Prepared in cooperation with the Rhode Island Water Resources Board

Hydrologic, Vegetation, and Soil Data Collected in Selected Wetlands of the Big River Management Area, Rhode Island, From 2008 Through 2010

Data Series 666

U.S. Department of the Interior
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Cover. Clockwise starting with top left -

A. Herbaceous-survey plot at Cedar Swamp, West Greenwich, Rhode Island
(photo taken by Jason Sorenson)

B. Instrument shelter at Scarboro Swamp, West Greenwich, Rhode Island
(photo taken by Meredith Borenstein)

C. Vegetation at Cedar Swamp, West Greenwich, Rhode Island
(photo taken by Robert Breault)

D. Bear Brook near the piezometer cluster site, Coventry, Rhode Island
(photo taken by Jason Sorenson)

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Acknowledgments

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Conversion Factors and Datum

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
acre	4,047	square meter (m^2)
acre	0.4047	hectare (ha)
square foot (ft^2)	0.09290	square meter (m^2)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:
°F=(1.8×°C)+32
Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:
°C=(°F–32)/1.8
Vertical coordinate information is referenced to the National Geodetic Vertical Datum of 1929 (NGVD of 1929).
Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).
Altitude, as used in this report, refers to distance above the vertical datum.

Acronyms and Abbreviations

BRMA	Big River Management Area
dbh	diameter at breast height
GIS	geographic information system
GPS	Global Positioning System
MM	management model
PVC	polyvinyl chloride
RIWRB	Rhode Island Water Resources Board
URI	University of Rhode Island
USGS	U.S. Geological Survey

Hydrologic, Vegetation, and Soil Data Collected in Selected Wetlands of the Big River Management Area, Rhode Island, From 2008 Through 2010

By Meredith S. Borenstein,[1] Francis C. Golet,[2] David S. Armstrong,[1] Robert F. Breault,[1] Timothy D. McCobb,[1] and Peter K. Weiskel[1]

Abstract

The Rhode Island Water Resources Board planned to develop public water-supply wells in the Big River Management Area in Kent County, Rhode Island. Research in the United States and abroad indicates that groundwater withdrawal has the potential to affect wetland hydrology and related processes. In May 2008, the Rhode Island Water Resources Board, the U.S. Geological Survey, and the University of Rhode Island formed a partnership to establish baseline conditions at selected Big River wetland study sites and to develop an approach for monitoring potential impacts once pumping begins. In 2008 and 2009, baseline data were collected on the hydrology, vegetation, and soil characteristics at five forested wetland study sites in the Big River Management Area. Four of the sites were located in areas of potential drawdown associated with the projected withdrawals. The fifth site was located outside the area of projected drawdown and served as a control site. The data collected during this study are presented in this report.

Introduction

Water demand in Rhode Island is increasing (Deb and others, 1991; Wild and Nimiroski, 2004; Granato and Barlow, 2005). Concerned that increases in demand may exhaust the capacity of existing water supplies, the Rhode Island Water Resources Board (RIWRB) proposed the establishment of public supply wells in the Big River Management Area (BRMA). The BRMA encompasses 8,600 acres [3,480 hectares (ha)] within the Pawtuxet River watershed and includes parts of the towns of Coventry, Exeter, and West Greenwich (fig. 1).

The BRMA is composed mainly of upland and wetland forest [4,374 acres (1,770 ha) of needle-leaved evergreens and 1,781 acres (721 ha) of deciduous trees] and nonforested wetlands [1,288 acres (521 ha)]. In addition, the area contains 233 acres (94 ha) of agricultural lands and 407 acres (165 ha) of gravel mining, residential development, and other land uses (Rhode Island Geographic Information System, 2005). The dominant wetland types in the management area are riverine marshes, scrub-shrub and forested wetlands, riverine open water, and ponds (Rhode Island Geographic Information System, 1993). The Big River flows north into the Flat River Reservoir.

[1]U.S. Geological Survey
[2]University of Rhode Island

Previous Studies in the Big River Management Area

Several U.S. Geological Survey (USGS) reports have been published on water resources within the Big River watershed. Craft (2001) documented a hydrogeologic data collection effort. Stone and Dickerman (2002) described the geologic setting and properties of the glacial sediments, including the results of aquifer tests. Granato and others (2003) described the development and simulations of a numerical model designed to analyze the effects of selected groundwater development options on streamflow. Granato and Barlow (2005) described the optimization techniques used to evaluate the potential effects of instream-flow criteria and water-supply demands on groundwater development options and resultant streamflow depletions in the Big River area.

Research Objectives

The overall goal of the study described here was to increase understanding of the wetlands of the BRMA and lay the groundwork for assessing potential impacts of groundwater withdrawals on these wetlands and their ecological processes. The specific objectives were to (1) establish baseline conditions at selected Big River wetland study sites prior to installation of proposed public supply wells, and (2) develop a protocol for monitoring potential impacts of groundwater withdrawal on those wetlands once pumping begins. In addition, this study was designed to improve understanding of surface water and groundwater interaction in the wetlands of the BRMA.

Methods and Baseline Data

Baseline ecological conditions for Big River wetlands were established through selection and delineation of representative study sites; monitoring of site hydrology using nested piezometers, water-table wells, and surface moisture measurements; sampling of vegetation structure, floristic composition, and relative wetness; and description of soil profiles, thickness of organic-rich layers, and hydraulic properties.

Selection of Wetland Study Sites

Wetlands were selected for evaluation based on their location within areas of water-table drawdown projected by management model 9 (MM09; Granato and Barlow, 2005). This groundwater flow model estimates the amount of groundwater that may potentially be withdrawn from three basins in the study area (Big River Basin, Carr River Basin, and Mishnock River Basin) when constrained by streamflow requirements and by the maximum rates of withdrawal at 13 existing and hypothetical well sites. Wetlands within the projected drawdown areas were identified through inspection of the Rhode Island Geographic Information System (Rhode Island Geographic Information System, 1993) wetlands database, the Rhode Island Soil Survey (Rector, 1981), USGS topographic maps, stereoscopic interpretation of panchromatic aerial photographs from 1980, and examination of true-color digital orthophotographs taken in 2004. A list of threatened and endangered species, obtained from the Rhode Island Natural Heritage Program, also was used to identify potential wetland study sites of interest in the BRMA (Enser, 2007).

An initial pool of 15 potential wetland study sites included a variety of wetland types, hydrogeomorphic settings, water regimes, soil types, and degrees of drawdown. During field visits, these wetland study sites were evaluated in terms of minimum acceptable size [less than 40 meters (m) wide] for vegetation sampling, lack of disturbance by humans or beavers, and accessibility. Wetlands along the main stem of the Big River were not considered because of the biannual water-level manipulation downstream at the Flat River Reservoir. Five sites were selected for study (fig. 1). Four wetland study sites (fig. 2) from north to south (Bear Swamp, Reynolds Swamp, Cedar Swamp, and Scarboro Swamp) were located within areas projected for water-table drawdown under MM09. A fifth wetland study site, Congdon Mill Swamp, was selected as a control or reference site; it was located approximately 2 miles [3.22 kilometers (km)] south of Scarboro Swamp (fig. 3) and outside the area of projected drawdown. Bear, Cedar, and Scarboro Swamps were forested wetlands located along perennial streams. Reynolds Swamp was a forested wetland located northwest of Reynolds Pond and was the only site not directly associated with a flowing water body. Congdon Mill Swamp was a forested wetland that had riparian and nonriparian sections and contained the full range of soil types and water regimes found at the other four sites (table 1).

