SEAPLANE FACILITIES

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Seaplane Facilities

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Table of Contents

Appendix

List of Illustrations

Tables

Introduction

In the rapidly expanding field of aviation, consideration should be given to the utilization of the many lakes, rivers, and harbors which offer natural landing facilities for seaplane operations. Seaplane landing facilities will not supplant the need for airports to serve scheduled air carrier operations and other flying activities. In some cases, however, they can supplement major airport facilities by utilizing close-in or downtown landing facilities in congested areas usually not possible with airports. In some cases, non-scheduled or scheduled intrastate seaplane passenger-service routes are desirable where surface transportation by land or water is tedious and time consuming.

Seaplane facilities may range in development from a simple mooring buoy and boat, small beaching ramp. pier or floating dock, to the more highly developed bases consisting of on-shore buildings for offices, hangars, recreation, repair shops, and shore-line docks and ramps. Figures 1 and 2 indicate examples of seaplane facilities at a town or city and a recreation area.

The planning problem concerning seaplane landing facilities poses such questions as: Does your community need a seaplane base? If so, where should it be located? What on-shore or off-shore improvements should he provided for now and in the future?

It is the purpose of this publication to answer questions such as these and to assist local communities or persons interested in solving aviation problems concerning seaplane facilities.

Seaplane Facilities

Estimating Seaplane Facility Needs

A community may have aeronautical need for one or more seaplane facilities due to either *aeronautical demand* or *other aircraft-use factors,* or both.

Aeronautical demand can be objectively measured in terms of how many seaplanes a community has now and how many it will have in the future.

Aircraft use factors are those parts of aeronautical need which may be defined as: (1) geographical isolation; (2) lack of suitable sites for airports; (3) fixed-base operations to serve special activities; and, (4) natural routes of flight where emergency or repair facilities may be required on lengthy flights.

Aeronautical Demand

Available seaplane statistics are limited to ownership in States and counties as of March 1, 1949. A study of these statistics shows that there are two major factors controlling seaplane ownership: (1) large masses of urban population; (2) availability of water. The above factors are substantiated by the classification of each State into one of four categories on the basis of its 1940 urban population and the number of square miles of inland water. The following summary table fixes the selected criteria as significant. Details by States are presented in table 5.

Summary.—**Number of Seaplanes for Urban Population and Square Miles of Inland Water Area**

Number of States	Number of seaplanes	1940 urban population		1940 square miles inland water area	
		1,000,000 or more	Less than 1,000,000	1,000 or more	Less than 1,000
7	841	X		X	
12	616	X			X
5	302		X	X	
25	289		X		X
[1] 49	2,048				

[1] Includes District of Columbia.

Figure 1. An Ideal Location for a Seaplane Facility Near a Community

For counties, the study also shows that urban population plus large bodies of water are requirements for a county's having a significant number of seaplanes. When these counties are associated with and grouped by the population size of their largest community, the effect is even more pronounced.

Therefore, when urban population mass plus suitable available water are associated closely, there will be a demand for seaplanes in a community.

Aircraft Use Factors

The determination of aircraft use factors affecting the need for seaplane bases requires a different approach from that of estimating the seaplane potential for a given community. There are many instances where a seaplane landing facility will be practical and profitable for reasons other than large seaplane ownership. To determine these exceptions, one must consider a large geographical area. These larger areas, when studied closely, will reveal many characteristics suggesting the establishment of seaplane facilities. For instance, seaplane bases will frequently be necessary on opposite shore-lines of large bodies of water in cases where there is a need for the interchange of ground or air transportation and for refueling purposes. Lakes in mountain or forest areas may be attractions for those who are interested in the out-of-doors, thereby offering opportunities for the development of seaplane facilities. Terrain which contains flight barriers not conducive to single-engine land-plane use may suggest natural flight paths over routes more adapted to seaplane flying. Between points of origin and destination, overnight accommodations, refueling or emergency facilities should be considered at proper intervals. Such factors as the above cannot be measured in exact terms of potential use. However, by making a proper analysis and evaluation of the over-all area considerations as they concern natural land character, natural routes of travel and desirable places to go for recreation or business, seaplane base requirements can be determined.

Extent of Area To Consider

The first step in estimating needs will be that of determining the extent of the area requiring study. When the area is metropolitan and complex in character or includes two or more individual small or medium-sized communities sufficiently close to be considered as a single entity, a study of total aircraft potentials-airport and seaplane base requirements for the entire area-should be undertaken. If a complex situation does not exist, only seaplane landing-facility requirements need be undertaken for each individual community.

Considerations of larger areas should include a study of topographic, rural, mountain, forest or resort-type area conditions, as previously mentioned. Studies of this type should be conducted on a State-wide or regional

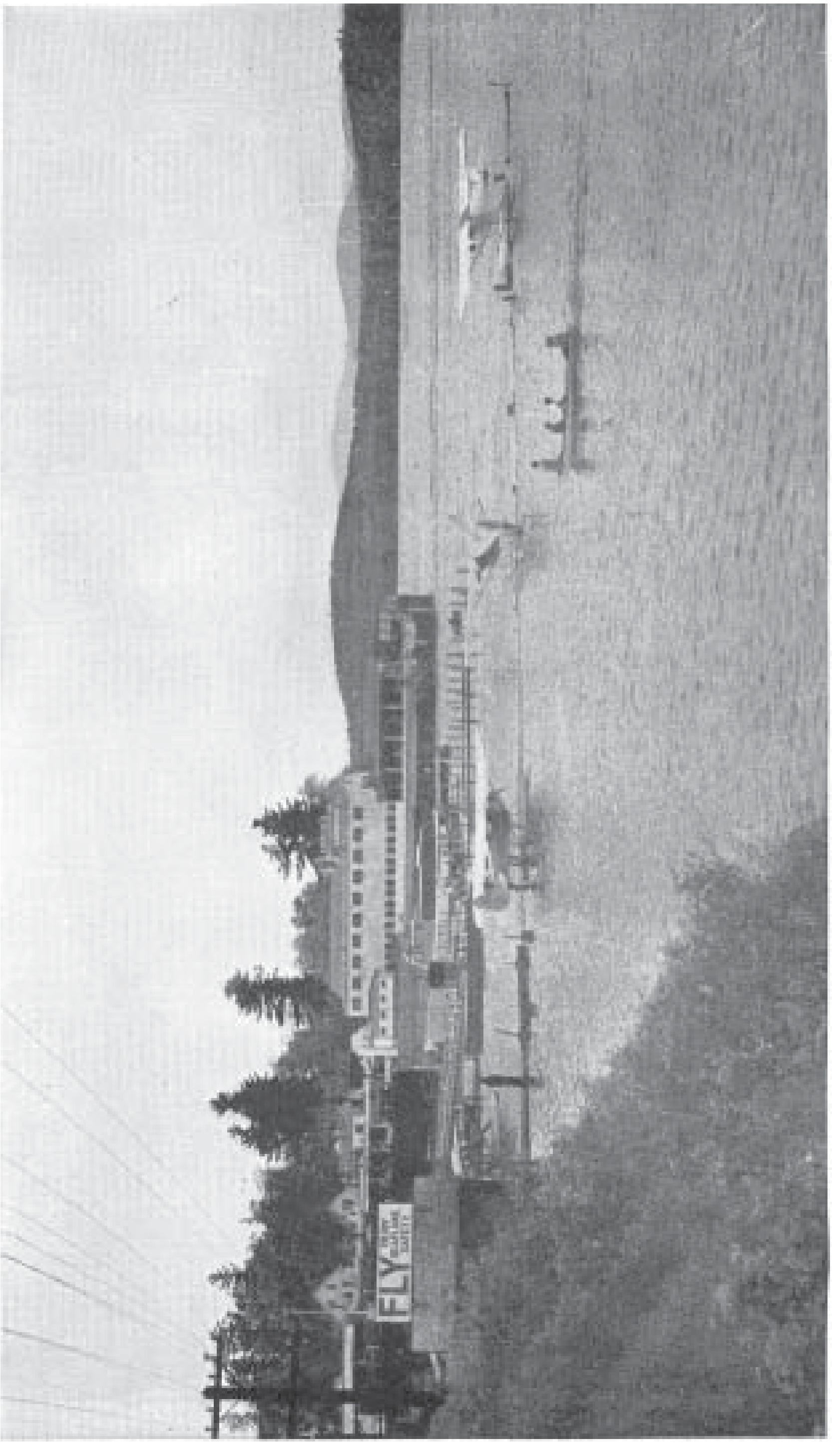


Figure 2. Popular Seaplane Facility at a Resort Area

basis in order to determine the emergency or recreation aspects of seaplane flying.

Forecasting Seaplane Use

When larger areas, such as regions, are being considered in formulating seaplane facility requirements, the problem is one of studying those considerations mentioned previously under “Aircraft Use Factors.” Use a base map of the states or regions indicating all lakes, rivers, harbors, mountains, forests, resort, and recreation areas. Spot all existing seaplane bases, towns and cities having a significant number of existing and potential seaplanes. Note all significant recreation areas offering such attractions as fishing, hunting and camping where bodies of water are available. Land areas, separated by large bodies of water, islands and communities on shore-lines difficult to reach by surface transportation over water or land will be obvious. Route studies between these points and between communities having the largest concentration of seaplane population, should be roughly outlined before a final pattern is established. When logical routes have been finally established to and from points of origin, the planner can determine where overnight service and emergency accommodations will be necessary. The need will be further strengthened in those cases where there are existing or potential seaplanes. It should be remembered that in cases where rivers, chains of lakes, or long-projected shore-lines occur, natural routes of flight are suggested. When considering intermediate stops along these routes, no point should be greater than 400 miles or less than 100 miles from the next nearest point for safety and economy of operations. This, of course, does not apply to areas of mass population where multiple seaplane facilities are required to satisfy the local requirements.

An example of area planning is shown in figure 3.

Community Seaplane Potential

National estimate: The present utility of seaplanes is limited not only by the necessary association with bodies of suitable water and related facilities, but also by economic considerations. Compared to land planes, seaplanes constitute a comparatively small proportion of the total aircraft in the country. During 1948, only 2,048 of the 94,821 aircraft in the United States were registered as seaplanes. However, the seaplane potential is many times greater. For example, of the 18,743 Piper aircraft in the country, 17,638 are licensed for conversion into seaplanes. Development in seaplane facili-ties could, therefore, easily bring about wider use of seaplanes. While it is exceedingly difficult to measure such intangibles, a national estimate is both desirable and necessary. The range for such a figure is quite wide; nevertheless, it is believed that an estimate of between 5,000 and 8,000 seaplanes by the end of 1955 is a reasonable one for the purposes of planning.

Community Projection Factors

The estimated 5,000 to 8,000 seaplanes in the United States by 1955 yield projection factors between 2-1/2 to 4 times the approximate 2,000 sea-planes now registered. This means that the estimators will have to decide on the basis of all relevant factors and data whether to use the lower or the higher projection factor or one between the two for each particular community. Among the data to be examined are the population size and density of the community, the accessibility of this population to water and

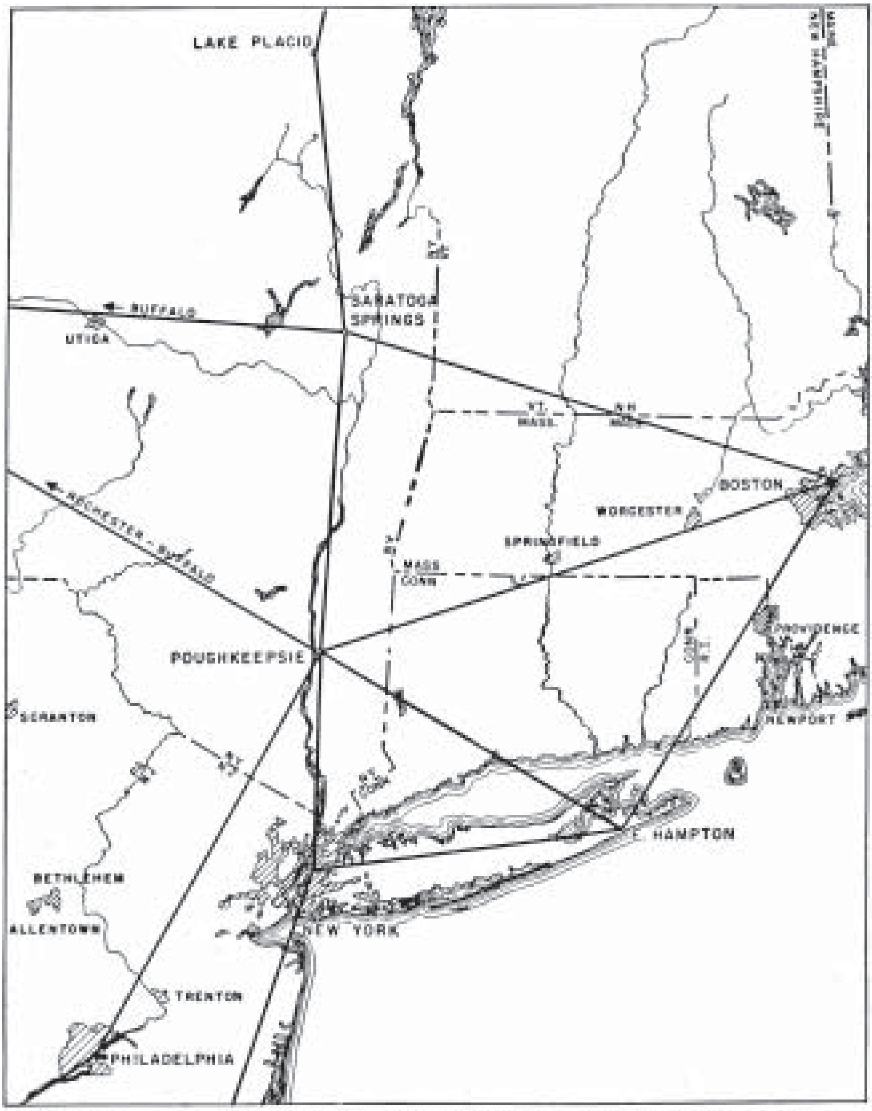


Figure 3. Area Method of Studying Routes and Seaplane Base Locations

to seaplane facilities, total aircraft and per capital aircraft ownership, and the ratio of seaplanes to all aircraft. The latter relationship should be tested, where possible, for validity through time by calculating similar relationships over a period of years.

Making the Forecast

This involves the multiplication of the seaplane base figure (number of seaplanes in the community during the current year) by the community projection factor. The result will be a weighted estimate as to the probable number of seaplanes which a community may expect at the future date (1955). Two theoretical examples follow.

(a) A community with a high projection factor

Seaplane base figure	20
Projection factor	4
Estimate for 1955	80

(b) A community with a low projection factor

Seaplane base figure	20
Projection factor	2-1/2
Estimate for 1955	50

There may be some communities which do not have any seaplanes at the present time but have the basic requisites, namely suitable bodies of water and a large urban population, for seaplane development. The potential for such communities may be established on the basis of national averages. The estimate of 5,000-8,000 seaplanes by 1955 corresponds to approximately 5 to 8 percent of 1948 national total aircraft registration. In any community which may have a seaplane potential but does not have any seaplanes registered at the present time, an estimate of potential for planning purposes may be obtained by taking 5 to 8 percent of 1948 community registered aircraft.

II. Site Selection

Certain desirable standards have been established by which to determine correctness of size and location of the water area for landing seaplanes.

The necessary size of a landing area will depend upon these factors: The performance characteristics of the seaplanes expected to use the landing area, presence or absence in surrounding area of existing or potential obstructions, water currents, and wave action.

Location of the landing area and related shore developments will be influenced by these factors: Presence of other seaplane bases and airports in the general area; accessibility; character of development of the surrounding area; meteorological and atmospheric conditions, such as fog, wind, and smoke.

