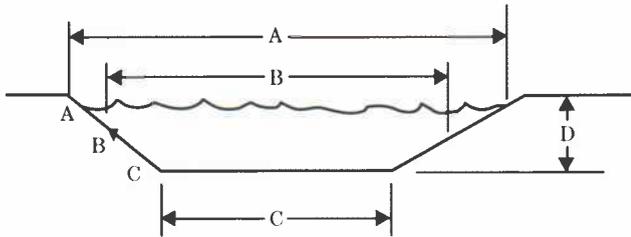


Appendix A

Estimating the Volume of an Excavated Pond

The volume of a pond can be estimated by using the prismatic formula:

$$V = \frac{(A + 4B + C)}{6} \times \frac{D}{27}$$



where:

- V = volume of excavation (yd³)
- A = area of excavation at ground level (ft²)
- B = area of excavation at the middle depth of the pond (ft²)
- C = area of excavation at the bottom of the pond (ft²)
- D = average depth of the pond in (ft)
- 27 = factor converting cubic feet to cubic yards

Note: When using meters for area and depth, 27 is not needed. The formula would then be:

$$V = \frac{(A + 4B + C)}{6} \times D$$

where:

- V = volume of excavation (m³)

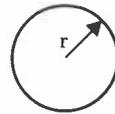
This formula can be used for ponds of any shape. The area of excavation can be determined either by planimetry on the plans or by using geometric formulas for areas. The following formulas give the area of some common shapes.

Rectangle:



Rectangle $A = wl$

Circle:



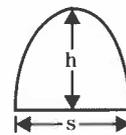
Circle $A = \pi r^2$ or $3.14r^2$

Quadrant:



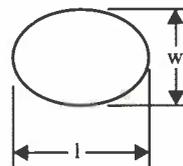
Quadrant $A = \frac{\pi}{4} r^2$ or $0.7854r^2$

Parabola:



Parabola $A = 0.67 sh$

Ellipse:

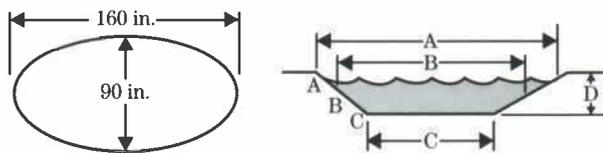


Ellipse $A = \frac{\pi}{4} wl$ or $0.7854 wl$

Example A-1 Determining the volume of an elliptical pond

As an example, determine the volume of an elliptical pond with a major axis (*l*) of 160 ft, a minor axis (*w*) of 90 ft at the surface, a depth (*D*) of 8 ft, and 2:1 side slopes. Use the prismoidal formula:

$$V = \frac{(A + 4B + C)}{6} \times \frac{D}{27}$$



Step 1: Calculate the area of the surface (*A*) using the formula,

$$\text{Area} = \frac{(\pi)}{4} wl \text{ for an ellipse}$$

$$A = \frac{3.14}{4} (90 \times 160)$$

$$A = 11,304 \text{ ft}^2$$

Step 2: Determine the dimensions of the bottom (*C*). Since the side slopes are 2:1 and depth is 8 feet, the bottom will be 16 feet narrower than the surface. The bottom dimensions would then be 58 feet (*w*) by 128 feet (*l*).

Step 3: Calculate the area of the bottom (*C*) using

$$C = \frac{3.14}{4} (58 \times 128)$$

$$C = 5,828 \text{ ft}^2$$

Step 4: Determine the dimensions of the middle depth (*B*). Since the middle depth lies equally between the surface and the bottom, the dimensions can be determined by adding the surface and bottom dimensions together and dividing by 2.

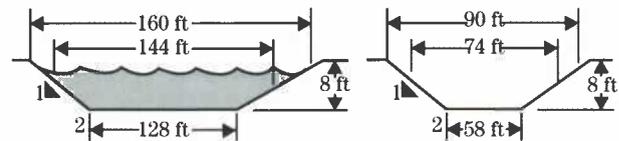
$$\frac{160 + 128}{2} = 144 \text{ (major axis)}$$

$$\frac{90 + 58}{2} = 74 \text{ (minor axis)}$$

Step 5: Calculate the area of the middle depth (*B*) using Area = (pi) *wl*.

