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TIDAL BENCH MARKS

STATE OF

OREGON

By

L. A. COLE

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TIDAL BENCH MARKS, STATE OF OREGON

By L. A. COLE, *Associate Mathematician, United States Coast and Geodetic Survey*

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INTRODUCTION

In connection with its hydrographic operations the United States Coast and Geodetic Survey has established from time to time many tidal bench marks along our coasts. Numerous requests from engineers and others for descriptions and elevations of these bench marks have lead the bureau to begin publishing the data which are in manuscript form in the files, in order to be able to furnish the information more promptly and economically. In addition to the bench marks established by this survey, there are included also the bench marks of other organizations, such as municipal, State, and Federal engineers, which have been used by this bureau in the execution of the hydrographic work along the coast.

This information is being made available by sections of the coasts. The present volume is the eighth of the series. The seven volumes which have previously been issued are listed on page 16 of this publication. It is the intent to issue similar volumes from time to time until all sections of the coasts have been covered.

STANDARD BENCH MARK

Various kinds of bench marks have been used to indicate the point of which the elevation was determined. Among these are nails in piles or other structures; small crosses and squares cut in curbstones and doorsteps; bolts in ledges, bowlders, and the foundations of buildings; and sometimes just a well-defined point on a fixed object has been used. Since such marks may lack permanence and are often

hard to identify, this bureau has adopted a standard brass disk identification mark. The standard brass disk is $3\frac{5}{8}$ inches in diameter and has a shank or stem on the back 3 inches long for insertion in a building or other substantial support.

At present there are two types of standard disk bench marks. The type shown in Figure 1 was formerly used in all leveling work of the bureau but is now used chiefly by hydrographic parties in connection with the establishment of tide stations, while the type (4) shown in Figure 2, which provides a place for inserting the elevation above mean sea level, is used chiefly for lines of the first-order level net. In the descriptions of the bench marks in this publication no distinction is made between the two types, both being called standard disks. The other forms of the standard brass disk shown in Figure 2, though not intended primarily for bench marks, may be used as such when their elevations have been determined.

DATUM PLANES

In all engineering work where it is necessary to determine differences in elevation by spirit levels, and especially where it is desired to coordinate the work of various surveys, it is in the interest of efficiency and economy that a uniform datum be used. It has frequently happened that the various engineers operating in the same locality have used different arbitrary datums, which has led to much confusion. This condition can be obviated by the adoption of a single reliable datum. Datums based on tidal definition are the best for both practical and scientific work, since they may be recovered even though all bench-mark connections be destroyed.

Of all the tidal datums, mean sea level is the most nearly fixed and, in general, the most satisfactory for land elevations. By a network of first-order levels it has been carried to many parts of the interior of the country, and new level lines are being added to this level net each year.

Mean sea level as determined by this bureau is derived from the hourly heights of the tide observed at a primary tide station. These hourly heights are referred to the zero of a fixed tide staff which has been connected with a primary bench mark by spirit levels. Because of the disturbing influences of wind and weather, an accurate determination of mean sea level must be based on observations extending over a considerable period of time. In general, a series of tidal observations three years in length will, when corrected by comparison with the results from a suitably located primary station, determine mean sea level within 0.02 foot; observations covering a period of a year will determine it to 0.05 foot, and a month of observations may be considered to determine it within 0.10 foot.

On inside bodies of water draining large areas which are subject to a considerable fresh-water run-off mean sea level is somewhat higher than on the open coast. In tidal rivers where the seasonal variations in run-off cause relatively large fluctuations in level it is sometimes preferable to speak of mean river level rather than mean sea level, though mean river level is determined by averaging the hourly heights of the tide in precisely the same manner as mean sea level is determined.

