.20
634  48.74
724  41.32
760  37.86  Bluff Station
814  19.51  Foot of Bluff

Profile date:  8/2/57
Average loss/yr:  2.3  Bluff
Average loss/yr:  2.2  Foot

2.2 Average

Lat.  41° 55'  26.9"
Long.  69° 58'  36.5"
Az.   253°  20'

Dist. Elev. Remarks

0  73.89  Top of Mon.
0  73.46
46  70.90
99  65.50
188  59.66
262  63.17
357  60.85
367  61.26
373  61.22  Bluff Station
456  16.44  Foot of Bluff

Profile date:  8/15/57
Average loss/yr:  2.2  Bluff
Average loss/yr:  2.4  Foot

2.3 Average
Lat.  41°  55'  31.1''
Long.  69°  58'  40.4''
Az.  253°  25'

Dist. Elev. Remarks

<table>
<thead>
<tr>
<th>Dist.</th>
<th>Elev.</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>88.86</td>
<td>Top of Mon.</td>
</tr>
<tr>
<td>0</td>
<td>88.44</td>
<td></td>
</tr>
<tr>
<td>54</td>
<td>84.98</td>
<td></td>
</tr>
<tr>
<td>111</td>
<td>86.50</td>
<td></td>
</tr>
<tr>
<td>175</td>
<td>81.48</td>
<td></td>
</tr>
<tr>
<td>233</td>
<td>82.50</td>
<td></td>
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<tr>
<td>288</td>
<td>81.44</td>
<td></td>
</tr>
<tr>
<td>356</td>
<td>76.84</td>
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</tr>
<tr>
<td>451</td>
<td>74.54</td>
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</tr>
<tr>
<td>469</td>
<td>71.29</td>
<td></td>
</tr>
<tr>
<td>479</td>
<td>66.04</td>
<td>Bluff Station</td>
</tr>
<tr>
<td>595</td>
<td>20.29</td>
<td>Head of Terrace</td>
</tr>
<tr>
<td>627</td>
<td>19.90</td>
<td>Terrace Station</td>
</tr>
<tr>
<td>628</td>
<td>17.43</td>
<td>Foot of Terrace</td>
</tr>
</tbody>
</table>

Profile date: 8/5/57

Average loss/yr: 2.3 Bluff
Average loss/yr: 3.0 Foot
2.6 Average

Lat.  41°  55'  35.5''
Long.  69°  58'  41.0''
Az.  253°  25'

Dist. Elev. Remarks

<table>
<thead>
<tr>
<th>Dist.</th>
<th>Elev.</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>87.04</td>
<td>Top of Mon.</td>
</tr>
<tr>
<td>0</td>
<td>86.94</td>
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<tr>
<td>47</td>
<td>86.41</td>
<td></td>
</tr>
<tr>
<td>72</td>
<td>88.26</td>
<td></td>
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<tr>
<td>132</td>
<td>87.64</td>
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</tr>
<tr>
<td>293</td>
<td>78.53</td>
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</tr>
<tr>
<td>370</td>
<td>81.11</td>
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<tr>
<td>397</td>
<td>78.44</td>
<td></td>
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<tr>
<td>401</td>
<td>78.34</td>
<td>Bluff Station</td>
</tr>
<tr>
<td>502</td>
<td>20.34</td>
<td>Head of Terrace</td>
</tr>
<tr>
<td>516</td>
<td>20.29</td>
<td>Terrace Station</td>
</tr>
<tr>
<td>518</td>
<td>16.13</td>
<td>Foot of Terrace</td>
</tr>
</tbody>
</table>

Profile date: 8/7/57
Monument lost: 3/16/59

Average loss/yr: 2.7 Bluff
Average loss/yr: 3.0 Foot
2.9 Average
Lat.  41° 55'  40.2"
Long.  69° 58'  43.0"
Az.  253° 20'

Dist. Elev. Remarks

0  74.45  Top of Mon.
0  73.97
100  51.60
199  43.92
328  43.59
395  42.38
410  37.38
453  35.08
464  33.86
485  30.44  Bluff Station
521  21.49  Edge of blow-out
527  15.62  Foot of Bluff

Profile date:  8/7/57

Average loss/yr:  2.4 Bluff
Average loss/yr:  2.6 Foot

2.5 Average

Lat.  41° 56' 16.3"
Long.  69° 59' 00.2"
Az.  250° 02'