Identification of Wetland Edges

The location of the edge, or perimeter, of each wetland study site was approximated through stereoscopic interpretation of large-scale (1:12,000) aerial photographs. Toward the upland end of the baseline transect established at each site (see Establishment of Sampling Belt Transects below), the wetland edge was located and staked at the boundary between hydric (wetland) and nonhydric (upland) soils. Hydric soils were identified using criteria described by the New England Hydric Soils Technical Committee (2004). Perimeter coordinates were collected with a handheld Global Positioning System (GPS) unit. The GPS data points were then plotted using a geographic information system (GIS), and the location of the wetland perimeter was defined by interpolation (Haag and others, 2005). Study sites were mapped using GIS and classified according to the National Wetlands Inventory methodology (Cowardin and others, 1979; table 1).

Establishment of Sampling Belt Transects

At each wetland study site, a baseline transect was established that extended from the upland into, and in some cases through, the wettest part of the wetland. Three to six belt transects for sampling wetland surface moisture, groundwater levels, soils, and vegetation were laid out perpendicular to the baseline transect at a spacing of 32.8 to 144 feet (ft) [10 to 44 meters (m)], depending on the length of the baseline transect, which varied from site to site. Each belt transect was 52.4 ft (16 m) long and 19.7 ft (6 m) wide and centered on the baseline transect (fig. 4). Belt transects were located so as to maximize the diversity of ground altitude, soil types, water levels, and vegetation sampled within each wetland study site. Belt transect coordinates were collected using a GPS unit.

Monitoring Wetland Hydrology

The hydrology of each wetland study site was characterized through both groundwater measurements and surface-moisture assessments. The depth to the water table was measured biweekly during the 2009 growing season (April 15–November 30). Allen and others (1989) established these dates based on that period of the year when soil temperatures were continuously above biological zero (5 degrees Celsius) at their study site in southern Rhode Island. Shallow water-table wells were constructed of 1.25-inch (in.) [3.2-centimeter (cm)] perforated polyvinyl chloride (PVC) pipe and were capped. One well was installed near the center of each belt transect (fig. 4) and within the plant root zone to a depth ranging from 0.5 to 3 ft (0.2 to 0.9 m) below land surface, depending on the depth to a dense soil layer, if present. One belt transect at each wetland study site was instrumented with a nest of three piezometers (figs. 5–9), including one shallow piezometer, which was installed in the peat to a depth of 0.5 to 3 ft (0.15 to 0.9 m); one intermediate piezometer, which was installed to a depth of 3 to 6 ft (0.9 to 1.8 m) in either sand or peat, depending on the characteristics of the site; and one deep piezometer, which was installed in the underlying stratified sediments to a depth of 8 to 23 ft (2.4 to 7.0 m). These three piezometers were outfitted with data-loggers, which recorded water levels at 15-minute intervals.

Physical properties of piezometer sites measured continuously between July 2008 and January 2010 are available in table 2, and physical properties of piezometer sites measured intermittently between June 2008 and January 2010 are listed in table 3. Water-level data collected continuously between July 2008 and January 2010 are reported in table 4. Water-level data collected intermittently between October 2008 and December 2009 are reported in table 5.

Surface moisture was monitored monthly during the growing season at 20 sampling points along each belt transect (fig. 4). If surface water was present, the depth of the surface water was measured. If surface water was absent, the soil at the ground surface was characterized as saturated or nonsaturated, depending on whether water appeared under the pressure of a human foot. A summary of surface moisture conditions is available in table 6.

Wetland Vegetation Sampling

Trees, saplings, shrubs, herbs, and mosses growing within belt transects at each wetland study site were identified and quantified using the methods outlined below.

Plant Life Forms Sampled

Wetland vegetation was sampled in five life-form layers—trees, saplings, shrubs, herbs, and mosses (table 7). Trees were defined as woody plants with a stem diameter at breast height (dbh) of at least 5.0 in. (12.7 cm). Saplings were woody plants with a dbh ranging from 2.0 to 4.9 in. (5.1 to 12.6 cm). Shrubs were woody plants at least 3.3 ft (1.0 m) tall with stem diameter of less than 2.0 in. (5.1 cm). The herb layer included all nonwoody vascular plants except mosses, as well as woody plants less than 3.3 ft (1.0 m) tall. The only moss sampled was peat moss (*Sphagnum* spp.), which grows only in wetlands.

Vegetation Plot Size and Layout

Plants from each life-form layer were sampled in permanent plots laid out in a systematic fashion within each 19.7-ft × 52.4-ft (6-m × 16-m) belt transect (fig. 4). Fixed plots provide an ideal method for monitoring changes in vegetation over time (Haag and others, 2005). Accurate estimates of plant abundance and structural characteristics require that plot size increase with life-form height (Mueller-Dombois and Ellenberg, 2002). In this study, trees and saplings were sampled in four contiguous 258-square foot (ft^2) [24-square meter (m^2)] plots within each belt transect, shrubs were sampled in four 53.8-ft^2 (5-m^2) plots, and herbs and *Sphagnum* moss were sampled in twelve 10.8-ft^2 (1-m^2) plots (fig. 4; table 7).

To minimize human disturbance of shrubs, herbs, and mosses, no plots were located within 3.3 ft (1 m) of a belt transect center line or within 9.8 ft (3 m) of a baseline transect. One-in. (2.5-cm)-square oak stakes were used to mark the ends of each belt transect center line and two adjacent corners of each herb plot. Stakes that marked each herb plot assured that a 3.3-ft × 3.3-ft (1-m × 1-m) PVC sampling frame could be situated in exactly the same position during subsequent sampling sessions. Herb plots were later marked with landscaping nails or steel reinforcing rod so that they can be located in the future using a metal detector.

Vegetation Sampling Procedures

Trees, saplings, and shrubs were sampled between July and August 2008. Herbs and mosses were sampled between July 8 and August 8, 2008, and between June 22 and July 31, 2009. All plants except *Sphagnum* were identified to species level; taxonomy was based on Gleason and Cronquist (1991). The same investigator sampled all 252 herb plots in 2008 and 2009.

Trees, saplings, and shrubs were sampled primarily for broad characterization of the wetland study sites; hence they were only sampled during the first year of this study. Because of the persistent nature, relatively deep roots, and tolerance for variable soil and moisture conditions of these plants, the composition of the species in the plots that include trees, saplings, and shrubs is unlikely to change dramatically or quickly, even if site hydrology becomes significantly drier as a result of groundwater withdrawal. Because herbs and *Sphagnum* are very shallowly rooted, they are likely to be highly sensitive to changes in soil moisture over time; thus these life forms were sampled for site characterization purposes and to provide baseline data for assessing the potential impacts from groundwater withdrawal.

