AQUATIC MESOHABITAT ASSESSMENT AND MAPPING REPORT

Northfield Mountain Pumped Storage Project (No. 2485)
and Turners Falls Hydroelectric Project (No. 1889)

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1 INTRODUCTION

The Turners Falls Project is licensed to FirstLight Hydro Generating Company (FirstLight). Operation of the Turners Falls Project may potentially affect aquatic habitat in the Connecticut River in the project vicinity by discharges from the spillway at Turners Falls and/or the powerhouse at Cabot Station. To better understand the types and distribution of riverine habitat, FirstLight therefore conducted an aquatic mesohabitat assessment within the Connecticut River below Turners Falls Dam. This effort aids the relicensing process by quantifying the type and extent of aquatic mesohabitat potentially impacted by project operations (FirstLight 2012). Prior to this effort no such habitat information existed.

1.1 Issue

Determine the effect of Project operations on aquatic resources within the Turners Falls bypass reach and riverine portions of the Connecticut River between Cabot Station and the natural downstream hydraulic control (located in the vicinity of Dinosaur Footprints Reservation).

1.2 Study Objective

The objective of the aquatic mesohabitat assessment is to gain a preliminary understanding of the aquatic mesohabitat resources in the two reaches described above. In each of these reaches, aquatic mesohabitat will be delineated and mapped. The assessment will provide data that will support and focus other relicensing activities needed to assess Project effects on riverine resources.

1.3 Background

FirstLight has identified aquatic mesohabitat characterization and mapping as beneficial information to help define whether or to what degree Project operations are impacting aquatic resources. FirstLight is not aware that any comparable aquatic habitat mapping has been conducted in the study area.

1.3.1 Turners Falls Hydroelectric Project

The Turners Falls Hydroelectric Project is located on the Connecticut River at river mile 122 (above Long Island Sound) in the towns of Gill and Montague, MA. The Turners Falls Dam is the second dam on the Connecticut River mainstem, and is located approximately 34 miles upstream of the lowermost Holyoke Dam (Figure 1). The major facilities of the Turners Falls Hydroelectric Project include the dam, gatehouse, power canal, Station No. 1, and Cabot Station (Figure 2).

The power canal is approximately 2.1 miles long and ranges in width from approximately 920 feet in the Cabot Station forebay (downstream end of canal) to 120 feet in the canal. The canal has a design capacity of approximately 18,000 cubic feet per second (cfs). There are several entities that can withdraw water from the canal; Table 1 lists the water users, approximate hydraulic capacity, and FERC project number (where applicable).

Southworth Paper and Turners Falls Hydro, LLC have indentured water rights. FirstLight has an agreement with both of these entities not to generate power, thus providing FirstLight with additional flow for generation at their facilities. However, these two hydropower facilities do generate power when Turners Falls Dam is spilling water due to excessive inflow. The USGS, which withdraws water for the Conte Anadromous Fish Laboratory, also has an agreement with FirstLight relative to its water usage; however, its water use is minimal.

Per the current FERC license for the Turners Falls Hydroelectric Project, FirstLight is required to release a continuous minimum flow of 1,433 cfs (0.2 cfs per square mile of drainage area) or inflow to the reservoir, whichever is less, from the Project into the Connecticut River. FirstLight typically maintains the minimum flow requirement through discharges at Cabot and/or Station No. 1.

