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Saugus Iron Works National Historic Site Amphibian and Reptile Inventory

March – September 2001

Natural Resource Report NPS/NETN/NRR—2010/248

ON THE COVER
Northern two-lined salamander - Saugus Iron Works NHS is a locally important site for this stream-dwelling salamander.
Photograph by: Dave Brotherton

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Robert P. Cook

National Park Service
Cape Cod National Seashore
Wellfleet, MA 02667

David K. Brotherton

Department of Herpetology
Wildlife Conservation Society
Bronx Zoo
Bronx, NY 10460-1099

John L. Behler[1]

Department of Herpetology
Wildlife Conservation Society
Bronx Zoo
Bronx, NY 10460-1099

[1] deceased

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Executive Summary

Under a National Park Service /Wildlife Conservation Society Cooperative Agreement, an inventory of amphibians and reptiles at Saugus Iron Works National Historic Site (SAIR) was conducted one day per month from April through September 2001. Five standard methods were employed: anuran calling surveys, time-constrained searches, coverboard surveys, turtle trap surveys, and minnow trap surveys. In addition, animals encountered outside of standardized surveys (temporally or spatially) were recorded as incidental encounters.

The four amphibian and reptile species documented in 2001, plus one observed in 2000, represent 50% (5/10) of the species already known or believed to be potentially occurring at SAIR. Species recorded were northern green frog, northern two-lined salamander, northern brown snake, and common garter snake, plus common snapping turtle in 2000. The diversity of herpetofauna at SAIR is limited by its small size, history of disturbance, limited habitats, and urban location. There are no ponds present and the Saugus River is well drained, with little standing water at low tide. Amphibians and reptiles at SAIR are largely limited to species that do not breed in ponds, have small home ranges and are capable of maintaining a population in a small habitat patch, or are mobile species that disperse along the river or across the adjacent uplands. For these latter, successful movement to SAIR across the adjacent landscape or along the Saugus River is challenging due to urban development and culverts.

Of the species found in SAIR, northern two-lined salamander is the most habitat specific. All life stages (eggs, larvae, and adult) are spent in stream habitat. In spite of the park's history of disturbance and presence in an urban landscape, northern two-lined salamanders are abundant at SAIR, primarily in the small stream/seep east of the maintenance building. The remaining species – northern brown snake, common garter snake, northern green frog, and common snapping turtle – are urban-tolerant generalists. Both brown and garter snakes can persist in small habitat patches such as SAIR, whereas northern green frogs and common snapping turtles likely utilize SAIR as part of larger home ranges. The Slag Heap and uplands of the Historic/Administrative survey area provide an important and rare habitat feature in an urban area: turtle nesting habitat adjacent to the river. This spares females a risky nesting foray across roads, which is a major source of mortality. The Historic/Administrative area's long history of use for turtle nesting suggests that female turtles using this stretch of river return to use it repeatedly.

The herpetofauna of SAIR are subjected to numerous stressors, including global ones such as acid precipitation and mercury deposition; regional ones such as water pollution, streamflow alterations, and road kill; and local ones such as invasive alien plants and animals. However, the impacts of regional and local stressors may be lessening, and staff at SAIR should continue their efforts to improve the site's environmental quality. Although it is unlikely that SAIR will ever support an extensive herpetofauna, it is an important part of a larger system of protected "greenspace" along the Saugus River, and provides regionally important habitat. It is likely that, over time, additional species will be recorded at SAIR, particularly as environmental conditions improve. A monitoring program which uses coverboard surveys, searches of the marshes and stream, surveys of the Saugus River with minnow traps and turtle traps, and general time-constrained searches is recommended.

Acknowledgements

Funding for this project was provided by the National Park Service, and many people helped with fieldwork and logistics. Tami Ransom and Eric Leibgold spent long days and many hours in the field, as well as recording and inputting field data. SAIR NHS staff Carl Salmons-Perez, Frank Studinski, Bill Fuchs, and Marc Albert provided critical logistic support and background information, and/or contributed important observations. Adam Kozlowski and Tim Shepherd of the Northeast Temperate Network helped with data review and created the maps used in this report.

Preliminary drafts of this report were improved as a result of critical review and comments by Marc Albert, Adam Kozlowski, and Brian Mitchell and Ed Sharron helped in final formatting of this report.

Introduction

Saugus Iron Works National Historic Site (SAIR) was established by Congress on 5 April 1968 to preserve the archeological and historic resources and museum collections associated with America's first successful iron works, which operated on site from 1646 to about 1670 (NPS 2003). SAIR is located in the town of Saugus, Massachusetts (42° 28' N, 71° 0' W), 18 km (11 miles) north of Boston. The 8 acre (3.2 ha) site consists primarily of a developed and landscaped historic core adjacent to the Saugus River, which flows through the park, plus riparian woodlands and marshes, and a small stream/seep that feeds into the Saugus River. At the time this survey began, over two hundred species of plants, 35 species of birds, 10 species of mammals, five species of reptiles and amphibians, and at least four species of fish had been recorded in the park.

In 1998, a Cooperative Agreement between the National Park Service (NPS) and the Wildlife Conservation Society was formed to assess amphibian and reptile assemblages within the parks of the "New England Cluster" of the National Park Service. Since information was lacking or inadequate for the amphibians and reptiles of SAIR, a comprehensive, broad-based inventory was conducted in 2001 using a number of survey techniques. As part of this inventory project, SAIR was surveyed one day per month from April through September 2001. While the goals of the project varied between parks, they generally were as follows:

- Assist the park service in documenting at least 90% of the species currently estimated to occur in the park.
- Determine the occurrence and status of species of management concern (e.g., state and federal *Threatened*, *Endangered*, and *Special Concern Species*, and other declining species).
- Determine abundance categories, distribution, and habitat use of documented species.
- Identify critical habitats of *Threatened*, *Endangered*, and *Special Concern* species.
- Provide a basis for the future development of a long term monitoring program.
- Analyze species occurrence against historical occurrence and evaluate the state of the park's herpetofauna, on a site and regional scale.

Because of the site's small size, relatively recent establishment, and location in a highly urbanized landscape, it is not possible to determine what the "historic" herpetofauna of SAIR was. Nyman (1991) lists 18 species of amphibians and 17 species of reptiles as historically present in the 47 square mile Saugus River basin. Many of these species have large home ranges, and most of them were historically widespread and use a combination of aquatic and terrestrial habitats in the course of their annual life cycle. It is therefore likely that many of these species at least occasionally utilized the habitats historically present at SAIR. However, because SAIR is small and lacks any of the pond or lake habitat used for most amphibian breeding, most of these historic occurrences would have involved animals using SAIR as a small part of a much larger landscape needed to support viable populations.

An “estimate” of species known to or possibly occurring at SAIR was generated based on interviews with park staff, site reconnaissance on 27 June 2000, observations from the Saugus River Basin (Nyman 1991), and data collected by the Massachusetts Herp Atlas (Jackson et al. 2010) . Staff observations included common snapping turtle (*Chelydra s. serpentina*), common garter snake (*Thamnophis s. sirtalis*), painted turtle (*Chrysemys picta*), and northern green frog (*Lithobates clamitans melanota*). Species observed on 27 June 2000 were northern two-lined salamander (*Eurycea b. bislineata*), northern green frog, and common snapping turtle. Nyman (1991) recorded 11 amphibian and five reptile species for the entire Saugus River Basin and from 1992 through 1998, and eight amphibian and 10 reptile species were confirmed within the 25 square kilometer Massachusetts Herp Atlas block that contains SAIR (Jackson et al. 2010). Based on these observations, the habitat use and life history of species known from the region, and the amount and type of habitat present at SAIR, we estimated that in addition to the five species already observed at SAIR, the following five were likely to or might presently occur or occasionally utilize habitats at SAIR: eastern red-backed salamander (*Plethodon cinereus*), spring peeper (*Pseudacris crucifer*), American bullfrog (*Lithobates catesbeiana*), northern brown snake (*Storeria d. dekayi*), and northern water snake (*Nerodia s. sipedon*). Thus, although it was not possible to provide a meaningful estimate of the historic herpetofauna, our estimate of the species currently known or potentially present at SAIR was 10 species (Appendix A).

Study Area

Saugus Iron Works is the site of the first integrated iron works in North America, which operated from 1646 to about 1670. A set of reconstructed iron works structures, including a blast furnace, forge, and a rolling and slitting mill are maintained on site, along with a restored early eighteenth century house. The approximately 8 acre (3.2 ha) site consists of a historic zone of buildings with shade trees, flowerbeds, and lawn, and a "natural zone" consisting of the land on either side of the Saugus River and associated seeps/streams, tidal freshwater marshes, and woodlands. The "natural zone" has been severely impacted by human activities, as evidenced by the presence and abundance of invasive alien plant species. At the time of this survey, roughly half of the marsh was dominated by common reed (*Phragmites australis*) and purple loosestrife (*Lythrum salicaria*), with the rest dominated by the narrow-leaved cattail (*Typha angustifolia*). The riparian woodlands were dominated by the invasive alien Norway maple (*Acer platanoides*), with some native species such as red maple (*Acer rubrum*), silver maple (*Acer saccharinum*), boxelder (*Acer negundo*), American beech (*Fagus grandifolia*), white oak (*Quercus alba*), scarlet oak (*Quercus coccinea*), black cherry (*Prunus serotina*), and shagbark hickory (*Carya ovata*) also present (Clemants 1997). Subsequent to the survey, ecological restoration activities have converted the marsh to a combination of tidal mudflat and freshwater tidal marsh, and many Norway maples have been removed from the riparian zone. The principal habitats for amphibians and reptiles are the Saugus River channel, a small unnamed stream/seep that flows into the west side of the Saugus River below the maintenance building, small patches of riparian forest on both sides of the river, marshes on both sides of the river, and fields, lawns and landscape plantings comprising the historic/administrative zone.