$$B = \frac{3.14}{4} (74 \times 144)$$

$$B = 8,365 \text{ ft}^2$$



Step 6: Determine the volume in cubic yards.

$$V = \frac{[11,304 + (4 \times 8,365) + 5,828]}{6} \times \frac{8}{27}$$

$$V = \frac{50,592}{6} \times \frac{8}{27}$$

$$V = 2,498 \text{ or approx. } 2,500 \text{ yd}^3$$

Example A-2 Determining area of the surface, the middle depth, and bottom

The area of the surface, the middle depth, and bottom can also be determined by using a planimeter. In this example, the pond was drawn at a 1 inch = 40 feet scale and has a depth of 8 feet.

Step 1: Measure the surface area (*A*) using a planimeter. Convert the measurement from square inches into square feet. (A factor of 1,600 is used to convert square inches into square feet for a scale of 1 inch = 40 feet.)

$$A = 10.0 \text{ in}^2 \times 1,600 = 16,000 \text{ ft}^2$$

Step 2: Measure the middle depth (*B*) area and convert to square feet.

$$B = 7.7 \text{ in}^2 \times 1,600 = 12,320 \text{ ft}^2$$

Step 3: Measure the bottom (*C*) and convert to square feet.

$$C = 5.5 \text{ in}^2 \times 1,600 = 8,800 \text{ ft}^2$$

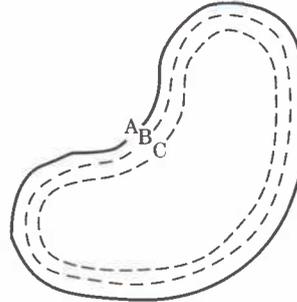
Step 4: Use the prismoidal formula to estimate volume of excavation in cubic yards.

$$V = \frac{(A + 4B + C)}{6} \times \frac{8}{27}$$

$$V = \frac{[16,000 + (4 \times 12,320) + 8,800]}{6} \times \frac{8}{27}$$

$$V = \frac{74,080}{6} \times \frac{8}{27}$$

$$V = 3,658 \text{ yd}^3$$



Scale: 1 inch = 40 feet

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Appendix B

Flood-Tolerant Native Trees and Shrubs

Flooding creates several conditions that are unfavorable to most woody species. The most critical condition appears to be the depletion of soil oxygen that is critical to plants. The lack of oxygen favors anaerobic bacteria, which can lead to the development of toxic organic and inorganic byproducts. A plant's ability to survive flooding is dependent on many factors; among them are flood depth, flood duration, flood timing, plant age and size, wave action, and substrata composition.

The plant lists in tables B-1 through B-4 were taken from the Corps of Engineers Technical Report E-79-2, Flood Tolerance of Plants: A State-of-the-Art Review. The ratings used are intended only to be a relative classification. Tolerance will vary with local conditions. The plants are divided into four groups: very tolerant, tolerant, somewhat tolerant, and intolerant. Each plant was also given a range coinciding with the plant growth regions, figure B-1, developed from USDA Miscellaneous Publication 303, Native Woody Plants of the United States, by William R. Van Dersal.