The seaplane landing area in relation to a waterfront community (fig. 4) shows the favorable relationship of a seaplane facility to a typical community in general and more particularly to other waterfront activities. The

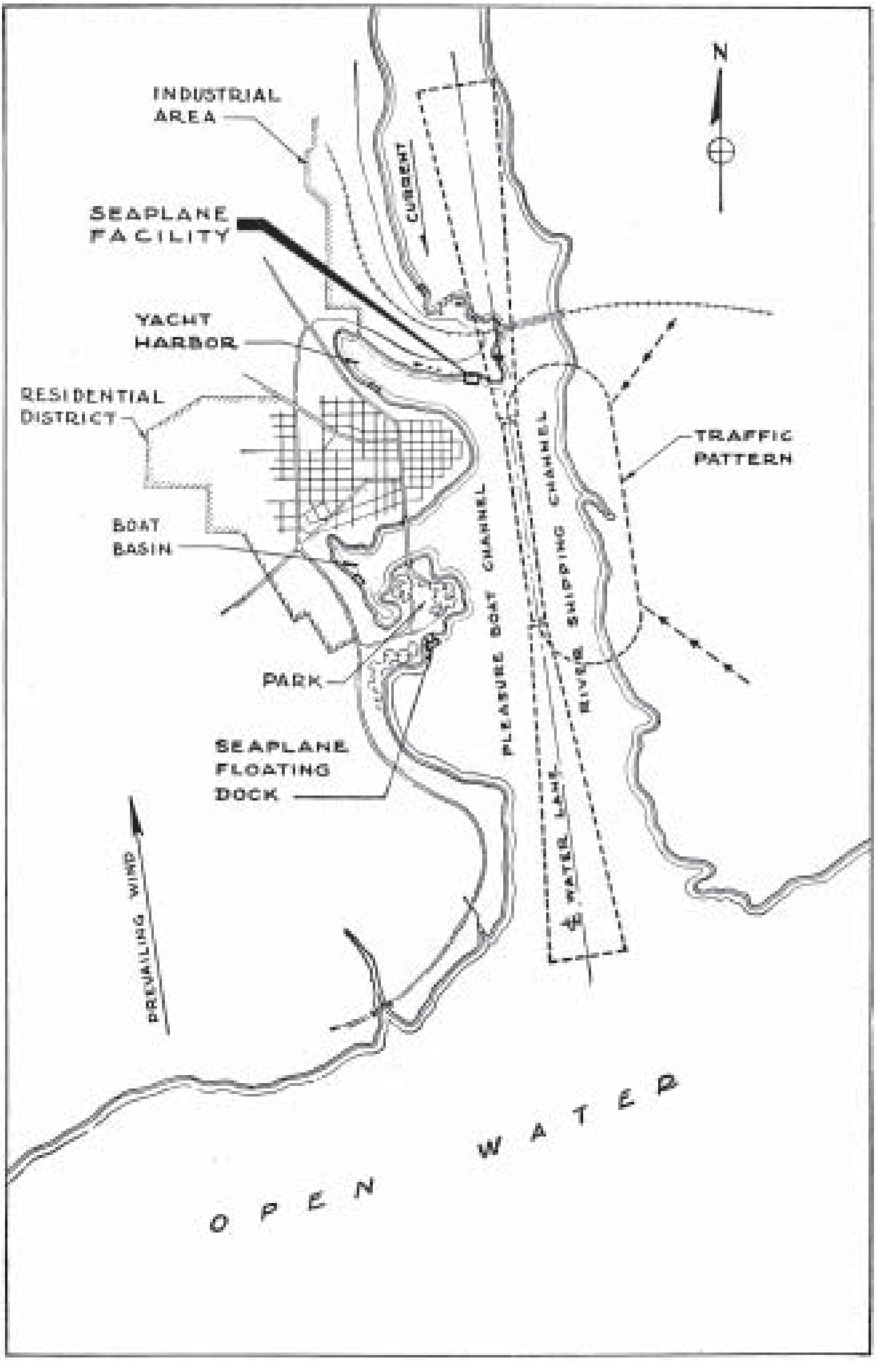


Figure 4. Seaplane Landing Area in Relation to Other Elements of a Waterfront Community

site location is "close-in" to town and in good relation to the business and industrial waterfront area, with convenient access routes to the residential areas. In addition, the traffic pattern and approaches do not pass over the existing developed community. Pleasure boating can operate along the west shore-line with safety and without interference or disturbance from seaplanes. If the community attracted itinerant aviation it would be possible to provide a floating dock-for enplaning and deplaning only-in the park area. Aircraft servicing would still be provided at the main facility. In general, river shipping would be along the east shore with ample turning and docking area north of the railroad and bridge. The location of the seaplane facility protects it from down-river currents and prevailing north winds. All climbs and approaches are over water, thereby providing the highest degree of safety.

Water Areas

In selecting an adequate site within the areas deemed feasible for water flying, it will be necessary to choose one having the proper water-area dimensions, depth, and approach or glide path ratio for the types of planes to be accommodated. Table 1 shows by comparative groups the recommended minimum standards for water landing areas. Generally, most localities will not be concerned with lengths of water areas of 5,000 feet or more. Larger installations are primarily for large commercial aircraft and military operations.

Prevailing Winds

The direction and velocity of prevailing winds over the surface of the water will be the controlling factor in determining the direction of water lanes. It is not necessary to consider winds of three miles per hour or less when making these determinations.

The peculiarities of surface winds over water, the channelizing effect caused by shore-line terrain or banks, and the effects of thermal air currents will produce wind conditions over water which will in many cases be at variance with wind data for land areas as close as a quarter of a mile away.

Recorded wind observations taken in the immediate vicinity of the site over a long period of time are most desirable but in a great many cases will be unobtainable. When the information is unobtainable, the next best data is that obtained for a nearby locality or airport. Wind data of this source may not be directly applicable to the site considered, as many on-site factors can change wind conditions considerably. Therefore, it is important that the latter type of data be checked by comparing the observed wind conditions at the proposed water operating area with winds being observed at the nearby location. These comparisons should be made under conditions of high and low wind velocities from all quarters on both clear and cloudy days and at substantially different temperatures.

Table 1.—Recommended Minimum Standards for Water Landing Areas

Minimum length in feet (Sea level)	Minimum width in feet	Minimum depth in feet	Turning basin in feet-diameter	Remarks
2, 500	200	3	None	Minimum for limited small float plane operation. Approaches should be 20:1 or flatter for a distance of at least 2 miles.
3, 500	300	4	None	Minimum for limited commercial operation. Approaches should be 40:1 or flatter for a distance of at least 2 miles.
5, 000	500	10	1, 000	Minimum for extensive commercial operation. Approaches should be 40:1 or flatter for a distance of at least 2 miles.
10, 000	700	15	2, 000	Unlimited. Approaches should be 50:1 or flatter for a distance of at least 2 miles.

Notes

The lengths indicated above are for glassy water, no wind, sea level conditions at standard temperature of 59° Fahrenheit.

The lengths shown will be increased at the rate of 7 percent for each 1,000 feet of elevation above sea level. This corrected length shall be further increased at the rate of one-half of 1 percent for each degree that the mean temperature of the hottest month of the year, averaged over a period of years, exceeds the standard temperature.

See figure 5 which contains a chart entitled "Effect of Elevation and Temperature on Water-Lane Lengths."

Lacking data from these sources, it is advisable to consult local sailing and boating interests or residents of the area who may be able to supply general information regarding the winds in the vicinity of the water operating area. Some additional information possibly may be gathered by observing the character of trees and vegetation on the shore line. Thick and coarse bark on one side of the tree or the bending or leaning attitudes are often indicative of wind direction.

When the water landing area consists of a single lane (covering two wind directions) the greatest percentage of wind coverage should be obtained. In many cases these single-lane operating areas cannot be oriented to take maximum advantage of the prevailing winds. In this regard, a shifting of the direction of the water lane should be effected so as to utilize the greatest possible wind coverage in conjunction with water currents and approach conditions. The influence of approach zones and currents is explained under these two respective headings that follow. Where all-way landings and take-offs can be provided, a study of the wind conditions will indicate the primary and secondary water-lane directions.

In each of the above cases, as previously mentioned, recorded wind observation is the desirable information to use. Information concerning the study and use of recorded wind rose data is available in the Civil Aeronautics Administration publication, “Airport Design.”

Approach Zones

For seaplane operations the ideal approach zone is one which permits unobstructed approaches over water at a ratio of 40 : 1 or flatter, with ample clearance on either side of the approach zone center line. The width of the zone should increase from the ends of the water lanes so that at a distance of one mile from the end of the water lane, the zone is approximately the width of the water lane plus 1,000 feet.

Under favorable temperature conditions a water-borne aircraft will leave the water and fly level for approximately four (4) seconds and a distance of about 400 feet before starting to climb. The rate of climb after this four - second period is about 20 : 1. This ratio allows for a very limited margin of safety and requires maximum aircraft and engine performance at full load. Where commercial operations are anticipated, it is recommended that the approach angle should be 40 : 1 or flatter.

The approach zones should be over water, wherever possible, thereby permitting a reasonably safe landing in the event of power failure during initial climb or landing approach. Furthermore, for obvious safety reasons, climbs and approaches should not be made over populated areas, beaches and similar shore developments. Apart from the all-important safety factors involved, such maneuvers can create ill will and antagonism on the part of local inhabitants and boating interests. Where a suitable water area exists and the shore and surrounding development prohibits straight-away approach zones, it may be possible to establish operations in which an over-water climbing turn or let-down procedure is used.

Currents and Water-Level Variations

Currents and changes in water level usually will not be great enough to cause construction or operational difficulties. Only under extraordinary conditions will currents affect size requirements of the water landing area. Landing and take-off operations can be conducted in water currents in excess of 6 knots (7.0 m. p. h.) but any taxiing operation between the water lanes and the shore facilities will usually require the assistance of a surface craft. Currents in excess of 3 knots (3.5 m. p. h.) usually cause some difficulty in handling seaplanes, particularly in slow taxiing while approaching floating docks, or in beaching operations. In some cases undesirable currents may be offset to some extent by advantageous prevailing winds. Locations of the following types should be avoided: (1) Where the currents exceed 6 knots (7.0 m. p. h.); (2) Where unusual water turbulence is caused by a sharp bend in a river, the confluence of two currents, or where tide rips are prevalent.

As a general rule if the change in water levels exceeds 18 inches, it will be necessary to utilize floating structures or moderately inclined beaching accommodations to facilitate handling of aircraft at the shore-line or water front. Where water-level variations are in excess of 6 feet, special or extended developments to accommodate the aircraft must be made. These developments might require a dredged channel, extended piers or special hoisting equipment depending upon the slope of the shore. It follows that the greater the water variation, the more extensive will be the facility requirements. A listing of tidal ranges that can be expected at various coastal points around the United States is included in the Appendix, table 6.

Water-Surface Conditions

Open or unprotected water-operating areas may become so rough under certain conditions of winds and currents as to prohibit operations; hence, the varying water conditions at the proposed site must be investigated. The average light plane (3,000 pounds or less), equipped with twin floats, can be operated safely in seas running to about 15 inches measured from crest to trough, while 18-inch seas will restrict normal safe operations of these aircraft. Larger float-equipped or hull-type aircraft ranging in weight from 3,000 to 15,000 pounds can generally be operated safely in seas running as high as 2 feet measured from crest to trough. At the other extreme, smooth or dead calm water is undesirable because of the difficulty experienced in lifting the floats or bull from the water during take-off. The most desirable conditions exist when the surface of the water is moderately disturbed; having ripples or waves approximately 3 to 6 inches high. Locations at which excessive ground-swell action may be encountered should be given careful consideration to determine the effect of such action on the intended operations.

Another consideration which must be taken into account, when examining the water surface conditions, is the presence of floating debris. Areas in which there is an objectionable amount of debris for considerable periods of time should be avoided.

Sheltered Anchorage Areas

A cove, small bay, or other protected area is desirable for use as a seaplane anchorage or mooring area in order to relieve floating-dock or onshore parking. A sheltered area that is protected from winds and currents is required, particularly if overnight or unattended tie-ups are to be made at locations where sudden and sometimes unexpected storms or squalls develop. Appreciable currents and winds in the anchorage area make the approach and picking up of a buoy more difficult and at times will call for the assistance of a boat. The anchorage area should be within sight and calling distance of the floating dock or ramp if possible. It also should be located so as to permit unrestricted maneuvering of the aircraft when approaching the buoys.

Bottom Conditions

The type and condition of the bottom at the proposed seaplane-facility site can influence the arrangement of the various components thereof, the means of construction of the fixed structures, and the water operations to and from the shore-line.

Reservoirs and other artificial bodies of water often are flooded natural land areas and frequently are not grubbed (stumps and logs removed) before flooding. This situation causes anchors and anchor lines to foul and, over a period of time, can create a hazard if these submerged objects rise to the surface and remain partially or totally submerged.

Obstructions which project from the bottom and constitute a hazard should be removed or, if this is impractical, must be suitably and conspicuously marked to indicate their presence to those utilizing the water area.

A hard bottom composed of shale or solid rock formations will make the construction of fixed off-shore structures difficult and costly. Anchors also tend to drag over this type of bottom. Unless specially designed mooring anchors are used, precautions should be taken by selecting a more suitable anchorage area. Where boulders are found on the bottom, some construction difficulties may be encountered and anchor lines may tend to foul. Mud bottoms ordinarily present little or no difficulty.

The On-Shore Facility

No site for the on-shore development should be given serious consideration until it is known that adequate room is available for all of the space-taking elements required. Determination of size will require knowledge of: (I) How many planes will need hangars or tie-down space; (2) how many car parking spaces will be necessary; (3) how many patrons will use the facility; (4) whether a small office will suffice or whether an administration building with facilities for eating, refreshments, and other nonaviation activities is required; (5) how much outdoor common space, such as for lawns, walks, terrace, etc., is needed. Answers to numbers I and 2 can be fairly accurately measured while 3, 4, and 5 will depend upon local conditions varying from a very simple installation, in remote recreation areas, to large installations in metropolitan areas. Minimum unit requirements are as follows:

Minimum Unit Requirements for a Single On-Shore Facility

Item	*Facility*	*Area in Square Feet*
1 plane ----------------------------	Hangar or tie-down space ---	3,000
1 car ------------------------------	Parking space -----------------	250
Office ----------------------------	Small building ----------------	80
Common outdoor space --------	Walks, lawn, or open space –	20 percent of above total

To compute the number of square feet for a given facility, multiples of the above criteria may be used. For example, a facility basing 15 aircraft in the water and 6 on land would need a maximum of 21 car-parking spaces (one for each plane) during maximum use period, plus one for each employee; i. e., approximately 25 cars or 6,250 square feet of area. Hangar or tie-down space for 6 planes would occupy 18,000 square feet. One small office building with food counter would require another 400 square feet. Finally, the common outdoor use space would occupy about 4,930 square feet (this figure representing 20 percent of the sum of the other areas). Accordingly, the total area would amount to about 29,580 square feet or about seven-tenths of an acre.

In addition to being adequate in size, the shore facility should be located reasonably close to the water-operating area to eliminate long taxiing operations.

The availability of utilities such as electricity, water, telephone and sewage should be investigated. The basic installation may not require all utilities, but water and sanitary facilities of some sort should be provided for at all locations. In remote rural areas, established water lines and sewerage facilities will be out of the question. If such is the case, well water and chemical toilet units are feasible. State or local sanitary codes must be respected when it is planned to install water and sanitary facilities of this nature.

The most desirable sites have a moderately sloping shore-line and a water depth suitable to permit aircraft taxiing operations as close to the shore-line as possible. Excessive fluctuations in water level are not desirable since this condition requires expensive shore-line installations. Care should be taken to determine whether the water level off-shore will permit aircraft operations when the water level is low.

In all cases, the area for a seaplane facility should be sufficient in extent to form a complete unit without any interior private holdings and with good boundary alignment for complete land utilization and protection. It may also be desirable in some cases to secure a liberal set-back from the highway in order to protect the project and adjacent property from noise and glare and to provide room for widening any highway paralleling the property line. If sufficient land is available, a greenbelt all around the project will enhance the desirability of a seaplane facility in a neighborhood area.

General Planning Considerations

Having determined the best site available from the aeronautical point of view, other elements of community, county and state planning should be considered. These elements are accessibility, land use, and area controls.

Accessibility

Probably the most obvious consideration influencing the location of a seaplane facility is its proximity to the ultimate destination and source of the users. The ability of the airplane to cover long distances in a short space of time often is cited as its outstanding attribute. To retain this advantage, every effort should be made to locate the facility convenient to good streets and rapid or mass transportation facilities in urban areas, and to major highways or good roads in rural areas. Utilization of speed boats and other surface water transportation should also be carefully explored. If these associated means of access and transportation are overlooked, minimum use of the facility can be expected. To determine the most convenient location in urban areas, a sketch study should be made on an existing map of the community to show the residences of all existing and potential seaplane owners and business and shopping centers. This information will enable the planner to determine the best location for a facility in relation to transportation routes and from a standpoint of convenience to users. In rural or recreation areas were the seaplane is used primarily for sport, location of the facility with regard to access will not be a serious problem except that the means of access or transportation for fuel, repairs, and supplies must be adequate.

Land Use

Locating a facility in a residential neighborhood where let-down and take-off procedures occur over homes may be a source of annoyance to residents in the area. Unless flight traffic procedures can be developed which will eliminate the objection of take-offs and landings of this nature, the planner should seek a location where the existing land use will be benefited by seaplane activities. Personal seaplane flying is desired in certain neighborhoods where boating and seaplaning are of mutual interest. Here the seaplane facility will be as much an asset to the community as a yacht club. The onshore development might well include a combination office and club house for seaplane and boating interests. Normally there will be little use for a personal seaplane facility in an industrial area where local truck and auto traffic congestion make access time-consuming and undesirable.

Planning the location of a seaplane facility, whether it is in an urban or rural area is as important as planning the location of highways, parks, water supply, and housing. Each has its place in the economic and leisure life of the environment and each should complement the activities and physical development of the other.

It follows that there should be close cooperation with the local planning or engineering agency in selecting a site which will be in accord with all other elements of the area master plan if such a plan exists. When no such plan exists, every effort should be made to recognize existing conditions and future proposals so that the seaplane facility can take its proper place in the community.

Area Controls

The water area from which seaplane facility operations are conducted is public property in a majority of cases and, therefore, is available for use by other interests as well as aviation. Both land and water areas may be subject to local, county, State, and Federal regulations or ordinances.

The controls which affect the establishment and operation of a seaplane facility can be divided into three major classifications, as follows: The regulation of (1) construction in and use of the water area, (2) construction on and use of the land area, and (3) water and air traffic. In many areas some of the restrictions mentioned may not apply to the location selected; however, the possibility that these controls exist should be investigated and whatever permits, easements, leases, or licenses may be required should be obtained prior to the development of the facility.

It is impractical in a publication of this type to include the numerous ordinances and regulations which control the construction in and use of the many rivers, lakes, reservoirs, and waterways throughout the United States and its Territories. The following is a partial list of Federal agencies which may exercise control over water or adjacent land areas:

Department of the Army: U. S. Corps of Engineers.

Department of the Interior: Bureau of Reclamation, National Park Service, Fish and Wildlife Service.