Dist. Elev. Remarks

0  84.84  Top of Mon.*
0  83.42  On road
32  87.02  E. top of road cut
53  85.03
83  79.35
140  73.30
250  88.56
302  87.97
390  97.41
407  95.43
419  95.21
423  92.08
447  85.76  Bluff Station
560  15.80  Foot of Bluff

Profile date:  8/9/57

Average loss/yr:  3.0 Bluff
Average loss/yr:  3.4 Foot

3.2 Average

* Monument placed 12 feet west of true origin, which falls on asphalt road.
### Profile 1

<table>
<thead>
<tr>
<th>Dist. Elev.</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>104.45 Top of Mon.</td>
</tr>
<tr>
<td>0</td>
<td>103.73</td>
</tr>
<tr>
<td>100</td>
<td>97.68 W. edge of road fill</td>
</tr>
<tr>
<td>161</td>
<td>93.70 E. edge of road fill</td>
</tr>
<tr>
<td>281</td>
<td>91.89</td>
</tr>
<tr>
<td>341</td>
<td>93.96</td>
</tr>
<tr>
<td>405</td>
<td>96.14</td>
</tr>
<tr>
<td>425</td>
<td>95.82 Bluff Station</td>
</tr>
<tr>
<td>543</td>
<td>12.01 Foot of Bluff</td>
</tr>
</tbody>
</table>

**Profile date:** 8/13/57

**Average loss/yr:** 3.3 Bluff

**Average loss/yr:** 3.4 Foot

**3.3 Average**

---

### Profile 2

<table>
<thead>
<tr>
<th>Dist. Elev.</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>108.37 Top of Mon.</td>
</tr>
<tr>
<td>0</td>
<td>107.70</td>
</tr>
<tr>
<td>60</td>
<td>102.36</td>
</tr>
<tr>
<td>116</td>
<td>92.86</td>
</tr>
<tr>
<td>228</td>
<td>83.49</td>
</tr>
<tr>
<td>303</td>
<td>75.51</td>
</tr>
<tr>
<td>387</td>
<td>75.66</td>
</tr>
<tr>
<td>432</td>
<td>78.27</td>
</tr>
<tr>
<td>440</td>
<td>78.59 Bluff Station</td>
</tr>
<tr>
<td>556</td>
<td>9.74 Foot of Bluff</td>
</tr>
</tbody>
</table>

**Profile date:** 8/13/57

**Average loss/yr:** 3.0 Bluff

**Average loss/yr:** 3.1 Foot

**3.0 Average**
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>41° 56' 44.1&quot;</td>
<td>69° 59' 10.2&quot;</td>
<td>247° 00'</td>
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<td></td>
<td></td>
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</table>

### Dist. Elev. Remarks

<table>
<thead>
<tr>
<th>Dist.</th>
<th>Elev.</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>106.97</td>
<td>Top of Mon.</td>
</tr>
<tr>
<td>0</td>
<td>106.57</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>107.83</td>
<td></td>
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<tr>
<td>77</td>
<td>104.03</td>
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<tr>
<td>94</td>
<td>99.96</td>
<td></td>
</tr>
<tr>
<td>142</td>
<td>99.05</td>
<td></td>
</tr>
<tr>
<td>154</td>
<td>96.72</td>
<td>Bluff Station</td>
</tr>
<tr>
<td>271</td>
<td>10.88</td>
<td>Foot of Bluff</td>
</tr>
</tbody>
</table>

**Profile date:** 8/13/57

**Average loss/yr:** 4.4 Bluff

**Average loss/yr:** 4.0 Foot

4.2 Average
101

Lat.  41° 57'  02.3"
Long.  69° 59'  21.6"
Az.    246°  09'

Dist. Elev. Remarks

0  73.95  Top of Mon.
  73.30
  78.93
  82.63
  83.44
  95.29
  94.31
  93.92
  89.47
  83.49
271  76.78  Bluff Station
383  5.23  Foot of Bluff

Profile date: 8/13/57

Average loss/yr: 1.7  Bluff
Average loss/yr: 2.0  Foot
  1.9  Average

102

Lat.  41° 57'  10.1"
Long.  69° 59'  30.1"
Az.    246°  09'

Dist. Elev. Remarks

0  14.93  Top of Mon.
    76  4.60
  134  2.72  Edge of bog
  296  2.80  Edge of bog
  362  5.15
  398  10.19
  450  25.61
  492  38.85
  534  46.74
  543  48.20
  561  43.48
  574  42.93
602  37.99  Bluff Station
638  16.69  Foot of Bluff

