Wetland Restoration Strategy

METHODS

SITE IDENTIFICATON METHODS

- Time lapse photo analysis
- Stressor checklist / site nomination form
- From old enforcement files
- MA-like mapping trends
- RIGIS Soils coverage from RI Soil Survey (Rector 1981)

SITE PRIORITIZATION METHODS

- Functional potential method (for single or multiple goals) → *wetlands only*
- Land use intensity and wetland sensitivity → *buffers only*
- Clusters (or sub basins)

CONFIRMATION METHODS

- Landowner research and contact
- Cross-reference enforcement files
- Field verification of potential sites (by professional)
- Field feasibility analysis (by professional)

EXCERPTS FROM:

Development of a Statewide Freshwater Wetland Restoration Strategy

Site Identification and Prioritization Methods

Nicholas A. Miller and Francis C. Golet

Department of Natural Resources Science
University of Rhode Island, Kingston
Kingston, RI 02881

Final Research Report

Prepared for

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Office of Water Resources

and

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Region 1

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RI DEM

Appendix E1. Comparison of methods for identifying potential restoration sites.[1]

	Method category[2]	Data source	Wetland status[3]	Overview of method	Pros	Cons	Time input	Relative value	Comments	Priority[4]
1	Field ID	**Stakeholder Surveys**	Degraded & Destroyed	Survey watershed stakeholders for restoration recommendations.	Familiarity with local wetlands; building of stakeholder support.	Biased toward accessible sites.	Med	Med	Supplemental to other methods; results may overlap other techniques.	High
2	PI	**1939 photos**	Destroyed	Visually compare with delineated 1988 photos, look for discrepancies (time-lapse analysis).	Excellent photos; most accurate historic data.	Differing scales; must digitize ID'd sites, manually assess entire watershed.	Med	High	1890's topos could provide similar data, over a greater time-span, but with much less accuracy.	High
3	PI	**Recent photos (1999?)**	Degraded	Compile a list of impacts; visually assess each wetland for signatures of those impacts.	Recent data; stereo view is a great advantage.	Wetlands not delineated on photos.	High	High	Orthos could provide similar data--no stereo, but easier to add to database.	Med
4	PI	**1988 photos**	Degraded	Use stereoscope to identify degrading impacts.	Wetlands already delineated; stereo view; access to photos.	Not the most recent dataset; small scale.	Med	High	Prior delineation of wetlands provides a distinct advantage over more recent photos.	High
5	PI/GIS	**1995 Orthophotos**	Degraded	View in GIS w/ outline of RIGIS wetlands; visually assess impacts.	Hybrid of PI and GIS; data already in GIS format; no scale differences.	No stereo view will limit ability to detect some impacts; grainy resolution.	Med	Med to High	1:12,000-scale; 1-meter pixel resolution.	High
6	PI/GIS	**1997 Orthophotos**	Degraded	View in GIS w/ outline of RIGIS wetlands; visually assess impacts.	Hybrid of PI and GIS; data already in GIS format; no scale differences; better resolution than '95 orthos.	No stereo view will limit ability to detect some impacts; not yet available!	Med	High	1:5,000-scale; 2-foot pixel resolution.	High
7	GIS	**RIGIS Land Use/Land Cover (LULC)**	Destroyed	Query for all polys coded as wetland in '88 but not in '95.	Can accurately ID changes in wetland extent btwn '88 and '95.	Is this more of a regulatory, enforcement issue?	Very Low	High	May detect permitted changes.	High

Appendix E1. Continued.

	Method category	Data source	Wetland status	Overview of method	Pros	Cons	Time input	Relative value	Comments	Priority
8	GIS	**RIGIS FEMA**	Destroyed	In GIS, overlay FEMA with LULC. Query for developed areas in floodplain.	Most accurate way to do this; floodplain bounds not easily ID'd in photos.	FEMA map probably only covers major rivers/streams; positional inaccuracies.	Low	High	Will reveal current violations, in addition to historic impacts. There may be a lot of them!	High
9	GIS	**1981 Soil Survey**	Destroyed	UD and Ur polygons next to hydric soils are potential fill sites.	Very quick way to ID major fill sites.	UD/Ur polys may denote excavation; min. map unit = 5 acres.	Low	High	Despite some limitations, this method is quick with useful results.	High
10	GIS	**RIGIS Roads dataset**	Degraded & Destroyed	Do an "intersect" of roads and wetlands in GIS.	Best way to ID road impacts; quick, and easy to add to database.	All sites must be field-verified to confirm degradation.	Low	High	Although these impacts could be identified using traditional aerial PI, this is much faster & easier.	High
11	GIS	**1890's topos**	Destroyed	Georeference in GIS; heads-up digitize around wetland symbols.	Oldest dataset available, detects 40-50 more years of wetland loss than '39 photos.	Wetland extent underestimated; wetland bounds are fuzzy.	Med to Low	Med	Perhaps do this to supplement info from 1939 photos (as time allows).	Med
12	GIS	**RIGIS Land Use/Land Cover**	Degraded	Convert to line cover, query for wetlands adjacent to nonvegetated upland.	Quickly and easily ID all wetlands lacking upland buffer.	Relying on accuracy of LULC data -- need to field-verify.	Low	High	Although redundant to PI methods, this method is quick & could verify the PI.	Med
13	GIS	**RIGIS Rivers & Streams**	Degraded	Do an overlay "identity" with LULC; query for lines that are adjacent to non-vegetated land uses.	Easy way to ID potential impacts to watercourses.	Same as above.	Low to Med	High	Although redundant to PI methods, this method is quick & could verify the PI.	Med
14	GIS	**RIGIS Lakes & Ponds**	Degraded	Same as above.	Same as above.	Same as above.	Low to Med	High	Same as above.	Med
15	GIS	**1939 photos**	Destroyed	Digitize photos or delineations into GIS; overlay with RIGIS wetlands; query for differences.	Fast analysis; can determine wetland loss (acreage); dataset is available for other analyses.	Greater set-up time; must verify each ID'd polygon (some polys represent error, not wetland loss).	High	High	This method could be very effective, but it duplicates the method with PI of 1939 aerial photos.	Low