Department of Agriculture: Soil Conservation Service, Forest Service.

The Treasury Department: U. S. Coast Guard.

Authoritative and useful information can usually be obtained from agencies in the general area of the proposed development.

III. The Master Plan

The master plan is a graphic and written record of the designer's *current* conception of the completed seaplane-facility development area, and of the fully considered relation between the existing condition, and the ultimate seaplane-facility scheme. The master plan is the essential controlling document of all planning and development work for the designated facility. As such, it establishes the priority of work to be undertaken and provides that due consideration be given to the effect that such work may have on other desirable objectives. Thus, by determining fundamental design conceptions far in advance of detail design and plan execution, the master plan serves to recognize, preserve, protect, and assure the best over-all uses and values of the designated seaplane-facility site.

The master plan indicates the distribution and inter-relation of carefully selected and defined use areas or other lesser areas dedicated to special purposes, thus the whole scheme, as it relates to the most advantageous use of the particular seaplane facility site, is delineated. Clear-cut graphic distinction is clearly defined and maintained throughout between existing conditions and proposed development. This can usually be accomplished in the case of seaplane bases on two sheets, one large-scale drawing of the on-shore and shore-line areas and one smaller-scale drawing of the water operating and surrounding areas. A distribution schedule of buildings showing size, shape, and use must be established before the design of a definite master plan study may be begun. The "schedule of building units by size" is based upon statistics showing the maximum estimate of people or aircraft that are to be accommodated.

Elements

The planner's aim is to present with all possible clarity a graphic picture of the existing and proposed conditions, both natural and man-made, embracing the entire site character, culture, and development.

The following elements should be included, whether within the seaplane facility site or adjacent to it:

1. Boundaries, as accurate as possible, of land actually owned or under option by the sponsoring agency or owner; boundaries and ownership of additional land proposed for acquisition, unless such disclosure of intent would jeopardize the acquisition program.

2. Boundaries of counties, towns, etc., with names; where applicable, section corner or section lines, with correct designations, including township numbers.

3. Boundaries of water area, lines of riparian rights, bulkhead and pier head lines.

4. Wind rose and meteorological data; orientation by north point; indication as true or magnetic.

5. General elevation by contours at suitable intervals should provide adequate representation of the land form without unduly congesting the plan. (Existing contours should be shown as dashed black lines. Contours should be numbered with figures of elevation to guarantee clear interpretation. Datum-U. S. bench mark, if possible, or reliable local elevation should be indicated and marginally described.)

6. Unusual topographic features-Cliffs, rock outcrops, and other elements of geographical significance.

7. Bodies of water and water courses, including accepted names of rivers, lakes, with direction of flow and high and low water lines. Soundings in each important water area.

8. Structures in block plan or by ground-floor plan delineation with grade of first floor.

9. Circulation-Approach routes with number or designation of highways; railroads; parking spaces, distinguished, if possible, as to width and type of construction such as concrete, gravel, or black top.

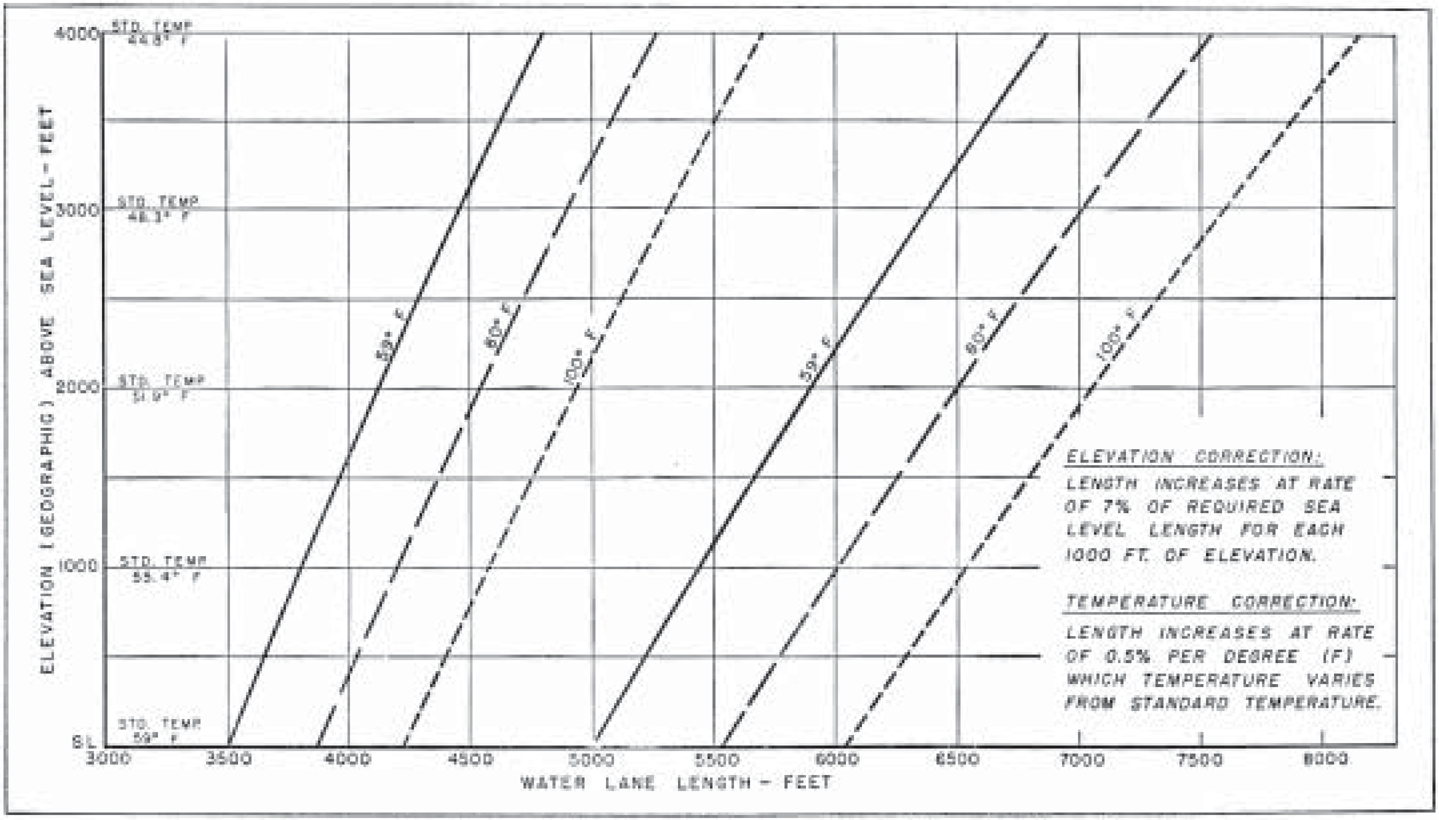


Figure 5. **Effect of Elevation and Temperature on Water-Lane Lengths**

10. Vegetative cover-Shown in mass outline, with important individual trees or groups, where the scale of drawing permits.

11. Utilities-Though normally entered on a separate sheet, may be shown if scale of drawing is sufficient to prevent confusion in delineation.

12. Use areas-Seaplane land facilities are usually small enough in size to be included on one drawing. The water area, however, will usually be so large an area that a separate sheet will be required for delineation. This sheet should show the water area in relation to the surrounding land area. Use areas may be broken down into four distinct elements, which together comprise the over-all development. These elements are: *(a)* the water-operating area; *(b)* the shore-line area; *(c)* the service, tie-down, and storage area; *(d)* the administration building and common-use area.

The Water-Operating Area

Most natural water areas will provide, without modification, the required dimensions necessary for seaplane operations. Where the available water area is limited, the minimum water-operating area must consist of one water lane for landings and take-offs and a taxi channel. A turning basin will be necessary in cases where turning must be confined to a restricted area because of water depth requirements or for the segregation of other water surface-craft activities. In some cases anchorage areas may be necessary.

Water Lanes

Minimum dimensions of water lanes necessary for seaplane operations are set forth in Table 1. Inasmuch as elevation and temperature affect water-lane length requirements, these factors must be considered and the lengths adjusted accordingly. Figure 5 presents a chart showing the effects of these factors

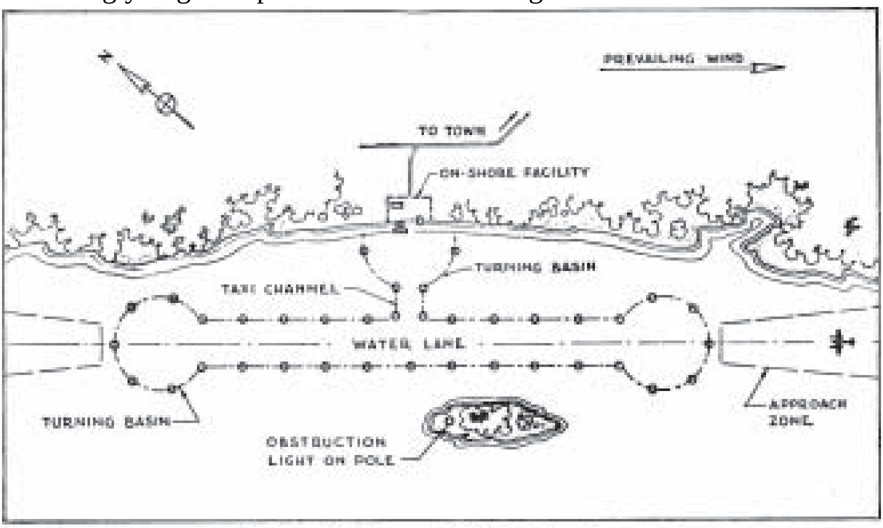


Figure 6. **General Operating Area**

on certain basic lengths. A typical lay-out for a single water-lane operating area is shown in figure 6.

Taxi Channel

For small seaplanes the taxi channel should have a minimum width of 125 feet, although a width of 150 feet or more is preferred. These channels should be located to provide direct access to the on-shore facility and when possible should be so oriented that approach to the ramp or floats will be into the prevailing wind. They should provide a minimum of 50 feet clearance between the side of the channel and the nearest obstruction.

Turning Basins

Turning basins will be required where the use of water area is restricted. A minimum radius of 125 feet should be available for surface turns. These turning basins should be located at both ends of the water lanes and adjacent to the shore-line area. The same minimum clearance criteria, i. e., 50 feet, should be used for the separation between the side of the turning basin and the nearest obstruction.

Anchorage Areas

Where anchorage areas are required, they should be located so as to provide maximum protection from high winds and rough water. The space requirements for an anchored aircraft, and the number and size of aircraft to be accommodated, will determine the size of the anchorage area. Each aircraft will swing around the mooring while anchored. To determine space needed, one must know the wing span and length of aircraft, the length of line and bridle, and the lowest water level. The length of anchor line should be at least six times the maximum depth at mean high water at the anchor location. In cases where the aircraft swing space is limited, the length of the anchor line may be shortened to not less than three times the high-water depth, provided the normal anchor weight or holding capacity is doubled. Short anchor lines cause hard riding and should not be used where swells or heavy wakes from boats are common. Center-to-center spacing of anchors, where small twin-float aircraft are to be moored, should not be less than twice the length of the longest anchor line plus 125 feet. For larger types of aircraft, including flying boats and amphibians this spacing should be increased by an additional 100 feet. A general lay-out of anchorages is shown in figure 7.

The Shore-Line Area

Shore-line installations are partly on land and in the water. They are required to perform two general functions: (1) to provide servicing, loading and unloading, handling and tie-up facilities for seaplanes without removing

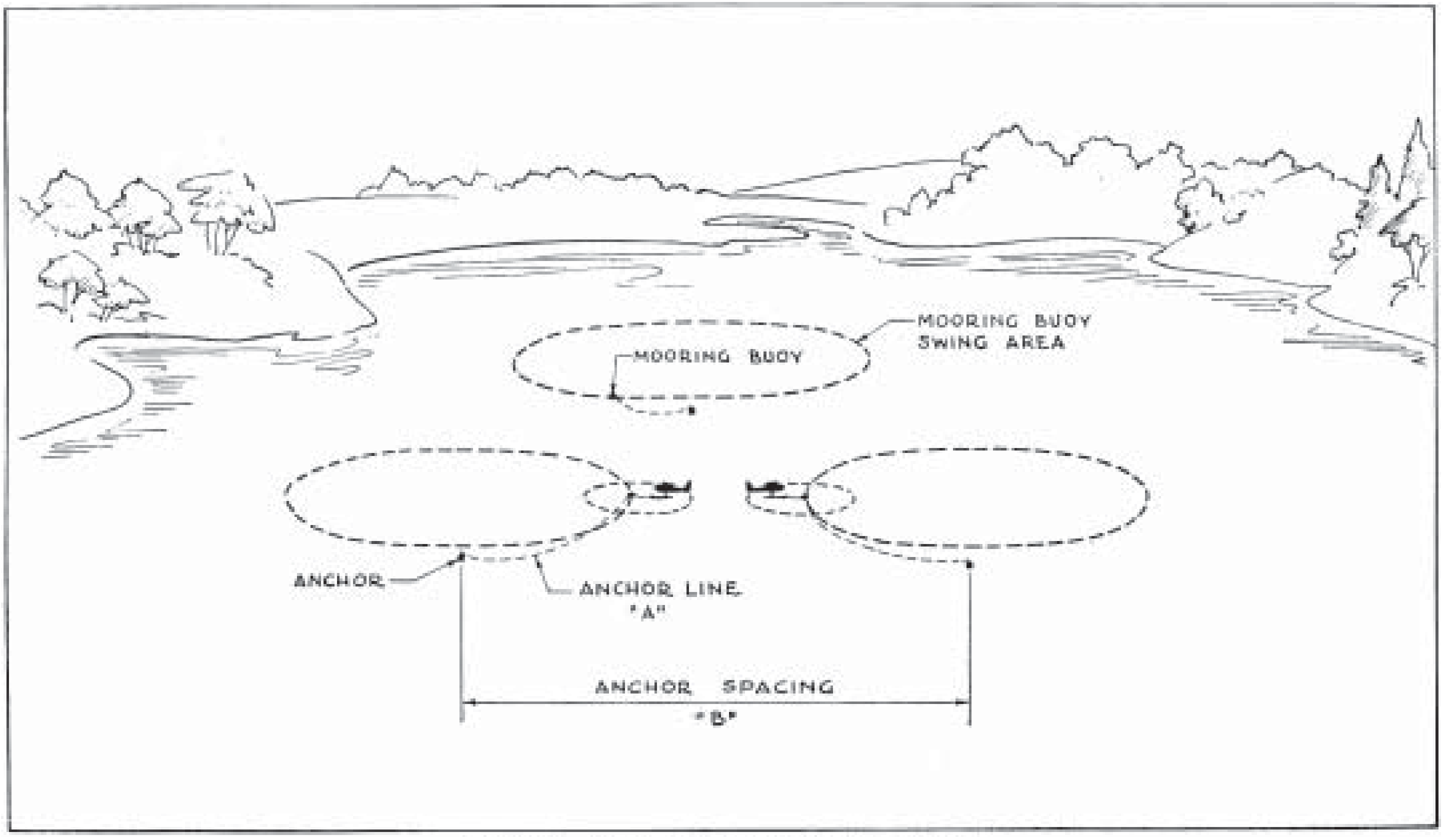


Figure 7. **General Layout of Anchorage Areas**

them from the water, and (2) to provide haul-out facilities for removing seaplanes from the water.

The types, size, and arrangement of these installations will be determined by water conditions, the topography of the land adjacent to the water, the configuration of the bottom of the water area, the number and type of planes to be docked or removed from the water, and wind conditions. The installation will vary from a simple wood-plank platform to the more elaborate ramps with railway facilities, piers, and floats.

Ramps

The simplest form of ramp consists of a wood-plank platform approximately 15 feet by 20 feet, laid on a sloping shore, with half its length in water. A device such as this will allow a small float plane to taxi up and out of the water. The use of such a ramp is predicated upon a relatively constant water level and the shore slope no steeper than 8 to 1.

The slope of any ramp should not be greater than 7 to 1, with gradual slopes down to 10 to 1 being preferred. Slopes less than 10 to I usually are too long and hence costly to construct.

Table 7 in the appendix shows the maximum draft of seaplanes of various weights and types. These data are useful in determining the depth to which the submerged end of a ramp must be lowered. A depth of ramp toe of 4 feet will provide sufficient depth for most types of water-borne aircraft in use today; a depth of 3 feet will permit handling of all but the heaviest type of amphibians. For small, light, float planes a depth of about 18 inches is adequate. In all cases, this dimension should be established for mean low water.

A ramp width of 15 feet is the minimum for small twin-float or amphibian aircraft operations when the water and wind conditions are relatively calm. By adding 5 feet to this minimum width, practically all water-borne aircraft of gross weights up to approximately 15,000 pounds can be handled with safety, and pilots of small seaplanes can make an unattended ramp approach under adverse conditions. In figuring the ramp width, the outside-to-outside float dimensions of twin float aircraft and the treads of amphibian aircraft are important factors and for reference are shown in the appendix, table 7. The maximum dimension-based on the largest aircraft to be accommodated-plus additional space in either side to allow for drift when approach-ing, and safe working space for personnel when handling an aircraft on the ramp, determines the minimum practical width. Ramp-width determination does not necessitate consideration of wheel tread of present-day float plane dollies. Normally, the dolly wheels are spaced to fall between the floats, and in cases where the wheels are outside, the tread is 16 feet or less.

