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Spotted Turtle Use of a Culvert Under Relocated Route 44 in Carver, Massachusetts

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Abstract: A new highway alignment for relocated Route 44 in Carver, Massachusetts, resulted in the direct alteration of 2.5 acres and indirect alteration of 3.9 acres of habitat for three statelisted turtle species: the wood turtle (*Clemmys insculpta*), spotted turtle (*Clemmys guttata*), and eastern box turtle (*Terrapene c. carolina*).

As part of the mitigation requirements for impacts to rare species habitat, the Massachusetts Highway Department (MassHighway) conducted a twoyear preconstruction study to determine the habitat preferences and seasonal movements of the statelisted species. The study determined that no wood turtles were present in the study area, that there was a large but declining population of box turtles, and that two highly used spotted turtle habitats would be bisected by the proposed highway entrance ramp. An intermittent stream channel proposed to be piped under the new entrance ramp was identified as a primary travel corridor between the two habitats.

Based on the findings of the preconstruction study, MassHighway identified a simple solution to allow the stream channel to continue to provide a migratory corridor for spotted turtles. To achieve this goal, MassHighway increased the proposed culvert size from a 24inch pipe to a 6foot by 6foot box culvert. In the spring and summer of 2004, postconstruction monitoring was conducted to determine the effectiveness of the culvert as a spotted turtle crossing structure. Nine turtles were fitted with radio transmitters and thread bobbins and followed three times per week in the spring and early summer, and once per week in the late summer to determine culvert effectiveness. Direct evidence (thread trails, visual observation) was documented for seven turtles, and indirect evidence (radio telemetry points on both sides of the culvert, visual observation) was documented for 13 turtles, confirming the use of the culvert as a crossing structure. A future study is recommended to document potential effects of traffic and noise on the spotted turtle population, continued use of the culvert, and potential changes to rare species habitat from the highway construction.

Introduction

In 2002, the Massachusetts Highway Department (MassHighway) began construction of relocated U.S. Route 44 between Carver and Plymouth. Construction of the new highway entrance ramp for Route 44 in Carver resulted in the direct alteration of 2.5 acres of prime rare species habitat and indirect alteration of 3.9 acres of prime rare species habitat. MassHighway conducted extensive mitigation measures to compensate for unavoidable impacts to rare species habitat, including acquisition of 27.8 acres of prime and suitable rare species habitat (a mitigation ratio of 6.4:1) and commitment to complete a twoyear preconstruction study developed by the Natural Heritage and Endangered Species Program (NHESP) to determine the seasonal movements and habitat preferences for wood turtles, spotted turtles, and eastern box turtles.

Field work for the preconstruction study was conducted in 1998 and 1999. Results of the study indicated that wood turtle habitat did not occur in the area, that there was a healthy population of spotted turtles in the emergent wetland adjacent to Route 58 (Wetland 17), and that there was a large but declining population of box turtles. The study also concluded that spotted turtles used a stream channel tributary to the Winnetuxet River and adjacent wetlands to travel to Turtle Pond, a vernal pool located approximately 550 feet east of Wetland 17. The results of the study determined that spotted turtle habitat would be bisected by the new Route 44 entrance ramp.

All environmental clearances and permits were already acquired for the project, and there was no requirement or obligation to further mitigate impacts to the turtle habitat. However, based on the findings of the study, MassHighway identified a simple solution to not only address the direct impacts to habitat, but to provide a critical wildlife passage link that would preserve the greater habitat area and prevent isolation and eventual elimination of 6.5 acres of prime spotted turtle habitat in Wetland 17. To achieve this goal, MassHighway increased the size of the proposed culvert, from a 24inch reinforced concrete pipe to a 6foot by 6foot concrete box culvert, which would not only convey the stream but provide migratory passage for spotted turtles under the highway interchange ramp.

Study Area

The main population of spotted turtles is located in an open emergent marsh, Wetland 17, containing soft rush (*Juncus effusus*), common cattail (*Typha latifolia*), common reed grass (*Phragmites australis*), steeplebush (*Spiraea tomentosa*), and tussock sedge (*Carex stricta*). Two intermittent streams traverse Wetland 17 and converge approximately 100 feet west of the newly constructed Route 44 entrance ramp to form the main tributary to the Winnetuxet River. The main intermittent stream (north channel) is fed by runoff from Route 58 to the west, and flows into the Winnetuxet River approximately 1,300 feet east. A second intermittent stream (south channel) also collects runoff from Route 58. Both channels are approximately three to five feet wide, with depths ranging from 0 to 2.5 feet, depending on the season. The substrate consists of a deep organic layer. The banks are heavily vegetated with overhanging soft rush and tussock sedge.

