Low-Water Photography in Cobscook Bay, Maine

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SUMMARY: *Infrared photography provides an extremely effective means of mapping shorelines. Inasmuch as a relatively thin film of water (3 inches or less) photographs black, or very dark, in contrast with the shore, the water's edge is sharply defined. The Cobscook Bay, Maine, project is an interesting example of the use of infrared photography for accurately mapping mean-low water and half-tide level-lines or contours.*

THE coastal mapping discussed in this series of papers is done for the publication of nautical charts, but the maps have many collateral uses; they are used in the exploration and conservation of resources, in the settlement of boundaries, in the planning and construction for the protection of beach properties, for drainage and other land development problems, and for all forms of engineering construction including the building of port facilities, construction of bridges, and, in this case, for studies of water-power.

Many readers of this paper will remember the Passamaquoddy Tidal-Power Project that received so much attention prior to and, particularly, during the early 1930s. The project was not then completed but is again under study by the Corps of Engineers. One plan for this power development is illustrated in Figure 1 and is outlined briefly as background information. The water storage-area comprises some 130 square miles of Passamaquoddy Bay in New Brunswick and Cobscook Bay in Maine. The intake and outlet of tidal water into this vast storage-area will be controlled by dams and water gates that will also permit navigation to and from the Bay of Fundy. The inlet of tidal waters will be through gates at the Eastern entrance to Passamaquoddy Bay (outside of and north of the limits of Figure 1). Passamaquoddy Bay will then comprise the upper water storage-area. Power generating-stations will be located in the narrow pass between Passamaquoddy and Cobscook Bays just north of Eastport. Water will be let out of the lower pool at the gates between Eastport and Lubec and controlled so that the minimum head between the upper and lower pools for generation of power will be not less than 6 or 8 feet. The vast volume of water will permit power generation under relatively small head.

For detailed studies of this project, the Corps of Engineers must compute the volume of water storage between the mean-high and mean-low water planes in both the upper and lower pools. The shoreline of Passamaquoddy Bay (the upper pool) is relatively regular and steep, and the volume can be computed from maps available from the Canadian government and from early surveys (1865) by the Coast and Geodetic Survey. More detailed maps are required, however, for Cobscook Bay because of the very irregular shoreline and the extensive tidal flats.

The Passamaquoddy survey unit of the New England Division, Corps of Engineers brought this problem to the Coast and Geodetic Survey in late August 1956. The need was for tidal data (range and time) and for large-scale maps of Cobscook Bay showing the mean high-water line, the half-tide level line, and the mean low-water line or contour. Large-scale topographic maps (1:10,000) completed in 1948 and showing the mean high-water line in detail were available, but little or no information for the half-tide level contour was included. The low-water line which had been delineated on large-scale hydrographic surveys made in 1887 was adequate for charting, but it was not in sufficient detail for this purpose. It was de-

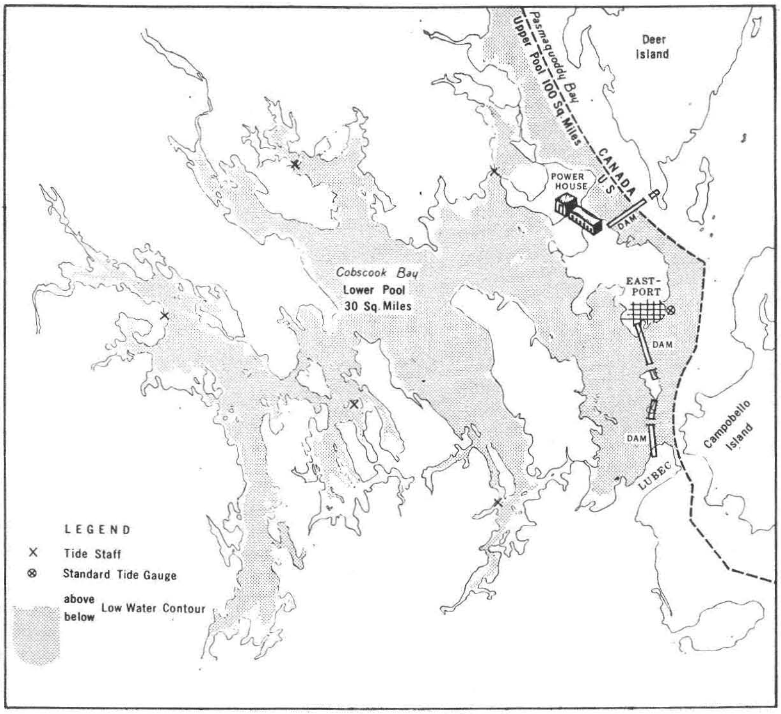

FIG. 1. Map of Cobscook Bay and vicinity.

cided to add the half-tide and low-water contours to the topographic maps from photography taken at those tide stages. This could be done by stereoscopic contouring from low-water or minus-tide photography, or by tracing the water line provided infrared photographs were taken at half-tide and low-water stages. The latter method seemed preferable and turned out to be an excellent choice. The Bureau had recently purchased a Wild camera with infragon cone and thus was well equipped to accomplish infrared photography.

Photographing the area at exactly the right stages of the tide, however, was no small problem. The low-water photography could be taken only on those days when the tide receded to or below mean-low water during photographic daylight. This low-water stage occurs about 30 odd times per month on or about half of the low-waters, but as the time of low-water progresses approximately one hour each day, it occurs only a relatively few times per month during those hours when sufficient light is available for photography. The problem was not quite so acute for the half-tide photography because this exact stage occurs about every $12\frac{1}{2}$ hours or about 58 times per month.