Profile date: 8/14/57

Average loss/yr: 1.7  Bluff
Average loss/yr: 2.3  Foot
  2.0  Average
<table>
<thead>
<tr>
<th>Lat.</th>
<th>41° 57'</th>
<th>29.6&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long.</td>
<td>69° 59'</td>
<td>35.7&quot;</td>
</tr>
<tr>
<td>Az.</td>
<td>246° 10'</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dist. Elev. Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 96.12 Top of Mon.</td>
</tr>
<tr>
<td>0 95.38</td>
</tr>
<tr>
<td>38 89.81</td>
</tr>
<tr>
<td>77 92.04 Bluff Station</td>
</tr>
<tr>
<td>203 14.64 Foot of Bluff</td>
</tr>
</tbody>
</table>

Profile date: 8/14/57

Average loss/yr: 1.7 Bluff
Average loss/yr: 2.5 Foot
2.1 Average

<table>
<thead>
<tr>
<th>Lat.</th>
<th>41° 57'</th>
<th>39.2&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long.</td>
<td>69° 59'</td>
<td>46.1&quot;</td>
</tr>
<tr>
<td>Az.</td>
<td>246° 10'</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dist. Elev. Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 63.42 Top of Mon.</td>
</tr>
<tr>
<td>0 62.78</td>
</tr>
<tr>
<td>63 64.55</td>
</tr>
<tr>
<td>135 69.84</td>
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<td>227 66.64</td>
</tr>
<tr>
<td>285 64.82</td>
</tr>
<tr>
<td>328 66.86</td>
</tr>
<tr>
<td>371 75.27</td>
</tr>
<tr>
<td>390 74.36</td>
</tr>
<tr>
<td>401 71.03</td>
</tr>
<tr>
<td>431 69.58 Bluff Station</td>
</tr>
<tr>
<td>503 14.12 Foot of Bluff</td>
</tr>
</tbody>
</table>

Profile date: 8/14/57

Average loss/yr: 3.2 Bluff
Average loss/yr: 4.3 Foot
3.8 Average
<table>
<thead>
<tr>
<th>Dist.</th>
<th>Elev.</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>32.78</td>
<td>Top of Mon.</td>
</tr>
<tr>
<td>30</td>
<td>32.96</td>
<td></td>
</tr>
<tr>
<td>63</td>
<td>28.56</td>
<td></td>
</tr>
<tr>
<td>328</td>
<td>26.36</td>
<td>S. side of road</td>
</tr>
<tr>
<td>395</td>
<td>34.03</td>
<td></td>
</tr>
<tr>
<td>446</td>
<td>35.82</td>
<td></td>
</tr>
<tr>
<td>543</td>
<td>49.08</td>
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</tr>
<tr>
<td>660</td>
<td>13.63</td>
<td>Foot of Bluff</td>
</tr>
</tbody>
</table>

Profile date: 8/14/57

Average loss/yr: 2.7 Bluff
Average loss/yr: 2.9 Foot
2.8 Average

<table>
<thead>
<tr>
<th>Dist.</th>
<th>Elev.</th>
<th>Remarks</th>
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<tbody>
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<td>28.42</td>
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<tr>
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<td>15.88</td>
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<tr>
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<td>6.50</td>
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<tr>
<td>362</td>
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<td></td>
</tr>
<tr>
<td>448</td>
<td>23.17</td>
<td></td>
</tr>
<tr>
<td>517</td>
<td>26.08</td>
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<tr>
<td>529</td>
<td>27.00</td>
<td>Bluff Station</td>
</tr>
<tr>
<td>551</td>
<td>16.51</td>
<td>Foot of Bluff</td>
</tr>
</tbody>
</table>

Profile date: 8/16/57

Average loss/yr: 1.7 Bluff
Average loss/yr: 1.6 Foot
1.7 Average
<table>
<thead>
<tr>
<th>Dist.</th>
<th>Elev.</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
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</tr>
<tr>
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<tr>
<td>218</td>
<td>19.35</td>
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<td>319</td>
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<td>471</td>
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<td>508</td>
<td>35.73</td>
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<tr>
<td>551</td>
<td>29.28</td>
<td></td>
</tr>
<tr>
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<tr>
<td>699</td>
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<tr>
<td>723</td>
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<tr>
<td>769</td>
<td>15.79</td>
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</tbody>
</table>

Profile date: 8/16/57

Average loss/yr: 0.8 Bluff
Average loss/yr: 2.0 Foot

1.4 Average

<table>
<thead>
<tr>
<th>Lat.</th>
<th>41° 58' 02.4&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long.</td>
<td>70° 00' 05.1&quot;</td>
</tr>
<tr>
<td>Az.</td>
<td>243° 54'</td>
</tr>
</tbody>
</table>