Methods

Sampling Overview

Sampling at SAIR was conducted by a two person crew as part of an effort to survey the herpetofauna of four NPS sites during the 2001 field season. Because the herpetofauna of most sites in the northeast United States consists of a variety of species, each with differing periods of greatest activity/detectability (which can also vary somewhat annually), the sampling plan called for distributing the sampling effort over the course of the spring and summer activity season. Given this, and the logistics of sampling at four sites (located in Cornish, NH, Saratoga NY, Lexington, MA, and Saugus, MA), we sampled sites in bouts that varied in duration in proportion to a site's size and presumed faunal/zoogeographic complexity.

Over the course of a month the crew sampled a site and moved on to the next, such that a full round of sampling was conducted each month during the months of April, May, June, August, and September. For SAIR, each monthly sampling bout was one day long, beginning in early to mid-morning and lasting until mid-afternoon or sunset.

Both general and targeted standard survey methods were used in stream, wetland, and upland habitats. Multiple methods were often used in a given habitat because these habitats might support several amphibian and reptile species and require several methods to sample the entire herpetological community. The habitat of each standardized survey site was classified to provide a general description of each survey site (Appendix B). Site selection for standardized surveys was designed to sample across the range of habitat types available (Table 1, Figure 1). Because of the park's small size, all sites were sampled.

Table 1. Overview of standardized survey sites at Saugus Iron Works NHS and sampling methods used at each site.

Site	Habitat Type	Calling Survey	Coverboard	Time-constrained Search	Turtle Trap	Minnow Trap
Saugus River	river channel			X		X
Marsh	freshwater marsh	X		X	X	X
Stream/Seep	permanent stream/seep			X		
East Woodland	hardwood forest		X	X		
Historic/ Administrative	landscaped and field		X	X		

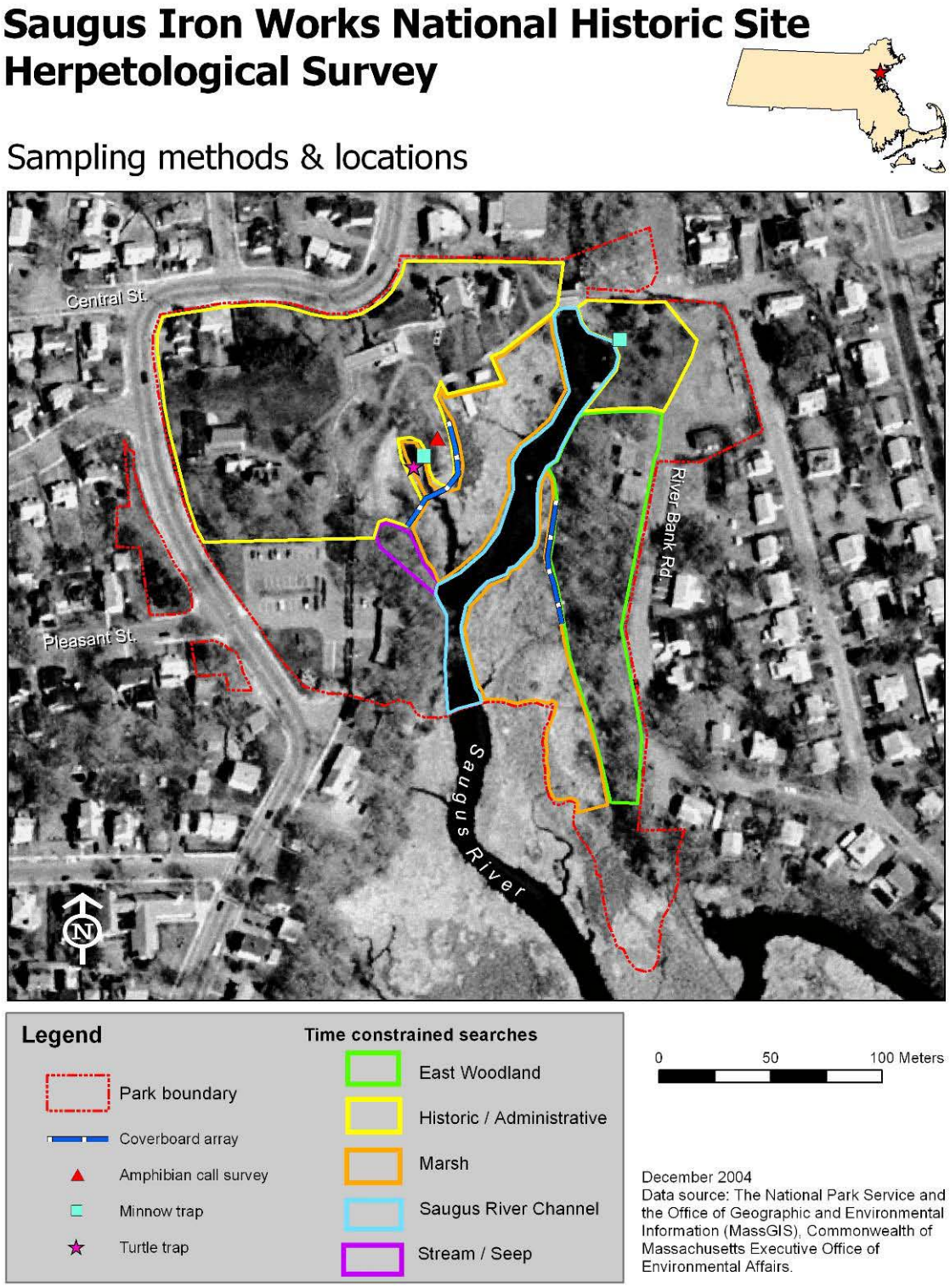

Figure 1. Location of standardized sampling sites and time-constrained search areas used in herpetofaunal inventory at Saugus Iron Works National Historic Site.

Anuran Calling Surveys (ACS)

Anuran calling surveys were conducted using the Wisconsin frog and toad survey method (Heyer et al. 1994). Anuran calling surveys record the presence of species at specific sites and provide an index of abundance based on the calling intensity of species heard. Call index values and criteria for assigning them are: 0 = no calls, 1 = individuals can be counted (no overlapping of calls), 2 = overlapping of calls (can still be counted), 3 = full chorus (calls are constant and individually indistinguishable). The surveyors arrived at each sample site at least a half-hour after dusk and listened for anuran calls for 5 minutes, recording an index value for each species heard. For each sampling occasion, the number of individuals of each species calling was also counted or estimated.

Due to variable activity patterns among anuran species, multiple calling surveys conducted throughout spring and early summer months are necessary to thoroughly document species presence at a site (Conant and Collins 1998, Crouch and Paton 2002). Anuran calling surveys, conducted from atop the "Slag Heap," sampled the Marsh on 22 April, 25 May, and 23 June 2001.

Time Constrained Search (TCS)

Habitat-specific time-constrained search (TCS) was conducted in all habitats likely to support amphibians and reptiles, i.e., Stream/Seep, Saugus River Channel, East Woodland, Marsh, and Historic/Administrative. Each marsh, stream or river section, or upland TCS area (East Woodland and Historic/Administrative) was searched for a pre-determined period of time, which was commensurate with size. The amount of time allotted to search an area on a given occasion was not enough to search all available cover, and searchers used an approach intended to maximize the numbers and diversity of captures by moving through the area and searching under the best available cover (e.g. logs, rocks, boards, metal debris) favored by amphibians and reptiles (Bury and Raphael 1983), and by dip netting in ponds and marshes (Heyer et al. 1994). Although the original plans called for sites within each habitat type to be sampled the same number of times, and sampling sessions at a given site to be the same duration each time, due to the exigencies of field work, this was not always possible. Results of TCS were standardized as a capture rate (CR) for each species, calculated by dividing the total number of individuals recorded by the total search effort (person hours) spent for each search. Person hours are the total amount of time spent searching, multiplied by the number of people participating in the search.

Stream/River TCS

The Stream/Seep and the Saugus River Channel sites were searched on 22 April, 25 May, 23 June, 22 August, and 15 September 2001 for a total search time of 2.7 and 3.7 search hours respectively. Starting and ending times (Eastern Standard Time) and the number of people searching were recorded. Investigators systematically moved upstream, using a dip net in the stream to capture amphibians as rocks were overturned. Rocks, logs, and debris were overturned and searched under. Identification and life stage (adult or larva) were recorded for each animal captured. The adult life stage was defined as any individual not in the larval stage and the larval stage was defined as an individual with gills, showing pre-metamorphic characteristics.

Woodland TCS

The East Woodland area was searched on 22 April, 25 May, 23 June, 22 August, and 15 September 2001 for a total search time of 3.3 search hours. Start and end times, number of searchers, and the identification, number, and sex of individuals found were recorded.