Appendix E1. Concluded.

	Method category	Data source	Wetland status	Overview of method	Pros	Cons	Time input	Relative value	Comments	Priority
16	GIS	**1930's - 40's Soil Surveys**	Destroyed	Scan & georegister; heads-up digitize hydric soils; overlay with RIGIS wetlands; query for differences.	An old dataset; good historic info; could estimate wetland loss.	Archaic soil classifications; error from differing scales; extensive setup time.	High	Med	This provides results similar to other techniques (e.g., 39 photos), but has more drawbacks.	Low
17	GIS	**RIGIS Wells & Wellheads**	Degraded	Overlay with RIGIS wetlands; query for wetlands in wellhead protection areas.	The only way to identify this type of impact.	Impact to wetland is not certain, but potential.	Very Low	Low	These areas are currently being used. There's little chance for restoration.	Low

[1]Recommended methods have been highlighted.

[2]Field ID = identification of sites in the field; PI = aerial photo-interpretation; GIS = Geographic Information System analyses.

[3]Destroyed wetlands have been converted to upland habitat; degraded wetlands are existing wetlands with functions that have been compromised.

[4]Priority levels for each option are based on all of the preceding information.

Field Identification of Potential Freshwater Wetland Restoration Sites: Guidelines

DEGRADATION OF WETLANDS

1. Partial Drainage (Still wetland)

Wetlands have often been ditched to lower water levels for mosquito control, farming, forestry, or other land uses. Partial drainage of wetlands reduces the depth and duration of flooding and soil saturation, which leads to changes in the structure and species of vegetation present, habitat quality, and other wetland functions.

What to look for: Look for ditches within, or exiting, wetlands.

2. Excessive Sedimentation

Excessive sedimentation is often the result of certain human land uses directly abutting wetlands, and it can therefore be a symptom of inadequate upland buffering (see #9). Wetlands that are adjacent to gravel and sand mining operations, plowed agricultural lands, unpaved roads, or paved roads that are "sanded" in the winter are at high risk. Sedimentation affects water depth and the duration of flooding in wetlands, vegetation composition, and wildlife habitat quality.

What to look for: The best way to verify this impact is to locate wetland edges directly adjacent to one of the land uses listed above, and then to dig a small hole. Look for sand, gravel, or silt deposits overlying organic-rich (black or dark brown) wetland soils. If sediments are entering the wetland from a single point, they will often form a fan-shaped deposit. Invasive species and plants more typical of uplands may grow on these deposits. Streams or ponds that receive excessive sedimentation will appear turbid, or muddy.

3. Dumping

Old tires, abandoned vehicles, tree stumps, demolition debris, discarded appliances, and other debris have often been dumped into wetlands. In addition to being an eyesore, these waste products may leach contaminants into the wetlands. We will be focusing on removal of trash at sites where repeated dumping has occurred.

What to look for: Look for discarded debris in wetlands.

4. Impoundment

The duration and depth of flooding of some wetlands has been increased through the blockage or constriction of surface water flow from the wetlands. Such a change in water regime can cause dramatic changes in wetland vegetation, wildlife species, and functions such as water quality improvement. The most common causes of impoundment are dam construction, undersized culverts under roads constructed across wetlands, accumulation of sediment in culverts, and dumping of fill in waterways.

What to look for: Look for instances, especially along highways, where wetlands on the upstream side of the road are noticeably wetter than on the downstream side, and especially where flow through culverts is obstructed due to sediment accumulation.

5. Invasive Species

Invasive plant species often form dense stands, spread rapidly, and outcompete native vegetation. This reduces wetland plant diversity and the quality of habitat for wildlife. *Lythrum salicaria*, or purple loosestrife, is an aggressively spreading weed of Eurasian origin that is now well established in many areas of the northeastern United States. *Phragmites australis*, the common reed, often becomes established where the soil has been exposed by grading or filling. Both of these species can spread quickly; even small stands may cause problems and should be reported.

What to look for: See the attached drawings to help identify these species in the field. Purple loosestrife can grow up to 6-7 feet tall and produces purplish-pink flowers in July and August. It persists and appears brown throughout the winter. *Phragmites* can grow up to 15 feet tall, and also persists through the winter.

6. Removal of Wetland Vegetation

Trees may have been removed from some forested wetlands for timber or fuelwood. In a few cases, wetlands may have been cleared for "aesthetic" purposes, primarily to enhance visibility. If no other alterations have been made (e.g., to hydrology), these wetlands may be relatively easy to restore.

What to look for: Look for wetlands where vegetation has been cut (i.e., where tree stumps or other remains of plants are evident).