Dist. Elev. Remarks

<table>
<thead>
<tr>
<th>Dist.</th>
<th>Elev.</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>63.48</td>
<td>Top of Mon.</td>
</tr>
<tr>
<td>0</td>
<td>62.73</td>
<td></td>
</tr>
<tr>
<td>47</td>
<td>66.45</td>
<td></td>
</tr>
<tr>
<td>79</td>
<td>65.47</td>
<td></td>
</tr>
<tr>
<td>107</td>
<td>66.87</td>
<td></td>
</tr>
<tr>
<td>157</td>
<td>61.08</td>
<td></td>
</tr>
<tr>
<td>177</td>
<td>58.28</td>
<td></td>
</tr>
<tr>
<td>199</td>
<td>55.16</td>
<td></td>
</tr>
<tr>
<td>213</td>
<td>49.40</td>
<td>Bluff Station</td>
</tr>
<tr>
<td>264</td>
<td>15.23</td>
<td>Foot of Bluff</td>
</tr>
</tbody>
</table>

Profile date: 8/16/57

Average loss/yr: 0.7 Bluff
Average loss/yr: 1.5 Foot

1.1 Average
Lat. 41° 58' 20.2"
Long. 70° 00' 15.6"
Az. 243° 54'

Dist. Elev. Remarks
0 72.86 Top of Mon.
0 72.30
161 62.44
313 64.78
338 57.83
377 60.35
419 54.88
489 56.90
572 57.82
587 54.85
593 55.19
601 52.41
654 44.87 Bluff Station
699 15.74 Foot of Bluff

Profile date: 8/16/57
Average loss/yr: 1.0 Bluff
Average loss/yr: 1.6 Foot

Lat. 41° 58' 37.8"
Long. 70° 00' 25.9"
Az. 243° 51'

Dist. Elev. Remarks
0 118.60 Top of Mon.
0 118.05
106 132.78
156 134.35
207 127.07
327 116.55
418 124.03
448 119.17
487 106.99
501 107.24 Bluff Station
643 14.49 Foot of Bluff

Profile date: 8/20/57
Average loss/yr: 2.2 Bluff
Average loss/yr: 2.3 Foot
2.3 Average
1.3 Average
Lat.  41°  58'  46.4"
Long.  70°  00'  30.7"
Az.    243°  51'

Dist. Elev. Remarks

0  89.93  Top of Mon.
0  89.58
176  115.14
375  117.86  Bluff Station
533  16.39  Foot of Bluff

Profile date:  8/20/57
Average loss/yr:  3.1  Bluff
Average loss/yr:  3.5  Foot

3.3 Average
### Dist. Elev. Remarks

<table>
<thead>
<tr>
<th>Dist.</th>
<th>Elev.</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>134.23</td>
<td>Top of Mon.</td>
</tr>
<tr>
<td>0</td>
<td>133.78</td>
<td></td>
</tr>
<tr>
<td>69</td>
<td>134.16</td>
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</tr>
<tr>
<td>145</td>
<td>128.26</td>
<td></td>
</tr>
<tr>
<td>275</td>
<td>125.45</td>
<td></td>
</tr>
<tr>
<td>360</td>
<td>136.92</td>
<td></td>
</tr>
<tr>
<td>461</td>
<td>147.29</td>
<td></td>
</tr>
<tr>
<td>472</td>
<td>143.39</td>
<td></td>
</tr>
<tr>
<td>651</td>
<td>155.53</td>
<td></td>
</tr>
<tr>
<td>664</td>
<td>147.62</td>
<td></td>
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<tr>
<td>762</td>
<td>136.91</td>
<td>Bluff Station</td>
</tr>
<tr>
<td>951</td>
<td>17.27</td>
<td>Foot of Bluff</td>
</tr>
</tbody>
</table>