The dbh of each tree and sapling was measured in centimeters using a diameter tape, and stem density values in stems per hectare were computed. Stem basal area [measured in square meters per hectare (m^2/ha)] was computed for deciduous and evergreen species separately. Total sample size for trees and saplings ranged from 3,100 ft^2 (288 m^2) at Scarboro Swamp (three belt transects) to 6,200 ft^2 (576 m^2) at Congdon Mill Swamp (six belt transects). Values from individual belt transects were combined to produce a single value for the site. Tree canopy cover (reported as a percentage) was calculated from 18 presence-absence determinations made at 6.6-ft (2-m) intervals along the two 52.4-ft (16-m) edges of each belt transect using a densitometer (fig. 4). Canopy cover for evergreen and deciduous trees at each wetland study site was calculated as a percentage of all points sampled in a given wetland study site. Tree and sapling data are available in table 8.

All shrubs within the five 5-m^2 plots associated with each belt transect were counted by species. Shrub density was expressed as stems per square meter and as stems per hectare for each belt transect and each wetland study site. Shrub data are available in table 9.

Herbs and mosses were sampled during the 2008 and 2009 growing seasons to permit analysis of natural annual variation prior to pumping. Using cover classes (table 10), the abundance of each herb species in 2008 and 2009 was estimated visually within the 1-m × 1-m sampling frame (fig. 4). For each plot, the abundance of each species was recorded as the midpoint value of its cover class. Percent cover of herb-layer vegetation is reported in tables 11A–E. Total herb cover and *Sphagnum* cover also were estimated in each herb plot, using the same cover classes and midpoint values. Midpoint values for the 12 plots on each belt transect were averaged to obtain an estimate of cover by belt transect. Total herb and *Sphagnum* moss cover for each wetland study site were calculated as the average of all the herb plots in all belt transects in a given wetland study site (table 12).

During the late 1980s, the U.S. Fish and Wildlife Service published the National List of Plant Species that Occur in Wetlands (Reed, 1988), which assigned each species known to occur in U.S. wetlands to one of five indicator categories describing a plant's probability (or frequency) of occurrence in wetlands. Using a preliminary draft of the list, Wentworth and others (1988) devised a method using weighted averaging, for quantifying the relative wetness of a site based on the relative abundance of plants in each of the indicator categories. A numerical value, termed an ecological index, was assigned to each category and then used with the abundances of all plant species found in a plot to generate a weighted average, ranging from 1 to 5, that represented the relative wetness of that plot, based on plants. The formula for calculating this weighted average may be written as follows:

$$WA = \frac{\left[1\times\left(AOBL\right)\right] + [2\times(AFACW)] + [3\times(AFAC)] + [4\times(AFACU)] + [5\times(AUPL)]}{AOBL + AFACW + AFAC + AFACU + AUPL} \quad (1)$$

where

WA	=	weighted average
A	=	abundance, in percent cover
OBL	=	obligate wetland (ecological index 1)
FACW	=	facultative wetland (ecological index 2)
FAC	=	facultative (ecological index 3)
FACU	=	facultative upland (ecological index 4)
UPL	=	obligate upland (ecological index 5)

Tables 11A–E provide the wetland indicator status and ecological index for each herb species, as well as the weighted average for each sampling plot at the Big River wetland study sites.

Soil Sampling

Groundwater withdrawal has been associated with soil subsidence in wetlands (Rochow and Rhinesmith, 1991; Mortellaro and others, 1995). The thickness of organic-rich soil material in the BRMA was measured to provide a baseline for assessing soil subsidence in future years. Organic-rich soil material is defined to include both organic material and organic-rich mineral material as defined by the Soil Conservation Service (1993). In July 2008, the combined thickness of organic-rich soil material was estimated, using a tile probe, at six points along the center line of each belt transect; measurements were located at 6.6-ft (2-m) intervals beginning at 9.8 ft (3 m) from the baseline transect in each direction (fig. 4). The six measurements were then averaged to calculate the mean thickness of organic-rich soil material for each belt transect (table 13). Up to 36 additional measurements of organic-rich soil material were collected outside of the belt transects at each wetland study site (table 14).

In July 2009, a soil profile was described within 3.3 ft (1 m) from the center of each belt transect (fig. 4), except for Reynolds T4, where there was 2.0 ft (0.6 m) of standing water. A bucket auger was used to pull soils from the ground so horizons could be described to a depth of approximately 4.9 ft (1.5 m). Descriptions include horizon name, depth, boundary, texture, color, redoximorphic features if present, structure, and consistence (Soil Conservation Service, 1993; table 15). The abundance of roots also was noted for each soil horizon.

Soil cores were collected from five locations (one from each wetland study site) for analysis of unsaturated and saturated hydraulic properties. Cores were collected using a piston corer and slide hammer to a depth of up to 4.0 ft (1.2 m). Soil hydraulic properties are reported in table 16.

Summary

Between June 2008 and January 2010, the U.S. Geological Survey collected hydrologic, vegetation, and soil data to establish baseline conditions at selected wetland study sites and to develop an approach for monitoring potential impacts from groundwater withdrawals in the Big River Management Area, Rhode Islands. This report presents the field data collected and laboratory soil analyses performed.