Field TCS

The Historic/Administrative area was searched on 22 April, 25 May, 23 June, and 22 August 2001 for a total search time of 2.8 search hours. Start and end times, number of searchers, and the identification, number, and sex of individuals found were recorded.

Wetland TCS

The Marsh area was searched 22 April, 25 May, 23 June, and 22 August 2001 for a total search time of 4.7 search hours. Searches were conducted by traversing the entire marsh, sampling with a dip-net for amphibian larvae and adults, as well as turtles and snakes. Start and end times, number of searchers, and the identification, number and sex of individuals found were recorded.

Coverboards (CB)

Coverboards (Grant et al. 1992) were used primarily to inventory snakes and terrestrial amphibians. Boards were 0.6m x 1.2m (2' x 4') and made of corrugated sheet metal or plywood. In March 2001, coverboards were deployed on top of vegetation in the Historic/Administrative area above its edge with the Marsh, and in the East Woodlands, also above its edge with the Marsh (Figure 1). At each site, eight boards were placed 5 meters apart in linear "arrays" consisting of alternating wood and metal boards. Coverboards were checked on 22 April, 25 May, 23 June, 22 August, and 15 September 2001.

Capture rates (CR) were calculated as the number of captures of each species divided by the total number of board checks for each site. Each time a board was checked constituted a "board check". Therefore, a site with eight boards visited five times equaled 40 board checks. The number of captures per 100 coverboard checks was calculated as:

$$CR = \frac{(\text{\# of individuals captured})}{(\text{total \# of board checks})} \times 100$$

Turtle Trap Surveys (TTS)

Funnel traps made of D-shaped metal hoops and 2.6 cm (1") nylon mesh were used to sample the Marsh for aquatic turtles such as painted and common snapping turtles. Since visits to the park were only conducted one day a month, two traps, baited with sardines in vegetable oil, were set in the Marsh and checked on the same day on 25 May and 23 June 2001, for a total of four trap days. Turtle abundance was quantified as a capture rate, captures per 100 trap days.

Minnow Trap Surveys (MTS)

Standard funnel-shaped wire mesh minnow traps measuring 15.2 cm x 15.2 cm x 30.5 cm (6" x 6" x 12") were used to sample shallow pond areas for adult and larval salamanders, adult and larval anurans, and aquatic snakes (Heyer et al. 1994). Since visits to the park were only conducted one day a month, two traps were deployed per site in the Marsh and Saugus River Channel on 22 April, 25 May, 23 June, and 22 August 2001 and checked the same day, for a total of eight trap days per site (16 trap days total). Since this method primarily captures amphibians, which were not marked for individual recognition, abundance was quantified as total captures (rather than unique individuals) per 100 trap days.

Incidental Encounters (IE)

Any encounter with an amphibian or reptile not recorded during one of the standardized surveys was considered an incidental encounter. These were recorded on observation cards ("Green Cards") to augment data collected during formal surveys, and include credible observations made by park staff and visitors. For each incidental encounter the species, life stage, method of documentation, as well as location, habitat, and UTM coordinates were recorded.

Quantifying Abundance

Quantifying actual abundance of the species encountered was not possible for a number of reasons. The methods used generally did not estimate actual population size, but rather provided a method-specific index of abundance, such as a capture rate (catch per unit effort). In addition, each of the methods used provided a sample biased towards a particular species, group of species, or sex. Although sampling effort was divided among the different methods in an attempt to compensate for possible sampling bias, the amount of sampling bias, the extent to which the use of different methods may have balanced this bias, and the influence of other covariates, such as habitat type and breeding habits, were not estimated.

An index of overall abundance for each species was derived by summing the number of adult form individuals (as opposed to eggs or larvae) encountered during each of the six survey methods. For time-constrained search, coverboard checks, turtle and minnow trap surveys, and incidental encounters, the numbers of adults of a given species encountered during each sampling occasion were summed. Because amphibians were not marked for individual identification, for the purposes of estimating an overall index of abundance, reptiles were also treated as though they had not been marked.

Although the total numbers recorded for each species provide an index of abundance, it is an uncalibrated index and its relationship to actual abundance is unknown. These numbers, and their derivatives, are best viewed as indicating the order of magnitude of a species' abundance and providing a reasonably accurate representation of relative and ranked abundance within taxonomic orders. Although these numbers are of value for some inter-specific comparisons and community analysis, and are likely accurate in identifying abundant versus rare species, differences between species whose index of abundance are of the same order of magnitude may not reflect true differences in abundance.

Data Management

Common and scientific names and spellings are those of the Integrated Taxonomic Information System (ITIS) at the time data were collected. Data collected during the course of this study were entered into a Microsoft Access database that is associated with this report. The original data sheets are archived with the Northeast Temperate Network (NETN) Inventory and Monitoring program located at Marsh-Billings-Rockefeller National Historical Park in Woodstock, Vermont. Given the low-impact nature of this study, voucher specimens of live animals were not collected. NETN's data manager can be contacted to obtain unpublished data files produced by this study.

A Garmin III Plus Global Positioning System (GPS) unit was used to record the coordinates of each survey site (Appendix C). GPS locality data were recorded as Universal Transverse Mercator (UTM) grid coordinates (zone 18 N) with X = x-axis or Easting, and Y = y-axis or Northing, using the NAD1983 datum.

Supplemental Data

Observations made in years subsequent to this survey (e.g. McNiff and Albert 2010) have expanded, clarified, and/or confirmed aspects of our knowledge of SAIR's amphibians and reptiles. Although we have not incorporated these data into any of the tables of this report, the discussion and species account sections of this report do include this information.

Results

Overview of Park Herpetofauna

Four species – northern two-lined salamander, northern green frog, northern brown snake, and common garter snake – were recorded during surveys in 2001. When combined with a common snapping turtle nest observed during reconnaissance in 2000, these five species represent 50% of the species thought to possibly occur at SAIR (Appendix A). Amphibians dominated the herpetofaunal community, accounting for 80% of the 25 adult form individuals recorded and 100% of larvae. By order, salamanders comprised 72% (18/25) of all adult forms recorded, snakes 20% (5/25), and anurans (frogs and toads) 8% (2/25). The northern brown snake and common garter snake were both recorded from "field" habitat within the Historic/Administrative zone. Northern two-lined salamanders were only found in the Stream/Seep, and northern green frogs were recorded from the Saugus River Channel. Target species were recorded from three of five survey sites, but each of the four species recorded was only recorded from one survey site/habitat type. The greatest number of individuals were recorded from the Stream/Seep, while no individuals were recorded in either the Marsh or East Woodland habitats (Table 2, Figure 2).

Table 2. Number of adult form individuals recorded and species richness (S) at each of five standardized surveys sites in Saugus Iron Works National Historic Site in 2001. Frequency of Occurrence (FO) is number of sites a species was recorded from, divided by total number of sites.

	Common Garter Snake	Northern Brown Snake	Northern Green Frog	Northern Two-lined Salamander				
Site	Adult	Adult	Adult	Adult	Larvae	Total Adults	% Adults	S
Saugus River			2			2	8	1
Marsh						0	0	0
Stream/Seep				18	15	18	72	1
East Woodland						0	0	0
Historic/ Administrative	3	2				5	20	2
Total # of Individuals	3	2	2	18	15	25	100	4
Total # of sites	1	1	1	1	1	3		
FO (%)	20	20	20	20	20	60		

Survey Method Summaries

Of the standardized survey methods, both stream TCS and CB detected two species each. Northern green frog and northern two-lined salamander were detected with TCS and common garter snake and northern brown snake were detected with the CB method. Stream TCS was the single most productive method, accounting for all amphibians recorded and 19 of 25 (76%) of all adults. Two species, both recorded during standardized surveys, were also recorded as incidental encounters (Table 3).

Saugus Iron Works National Historic Site
Herpetological Survey

Species Locations

Legend

- *Eurycea bislineata* (Northern Two-lined Salamander)
- *Rana clamitans melanota* (Northern Green Frog)
- *Storeria dekayi* (Northern Brown Snake)
- *Thamnophis sirtalis* (Common Gartersnake)
- Open Symbols - incidental species encounter not associated with established sampling procedure

- Park boundary
- East Woodland
- Historic / Administrative
- Marsh
- Saugus River Channel
- Stream / Seep

0 50 100 Meters

December 2004
Data source: The National Park Service and the Office of Geographic and Environmental Information (MassGIS), Commonwealth of Massachusetts Executive Office of Environmental Affairs.

Figure 2. Location of amphibian and reptile detections at Saugus Iron Works National Historic Site in 2001. Solid points represent central location of survey sites where a given species was recorded, not each individual. Open symbols represent incidental encounter sites.

Table 3. Number and species richness (S) of amphibians and reptiles recorded by survey method at Saugus Iron Works NHS in 2001.

	Common Garter Snake	Northern Brown Snake	Northern Green Frog	Northern Two-lined Salamander				
Survey Method	Adult	Adult	Adult	Adult	Larvae	Total Adults	% Adults	S
Anuran Calling Survey						0	0	0
TCS Stream			2	17	15	19	76	2
TCS Field						0	0	0
TCS Woodland						0	0	0
TCS Marsh						0	0	0
Coverboards	3	1				4	16	2
Minnow Trap Surveys						0	0	0
Turtle Trap Surveys						0	0	0
Incidental Encounter		1		1		2	8	2
Total	3	2	2	18	15	25	100	4

Anuran Calling Surveys

No anurans were heard during the three calling surveys conducted in April, May, and June 2001.