**Profile date:** 8/21/57

**Average loss/yr:** 3.2 Bluff

**Average loss/yr:** 3.4 Foot

3.3 Average
<table>
<thead>
<tr>
<th></th>
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<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>144.99 Top of Mon.</td>
<td>41°</td>
<td>70°</td>
<td>241°</td>
<td>0</td>
<td>114.03 Top of Mon.</td>
<td>41°</td>
<td>70°</td>
<td>241°</td>
</tr>
<tr>
<td>0</td>
<td>144.44</td>
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<td></td>
<td>0</td>
<td>113.38</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>206</td>
<td>149.03</td>
<td></td>
<td></td>
<td></td>
<td>102</td>
<td>109.19</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>261</td>
<td>145.71</td>
<td></td>
<td></td>
<td></td>
<td>148</td>
<td>110.75</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>328</td>
<td>150.31</td>
<td></td>
<td></td>
<td></td>
<td>192</td>
<td>107.84 Bluff Station</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>333</td>
<td>150.58 Bluff Station</td>
<td></td>
<td></td>
<td></td>
<td>321</td>
<td>16.50 Foot of Bluff</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>532</td>
<td>23.49 Foot of Bluff</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Profile date: 8/22/57

Average loss/yr: 1.8 Bluff
Average loss/yr: 2.0 Foot

1.9 Average
<table>
<thead>
<tr>
<th>Dist. Elev.</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>42.99 Top of Mon.</td>
</tr>
<tr>
<td>0</td>
<td>42.49</td>
</tr>
<tr>
<td>66</td>
<td>21.60</td>
</tr>
<tr>
<td>173</td>
<td>18.83</td>
</tr>
<tr>
<td>321</td>
<td>27.51</td>
</tr>
<tr>
<td>406</td>
<td>53.87</td>
</tr>
<tr>
<td>420</td>
<td>46.40 Bluff Station</td>
</tr>
<tr>
<td>463</td>
<td>13.47 Foot of Bluff</td>
</tr>
</tbody>
</table>

Profile date: 8/22/57

Average loss/yr: 2.7 Bluff
Average loss/yr: 2.1 Foot
Average: 2.9 Average

Lat. | 41° 59' | 38.5"
Long. | 70° 01' | 06.1"
Az. | 241° 56' |

Dist. Elev. Remarks

0 | 57.01 Top of Mon.
0 | 56.52
314 | 19.88
409 | 11.11
783 | 56.50
860 | 69.42
944 | 77.75
949 | 78.68 Bluff Station
1037 | 22.16 Foot of Bluff

Profile date: 8/22/57

Average loss/yr: 2.8 Bluff
Average loss/yr: 3.2 Foot
Average: 3.0 Average
<table>
<thead>
<tr>
<th>121</th>
<th>141</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lat.</strong></td>
<td>41° 59' 55.2&quot;</td>
</tr>
<tr>
<td><strong>Long.</strong></td>
<td>70° 01' 19.5&quot;</td>
</tr>
<tr>
<td><strong>Az.</strong></td>
<td>239° 22'</td>
</tr>
<tr>
<td>0 5.00</td>
<td>Top of Pipe (in marsh)</td>
</tr>
<tr>
<td>0 3.50</td>
<td>E. Side' of drainage ditch</td>
</tr>
<tr>
<td>42 6.59</td>
<td></td>
</tr>
<tr>
<td>107 13.25</td>
<td></td>
</tr>
<tr>
<td>247 21.87</td>
<td></td>
</tr>
<tr>
<td>380 41.09</td>
<td></td>
</tr>
<tr>
<td>451 45.37</td>
<td></td>
</tr>
<tr>
<td>474 43.79</td>
<td></td>
</tr>
<tr>
<td>501 33.09</td>
<td>Bluff Station</td>
</tr>
<tr>
<td>547 15.49</td>
<td>Foot of Bluff</td>
</tr>
<tr>
<td>Profile date: 8/22/57</td>
<td></td>
</tr>
<tr>
<td>Average loss/yr: 2.2</td>
<td>Bluff</td>
</tr>
<tr>
<td>Average loss/yr: 3.0</td>
<td>Foot</td>
</tr>
<tr>
<td>2.6</td>
<td>Average</td>
</tr>
<tr>
<td>------------</td>
<td>--------------------</td>
</tr>
<tr>
<td>0</td>
<td>72.78 Top of Mon.</td>
</tr>
<tr>
<td>253</td>
<td>66.45</td>
</tr>
<tr>
<td>396</td>
<td>76.40</td>
</tr>
<tr>
<td>547</td>
<td>79.66</td>
</tr>
<tr>
<td>552</td>
<td>79.56 Bluff Station</td>
</tr>
<tr>
<td>639</td>
<td>6.89 Foot of Bluff</td>
</tr>
</tbody>
</table>