1.3.2 Bypass Reach

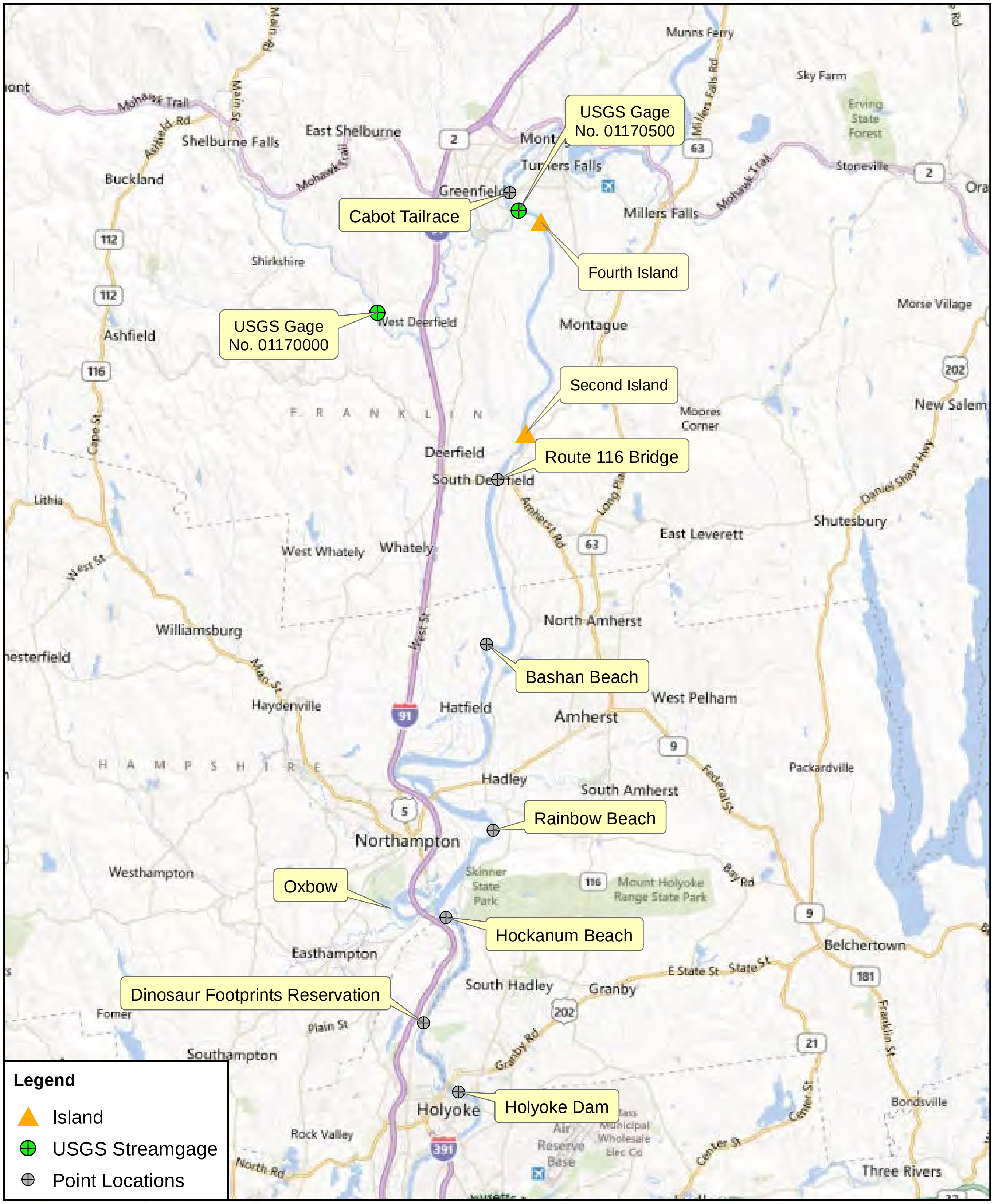
The canal bypasses approximately 2.7 miles of the Connecticut River. The bypass reach receives flow from one major tributary, Fall River, which empties into the upstream end of the bypass reach, approximately 0.16 miles below the dam. The drainage area of Fall River is approximately 34.2 square miles. Station No. 1 discharges into the bypass reach approximately 0.9 miles downstream of the Turners Falls Dam.

Per the current FERC license, a continuous minimum flow of 200 cfs is maintained in the bypass reach starting on May 1, and increases to 400 cfs when fish passage begins by releasing flow through the bascule gate. The 400 cfs continuous minimum flow is provided through July 15.

In addition, to protect shortnose sturgeon habitat use, a continuous minimum flow of 120 cfs is maintained in the bypass reach from July 16 until the river temperature drops below 7°C, which typically occurs in November.

Table 1: Entities Having Rights to Withdraw Water from Canal.

Facility Name	Owner	Hydraulic Capacity (cfs)	FERC Project
Southworth Paper Hydro	Southworth Paper	113 cfs	N/A
Turners Falls Hydro, LLC	Turners Falls Hydro	288 cfs	2622
Station No. 1 Hydro	FirstLight Hydro Generating Co.	2,210 cfs	1889
Cabot Hydro	FirstLight Hydro Generating Co.	13,728 cfs	1889
Conte Anadromous Fish Lab	USGS	Variable	N/A