Time Constrained Searches

Saugus River Channel and Stream/Seep TCS: Two species were detected during TCS in the two stream/river sites sampled. A total of 17 adult and 15 larval northern two-lined salamanders were recorded from the Stream/Seep and two northern green frogs were recorded in the Saugus River Channel (Table 4).

Historic/Administrative, Marsh, and East Woodland: No amphibians or reptiles were recorded during TCS in marsh, field, or woodland habitats.

Coverboards

A total of 38 board checks in the Historic/Administrative area produced one northern brown snake and three common garter snakes. No amphibians or reptiles were observed in 40 board checks in the East Woodland area (Table 5).

Turtle Traps

No amphibians or reptiles were recorded in two days (4 trap days) of turtle trapping in the Marsh.

Minnow Traps

No amphibians or reptiles were recorded in four days (16 trap days) of minnow trapping in the Marsh and the Saugus River Channel areas.

Incidental Encounter

One northern brown snake was recorded from the Slag Heap within the Historic/Administrative area and one northern two-lined salamander was recorded from the Stream/Seep (Table 3).

Table 4. Number of amphibians recorded during time-constrained surveys at Saugus Ironworks National Historic Site in 2001. The capture rate (CR) is the number of individuals captured divided by total search effort (individuals/hour).

			Northern Two-lined Salamander		Northern Green Frog
			# individuals (CR)		# individuals (CR)
Site	Date	Search Hours	adult	larvae	adult
Saugus River Channel	22-Apr	0.7			
	25-May	1.0			
	23-Jun	0.8			
	22-Aug	0.7			2 (2.9)
	15-Sep	0.5			
	Total	3.7	0 (0)	0 (0)	2 (0.5)
Marsh	22-Apr	1.0			
	25-May	1.3			
	23-Jun	1.2			
	22-Aug	1.2			
	Total	4.7	0 (0)	0 (0)	0 (0)
Stream/Seep	22-Apr	0.5	3 (6.0)	3 (6.0)	
	25-May	0.7	2 (2.9)	3 (4.3)	
	23-Jun	0.7		5 (7.1)	
	22-Aug	0.3	2 (6.7)	1 (3.3)	
	15-Sep	0.5	10(20.0)	3 (6.0)	
	Total	2.7	17(6.3)	15(5.6)	0 (0)
Historic/Administrative	22-Apr	0.7			
	25-May	1.0			
	23-Jun	0.7			
	22-Aug	0.5			
	Total	2.8	0 (0)	0 (0)	0 (0)
East Woodland	22-Apr	0.7			
	25-May	0.8			
	23-Jun	0.7			
	22-Aug	0.7			
	15-Sep	0.5			
	Total	3.3	0 (0)	0 (0)	0 (0)

Table 5. Number of snakes recorded during coverboard surveys in Saugus Ironworks National Historic Site, 2001. Capture rate (CR) is the number of captures per 100 board checks. Board checks are number of boards/site, multiplied by number of site visits.

Site	Habitat	Common Garter Snake	Northern Brown Snake	Total # Snakes	S[1]	# Boards	# Site Visits	# Board Checks	# Boards w/Snakes
East Woodland	hardwood forest	0 (0)	0 (0)	0 (0)	0	8	5	40	0
Historic/ Administrative	landscaped/field	3 (7.9)	1 (2.6)	4 (10.5)	2	8	5	38[2]	2
Total		3 (3.8)	1 (1.3)	4 (5.1)	2	16	10	78	2

[1]S = species richness. [2]Two boards were submerged on one occasion.

Discussion

Community Analysis, Factors Affecting Species Presence, and Important Habitats

Of the 44 species of native, non-marine amphibians and reptiles that occur in Massachusetts, the numbers of species are fairly evenly divided among the four orders present: 10 salamander, 10 anuran, 10 turtle, and 14 snake (Cardoza and Mirick 2009). Although only a small number of species occur at SAIR, the species composition recorded in 2000-2001 is also fairly evenly distributed among the four orders (one salamander, one frog, one turtle,two snakes). Not surprisingly, within each order, the species present at SAIR are among the most urban tolerant of the group.

The diversity of herpetofauna at SAIR is limited by its small size, history of disturbance, urbanized location, and limited habitats. There are no ponds present and the Saugus River and associated marshes are well drained, with four foot tidal fluctuations that leave little standing water at low tide. Moreover, of the five miles of Saugus River upstream of SAIR, pools occupy only 1.3% of this length (MA DEM 2002), which suggests there may be few individuals of pool-dwelling species available to colonize or transit through SAIR. This lack of ponds or sluggish river habitat at and above SAIR precludes the use of SAIR by many of the amphibian and turtle species found in eastern Massachusetts. Thus, amphibians and reptiles at SAIR are largely limited to species that do not breed in ponds, have small home ranges and are capable of maintaining a population in a small habitat patch, or are mobile species that disperse along the river or across the adjacent uplands and include SAIR as part of a larger home range. For these latter, successful movement across the adjacent landscape is challenging due to the level of urbanization. Although there are larger patches of wetland/upland habitat complexes nearby, including Marion Road swamp (~125 meters away), Pranker's Pond (less than 1 km away), Breakheart Reservation, and Lynn Woods, the intervening urban development of homes and roads largely isolates these sites from SAIR. Some species occurring at these sites (e.g. spring peeper) have not been recorded at SAIR. Furthering the isolation of SAIR along the Saugus River corridor are restrictive culverts under roads. These structures date from a time period when flow of water, not passage of wildlife along a riparian corridor, was the prime design consideration.

Of the species found in SAIR, northern two-lined salamander is the most habitat specific. Its entire life cycle (eggs, larvae, and adults) is spent in stream habitat, although adults may be found short distances upland from streams. In spite of the park's history of disturbance and presence in an urban landscape, northern two-lined salamanders are abundant at SAIR, primarily in the small Stream/Seep east of the SAIR maintenance building. Maintaining the integrity and quality of this site should be a high priority. An individual was also found under rocks in a seep on the east side of the Saugus River on 21 July 2010, indicating that this urban tolerant species occurs elsewhere at SAIR. The remaining species recorded – northern brown snake, common garter snake, northern green frog, and common snapping turtle – utilize a variety of habitats and are more general in their requirements, allowing them to survive in urbanized landscapes. Both northern brown and common garter snakes are capable of persisting on "weedy" lots in urban areas and SAIR provides adequate quantity and quality of habitat for these two species. In contrast, eastern milk snakes (*Lampropeltis t. triangulum*), one of which was observed at SAIR

in 2009 (McNiff and Albert 2010) generally require much larger habitat patches than present at SAIR, and the origins of this individual are uncertain.

The northern green frogs observed at SAIR are likely non-breeding individuals using the Saugus River as a dispersal corridor and juvenile habitat, and the common snapping and painted turtles likely move up and down the river and riparian habitats through SAIR. The Slag Heap and uplands of the Historic/Administrative zone provide an important and rare habitat feature in an urban area: turtle nesting habitat immediately adjacent to the river. This spares females a risky nesting foray across roads and through urban neighborhoods, a major source of mortality for urban turtles. The long history of its use for turtle nesting suggests that female turtles using this stretch of river return to use it repeatedly over the years. Potentially-occurring species such as American bullfrog or northern water snake would use SAIR similarly and the mostly terrestrial spring peeper could range into SAIR outside of breeding season from other nearby habitat patches.

The recent restoration of the turning basin and freshwater wetland (James-Pirri et al. 2010a) is unlikely to have much effect on the herpetofauna of the park. The lack of habitat for pond-breeding and pond-dwelling species, plus the site's relatively small size and highly urbanized adjacent landscape will continue to be the primary limitations to herpetofaunal diversity. However, with continued observations and documentation of animals seen on site by SAIR staff, the number of amphibian and reptile species recorded at SAIR is likely to grow.

Stressors

Given its urban location, SAIR is subjected to numerous stressors, both local and global. Global stressors tend to affect large geographic areas, often far removed from their ultimate cause or source. Global stressors include ultraviolet-B radiation and atmospherically transported pollutants such as mercury and acid rain. Stressors such as other heavy metals, chemicals found in fertilizers, herbicides, and pesticides, habitat degradation, disease, road mortality, and introduced species (Dunson et al. 1992, Blaustein 1994, Blaustein et al. 1994, Pechmann and Wilbur 1994, Hunter et al. 1999, Daszak et al. 2000, Knapp and Matthews 2000) may also be widespread in their scope, but tend to be more variable across the landscape in their intensity. Thus their impacts may be at either a regional or local level.