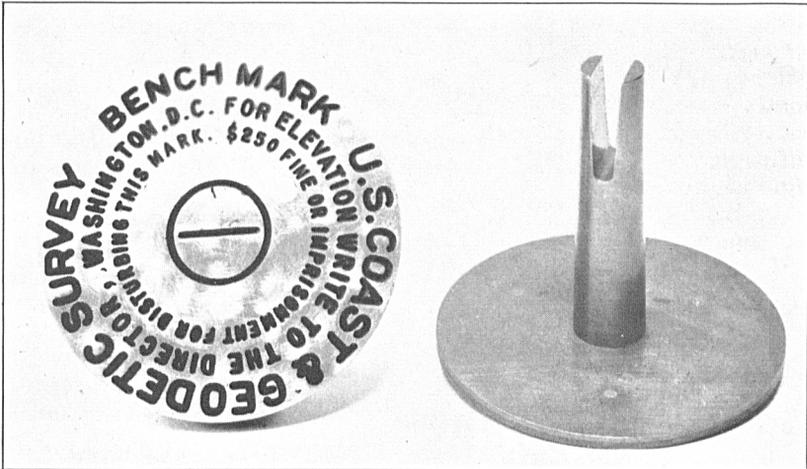


FIGURE 1.—STANDARD TIDAL BENCH MARK

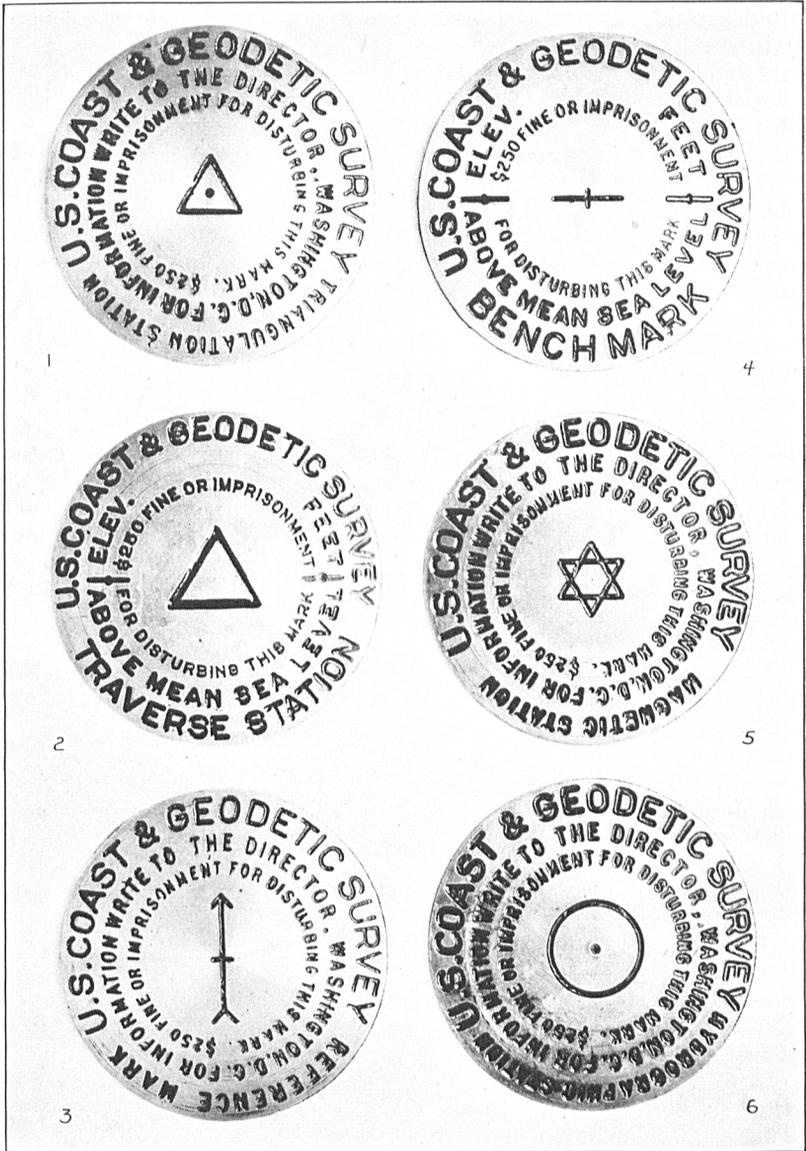


FIGURE 2.—STANDARD MARKS OF THE U. S. COAST AND GEODETIC SURVEY

- | | |
|--------------------------------|-------------------------------|
| 1. Triangulation station mark. | 4. Bench mark. |
| 2. Traverse station mark. | 5. Magnetic station mark. |
| 3. Reference mark. | 6. Hydrographic station mark. |

While mean sea level is the most nearly uniform, or fixed, datum over a wide area and is the primary datum through which different surveys may be coordinated, other datums are also useful for hydrographic work and harbor engineering. On the Pacific coast of the United States, where there is generally considerable diurnal inequality in consecutive high waters and consecutive low waters, mean lower low water has been adopted as the hydrographic datum to which all soundings on charts and the predicted heights in tide tables are referred. Therefore, the elevations of the bench marks in this publication are referred to mean lower low water as well as to either mean sea level or half tide level, as the case may be. Those bench marks which have been connected with the first-order level net are referred to mean sea level, called sea-level datum; all other bench marks are referred to half tide level. The relations of other tide planes to mean lower low water are given in the table following the descriptions and elevations of the bench marks for each station.

Half tide level is determined from the high and low water readings and lies midway between the planes of mean high water and mean low water. It should be carefully distinguished from mean sea level, which is determined from the hourly heights of the tide. For most places on the open coast half tide level does not differ much from mean sea level, and for practical purposes the two planes may be used as if identical. On inside waters, especially on the upper reaches of tidal rivers, there may be a considerable difference in the elevations of the two planes. The relation between these two planes at any place is fairly constant, and for places where the relation has been accurately determined from a year or more of observations the one may readily be derived from the other.

Higher high water is the mean height of all the higher high waters for the period of observations, while mean high water is the mean height of all the high waters, including higher high waters and lower high waters. Lower low water is the mean height of all the lower low waters for the period of observations, while mean low water is the mean height of all the low waters, including lower low waters and higher low waters.

The difference in height between mean high water and mean low water corresponds to the mean range of tide. The relation of mean high water and mean low water to mean tide level at any point is equal to one-half the mean range of tide above and below that datum. The mean range of tide varies considerably from place to place, depending in a large measure on the location, depth of water, and configuration of the coast line. Therefore mean high water and mean low water are not uniform datums over a large area, like mean sea level and mean tide level, but vary in accordance with the differences in the range of the tide over that area.

The highest and lowest tides represent the probable extreme heights for each locality and in places where long series of observations are not available have been estimated to the nearest half foot based on the highest and lowest values observed in that region, especially at the nearest primary tide station where long series of tides have been observed. The purpose of furnishing these highest and lowest elevations is to give the engineer an approximation of the extreme stages of the water that may occur in the different localities.

BASES OF ELEVATIONS

The elevations of the bench marks at the various tide stations are in most cases based on local tidal observations which have been reduced to mean values by comparison with simultaneous observations at other stations where longer series of tides have been observed. As explained on page 2, regarding the determination of mean sea level, the accuracy of the elevations of the bench marks at the different tide stations will, in general, vary in accordance with the lengths of the tidal series upon which they depend. A statement in regard to the length of the tidal series at each station precedes the descriptions of the bench marks at that station.

CHANGES IN ELEVATION

Although a bench mark may appear to be quite permanent in character and correspond with its description, the elevation may have changed materially since its determination because of settling of the immediate locality from construction work or from other causes. Engineers are therefore cautioned to make use of at least two bench marks where possible. They will confer a favor on the profession and on this bureau by reporting to the Director, United States Coast and Geodetic Survey, Washington, D. C., or to the inspector, United States Coast and Geodetic Survey, Room 202, Burke Building, Seattle, Wash., or to the inspector, United States Coast and Geodetic Survey, 510 Customhouse, San Francisco, Calif., any changes in elevation or destruction of bench marks noted, in order that information in regard to these marks may be kept up to date and this publication revised when necessary.

DESCRIPTIONS AND ELEVATIONS OF TIDAL BENCH MARKS

[The year of establishment, when known, is given in parentheses following the number of the bench mark]

BROOKINGS

The elevations of the following bench marks are based on 150 high waters and 151 low waters observed during the period August 10 to October 27, 1928, reduced to mean values by comparison with simultaneous observations at the primary tide station at San Francisco.

Bench mark 1 (1928), Brookings, is a standard disk stamped, "1/1928," near center of highest rock surrounded by water about 325 feet west of California-Oregon Lumber Co.'s dock, about 4 feet below highest part of rock and to the north of it. Elevation: 29.14 feet above mean lower low water; 25.44 feet above half tide level.

Bench mark 2 (1928), Brookings, is a standard disk, stamped "2/1928," on highest point of first prominent rock from shore about 325 feet west of California-Oregon Lumber Co.'s dock and halfway between bench mark 1 and the shore. Elevation: 23.30 feet above mean lower low water; 19.60 feet above half tide level.

Bench mark 3 (1928), Brookings, is a standard disk, stamped "3/1928," near shore end of California-Oregon Lumber Co.'s dock on prominent rock 50 feet high. The mark is about 2 feet higher than the dock and about 4 feet east of the inner end, and on the south side of the rock. Elevation: 32.17 feet above mean lower low water; 28.47 feet above half tide level.