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Figures

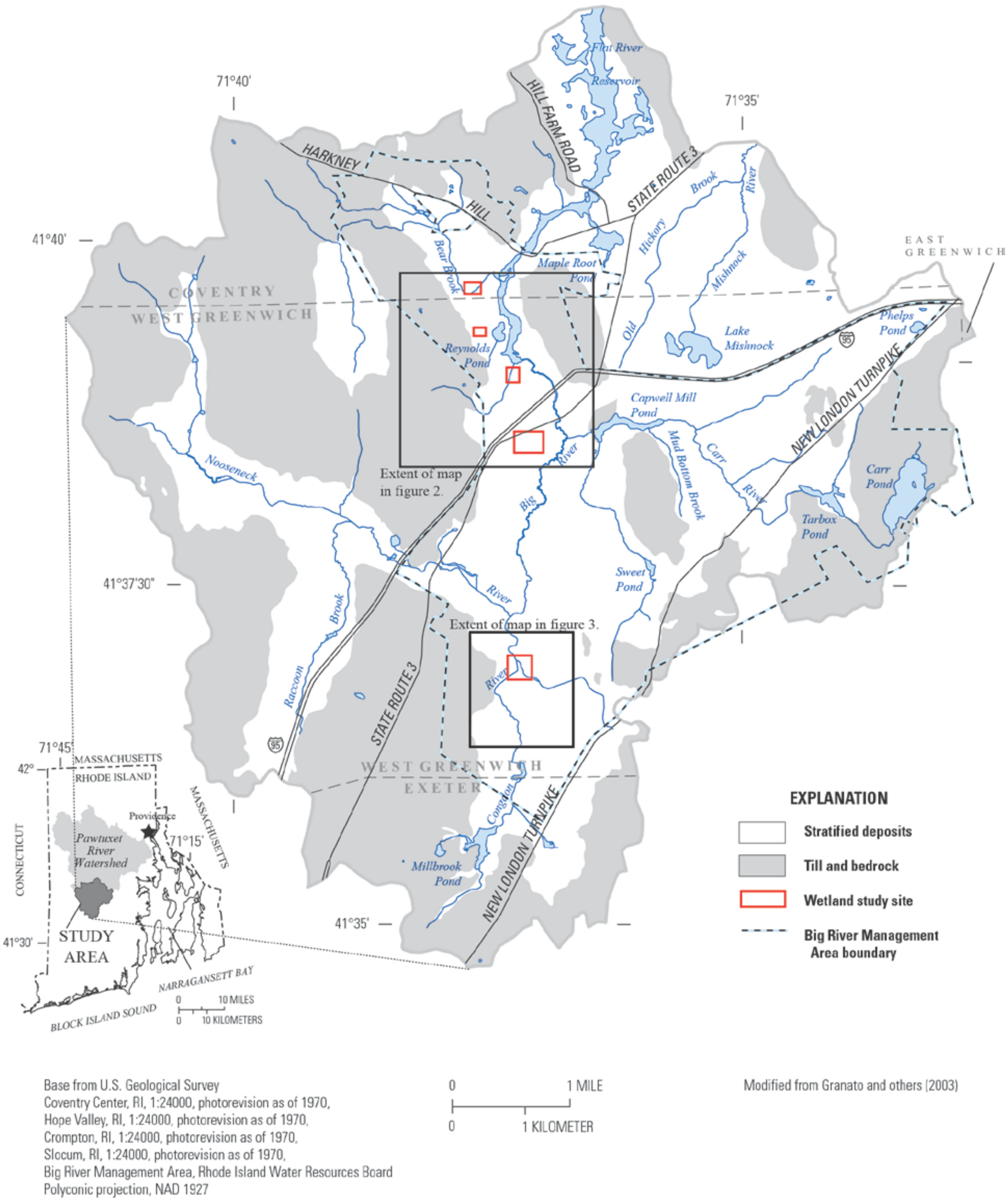

Figure 1. Map showing the location of the Big River study area, surficial geologic deposits, wetland study sites, and the boundary of the Big River Management Area, Rhode Island.

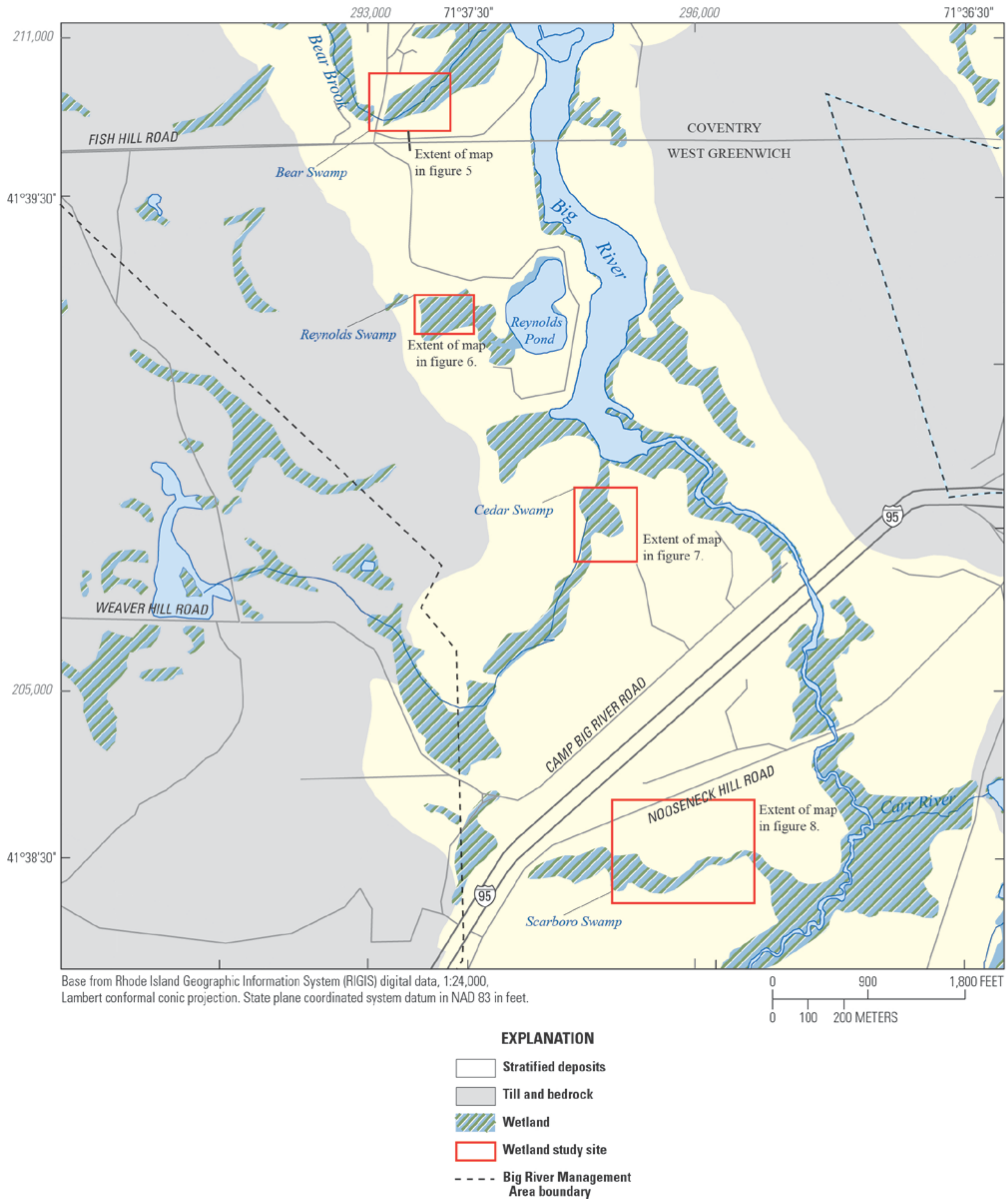

Figure 2. Map showing the location of the Bear Swamp, Reynolds Swamp, Cedar Swamp, and Scarboro Swamp wetland study sites in the Big River Management Area, Rhode Island.