7. Removal of Soil or Peat Deposits

In many areas of the world organic, peaty soils are harvested for horticultural use or for fuel. This is not a common occurrence in Rhode Island, but it has occurred in isolated areas.

What to look for: Look for cut banks or other signs of excavation in wetlands with peaty soils.

8. Stream Channelization

Streams may have been channelized to reduce local flooding problems. Unfortunately, these modifications destroy habitat and result in increased flooding problems downstream. The hydrology of wetlands adjacent to streams may also be altered as a result of channelization.

What to look for: Look for stream channels that have been straightened, deepened, or widened, and that have banks or bottoms consisting of artificial materials (e.g., rip-rap, concrete). In some cases, however, rip-rap or stone may be necessary near bridges that span rivers in order to curb erosion.

9. Removal of Adjacent Upland Vegetation

Naturally vegetated areas located between wetlands and more intensive human land uses help protect wetlands from polluted runoff and sedimentation, provide important wildlife habitat, reduce human harassment of wetland wildlife, and contribute to the scenic or aesthetic value of wetlands. Naturally vegetated areas also protect the shores of streams and ponds; without these areas, erosion may occur. By restoring areas where such vegetation has been removed, we can better maintain wildlife habitat, water quality, and scenic amenities within wetlands.

What to look for: Look for wetlands where natural vegetation has been removed from the adjacent upland and where any of a variety of human land uses (e.g., sand and gravel mining, urban development) continues right down to the wetland edge. Erosion of streambanks or pondshores may also indicate insufficient natural vegetation.

DESTRUCTION OF WETLANDS

Wetland that has been destroyed may be very difficult to identify in the field. Historic data (e.g., old topographic maps, aerial photographs, and soil surveys) provide the best clues as to where these wetlands formerly occurred. The knowledge and memories of local watershed residents may also help to determine what the landscape looked like prior to development.

1. Filling

Some wetlands have been filled to establish substrates suitable for construction. Filling may also result from disposal of dredged material. Wetlands may be partially or completely destroyed by filling.

What to look for: Wetlands **completely** destroyed by filling will be difficult to identify in the field because they will not exhibit any characteristics typical of wetlands. Knowledge of what the landscape looked like prior to development may help. Wetlands that have been **partially** filled may have steep slopes or banks at the edges of the fill deposits, while natural wetland edges are more likely to slope gradually into upland.

2. Complete Drainage

Ditching may alter local hydrology sufficiently to completely destroy wetlands. Afterward, these areas may have been developed or used for agriculture. After moisture has been removed from the soils, organic material tends to decompose, causing the soil surface to subside.

What to look for: Look at ditch-banks for soils that appear to have been wet in the past. Black layers (indicating high organic matter content) which overlie bright gray mineral layers are typical of many wetland soils—even those that have been drained.

Wetland Restoration

Site Nomination Form

Please fill out this form as completely as possible—one form for each site. If you need more room, please attach additional sheets. Proposed sites will be considered for addition to our list of potential restoration sites in your watershed. If you would like to discuss any sites in further detail, or if you need more forms, please contact Nick Miller by phone at (401) 874-7058 or by email at nick@uri.edu. Thank you very much for your valuable time and assistance.

1. Your name and contact information:

   Name: _____

   Address: _____

   _____

   _____

   Phone: _____

   Email: _____

2. Type of wetland (e.g., forested swamp, shrub swamp, marsh, bog, wet meadow, pond, stream) or upland adjacent to wetland:

   _____

3. Name of wetland (if available): _____

4. Location of wetland (This information is vital; please provide a detailed description and mark the location of the site on the attached map.):

   _____

   _____

   _____

   _____

5. Wetland ownership (check one, if known):

Federal_____ State_____ Municipal_____ Conservation organization_____

Private_____

6. If privately owned, please provide any known contact information:

Landowner:_____

Address: _____

_____

_____

Phone number: _____

7. Types of impacts present (see attached guidelines):

_____

_____

_____

_____

8. Approximate age of impact (if known): _____

Completed forms should be submitted by May 31st to:

Nick Miller
Department of Natural Resources Science
210B Woodward Hall
University of Rhode Island
Kingston, RI 02881

UNIVERSITY OF RHODE ISLAND

RI DEM

EPA

EXCERPTS FROM:

Wetland Restoration Plan for the Woonasquatucket River Watershed, Rhode Island

Francis C. Golet, Dennis H.A. Myshrall, Nicholas A. Miller, and Michael P. Bradley

Department of Natural Resources Science
University of Rhode Island
Kingston, RI 02881

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RI DEM

Table 1. Functional assessment form for potential wetland restoration sites.