The elevations of tide planes at Brookings referred to mean lower low water are as follows:

	Feet
Highest tide-----	9.50
Higher high water-----	6.80
Mean high water-----	6.20
Half tide level-----	3.70
Mean low water-----	1.20
Lower low water-----	0.00
Lowest tide-----	- 3.00

WEDDERBURN, BOGUE RIVER

The elevations of the following bench marks are based on six months of automatic tide-gauge records for the period December 1, 1927, to May 31, 1928, reduced to mean values by comparison with simultaneous observations at Astoria, Oreg.

Bench mark 1 (1927), Wedderburn, is a standard disk, stamped "1/1927," cemented into a drill hole in an old concrete foundation block. It is located 27.7 feet from the most northerly corner of the Macleay Estate Co. store building and about 10 feet from the easterly side of the building. Elevation: 14.10 feet above mean lower low water; 11.20 feet above half tide level.

Bench mark 2 (1927), Wedderburn, is a standard disk, stamped "2/1927," set in the top of a concrete-filled tile. The tile is 4 inches inside diameter and 3 feet long, the bottom of which was set in a mass of concrete, with top flush with ground. The mark is 123.5 feet north from the most northerly corner of the Macleay Estate Co. store building and is on the opposite or westerly side of the highway. Elevation: 26.66 feet above mean lower low water; 23.76 feet above half tide level.

Bench mark 3 (1927), Wedderburn, is a standard disk, stamped "3/1927," set in the top of a concrete-filled tile in the same manner as bench mark 2. It is about 10 feet from the intersection of the road leading to the ferry and the road leading to the Wedderburn Hotel, on the right side of the ferry road when approaching the ferry. Elevation: 26.44 feet above mean lower low water; 23.54 feet above half tide level.

Bench mark 4, Wedderburn, is a Bureau of Public Roads standard disk set in the top of a concrete post flush with the ground. It is 40.2 feet north of the westerly corner of the Macleay Estate Co. warehouse beside the highway and is 99.1 feet east of bench mark 2 on the opposite side of the road. Elevation: 16.12 feet above mean lower low water; 13.22 feet above half tide level.

Bench mark 5, Wedderburn, is a Bureau of Public Roads standard disk set in the top of a concrete post flush with the ground. It is on the opposite or westerly side of the road from bench mark 4, distant 50.1 feet. Elevation: 21.05 feet above mean lower low water; 18.15 feet above half tide level.

The elevations of tide planes at Wedderburn referred to mean lower low water are as follows:

	Feet
Highest tide.....	11. 00
Higher high water.....	5. 50
Mean high water.....	4. 90
Half tide level.....	2. 90
Mean low water.....	0. 90
Lower low water.....	0. 00
Lowest tide.....	-3. 00

PORT ORFORD

The elevations of the following bench marks are based on automatic tide-gauge records as follows: Two months, August 20 to October 16, 1924; three months, June 5 to August 29, 1925; and supported by four months, June 1 to September 30, 1928. Each of these series of observations has been reduced to mean values by comparison with simultaneous observations at San Francisco, Calif.

Bench mark 1 (1924), Port Orford, is a standard disk set in a large rock about 200 feet from the end of the wharf and about 20 feet north of the night watchman's shanty. The bench mark is about 8 feet from the offshore edge of the dock and is plainly visible from the dock. Elevation: 19.91 feet above mean lower low water; 16.01 feet above half tide level.

Bench mark 2 (1924), Port Orford, is a standard disk set in a large rock between the dock and a building belonging to the Macleay Estate Co. and occupied by the Standard Oil Co. and about 50 feet from the end of the dock. The mark is nearest the south end of the building and is clearly visible from the dock. Elevation: 18.89 feet above mean lower low water; 14.99 feet above half tide level.

Bench mark 3 (1924), Port Orford, is a standard disk set in the large rock immediately south of the Standard Oil Co. building and is within 6 feet of the building. At high tide the point can only be reached by boat. The mark is visible from the dock. Elevation: 18.08 feet above mean lower low water; 14.18 feet above half tide level.

Bench mark 56 MP (1927), Port Orford, is an iron post stamped "56 MP" in front yard of former Knapp Hotel, in center of lawn, with top incased in cement in 8-inch steel pipe 2 feet long. This mark was originally established by the United States Geological Survey, but was rebuilt October 20, 1927, by the Oregon State Highway Department at original height in 1898. Elevation: 59.38 feet above mean lower low water; 55.48 feet above half tide level.

The elevations of tide planes at Port Orford referred to mean lower low water are as follows:

	Feet
Highest tide.....	10. 00
Higher high water.....	7. 20
Mean high water.....	6. 50
Half tide level.....	3. 90
Mean low water.....	1. 30
Lower low water.....	0. 00
Lowest tide.....	-3. 00

BANDON, COQUILLE RIVER

The elevations of the following bench marks are based on three months of automatic gauge records made during the periods October 1 to October 30, 1925 and June 1 to July 28, 1928, reduced to mean values by comparison with simultaneous observations at San Francisco.

Bench mark 2 (1922), Bandon, is a standard disk set in the concrete sidewalk at the northwest corner of the First National Bank at the corner of Second Street and Alabama Avenue, Bandon, Oreg. Elevation: 13.54 feet above mean lower low water; 9.89 feet above half tide level.

Bench mark 4 (1922), Bandon, is the top of a half-inch bolt set in concrete on the west side of the Biggs and Buckingham Building. It is the bolt nearest First Street and is 3 feet from the corner of the building. The bolt may be identified by a triangular cement form in which the lower three-quarters of the bolt is embedded. Elevation: 14.05 feet above mean lower low water; 10.40 feet above half tide level.

Bench mark 5 (1922), Bandon, is a standard disk set in the concrete base of a wall which serves as the first step of a series of steps leading to the United States Coast Guard quarters at Bandon, Oreg. Elevation: 20.49 feet above mean lower low water; 16.84 feet above half tide level.

The elevations of tide planes at Bandon referred to mean lower low water are as follows:

	Feet
Highest tide -----	9.50
Higher high water -----	6.80
Mean high water -----	6.20
Half tide level -----	3.65
Mean low water -----	1.10
Lower low water -----	0.00
Lowest tide -----	-3.00

COOS BAY COAST GUARD STATION

The elevations of the following bench marks are based on 63 high waters and 59 low waters observed during the period September 18 to October 25, 1928, reduced to mean values by comparison with simultaneous observations at Newport, Oreg.

Bench mark 1 (1928), Coos Bay Coast Guard Station, is a standard disk cemented in a drill hole in the top of the concrete bulkhead at the northeast corner of the boathouse of the Coos Bay Coast Guard Station. The disk is about 2 feet from the corner of the building and situated in the center of the top face of the bulkhead. Elevation: 20.47 feet above mean lower low water; 16.87 feet above half tide level.