FIRSTLIGHT POWER RESOURCES

AQUATIC HABITAT MAPPING STUDY

Figure 1: Study Area

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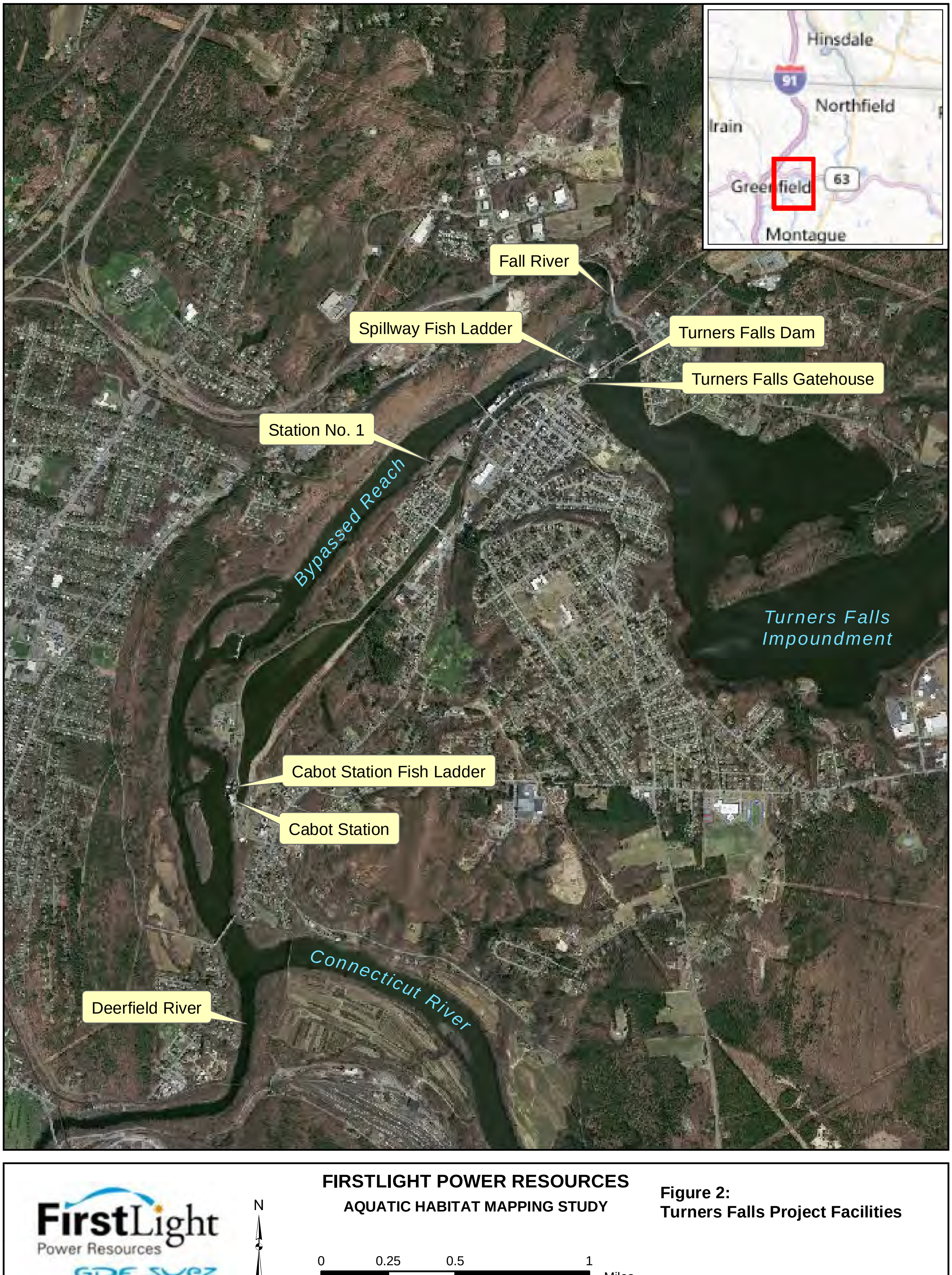

FirstLight Power Resources
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FIRSTLIGHT POWER RESOURCES

AQUATIC HABITAT MAPPING STUDY

Figure 2:
Turners Falls Project Facilities

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2 METHODS

2.1 Study Area

The study area encompasses the bypass reach of the Connecticut River between Turners Falls Dam (river mile 122) and the Cabot tailrace, and also the river between Cabot Station and the hydraulic control at Dinosaur Footprints State Park (Dinosaur Park) (river mile 88) as shown in Figure 1. Downstream of Dinosaur Park, project impacts are negligible because the river is backwatered by the Holyoke Project impoundment. The study area is divided into two distinct sections of the Connecticut River as follows:

- The bypass reach extending from the Turners Falls Dam (drainage area approximately 7,160 square miles) to the Cabot Station discharge (see Figure 1),
- The 30+ mile-long riverine reach from the Cabot Station discharge to a natural hydraulic control located in the vicinity of Dinosaur Footprints Reservation (drainage area approximately 8,300 square miles; see Figure 2).

2.2 Field Survey

The mesohabitat field assessment was conducted between July 23 and 26, 2012. During the survey the bypass reach flow was maintained at the seasonal minimum flow of approximately 120 cfs. Flows below Cabot Station were maintained below 4,500 cfs to facilitate observations of mesohabitat breaks such as hydraulic controls.

A Trimble Geo XH handheld GPS unit (equipped with a data dictionary aiding in feature attribution) was used to define boundaries between each contiguous mesohabitat segment moving from upstream to downstream. The point feature fields included qualitative categorizations of mesohabitat (primary, secondary, and tertiary), substrate classification (primary, secondary and tertiary), embeddedness classification (optimal/sub optimal), wetted width (estimate in feet) at each boundary, cover classification (primary, secondary and tertiary), and an estimate of cover extensiveness (expressed as a percentage of the mesohabitat). Along with geo-referenced information, a change in mesohabitat was documented with photographs (Appendix A).

The relatively shallow bypass reach was surveyed on foot; however, a vessel was required for the riverine sections. Each unique mesohabitat reach was classified into one of six habitat classes following these definitions set forth in the study plan:

- **Riffle:** shallow, moderate velocity, turbulent, high gradient, moderate to large substrates (cobble/gravel)
- **Rapid:** shallow, moderate to high velocity, turbulent, chutes and eddies present, high gradient, large substrates or bedrock
- **Run:** moderately deep to deep, well defined non-turbulent laminar flow, low to moderate velocity, well defined thalweg, typically concave stream geometry, varying substrates, gentle slope
- **Glide:** moderately shallow, well defined non-turbulent laminar flow, low velocity, well defined thalweg, typically flat stream geometry, typically finer substrates, transitional from pool
- **Pool:** deep, low velocity, well defined hydraulic control at outlet
- **Backwater:** varying depth, minimal or no velocity, long backwatered reaches

2.3 Flow Calculation

Flows were determined by instrumentation recorded at the FirstLight Power Control Room and were pre-coordinated and set daily by the operations staff. The survey was conducted during a period of relatively low flow. Records from USGS gage # 01170500 CT River at Montague City were used to describe the flow relationship between the study period and historic flows. During the 4-day study the mean daily discharge between the hours of 8:00 to 17:00 was 4,394 cfs while during the previous four years the mean daily discharge during the same hours of the day was 19,521 cfs (Figure 3). During this period the Deerfield River (a significant tributary that enters the study area a short distance downstream from Cabot Station) discharged between approximately 250-350 cfs; these flows were somewhat lower than the long-term daily median values for each corresponding date (Figure 4).