Mercury is transported atmospherically and often deposited far from the source. Upon entering aquatic ecosystems, particularly acidified ones, mercury is biologically and chemically converted to methylmercury, a biologically active and highly toxic form (Bank et al. 2005) that can be accumulated by aquatic organisms to the point of causing lethal or sub-lethal effects. Anthropogenically produced mercury deposition is occurring throughout the Northeast, and even aquatic systems of relatively undeveloped areas such as Acadia National Park (Bank et al. 2006) and Cape Cod National Seashore contain high levels of mercury. Because methylation of mercury increases at low pH, either naturally acidic waters or acid rain, can lead to elevated concentrations of methyl mercury. This process has been linked to the decline of northern dusky salamanders at Acadia NP, and both northern green frogs and northern two-lined salamanders also show elevated mercury levels (Bank et al. 2006, Bank et al. 2007) there. Given that both acid precipitation and mercury deposition occurs in the vicinity of SAIR (Likens et al. 1996, Chalmers et al. 2005), it is reasonable to conclude that SAIR is subjected to inputs from both of

these stressors. However, the Saugus River is circumneutral, averaging pH 7.28, with acceptable levels of acid neutralizing capacity (James-Pirri et al. 2010b). Thus, at present, the buffering capacity of SAIR waters is likely preventing acidification and tempering the levels of methylmercury present. Mercury levels of river sediments at SAIR do not exceed sediment quality guidelines and mercury levels in river waters are below benchmarks for "reference stream" in the region, but values were greater than those proposed to be protective of wildlife (James-Pirri et al. 2010b).

Although SAIR is subjected to these global stressors, considering the extensive urbanization that surrounds it, and the history of the Saugus as one of the first American rivers to be harnessed for industrial purposes (MA DEM 2002), it is likely that localized stressors have had a greater impact on its amphibians and reptiles than global stressors. As noted above, the site's small size and lack of pond habitat limits the number of species capable of persisting there. In addition, the general decline of herpetofauna in the Boston region, and SAIR's isolation within this highly fragmented, urbanized landscape limits both the availability and ability of species to colonize or re-colonize SAIR in the event of a local extinction. The threat of roadkill is high for any animals that move out of SAIR into the adjacent neighborhood, as well as any animals dispersing from any nearby habitat patches.

The Saugus is a Class B water quality river and continues to be used for a variety of industrial purposes. Its fish populations are not thriving (MA DEM 2002), and both its fish and aquatic invertebrate communities are dominated by pollution-tolerant species (James-Pirri et al. 2010b). In terms of physical-chemical stressors, James-Pirri et al. (2010b) summarized the Saugus River thus: "Physically, the only Riverine Resource that appears to be in good condition is water quality as it relates to acid neutralizing capacity (ANC) and pH. Dissolved oxygen, salt, and trace metals can occasionally exceed desirable thresholds. Fecal coliform, nutrients, and temperature modifications are persistent impairments to the water quality of the river. Contaminants are present in river sediments and some such as lead, chromium, and nickel, occasionally exceed threshold values." In addition, Saugus River sediment samples also contain levels of organochlorine compounds and semi-volatile organic compounds that exceeded sediment quality guidelines (James-Pirri et al. 2010b).

Similar to the aquatic resources, the terrestrial habitats of SAIR have been dramatically altered from their natural condition by over 350 years of intense manipulation, which has facilitated the invasion of many non-native plants. Most of the uplands of SAIR are in the Historic/Administrative area, dominated by lawn, ornamental plantings, and coarse "weedy" vegetation near the Slag Heap. The small amount of successional forest on the east and west side of the river is dominated by invasive plant species. The most prolific of the invasive, non-native species in SAIR are common reed, purple loosestrife, Japanese knotweed (*Polygonum cuspidatum*), multiflora rose (*Rosa multiflora*), curly pondweed (*Potamogeton crispus*), mugwort (*Artemisia vulgaris*), and Norway maple (*Acer platanoides*). Most of the aquatic invasives were removed in the restoration of the turning basin in 2007 (James-Pirri et al. 2010a) and the park has been working to remove terrestrial species such as multiflora rose and Norway maple and oriental bittersweet (*Celastrus orbiculatus*) throughout the park (SAIR, Marc Albert , Stewardship Program Manager, pers. comm.).

While these efforts continue, it is clear that the vegetation of SAIR will remain highly impacted and dominated by non-native species for a long time.

Another stressor likely affecting terrestrial amphibians at SAIR is non-native earthworms. The earthworms currently found in New England are non-native (Schaetzl and Anderson 2005) and have been linked to decreased leaf litter, invasion by non-native plants, and declines in numbers of terrestrial salamanders (Maerz et al. 2009). Casual observations at SAIR suggest that the leaf litter layer in forest habitats is very thin, and suggest that the quality of the forest floor habitats at SAIR may be limiting to terrestrial amphibians, perhaps explaining the lack of any records of red-backed salamanders there.

Recommendations for Management and Future Inventory and Monitoring

Many of the stressors affecting the amphibians and reptiles of SAIR are broad global or continental scale ones beyond direct NPS control, but some of the more local regional and site-specific stressors are within the ability of SAIR and other NPS staff to affect changes. First and foremost, SAIR and the NPS should continue to work at the regional level with state and local agencies on planning and remediation projects aimed at improving environmental quality of the Saugus River and its watershed. Reducing water pollution, restoring more natural streamflow, and replacing old culverts with new designs to enhance wildlife passage are just some of the ways to ameliorate some of the problems identified in the Saugus River watershed analysis (MA DEM 2002) and SAIR condition assessment (James-Pirri et al. 2010b).

On site, efforts should continue to control invasive alien plants and increase the dominance of native vegetation. Park staff and managers should also be careful to minimize any direct mortality of animals. We are not aware of any reports of road kill or mower mortality in the park, and SAIR staff should continue to be mindful of common snapping turtle use of SAIR and be careful when mowing during their nesting season, late May through June. Areas of coarse vegetation that do not receive regular mowing are best mowed/cut during the cold months, when snakes and turtles are not active. Protecting the Stream/Seep is important for maintaining the population of northern two-lined salamanders. Given the local importance of this population, and the fact that it occurs in a very small, isolated habitat patch, it is important that the NPS ensures that the quantity and quality of water flowing into this small tributary of the Saugus River continues undiminished. Although we are not aware of any proposals that could potentially alter local hydrology, staff and managers at SAIR should be mindful of the importance of maintaining current hydrology. Also, considering that runoff from the main parking lot flows into the seep, it is important to ensure that spills and leakage from vehicles and street run-off does not enter the stream.

Although it is unlikely that SAIR will ever support an extensive herpetofauna, it is an important part of a larger system of protected areas or “greenspace” along the Saugus River, and does provide some regionally important habitat, e.g. Stream/Seep for northern two-lined salamanders. It is likely that, over time, additional species will be recorded at SAIR, particularly if environmental conditions improve, either watershed-wide or site-specific, and efforts to improve biological connectivity are made. Given this, inventory and monitoring of amphibians and reptiles should continue. A program of coverboard surveys (large plywood for snakes, small planks for terrestrial salamanders), searches of the marshes and stream, surveys of the Saugus

River with minnow traps and turtle traps, and general time-constrained searches are recommended. Systematic sampling is preferable, but even incidental observations, when well documented with photographic confirmation, can be valuable.

Species Accounts

Species Recorded at SAIR

Northern Two-Lined Salamander (Eurycea b. bislineata)

The northern two-lined salamander is likely the most widespread and abundant stream salamander in New England, and is the most urban tolerant (Klemens 1993). This stream salamander is typically more aquatic in nature than the northern dusky salamander, often found in the stream and splash zones of cool, swift moving streams. Females deposit eggs singly on the underside of flat rocks in streams (Pfingsten and Downs 1989, Petranka 1998). This species is considered common in Massachusetts except on Cape Cod (Klemens 1993). Nyman (1991) recorded northern two-lined salamanders at two sites within the Saugus watershed immediately north of Route 1: Hawkes Brook and Breakheart Reservation. He also speculated that northern two-lined salamanders may occur extensively in the Saugus River and its tributaries, but noted it was not abundant. There are few recent records in the Massachusetts Herp Atlas in the vicinity of SAIR. In the nine Herp Atlas quads centered on SAIR (an area of approximately 1350 km^2), there is only one record of this species, from the town of Belmont (Jackson et al. 2010), outside of the Saugus watershed.

Eight adults, 10 juveniles, and three clutches of eggs were recorded during pre-inventory site reconnaissance of SAIR on 27 June 2000. These were found during approximately one hour of searching under rocks in the small rocky stream/seep that flows out of the river bank, northeast of the maintenance shop. This site, now referred to as the Stream/Seep, extends approximately 75’ from its point of origin to the high tide line of the Saugus River. Time-constrained searches of the Stream/Seep in 2001 recorded 17 adults and 15 larvae during 2.7 search hours of effort in the same stream, and an additional adult form (juvenile) was recorded as an incidental encounter (Tables 2, 3, 4).

These observations indicate the northern two-lined salamander is common in the Stream/Seep at SAIR. The size/age structure and presence of eggs in 2000, and again in 2001, when a gravid (pregnant) female was observed laying eggs under a rock on 22 April 2001, all show it to be reproducing successfully. A follow-up survey, conducted on 21 July 2010, recorded 7 adults and 3 larvae in the Stream/Seep in 1 hour of search effort. In addition, an adult northern two-lined salamander was found as an incidental encounter under rocks on the east side of the Saugus River, in a small, rocky seep on the riverbank, just above the high tide line. These most recent observations indicate that the northern two-lined salamander remains common at SAIR, and is more widespread here than originally thought.