The new Route 44 entrance ramp constructed between Wetland 17 and the forested wetland east of Wetland 17 conveys the tributary to the Winnetuxet River under the entrance ramp via a 6foot by 6foot concrete box culvert. The 60foot long culvert was constructed below the streambed elevation, providing approximately four to six inches of organic substrate on the culvert bottom. In the vicinity of Wetland 17, the entrance ramp is 10 to 15 feet above the wetland, with 2:1 riprap sideslopes. During construction, the culvert was cut to match the 2:1 sideslopes, which shortened the effective culvert width from approximately 68 feet to 44 feet. Based on a culvert length of 44 feet, the openness ratio (OR: cross-sectional area of the culvert divided by its length) is 0.8. Although the culvert was designed and constructed prior to publication of the Draft Massachusetts River and Stream Crossing Standards: Technical Guidelines (University of Massachusetts-Amherst 2004), the culvert exceeds the recommended openness ratio of 0.75 for new crossing structures. Approximately 200 feet south of the culvert, the ramp is approximately three feet above the replacement wetland elevation. The steep, riprapped sideslopes that support the entrance ramp effectively serve as a barrier to turtles, and turtles are directed to the 6foot by 6foot box culvert if they intend to cross.

South of the main tributary to the Winnetuxet River, the red maple forested wetland ponds in several areas during the spring, and contains many braided, slowmoving channels that outflow from Turtle Pond and drain into the main tributary. A large portion of this wetland is paludal woodland, exhibiting mound and pool topography, with many sphagnum moss mats in the wetter areas. Red maple dominates the tree layer, with black gum (*Nyssa sylvatica*) as a common representative, and white pine (*Pinus strobus*) on hummocks within the wetland. In the lower forest layers, highbush blueberry (*Vaccinium corymbosum*) and northern arrowwood (*Viburnum dentatum*) are common. A dense growth of cinnamon fern (*Osmunda cinnamomea*) covers the forest floor.

Turtle Pond is a vernal pool east of Wetland 17 and south of the tributary to the Winnetuxet River. This abandoned cranberry bog is partially vegetated with shrub vegetation, including highbush blueberry, arrowwood, winterberry holly (*Ilex verticillata*), and cranberry (*Vaccinium macrocarpon*). The pool also contains swamp loosestrife (*Decodon verticillatus*), pondlily (*Nuphar variegatum*), three-way sedge (*Dulichium arundinaceum*), and large mats of sphagnum moss (*Sphagnum* sp.). Depths in the pool range from 2 inches to 2.5 feet.

Methods

Capture and characterization

Turtle capture was conducted daily between April 8 and April 29, 2004. Turtles were handcaptured by visually searching suitable habitat, and trapped using two 10inch diameter minnowstyle traps constructed of hardware cloth with escape hatches, funnel shaped entrances, and sized for spotted turtles. During the weeks of April 20 and 28, two unbaited hoop traps were set in Wetland 17 to capture two radio tagged turtles whose transmitters appeared to be failing (Turtles 30A and 50A).

Captured turtles were aged, sexed, measured, weighed, and notched for individual identification. Each captured turtle was also numbered with a bright orange nontoxic paint pen on its carapace for easier visual observation. Age was determined by counting annuli on each right plastral plate, which is a reasonable estimate of age for many turtle species (Sexton 1959). Turtles were sexed based on eye color, jaw color, vent location, and plastral concavity. Turtles were marked by notching marginal scutes, modified from Cagle (1939). A triangular metal file was used instead of the square file described by Cagle because the triangular file is less intrusive and produced equivalent notches.

Ernst et al. (1994) reported studies that found sexual maturity of spotted turtles was attained by the time they grow to a carapace length of 80 millimeters. We attempted to classify males and females at all ages, but classified spotted turtles with a carapace length of less than 80 millimeters as juveniles.

Monitoring

Thread trailing and radio telemetry were used to monitor the movements of the sample population. Radio telemetry was used to provide “snapshots” of movement, while thread bobbins were used to show actual movement trails. By using these monitoring techniques, effectiveness of the culvert could be determined.

Radiotelemetry

Nine turtles were fitted with radio transmitters (AVM model SM 1H; 164 MHz) between April 8, 2004, and May 19, 2004. Six radiotagged turtles (3 males; 3 females) that were documented to occur on both sides of the culvert during one or both years of the preconstruction study were a priority for the postconstruction study. These turtles were: 6A, 8, 25, 30A, 50A and 60A.