When compared the mean daily discharge during the sampling period, 4,394 cfs, with the July and annual flow duration curves for the Montague, MA USGS Gage, (1940-2010), the flow during the habitat mapping sampling period was exceeded about 70% of the time during July (Figure 5) and was exceeded annually over 90% of the time (Figure 6).

2.4 GIS Analysis

The existing publicly available hydrology polygon data for the study area from the USGS (USGS 2006) suffered from poor horizontal accuracy, and the feature type that represented the bypass reach was a line rather than a polygon. A polygon representing the banks of the Connecticut River between Turners Falls Dam and Holyoke Dam was drawn from leaf off aerial photography. The exact date of the flyover is unknown; however the river appears to be at or near bankfull as many low lying floodplains along the river were inundated. The banks were digitized at a scale of 1 inch to 1000 feet. After the initial digitizing, natural shoreline segments were simplified through the application of the Smoothing function.

During the field survey the survey crew indicated a complex of bifurcated channels with unique habitat. The locations of these channels may vary according to flow and bed topography and may become inundated at flows higher than those observed in the field. To digitize the bifurcated channel segments, aerial imagery were sourced that depicted low water conditions (USDA 2009). For linear habitat measurements, the NHD Plus flowline (USGS 2006) was clipped to the analysis region (Turners Falls to Dinosaur Park) and dissolved into one feature. The linear habitat segments were attributed, lengths were calculated with ArcMap 10.0 and exported to Microsoft Access for further analysis.

Figure 3: Comparison of the daily mean flow at the USGS Montague City Gage during the July 2012 mesohabitat mapping study to the same dates over the preceding 4 years.

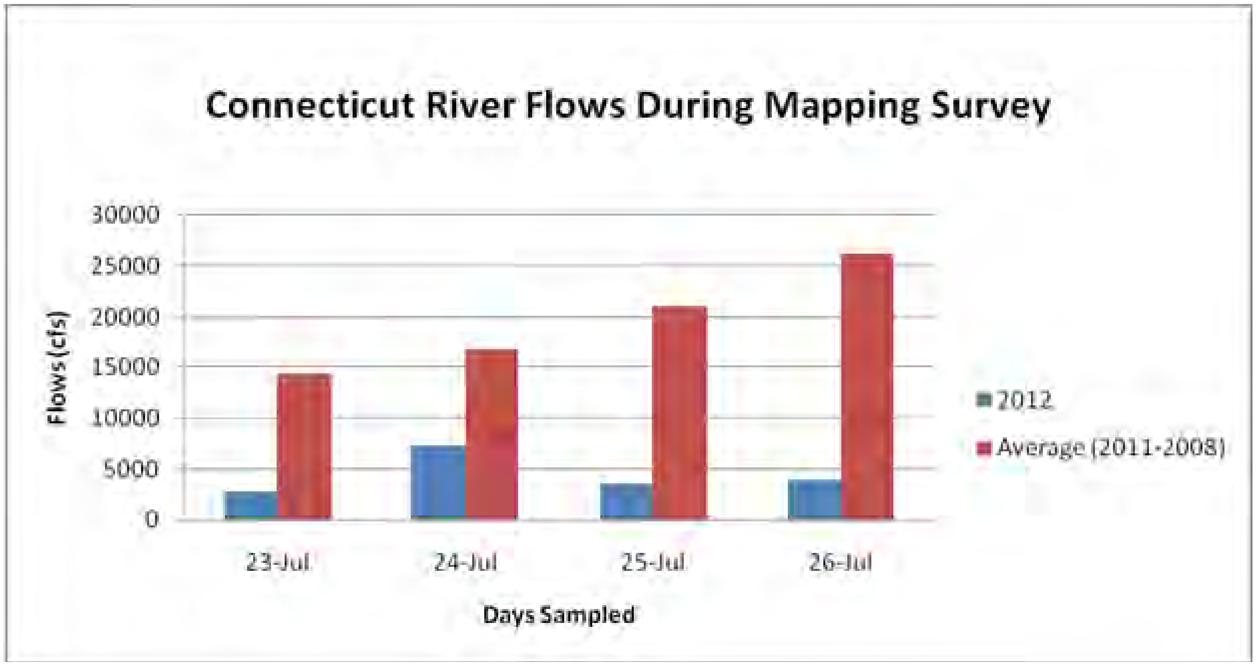


Figure 4: Daily discharge at the USGS Deerfield River gage in West Deerfield, MA during the mesohabitat survey.