Profile date: Jan., 1959
Average loss/yr: 1.5 Bluff
Average loss/yr: 2.4 Foot

Average loss/yr: 1.8 Bluff
Average loss/yr: 2.1 Foot

1.9 Average
<table>
<thead>
<tr>
<th>Station</th>
<th>Dist. Elev.</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top of Mon.</td>
<td>64.66</td>
<td></td>
</tr>
<tr>
<td>116</td>
<td>62.22</td>
<td></td>
</tr>
<tr>
<td>264</td>
<td>72.30</td>
<td></td>
</tr>
<tr>
<td>268</td>
<td>72.47</td>
<td>Bluff Station</td>
</tr>
<tr>
<td>363</td>
<td>17.91</td>
<td>Foot of Bluff</td>
</tr>
<tr>
<td>Terrace</td>
<td>21.07</td>
<td></td>
</tr>
<tr>
<td>543</td>
<td>21.62</td>
<td>Terrace Station</td>
</tr>
<tr>
<td>552</td>
<td>16.32</td>
<td>Foot of Terrace</td>
</tr>
</tbody>
</table>

Profile date: Nov. 1958

Average loss/yr: 0.9 Bluff

Average loss/yr: 2.3 Foot

1.6 Average
<table>
<thead>
<tr>
<th>Dist.</th>
<th>Elev.</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>5.78</td>
<td>Top of Mon.</td>
</tr>
<tr>
<td>81</td>
<td>5.65</td>
<td></td>
</tr>
<tr>
<td>152</td>
<td>11.72</td>
<td></td>
</tr>
<tr>
<td>188</td>
<td>15.40</td>
<td></td>
</tr>
<tr>
<td>285</td>
<td>16.48</td>
<td></td>
</tr>
<tr>
<td>319</td>
<td>23.64</td>
<td></td>
</tr>
<tr>
<td>332</td>
<td>26.76</td>
<td></td>
</tr>
<tr>
<td>341</td>
<td>30.72</td>
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</tr>
<tr>
<td>400</td>
<td>23.59</td>
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</tr>
<tr>
<td>450</td>
<td>23.52</td>
<td>Terrace Station</td>
</tr>
<tr>
<td>485</td>
<td>8.45</td>
<td>Foot of Terrace</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Profile date: Jan. 1959</td>
</tr>
</tbody>
</table>

Average loss/yr. at 16' contour: 0.6
Lat. 42° 03' 26.4"
Long. 70° 05' 35.6"
Az. 206° 56'

Dist. Elev. Remarks

0 6.76 Top of Mon.
0 6.53
34 8.94
123 22.99
173 20.46
268 30.94
308 29.46
343 27.56 Bluff Station
363 9.70 Foot of Bluff

Profile date: 1/28/59

Average loss/yr.
at 16' contour: 0.4

Lat. 42° 03' 28.2"
Long. 70° 05' 48.7"
Az. 206° 25'

Dist. Elev. Remarks

0 5.15 Top of Mon.
185 6.84
226 5.94
294 11.28
373 44.24
439 47.69
618 33.61
671 27.59
701 10.11 Foot of terrace

Profile date: 2/6/59

Average gain/yr.
at 16' contour: 0.6
### 153

<table>
<thead>
<tr>
<th>Dist.</th>
<th>Elev.</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>5.13</td>
<td>5.13 Top of Mon.</td>
</tr>
<tr>
<td>134</td>
<td>12.52</td>
<td></td>
</tr>
<tr>
<td>152</td>
<td>16.45</td>
<td></td>
</tr>
<tr>
<td>210</td>
<td>24.24</td>
<td></td>
</tr>
<tr>
<td>241</td>
<td>27.88</td>
<td></td>
</tr>
<tr>
<td>293</td>
<td>36.32</td>
<td></td>
</tr>
<tr>
<td>340</td>
<td>31.54</td>
<td></td>
</tr>
<tr>
<td>480</td>
<td>33.90</td>
<td>Terrace Station</td>
</tr>
<tr>
<td>520</td>
<td>13.31</td>
<td>Foot of Terrace</td>
</tr>
</tbody>
</table>