Site ID #: _____ **Date:_____**

Function	*	Criteria (highlighted criteria are necessary to the function)	O,E,S†	Source‡	Notes
Flood Abatement		1) Impervious surfaces cover > 20% of land within 500 feet of restoration assessment unit (RAU)**	O	L, f	
		2) Slopes within 500 feet of RAU are > 15%	O	L, f	
		3) Point-source discharge or concentrated stormwater flow into RAU	O	L, f	
		4) RAU borders or contains a lower perennial stream	O	l, F	
		5) RAU occurs within a basin	E	l, F	
		6) More than 50% of wetland unit (WU) area is dominated by dense, persistent vegetation (EM, SS, or FO)	E	L, f	***
		7) Developed flood-prone areas within 5 miles downstream of RAU (connection by stream or floodway required)	S	L	
Water Quality Improvement		1) Point-source discharge or concentrated stormwater flow into RAU	O	L, f	
		2) Impervious surfaces, active agricultural land, or barren land comprise > 20% of land within 500 feet of RAU	O	L, f	
		3) More than 50% of WU area is dominated by dense, persistent vegetation (EM, SS, or FO)	E	L, f	***
		4) RAU occurs within a basin	E	l, F	
		5) RAU has a constricted outlet	E	L, f	
		6) RAU is within a wellhead protection area	S	L	
		7) RAU borders or contains a water body that is on the Rhode Island List of Impaired Waters	S	L	
Wildlife Habitat		1) Wetlands and deepwater habitats comprise > 15% of land within 1 mile of RAU	E	L	
		2) RAU is contiguous with > 400 acres of moderate to high quality habitat (wetland or deepwater habitat, upland forest or shrubland, abandoned field, or agricultural land)	E	L	
		3) RAU > 5 acres	E	L	
		4) RAU contains wetland-dependent wildlife habitat (OW, marsh, bog, or fen)	E	L, f	***
		5) No point-source discharge or concentrated stormwater flow into RAU	E	L, f	
		6) Less than 0.25 acres of invasive plants in WU	E	l, F	***
		7) Moderate to high quality habitat (wetland or deepwater habitat, upland forest or shrubland, abandoned field, or agricultural land) comprises > 70% of land within 500	E	L, f	
	Y	8) Social significance assumed to be present	S		

(Continued)

Table 1. (Concluded).

Function	*	Criteria (highlighted criteria are necessary to the function)	O,E,S	Source	Notes
Fish Habitat		1) Permanent pond or lower perennial stream is present in RAU	O	l, F	
		2) No point-source discharge or concentrated stormwater flow into RAU	E	L, f	
		3) Permanent pond or lower perennial stream within RAU is bordered by trees or shrubs for > 75% of its length	E	L, f	
		4) Impervious surfaces cover < 20% of land within 500 feet of RAU	E	L, f	
		5) Open water, if present in RAU, > 2 acres	E	L	***
	Y	6) Social significance assumed to be present	S		
Heritage Aesthetics Recreation Education Research Open space Biodiversity		1) RAU is physically or visually accessible	O	F	
		2) RAU borders or contains public land	O	L, f	
		3) RAU contains open water	O	L, f	***
		4) No point-source discharge or concentrated stormwater flow into RAU	E	L, f	
		5) No evidence of noise pollution or trash in RAU	E	F	
		6) RAU contains 3 or more wetland types	E	L, f	***
		7) Uncommon wetland type (bog, fen, marsh, wet meadow, or cedar swamp) is present in RAU	E	L, f	***
		8) Waterbird habitat (OW or marsh) is present in RAU	E	L, f	***
		9) Moderate to high quality habitat (wetland or deepwater habitat, upland forest or shrubland, abandoned field, or agricultural land) comprises < 50% of land within 1 mile	S	L	
		10) Wetlands and deepwater habitats comprise < 10% of land within 1 mile of RAU	S	L	
		11) RAU is located within 1 mile of a school or college	S	L	

* Mark each box as Y, N, D, or NA (i.e., yes, no, don't know, or not applicable)

† O = opportunity; E = effectiveness; S = social significance

** Restoration assessment unit (RAU) may include (1) potential restoration site (PRS) and contiguous wetland unit (WU) or (2) just PRS (if no contiguous wetland is present).

‡ L,l = lab data; F,f = field data. Upper case signifies primary source; lower case signifies secondary source.

*** Not applicable if entire wetland unit has been destroyed.

Appendix B. Functional assessment criteria for potential wetland restoration sites: Rationale and data collection methods.

Introduction

This appendix provides the rationale behind each of the functional assessment criteria listed in Table 1; it also describes the procedures used in collecting data for the assessments. Descriptions are provided for field and lab assessments of individual criteria. In each case, field and lab techniques have been designated as the primary, secondary, or sole source of information. Primary sources provided the bulk of the assessment data, while secondary sources were used to augment—or as a check upon—primary sources. Whenever conflicts occurred between field observations and lab data, field observations always took precedence. Certain criteria were designated as "necessary to the function" (see below, and see Table 1). If one of those criteria was not satisfied, then the function could not be provided at that site and assessment was discontinued. In an individual assessment, the restoration assessment unit (RAU) was either (1) the potential restoration site (PRS) and its contiguous wetland unit (WU) or (2) just the PRS (if no contiguous wetland was present).

Function: FLOOD ABATEMENT

FA1: Impervious surfaces cover > 20% of land within 500 feet of RAU

Rationale: Wetlands bordered by impervious surfaces (e.g., roads, sidewalks, paved parking lots, buildings) are likely to receive significant amounts of runoff during storm events. As a result, these wetlands have a great opportunity to desynchronize floodwaters.

Lab assessment (primary source): Arc/Info was used to generate 500-foot buffer regions for each assessment unit. Buffer regions were intersected with the RIGIS land use coverage to determine the percentage of impervious land use types (Appendix C).

Field assessment (secondary source): Field notes were recorded on the presence or absence of impervious surfaces in the vicinity of the assessment unit. Particular attention was paid to impervious surfaces that may have been constructed since 1995 (the date of the RIGIS land use data).