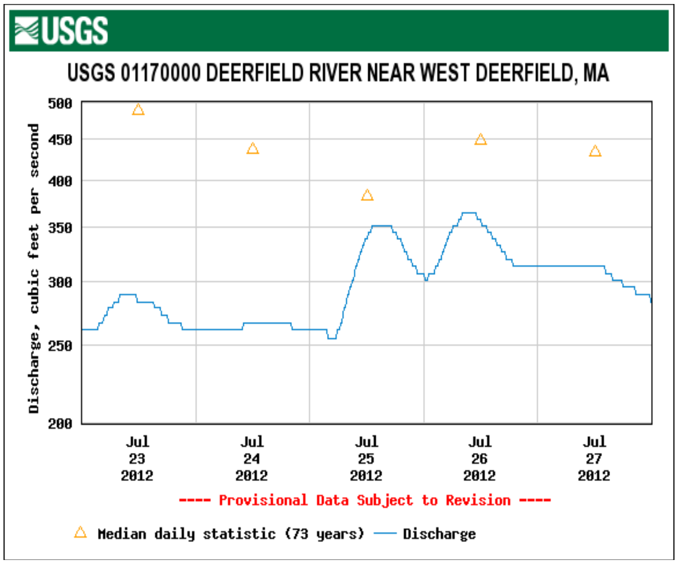


Figure 5: Connecticut River at Montague, MA, Jul-Sep Flow Duration Curve, Apr 1940-Sep 2010.

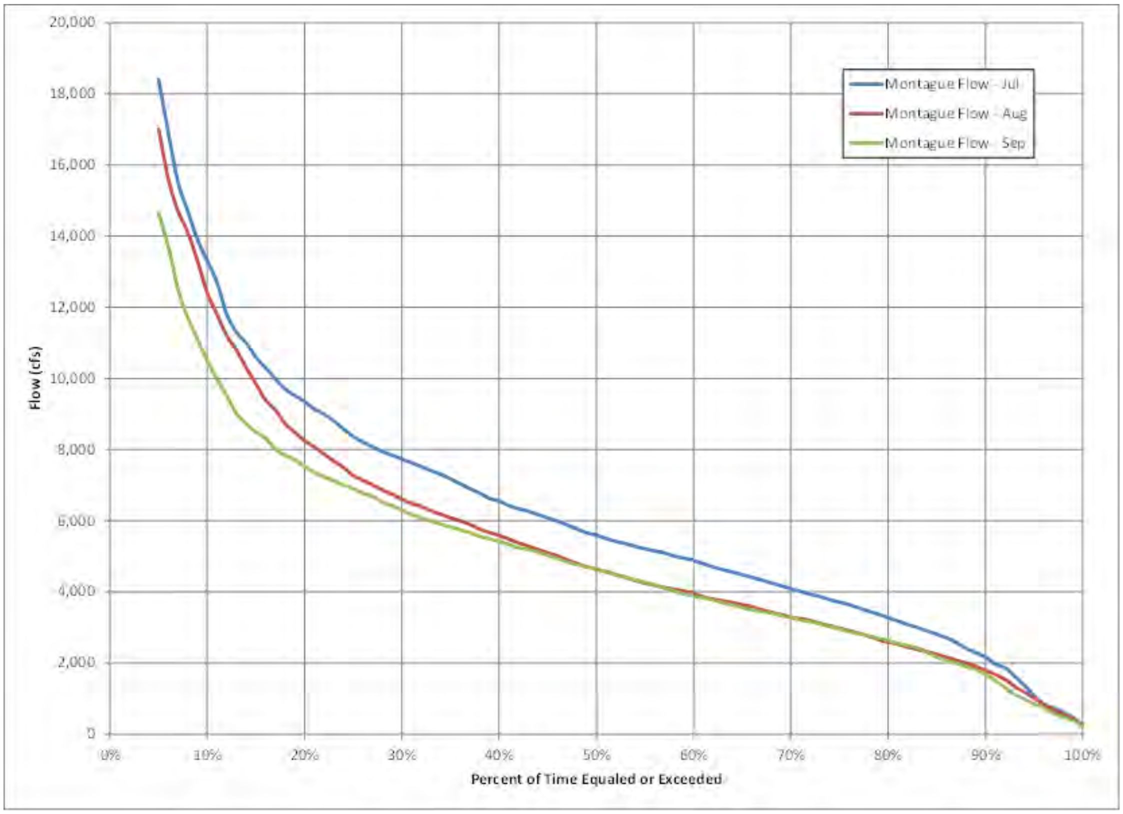
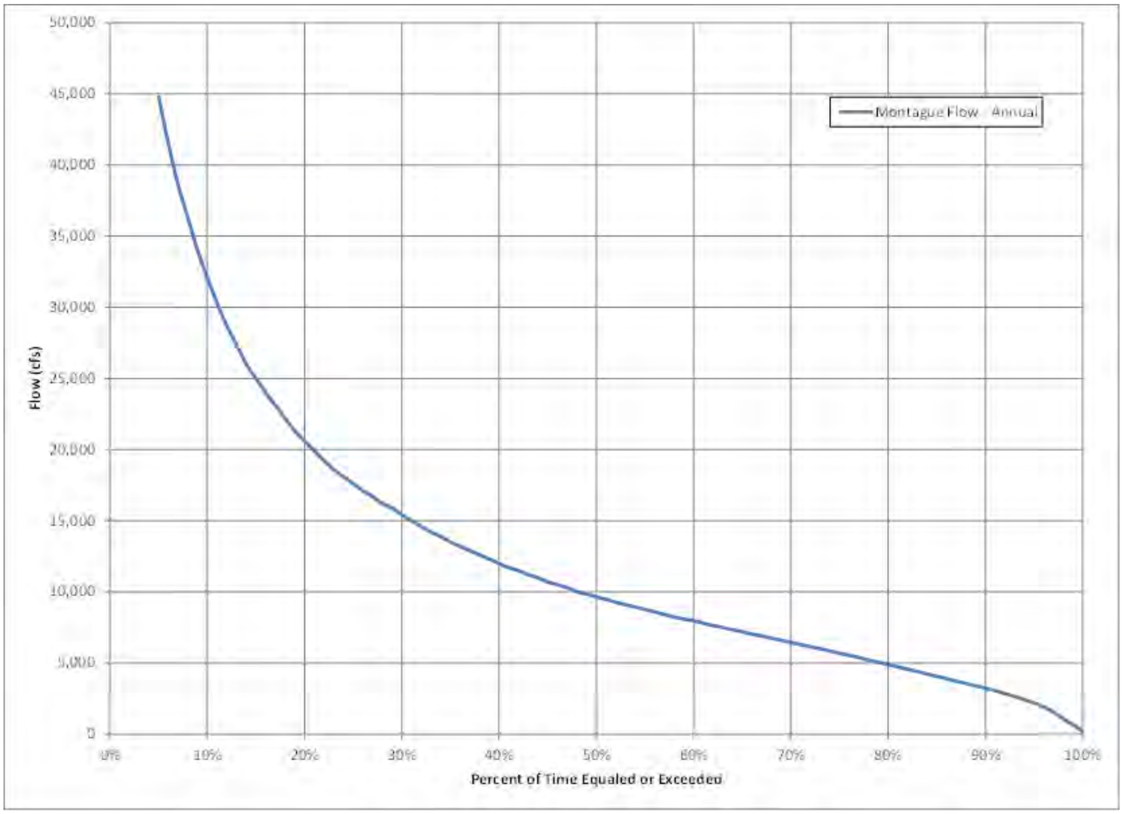