Figure B-1 Plant growth regions

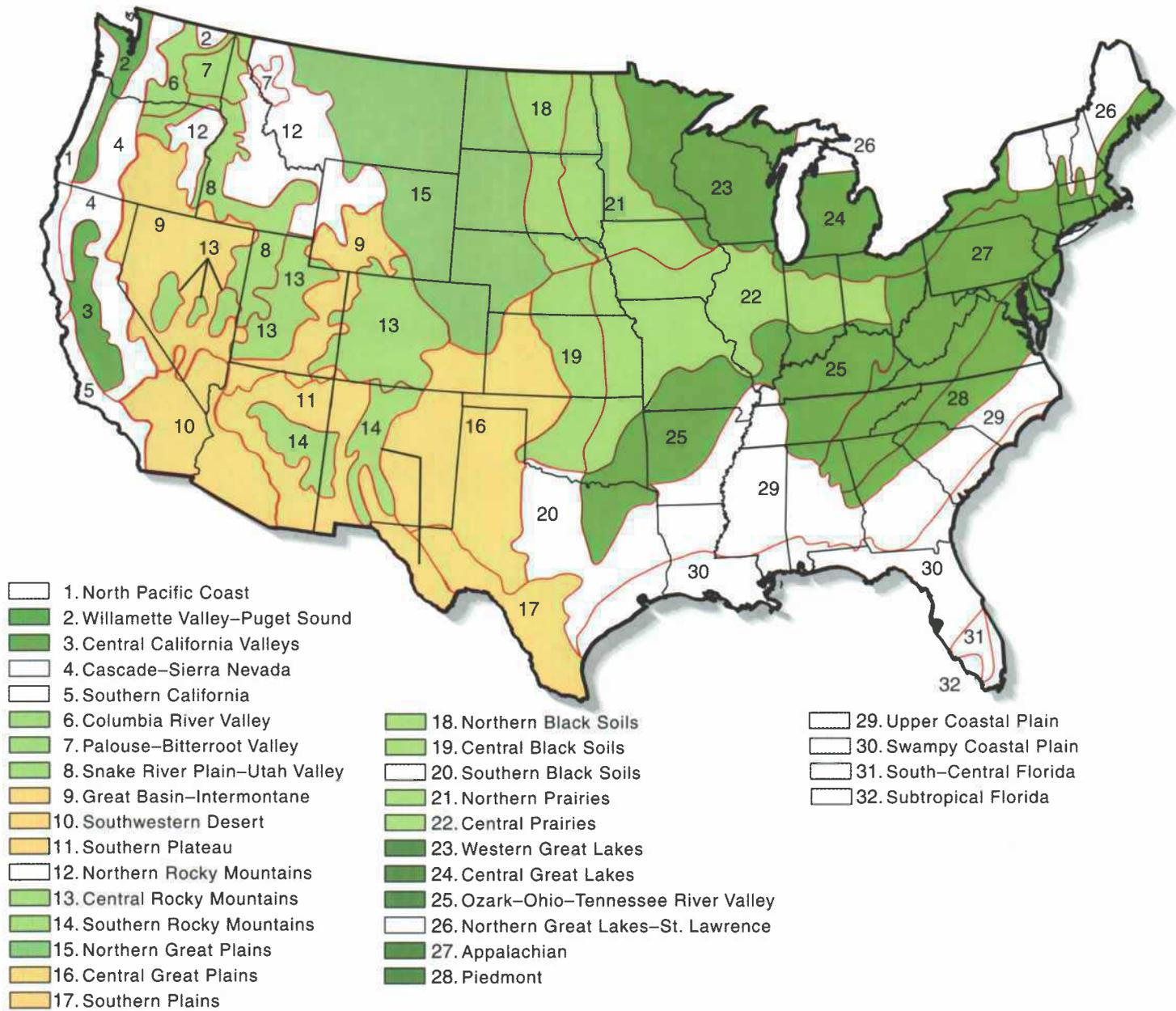


Table B-1 Flood tolerance of **very tolerant** native plants

[These plants are able to survive deep, prolonged flooding for more than 1 year.]

Scientific name	Common name	Range
<i>Carya aquatica</i>	Water hickory	20, 25, 28, 29, 30
<i>C. illinoensis</i>	Pecan	16, 20, 22, 25, 29, 30
<i>Cephalanthus occidentalis</i>	Buttonbush	3-5, 11, 16, 17, 19-30
<i>Cornus stolonifera</i>	Redosier dogwood	4, 7-9, 11-15, 18, 21 -28
<i>Forestiera acuminata</i>	Swamp privet	20, 22, 25, 29, 30
<i>Fraxinus pennsylvanica</i>	Green ash	15, 18, 20-30
<i>Gleditsia aquatica</i>	Waterlocust	20, 25, 28-30
<i>Illex decidua</i>	Deciduous holly	16, 17, 20, 25, 28-30
<i>Nyssa aquatica</i>	Water tupelo	25, 29, 30
<i>Planera aquatica</i>	Water elm	20, 25, 29, 30
<i>Quercus lyrata</i>	Overcup oak	20, 22, 25, 28-30
<i>Salix exigua</i>	Narrow leaf willow	4-16
<i>S. hookeriana</i>	Hooker willow	1
<i>S. lasiandra</i>	Pacific willow	1-5, 11, 13, 14
<i>S. nigra</i>	Black willow	16, 17, 19-30
<i>Taxodium distichum</i>	Baldcypress	17, 20, 25, 28-32

Table B-2 Flood tolerance of **tolerant** native plants

[These plants are able to survive deep flooding for one growing season, with significant mortality occurring if flooding is repeated the following year.]