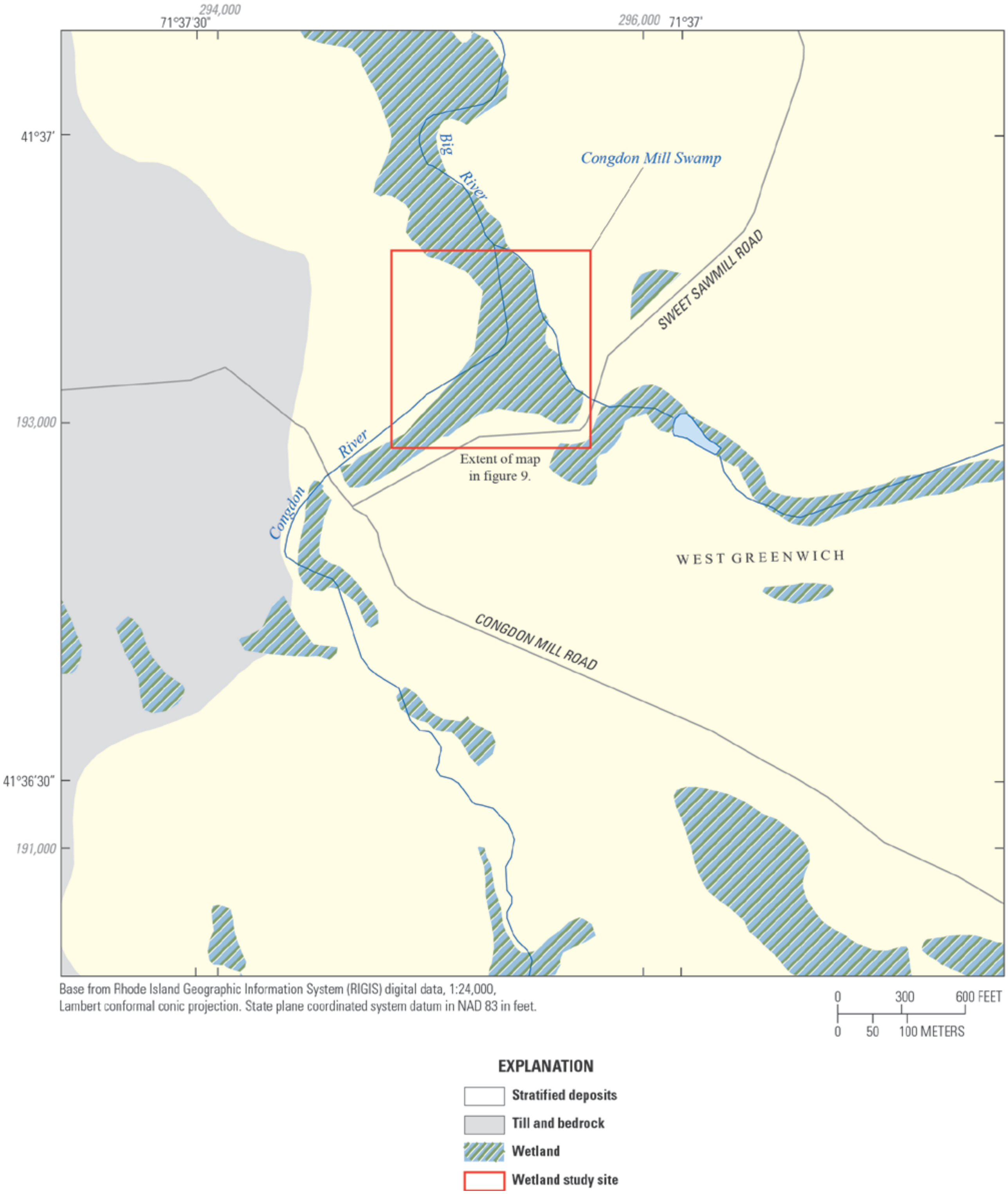

Figure 3. Map showing the location of the Congdon Mill Swamp wetland study control site in the Big River Management Area, Rhode Island.

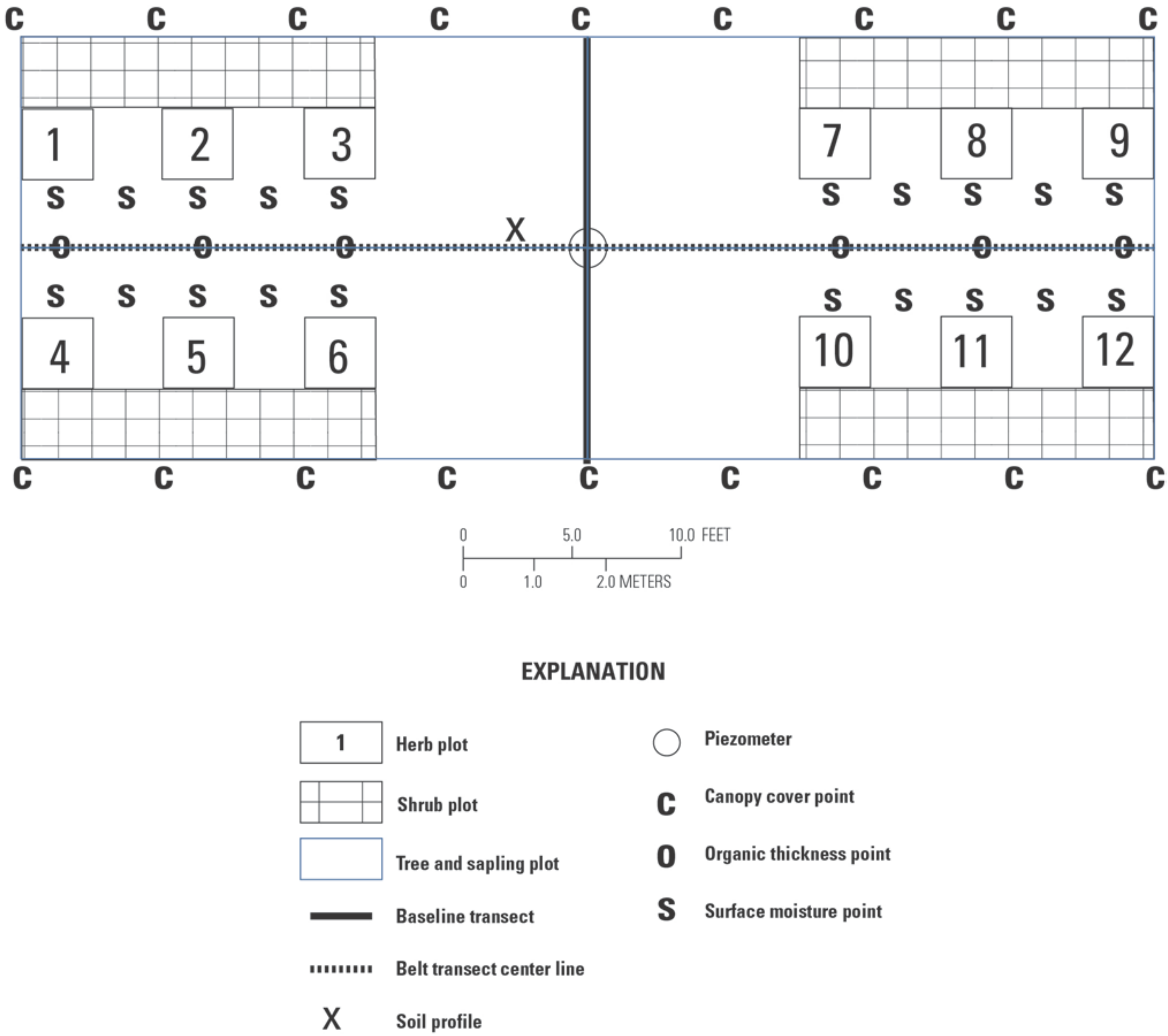

Figure 4. Schematic diagram showing the hydrologic, vegetation, and soil sampling design for a typical belt transect. Each belt transect was 19.7 feet (6 meters) wide and 52.4 feet (16 meters) long.