Piers

Piers or fixed over-water structures can be utilized where the variation in water level is 18 inches or less. The pier should extend into the water to a point where the water depth is adequate for the types of aircraft to be handled. The usual design for a pier incorporates an access walk approximately 5 feet in width with hand railings on both sides and an open-decked handling area approximately 30 by 50 feet at the walk's end. An open-decked area of this size will provide tie-up space for four small or three large seaplanes. On long piers, where the walking distance is too great for convenient handling of service equipment, a small storage shed may be located near the open-decked area. Fueling and lubrication facilities should also be located at the end of the pier.

Floats and Gangways

Floats offer the greatest flexibility in providing docking facilities. This type of unit rides with wave action and is equally satisfactory in areas of great or negligible water-level variations. Universal action must be provided in anchoring or attaching floats together. Figure 8 shows various types of floats for docking. A float which provides an unobstructed wing clearance of 17 feet will permit practically any twin-float seaplane or small amphibian aircraft to come along its side safely.

Floats are usually connected to the shore or pier by booms and a gangway. The maximum water-level variation dictates the length of the gangway. In no case should gangways be less than 15 feet in length and should be at least 5 feet in width. Hand rails, preferably on both sides, should be provided to assist persons using the way. A 2.75 : 1 slope ratio is the maximum for safe and easy walking and to prevent the handrails from becoming an obstruction to wings.

In some locations it may be desirable to anchor the float off-shore with anchors and anchor lines with connection to the shore by a floating walkway. A floating walkway 5 feet or less in width must have outriggers spaced longitudinally approximately every 10 feet. Outriggers 8 to 10 feet long will prevent excessive rolling of the walk.

Spacing

The desired clearances between the various docking units and ramps obviously will have a decided influence on their arrangement and location. Each docking unit should be so located that an aircraft may approach and tie up in anyone of the units when adjacent units are occupied. When aircraft are operated between the various units under their own power, the recommended minimum separation between the near faces of piers, floats, ramps or marine railway is 50 feet because a water-borne aircraft can normally be taxied safely past obstructions as close as about one half of its wing span. Where aircraft are moved between units by hand, the separation

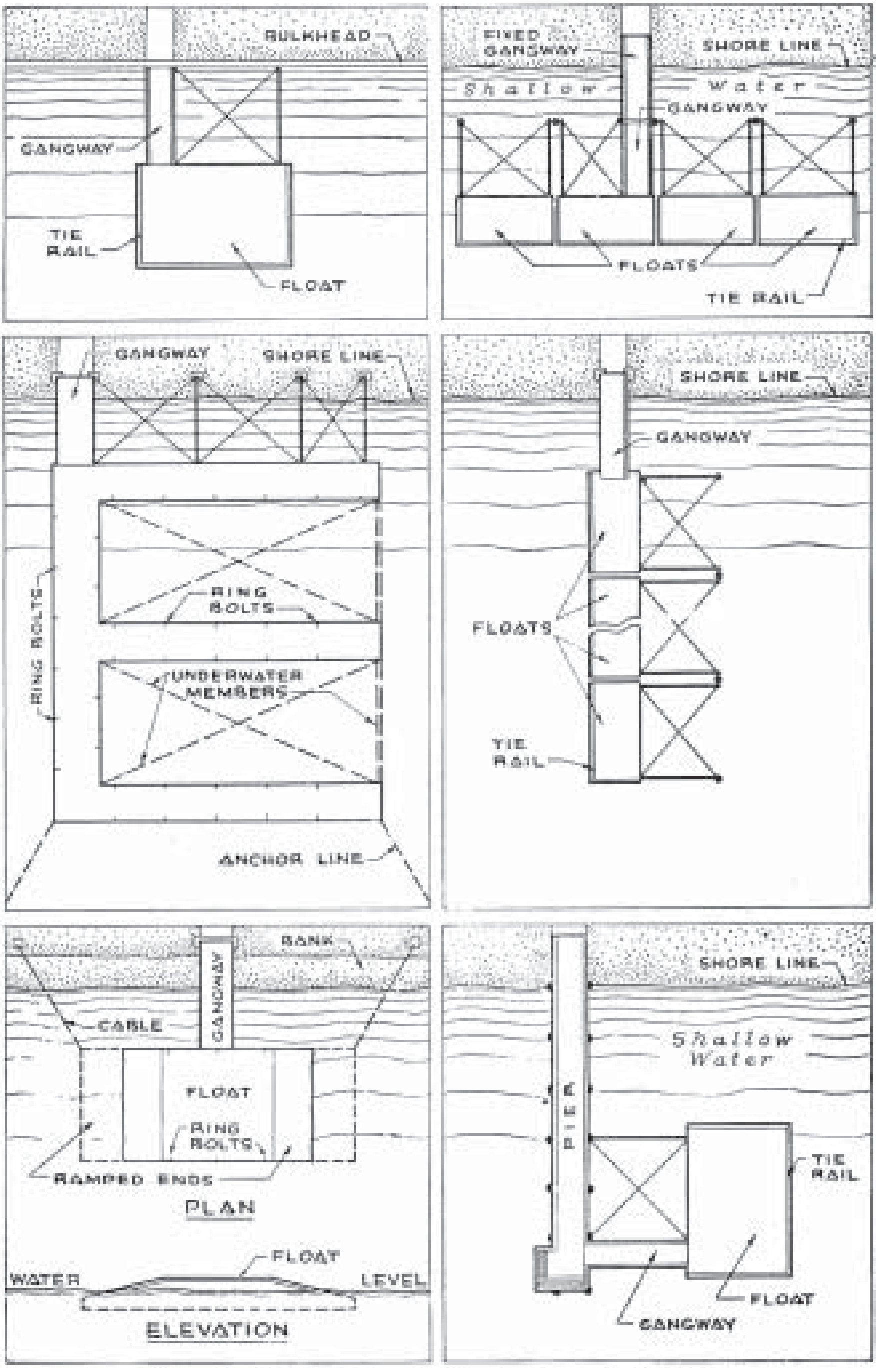


Figure 8. **Various Types and Arrangements of Floats**

between the units may be less than 50 feet to facilitate handling. A minimum of 100 feet of unobstructed water should be available directly off-shore from a ramp in the direction from which approaches normally will be made.

Floating Barges

The lease or purchase of land for a seaplane-facility site may be a problem at some desirable locations and yet pier or gangway rights may, be easily obtained. At such locations a floating barge, anchored off-shore, makes an excellent facility. An office, lounge, and service shop can be included "aboard" and by adding a floating dock alongside and ramps at the ends, a very practical and efficient facility results. The floating barge may be anchored direct to the shore or a pier by booms and a gangway, or anchored off-shore in a fixed position. Some operators prefer to allow the barge to drift down-wind or down-water from a single anchor. Boat transportation will be needed if the unit is mobile and moored off-shore. The very uniqueness of this type of installation will, in some localities, attract many persons otherwise not directly interested in water flying. The possibility of organizing this activity on a club basis should not be overlooked. This type of installation can be made more attractive by appropriate use of paint, colorful deck chairs, awnings, marine appointments, and recreation facilities.

Some units are in operation today where an entire barge is floating but is attached to the shore. Large logs are decked over and form the base for the entire structure, which is in some cases 150 feet long by 100 feet wide, in a series of flexible units.

The Service, Tie-Down, and Storage Area

This element will occupy more space than any other on-shore facility. For safety and convenience, it should be separated from other incidental activities on the site, either by adequate buffer space, fencing, or both. Every effort should be made to locate floating docks and piers so that access to them by the public will not require crossing the apron or hangar area.

Hangars

Both storage and repair hangars should be located so as to permit the off-site delivery of repair material and use by service personnel over a route as direct as possible and without interference with the movement of aircraft. The service and storage hangar area should be located in such a position in relation to the ramp or marine railway that aircraft may be moved there as directly as possible, with the least possible amount of disturbance to tied down aircraft or aircraft already in repair parking spaces.

The amount of space required for apron tie-down and hangar facilities will depend upon the number and types of aircraft that are to be accommodated. Dimensions of various aircraft are shown in the Appendix,

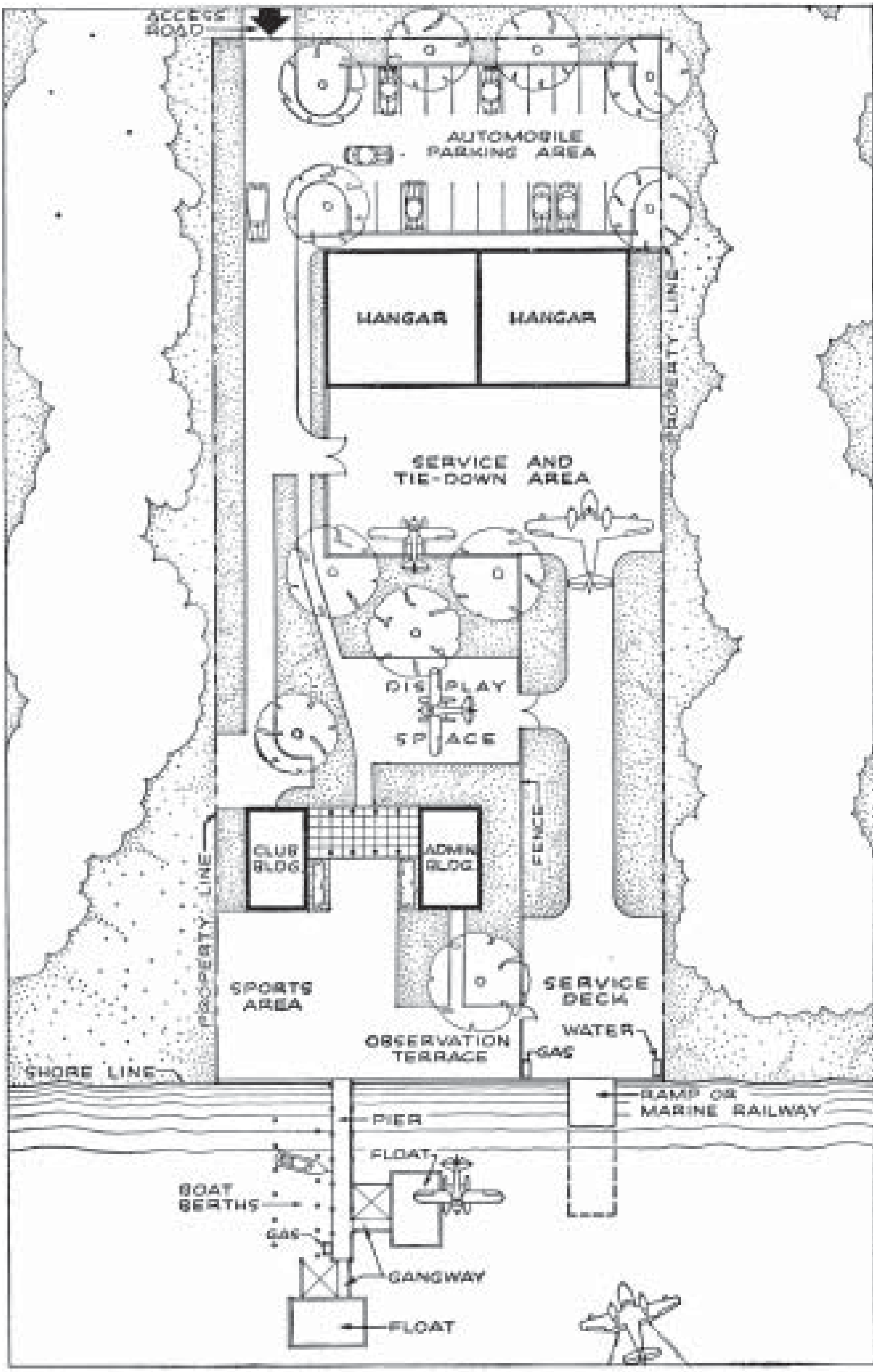


Figure 9. Typical Layout of On-Shore and Shore-Line Development

table 7. This information can be used to determine the space required for taxiing, turning, and storing.

The many standard types and sizes of hangars for land-based aircraft are adaptable to water-borne aircraft. These standard building types may be found in the CAA publication "Single and Multiple Unit Hangars-Light Aircraft." Hangars should be located in an orderly and functional relation to haul-out and ramp facilities, and to eliminate as much noise and confusion as possible should be sufficiently separated from the administration building and common public-use areas.

The Administration Building and Common-Use Area

In simple installations, it may be necessary to utilize a hangar for both aircraft service and office space. In larger projects a separate administration building may be required to provide adequate space for the manager's office, passenger and pilot lounge, display space, restaurant or snack bar, and observation deck. A community room for public use, such as for lectures, meetings and classes should not be overlooked if needed. The building should not be over-sized or monumental in character. Only a simple, functional design, adequate to take care of the estimated needs, is required. The location should be in a prominent position on the site, readily accessible to aircraft arrival arid to customers and visitors from the on-shore approach. Like airport administration buildings, visibility of the water area from the administration building is needed for the control of aircraft at locations where traffic in and out requires two-way radio communications.

Ample outdoor space reserved immediately adjacent to the administration building for public use is desirable. This space may consist of a small lawn or paved terrace on the water area side or, in more sizable installations, a larger section broken down into recreation areas, an outdoor dining terrace and lawn.

Access

Access to the land area, both for customers and for service and delivery, should ordinarily be a two-way, all-weather road. However, when a long access road is required and the traffic to and from the facility is not seasonal but relatively constant and without peaks, a one-way road will suffice. In such cases, turn-outs should be provided at convenient intervals. The plan should be designed for one traffic connection with the main highway or street, in order that its free-way may be preserved. A public highway should never be used as a part of the road system within a project if public use for through traffic is to continue after the project has been put into operation. Through traffic will unduly congest the land facility, could be hazardous to pedestrians, and splits the property into two separate units which is undesirable.

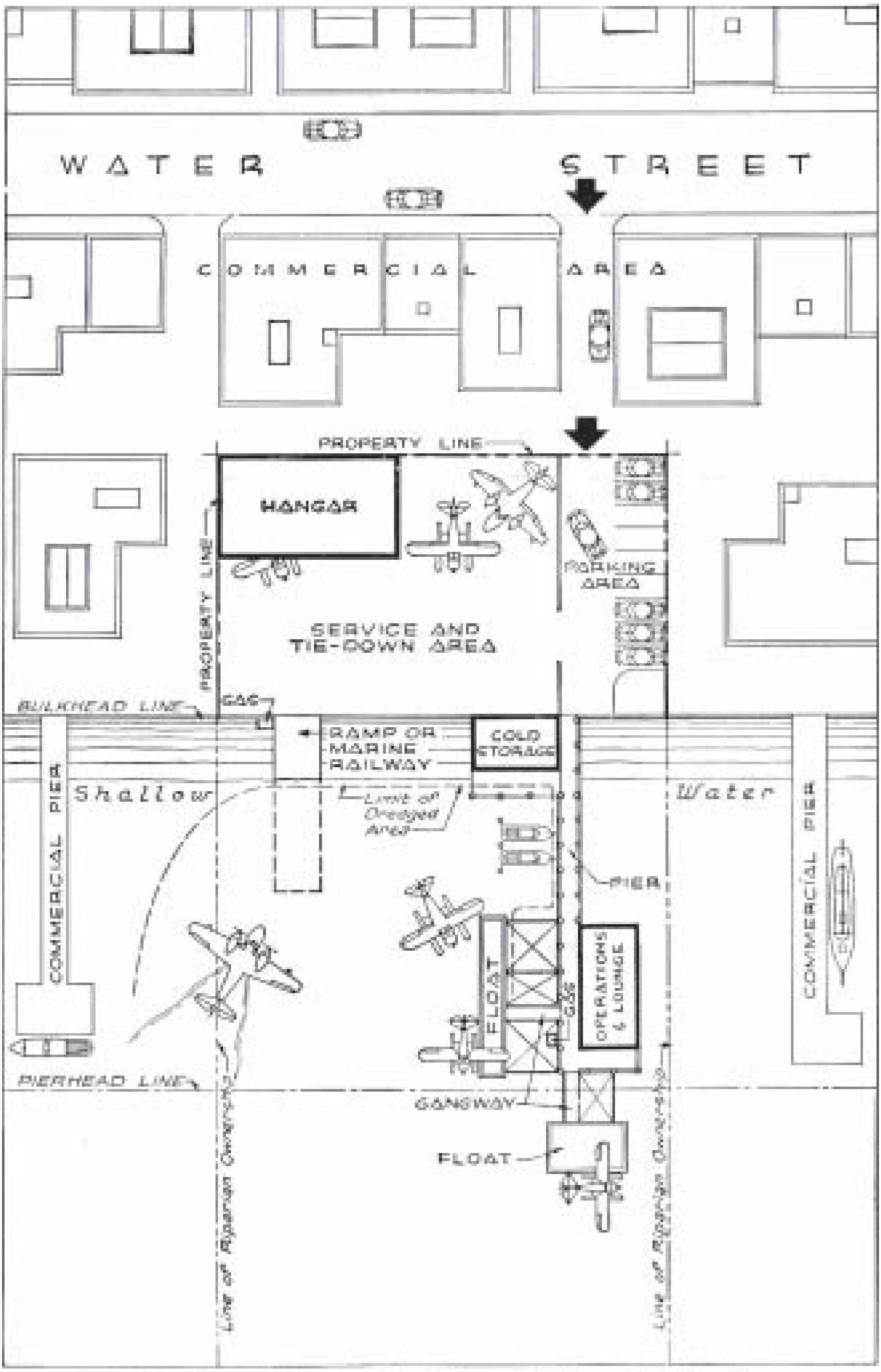


Figure 10. **Typical Layout of On-Shore and Shore-Line Development**

Roads

Vehicular circulation must be provided for deliveries of gasoline, oil, fuel, and for refuse removal. These routes will influence walks and interior road system and to some extent the pattern of the master plan. In order to reduce development costs and maintenance, it is advisable to concentrate buildings for certain uses in areas with servicing facilities such as a service road, on one side. When topography and shape of tract are favorable, this type of plan affects economies.