Profile date: 2/6/59

Average gain/yr.
at 16' contour: 1.9

### 154

<table>
<thead>
<tr>
<th>Dist.</th>
<th>Elev.</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>4.12</td>
<td>4.12 Top of Mon.</td>
</tr>
<tr>
<td>109</td>
<td>8.23</td>
<td></td>
</tr>
<tr>
<td>164</td>
<td>20.28</td>
<td></td>
</tr>
<tr>
<td>301</td>
<td>14.95</td>
<td></td>
</tr>
<tr>
<td>517</td>
<td>11.16</td>
<td></td>
</tr>
<tr>
<td>731</td>
<td>5.53</td>
<td></td>
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<tr>
<td>851</td>
<td>36.81</td>
<td></td>
</tr>
<tr>
<td>882</td>
<td>37.16</td>
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</tr>
<tr>
<td>994</td>
<td>27.13</td>
<td></td>
</tr>
<tr>
<td>1063</td>
<td>36.89</td>
<td>Bluff Station</td>
</tr>
<tr>
<td>1105</td>
<td>21.24</td>
<td>Foot of Bluff</td>
</tr>
</tbody>
</table>

Profile date: 4/23/59

Average gain/yr.
at 21' contour: 3.0
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>0 24.53 Top of Mon.</td>
<td>42° 03' 35.7&quot;</td>
<td>70° 06' 27.0&quot;</td>
<td>204° 03' 25&quot;</td>
</tr>
<tr>
<td>59 32.31</td>
<td>116 13.51</td>
<td>471 10.49</td>
<td>761 8.11</td>
</tr>
<tr>
<td>835 30.16</td>
<td>901 14.14</td>
<td>1145 31.22</td>
<td>1181 28.31</td>
</tr>
<tr>
<td>1302 26.35 Bluff Station</td>
<td>1336 24.88 Foot of Bluff</td>
<td>1405 18.38 Foot of Terrace</td>
<td></td>
</tr>
</tbody>
</table>

Profile date: 6/1/59

Average gain/yr.
at 19' contour: 3.3

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0 5.20 Top of Mon.</td>
<td>42° 03' 35.8&quot;</td>
<td>70° 06' 41.3&quot;</td>
<td>204° 03' 30&quot;</td>
</tr>
<tr>
<td>177 37.14</td>
<td>182 37.27</td>
<td>288 12.37</td>
<td>344 27.54</td>
</tr>
<tr>
<td>510 8.74</td>
<td>788 6.80</td>
<td>814 11.90</td>
<td>860 11.95</td>
</tr>
<tr>
<td>997 15.98</td>
<td>1233 34.68</td>
<td>1433 34.68</td>
<td>1555 27.35</td>
</tr>
<tr>
<td>1749 34.10</td>
<td>1810 31.74 Terrace Station</td>
<td>1843 16.40 Foot of Terrace</td>
<td></td>
</tr>
</tbody>
</table>

Profile date: 7/10/59

Average gain/yr.
at 17' contour: 3.5
<table>
<thead>
<tr>
<th>Dist.</th>
<th>Elev.</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>5.96</td>
<td>Top of Mon.</td>
</tr>
<tr>
<td>149</td>
<td>25.25</td>
<td></td>
</tr>
<tr>
<td>289</td>
<td>6.82</td>
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</tr>
<tr>
<td>586</td>
<td>5.84</td>
<td></td>
</tr>
<tr>
<td>793</td>
<td>5.83</td>
<td></td>
</tr>
<tr>
<td>1019</td>
<td>6.07</td>
<td></td>
</tr>
<tr>
<td>1259</td>
<td>8.83</td>
<td></td>
</tr>
<tr>
<td>1482</td>
<td>21.25</td>
<td>Terrace Station</td>
</tr>
<tr>
<td>1877</td>
<td>35.55</td>
<td></td>
</tr>
<tr>
<td>1884</td>
<td>35.53</td>
<td>Terrace Station</td>
</tr>
<tr>
<td>1947</td>
<td>16.29</td>
<td>Foot of Terrace</td>
</tr>
</tbody>
</table>

Profile date: 7/13/59

Average gain/yr.
at foot of terrace: 5.3

---

<table>
<thead>
<tr>
<th>Dist.</th>
<th>Elev.</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>29.96</td>
<td>Surface</td>
</tr>
<tr>
<td>238</td>
<td>32.20</td>
<td></td>
</tr>
<tr>
<td>504</td>
<td>32.97</td>
<td></td>
</tr>
<tr>
<td>698</td>
<td>51.52</td>
<td></td>
</tr>
<tr>
<td>1024</td>
<td>18.97</td>
<td></td>
</tr>
<tr>
<td>1078</td>
<td>20.93</td>
<td></td>
</tr>
<tr>
<td>1154</td>
<td>10.98</td>
<td></td>
</tr>
<tr>
<td>1208</td>
<td>18.29</td>
<td></td>
</tr>
<tr>
<td>1276</td>
<td>6.26</td>
<td></td>
</tr>
<tr>
<td>1543</td>
<td>8.59</td>
<td></td>
</tr>
<tr>
<td>1643</td>
<td>19.53</td>
<td></td>
</tr>
<tr>
<td>1714</td>
<td>41.40</td>
<td></td>
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<tr>
<td>1738</td>
<td>35.22</td>
<td></td>
</tr>
<tr>
<td>1902</td>
<td>32.26</td>
<td></td>
</tr>
<tr>
<td>1905</td>
<td>32.26</td>
<td>Edge old Terrace</td>
</tr>
<tr>
<td>1927</td>
<td>21.15</td>
<td></td>
</tr>
<tr>
<td>1977</td>
<td>17.85</td>
<td>Edge new Terrace</td>
</tr>
<tr>
<td>1983</td>
<td>12.35</td>
<td>Foot new Terrace</td>
</tr>
</tbody>
</table>