It was theorized that these turtles would attempt to maintain the same home range and movement patterns that they exhibited prior to the highway construction, and that tracking these turtles would yield more useful information on whether and how they crossed than for those turtles that were either known to not cross, or did not have preconstruction data recorded. Three additional turtles (2 females, 1 male) were also fitted with radio transmitters for a total of nine radio tracked turtles. These turtles were: 13, 52 and 550.

Radio transmitters were glued to the right rear side of each turtle’s carapace with a fastsetting, twopart epoxy. Turtles were released at their point of capture within one hour. Spotted turtles were tracked three times a week through June 30, and once a week from July 1 through September 30. Radio transmitters were removed from all but one turtle during

the first week of October before the turtles entered dormancy (the signal on one turtle was lost before its transmitter could be removed). Each turtle was tracked to within one foot of its location, and point coordinates were recorded with a handheld Global Positioning System (GPS) unit (Garmin GPS II Plus). Coordinates were transferred to an aerial photo base and used to determine turtle home ranges.

Five females and 4 males were fitted with radio transmitters and tracked for the field season or until the signal was lost. Turtle 6A was initially fitted with a radio transmitter but did not move from its original capture location for 4 weeks of tracking, so her transmitter was removed and placed onto another female (Turtle 52) that had been observed passing through the culvert.

Thread trailing
From the date of capture through June 30, the nine radiotagged turtles were also fitted with thread bobbins to assist in locating travel corridors and provide direct evidence of culvert use. Bobbin attachment was modified from methodology employed by Wilson 1994 with bobbins obtained from Coats North America (formerly Barbour Threads). Bobbins were approximately three grams and contained 200 yards of thread. Bobbins were placed in ¾inch diameter heat-shrinkable tubing (Russell industries, Inc., HUG-34-4PB) then heated so that the tubing encased the thread bobbin. The encased thread bobbin was then epoxied onto the turtle's carapace and edges were smoothed over with caulking to prevent tangling. Bobbins were tied to vegetation and unraveled as turtles moved. Expelled thread was followed each day for three consecutive days to determine individual movement paths. A sketch of the thread trail was drawn, illustrating the movement. Expelled thread was collected daily and removed to minimize the possibility of tangling. Thread bobbins were removed from all turtles during the week of June 30, 2004.

Data and analyses
Based on radio tracking and thread trailing data gathered over the field season, maps of each turtle's home range and movements were generated. Home ranges were determined by the minimum convex polygon method for ArcView 3.x, v. 1.2 (Jenness 2004). Turtles with at least 10 observations over a sixweek period were included in the home range analyses. Because the home range maps contain locationspecific data for a statelisted species, the home range analyses are provided descriptively and not graphically.

Results and Discussion

Spotted turtles were captured from April 8 to July 7, 2004. This section provides the results of the 2004 captures, with comparisons to the 19981999 preconstruction study, as well as a description of the effectiveness of the culvert as a connectivity link between Wetland 17 and Turtle Pond. Home range estimates are also provided for radio tracked individuals, with comparisons to the 19981999 preconstruction study.

Population dynamics
Fifty-six individual spotted turtles were captured during the 2004 study. In 2004, 35 of the 56 turtles (63%) were recaptures, while 21 were new captures (37%). Four turtles captured for the first time in 2004 had been notched by others prior to 1998. As with previous years, most turtles (41 individuals, representing 73%) were captured in April. The majority of the captures (46 turtles; 82%) occurred in Wetland 17, followed by seven captures in Turtle Pond (12%), and three turtles in the red maple forested wetland (6%). As with previous years, most turtles (55 individuals; 98%) were captured by hand. Six turtles were caught in traps in Wetland 17, five of which were 2004 recaptures.

The population of spotted turtles appears to be healthy. To date, 81 spotted turtles have been captured and marked. Forty spotted turtles were captured and marked during the 1998 field season, 20 turtles were captured and marked in the 1999 field season, and 21 during 2004. Of the 81 turtles, 13 were previously captured and marked by others.

In 2004, new captures were skewed towards females (9 individuals) and juveniles (8 individuals), with four male captures (table 1). This ratio is similar to 1999 captures. Over the three field seasons, juveniles comprised greater than onethird of the population (31 individuals; 38%), indicating substantial juvenile recruitment into the population.