Bench mark 2 (1928), Coos Bay Coast Guard Station, is a standard disk cemented in a drill hole in the top of the concrete breakwater which is situated about 150 feet westerly from the boat runway of the Coos Bay Coast Guard Station. The disk is situated about 2 feet from the seaward end of the high section of the breakwater. The breakwater from this point, seaward, is about 3 feet lower. Elevation: 14.58 feet above mean lower low water; 10.98 feet above half tide level.

Bench mark 3 (1928), Coos Bay Coast Guard Station, is a standard disk cemented in a drill hole in the face of the outer and seaward end of the concrete breakwater which is situated about 150 feet westerly from the Coos Bay Coast Guard Station. The disk is in the center of the top face and about 1 foot from the end of the breakwater. A bench mark of the United States Army Engineers is 1 foot inshore from this mark. Elevation: 12.59 feet above mean lower low water; 8.99 feet above half tide level.

Bench mark 4 (1928), Coos Bay Coast Guard Station, is a standard disk cemented in a drill hole in the top of a knob of rock which rises from an extensive rock ledge that is situated immediately westerly of the boat runway of the Coos Bay Coast Guard Station. The disk is about 30 feet west of the runway and about the same distance north of the low bluff which extends from the boathouse to the low concrete breakwater. The knob of rock is the second most prominent one in this section of ledge. The knob is about 2½ feet high and about 3 feet in diameter. A patty of neat cement 10 inches in diameter surrounds the disk. Elevation: 10.40 feet above mean lower low water; 6.80 feet above half tide level.

Bench mark 12.3, Coos Bay Coast Guard Station, established by United States Army Engineers, is the top of the last ring bolt which is cemented in the top face of the breakwater and about 2 feet from the seaward end of same. The United States Engineer elevation (12.3) has been chiseled into the concrete with arrow pointing toward the reference point. This elevation is believed to have been determined from observations at Empire in 1890. The following elevations are based on the observations taken at Coos Bay Coast Guard Station in 1928. Elevation: 12.81 feet above mean lower low water; 9.21 feet above half tide level.

The elevations of tide planes at Coos Bay Coast Guard Station referred to mean lower low water are as follows:

	Feet
Highest tide.....	9.50
Higher high water.....	6.70
Mean high water.....	6.10
Half tide level.....	3.60
Mean low water.....	1.10
Lower low water.....	0.00
Lowest tide.....	-3.00

EMPIRE, COOS BAY

The elevations of the following bench marks are based on one year of tidal observations for the period June, 1922, to May, 1923, inclusive, reduced to mean values by comparison with simultaneous observations at San Francisco.

Bench mark 4 (1922), *Empire*, is a standard disk cemented in a drill hole in the concrete base of a large steel tank in the United States Engineer yard. The tank is quite prominent and is used for fuel supply for the United States Engineer dredge. The mark was placed on the base at the nearest point to the bay. A valve lies about $1\frac{1}{2}$ feet south of the mark. Elevation: 12.89 feet above mean lower low water; 9.34 feet above half tide level.

Bench mark 5 (1922), *Empire*, is the center of the top of the remaining portion of the stone that formerly held bench mark 3. Only the letters "C. S." are left on the stone and the side from which the lost portion of stone was cut away is exposed to the road. The stone is near the southeast corner of the yard formerly occupied by the Coos County courthouse and is at the edge of the curb on the north side of G Street about 15 feet southwest of United States Geological Survey iron post, just north of the walk and west of the filling station. It is 10 feet north of the north edge of roadway of G Street and 24 feet west of the west edge of Broadway. Elevation: 46.78 feet above mean lower low water; 43.23 feet above half tide level.

Bench mark 6, *Empire*, established by the United States Geological Survey, is a 3-inch pipe, capped and embedded in the ground. It projects about 9 inches above the ground. The stamped elevation on the cap is "44 feet." It lies in the old courthouse yard, 1 foot west of the northwest corner of a filling station, and is 12 feet north of G Street and 12 feet west of Broadway. The courthouse itself is in ruins. Elevation: 47.68 feet above mean lower low water; 44.13 feet above half tide level.

Bench mark 7 (1924), *Empire*, is a standard disk cemented in a drill hole in the concrete base of a large steel tank in the United States Engineer yard. The tank is quite prominent and is used for fuel supply for the Engineer dredge. The mark is at the northeast side of the tank about 32 feet in a clockwise direction around the circumference of the tank from the ladder on the side of the tank. Bench mark 4 is located in the concrete base of this same tank at a point nearest to the bay. Elevation: 12.89 feet above mean lower low water; 9.34 feet above half tide level.

Bench mark 8 (1924), *Empire*, is a standard disk set in a concrete post about 10 inches square and 3 feet deep, the top of the post projecting about 3 inches above the ground. It is in the United States Engineer yard near the entrance gate and south of the driveway and about due east of the north tangent of the fuel-oil tank. It is 2 feet north of the jog in the boundary fence line and 26 feet west of the eastern boundary fence line of the Engineer yard. Elevation: 14.16 feet above mean lower low water; 10.61 feet above half tide level.

Bench mark 9 (1924), *Empire*, is a standard disk set in a concrete post about 10 inches square and 3 feet deep, the top of the post projecting about 3 inches above the ground. It is situated in the northeast corner of the United States Engineer yard, about 8 feet south of the northern boundary fence line and 37 feet west of the eastern boundary fence line. Elevation: 12.87 feet above mean lower low water; 9.32 feet above half tide level.

Bench mark 10 (1924), *Empire*, is a standard disk set in a concrete post about 10 inches square and 3 feet deep, the top of the post projecting about 3 inches above the ground. It is situated at the southeast corner of the intersection of the lane known as G Street and the lane which runs south of and parallel to Broadway and is about 75 feet east of the northeast corner of the United States Engineer yard. It is just outside the private property line which is inclosed by a wooden fence. Bench marks 9 and 10 are in range with the

flagpole of the United States Engineer yard. Elevation: 23.48 feet above mean lower low water; 19.93 feet above half tide level.

The elevations of tide planes at Empire referred to mean lower low water are as follows:

	Feet
Highest tide-----	9.50
Higher high water-----	6.70
Mean high water-----	6.00
Half tide level-----	3.55
Mean low water-----	1.10
Lower low water-----	0.00
Lowest tide-----	-3.00

MARSHFIELD, COOS BAY

The elevations of the following bench marks are based on 14 high waters and 15 low waters observed during the period July 5 to July 12, 1922, reduced to mean values by comparisons with simultaneous observations at Presidio, Calif., and Empire, Oreg.