Roads should be planned economically, but must be adequate in width to serve the anticipated traffic, to permit easy circulation and safe driving. In some instances, they may afford parking space on one or both sides, depending on the solution of a particular site problem. Some service roads may be desired for limited use. In such cases the entrance can be barred by removable posts or chains.

Preferred road widths are given in the following list:

Service Roads	*Width in Feet*
One lane (for service only)	10
Two lanes (service and project traffic	16
Project Roods	
Two lanes (occasional parallel parking only)	18
Two lanes (in regions of heavy snowfall)	20
Two lanes (parallel parking on one side)	26
Two lanes (parallel parking on both sides)	32
Two lanes (diagonal parking on one side)	36
Two lanes (diagonal parking on both sides)	52
Two lanes (perpendicular parking on one side)	40
Two lanes (perpendicular parking on both sides)	60

Parking Areas

Provision of parking areas for cars must be made. As previously mentioned, one should allow one car for each based aircraft, one car for each employee, plus a ratio of visitors’ cars commensurate with the judgment of local interest in the use of the facility. An over-all space of 250 square feet of area will be required for each car. The type of parking space lay-out will, of course, depend upon the space and shape of the area available for the installation.

Parking areas should not be located so that pedestrians must cross a public road to reach the facility proper. This creates an unnecessary hazard, particularly to unescorted children who might dash across the public highway. Parking areas should be located convenient to the on-shore and shore-line facilities. In no case should the pedestrians be required to walk a distance greater than 200 feet from the parking area or service road to reach buildings or shoreline.

Walks

All walks should be laid out for direct access to and from the facilities to be reached. Like roads, they should not be over-sized in the interest of

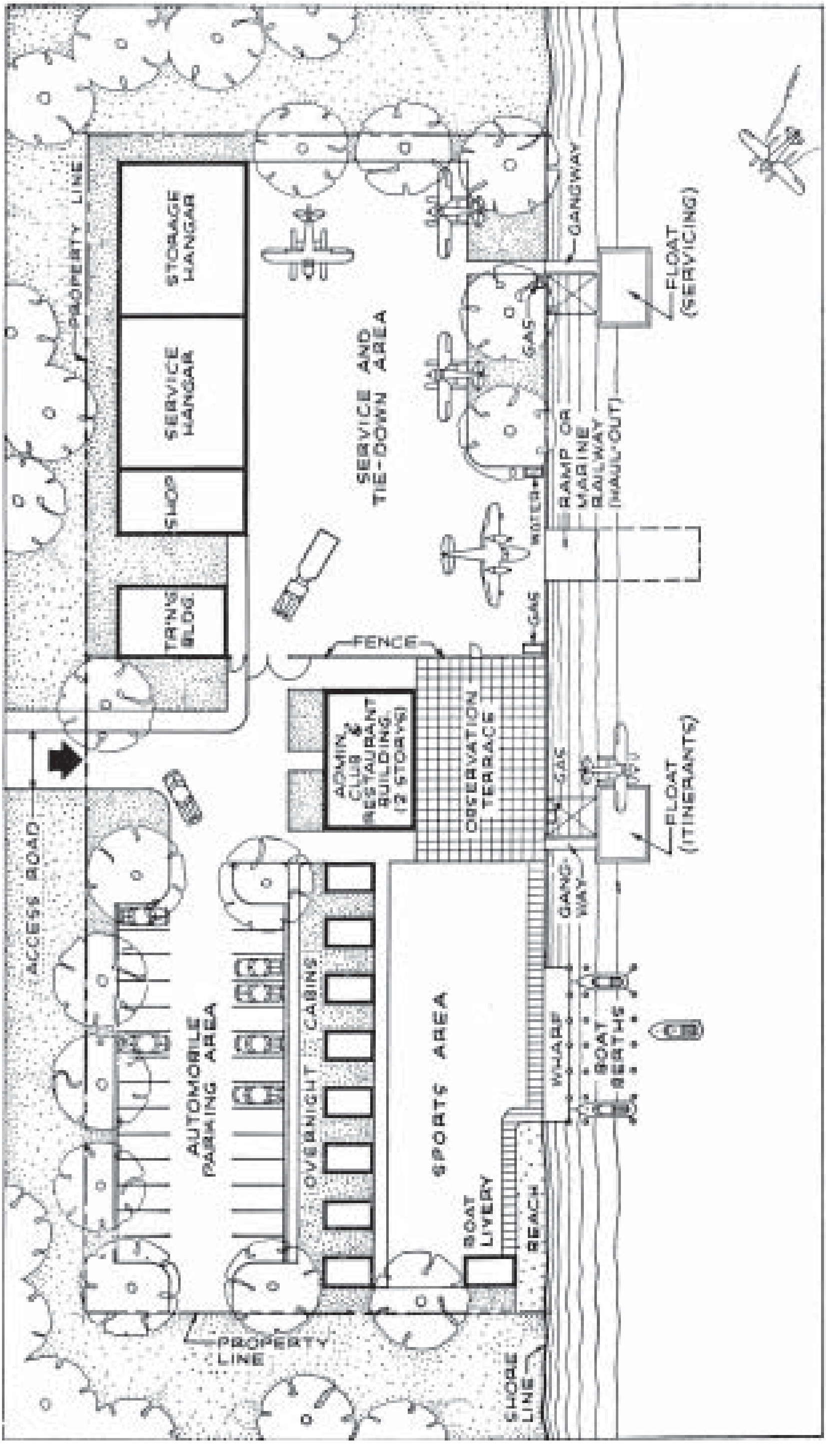


Figure 11. Typical Layout of On-Shore and Shore-Line Development

economy of construction and maintenance. Recommended walks widths are:

Capacity	*Width*
Public walk serving less than 100 persons feet ---------------------------	3 feet
Normal standard walk ---	4 feet
Walk serving over 400 persons --	5 feet

All walks should clear obstructions (as planting, fences, etc.) by 2 feet. A void steps in walks; single risers should *never* be used in public walks. Avoid stepped ramps. A 1O-to-15 percent gradient is preferred to steps. Walks at parking areas where cars park perpendicular to the curb should be determined to allow for car overhang. Five feet plus curb is minimum unless a strip of special pavement (used paving block) is provided at the curb.

Organization of the Plan

Although economy and rational organization must be the primary consid-eration in the design of the master plan for a project in which low first costs and low operating costs are essential, the skill of the designer and his pref-erence for one type of plan organization over another will influence decisively the character and appearance of the resulting plan.

The designer may choose a lay-out which is formal and symmetrical or informal and casual. In either case, a pleasing result depends more on the designer's skill in handling scale and proportion than on choice of pattern. It is important that the site plan grow logically out of the requirement of the building types, topography, orientation, and servicing, rather than that from preconceived patterns.

Figures 9, 10, and 11 show lay-outs on three distinctly different shapes of land area. These lay-outs indicate the inter-relationship of each use area. From arrangements such as these, studied in accordance with the previous discussion on the master plan elements and the general water-operating area shown in figure 6, the master plan is developed.

Stage Development

When the master plan for a facility has been prepared, a community is in a position to program the site development in successive stages as the needs arise.

Figure 12 illustrates the principle of stage development for a sample lay-out of on-shore and shore-line installations at a small town or resort area. This lay-out may be a satisfactory arrangement for a specific problem. It should not be used as a recommended scheme since each site will have its individual shape, contours, and other site conditions which will influence the design. Four successive stages are indicated, with each stage expanding the functional operation of the basic unit. It should be noted that this draw-ing is not a complete master plan since it does not show the water lanes, approaches, and other general area characteristics.

Stage 1

The first stage will consist of those elements which are the basic requirements for an operating facility. It will include the water landing lanes, mooring area, floating dock, gangway, gasoline pump, operations building, access road, auto parking area, and walks and lawns. The first stage does not include a ramp, but a temporary beaching ramp can be made to permit aircraft to be placed on shore. This can be accomplished by grading and laying rough timber or planking on the beach.

Stage 2

The second stage will provide a ramp or marine railway and a service and tie-down area. The ramp will provide a second location at which refueling

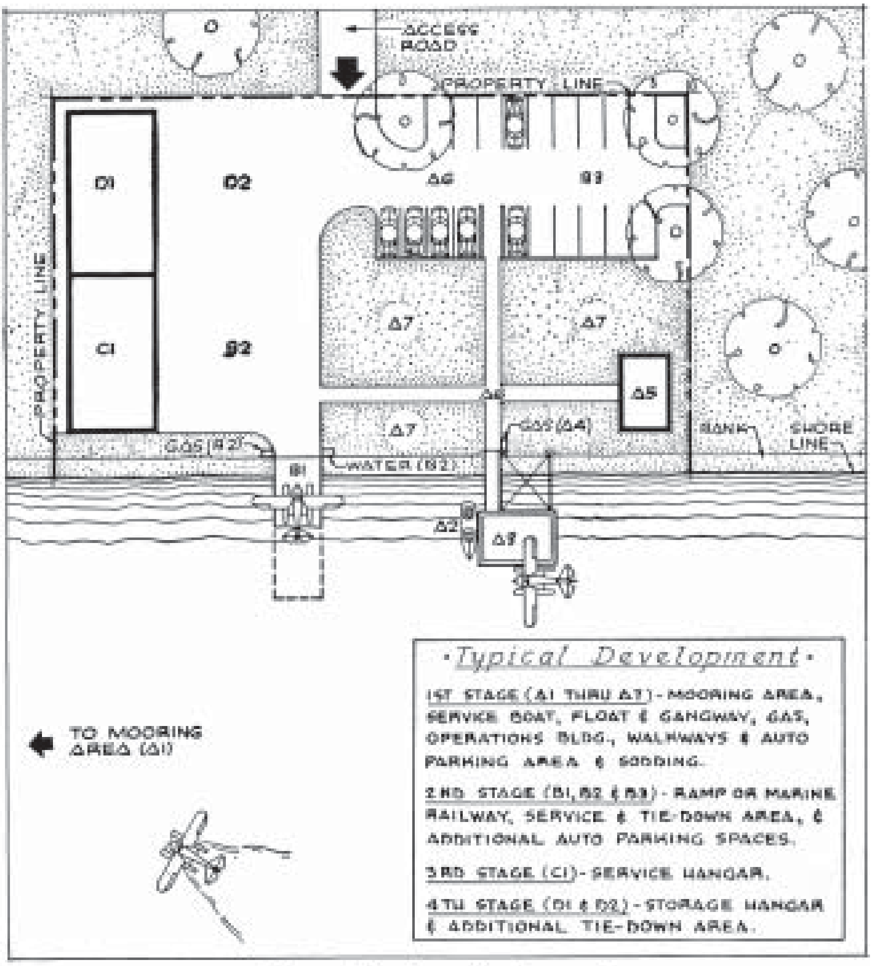


Figure 12. **Stage Development**

services, loading, and unloading of aircraft may be accomplished. A fresh water supply should be installed at the ramp to wash down planes before they are placed in their on-shore parking positions. As more users are frequenting the facility, more parking area has been included. Where required, the shore line should be stabilized. or bulkheaded at this stage in order to provide for present and future needs. The planting of all trees and shrubs should also be accomplished.

Stage 3

This stage provides for the construction of a service hangar which will permit the operator to appreciably increase the type and quality of seaplane services. The addition of this unit will make it possible to provide all-weather services such as minor and major repairs and limited aircraft storage.

Stage 4

The principal work undertaken in the final stage consists of a storage hangar and additional tie-down parking apron. Expansion of the operations building may also be undertaken to provide revenue-producing facilities such as a lunchroom, aviation display rooms, public observation space, and amusement equipment.

IV. Design and Construction

Because of the wide variety of designs of structures which will give satisfactory service, no effort will be made in this section to give other than general design criteria. By adhering to these general requirements, units may be constructed that best fit the individual's needs and finances.

In all cases, sound engineering practices should be followed to insure adequate strength and life of the various members of these structures. Inasmuch as materials of construction are a matter of choice and convenience, they have been left to the discretion of the builder.

Shore-Line Installations

The standards recommended for those installations located along the shoreline are basic. Conformance with them will produce practical units designed for a maximum of operational safety and ease. These units may be utilized as individual installations or in numerous combinations, depending upon the extent of development desired. Where stage development is planned, the units should be so located as to fit properly into the master plan.

Piers

The commonest forms are the small pier, wharf (dock), and modifications thereof. When fixed structures are used for commercial operations (pas-

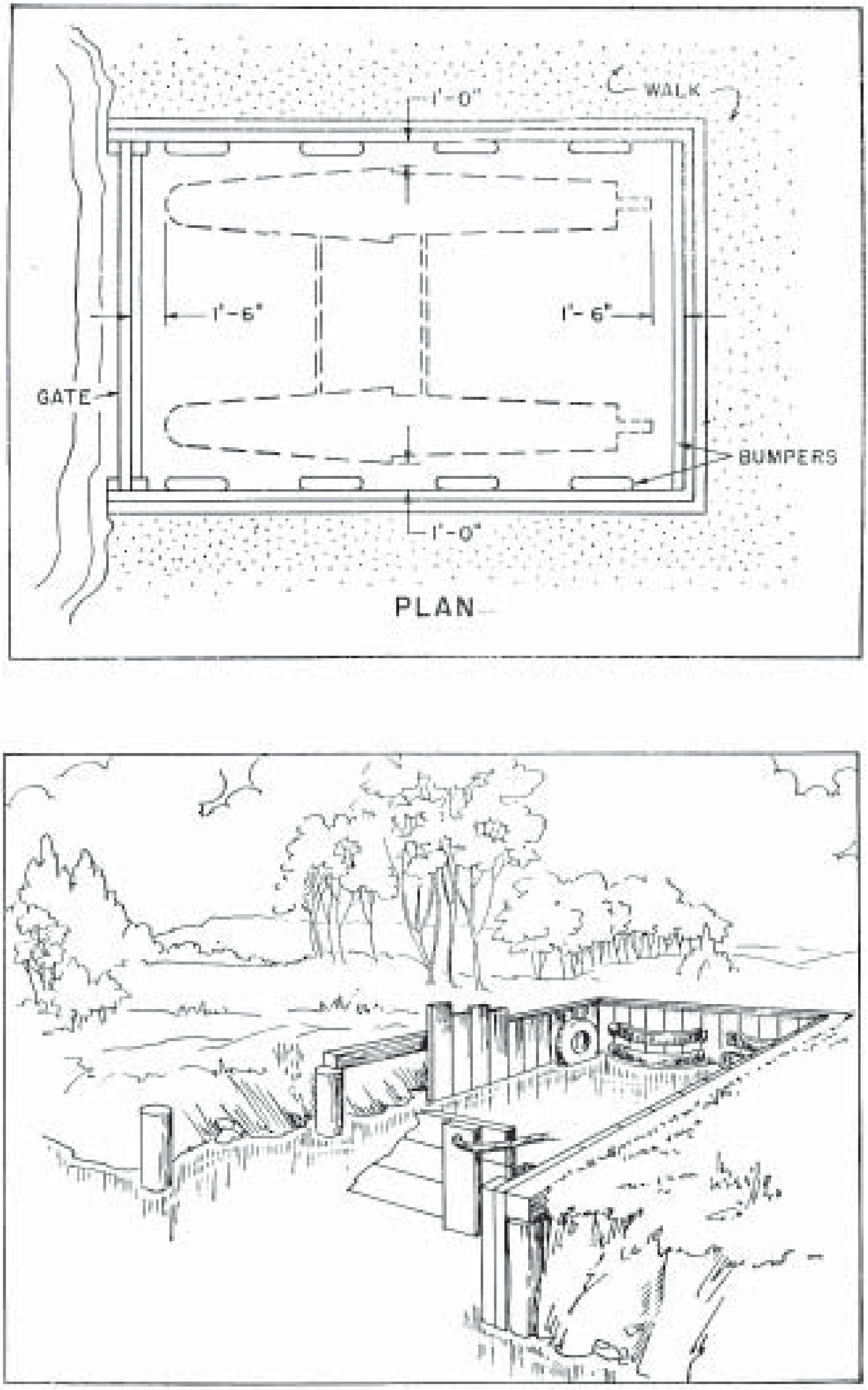


Figure 13. **Seaplane Slip-Way**

sengers and cargo), the supporting timbers and decking must be designed to support live loads of at least 100 pounds per square foot.

In most locations timber piers are least expensive. Decking spaced with a l/2-inch gap between planks will allow for drainage and expansion. Since piers and wharves are constructed with decks above mean high water, it is evident that most of the timber supporting members will be subject to alternate wetting and drying. To prevent decay, creosoted or similarly treated timbers must be used.

Where piling is to be used in the construction of a facility, water jetting is an easy and inexpensive method of setting a pile in a bottom consisting of sand, gravel, or similar loose materials. Details of this process can be obtained from most engineering textbooks.

Unless temporary use of seaplane facilities is contemplated, all piers, wharves (docks), gangways, floats, ramps, marine railways, bulkhead walls, and appurtenances should be constructed with a view to maximum permanency. The additional cost of non-corrosive metal fittings and creosote-treated timber members is usually offset by the increased durability and greater life expectancy they insure.

A table of wood preservative treatment is included in the appendix.