Overall, females were captured at slightly greater ratio than males (1.2:1), although in 1998, males outnumbered females by a 1.3:1 ratio. This trend is not similar to what has been reported in the literature, where several studies have documented a male bias in turtle populations when there is an adjacent major roadway such as Route 58 (Aresco 2005, Steen and Gibbs 2004, Gibbs and Shriver 2002). Some researchers theorize that populations contain higher numbers of males because females are physiologically required to seek open, sandy upland areas for nesting, which may involve higher roadcrossing frequency than males, thereby exposing females to greater vulnerability from vehicle mortality.

Table 1. Age and Sex Ratio of Spotted Turtle Captures

Capture Year	Adult Captures		Juvenile Captures*	Total captures
	Male	Female		
1998	14	11	15	40
1999	5	7	8	20
2004	4	9	8	21
Total	23	27	31	81

* Juveniles were classified as those individuals with a carapace length less than 80 millimeters

In the study area, the slight female bias may be caused by nest site selection. Like many chelonians, sex determination in spotted turtles is temperaturedependent. Temperatures at or above 86 degrees Fahrenheit during egg maturation produce all females (Ernst et al. 1994). Roadways can provide seemingly suitable nesting sites as they often have higher soil temperatures, lack canopy cover, and exhibit higher ambient temperatures because of the heat that pavement absorbs and attracts (Aresco 2005). If nesting is occurring adjacent to Route 58, it is likely that more females than males are being produced. Preliminary assessments of juvenile sex, while unreliable because sexual differentiation is not well established in juveniles, indicates that many more females are present in the study area than males. Of the 31 juvenile captures, 23 were female, 4 were male, and 4 were undetermined.

Eight dead spotted turtles were encountered during the three field seasons (five in 1998, two in 1999, and one in 2004). Two adult females (Turtles 43 and 50) and four juveniles were found dead on the Route 58 shoulder (east side), and two dead juveniles were found in Wetland 17. It is likely that the females were either attempting to cross Route 58 to nest in uplands on the west side of the road, or were attempting to nest on the roadway sideslopes. However, the high number of recaptures observed between the postconstruction and preconstruction study appears to indicate that the sexually mature individuals are experiencing relatively low mortality rates.

Based on the slight female bias in the population, and the large number of recaptures observed in 2004, Route 58 does not appear to cause additive mortality. The proportional ratio could mean that the Route 58 and 44 are not a large source of additive mortality. Females may also be nesting in close proximity to Wetland 17 and/or Turtle Pond in areas that do not require roadway crossings.

Home range analysis

In, 2004, radio tracked turtles consisted of five females and four males. Five spotted turtles tracked during both preconstruction seasons (Turtle 5A, 6A, 8, 30A, and 60), and one individual tracked in 1999 (Turtle 25) was radio tracked in 2004. Two turtles captured in 1999 but not previously tracked (Turtles 52 and 550) and one 2004 capture (Turtle 13) were tracked in 2004. Originally, four females and four males were fitted with radio transmitters. After four weeks of tracking, Turtle 6A's signal was weak, and movement appeared to be minimal based on thread bobbin tracking. Her radio transmitter and thread bobbin were removed, and a new transmitter and thread bobbin was fitted to another female (Turtle 52).

Mean home range size for males was 3.1 acres in 2004 and 3.3 acres over the three years (table 2). Female mean home range was slightly smaller (2.6 acres in 2004 and 2.1 acres between years). Male home ranges varied from 1.4 to 4.9 acres in 2004, and female home ranges varied from 1.7 to 3.6 acres. Our data are consistent with Graham's (1995) result of 1.98 acres. His average, however, may be low because only three individuals were tracked. In western Massachusetts, Milam and Melvin (2001) found home ranges varied from 0.5 acres to 85 acres, with a mean home range of 8.9 acres in a study involving 26 individuals. Larger home ranges were attributed to the longer tracking period of study and inclusion of all data points in the analyses. The smaller home ranges observed in this study may be attributed to higher quality habitat in a smaller area.