Bench mark 2, *Marshfield*, is a United States Geological Survey bronze tablet stamped "11," set vertically in the wall at the northeast corner of the El Dorado Building, which is situated at the southwest corner of Front and Commercial Streets. It is about 1 foot above the cement sidewalk and 1½ feet from corner of building on the Commercial Street side. Elevation: 14.82 feet above mean lower low water; 11.12 feet above half tide level.¹

Bench mark 4 (1922), *Marshfield*, is a standard disk set in the concrete base of the building on the southwest corner of Curtis Avenue and Broadway. The mark was placed on the north side of the building near the northeast corner. Elevation: 13.16 feet above mean lower low water; 9.46 feet above half tide level.

Bench mark 5 (1922), *Marshfield*, is a standard disk set in the concrete base of the first National Bank Building. This building is on the northwest corner of Broadway and Central Avenue. The mark was placed on the east side near the southeast corner of the building. Elevation: 13.22 feet above mean lower low water; 9.52 feet above half tide level.

The elevations of tide planes at Marshfield referred to mean lower low water are as follows:

	Feet
Highest tide-----	9.50
Higher high water-----	6.90
Mean high water-----	6.30
Half tide level-----	3.70
Mean low water-----	1.10
Lower low water-----	0.00
Lowest tide-----	-3.00

UMPQUA RIVER JETTY

The elevations of the following bench marks are based on 15 high waters and 15 low waters observed during the period September 7 to September 15, 1928, reduced to mean values by comparison with simultaneous observations at Newport, Oreg.

Bench mark 3a (1928), *Umpqua River Jetty*, is the top of the pipe in the cement block marking the Engineers, 1916, north base. There is a wooden tripod over end. Since 1920, north base appears to have been undermined by shifting sands and was reestablished at a different elevation. Therefore bench mark 3a supersedes old bench mark 3 which was lost. Elevation: 16.53 feet above mean lower low water; 12.93 feet above half tide level.

Bench mark 5 (1928), *Umpqua River Jetty*, is a large square spike in the northeast leg of the Coast Guard lookout tower. The mark is situated about 3 feet above the ground and is marked by a diamond-shaped figure made of 40-penny nails driven into the wood. The spike passes horizontally through the diamond-shaped figure. The point of reference is on the top of spike at the center of the diamond. The diamond-shaped figure is about 2 inches on each side. Elevation: 19.97 feet above mean lower low water; 16.37 feet above half tide level.

¹ These elevations supersede those previously published for this bench mark, the change resulting from changed tidal conditions in Coos Bay.

Bench mark 6 (1928), *Umpqua River Jetty*, is the center nail in a group of four nails that is surrounded by a triangle over figure formed by driving nails into the top of a square piece of timber 8 by 8 inches. The triangle is about 2 inches on each side. The timber projects from the sand about 1 foot and is situated about on a line between the seventh trestle bent from the loading platform and the Coast Guard lookout tower. Elevation: 20.24 feet above mean lower low water; 16.64 feet above half tide level.

Bench mark 7 (1928), *Umpqua River Jetty*, is a standard disk cemented into the top of a 1-inch pipe about 5 feet northeast of the northeast leg of the old water tank. The pipe projects about 6 inches above the ground. The Coast Guard lookout tower is just visible past the southern side of the southwest leg of the old water tank. Elevation: 14.38 feet above mean lower low water; 10.78 feet above half tide level.

The elevations of tide planes at Umpqua River Jetty referred to mean lower low water are as follows:

	Feet
Highest tide.....	9.50
Higher high water.....	6.80
Mean high water.....	6.10
Half tide level.....	3.60
Mean low water.....	1.10
Lower low water.....	0.00
Lowest tide.....	-3.00

GARDINER, UMPQUA RIVER

The elevations of the following bench marks are based on three high waters and three low waters observed during the period August 6 to August 7, 1920, reduced to mean values by comparison with simultaneous observations at Umpqua River Jetty.

Bench mark 5 (1920), *Gardiner*, is a standard hydrographic station mark set in a 10-inch concrete block projecting about 1 inch above the ground. The bench mark is located about 30 feet north of the northeast end of Gardiner Mill Store and just off the edge of walk leading to Gardiner Mill Store Dock. Elevation: 11.63 feet above mean lower low water; 8.08 feet above half tide level.

Bench mark 6 (1920), *Gardiner*, is a brass plate set in sidewalk and marking south end of property line of the First National Bank of Gardiner. The bank is on east side of Main Street across from Gardiner Mill Store. Elevation: 12.79 feet above mean lower low water; 9.24 feet above half tide level.

Bench mark 7 (1920), *Gardiner*, is a nail driven in center of a triangle formed by nails driven in a pile. This pile, the fourth from the shore end, helps support a walk on southern side of Mill Store Building which leads to Mill Store Dock. Elevation: 9.43 feet above mean lower low water; 5.88 feet above half tide level.

The elevations of tide planes at Gardiner referred to mean lower low water are as follows:

	Feet
Highest tide.....	9.30
Higher high water.....	6.80
Mean high water.....	6.10
Half tide level.....	3.55
Mean low water.....	1.00
Lower low water.....	0.00
Lowest tide.....	-2.50

NEWPORT, YAQUINA BAY

The elevations of the following bench marks are based on the mean lower low water of the United States Army Engineers supported by five months of automatic gauge records made during the period May 1 to September 30, 1928, reduced to mean values by comparison with simultaneous observations at San Francisco.

Bench mark 2 (1914), *Newport*, is a standard disk set in a cylindrical concrete pier 9 inches in diameter at top and 3.5 feet deep, set flush with the surface of the ground. It is located on Bay Street near the corner of Front Street. In 1927 bench mark 2 was found to be 0.45 foot higher than when established. Cause of change unknown. Elevation: 19.70 feet above mean lower low water; 15.45 feet above half tide level.

Bench mark 3 (1914), *Newport*, is a standard disk set in a cylindrical concrete pier, 9 inches in diameter and 3.5 feet deep, set flush with the surface of the ground. It is on Case Street near the intersection with Front Street. Elevation: 18.95 feet above mean lower low water; 14.70 feet above half tide level.

Bench mark 4 (1928), *Newport*, is a standard disk set in the vertical face of the concrete bulkhead which forms the southern side of Front Street. It is 6 inches below top of wall and 3 feet east of runway leading to Coast Guard boathouse. Elevation: 12.88 feet above mean lower low water; 8.63 feet above half tide level.