FA2: Slopes within 500 feet of RAU are > 15%

Rationale: Wetlands bordered by steep slopes are likely to receive significant amounts of surface runoff during storm events. These wetlands have a great opportunity to desynchronize floodwaters.

Lab assessment (primary source): The RIGIS soils coverage, assessment units with 500-foot buffers, and 1997 orthophotos were viewed simultaneously in ArcView. Soil map units coded as "D" (i.e., soils with slopes > 15 %) that occurred within 500 feet of assessment units were

identified. If any such soil map units were encountered, the criterion was considered to be satisfied. Where the aspect of the slope was unclear, collateral data sources (e.g., topographic maps or stereopairs of aerial photos) were consulted.

Field assessment (secondary source): Field notes were recorded on the slope of land bordering the assessment units.

FA3: Point-source discharge or concentrated stormwater flow into RAU

Rationale: Surface water that has been routed into a wetland (e.g., from roads, parking lots, or point-source discharges) increases the opportunity for that wetland to desynchronize floodwaters.

Lab assessment (primary source): Assessment units that receive point-source discharges were identified by viewing orthophotos, assessment units, and the RIGIS coverage of point-source discharges in ArcView. In addition, 1988 aerial photos were interpreted in stereo to determine where channels have been constructed between roads or parking lots and wetlands.

Field assessment (secondary source): Field inspections were necessary whenever lab assessment was inconclusive.

FA4: RAU borders or contains a lower perennial stream

Rationale: Wetlands that contain, or are adjacent to, lower perennial streams have an opportunity to receive floodwaters via overbank flow.

Field assessment (primary source): The presence or absence of stream floodplains was determined in the field.

Lab assessment (secondary source): Aerial photos were viewed in stereo to determine the presence of lower perennial streams in, or adjacent to, assessment units.

FA5: RAU occurs within a basin

Rationale: Wetlands occurring in basins can effectively store floodwater; slope wetlands cannot. This criterion was considered "necessary to the function." Potential restoration sites that lacked contiguous wetland were assumed to occur within a basin.

Field assessment (primary source): Field observations were made to determine whether wetland units occurred in basins or on slopes.

Lab assessment (secondary source): 1988 aerial photos were interpreted in stereo to determine whether wetland units occurred in basins or on slopes.

FA6: More than 50% of WU area is dominated by dense, persistent vegetation (EM, SS, or FO)

Rationale: Dense wetland vegetation can reduce downstream flood levels and delay flood crests by reducing floodwater velocity. Persistent vegetation (e.g., woody plants, persistent emergents) can perform this function even outside of the growing season.

Lab assessment (primary source): Wetland types and their corresponding areas were determined from the RIGIS wetlands database.

Field assessment (secondary source): The presence of dense, persistent, wetland vegetation was noted in the field. Where conflicts with the RIGIS wetlands database existed, field observations always overrode lab assessments.

FA7: Developed flood-prone areas within 5 miles downstream of RAU (connection by stream or floodway required)

Rationale: The flood abatement function for wetlands is socially significant if there are developed flood-prone areas downstream. For purposes of this assessment, the assessment unit must be connected to developed flood-prone areas by surface water at the time of flooding.

Lab assessment (sole source): Orthophotos, RIGIS land use and FEMA coverages, and assessment units were inspected in ArcView to determine the presence of developed flood-prone areas and to measure the distance between those areas and the assessment unit in question.

Field assessment: This criterion was not assessed in the field.

Function: WATER QUALITY IMPROVEMENT

WQ1: Point-source discharge or concentrated stormwater flow into RAU

Rationale: Wetlands that receive pollution from point-source discharges or concentrated runoff from roads and parking lots have greater opportunity to improve water quality than wetlands not receiving such inputs.

Lab assessment (primary source): Assessment units that receive point-source discharges were identified by viewing orthophotos, assessment units, and the RIGIS coverage of point-source discharges in ArcView. In addition, 1988 aerial photos were interpreted in stereo to determine where channels have been constructed between roads or parking lots and wetlands.

Field assessment (secondary source): The presence of point-source discharges or concentrated stormwater inflow was noted at all sites visited in the field.

WQ2: Impervious surfaces, active agricultural land, or barren land comprise > 20% of land within 500 feet of RAU

Rationale: Impervious surfaces, active agricultural land, and barren land have high potential to add nutrients, sediment, and other pollutants to surface water and groundwater. Wetlands receiving these inputs therefore have the opportunity to improve water quality.

Lab assessment (primary source): Arc/Info was used to generate 500-foot buffer regions for each assessment unit. Buffer regions were intersected with the RIGIS land use coverage to determine the percentage of impervious surfaces, active agricultural land, and barren land (Appendix C).

Field assessment (secondary source): Field notes were recorded on the presence or absence of impervious surfaces, active agricultural land, or barren land in the vicinity of the assessment unit. Particular attention was paid to land use changes since 1995 (the date of the RIGIS land use data).

WQ3: More than 50% of WU area is dominated by dense, persistent vegetation (EM, SS, or FO)

Rationale: Dense wetland vegetation can serve as a filter for pollutants and can also impede the flow of water, causing sediments and associated pollutants to drop out of suspension. Persistent vegetation (e.g., woody plants, persistent emergent species) can perform this function even outside of the growing season.

Lab assessment (primary source): Wetland types and their corresponding areas were determined from the RIGIS wetlands database.