Scientific name	Common name	Range
<i>Acer negundo</i>	Boxelder	17-30
<i>A. rubrum</i>	Red maple	19-30
<i>A. saccharinum</i>	Silver maple	18-30
<i>Alnus glutinosa</i>	Black alder	26-27
<i>Amorpha fruticosa</i>	False indigo	5, 10, 11, 15-29
<i>Betula nigra</i>	River birch	20, 22, 23, 25-29
<i>Celtis occidentalis</i>	Hackberry	15, 16, 18, 20-30
<i>Diospyros virginiana</i>	Persimmon	20, 22, 25, 27-31
<i>Kalmia polifolia</i>	Bog laurel	4, 12, 23, 24, 26, 27
<i>Ledum groenlandicum</i>	Labrador tea	4, 12, 23, 24, 26, 27
<i>Liquidambar styraciflua</i>	Sweetgum	20, 22, 25, 27-30
<i>Nyssa sylvatica</i>	Blackgum	20, 22, 24-30
<i>Pinus contorta</i>	Lodgepole pine	2, 4, 10, 12-15
<i>Platanus occidentalis</i>	Sycamore	16, 20-22, 24-30
<i>Populus trichocarpa</i>	Black cottonwood	1-8, 12, 13
<i>Quercus lyrata</i>	Overcup oak	20, 22, 25, 28-30
<i>Q. palustris</i>	Pin oak	21-25, 27, 29
<i>Sambucus callicarpa</i>	Pacific red elder	1,2,4
<i>Spirea douglasii</i>	Hardhack	1-4
<i>Tamarix gallica</i>	French tamarisk	3, 4, 9-11, 13, 16, 19, 22, 25, 29, 30
<i>Thuja plicata</i>	Western redcedar	1, 2, 4, 6, 7, 12
<i>Ulmus americana</i>	American elm	15, 16, 18-23, 25-30
<i>Vaccinium uliginosum</i>	Blueberry	1, 4, 12-14, 23, 24, 26, 27

Table B-3 Flood tolerance of **somewhat tolerant** native plants

[These plants are able to survive flooding or saturated soils for 30 consecutive days during the growing season.]

Scientific name	Common name	Range
<i>Alnus rugosa</i>	Hazel alder	20, 22-29
<i>Carpinus caroliniana</i>	Ironwood	20-30
<i>Celtis laevigata</i>	Sugarberry	11, 16, 17, 20, 22, 25, 29, 30
<i>Cornus nuttallii</i>	Pacific dogwood	1-5
<i>Crataegus mollis</i>	Downy hawthorn	
<i>Fraxinum americana</i>	White ash	20, 22-25, 27-30
<i>Gleditsia triacanthos</i>	Honeylocust	16, 20, 22-27, 29, 30
<i>Ilex opaca</i>	American holly	20, 25, 27-30
<i>Juglans nigra</i>	Black walnut	18-30
<i>Juniperus virginiana</i>	Eastern redcedar	18, 20-29
<i>Malus spp.</i>	Apple	
<i>Morus rubra</i>	Red mulberry	16-25, 27-30
<i>Ostrya virginiana</i>	Eastern hophornbeam	15, 18, 20-25, 27-30
<i>Picea stichensis</i>	Sitka spruce	1
<i>Pinus echinata</i>	Shortleaf pine	20, 25, 27-30
<i>P. ponderosa</i>	Ponderosa pine	4
<i>Populus grandidentata</i>	Bigtooth aspen	21-23, 25-28
<i>Quercus alba</i>	White oak	20, 22-30
<i>Q. bicolor</i>	Swamp white oak	21-28
<i>Q. imbricaria</i>	Shingle oak	22-25, 27, 28
<i>Q. macrocarpa</i>	Bur oak	15, 16, 18-30
<i>Q. nigra</i>	Water oak	17, 20, 25, 28-30
<i>Q. phellos</i>	Willow oak	20, 25, 27-30
<i>Q. rubra</i>	Northern red oak	21 -27
<i>Rhus glabra</i>	Smooth sumac	6-9, 11, 14, 15, 17-31
<i>Tilia americana</i>	American basswood	20-27
<i>Tsuga heterophylla</i>	Western hemlock	1, 2, 4, 6, 12
<i>Ulmus alata</i>	Winged elm	17, 20, 25, 28-30
<i>U. rubra</i>	Red elm	25, 27, 29
<i>Viburnum prunifolium</i>	Blackhaw	20, 22-25, 27-30

Table B-4 Flood tolerance of **intolerant** native plants

[These plants are unable to survive more than a few days of flooding during the growing season without significant mortality.]