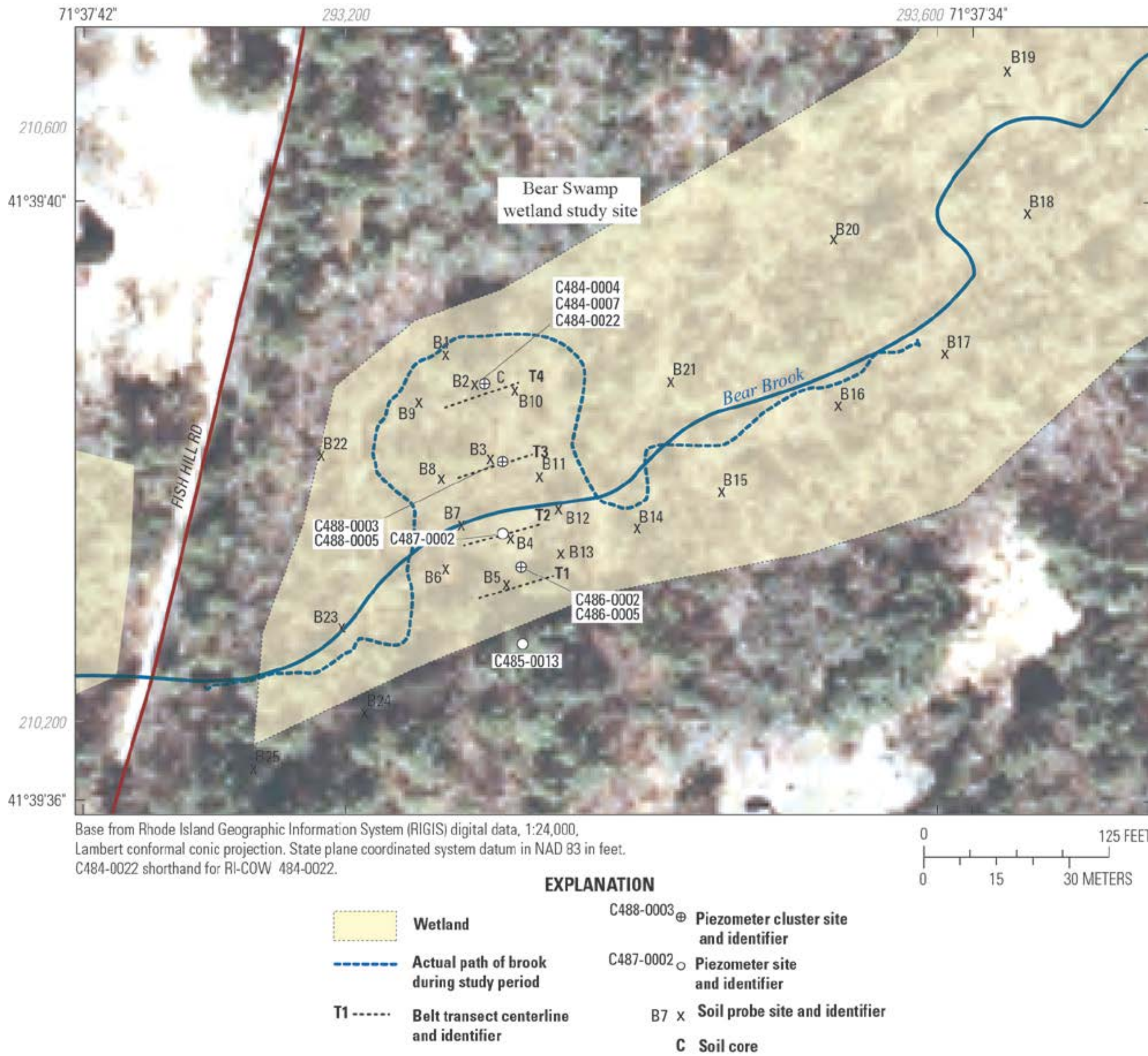

Figure 5. Map of the Bear Swamp wetland study site in the Big River Management Area, Rhode Island, showing locations of transect lines, piezometers, and soil probes.