Field assessment (secondary source): The presence of dense, persistent, wetland vegetation was noted in the field. Where conflicts with the RIGIS wetlands database existed, field observations always overrode lab assessments.

WQ4: RAU occurs within a basin

Rationale: Basin wetlands retain greater volumes of water for longer periods of time than slope wetlands. Greater retention time permits increased interaction between plants or soil and pollutants, as well as settling of suspended solids.

Field assessment (primary source): Field observations were made to determine whether wetland units occurred in basins or on slopes.

Lab assessment (secondary source): 1988 aerial photos were interpreted in stereo to determine whether wetland units occurred in basins or on slopes.

WQ5: RAU has a constricted outlet

Rationale: Wetlands with constricted outlets have the potential to retain polluted water for extended periods of time. Long retention times allow for increased interaction between plants or soil and pollutants, as well as settling of suspended solids.

Lab assessment (primary source): Assessment units, orthophotos, and RIGIS stream coverages were viewed simultaneously in ArcView. Stereo interpretation of aerial photos also was useful.

Field assessment (secondary source): The presence and relative size of outlets was noted in the field, particularly in cases where no outlet was detected during the lab analysis.

WQ6: RAU is within a wellhead protection area

Rationale: Wetlands within wellhead protection areas are in a position to improve the quality of groundwater used for drinking. Therefore, there is social significance to restoration of such wetlands.

Lab assessment (sole source): Assessment units, orthophotos, and RIGIS wellhead protection areas were viewed simultaneously in ArcView.

Field assessment: This criterion was not assessed in the field.

WQ7: RAU borders or contains a water body that is on the Rhode Island List of Impaired Waters

Rationale: Wetlands that border or contain Impaired Waters are in a position to improve the quality of those waters. For that reason, these wetlands are socially significant.

Lab assessment (sole source): Assessment units, orthophotos, and State-listed Impaired Waters (identified as a subset of RIGIS water bodies) were viewed simultaneously in ArcView.

Field assessment: This criterion was not assessed in the field.

Function: WILDLIFE HABITAT

WH1: Wetlands and deepwater habitats comprise > 15% of land within 1 mile of RAU

Rationale: Wetlands that are in close proximity to other wetlands, or that are part of large wetland complexes, are more effective than isolated wetlands at providing habitat for wetland wildlife. Where wetlands are abundant, many species of wildlife are able to move among them to satisfy their diverse habitat requirements.

Lab assessment (sole source): The RIGIS wetland coverage was converted to a grid with 10-x10-meter cells. An .aml was run in ArcGrid to determine the number of cells within 1 mile of each assessment unit that were designated as wetland or deepwater habitat. Values were then converted to percentages.

Field assessment: This criterion was not assessed in the field.

WH2: RAU is contiguous with > 400 acres of moderate to high quality habitat (wetland or deepwater habitat, upland forest or shrubland, abandoned field, or agricultural land)

Rationale: Some wetland wildlife species can breed successfully in small patches of habitat. However, certain "interior" species are only successful in wetlands surrounded by extensive natural habitat; other species (e.g., deer, otter) have large home ranges and also require extensive natural areas. Contiguity of natural habitats also enables wildlife dispersal among wetlands; successful dispersal, in turn, ensures genetic diversity and lessens the chance of localized extirpations. To provide habitat for interior species and species with large home ranges, restoration efforts should focus on wetlands that are contiguous with extensive, moderate to high quality habitat.

Lab assessment (sole source): An Arc/Info coverage of moderate to high quality wildlife habitat was created by intersecting RIGIS land use data and road data (major roads were considered habitat edges). Wildlife habitat polygons > 400 acres were viewed along with assessment units in ArcView, and contiguity was assessed.

Field assessment: This criterion was not assessed in the field.

WH3: RAU > 5 acres

Rationale: Large wetlands are capable of supporting larger—and, therefore, more viable—wetland-dependent wildlife populations. Large wetlands also better satisfy the habitat requirements of wetland-dependent species with large home ranges.

Lab assessment (sole source): The attribute table for the assessment units was queried to determine unit area.

Field assessment: This criterion was not assessed in the field.

WH4: RAU contains wetland-dependent wildlife habitat (OW, marsh, bog, or fen)

Rationale: Wetlands that contain open water, marsh, bog, or fen are more likely to support wetland-dependent wildlife than wetlands without these habitats. For the purpose of this assessment, wetlands that were dominated by invasive plant species were not considered to be viable wetland-dependent wildlife habitat.

Lab assessment (primary source): Wetland habitat types were determined by viewing the RIGIS wetlands coverage, which has a minimum map unit of 0.25 acres.

Field assessment (secondary source): The presence of wetland-dependent wildlife habitat was noted during field work. When conflicts with the RIGIS database occurred, field observations always overrode lab assessments.

WH5: No point-source discharge or concentrated stormwater flow into RAU

Rationale: To remain healthy and viable, wildlife populations require clean water. Restoration success for the wildlife habitat function is likely to be greater if water quality is good.

Lab assessment (primary source): Assessment units that receive point-source discharges were identified by viewing orthophotos, assessment units, and the RIGIS coverage of point-source discharges in ArcView. In addition, 1988 aerial photos were interpreted in stereo to determine where channels have been constructed between roads or parking lots and wetlands.

Field assessment (secondary source): The presence of point-source discharges or concentrated stormwater inflow was noted at all sites visited in the field.