Scientific name	Common name	Range
<i>Acer macrophyllum</i>	Bigleaf maple	1-5
<i>A. saccharum</i>	Sugar maple	15, 18, 21-29
<i>Alnus rubra</i>	Red alder	1, 2, 5, 6
<i>A. sinuata</i>	Sitka alder	2, 4, 6, 7, 12
<i>Betula lutea</i>	Yellow birch	21-28
<i>B. papyrifera</i>	Paper birch	12, 13, 15, 18, 21-24, 26, 27
<i>B. populifolia</i>	White birch	24, 26-28
<i>Buxus sempervirens</i>	Boxwood	
<i>Carya cordiformis</i>	Bitternut hickory	20, 22-30
<i>C. laciniosa</i>	Shellbark hickory	22, 24, 25, 27, 28, 29
<i>C. ovata</i>	Shagbark hickory	21-30
<i>C. tomentosa</i>	Mockernut hickory	20, 22, 24, 25, 27-30
<i>Cercis canadensis</i>	Eastern redbud	22-25, 27-30
<i>Cornus florida</i>	Flowering dogwood	20, 22-25, 27-30
<i>Corylus avellana</i>	Filbert	
<i>C. rostrata</i>	Hazel	15, 18, 21-29
<i>Cotoneaster spp.</i>	Cotoneaster	
<i>Fagus grandifolia</i>	American beech	20, 22-30
<i>Gymnocladus dioica</i>	Kentucky coffeetree	19, 21-25, 27
<i>Ilex aquifolium</i>	Holly	
<i>Philadelphus gordonianus</i>	Mock orange	4, 6-8, 12
<i>Picea abies</i>	Norway spruce	
<i>P. pungens</i>	Colorado spruce	9, 12, 13, 14
<i>P. rubens</i>	Red spruce	27
<i>Pinus strobus</i>	Eastern white pine	21-24, 27
<i>P. taeda</i>	Loblolly pine	19, 20, 22, 25, 28-30
<i>Populus tremuloides</i>	Quaking aspen	1, 2, 4, 6-9, 11, 15, 18, 21-27
<i>Prunus americana</i>	Wild plum	12-25, 27-30
<i>P. emarginata</i>	Bitter cherry	1, 2, 4, 6, 8-14
<i>P. laurocerasus</i>	Cherry-laurel	
<i>P. serotina</i>	Black cherry	11, 18-30
<i>Psuedotsuga menziesii</i>	Douglas fir	
<i>Pyrus rivularis</i>	Wild apple	1, 2, 4
<i>Q. marilandica</i>	Blackjack oak	16, 19, 20, 22, 24, 25, 27-30
<i>Q. muehlenbergii</i>	Chinquapin oak	11, 16, 20-30
<i>Q. shumardii</i>	Texas oak	16, 20, 22, 24, 25, 27-29
<i>Q. stellata</i>	Post oak	19, 20, 22, 25, 27-30
<i>Q. velutina</i>	Black oak	20, 22-30
<i>Rhamnus purshinana</i>	Cascara	1-4, 6, 7, 9, 11, 12
<i>Rubus procerus</i>	Blackberry	

Table B-4 Flood tolerance of **intolerant** native plants—Continued.

[These plants are unable to survive more than a few days of flooding during the growing season without significant mortality.]

Scientific name	Common name	Range
<i>Sassafras albidum</i>	Sassafras	20, 22-30
<i>Sorbus aucuparia</i>	Rowan tree	21, 22, 27
<i>Symphoricarpos occidentalis</i>	Snowberry	15, 18, 21-24
<i>Syringa vulgaris</i>	Lilac	
<i>Thuja occidentalis</i>	American arborvitae	22-24, 26, 27
<i>Tsuga canadensis</i>	Eastern hemlock	22-25, 27, 28

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