Profile date: 12/3/59

Average gain/yr.
at foot of terrace: 3.2
159

Lat.  42°  03'  43.6"
Long.  70°  07'  17.8"
Az.   201°  55'

Dist. Elev. Remarks

0     8.11  Top of Mon.
172   30.71
201   18.72
280   6.78
407   4.49
508   13.00
858   5.03
1145  5.19
1506  3.16  Edge of Bog
1527  6.42
1586  4.36
1670  33.58
1749  17.29
1888  31.23
1985  34.71
2025  28.13
2116  33.56  Edge of Terrace
2144  21.92  Foot of Terrace

Profile date:  12/2/59

Average gain/yr.
at foot of terrace:  2.1
<table>
<thead>
<tr>
<th>Latitude (Lat.)</th>
<th>42° 04' 41.2&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Longitude (Long.)</td>
<td>70° 13' 00.5&quot;</td>
</tr>
<tr>
<td>Azimuth (Az.)</td>
<td>352° 10' True</td>
</tr>
</tbody>
</table>

**Dist. Elev. Remarks**

<table>
<thead>
<tr>
<th>Distance (Dist.)</th>
<th>Elevation (Elev.)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>10.67</td>
<td>El, Top Monument</td>
</tr>
<tr>
<td>270</td>
<td>12.25</td>
<td></td>
</tr>
<tr>
<td>327</td>
<td>27.65</td>
<td></td>
</tr>
<tr>
<td>498</td>
<td>49.07</td>
<td></td>
</tr>
<tr>
<td>603</td>
<td>34.33</td>
<td></td>
</tr>
<tr>
<td>665</td>
<td>32.26</td>
<td></td>
</tr>
<tr>
<td>711</td>
<td>28.17</td>
<td>Bluff</td>
</tr>
<tr>
<td>735</td>
<td>20.80</td>
<td></td>
</tr>
<tr>
<td>754</td>
<td>18.78</td>
<td></td>
</tr>
<tr>
<td>827</td>
<td>12.18</td>
<td>Crest</td>
</tr>
<tr>
<td>996</td>
<td>0.00</td>
<td>Water edge at 1500 hours 4/17/62 assumed to be 0.00 feet</td>
</tr>
</tbody>
</table>

**Profile Date 4/17/62**

- 1962 Bluff: 711
- 1888 Bluff: 623
- Gain: 88 feet

---

<table>
<thead>
<tr>
<th>Distance (Dist.)</th>
<th>Elevation (Elev.)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>23.14</td>
<td>Top of Monument</td>
</tr>
<tr>
<td>72</td>
<td>14.36</td>
<td></td>
</tr>
<tr>
<td>186</td>
<td>9.66</td>
<td></td>
</tr>
<tr>
<td>288</td>
<td>14.11</td>
<td>Foot of dune</td>
</tr>
<tr>
<td>368</td>
<td>47.73</td>
<td>Top of dune</td>
</tr>
<tr>
<td>614</td>
<td>41.31</td>
<td>Top of bluff</td>
</tr>
<tr>
<td>668</td>
<td>23.62</td>
<td>Foot of bluff</td>
</tr>
<tr>
<td>730</td>
<td>16.67</td>
<td>Backshore</td>
</tr>
<tr>
<td>789</td>
<td>15.08</td>
<td>Foreshore</td>
</tr>
<tr>
<td>831</td>
<td>10.00</td>
<td>*El. at water’s edge 1020 hours 4/17/62 taken to be 10 feet</td>
</tr>
</tbody>
</table>

1962 Crest: 827
1888 Crest: 843
Loss: 16 feet
NO. 91
AZ. 
ELEV. 

NO. 92
AZ. 
ELEV.