Figure 6: Connecticut River at Montague, MA, Annual Flow Duration Curve, Apr 1940-Sep 2010.



3 RESULTS

3.1 Mesohabitat

Representative photographs are found in Appendix A and detailed mesohabitat maps of both the bypass reach and the reach below Cabot are found in Appendix B.

3.2 Bypass Reach

The mesohabitat features in the bypass reach are listed in (Table 2). Pool habitat dominates the bypass reach with a total length of 7,485 feet (Table 3) followed by run and backwater. Riffle and glide mesohabitats are less common. Much of this reach is bedrock controlled and therefore substrate is a function of larger cobbles broken from the bedrock-based material. Embankments are steep sided. There are few areas with fines.

3.3 Reach Below Cabot Station

The reach below Cabot Station forms a wide floodplain with alluvial-dominated substrates, is generally wider than the bypass reach, and displays somewhat meandering channel forms in many places. Discharge from the Deerfield River was low and therefore did not obscure mesohabitat boundary breaks in the study area. Dominant mesohabitat and substrate by river mile for this reach was run with sand substrate (Table 4). The Oxbow, south of Northampton, MA, an offshoot of the Connecticut River at river mile 92 contains a long reach of backwater habitat.

Habitat characteristics in this reach are considerably different from those encountered in the bypass reach. The low gradient, alluvial characteristic of this reach results in limited mesohabitat variability and in many cases very gradual or subtle transitions from one mesohabitat type to the next contiguous type. Approximately 77% of the mesohabitat in the riverine reach is comprised of run (139,283 feet) (Table 5) with pool comprising the next most abundant mesohabitat type (13%). Riffle habitat is extremely uncommon and is most concentrated in the stream reach immediately downstream from the Cabot Station discharge (Figure 2 in Appendix B).

Table 2: Primary Mesohabitat and Substrate Classifications by River Mile within the Turners Falls Bypass Reach. Note: river mile 0.0 datum is Old Saybrook, CT.