The elevations of tide planes at Newport referred to mean lower low water are as follows:

	Feet
Highest tide-----	11.00
Higher high water-----	7.60
Mean high water-----	7.25
Half tide level-----	4.25
Mean low water-----	1.25
Lower low water-----	0.00
Lowest tide-----	-3.00

TOLEDO, YAQUINA RIVER

The elevations of the following bench marks are based on the lower low-water datum of the United States Army Engineers at Toledo and the mean tide level at Newport transferred to Toledo by spirit levels.

Bench mark 1 (1914), *Toledo*, is a standard disk set in a pier of concrete 8 inches square and 3 feet long located at the southwest corner of the dock house on the city dock and set flush with the ground surface. Elevation: 11.63 feet above mean lower low water; 7.68 feet above half tide level.

Bench mark 2 (1914), *Toledo*, is a standard disk set in a pier of concrete 8 inches square and 3 feet long with the top flush with the surface of the ground near the southeast corner of the dock house on the city dock. Elevation: 11.74 feet above mean lower low water; 7.79 feet above half tide level.

Bench mark A 3, *Toledo*, established by United States Army Engineers, is the surface of the concrete floor just inside the western doorway of the Toledo Creamery. Elevation: 13.64 feet above mean lower low water; 9.69 feet above half tide level.

Bench mark A 4, *Toledo*, established by United States Army Engineers, is a large wire spike driven in the eastern end of the south abutment of the Southern Pacific Railroad trestle across Depot Slough. Elevation 15.51 feet above mean lower low water; 11.56 feet above half tide level.

The elevations of tide planes at Toledo referred to mean lower low water are as follows:

	Feet
Highest tide-----	11.00
Higher high water-----	7.60
Mean high water-----	7.00
Half tide level-----	3.95
Mean low water-----	0.90
Lower low water-----	0.00
Lowest tide-----	-2.50

YAQUINA HEAD

The elevations of the following bench marks are based on four high waters and four low waters observed July 24 to July 26, 1928, reduced to mean values by comparison with simultaneous observations at Newport, Oreg.

Bench mark 1 (1928), *Yaquina Head*, is a standard disk set in drill hole in cement on top of boulder which rises 4 feet above gravel, 6 feet north of west end of sea wall, in the small cove on the south side of Yaquina Head about one-fourth mile southeast of the lighthouse. A small concrete sea wall has been constructed here and a wooden trestle erected for hoisting boats. A small cabin lies on top of bluff directly back of mark. Elevation: 19.46 feet above mean lower low water; 15.21 feet above half tide level.

Bench mark 2 (1928), *Yaquina Head*, is a standard disk set in cement in drill hole on top of southeast corner of sea wall. Elevation: 15.70 feet above mean lower low water; 11.45 feet above half tide level.

Bench mark 3 (1928), *Yaquina Head*, is a standard disk set in cement in a drill hole on top of large outlying rock with comparatively flat top, about 98

feet southeast of bench mark 2. Elevation: 12.20 feet above mean lower low water; 7.95 feet above half tide level.

The elevations of tide planes at Yaquina Head referred to mean lower low water are as follows:

Highest tide.....	11.00
Higher high water.....	8.10
Mean high water.....	7.40
Half tide level.....	4.25
Mean low water.....	1.10
Lower low water.....	0.00
Lowest tide.....	-3.00

GARIBALDI, TILLAMOOK BAY

The elevations of the following bench marks are based on eight months' observations made during the period September 1, 1926, to September 30, 1927, reduced to mean values by comparison with simultaneous observations at the primary tide stations at Seattle and San Francisco.

Bench mark 1 (1926), *Garibaldi*. is a standard disk set in a piece of 3½-inch pipe 3 feet long filled with concrete. It is located about 2 feet south of the south side of the shipping clerk's office of the Hammond Tillamook Lumber Co., which is about 150 yards north of the dock. Elevation: 14.24 feet above mean lower low water; 10.29 feet above half tide level.

Bench mark 2 (1926), *Garibaldi*. is a standard disk set in a 4-inch sheet-iron pipe, about 3½ feet long, about 20 feet west of the railroad spur and 2 or 3 paces south of fire hydrant No. 17, on the grounds of the Hammond Tillamook Lumber Co. Elevation: 14.42 feet above mean lower low water; 10.47 feet above half tide level.

Bench mark 3 (1926), *Garibaldi*. is a standard disk set in a piece of 6-inch sewer tile. It is at the north face of a dry kiln which is across the tracks from the building in which sashes are made. A ball field is just north of the kiln, and at the time of placing the bench mark a set of transformers were to be set up between the dry kiln and the railroad spur. Bench mark is about 70 feet east of the tracks. Elevation: 11.55 feet above mean lower low water; 7.60 feet above half tide level.

Bench mark 4 (1927), *Garibaldi*. is a standard disk set in a 2-foot length of stovepipe filled with concrete and almost level with the ground, at the west end of the board fence just south of the main railroad tracks. It is just beside an electric-light pole and 5 yards south of the first industrial tracks south of the main line. Elevation: 12.92 feet above mean lower low water; 8.97 feet above half tide level.

Bench mark 5 (1927), *Garibaldi*, is a standard disk set in a 2-foot length of stovepipe filled with concrete and almost level with the ground. It is just south of the west bulkhead of the railroad trestle, 10 yards north of the industrial tracks just south of the main line, and about 10 yards west of the road which goes under the trestle. Elevation: 11.94 feet above mean lower low water; 7.99 feet above half tide level.

Bench mark 6 (1927), *Garibaldi*, is a standard disk set in concrete, with a section of stovepipe used for a form. It is north of the highway and just across the street from the office of the Hammond Tillamook Lumber Co. (formerly the Whitney Co.) at the southwest corner of the A. S. Bent Co. store. Elevation: 13.62 feet above mean lower low water; 9.67 feet above half tide level.

The elevations of tide planes at Garibaldi referred to mean lower low water are as follows:

Highest tide.....	11.00
Higher high water.....	7.40
Mean high water.....	6.70
Half tide level.....	3.95
Mean low water.....	1.20
Lower low water.....	0.00
Lowest tide.....	-3.00

FORT STEVENS, COLUMBIA RIVER

The elevations of the following bench marks are based on two years of automatic gauge records for the years 1905 and 1906, loaned to this bureau by the United States Army Engineers, from which our own tabulations and reductions were made. These observations were reduced to mean values by comparison with simultaneous observations at the primary tide station at San Francisco, Calif.

The mean sea level derived from this series was adopted as the datum for the control of the first-order level net in this locality. (See First-order leveling in Oregon, Special Publication No. 122, p. 11.)