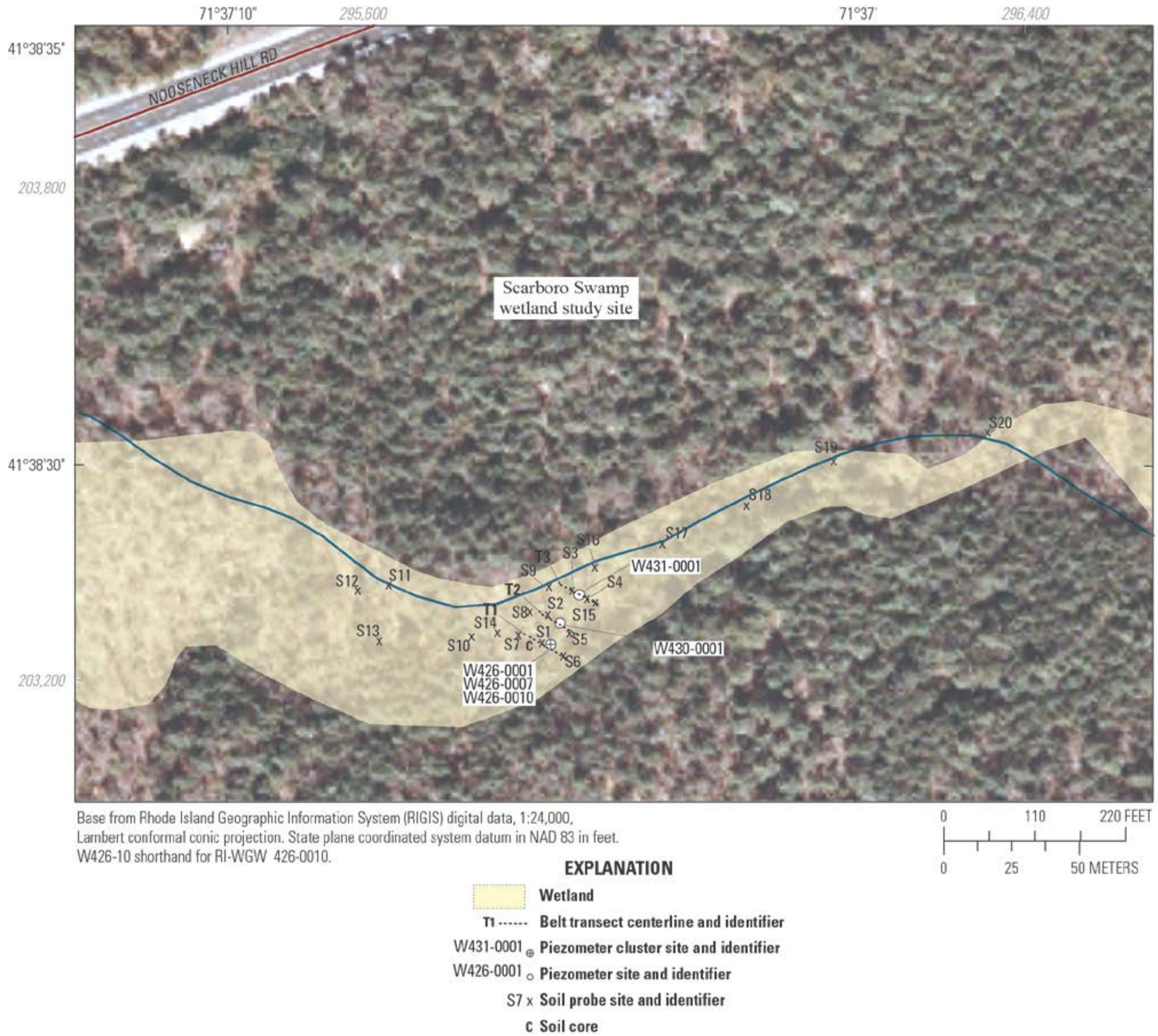

Figure 6. Map of the Scarboro Swamp wetland study site in the Big River Management Area, Rhode Island, showing locations of transect lines, piezometers, and soil probes.

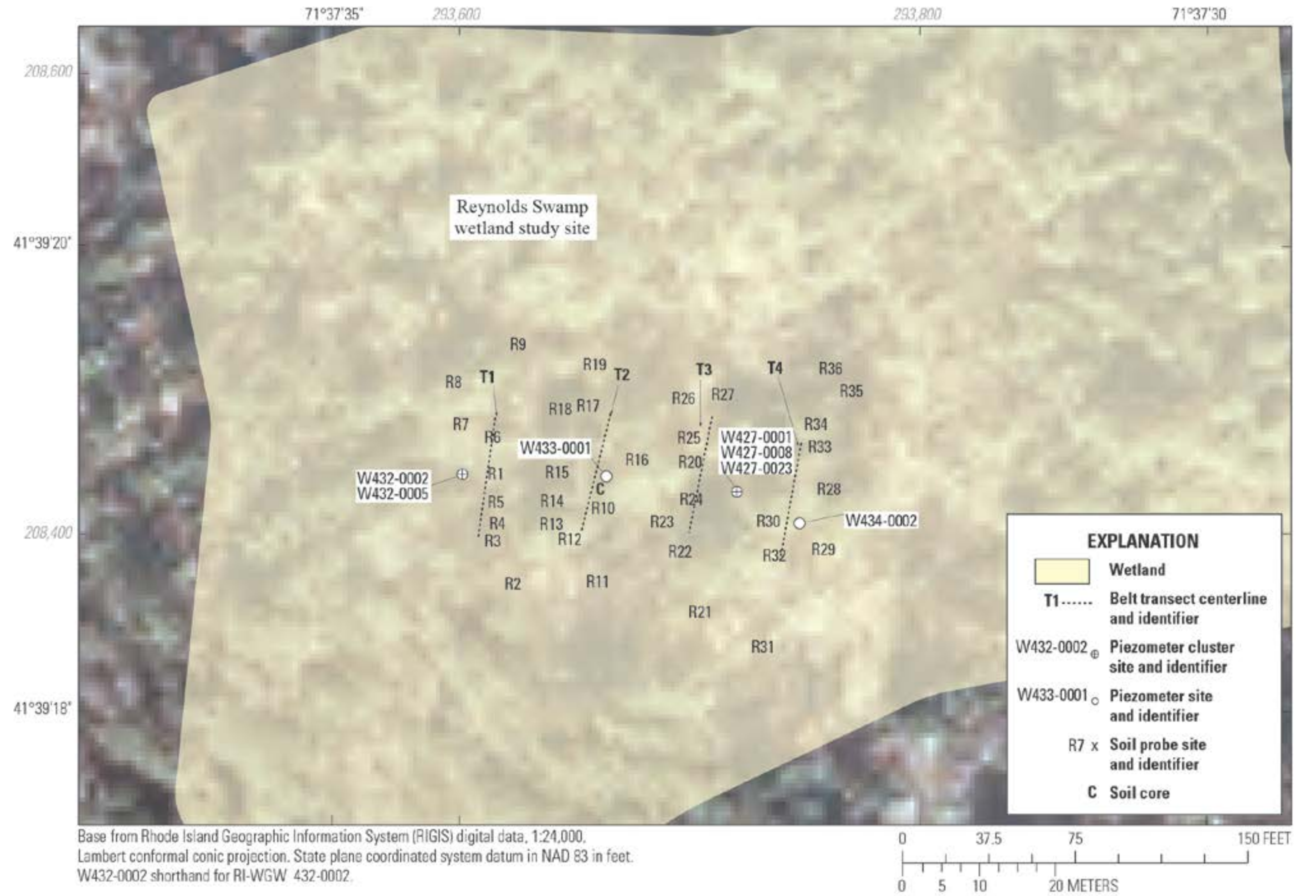

Figure 7. Map of the Reynolds Swamp wetland study site in the Big River Management Area, Rhode Island, showing locations of transect lines, piezometers, and soil probes.