Cumulative River Mile	Channel Notes	Primary Mesohabitat	Primary Substrate	Primary Cover	Embeddedness	Habitat ID
123	Main Channel	Pool	Bedrock	boulders	optimal	po 68.0
122	Main Channel	Pool	Bedrock	boulders	optimal	po 68.0
122	LB Bifurcated Channel	Pool	Bedrock	boulders	optimal	po 68.0
122	Main Channel	Riffle	Bedrock	boulders	unknown	rf 68.0
122	LB Bifurcated Channel	Riffle	Bedrock	boulders	unknown	rf 68.0
122	Main Channel	Run	Bedrock	Depth	sub optimal	ru 67.9
122	Main Channel	Pool	Boulder	depth	optimal	po 67.8
122	Main Channel	Pool	Cobble	depth	optimal	po 67.8
122	Main Channel	Pool	Cobble	boulders	optimal	po 67.8
122	Main Channel	Run	Cobble		optimal	ru 67.5
122	Main Channel	Run	Cobble		sub optimal	ru 67.5
122	Main Channel	Run	Bedrock	boulders	optimal	ru 67.5
122	Main Channel	Riffle	Cobble	boulders	optimal	ri 66.9
121	Main Channel	Riffle	Cobble	boulders	optimal	ri 66.9
121	Main Channel	Run	Boulder	boulders	Optimal	ru 66.8
121	Main Channel	Run	Cobble	boulders	optimal	ru 66.8
121	Main Channel	Pool	Cobble	depth	sub optimal	po 66.6
121	LB Bifurcated Channel	Pool	Cobble	Depth	sub optimal	po 66.6
121	LB Bifurcated Channel	Riffle	Cobble	Boulders	Optimal	rf 66.5
121	LB Bifurcated Channel	Run	Cobble	Boulders	optimal	ru 66.4
121	LB Bifurcated Channel	Pool	Cobble	Boulders	Sub optimal	po 66.4
121	Main Channel	Backwater	Gravel	Backwaters	Marginal	bw 66.4
121	Main Channel	Pool	Cobble	Boulders	sub optimal	po 66.4
121	Main Channel	Glide	Cobble	Boulders	sub optimal	gl 66.4
121	RB Bifurcated Channel	Pool	Cobble	Depth	sub optimal	po 66.6
121	RB Bifurcated Channel	Riffle	Cobble	Boulders	optimal	rf 66.5 rb
121	RB Bifurcated Channel	Run	Cobble	Boulders	optimal	ru 66.4 rb
120	RB Bifurcated Channel	Backwater	Cobble	Backwaters	sub optimal	bw 66.4
120	Main Channel	Backwater	Gravel	Backwaters	Marginal	bw 66.4
120	Main Channel	Backwater	Cobble	Backwaters	sub optimal	bw 66.4

Table 3: Primary Mesohabitat Summation by Length within the Bypass Reach.

Primary Mesohabitat	Length (ft)	Percent
Pool	7,485.4	36%
Run	5,344.7	25%
Backwater	4,479.1	21%
Riffle	3,037.0	14%
Glide	725.3	3%
Total	21,071.5	

Table 4: Primary Mesohabitat and Substrate Classifications by River Mile below Cabot Station

Cumulative River Mile	Channel Notes	Primary Mesohabitat	Primary Substrate	Primary Cover	Embeddedness	Habitat ID
120	Main Channel	Run	Cobble	Depth	Sub optimal	ru 65.8
120	Main Channel	Riffle	Cobble	Unknown	Optimal	rf 65.7
120	Main Channel	Run	Cobble		Optimal	ru 65.6
119	Main Channel	Run	Cobble		Optimal	ru 65.6
119	Main Channel	Run	Cobble	Boulders	Poor	ru 65.6
119	Main Channel	Pool	Gravel	depth	Unknown	po 65.1
119	Main Channel	Run	Cobble	Depth	Marginal	ru 64.8
118	Main Channel	Run	Cobble	Depth	Marginal	ru 64.8
118	Main Channel	Run	Cobble	Boulders	Optimal	ru 64.8
117	Main Channel	Run	Cobble	Boulders	Optimal	ru 64.8
117	Main Channel	Run	Cobble		Sub optimal	ru 64.8
116	Main Channel	Run	Cobble		Sub optimal	ru 64.8
115	Main Channel	Run	Cobble		Sub optimal	ru 64.8
114	Main Channel	Run	Cobble		Sub optimal	ru 64.8
114	Main Channel	Pool	Unknown	Depth	Unknown	po 60.0
114	Main Channel	Glide	Cobble		Poor	gl 59.7
113	Main Channel	Glide	Cobble		Poor	gl 59.7
113	Main Channel	Pool	Sand	Depth	Poor	po 59.5
113	Main Channel	Glide	Sand		Poor	gl 58.7
112	Main Channel	Glide	Sand		Poor	gl 58.7
112	Main Channel	Pool	Sand	Depth	Poor	po 58.5
112	Main Channel	Run	Gravel	Woody Debris	Sub optimal	ru 57.6
111	Main Channel	Run	Gravel	Woody Debris	Sub optimal	ru 57.6
111	Main Channel	Pool	Unknown	Depth	Unknown	po 57.1
110	Main Channel	Pool	Unknown	Depth	Unknown	po 57.1
110	Main Channel	Run	Gravel		Marginal	ru 56.2
109	Main Channel	Run	Gravel		Marginal	ru 56.2
108	Main Channel	Run	Gravel		Marginal	ru 56.2
107	Main Channel	Run	Gravel		Marginal	ru 56.2
106	Main Channel	Run	Gravel		Marginal	ru 56.2
106	Main Channel	Glide	Sand		Poor	gl 51.3
106	Main Channel	Run	Sand		Poor	rn 51.0
105	Main Channel	Pool	Unknown	Depth	Unknown	po 50.6
105	Main Channel	Run	Sand		Poor	rn 51.0
104	Main Channel	Pool	Unknown	Depth	Unknown	po 50.6
103	Main Channel	Pool	Unknown	Depth	Unknown	po 50.6
103	Main Channel	Run	Sand	depth	Poor	ru 49.2
102	Main Channel	Run	Sand	depth	Poor	ru 49.2
101	Main Channel	Run	Sand	depth	Poor	ru 49.2