Bench marks A 3 and A 31 were connected with the first-order level net by this bureau in 1920. The other bench marks in this list were connected by levels with bench marks A 3 and A 31 by J. A. Sutherland for the Pacific Power & Light Co. in February, 1929, and their elevations have been adjusted to agree with elevations given in Special Publication No. 122.

Bench mark A 3, Fort Stevens, established by the United States Army Engineers, is a brass plug set in a tile filled with concrete about 12 feet from the southwest leg and 20 feet from the southeast leg of the meteorological tower and 8 feet from the edge of the concrete floor. Elevation: 23.74 feet above mean lower low water; 19.23 feet above sea-level datum.

Bench mark A 31 (1920), Hammond, is a standard disk set in a concrete post on the Spokane, Portland & Seattle Railway, 300 feet east of the depot, 12 feet south of the track, at the most northern point at which the right of way is close to the river's edge. Elevation: 15.64 feet above mean lower low water; 11.13 feet above sea-level datum.

Bench mark 9.33, Fort Stevens, is a United States Geological Survey copper nail, at east entrance to military reservation in base of west face of south concrete portal opposite the word "Fort." Elevation: 13.84 feet above mean lower low water; 9.33 feet above sea-level datum.

Bench mark 18, Fort Stevens, is a United States Geological Survey brass tablet stamped "18-1929" set in the northwest corner of the concrete base of the flagpole. Elevation: 22.51 feet above mean lower low water; 18.00 feet above sea-level datum.

Bench mark 17.48, Fort Stevens, is a chiseled square on the south end of the bottom step of the east entrance at the south end of the guardhouse. Elevation: 21.99 feet above mean lower low water; 17.48 feet above sea-level datum.

Bench mark 12.07, Fort Stevens, is a copper bolt in concrete post in Battery Clark at rear of Pit B, 74 feet from the edge of the concrete battery floor and directly opposite letter B in "Pit B." Elevation: 16.58 feet above mean lower low water; 12.07 feet above sea-level datum.

Bench mark 13.59, Fort Stevens, is a stone post lettered "U. S.," 12 feet from the middle of the west end of the old wooden power house. This bench mark is the same as R 31 (U. S. E.) in Special Publication No. 122, page 63, but the elevation has been increased 0.015 foot by the installation of a United States Geological Survey copper nail and washer in top. Elevation: 18.10 feet above mean lower low water; 13.59 feet above sea-level datum.

Bench mark 9.34, Fort Stevens, is a United States Geological Survey copper nail in the southwest corner of square concrete power and telephone conduit manhole 33, 80 feet northwest of the northwest corner of United States Engineer office building, 10 feet north of graveled roadway. Elevation: 13.85 feet above mean lower low water; 9.34 feet above sea-level datum.

Bench mark A 2, Fort Stevens, is a United States Army Engineer chiseled cross in the top of concrete footing in the northeast corner of searchlight 3. Elevation: 12.65 feet above mean lower low water; 8.14 feet above sea-level datum.

Bench mark A 1, Fort Stevens, is a United States Army Engineer chiseled cross in the top of the concrete footing at the southwest corner of searchlight 4. Elevation: 12.69 feet above mean lower low water; 8.18 feet above sea-level datum.

The elevations of tide planes at Fort Stevens referred to mean lower low water are as follows:

	Feet
Highest tide.....	11.50
Higher high water.....	8.50
Mean high water.....	7.80
Half tide level.....	4.55
Sea-level datum.....	4.51
Mean low water.....	1.30
Lower low water.....	0.00
Lowest tide.....	-2.50

ASTORIA

The elevations of the following bench marks are referred to Astoria lower low-water datum based on one year of observations from August 20, 1875, to

August 22, 1876, and to the sea-level datum of the first-order level net by spirit-leveling connections. The range and inequalities through which the other tide planes given in the table following the descriptions of these bench marks are referred to the Astoria lower low-water datum and based upon three years' observations for the period November, 1873, to October, 1876, inclusive.

Bench mark F 31 (1920), *Astoria*, is a standard disk cemented in a hole on the east end of the first step, at the front (Commercial Street) entrance to Clatsop County courthouse. Elevation: 22.97 feet above Astoria lower low-water datum; 18.77 feet above sea-level datum.

Bench mark A 32 (U. S. E. A-1), *Astoria*, is a cross chiseled in the sandstone, with the letters "B. M. U. S. E." alongside it. It is on the southeast corner of the customhouse and post office, in the water table of the building. Elevation: 21.97 feet above Astoria lower low-water datum; 17.77 feet above sea-level datum.

Bench mark U 31 (1920), *Astoria*, is the bench mark of origin for the city, at the southeast corner of the customhouse and post office, consisting of the highest nub of rough cut stone forming the base of the iron railing. Elevation: 20.75 feet above Astoria lower low-water datum; 16.55 feet above sea-level datum.

Bench mark E 31 (1920), *Astoria*, is a standard disk set in the top of a concrete post, in front of the port of Astoria office building, in the west side of the terrace, 1 foot inside the curbing. Elevation: 16.54 feet above Astoria lower low-water datum; 12.34 feet above sea-level datum.

The elevations of tide planes at Astoria referred to Astoria lower low-water datum are as follows:

	Feet
Highest tide	11.50
Higher high water	8.26
Mean high water	7.56
Half tide level	4.36
Sea-level datum	4.20
Mean low water	1.16
Astoria lower low-water datum	0.00
Lowest tide	-2.50

ASTORIA (TONGUE POINT)

The elevations of the following bench marks are referred to mean lower low water based on one year of observations during the period February 1, 1925, to January 31, 1926, reduced to mean values by comparison with simultaneous observations at Seattle and San Francisco and to the sea-level datum of the first-order level net by spirit-leveling connections made by the Pacific Power & Light Co. in 1929.

Bench mark 1 (1925), *Astoria (Tongue Point)*, is a standard disk cemented in a drill hole in the north wall of the oil house of the United States lighthouse depot, about 2 feet above the ground and 1 foot from the northeast corner of the house. Elevation: 19.46 feet above mean lower low water; 15.44 feet above sea-level datum.

Bench mark 2 (1925), *Astoria (Tongue Point)*, is a standard disk cemented in a drill hole in the sea wall about 1 foot south of the north end and 2 feet above the bottom of the wall. Elevation: 11.60 feet above mean lower low water; 7.58 feet above sea-level datum.

Bench mark 3 (1925), *Astoria (Tongue Point)*, is a standard disk cemented in a drill hole in the stone wall of the upper fill, between the oil house and machine shop, at about the center of the wall and 1 foot above the ground. Elevation: 13.38 feet above mean lower low water; 14.36 feet above sea-level datum.