Our records for SAIR extend the current known distribution of northern two-lined salamanders in the Saugus watershed over 3 km further south. Additionally an adult northern two-lined salamander was found in about 1 hour of searching on 21 July 2010 in a small tributary of the Saugus just east of Pranker’s Pond, filling in the gap between SAIR and the records of Nyman (1991). Because northern two-lined salamanders are less likely to be found by casual observers, they may be under-represented in recent Herp Atlas records and Nyman’s (1991) characterization of them as widespread but not abundant may generally be true. However,

northern two-lined salamanders are common at SAIR and, in spite of SAIR's urban setting, the capture rate of adults (6.3 individuals/search hour) and larvae (5.6 individuals/search hour) (Table 4) compares favorably with capture rates at Saint-Gaudens NHS (SAGA) in rural New Hampshire and Acadia National Park in Maine. At SAGA's Blow-Me-Up Brook, the capture rate in 2001 (by the same field crew that surveyed SAIR) was 7.74 adults/search hour and 0.75 larvae/search hour (Cook et al. 2008). At Acadia, the capture rate for adults and larvae were 2.8 adults/search hour and 0.5 larvae/search hour (Brotherton et al. 2005).

Considering the paucity of species at SAIR and the apparent abundance of this population of northern two-lined salamanders, it is the most significant component of SAIR's herpetofauna. Given the local regional importance of this population, and the fact that it occurs in a very small, isolated habitat patch, it is important that the NPS ensures that the quantity and quality of water flowing into this small tributary of the Saugus River continues undiminished. Although we are not aware of any proposals that could potentially alter local hydrology, staff and managers at SAIR should be mindful of the importance of maintaining current hydrology. Also, considering that runoff from the main parking lot flows into the seep, it is important to ensure that spills and leakage from vehicles and street run-off does not enter the stream.

Northern Green Frog (Lithobates clamitans melanota)

The northern green frog is common and widespread throughout the eastern United States and Canada, using a wide range of wetland habitats (Klemens 1993). However, in northern populations, northern green frog tadpoles must overwinter in the breeding pond (Wright and Wright 1949), limiting successful reproduction to ponds that are permanent and semi-permanent. Although adult northern green frogs breed and forage in permanent ponds, non-breeding juveniles and dispersing adults may also be found in and along vernal ponds, streams, rivers, marshes, and on roads on rainy nights. Some adults are also known to hibernate in streams (Gibbs et al. 2007). Dorsolateral ridges extending down the back help distinguish the northern green frog from the American bullfrog in which the ridges are absent.

Because permanent ponds are more likely to survive urbanization than shallow, temporary ones, and have increased in some instances through the damming of streams (Schlauch 1976), permanent pond species such as northern green frogs have remained one of the most widespread and abundant amphibians of urban and suburban landscapes (Rubbo and Kiesecker 2005). Nyman (1991) recorded them from four sites within the Saugus watershed, including Breakheart Reservation and Reedy Meadows Conservation Area, and speculated it was found elsewhere. In the recent Massachusetts Herp Atlas project, there were nine records of northern green frogs in the nine Herp Atlas quads centered on SAIR (an area of approximately 1350 km^2), including one from the Golden Hills Area of Critical Environmental Concern, 4 km from SAIR (Jackson et al. 2010).

Site reconnaissance conducted on 27 June 2000 recorded one adult northern green frog in the Marsh and one juvenile in an aqueduct within the Historic/Administrative area. Surveys in 2001 recorded two adults in the Saugus River Channel during time-constrained surveys (Table 3), but none during calling surveys. More recently, a total of five northern green frogs were observed in the well within the Historic/Administrative district in July and August 2009 (McNiff and Albert 2010). Although northern green frogs are an urban tolerant species and are common in the SAIR

region, they are uncommon at SAIR. The lack of breeding habitat or any pond or non-tidal marsh habitat at SAIR seems to limit their numbers here, and the relatively few northern green frogs observed at SAIR are likely non-breeding individuals using the Saugus River as a dispersal corridor.

Common Snapping Turtle (Chelydra s. serpentina)

The common snapping turtle occurs from southern Canada, south through the mid-west and east coast, down to Florida and the Gulf of Mexico (Ernst et al. 1994). It is abundant and widespread in New York State (Gibbs et al. 2007) and New England (Klemens 1993), and is the largest freshwater turtle in the northeastern United States. It has a high tolerance for water pollution and tends to be among our most urban tolerant turtles (Klemens 1993). Although common snapping turtles occur in nearly all freshwater habitats and also in brackish marshes, adults tend to occur more frequently in permanent water bodies and are most abundant in shallow, muddy ones (Klemens 1993, Cook et al. 2007). These highly aquatic turtles are common in the United States, but because they are bottom walkers more than swimmers, and they bask in shallow waters along the shore of a pond or wetland rather than haul out like a painted turtle does, they are not as readily observable. Typical of all turtles, their eggs are laid on land. Female common snapping turtles must emerge from wetlands and travel overland in search of nesting areas, generally open, sandy, sparsely vegetated patches (Gibbs et al. 2007). They are often seen crossing roads in late spring to early summer. Females dig nests and deposit eggs in loose sand or soil, and the hatchlings emerge in the late summer or early fall (Ernst et al. 1994).

Locally, Nyman (1991) reported capturing adult common snapping turtles in Reedy Meadows conservation area and observed numerous predated eggs along the railroad tracks there. He also noted they were reported from SAIR and speculated that they occurred in sluggish deep water reaches of the Saugus River. In the recent Massachusetts Herp Atlas project, there were nine records of common snapping turtle in the Herp Atlas quads centered on SAIR (an area of approximately 1350 km^2), including one from the Golden Hills Area of Critical Environmental Concern, approximately 4 km from SAIR (Jackson et al. 2010).

Park staff have previously observed common snapping turtles nesting in the Slag Heap area and on open lawn areas. These reports were confirmed when several nest excavations and a depredated nest were recorded on the unvegetated area of the Slag Heap during site reconnaissance on 27 June 2000. Although no common snapping turtles were observed during surveys conducted in 2001, seven were observed in 2009 (McNiff and Albert 2010), both in the river and nesting in the Historic/Administrative area. These observations indicate that common snapping turtles do inhabit the Saugus River in and around SAIR, and use the uplands of SAIR for nesting. The open upland habitat in the Historic/Administrative area of SAIR provides an important and rare habitat feature in an urban area, turtle nesting habitat immediately adjacent to the river, which spares females a risky nesting foray across roads and through urban neighborhoods, a major source of mortality for urban turtles. The long history of its use for turtle nesting suggests that the female turtles using this stretch of river return to use it repeatedly over the years. Park staff and managers should be mindful of common snapping turtle use of SAIR and be careful when mowing during their nesting season, late May through June.

Painted Turtle (Chrysemys picta)

The painted turtle is the only North American turtle whose range extends across the continent, from southern Canada down through the Pacific northwest, midwest, and the northeast coast to Louisiana, Georgia, and the Carolinas (Ernst et al. 1994). There are four subspecies, with standard English names that describe each subspecies' distribution. The eastern painted turtle has an unmarked yellow plastron and the seams of the central and lateral carapace scutes are aligned, while the midland painted turtle has a variable dark marking on the plastron and alternating seams on the carapacial scutes (Ernst et al. 1994). Hybrid painted turtles are intermediate in these characters and are highly variable both within and among populations. In the Northeast and New England, the eastern painted turtle (*C. p. picta*) and the midland painted turtle (*C. p. marginata*) intergrade, forming a hybrid swarm (Pough and Pough 1968) and it is best referred to simply as "painted turtle".

In addition to a wide geographic distribution, painted turtles are widespread ecologically, occurring in a broad range of freshwater habitats, including vernal ponds. However, they prefer permanent, shallow, standing or slow-moving water bodies with soft bottoms and an abundance of aquatic vegetation (Ernst et al. 1994, Cook et al. 2007, Gibbs et al. 2007). Painted turtles are highly aquatic, feeding and hibernating in ponds. However, they lay their eggs on land and, as with all aquatic turtles, must leave the relative safety of the wetland and travel overland to patches of open habitat with well drained soils to nest.

Painted turtles have long been considered New England's most abundant turtle and because of their abundance and habit of basking on rocks, logs, and clumps of vegetation, they are also the region's most familiar and conspicuous turtle (Babcock 1919, Klemens 1993). Because permanent water bodies are more likely to survive urbanization, and have increased in some instances through the damming of streams, painted turtles tend to remain relatively common in urban and suburban areas (Schlauch 1976). Painted turtles were found extensively in the Saugus River basin, in lakes, marshes, and slow-moving backwaters of the Saugus, including in Reedy Meadows, Breakheart Reservation and SAIR (Nyman (1991). In the more recent Massachusetts Herp Atlas, painted turtle was the most recorded species in the nine Herp Atlas quads centered on SAIR (an area of approximately 1350 km^2), accounting for 24 of 209 (11.5%) of all records (Jackson et al. 2010).

Although park staff have previously observed painted turtles at SAIR, none were observed in 2000 or 2001, and only one was observed during 2 months of observations in summer 2009 (McNiff and Albert 2010). This suggests that despite the fact that painted turtles are an urban tolerant species that is widespread and common in the region, they are fairly rare at SAIR. Perhaps the 4 foot tidal range and near complete draining of water from the Saugus River at low tide limit its usefulness as habitat for painted turtles.