WH6: Less than 0.25 acres of invasive plants in WU

Rationale: Wetlands containing invasive plant species, such as *Phragmites australis* and *Lythrum salicaria,* are limited in their ability to provide foraging, roosting, or nesting habitat for native wildlife species. Where invasive species are already established in contiguous wetland, they are highly likely to colonize newly restored wetlands.

Field assessment (primary source): Stands of invasive species were sought out and catalogued in the field.

Lab assessment (secondary source): Lab analyses expedited field identification of invasive plant stands. The RIGIS wetlands database was used to identify wetland units that contained EM or SS wetland types, which are prone to colonization by invasive plants. In addition, orthophotos were used to view the perimeter of wetland units and to identify areas of disturbance, which offer prime colonization sites for invasives.

WH7: Moderate to high quality habitat (wetland or deepwater habitat, upland forest or shrubland, abandoned field, or agricultural land) comprise > 70% of land within 500 feet of RAU

Rationale: This criterion considers the immediate context of the assessment unit. Wetlands surrounded by the habitats listed above are more likely to support healthy wildlife populations.

Such areas are less prone to pollution or disturbance of wildlife due to human activity. Natural surroundings also may provide important foraging, nesting, or roosting habitat for wetland wildlife such as waterfowl, turtles, wading birds, and certain birds of prey.

Lab assessment (primary source): Arc/Info was used to generate 500-foot buffer regions for each assessment unit. Buffer regions were intersected with the RIGIS land use coverage in order to determine the percentage of moderate to high quality wildlife habitats present.

Field assessment (secondary source): The presence or absence of these habitats was noted in the field. Particular attention was paid to changes in land use that occurred since 1995 (the date of the RIGIS land use data).

WH8: Social significance assumed to be present

Rationale: Wetland wildlife has social significance because of its value for recreation, aesthetics, biodiversity, education, and research. These heritage values were assessed separately (see below), but social significance was assumed to be present in every case under the wildlife habitat function as well.

Function: FISH HABITAT

FH1: Permanent pond or lower perennial stream is present in RAU

Rationale: This criterion is necessary to the fish habitat function. Wetlands that contain perennial surface water have the opportunity to provide permanent habitat for fish. Wetlands adjacent to ponds, lakes, or lower perennial streams (Cowardin et al. 1979) have the opportunity to provide fish habitat during times of overbank flow.

Field assessment (primary source): Perennial surface water and lower perennial stream determinations were made in the field.

Lab assessment (secondary source): Although the RIGIS wetland and stream databases were useful for identifying the presence of ponds, lakes, and perennial streams, assessment of this criterion was most reliable in the field.

FH2: No point-source discharge or concentrated stormwater flow into RAU

Rationale: To remain healthy and viable, fish populations require clean water. Restoration success for the fish habitat function is likely to be greater if water quality is good.

Lab assessment (primary source): Assessment units that receive point-source discharges were identified by viewing orthophotos, assessment units, and the RIGIS coverage of point-source

discharges in ArcView. In addition, 1988 aerial photos were interpreted in stereo to determine where channels have been constructed between roads or parking lots and wetlands.

Field assessment (secondary source): The presence of point-source discharges or concentrated stormwater inflow was noted at all sites visited in the field.

FH3: Permanent pond or lower perennial stream within RAU is bordered by trees or shrubs for > 75% of its length

Rationale: Trees or shrubs that border a pond or stream provide shade and help to maintain cooler water temperatures. Such vegetation also contributes organic detritus which supports invertebrate prey items.

Lab assessment (primary source): Orthophotos were used to make a visual estimate of the percentage of pond edge or stream length that was bordered by trees or shrubs.

Field assessment (secondary source): Changes in vegetation extent that may have occurred since the date of the orthophotos (1997) were noted in the field.

FH4: Impervious surfaces cover < 20% of land within 500 feet of RAU

Rationale: Stormwater runoff from impervious surfaces (e.g., roads, sidewalks, paved parking lots, buildings) can significantly elevate the temperature of ponds and streams, adversely impacting fish populations. The extent of this problem should be related to the extent of impervious surfaces around the water body.

Lab assessment (primary source): Arc/Info was used to generate 500-foot buffer regions for each assessment unit. Buffer regions were intersected with the RIGIS land use coverage to determine the percentage of impervious land use types (Appendix C).

Field assessment (secondary source): Field notes were recorded on the presence or absence of impervious surfaces in the vicinity of the assessment unit. Particular attention was paid to impervious surfaces that may have been constructed since 1995 (the date of the RIGIS land use data).

FH5: Open water, if present in RAU, > 2 acres

Rationale: Large water bodies are capable of supporting large fish populations. They can also contain a great diversity of fish habitat, which can increase fish species diversity.

Lab assessment (sole source): The attribute table for assessment units was queried to determine open water area.

Field assessment: This criterion was not assessed in the field.

FH6: Social significance assumed to be present

Rationale: Fish have social significance because of their value for recreation, aesthetics, biodiversity, education, and research. These heritage values were assessed separately (see below), but social significance was assumed to be present in every case under the fish habitat function as well.

Function: HERITAGE

H1: RAU is physically or visually accessible

Rationale: Physical access to a wetland is necessary for recreation, research, and educational purposes. Aesthetic value can be appreciated from outside the wetland, as long as the site is visually accessible (e.g., from a nearby road or other prominent position on the landscape). Still other heritage values, such as open space and biodiversity, require neither physical or visual access.