Table 2: Spotted Turtle Home Range Sizes

Turtle	Male Size (acres)				Turtle	Female Size (acres)			
	1998	1999	2004	Mean		1998	1999	2004	Mean
8	5.2	3.9	3.1	4.1	5A	3.2	0.5	--	1.9
10A	5.4	3.5	--	4.5	6A	--	2.2	--	N/A
30A	1.5	4.2	3.1	2.9	13	--	--	2.7	N/A
60	1.0	2.7	1.4	1.7	25	--	2.0	2.5	2.3
550	--	--	4.9	N/A	50A	3.2	2.5	3.6	3.1
					52	--	--	1.7	N/A
					70A	0.5	1.0	--	0.8
					4002	0.1	1.0	--	0.6
Mean	3.3	3.6	3.1	3.3	**Mean**	1.7	1.5	2.6	2.1

Home ranges for five turtles were analyzed during the pre and postconstruction study. Most turtles showed large yeartoyear variations, with no consistent differences between pre and postconstruction. Turtle home ranges vary year to year, based on numerous factors such as climate and food resources.

Aquatic turtles such as spotted turtles are often found in welldefined populations (Gibbons 1968), and this was also observed for spotted turtles in the study area. Spotted turtles showed a great deal of overlap in their home ranges with other radioed turtles, as well as with other captured turtles. In 2004, six of the nine radioed turtles spent time in both Wetland 17 and Turtle Pond. All turtles, except Turtle 13, spent a portion of their time in Wetland 17. All turtles, except Turtle 6A and Turtle 60, spent a portion of their time in Turtle Pond.

Culvert effectiveness

Past studies have indicated that spotted turtles appear to maintain their corridors and movement patterns between years (Perillo 1997, Klemens 2000). In order to determine if the installation of a 6foot by 6foot culvert was an effective tool to maintain habitat connectivity used by this population of turtles, radio transmitters and thread trailing devices were attached to nine turtles.

Direct Evidence. Direct evidence such as thread trail or visual observation of a turtle moving through the culvert was used to confirm use of the 6foot by 6foot box culvert. Seven of the nine tracked individuals had been followed either in 1998 or in 1999. On average, bobbins were attached for nine weeks, collecting 27 days of movement throughout the late spring, when movement is typically at its highest. Turtle 30A had its bobbin attached for the longest time (11 weeks), while Turtle 52 had its bobbin attached for the shortest time (3 weeks).

Thread trailing was used to show actual movements by the turtles, compared to telemetry, which provided movement "snapshots." The benefit of thread trailing is that it allows researchers to directly observe individuals movement patterns. A list of the turtles and dates of tracking is provided in table 3.

Table 3. Spotted Turtles Tread Trailing Dates

	Dates	
Turtle	**Bobbin Attached**	**Bobbin Removed**
6A	April 12	May 12
8	April 8	June 8
13	April 15	June 8
25	April 16	June 8
30A	April 6	June 22
50A	April 8	June 4
52	May 19	June 8
60A	April 15	June 4
550	April 16	June 9

Bobbins were only functioning 3 consecutive days per week

Thread trailing provided direct evidence that the culvert was effective as a crossing structure and that the construction of the Route 44 access ramp will not negatively impact the ability of the turtle population to access Wetland 17, Turtle Pond, and other habitats.

Seven individuals (3 male, 3 female, 1 unknown) used the culvert seven times (table 4). A thread trail was observed five times indicating movement; two turtles that were not being tracked were visually observed moving through the culvert, and one unidentified individual (eluded capture) was visually observed moving through the culvert. Four of the nine turtles with bobbins used the culvert. Turtle 30A provided the most direct evidence of use, leaving a thread trail on two occasions. Females appeared to move in relation to nesting (mid-June), while males' movement appeared to correlate to mating (May).

Turtles 7, 54, and 70A were all observed at the culvert entrances multiple times but never observed traveling through or on both sides of the culvert. The culvert may provide additional usefulness other than maintaining connectivity. The culvert has 4 to 6 inches of organic substrate that may be used in thermoregulation as well as the shade it provides. The culvert may also provide foraging opportunities because of the different environment it provides for food resources.

Table 4. Spotted Turtles Culvert Use (Direct Evidence)

Turtle	Sex	Date	Direction	Method of Observation
8	Male	May 6	W17 - Turtle Pond	thread trail
15	Female	June 16	Turtle Pond - W17	visual observation
25	Female	June 17	Turtle Pond - 17	thread trail
30A	Male	May 6	Turtle Pond - W17	thread trail
		June 1	Turtle Pond - W17	thread trail
52	Female	June 16	Turtle Pond - W17	thread trail
5000	Male	April 28	Turtle Pond - 17	visual observation
Unidentified	--	May 18	W17 - Turtle Pond	visual observation

Indirect Evidence. Thirteen individuals were observed on both sides of the culvert during the field season. This determination was made using radio telemetry and from direct observation. It is likely that the turtles used the culvert because other pathways are improbable. The highway entrance ramp is elevated 10 to 15 feet above the wetland with steep, riprap slopes. The bottom three feet to five feet of the ramp sideslopes consist of twofoot to threefoot boulders, which would make it extraordinarily difficult for turtles to climb. Individuals would have to travel several hundred feet to the south with little cover to access a flatter portion of the ramp that could be more easily ascended.