Bench mark 4 (1925), *Astoria (Tongue Point)*, is a standard disk cemented in a drill hole in the sea wall at a point about even with the north side of the office building. Elevation: 11.61 feet above mean lower low water; 7.59 feet above sea-level datum.

Bench mark 5 (1925), *Astoria (Tongue Point)*, is a standard disk cemented in a drill hole in the south side of the brick corner post of the pump house, about one-half foot above the ground and about 1 foot from the southeast corner. Elevation: 16.15 feet above mean lower low water; 12.13 feet above sea-level datum.

Bench mark 97 (1929), *Astoria (Tongue Point)*, is a Pacific Power & Light Co. bronze tablet, stamped "97/1929," set in a 4-inch vitrified tile on Tongue

Point Naval Base Road, 260 feet northeast of Columbia River Highway concrete pavement, 19 feet east of center line of Naval Base Road near beginning of first curve. Elevation: 101.02 feet above mean lower low water; 97.00 feet above sea-level datum.

The elevations of tide planes at Astoria (Tongue Point) referred to mean lower low water are as follows:

	Feet
Highest tide -----	11. 50
Higher high water -----	8. 00
Mean high water -----	7. 40
Half tide level -----	4. 25
Sea-level datum -----	4. 02
Mean low water -----	1. 10
Lower low water -----	0. 00
Lowest tide -----	-2. 50

MULTNOMAH CHANNEL, PORTLAND

The elevations of the following bench marks are referred to the Columbia River datum, which is mean lower low water during the lowest river stages and which is based upon a general adjustment of the tidal data by the United States Army Engineers. They are also referred to the mean sea-level datum of the first-order level net through bench mark Y 14.

Bench mark 1 (1928), *Multnomah Channel*, is a standard disk set in a cylindrical mass of concrete $2\frac{1}{2}$ feet deep and about 10 inches in diameter. Top of mark is flush with surface of ground, on the west bank of the Multnomah Channel about one-third mile below the upper junction of the Multnomah Channel and the Willamette River. A small stream empties into the Multnomah Channel about 30 feet below the bench mark. Elevation: 13.60 feet above Columbia River datum; 14.52 feet above sea-level datum.

Bench mark 2 (1928), *Multnomah Channel*, is a standard disk set in a cylindrical mass of concrete on the west side of Multnomah Channel about 375 feet inshore from bench mark 1. There is a wide-branching lone tree about 15 feet northeast of bench mark 2. Elevation: 14.68 feet above Columbia River datum; 15.60 feet above sea-level datum.

Bench mark 3 (1928), *Multnomah Channel*, is a standard disk set in a cylindrical mass of concrete about 160 feet inshore from bench mark 2 and nearly on range with bench marks 1 and 2. It is about 40 feet west of the Spokane, Portland & Seattle Railroad at mileage about 8.9. Elevation: 22.65 feet above Columbia River datum; 23.57 feet above sea-level datum.

Bench mark Y 14 (1920), *Multnomah Channel*, is a standard disk set in a concrete post about $1\frac{1}{2}$ miles north of Linnton on the Spokane, Portland & Seattle Railway at mileage 8.7, 15 feet west of track. Elevation: 32.94 feet above Columbia River datum; 33.86 feet above sea-level datum.

The elevations of tide planes in Multnomah Channel referred to Columbia River datum are as follows:

	Feet
Highest river stage (June 7, 1894) -----	33. 20
Columbia River datum -----	0. 00
Sea-level datum -----	-0. 92
Lowest river stage -----	-1. 00

**PUBLICATIONS BY THE UNITED STATES COAST AND GEODETIC
SURVEY RELATING TO BENCH MARKS AND DATUM PLANES**

TIDAL BENCH MARKS

	Price
Special Publication No. 83 (Serial 193), Tidal Bench Marks, State of New York, 1922 -----	\$0.20
Special Publication No. 119 (Serial 320), Tidal Bench Marks, District of Columbia, 1925 -----	.05
Special Publication No. 128 (Serial 370), Tidal Bench Marks, State of Rhode Island, 1927 -----	.10
Special Publication No. 136, Tidal Bench Marks, State of Connecticut, 1927 -----	.10
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Special Publication No. 155, Tidal Bench Marks, State of Massachusetts, 1929 -----	.10

FIRST-ORDER LEVELING

Precise leveling in United States, 1900-1903, with readjustment of level net and resulting elevations; by J. F. Hayford. Report for 1903. Appendix 3, pp. 189-810, 2 illus. -----	.40
Same, reprint with changes of pp. 580-809, descriptions of bench marks. -----	.25
Precise leveling in United States, 1903-1907, with readjustment of level net and resulting elevations; by J. F. Hayford and L. Pike. 280 pp. 1 illus. -----	.45
Fourth general adjustment of precise level net in the United States and resulting standard elevations; by William Bowie and H. G. Avers. Special Publication No. 18. 328 pp., 5 illus. 1914 -----	.75
Precise leveling in Texas; by H. G. Avers. Special Publication No. 77; Serial 177. 185 pp., 19 illus. 1922 -----	.15
Precise leveling in Georgia; by H. G. Avers. Special Publication No. 95; Serial 240. 109 pp., 8 illus. -----	.15
First-order leveling in Oregon; by H. G. Avers. Special Publication No. 122; Serial 334. 80 pp., 9 illus. -----	.15
Precise triangulation, traverse, and leveling in North Carolina; by Walter D. Sutcliffe and Henry G. Avers. Special Publication No. 101; Serial 260. 184 pp., 17 illus. 1924 -----	.25

DATUM PLANES

Special Publication No. 41 (Serial 60), Use of Mean Sea Level as the Datum for Elevation, 1917 -----	.05
Special Publication No. 135, Tidal Datum Planes, 1927 -----	.30
Special Publication No. 139, Instructions for Tide Observations, 1928 -----	.20
Special Publication No. 154, Instructions, Primary Tide Stations 1929 -----	.10

All of the above publications are for sale by the Superintendent of Documents, Government Printing Office, Washington, D. C., to whom remittance should be sent.

NOTICE

The Coast and Geodetic Survey maintains field stations at Room 202, Burke Building, Seattle, Wash., and at Room 510, customhouse, San Francisco, Calif., in charge of experienced field officers of the bureau. At these stations complete files of United States Coast and Geodetic Survey charts, Coast Pilots, Tide Tables, Current Tables, and other publications relating to navigation may be consulted and information affecting navigation obtained without charge. The above publications are also on sale at these stations. The officers in charge will cooperate to the fullest extent possible in supplying information or rendering assistance to those to whom this bureau can be of service and in return will appreciate being informed of any changes affecting navigation or the description and elevation of any of our bench marks.

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