Northern Brown Snake (Storeria d. dekayii)

The brown snake is a species that ranges throughout most of the eastern half of the United States and into eastern Mexico (Ernst and Ernst 2003). The subspecies found at SAIR, the northern brown snake, occurs from South Carolina northward into central New England, southern Canada, and westward to lower Michigan and Ohio (Conant and Collins 1998). Formerly called "DeKay's snake," the northern brown snake was named after New York naturalist James Edward

Dekay (Conant and Collins 1998). It is widespread throughout New York and New England (Klemens 1993, Gibbs et al. 2007), and occurs statewide in Massachusetts, except for the islands of Martha's Vineyard and Nantucket (Cardoza and Mirick 2009).

This small, inconspicuous species inhabits moist upland and lowland habitats, and can be common in urban and suburban areas with plenty of cover (Conant and Collins 1998, Ernst and Ernst 2003). They are relatively small and sedentary, feed heavily on slugs and worms (Lazell 1976) and they give birth to live young, thus avoiding the need for "nesting habitat." These traits enable them to persist on small, disturbed patches of habitat, sometimes becoming more abundant in these settings than in undisturbed patches (Schlauch 1978). Northern brown snakes are urban tolerant (Klemens 1985) and in Massachusetts they are abundant in cities and suburbs (Lazell 1974), but there are limits to their ability to survive intense urbanization (Klemens 1993).

Nyman (1991) found one northern brown snake under a board at Reedy Meadows Conservation Area and speculated that this species occurred extensively in suitable habitat throughout the Saugus watershed. In the more recent Massachusetts Herp Atlas, northern brown snake was the eighth most recorded species in the nine Herp Atlas quads centered on SAIR (an area of approximately 1350 km^2), accounting for 10 of 209 (4.8%) of all records, including one in the town of Saugus at the Golden Hills ACEC (Jackson et al. 2010). In this survey, two northern brown snakes were observed in 2001 in the Historic/Administrative area, one under a coverboard and the second on top of the slag heap, apparently depredated. The capture rate at SAIR, 1.3 captures/100 board checks (Table 5), exceeds the capture rate of three sites sampled at Gateway NRA, but is lower than the capture rate of four other Gateway sites, which ranged from 3.11 to 100.0 captures/100 board checks (Cook, in prep). Thus, although brown snake populations are able to persist in small habitat patches such as SAIR, and SAIR provides plenty of seemingly suitable upland and marsh habitat for this species, it is not particularly common here.

Common Garter Snake (Thamnophis s. sirtalis)

The common garter snake is a species that ranges throughout the United States, except for Texas and the southwest, and all of southern Canada (Ernst and Ernst 2003). The subspecies found at SAIR, also known as the common garter snake, occurs primarily east of the Mississippi River from Florida northward into New York and southern New England and also into Canada (Conant and Collins 1998). In New York and southern New England, common garter snakes are widespread and common, both inland and along the coast, and are the most conspicuous and well known snake in this area (Klemens 1993, Gibbs et al. 2007). They are abundant throughout Massachusetts (Lazell 1974).

Common garter snakes are ubiquitous in New England (DeGraaf and Rudis 1983), found in a variety of habitats including meadows, marshes, woodlands, and cultivated and developed areas (Behler and King 1979). They are relatively urban tolerant because of their generalized food and habitat needs (Schlauch 1976), live birth of young, and ability to persist in relatively small habitat patches. But, they can decline in areas subject to intense urbanization (e.g. Ziminski 1970, Schlauch 1978). Nyman (1991) found one common garter snake under a board at Reedy Meadows Conservation Area and speculated that this species occurred widely in the Saugus River basin. That view is supported by the more recent Massachusetts Herp Atlas. Common garter snake was the second most recorded species (of 27) in the nine Herp Atlas quads centered

on SAIR (an area of approximately 1350 km^2), accounting for 22 of 209 (10.5%) of all records, including one in the town of Saugus at the Golden Hills ACEC (Jackson et al. 2010). The three common garter snakes found under coverboards in the Historic/Administrative Area in 2001 (Table 2 and Table 3) confirm earlier reports by SAIR staff, while the eight observed over the course of summer 2009 (McNiff and Albert 2009) demonstrate their continued persistence at SAIR and suggest this species is relatively common here. The 2001 capture rate at SAIR, 3.8 captures/100 coverboard checks (Table 5), exceeds the capture rate at the four Gateway NRA sites where the common garter snake occurs, which ranged from 0.44 to 2.24 captures/100 coverboard checks (Cook, in prep).

Eastern Milk Snake (Lampropeltis t. triangulum)

The eastern milk snake is a subspecies of the milk snake, which is one of the most widespread species of snakes, ranging from the east and mid-western United States down to Ecuador in South America (Ernst and Ernst 2003). The eastern milk snake occurs from northern Georgia and Alabama northward to Wisconsin and through the northeastern states into southern Canada (Conant and Collins 1998). Identifying characters include a "Y" shaped, cream-colored patch on the nape, and a black and white checkerboard pattern on the belly (Conant and Collins 1998). Eastern milk snakes are widespread in the northeast U.S., including Massachusetts (Lazell 1974) and occur both inland and along the coast in habitats ranging from woods, meadows, bogs, streams, and farmland. They are frequently associated with old farm fields, dilapidated structures, and trash piles, and thrive in such human altered habitats (Klemens 1993, Gibbs et al. 2007). Eastern milk snakes eat a wide range of prey items, have a large home range, and are primarily nocturnal and inconspicuous (Kjoss and Litvaitis 2001, Ernst and Ernst 2003). Their large home range makes them vulnerable to habitat fragmentation, and although still common in rural areas, they are absent from the most urbanized areas (Klemens 1993). Nyman (1991) did not record any, but stated that suitable habitats existed at Reedy Meadows and Breakheart Reservation. In the more recent Massachusetts Herp Atlas, eastern milk snake accounted for only 2 of 209 (1%) records in the nine Herp Atlas quads centered on SAIR (an area of approximately 1350 km^2). Only one of these records was in the town of Saugus (Jackson et al. 2010).

An eastern milk snake was observed on the ground near the SAIR herb garden on June 7, 2009 (McNiff and Albert 2010). Although not considered as a species likely to occur at SAIR and the photograph taken of this individual is poor quality, it shows the pattern of dorsal bands typical of this species. The origins of this animal remain uncertain and continued monitoring is needed to determine how regularly eastern milk snakes occur at SAIR.

Potentially-occurring Species Never Recorded at SAIR

Eastern Red-backed Salamander (Plethodon cinereus)

The eastern red-backed salamander is a lungless terrestrial salamander that is widespread and common throughout the Northeast, including New York State (Gibbs et al. 2007) and New England (Klemens 1993). It occurs as a number of different color morphs, with the red striped and unstriped (or lead-backed) the two most common and widespread (Petranka 1998). Although they reach their greatest density in well-drained deciduous and mixed forests with well developed leaf litter (Gibbs et al. 2007) and in some forest ecosystems dominate the vertebrate

biomass (Burton and Likens 1975), eastern red-backed salamanders are not necessarily restricted to mature forest habitats (Klemens 1993). At Cape Cod National Seashore, they can also be found in open habitat such as beneath power lines and under woody debris deposited by storm surge at the upper limits of salt marshes (R. Cook, pers. obs.). Because all embryonic and larval development takes place in the "aquatic" environment within the egg membrane, eastern red-backed salamanders are completely terrestrial and do not require wetlands for reproduction. This attribute, in conjunction with their small home range and limited movements, has facilitated their widespread distribution and made them one of the most urban tolerant amphibians, capable of persisting in small woodland patches in highly fragmented urban landscapes (Schlauch 1976, Gibbs 1998).

The eastern red-backed salamander is widespread and abundant in Massachusetts (Lazell 1974, Cardoza and Mirick 2009). Nyman (1991) recorded this species at two sites upstream from SAIR and speculated it may be widespread in wooded areas along the Saugus River. Recent data from the Massachusetts Herp Atlas project (Jackson et al. 2010) show this to be the most widespread and abundant amphibian in the SAIR region, including a recent record from the Golden Hills Area of Critical Environmental Concern, 4 km from SAIR. However, in spite of its ubiquity and urban tolerance, no eastern red-backed salamanders were observed in 2000 or 2001. SAIR is certainly large enough to support a population of eastern red-backed salamanders. However, declines in eastern red-backed salamanders have been observed at sites where non-native earthworms lead to leaf-litter loss and invasion by non-native plants (Maerz at al. 2009). Much of the forest floor at SAIR is occupied by non-native plants, and casual observation suggests that there is little leaf litter at SAIR. Thus, the quality of woodland habitat for this species at SAIR may be impaired. Additional searches of woodland habitats at SAIR for this species should be undertaken in the future to better determine if it is truly absent. Coverboards made of heavy boards and placed in the woodlands would aid this effort.

Spring Peeper (Pseudacris crucifer)

The spring peeper is widespread throughout the eastern United States and Canada (Klemens 1993) and ubiquitous, breeding in a wide range of wetland habitats. On Cape Cod, spring peepers breed in vernal ponds (both woodland and inter-dune), semi-permanent ponds, and in the marshy margins of permanent kettle and inter-dune ponds (Cook et al. 2006). Spring peepers are terrestrial outside of the breeding season, and utilize a broad range of terrestrial habitats (Gibbs et al. 2007). Its unique, high-pitched breeding call is often a deafening chorus of hundreds or even thousands of individuals. These loud and distinct calls, in combination with a prolonged calling season that stretches from mid-March to mid-May (Overton 1914), make it one of the most readily detectable of local anurans (Klemens 1993).