Thirteen individuals (8 male, 5 female) were observed on both sides of the culvert. Seven of the 13 individuals had transmitters. The culvert may have been used a total of 31 times by these 13 individuals (table 5). Overall, between direct and indirect observations, 14 different individuals possibly used the culvert for a total of at least 39 times.

Table 5. Spotted Turtles Culvert Use (Indirect Evidence)

Turtle	Sex	Date	Direction of Movement
1	Male	April 19 / May 13	Wetland 17 – Turtle Pond
8	Male	June 16 / July 14	Turtle Pond – Wetland 17
		August 3 / August 19	Wetland 17 – Turtle Pond
		August 24 / September 31	Turtle Pond – wetland17
15	Female	June 10 / June 16	Wetland 17 – Turtle Pond
18	Female	April 20 / June 10	Wetland 17 – Turtle Pond
25	Female	June 18 / June 22	Turtle Pond – Wetland 17
		August 10 / August 19	Wetland 17 – Turtle Pond
30A	Male	April 29 / May 5	Wetland 17 – Turtle Pond
		May 7 / May 12	Wetland 17 – Turtle Pond
		May 27 / June 1	Turtle Pond – Wetland 17
		June 8 / June 9	Wetland 17 – Turtle Pond
42	Male	April 20 / May 13	Wetland 17 – Turtle Pond
50A	Female	May 14 / May 18	Turtle Pond – Wetland 17
		August 10 / August 19	Wetland 17 – Turtle Pond
52	Female	June 10 / June 16	Wetland 17 – Turtle Pond
		June 18 / June 22	Wetland 17 – Turtle Pond
		June 22 / June 23	Turtle Pond – Wetland 17
		June 30 / July 7	Wetland 17 – Turtle Pond
		July 14 / July 21	Turtle Pond – Wetland 17
		July 21 / July 27	Wetland 17 – Turtle Pond
		August 10 / August 19	Turtle Pond – Wetland 17
60	Male	June 30 / July 7	Wetland 17 – Turtle Pond
		July 7 / July 21	Turtle Pond – Wetland 17
550	Male	June 30 / July 7	Turtle Pond – Wetland 17
		August 10 / August 19	Wetland 17 – Turtle Pond
4400	Male	April 29 / June 9	Wetland 17 – Turtle Pond
		June 9 / July 21	Turtle Pond – Wetland 17
5000	Male	April 19 / April 27	Wetland 17 – Turtle Pond
		April 29 / May 20	Wetland 17 – Turtle Pond
		June 10 / September 31	Turtle Pond – Wetland 17

Biographical Sketches: Delia R. J. Kaye, CWB, senior environmental scientist, Vanasse Hangen Brustlin, Inc. Ms. Kaye received a B.S. degree in wildlife biology from the University of Vermont and is pursuing a master's degree in biology from Harvard University Extension School. Her current work includes rare species habitat evaluations, wildlife studies, and wetland and stream restoration. Ms. Kaye served as field supervisor for the Route 44 turtle study.

Kevin M. Walsh, assistant deputy chief engineer, Environmental Section, Massachusetts Highway Department. Mr. Walsh has over 16 years of experience in environmental permitting of highway projects. As the environmental project manager for the Route 44 Relocation Project, he oversaw all aspects of environmental permitting and analysis for the project including coordination with the State, Federal, and local environmental agencies. He holds a bachelor's degree in environmental design.

Eric L Rulison, graduate student, Hofstra University. Mr. Rulison completed a B.S. degree in wildlife management at the University of New Hampshire and is pursuing a master's of science degree in biology from Hofstra University, where his research interests focus on effects of nuisance mammals on native rare species. While at VHB, he conducted much of the field work for the Route 44 turtle study as well as other studies involving rare reptiles and amphibians.

Christopher M. Ross, environmental analyst, Department of Environmental Protection. Mr. Ross is a graduate of Northeastern University with a bachelor's degree in civil engineering. Mr. Ross was the regional lead engineer for the permitting of the Route 44 project. He has over 17 years experience with DEP in the permitting and review of complex engineering issues associated with permits issued under the Wetlands Protection Act. Mr. Ross is also the regional liaison to MassHighway on interagency issues.

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