Slipways

Personal seaplane owners may in some cases want private slip ways in which to berth their planes. The principal requirement for this unit is that it be located where the water-level change is not greater than 2 feet and a minimum low-water depth of 2 feet. Figure 13 shows an inexpensive slipway which provides an excellent berth for a small float plane. The inside dimensions of the slipway should be 2 to 3 feet wider and 3 to 4 feet longer than the rudder-down float length. A gate should be provided to reduce wave action. Some form of bumper protection, such as old automobile tires and cut strips of tires, should be attached to the inside of the rear wall, sides, and gate to prevent damage to the aircraft floats. It is also advisable to provide some means of tying-up the aircraft while in the slipway.

Floats

All floats must have sufficient buoyancy to support the maximum anticipated loads. A small float (10 feet by 15 feet) for handling and tying-up a single plane should be able to support loads up to 2,000 pounds. Larger floats intended to provide tie-up for two or more aircraft should be capable of supporting gross loads up to 4,000 pounds. Floats as narrow as 7 feet can be used where a long, floating, dock facility parallel to the shore is desired. A good basic float for average operations would be approximately 20 feet wide and 30 feet long. The long side should parallel the shore-line

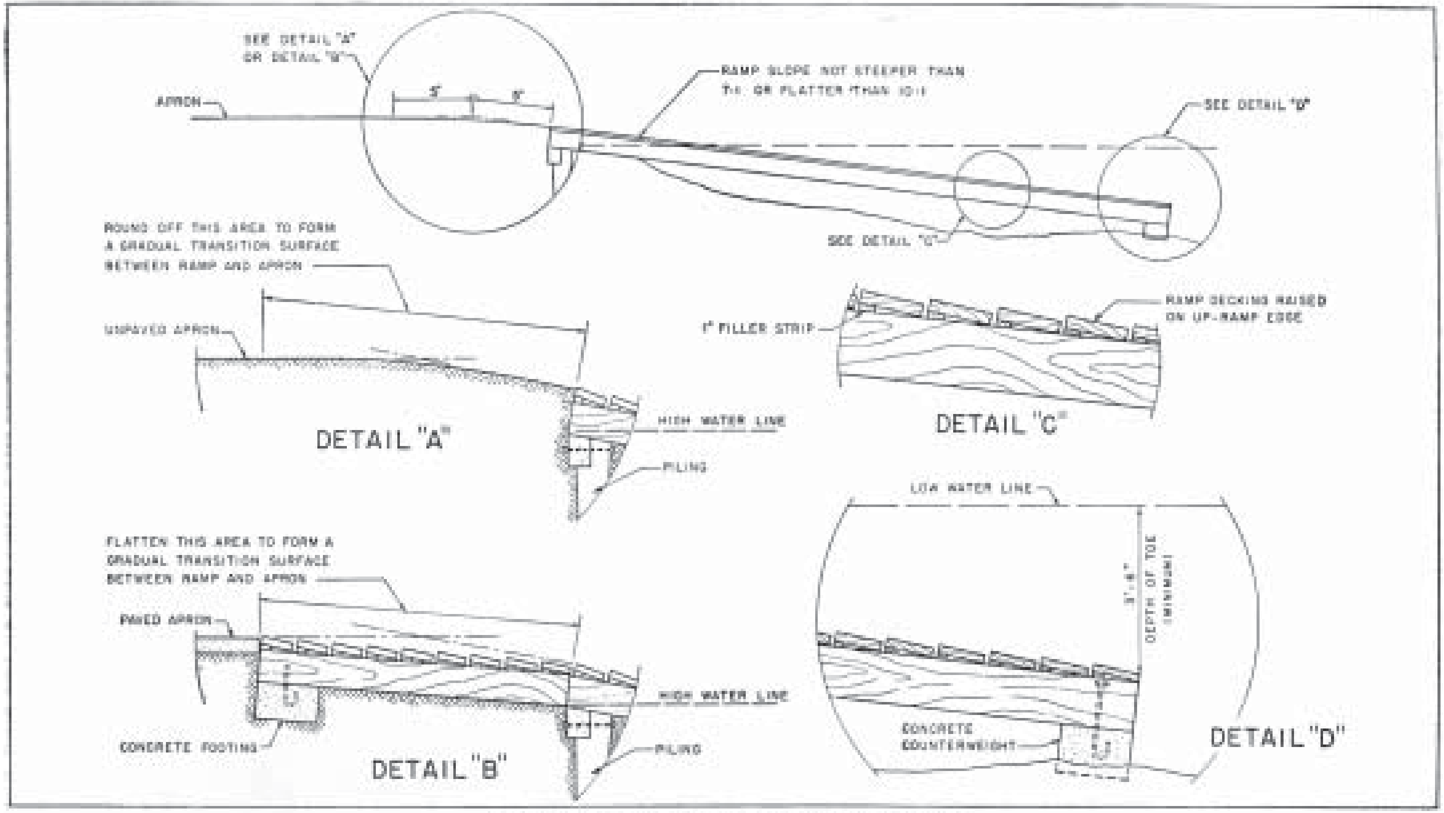


Figure 14. **Details of Ramp Construction**

or bulkhead. Tie-up cleats should be provided approximately 5 feet apart along the sides to facilitate the tying-up of aircraft. In this connection a continuous 2-inch by 4-inch wood rail raised approximately 2 inches above the float deck will permit making lines fast at any point along the sides. Corner posts can also be extended slightly above the deck, thereby serving as ballards. Bumpers for the protection of floats must be provided along those sides of the structure from which aircraft will operate.

Floats equipped with ramps at each end make good operational structures where amphibian aircraft are to be accommodated. The aircraft pulls up alongside the outer face of the float as the aircraft outrigger float rides up the ramp. An incline of approximately 8 to 1 is recommended for a ramp of this type.

Where the water level fluctuates in excess of 10 feet, special provisions must be made so that the shore hinge points of the attachment booms and gangway can be raised or lowered as the water level rises and falls. Figure 15, page 41, illustrates this principle at a site where the seasonal water level is subject to considerable variation.

The necessary buoyancy of floats can be obtained by placing watertight drums under the wooden superstructure. Fifty-five gallon steel drums have proved to be highly satisfactory and are commonly used. Drums should be placed symmetrically around the perimeter of the float to insure stability and can be fastened to the float by steel straps of sufficient length to extend around the drum and a main framing member of the float. If additional support is required, other drums can be placed under the central portion of the float. The load supporting characteristics of steel drums are shown in Table 2.

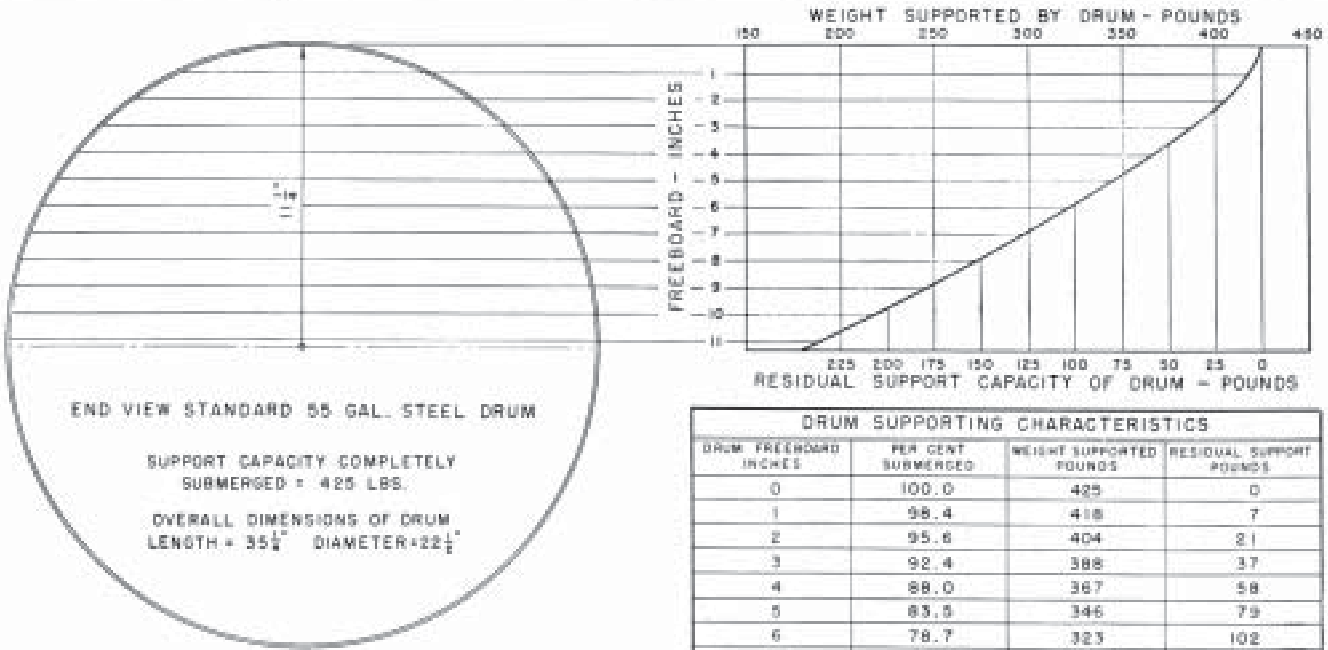
Satisfactory floats can be improvised by using life rafts, small floating docks, pontoons, and other similar equipment which can be obtained in the open market.

In remote regions where large and relatively straight timber is available, it may be desirable to construct a raft-type float. Useful data, relative to the weight and floatation characteristics of milled and unmilled timber, are given in Table 3.

Lumber used in float construction should be suitable treated as previously mentioned under Piers. All metal fixtures should be thoroughly cleaned and given one or two coats of red lead, tar, or asphaltic paint. Aluminum, magnesium, and alloys of these metals deteriorate in salt water and hence their use is discouraged. Where possible and practical, floating structures should be removed from the water periodically and retreated with preservatives in order to properly protect them.

Ramps

Ramps may vary widely in size, shape, and type from rough-log inclines to heavy-duty wood-decked, steel and concrete structures of fixed and hinge-type



FREEBOARD = VERTICAL DISTANCE TOP OF DRUM TO WATER LINE
WATER DISPLACED BY DRUM = 485 LBS.
WEIGHT OF STEEL DRUM = 60 LBS. (AVERAGE)
EFFECTIVE SUPPORT OF DRUM = 425 LBS.

DRUM SUPPORTING CHARACTERISTICS

DRUM FREEBOARD INCHES	PER CENT SUBMERGED	WEIGHT SUPPORTED POUNDS	RESIDUAL SUPPORT POUNDS
0	100.0	425	0
1	98.4	418	7
2	95.6	404	21
3	92.4	388	37
4	88.0	367	58
5	83.5	346	79
6	78.7	323	102
7	73.5	297	128
8	68.3	272	153
9	62.7	244	181
10	56.8	216	209
11	51.5	190	235

Table 2. **Load Supporting Characteristics of Standard 55 Gallon Drum**

FLOTATION

THE FREEBOARD OF UNTREATED TIMBERS AND LOGS MAY BE CLOSELY APPROXIMATED BY TAKING ONE-THIRD OF THE DEPTH OR DIAMETER OF THE MEMBERS.*
TREATED MEMBERS, BECAUSE OF THEIR ADDITIONAL WEIGHT, FLOAT DEEPER, HENCE HAVE LESS FREEBOARD THAN UNTREATED ONES OF THE SAME SIZE.

* BASED ON AVERAGE WEIGHT OF WOOD - 40 LBS. PER CUBIC FOOT

WROUGHT IRON & STEEL PIPE

INTERNAL DIA. INCHES	WEIGHT PER FOOT - POUNDS	
	STANDARD	EXTRA STRONG
2	3.65	5.02
2½	5.79	7.66
3	7.57	10.25
3½	9.11	12.50
4	10.79	14.98

WEIGHTS OF COMMON SUBSTANCES

SOLIDS			LIQUIDS		
SUBSTANCE	POUNDS PER CU. FT.		SUBSTANCE	POUNDS PER GALLON	POUNDS PER CUBIC FOOT
	AIR DRY	GREEN			
WOOD - GENERAL	40		CREOSOTE	8.7	65
BIRCH	44	57	GASOLINE	6.0	45
CHESTNUT	30	55	KEROSENE	6.7	50
CYPRESS	32	51	OIL - LUBRICATE	7.6	57
FIR	27-34	38-46	PAINT - MARINE	12.0	90
HEMLOCK	28	41-50	TURPENTINE	7.3	54
OAK	41-47	64	WATER		
PINE	25-41	35-55	FRESH	8.4	62.5
POPLAR	28	38	SALT	8.6	64
SPRUCE	28	33	ICE		56
CONCRETE	144		SNOW		8

Table 3. **Timber Weight and Flotation Data**

construction. Fixed ramps are usually weighted down or attached to a fixed in-water footing and a stable on-shore installation such as a sea wall. On the other hand, hinged ramps are permitted to rise and fall with the water by means of a hinged end on the shore side with the toe end of the incline in the water buoyed to a predetermined depth. Fixed ramps are not considered practical, nor is the additional cost justified where the water level variation is in excess of 8 feet. Ordinarily, piling or piers will be required to support the stringers of fixed ramps. Decking can be laid diagonally or at right angles to the line of travel with a 1/2-inch space between planks. The up-ramp edge of each plank should be raised about 1 inch to permit the hull of the plane to slide easily and to provide safer footing for personnel walking on the ramp. Figure 14 show this and other details of ramp design. All spikes, nails, and bolts used in attaching the decking should be countersunk to avoid damage to floats or tires.

Marine Railways

Where the shore is steep the most adaptable and desirable equipment for removing aircraft from the water is the marine railway. The railway consists of a pair of lightweight rails placed on a suitable support that slopes into the water and a flanged-wheel platform car which rides the rails. A suitable power unit of some sort must also be provided to draw the platform up the rails to the higher ground level. The car will return by gravity when the rail-slope ratio is 8 to 1 or steeper. A reversible power winch properly rigged with an endless cable will usually he required to return the platform to the water level if the incline is less than 8 to 1.

In all cases where a marine railway is used, it must extend far enough below mean low water so that the platform carriage can be dropped low enough to permit aircraft to taxi on the carriage with ease. A platform 20 feet wide, 20 to 30 feet in length, and inclined at a slope of 7 or 8 to 1, will handle the largest aircraft. The depth below mean low water to which the toe of the platform can be lowered will be the same as recommended for ramps.

The most economical type of support for the rails consists of a continuous line of timber stringers directly under and linear to the rails which in turn are supported by transverse ties. Pile bents are generally required in the water area and at all points ashore where the soil is too unstable for other types of foundations. If the soil at the shore end of the railway is stable and not subject to erosion, concrete piers or timber sleepers may be used and at considerable less cost than pile bents. Steel and iron are ordinarily used in fabricating the carriage to provide sufficient weight to submerge the wood platform and to keep the wheels from jumping the rails when an aircraft taxis on the platform. The platform should be decked in the same manner as a ramp.

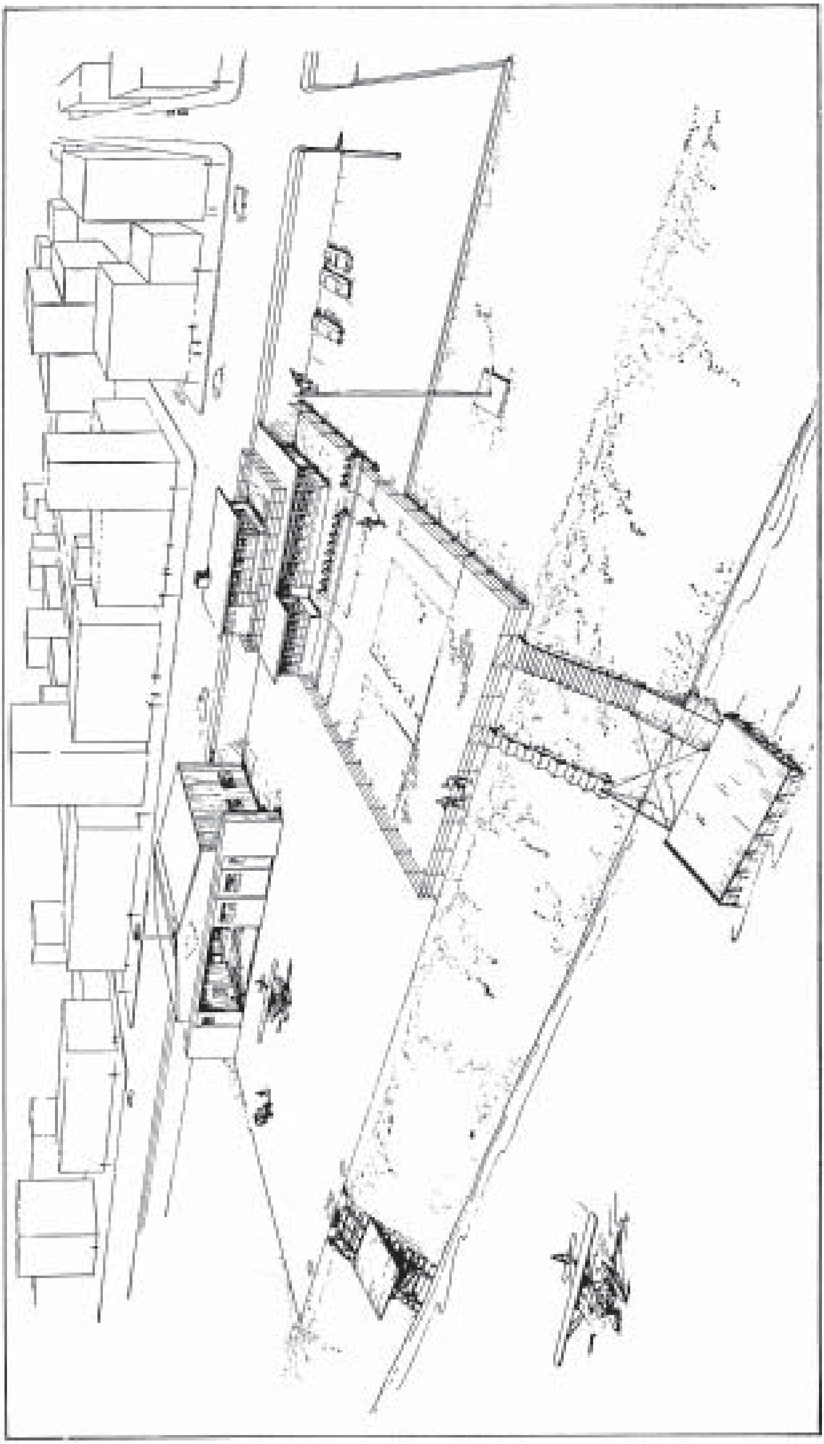


Figure 15. Marine Railway and Float

The ease of operations may be increased materially by adding a catwalk adjacent to the sides of the traveling platform or between the rails. Such an arrangement enables those using the installation to reach the traveling platform, regardless of its position along the incline. For convenient turning of aircraft, a turntable may be installed on the traveling platform.