Field assessment (sole source): If the wetland could be reached by a public road or viewed from the surrounding landscape, it was considered to be physically or visually accessible.

Lab assessment: This criterion was not assessed in the lab.

H2: RAU borders or contains public land

Rationale: Wetlands that are located on property that is open to the public are more likely to be visited for recreation, nature study, or research purposes than wetlands on private land.

Lab assessment (primary source): Assessment units were viewed along with RIGIS open space coverages in ArcView to determine which units fell within or bordered public land.

Field assessment (secondary source): Field observations were helpful for identifying recreation areas that have been established since the RIGIS coverages were created.

H3: RAU contains open water

Rationale: Sites containing open water may support swimming, fishing, waterfowl hunting, canoeing, or other popular water sports.

Lab assessment (primary source): The presence of open water was determined by viewing the RIGIS wetlands coverage. Stereo-interpretation of 1988 aerial photos and viewing of orthophotos also were helpful.

Field assessment (secondary source): The presence of open water bodies was noted during field work. Where conflicts with the RIGIS wetlands database existed, field observations always overrode lab assessments.

H4: No point-source discharge or concentrated stormwater flow into RAU

Rationale: The discharge of polluted water into a wetland can impair virtually all of the heritage values listed in Table 1.

Lab assessment (primary source): Assessment units that receive point-source discharges were identified by viewing orthophotos, assessment units, and the RIGIS coverage of point-source discharges in ArcView. In addition, 1988 aerial photos were interpreted in stereo to determine where channels have been constructed between roads or parking lots and wetlands.

Field assessment (secondary source): The presence of point-source discharges or concentrated stormwater inflow was noted at all sites visited in the field.

H5: No evidence of noise pollution or trash in RAU

Rationale: Restoration of the heritage function will be most effective in wetlands where degradation does not continue after restoration efforts are completed. Several of the heritage values listed in Table 1 would be impaired by excessive noise or trash.

Field assessment (sole source): Evidence of trash and excessive noise in and surrounding the assessment unit was recorded during site visits.

Lab assessment: This criterion was not assessed in the lab.

H6: RAU contains 3 or more wetland types

Rationale: Within a wetland, diversity in wetland types may contribute to increased aesthetic value, heightened educational and research opportunities, and greater biodiversity.

Lab assessment (primary source): The number of wetland types was determined by viewing the RIGIS wetlands coverage.

Field assessment (secondary source): The number of wetland types was noted during field work. Where conflicts with the RIGIS wetlands database existed, field observations always overrode lab assessments.

H7: Uncommon wetland type (bog, fen, marsh, wet meadow, or cedar swamp) is present in RAU

Rationale: Uncommon wetland types (i.e., bog, fen, marsh, wet meadow, or cedar swamp) are especially important for biodiversity, research, education, and aesthetics.

Lab assessment (primary source): Uncommon wetland types were assessed by viewing the RIGIS wetlands coverage.

Field assessment (secondary source): During site visits, the presence of uncommon wetland types was noted. Wetland types that were dominated by invasive plant species were not considered to be uncommon.

H8: Waterbird habitat (OW or marsh) is present in the WU

Rationale: The presence of waterbirds (e.g., waders, waterfowl, terns) in a wetland can be aesthetically pleasing, can promote recreation (e.g., through hunting, birdwatching), and can provide a key focus for educational field trips. Wetlands that contain open water or marsh have the potential to support waterbird populations.

Lab assessment (primary source): The presence of open water and marsh was assessed by viewing the RIGIS wetlands coverage.

Field assessment (secondary source): During site visits, the presence of open water and marsh habitats was noted. Marshes that were dominated by invasive plant species were not considered to be viable waterbird habitat.

H9: Moderate to high quality habitat (wetland or deepwater habitat, upland forest or shrubland, abandoned field, or agricultural land) comprises < 50% of land within 1 mile of RAU

Rationale: This criterion assesses the abundance of natural or semi-natural open space in the region surrounding an assessment unit. The open space value of wetlands will be greater in areas of the landscape where open space is scarce.

Lab assessment (sole source): The RIGIS land use coverage was converted to a grid with 10-x10-meter cells. An .aml was then run in ArcGrid to determine the number of cells within 1 mile of each assessment unit that was designated as wetland or deepwater habitat, upland forest or shrubland, abandoned field, or agricultural land. Values were converted to percentages.

Field assessment: This criterion was not assessed in the field.

H10: Wetlands and deepwater habitats comprise < 10% of land within 1 mile of RAU

Rationale: Wetland restorations that are accomplished in areas of the landscape where wetlands are scarce will have a positive effect on heritage values (aesthetics, recreation, education, research, open space, and biodiversity).

Lab assessment (sole source): The RIGIS wetland coverage was converted to a grid with 10-x10-meter cells. An .aml was then run in ArcGrid to determine the number of cells within 1 mile of each assessment unit that were designated as wetland or deepwater habitat. Values were converted to percentages.

Field assessment: This criterion was not assessed in the field.

H11: RAU is located within 1 mile of a school or college

Rationale: Wetlands that are close to schools or colleges are more likely to be used for education and research purposes.

Lab assessment (sole source): Points within the RIGIS schools coverage were buffered by 1 mile and viewed in ArcView along with assessment units and orthophotos.

Field assessment: This criterion was not assessed in the field.