As the Corps of Engineers was very desirous of having the needed information by December 1956, and as the detailed plans for the project were not completed until mid-September, only three days were available when the low-water photographs could be taken—September 30, October 1, and October 2. Otherwise, day-light low-water would occur too late in the season and the photography would have to wait until spring or early summer. A further problem was that Cobscook Bay is in latitude 45 degrees where the sun is so low in late September that photography must be done between 1,000 and 1,500 hours.

A further qualifying factor in this project was that the time of low-tide or half-tide does not occur at the same instant throughout the Bay. These times increase as the tide moves westward from Eastport to the western section of the Bay where the time of any tide stage is 80 minutes later than at Eastport. This actually was an aid to photography as the flight lines could be laid out so that the photography of north-south strips could progress from Eastport westward across the Bay at the same rate as the tide, and the entire series of low-water and half-tide photographs could be taken on one clear photographic day.

Adequate tidal information was available for Eastport, but data regarding the time and range of the tide in the various arms of the Bay were inadequate, and additional tide observations were necessary during photography to complete these data prior to delineating the half-tide and low-water contours. The project thus required these principal operations: (1) the establishment of tide staffs at five points in the upper reaches of the Bay, the reading of these staffs during photography, and completion of a 72 hour series of continuous hourly readings at each staff; (2) low-water and half-tide infrared photography; and (3) processing of tidal records and delineation of low-water and half-tide contours on copies of the existing topographic maps.

A seven-man survey party moved from Providence, Rhode Island to Eastport on September 21. Its members built the five tide staffs and began observations on September 29. This was no small undertaking and a great deal of the credit for the successful completion of the project belongs to these men who worked through all the daylight hours and much of the night until the tide observations were completed. The five tide stations are indicated in Figure 1 and were so situated as to obtain tidal data in the upper reaches of the Bay. Each staff had to cover a range of about 24 feet (the mean range of the tide is about 18 feet and under certain conditions it may be 24 feet or more) and in most cases the staffs had to be built well off from the shore so as to record the minus tides. It was difficult to weight and guy these staffs so as to hold them in the strong current generated by the rapid rise or fall of 18 to 24 feet of water in six hours. Water temperatures were about 51 degrees F. and hip boots do not offer much protection from the cold after a few hours of wading and slopping around the tide flats.

In mid-September the Photographic Mission (see LT Holmes' article in this series) was at Cold Bay, Alaska, and was just completing the season's photography along the Alaska Peninsula and in the Aleutian Islands. The Mission left Cold Bay on the 19th, arrived at Seattle on the 21st, completed the required engine checks, and arrived at Washington, D. C., on the 26th. Tests of the infrared film were necessary at Washington before undertaking the photography of Cobscook Bay. Only two days were available for this and the Washington area was pretty well socked in with rain and fog. Nevertheless, the Mission managed to get off the ground and fly outside of the weather for tests. It then moved to Bangor, Maine, arriving there on September 29.

Here was a gamble and not much different from the throw of dice. With all this preparation would we get photographic weather in the three available days? September 30 broke bright and clear and all tide staffs, including the staff at the Eastport gage, were occupied for observations during the low-water and half-tide photography. I can well remember sitting in a skiff reading the Eastport staff and listening for the drone of motors on that morning. We had the weather; would some mechanical failure on the plane make it impossible to take advantage of the weather? About 1000 I thought I detected a faint roar in the distance and soon the B-17 was overhead in the sunlight, taking simultaneously infrared and panchromatic single-lens photography. It was a beautiful sight and one that I shall not forget.

The half-tide photography was completed at about 1130 but the plane remained in the air to start the low-water photography at about 1300 and completed it at 1430. Additional lower-altitude, low-water photographs were taken on October 2 but the job had to wait for the tide and could not be completed until about 1630, much too late in the afternoon. There was not enough light and shadows of trees were long. This affected the quality of the panchromatic photography much more than the infrared; the low-water line on the latter turned out to be quite clear and was apparent even through dense tree shadows. Figures 2 and 3 are copies of infrared and panchromatic photographs of one of the tide flats, and while not as clear as the originals, they illustrate the difference in definition of the water line and the superior quality of the infrared photography for this purpose.

FIG. 2. Infrared photograph of low-water areas near Lubec, Maine.

FIG. 3. Panchromatic photograph of the same area shown in Figure 2.

The office work, consisting of the delineation of half-tide and mean-low water contours, was relatively easy. The tide observations were processed to give the exact times of the half and low tides on 30 September. This information, together with the times of photography recorded on the film, and a typical tide curve from the Eastport gage, permitted computing the exact tide stage when each photograph was taken. Copies of the base maps were reproduced in black on transparent, grained, plastic sheeting, the photographs were ratioed to exact shoreline scale, and the half-tide and low-water line then traced directly by registering each photograph to shoreline details on the maps.

The photographs were not taken at exactly half-tide and mean low-water stages, so the resulting curves were not exactly half-tide and mean-low water contours; each curve was zoned and labeled at frequent intervals to show the exact height above or below the datum for that particular section of the curve. Nearly all of the low-water curve and much of the half-tide curve was within ½ foot of exact datum, and the maximum variation of either curve from the exact datum was one foot.

In mapping tidal shoreline, it is practicable to take the infrared photography at the exact stages of mean-high or mean-low water as a short period of slack water always occurs at the change of the tide. However, this takes more time (additional photographic days) and was not necessary for the purpose of this project.

The completed maps and accompanying data were delivered to the Corps of Engineers in late November, 1956. This project was unusual, and its successful completion was very satisfying to the photogrammetric personnel of the Bureau. Further, it demonstrated the efficacy of infrared photography for shoreline mapping, and we look forward to its continued and increasing use in meeting many of our problems.

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