Figure 15 shows a marine railway installation at a location where the water level varies considerably during the year.

Hoisting Equipment

Where installations are developed along a high sea wall, high bulkhead, or steep bank, it may be necessary to install a hoisting device such as a jib crane, pillar crane, or guyed derrick to facilitate the removal of aircraft from the water.

There are many types of cranes or derricks which can be constructed of suitable local wood. Steel units may also be obtained as a standard prefabricated product from manufacturers. Hoisting devices of these types are usually operated by gasoline or electric motors; however, a geared hand winch is adequate to lift most light seaplanes. Detail information on the capacity, design, and installation of hoisting equipment may be found in appropriate engineering reference books.

Hoisting equipment should be capable of lifting a gross load equivalent to three times the maximum weight of aircraft to be handled. Cable and band-type slings will be necessary accessories to handle aircraft not equipped with hoisting eyes. Types of hoisting equipment and their utilization will vary with the operating needs of the individual site, hence a detail discussion will not be attempted here.

Mooring and Marking Details

Many methods of providing seaplane moorings and facility marking will produce satisfactory results. Several such methods are detailed in the following text. The Visual Air Marker described herein is a Civil Aeronautics Administration standard.

Anchors

Anchors vary in weight and shape depending on the use for which they are intended and the type of holding ground. Normal bottoms such as sand, clay, or similar formations permit the use of anchors which will “dig in.” Deep, soft, mud and silt bottoms require the use of mushroom-type or large base-area anchors which will not sink excessively into the sludge. For shale, smooth, rock or other hard bottoms a much heavier anchor will be necessary since the weight of the anchor is the principal holding factor. A 5.to.1O-pound cast-iron or steel boat anchor will be satisfactory, under normal con-

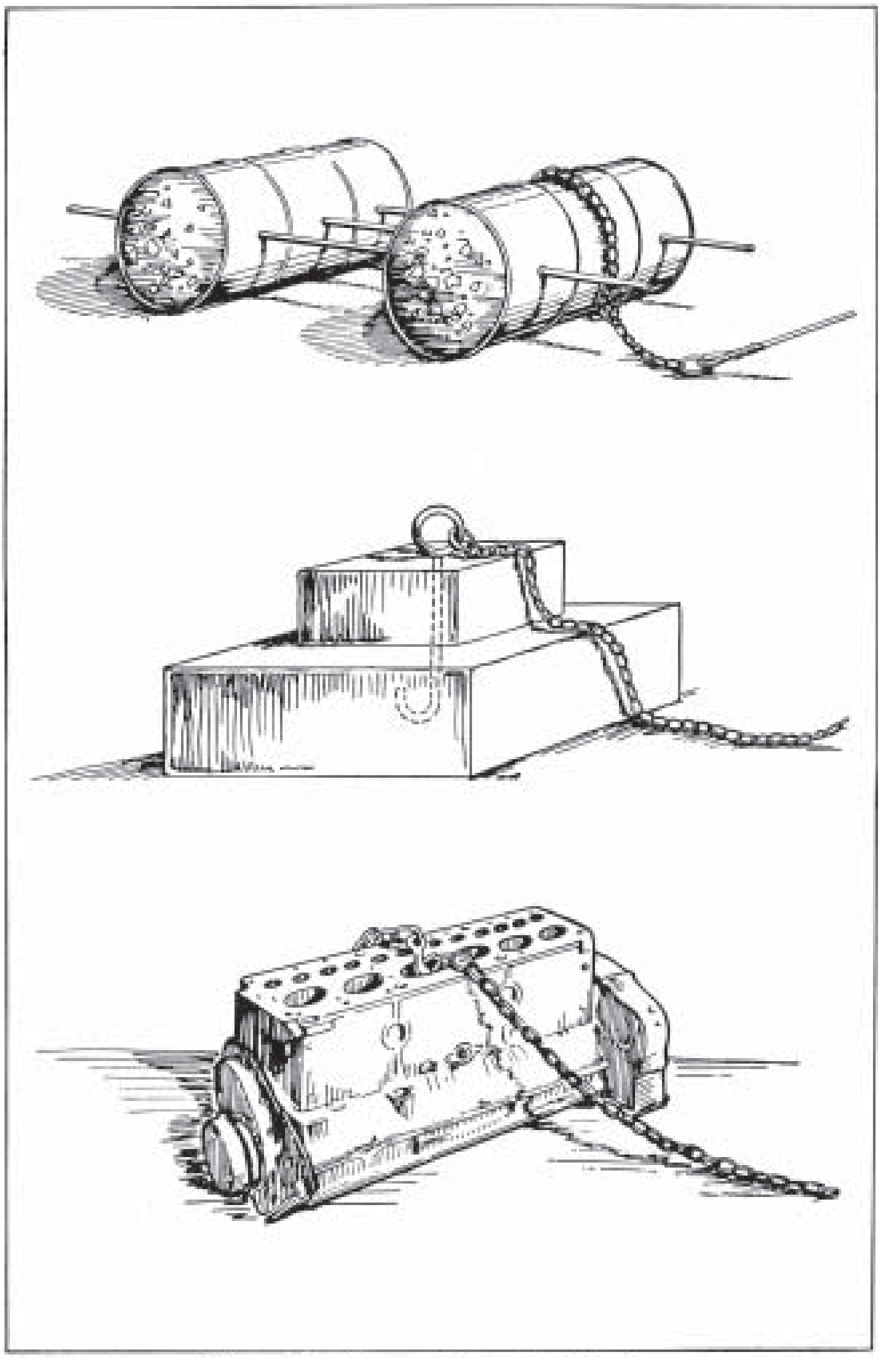


Figure 16. Types of Improvised Anchors

PROPERTIES OF WIRE ROPES & CHAINS

WIRE ROPE

SIZE	WEIGHT PER FT. – LBS.	WEIGHT PER FT. IN WATER–LBS.	APPROX. SAFE WORK LOAD LBS.	APPROX. BREAK LOAD – LBS.
¼"	0.10	0.08	880	4400
⅜"	0.22	0.17	1920	9600
½"	0.39	0.30	3360	16800
⅝"	0.62	0.49	5000	25000
¾"	0.89	0.70	7000	35000
⅞"	1.20	0.94	9200	46000
1"	1.58	1.24	12000	60000

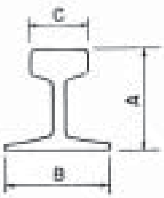
CHAINS

¼"	0.80	0.70	800	3200
⅜"	1.60	1.40	1800	7200
½"	2.60	2.27	3300	13200
⅝"	4.00	3.49	4800	19200
¾"	5.90	5.14	6800	27200
⅞"	8.00	6.97	9300	37200
1"	10.00	8.72	12000	48000

WEIGHTS OF STEEL BARS

SIZE INCHES	WEIGHT – POUNDS PER FOOT	
	SQUARE ■	ROUND ●
⅜	.478	.376
½	.850	.668
⅝	1.328	1.043
¾	1.913	1.502
⅞	2.603	2.044
1	3.400	2.670

STEEL RAILS



WEIGHT PER YARD – POUNDS	DEPTH–A INCHES	WIDTH–B INCHES	WIDTH–C INCHES
30	3 ⅛	3 ⅛	1 11/16
40	3 ½	3 ½	1 ⅞
60	4 ¼	4 ¼	2 ⅜
80	5	5	2 ½
100	5 ¾	5 ¾	2 ¾

Table 4. **Weight and Strength Characteristics of Wire Rope and Chain; Steel Rails and Bars**

ditions, for a temporary or emergency aircraft mooring. These anchors are also excellent for temporary night-lighting buoys or flotation lighting gear.

When computing the weight of permanent mooring or lighting-fixture anchors, the reduction in weight due to their submersion must be considered. The apparent weight reduction is equal to the weight of the water displaced by the anchor. Permanent marker or lighting-buoy anchors, other than typical boat anchors, should not weigh less than 250 pounds when submerged. Anchors for small aircraft mooring buoys should not weigh less than 600 pounds when submerged, and should be constructed so as to prevent rolling on the bottom. An excellent mooring-buoy anchor for aircraft of gross weights up to 15,000 pounds can be made from two large steel drums or wooden barrels filled with concrete and connected by heavy iron pipes 2 to 3 inches in diameter. A mooring-buoy unit of this kind will have a gross weight of approximately 2,200 pounds and a submerged weight of about 1,320 pounds. If a small aircraft mooring-buoy anchor is desired, a single-barrel unit constructed as above outlined will be satisfactory. One or two old automobile engines, chained to the anchor line will also provide an excellent, cheap, and easily obtained anchor. Anchors described above are shown on figure 16.

Anchor Lines

In addition to anchor lines being of required length, as previously covered in the section regarding anchorage areas, they must have certain other characteristics if they are to prove satisfactory. The strength of anchor lines normally is based on the safe working load being equal to or greater than the gross weight of the anchor. Under most wind and water conditions a 1/4-inch wire rope or chain will be strong enough for mooring aircraft up to 3,000 pounds gross weight, and 1/2-inch anchor chains or wire ropes will be satisfactory for mooring aircraft up to 15,000 pounds gross weight. In fresh water, mooring lines of the size indicated will remain serviceable for several years. In salt or brackish waters, due to the rapid deterioration of metals, the minimum sizes recommended above should be increased by 1/8-inch, unless stainless steel rope is used. A practical application would be to attach 25 to 50 feet of 5/8-inch or 3/4 -inch chain to the anchor and attach the anchor line to the other end of this heavy chain. Such an arrangement will materially reduce the strain and shock on the aircraft when riding in rough water or heavy swells.

Table 4 gives the weight and strength characteristics of wire rope and chain for determining anchor-line sizes.

Copper or bronze fittings should not be used in direct contact with steel fittings or lines unless they are insulated. Without insulation, electrolysis will take place.

Galvanized screw or pin shackles are recommended at the buoy and will allow the buoy to rotate on the anchor line. Where wire rope is used, the

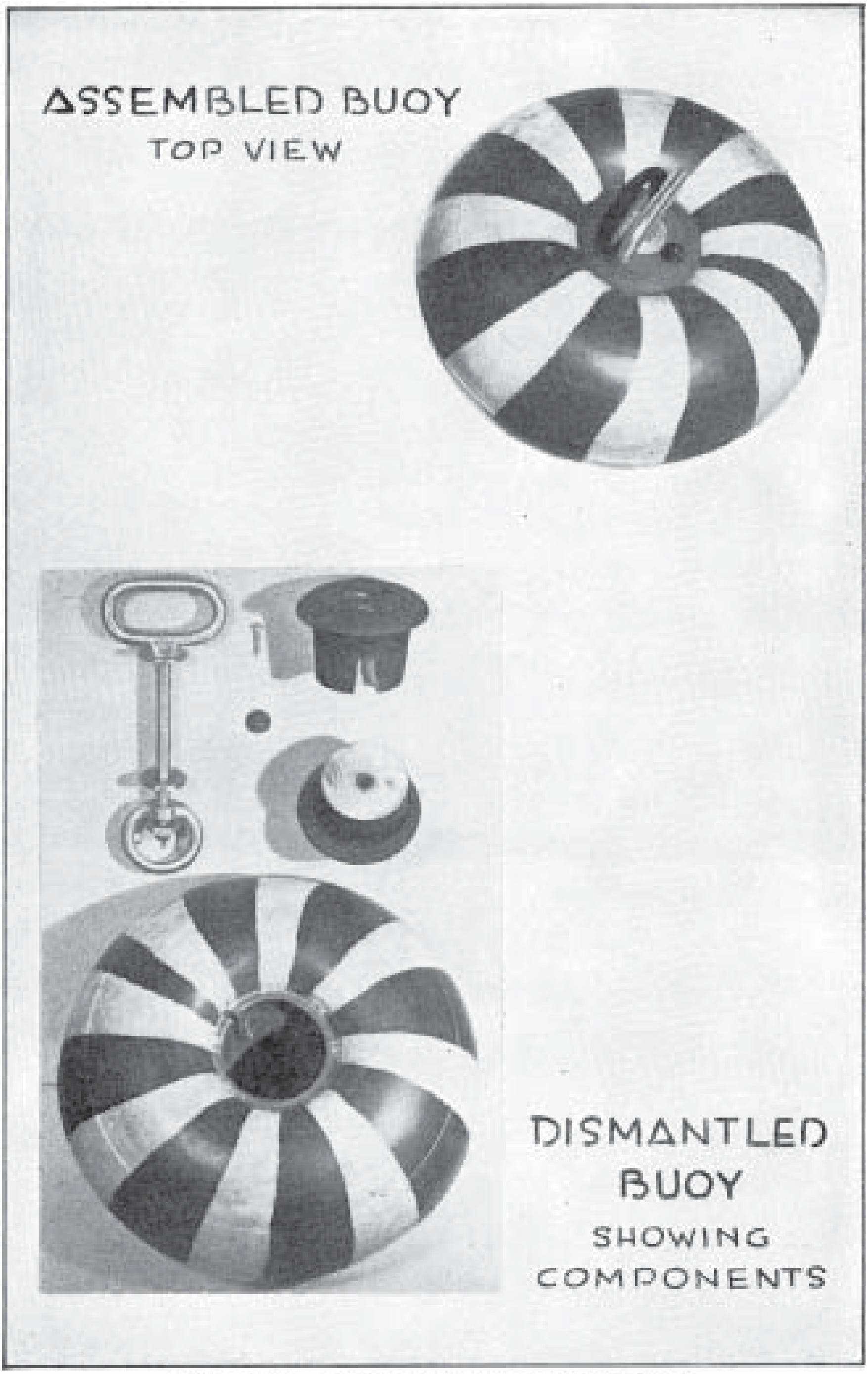


Figure 17. Small Mooring and Marker Buoy

ends should be doubled back over a thimble and made fast with rope clips or clamps.

Mooring Buoys

A mooring buoy must support the weight of the wire rope or anchor line. In addition, it will have to support flag standards, extra fittings, or lighting accessories when such extra equipment is required.

Marine supply houses offer many types and styles of mooring buoys which, with modifications, will fulfill the requirements for seaplanes. Any buoy which might damage floats or hulls if inadvertently struck during water operations should not be used.

Figure 17 shows a small mooring and marker buoy. Figure 18 illustrates the installed buoy in use with a bridle and shackle for mooring a seaplane.

Lighting

For night operations, water-lane lighting must be provided. The simplest and cheapest method is to install portable battery-operated lights on suitable buoys or flotation gear anchored along the left side of the lane when heading in the direction of landing. Underwater lighting is practical but it is a

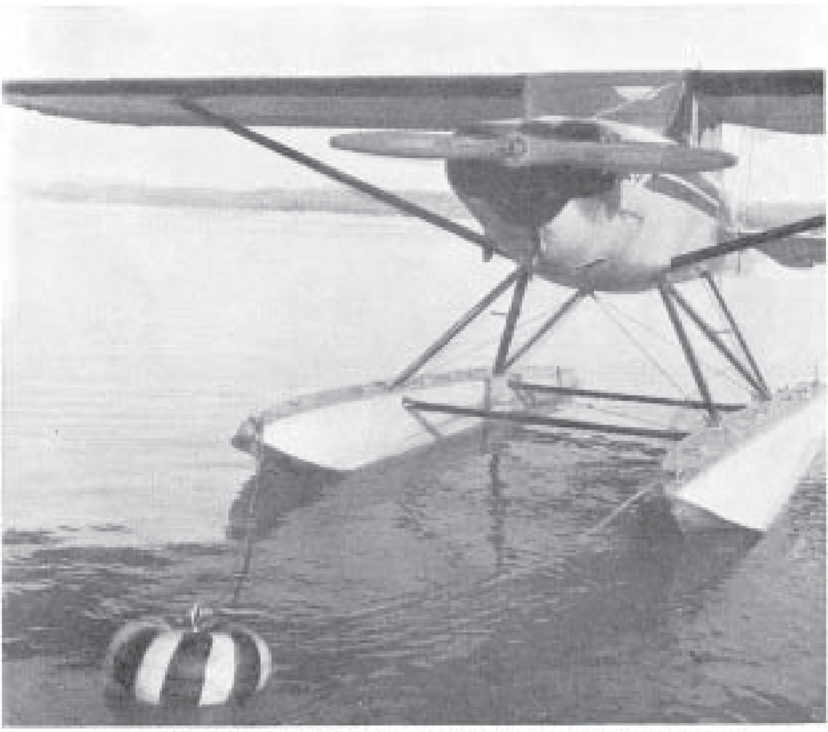


Figure 18. Seaplane Moored to Buoy with Bridle and Shackle

more elaborate and costly installation. Flood or spotlights should be installed on the shore to illuminate the floats, ramps, and piers.