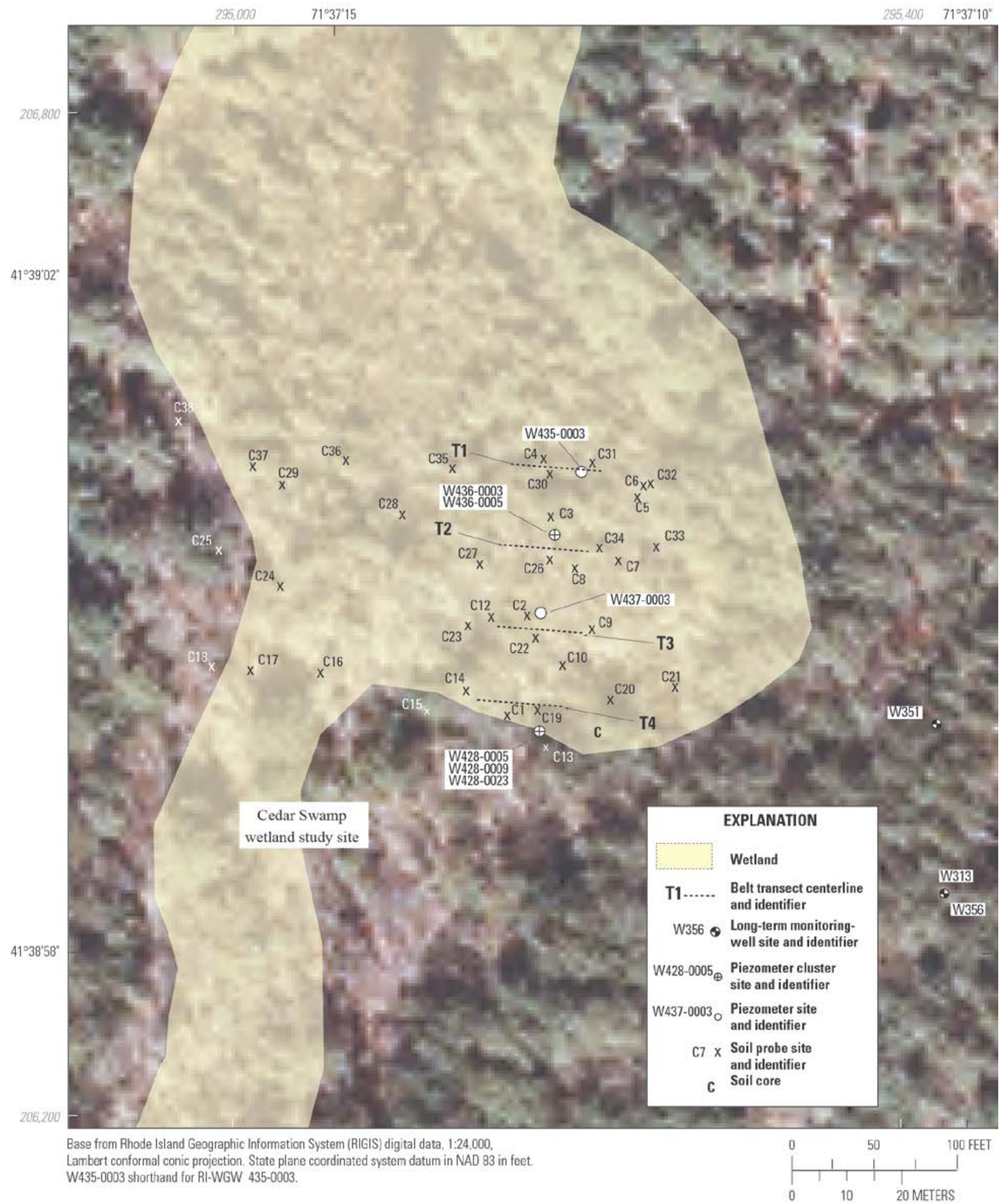

Figure 8. Map of the Cedar Swamp wetland study site in the Big River Management Area, Rhode Island, showing locations of transect lines, piezometers, monitoring wells, and soil probes.

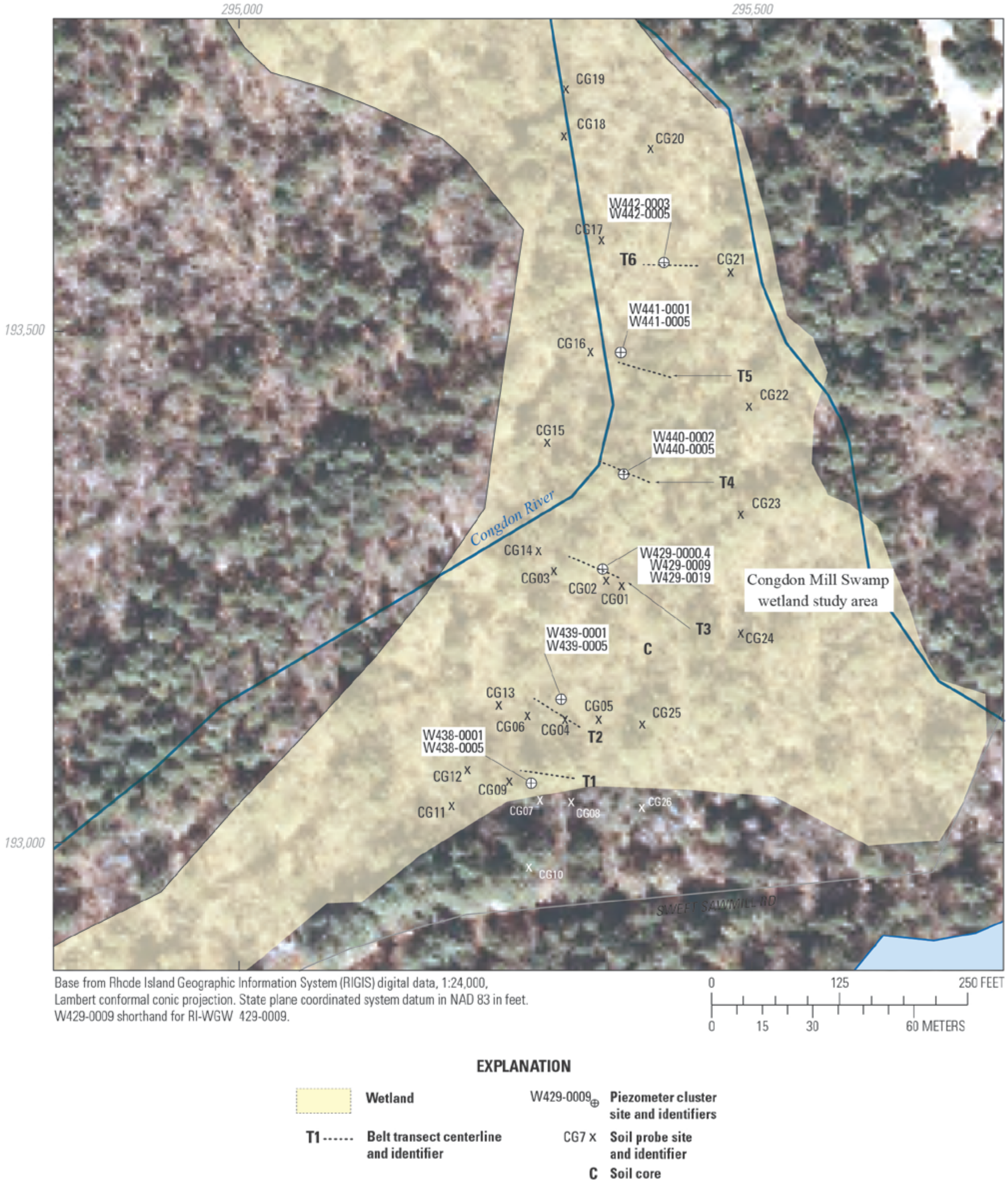

Figure 9. Map of the Congdon Mill Swamp wetland study site in the Big River Management Area, Rhode Island, showing locations of transect lines, piezometers, and soil probes.

Tables

(Click here for link to tables 1–16)

Table 11E. Herb-layer composition and relative wetness (weighted average) by sample plot in the Congdon Mill Swamp wetland study site in the Big River Management Area, Rhode Island, for the 2008 and 2009 growing seasons.

Table 12. Total herb and *Sphagnum* moss cover in 2008 and 2009 at the wetland study sites in the Big River Management Area, Rhode Island.

Table 13. Locations and thickness of organic-rich soil material determined using a soil probe along each belt transect in the five wetland study sites in the Big River Management Area, Rhode Island.

Table 14. Locations and thickness of organic-rich soil material determined using a soil probe outside of the belt transects in the five wetland study sites in the Big River Management Area, Rhode Island.

Table 15. Soil descriptions from test profiles in the five wetland study sites in the Big River Management Area, Rhode Island, in July 2009.

Table 16. Saturated and unsaturated properties determined by laboratory testing of soil cores from each of the five wetland study sites in the Big River Management Area, Rhode Island.

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