The spring peeper is abundant throughout Massachusetts (Lazell 1974) and among the most urban tolerant of amphibians (Schlauch 1976, Gibbs 1998). Nyman (1991) did not record spring peeper on field surveys in June and August, outside of spring peeper calling season. However, he speculated they occurred in Reedy Meadows and Breakheart Reservation, but not directly in the Saugus or its tributaries. In recent data from the Massachusetts Herp Atlas project (Jackson et al. 2010), spring peeper ranked fifth in records among amphibians in the SAIR region, 12 of 209 (5.7%) records, including a recent record from the Golden Hills Area of Critical Environmental Concern, 4 km from SAIR.

In spite of its ubiquity and urban tolerance, there have been no records of spring peeper at SAIR. This is primarily because there is no breeding habitat for spring peeper at SAIR. However, there are unconfirmed but reliable reports of calling spring peepers nearby at the Marion Street Swamp (125 meters NW of SAIR) and in the Pranker's Pond area (500 meters NW of SAIR). At least some of the animals breeding in these wetlands should be able to survive movements across the intervening urbanization on rainy nights and range onto SAIR outside of the breeding season. Therefore, spring peeper should be considered as a potentially-occurring species, primarily outside of breeding season.

American Bullfrog (Lithobates catesbeianus)

The American bullfrog is a widespread and common species throughout much of the Northeast, (Behler and King 1979, DeGraaf and Rudis 1983). Bullfrogs require two or more years for their tadpoles to metamorphose, hence they breed in open bodies of water such as lakes and permanent ponds (Conant and Collins 1998). Their primary habitat requirement is a permanent water body with abundant emergent and shoreline vegetation (Albright 1999). However, because American bullfrogs may require a few years beyond metamorphosis to reach adulthood and, in the case of males, attain a size capable of defending a breeding territory, juveniles will also inhabit temporary ponds and streams. This species is an aggressive predator and includes other frogs, young turtles, small snakes, and many invertebrates in its diet. It is adept at colonizing new habitats, especially those constructed or modified by humans (Lacki et al.1992) and is relatively urban tolerant (Klemens 1993).

American bullfrogs occur throughout most of Massachusetts and may be locally abundant (Lazell 1974). Nyman (1991) did not record any American bullfrogs, but speculated they would occur in permanent water bodies, such as those found in Reedy Meadows and Breakheart Reservation, but not directly in the Saugus or its tributaries. This prediction was borne out in the recent Massachusetts Herp Atlas project. American bullfrog was the fourth most recorded species in the Herp Atlas quads centered on SAIR (an area of approximately 1350 km^2), accounting for 16 of 209 (7.7%) records, including one from the Golden Hills Area of Critical Environmental Concern, 4 km from SAIR (Jackson et al. 2010). To date there have been no confirmed records of American bullfrog at SAIR, nor is there any breeding habitat there. However, considering the use of streams and rivers for dispersal, especially by juveniles (Klemens 1993, Gibbs et al. 2007), it is possible that American bullfrog may yet be recorded at SAIR and should therefore be considered as potentially occurring, at least as a transient.

Northern Water Snake (Nerodia s. sipedon)

The northern water snake is a sub-species of water snake that occurs from the northeastern United States and southeastern Canada westward into the mid-west (Conant and Collins 1998). In New York and New England, the northern water snake is widespread and common, occurring both along the coastal plain and inland, although it does not range into high elevations (Klemens 1993, Gibbs et al. 2007). Northern water snakes are primarily aquatic and occur in a broad range of freshwater wetlands, provided that they contain an abundance of cover and food, primarily fish and secondarily amphibians (Ernst and Ernst 2003). They are frequently observed basking on the shore, on rocks, and on branches overhanging the water and occasionally enter brackish

waters (Conant and Collins 1998, Ernst and Ernst 2003). Similar to the brown snake and garter snake, water snakes give birth to live young rather than laying eggs.

In Massachusetts, northern water snakes are widespread and common in and near ponds, slow moving streams, swamps, and vernal ponds, and are often seen basking on rocks (Lazell 1974, DeGraaf and Rudis 1983, Klemens 1993). Nyman (1991) did not observe any in the Saugus River basin, but felt they should be present at Reedy Meadows, Breakheart Reservation, and in sunny, quiet, waters along the Saugus River where prey and brushy cover exist. This view seems to be supported by the more recent Massachusetts Herp Atlas, in which there were eight records of water snake in the nine Herp Atlas quads centered on SAIR (an area of approximately 1350 km^2), including one in the town of Saugus at the Golden Hills ACEC, 4 km from SAIR (Jackson et al. 2010). However, there have been no records of water snakes at SAIR either prior to this survey, during this survey, or in 2009 (McNiff and Albert 2009). There is still the possibility that northern water snakes may occur at Saugus, most likely as individuals traveling along the Saugus River, but the low numbers of frogs present here probably limit the quality of habitat for water snakes and their inclination to remain.

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Appendix A. Records of amphibians and reptiles at and in the vicinity of Saugus Iron Works National Historic Site prior to 2001. Nyman (1991) covers the entire watershed of the Saugus River, and Herp Atlas records are for the approximately 25 km^2 Herp Atlas block that SAIR is located within (Quad 69, Block 4).

Common Name	Nyman 1991	Herp Atlas 1992-98	SAIR Staff	Cook 2000 Observations	(K)nown or (P)otential at SAIR
red-spotted newt	present				
blue-spotted salamander complex	present				
marbled salamander	historic report				
spotted salamander	historic report	confirmed			
four-toed salamander	possible				
northern dusky salamander	possible				
northern two-lined salamander	present			confirmed	K
E. red-backed salamander	present	confirmed			P
spadefoot toad	unlikely				
American toad	present				
Fowler's toad	possible				
spring peeper	likely	confirmed			P
gray treefrog	present				
American bullfrog	likely	confirmed			P
northern green frog	present	confirmed	reported	confirmed	K
northern leopard frog	possible				
pickerel frog	present	confirmed			
wood frog	present	confirmed			
common garter snake	present	confirmed	reported		K
eastern ribbon snake	possible				
northern ring-necked snake	possible	confirmed			
smooth green snake	possible				
black racer	possible				
eastern milk snake	possible	confirmed			
northern brown snake	present	confirmed			P
redbelly snake	possible				
northern water snake	likely	confirmed			P
eastern hognose snake	unlikely				
common musk turtle	possible	confirmed			
snapping turtle	present	confirmed	reported	confirmed	K
Blanding's turtle	possible	confirmed			
wood turtle	historic report				
eastern box turtle	possible				
spotted turtle	historic report	confirmed			
painted turtle	present	confirmed	reported		K

Appendix B. Habitat categories and types surveyed at Saugus Iron Works National Historic Site.

Habitat Category	Habitat Type	Description[1]
East Woodland	Woodland	Northeastern modified successional forest dominated by *Acer platanoides* (Norway maple), *Carya alba* (mockernut hickory), *Fagus grandifolia* (American beech), *Prunus serotina* (black cherry), and *Quercus rubra* (northern red oak).
Historic / Administrative	Fields, lawns and landscape plantings	Public and administrative zone characterized by buildings with shade trees, flowerbeds, and lawn. Also includes the historic 'slag heap' comprised of the inorganic waste from processing iron.
Marsh	Emergent Marsh	Seasonally and tidally flooded herbaceous alliance characterized by *Typha angustifolia* (narrowleaf cattail), common reed (Phragmites spp.), and *Phalaris arundinacea (reed canarygrass*) communities.
Saugus River Channel	River Channel	Tidally influenced river channel with floating and submerged aquatic vegetation.
Stream / Seep	Permanent Stream	Permanent stream (seep) on forested slope.

[1]Description follows Largay and Sneddon 2008

Appendix C. Coordinates for 11 standardized amphibian and reptile survey sites and two incidental encounter localities at Saugus Iron Works National Historic Site. For coverboards and stream time-constrained searches, the pair of coordinates represent the start and end points of linear features. For field and wetland time-constrained searches, the pair of coordinates represents centroids for the two areas searched. For anuran calling surveys, incidental encounters, minnow and turtle trap surveys, and woodland time-constrained searches, the single point indicates the location of the observer, observation, trap, or centroid of the area searched respectively.

Site	Survey Method	UTM X	UTM Y	UTM X	UTM Y
East Woodland	Coverboards	334998	4703693	335001	4703751
East Woodland	Woodland Time Constrained Search	335006	4703706		
Historic / Administrative	Coverboards	334939	4703785	334907	4703728
Historic / Administrative	Field Time Constrained Search	334889	4703792	335030	4703814
Historic / Administrative	Incidental Encounter	334936	4703777		
Marsh	Anuran Calling Survey	334936	4703777		
Marsh	Minnow and Turtle Trap Surveys	334930	4703769		
Marsh	Marsh Time Constrained Search	334958	4703769	334972	4703685
Saugus River Channel	Stream Time Constrained Search	334958	4703647	334993	4703834
Saugus River Channel	Minnow Trap Surveys	335018	4703821		
Stream / Seep	Stream Time Constrained Search	334921	4703727	334918	4703730
Stream / Seep	Incidental Encounter	334922	4703724		

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National Park Service
U.S. Department of the Interior

Natural Resource Program Center
1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525

www.nature.nps.gov