Detailed recommendations regarding beacon and obstruction lighting are contained in the following publications:

> Civil Aeronautics Administration Technical Standard Order N7 “Army-Navy-Civil Uniform Requirements for the Operation of Beacon Lights.” *December* 4, 1947.
>
> Civil Aeronautics Administration Technical Standard Order N2 “Army-Navy-Civil Uniform Requirements for Lighting Obstructions to Air Navigation.” *December* 16, 1946.

Visual Air Marking

Established seaplane facilities should be air marked in accordance with Civil Aeronautics Administration Technical Standard Order Nlla “Seaplane Facility Visual Air Marker.” The standardized seaplane facility marker established by this Technical Standard Order is shown in the Appendix.

Appendix

Table 5

Civil Aircraft, Square Miles of Inland Water and Urban Population by States

State	Civil aircraft, March 1, 1949			1940 square miles inland water	1940 urban population (thousands)
	All	Seaplanes	Percent		
New York	4, 626	293	6. 33	[1] 1, 647	11, 166
Washington	2, 249	158	7. 03	[1] 1, 215	922
Michigan	4, 422	155	3. 51	[1] 1, 194	3, 455
Pennsylvania	4, 215	123	2. 92	288	6, 587
California	10, 735	99	0. 92	[1] 1, 890	4, 902
Florida	2, 709	93	3. 43	[1] 4, 298	1, 046
Minnesota	2, 118	93	4. 39	[1] 4, 059	1, 390
Ohio	4, 392	93	2. 12	[1] 100	4, 613
Illinois	4, 662	81	1. 74	[1] 453	5, 810
Massachusetts	1, 425	77	5. 40	[1] 350	3, 859
Maine	635	75	11. 81	[1] 2, 175	343
New Jersey	1, 676	72	4. 30	[1] 314	3, 395
Wisconsin	2, 183	64	2. 93	[1] 1, 439	1, 679
Oregon	1, 789	60	3. 35	[1] 631	532
Louisiana	1, 051	51	4. 85	[1] 3, 346	980
Texas	7, 640	44	0. 58	[1] 3, 695	2, 911
Connecticut	694	42	6. 05	[1] 110	1, 158
West Virginia	669	31	4. 63	91	534
Indiana	2, 765	29	1. 05	[1] 86	1, 887
New Hampshire	315	28	8. 89	[1] 280	283
Iowa	2, 388	27	1. 13	294	1, 084
Missouri	2, 277	26	1. 14	404	1, 961
Tennessee	1, 212	21	1. 73	285	1, 027
Virginia	1, 443	19	1. 32	[1] 916	945
Maryland	1, 007	18	1. 79	[1] 690	1, 080
North Carolina	1, 775	15	0. 85	[1] 3, 570	974
Arkansas	1, 159	14	1. 21	377	431
Nebraska	1, 781	14	0. 79	584	514
Kansas	3, 092	13	0. 42	163	754
Mississippi	710	13	1. 83	296	432
Oklahoma	2, 424	12	0. 50	636	880
District of Columbia	673	11	1. 63	8	663
Kentucky	863	10	1. 16	286	849
Alabama	993	9	0. 91	[1] 531	856
Rhode Island	206	7	3. 40	[1] 156	653
Montana	1, 028	7	0. 68	822	212
Georgia	1, 375	7	0. 51	358	1, 073
North Dakota	1, 093	5	0. 46	611	132
Colorado	1, 320	5	0. 38	280	591

[1] State on ocean or Great Lakes.

Table 5—Continued

Civil Aircraft, Square Miles of Inland Water and Urban Population by States—Con.

State	Civil aircraft, March 1, 1949			1940 square miles inland water	1940 urban population (thousands)
	All	Seaplanes	Percent		
South Dakota	915	5	0.55	511	158
Nevada	417	5	1.20	738	43
Idaho	843	5	0.59	749	177
Vermont	210	4	1.90	331	123
South Carolina	737	3	0.41	[1] 461	466
New Mexico	743	3	0.40	155	176
Arizona	1,228	3	0.24	329	174
Utah	536	3	0.56	2,570	305
Delaware	235	2	0.85	79	139
Wyoming	511	1	0.20	408	94
States	94,164	2,048			
Territories	1,084	171			
TOTAL	95,248	2,219		45,259	

[1] State on ocean or Great Lakes.

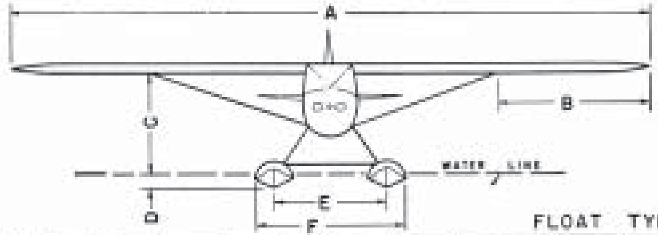
Table 6

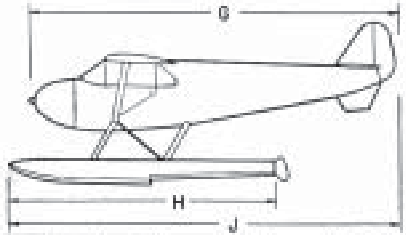
Tidal Range of Coastal Cities of the United States

[NOTE: Figure shown is spring [1] or diurnal [2] range, whichever is the greatest]

City	State	Feet	City	State	Feet
Eastport	Maine	20.7	Cape Hatteras	N. C.	4.3
Portland	Maine	10.2	Wilmington	N. C.	3.4
Boston	Mass.	11.0	Cape Fear	N. C.	5.1
Newport	R. I.	4.4	Charleston	S. C.	6.0
Bridgeport	Conn.	8.0	Savannah	Ga.	8.6
New Haven	Conn.	7.3	Atlantic Beach	Fla.	6.0
Port Chester	N. Y.	8.6	Miami	Fla.	3.0
Port Jefferson	N. Y.	7.7	Key West	Fla.	1.6
Montauk Point	N. Y.	2.4	Tampa	Fla.	2.0
Patchogue	N. Y.	.8	Apalachicola	Fla.	1.3
Rockaway	N. Y.	4.7	Mobile	Ala.	1.5
New York	N. Y.	5.3	Barataria Bay	La.	0.9
Red Bank	N. J.	3.6	Galveston	Tex.	1.4
Asbury Park	N. J.	5.0	Aransas Pass	Tex.	1.5
Atlantic City	N. J.	5.0	Brazos Santiago	Tex.	1.3
Cape May	N. J.	5.3	San Diego	Calif.	5.8
Wilmington	Del.	5.7	Los Angeles	Calif.	5.4
Ocean City	Md.	4.1	San Francisco	Calif.	5.7
Cape Charles	Va.	2.8	Eureka	Calif.	6.7
Baltimore	Md.	1.3	Kernville	Oreg.	6.1
Washington	D. C.	3.3	Astoria	Oreg.	8.2
Norfolk	Va.	3.0	Seattle	Wash.	11.3

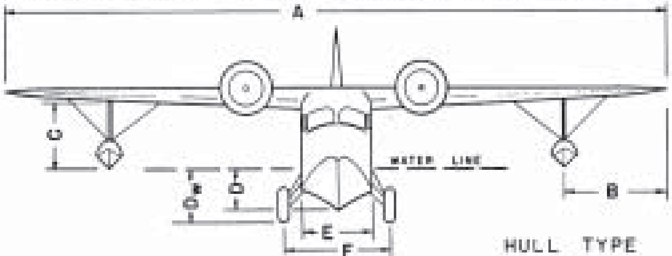
[1] Spring Range—Average difference between high and low water at new or full moon.
[2] Diurnal Range—Difference between mean higher high and mean lower low water.

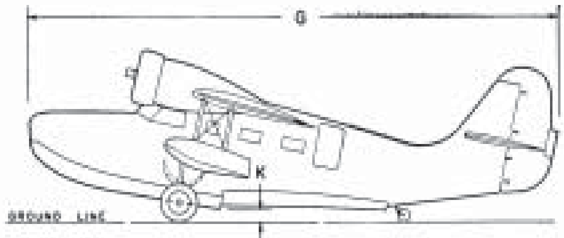




FLOAT TYPE

WT. GROUP POUNDS	A		B		C		D		E		F		G		H		J		REMARKS
	MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	
1200 - 1500	35'-0"	36'-3"	6'-9"	8'-1"	6'-0"	6'-9"	1'-0"	1'-2"	6'-3"	6'-3"	8'-0"	8'-4"	19'-9"	22'-6"	14'-8"	14'-10"	21'-0"	23'-0"	ADD MAX. OF 1'-6" TO FLOAT LENGTH FOR WATER RUDDER DOWN
1500 - 3000	32'-9"	36'-6"	7'-1"	7'-8"	6'-3"	7'-0"	1'-1"	1'-3"	6'-3"	7'-10"	8'-6"	10'-4"	20'-9"	26'-0"	14'-4"	17'-0"	22'-0"	27'-0"	
3000 - 5000	32'-0"	42'-0"	9'-0"	14'-0"	8'-0" •	8'-9"	1'-6"	1'-10"	8'-4"	9'-7"	10'-10"	12'-7"	24'-3"	27'-9"	19'-4"	21'-3"	26'-0"	30'-6"	• BI-PLANE = 3'-3"
5000 - 10000	47'-6"	51'-9"	9'-0"	14'-0"	8'-9" •	10'-0"	1'-10"	2'-2"	10'-3"	14'-0"	15'-6"	17'-9"	31'-9"	36'-3"	24'-9"	28'-9"	33'-9"	39'-6"	• L.W. MONOPLANE = 5'-0"

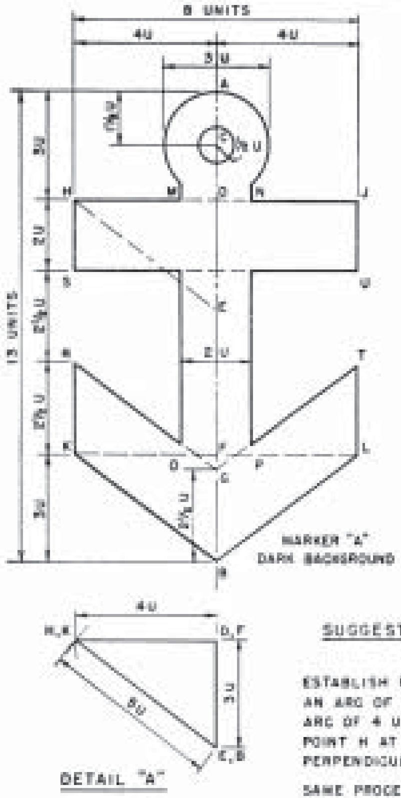


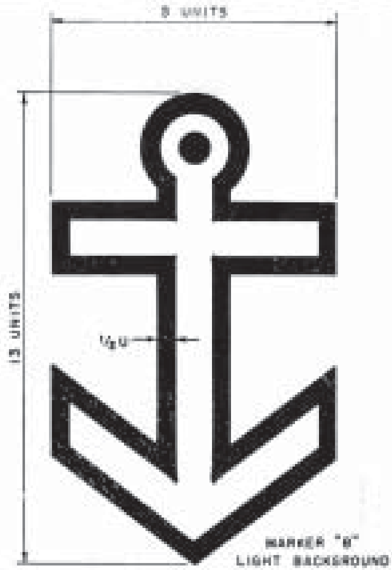


HULL TYPE

WT. GROUP POUNDS	A		B		C		D		Dw		E		F		G		K	REMARKS
	MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	MIN.	
2000 - 3000	34'-3"	36'-0"	5'-0"	5'-9"	2'-4"	3'-6"	1'-2"	1'-6"	2'-4"	2'-6"	3'-4"	4'-0"	5'-9"	8'-0"	24'-0"	26'-0"	0'-4"	FIGURES SHOWN INCLUDE BOTH SINGLE AND TWIN ENGINE AIRCRAFT.
3000 - 5000	37'-6"	40'-0"	5'-6"	6'-0"	3'-9"	4'-3"	1'-3"	1'-9"	2'-6"	3'-0"	4'-2"	4'-3"	7'-6"	8'-0"	27'-9"	31'-0"	0'-3"	"Dw" = GEAR FULLY EXTENDED
5000 - 15000	49'-0"	67'-0"	7'-10"	10'-10"	5'-0"	5'-0"	2'-0"	2'-9"	3'-6"	4'-0"	5'-0"	6'-0"	7'-6"	12'-8"	35'-0"	49'-0"	0'-6"	"K" = NORMAL CONDITIONS

Table 7. **Water-Borne Aircraft Dimensional Data by Aircraft Weight Groups**





SUGGESTED METHOD OF ERECTING PERPENDICULARS
DETAIL "A"

ESTABLISH POINT E ON LINE AB, 3 UNITS FROM POINT D. SWING AN ARC OF 5 UNITS RADIUS FROM POINT E AND AN INTERSECTING ARC OF 4 UNITS RADIUS FROM POINT D, THEREBY ESTABLISHING POINT H AT THEIR INTERSECTION. LINE HD WILL THEN BE PERPENDICULAR TO LINE AB.

SAME PROCEDURE TO BE FOLLOWED AT POINTS F, B, K.

LAYOUT PROCEDURE

1. ESTABLISH CENTER LINE OF MARKER AB 13 UNITS LONG.
2. ESTABLISH POINTS C, D, E, F AND G ALONG AB. LINE DE IS 3 UNITS LONG.
3. ERECT PERPENDICULARS DH AND FK. (SEE DETAIL "A")
4. PRODUCE LINE HD 4 UNITS TO J AND LINE KF 4 UNITS TO L.
5. ESTABLISH POINTS M, N, O AND P ESTABLISHING SHAFT OF ANCHOR 2 UNITS WIDE.
6. ESTABLISH POINTS R AND S BETWEEN K AND H AND T AND U BETWEEN L AND J.
7. CONNECT POINTS HS, RK, JU, TL, RG, TG, BK, BL, SU AND HJ.
8. SCRIBE ½ UNIT AND 1½ UNIT RADIUS CIRCLES ABOUT POINT C AND COMPLETE SHAFT.

UNIT DIMENSIONS FOR VARIOUS MARKER SIZES

MARKER LENGTH	MARKER WIDTH	UNIT DIMENSION
9'-9"	6'-0"	0' - 9"
13 - 0	8 - 0	1 - 0
16 - 3	10 - 0	1 - 3
19 - 6	12 - 0	1 - 6
22 - 9	14 - 0	1 - 9
26 - 0	16 - 0	2 - 0
32 - 6	20 - 0	2 - 6
39 - 0	24 - 0	3 - 0

NOTE:
ONE UNIT EQUALS 1/13TH OF OVERALL LENGTH

THIS DRAWING APPLIES TO TSO-N11

Seaplane Facility Visual Air Marker

Wood Preservation

If marine structures are to give long service it is imperative that some form of protection be afforded to prevent or inhibit the attacks of various types of insects, fungi, and marine borers. The termite, which is the most common and destructive of the insects, inhabits practically all areas of the United States. This insect most frequently enters the wood at or near the ground line. Fungi may be found, and will develop any time, where there is a proper amount of air, warmth, food, and moisture. The discharge of various waste material into bodies of water is often conducive to the growth of various wood-destroying fungi. The prevalence of marine borers is world-wide, and although they are usually found in salt or brackish waters slight infestation is at times found in rivers above the point of brackishness.

Some of the more generally used preparations for the preservation of woods are creosote materials, tar products, petroleum oils, zinc chloride preparations, and' arsenic compounds. The various treatments using these types of preparations have advantages and disadvantages depending upon the use to which the wood is put.

The most effective type of wood treatment is obtained by a pressure process whereby the preservative is forced into the wood. This pressure process may be either a full-cell or empty-cell treatment. As these names imply, the processes differ in the amount of preservative retained in the wood.

It has been found that the best practical protection for piling in salt or fresh water is a heavy and thorough application of coal-tar creosote or a creosote coal-tar solution. The mixture and degree of treatment determines

Minimum Recommended Preservative Treatments [1]

Use	Preservative	Minimum absorption, pounds per cubic foot		Remarks
		Empty cell	Full cell	
Piling,[2] land and fresh water.	Coal tar creosote or creosote coal tar solution.	8	16	
Piling,[2] salt water	Coal tar creosote		16	Where marine borer attack not severe
Do.	do.		22	Where marine borer attack usually severe.
Structural timber, pine—less than 5 inches thick.	Coal tar creosote or creosote coal tar solution.	10	16	Full cell treatment recommended for timber used in salt water.

[1] For Douglas fir piling above treatments may be reduced 25 percent.
[2] Except Douglas fir.

the life expectancy of the timber. On page 53 is a table of recommended minimum treatments for piles and timbers to be used under various conditions.

If more detailed information on this subject is desired, the reader is referred to a Department of Agriculture publication "Wood Handbook" which is on sale through the Superintendent of Documents, Washington 25, D. C., at a cost of 75 cents per copy.