Cumulative River Mile	Channel Notes	Primary Mesohabitat	Primary Substrate	Primary Cover	Embeddedness	Habitat ID
100	Main Channel	Run	Sand	depth	poor	ru 49.2
99	Main Channel	Run	Sand	depth	poor	ru 49.2
98	Main Channel	Run	Sand	depth	poor	ru 49.2
97	Main Channel	Run	Sand	depth	poor	ru 49.2
96	Main Channel	Run	Sand	depth	poor	ru 49.2
95	Main Channel	Run	Sand	depth	poor	ru 49.2
94	Main Channel	Run	Sand	depth	poor	ru 49.2
93	Main Channel	Run	Sand	depth	poor	ru 49.2
92	Main Channel	Run	Sand	depth	poor	ru 49.2
92	Main Channel	Backwater	Silt	depth	poor	obbw 37.7
91	Main Channel	Run	Sand	depth	poor	ru 49.2
90	Main Channel	Run	Sand	depth	poor	ru 49.2
89	Main Channel	Run	Sand	depth	poor	ru 49.2
88	Main Channel	Run	Bedrock	depth	optimal	rn 49.2

Table 5: Primary Mesohabitat Summation by Length Below Cabot Station.

Primary Mesohabitat	Length (ft)	Percent
Run	139,282.99	77%
Pool	24,149.05	13%
Backwater	11,144.94	6%
Glide	4,939.59	3%
Riffle	898.81	<1%
Total	180,415.37	

4 DISCUSSION

Habitat use of the varied mesohabitats found in the study area may be utilized by aquatic fauna at different life stages and may vary by season. The following discussion summarizes key aspects of the life history and mesohabitat uses associated with key migratory species managed for in the study area.

The Connecticut River in the study area provides spawning and nursery habitat for the federally endangered shortnose sturgeon (*Acipernser brevirostrum*), the diadromous species American shad (*Alosa sapidissima*) and blueback herring (*A. pseudoharengus*), and nursery habitat for American eel (*Anguilla rostrata*).

4.1 Shortnose Sturgeon

Shortnose sturgeon exhibit distinct movement patterns associated with spawning, feeding, and overwintering activities. In spring, pre-spawning adults move from overwintering grounds to spawning areas. Shortnose sturgeon in the upper river (i.e. above Holyoke, MA) spawn from the last week of April to mid-May, after the spring freshet (Taubert 1980; Buckley and Kynard 1985; Kynard 1997). Additional environmental conditions associated with spawning activity include decreasing river discharge following the spring freshet, water temperatures ranging from 8-12ºC, and bottom water velocities of 1.3-2.3 ft/sec (Dadswell et al. 1984; NOAA Fisheries 1998).

During spawning, sturgeon select channel habitats containing gravel, rubble, or rock-cobble substrates (Dadswell et al. 1984; NOAA Fisheries 1998). Successful spawning has been documented at two sites in the vicinity of Cabot Station (Vinogradov 1997). This area is the approximately 3,000 foot reach from the natural rock formation called Rock Dam (slightly above the Cabot tailrace) to 656 feet downstream of Cabot Station, where river depths are less than 33-feet and all common types of river habitat are present. Much of the river bottom in the area is rock and rubble.

Adults normally depart from spawning grounds soon after spawning and move rapidly to downstream feeding areas in spring, followed by local meandering in summer and winter. Shortnose sturgeon tend to inhabit the deep channel sections of large rivers for overwintering and feeding. They are known to occur at a wide range of depths: a minimum depth of 2 feet is needed for the unobstructed swimming by adults; but depths up to 98 feet, have been reported. They more commonly occur in waters less than 66 feet (Dadswell et al. 1984).

Daily habitat selectivity of 13 shortnose sturgeon (3 yearlings, 9 adults and 1 two-year old) was determined by tracking each fish with radio telemetry in the Connecticut River between Holyoke and Turners Falls Dams (Seibel 1991). These fish preferred gravel and rubble substrates in the summer, but most preferred sand in the winter. Juvenile and adults preferred similar habitats (Seibel 1991). The summer range of individuals was about 6.2 miles whereas their winter range was 1.2 miles or less. All fish overwintered in the deepest area within or downstream of their summer range. The reach between Second and Fourth Island was a major concentration area (Seibel 1991).

Deep channel areas suitable for sturgeon include pools, which account for 13% of the river downstream from the Cabot Station and 36% of the bypass reach mesohabitat (Tables 3 and 5). The most commonly occurring mesohabitat type below Cabot is run (77%) and pool is the dominant mesohabitat type (36%) in the bypass (Tables 3 and 5); most run habitat in both reaches exceeds the minimum depth requirement at the summer base flow at which habitat delineation was conducted in this study, and is therefore likely suitable for sturgeon.

4.2 American Shad

The study area may be used as spawning and nursery habitat for American shad. Pre-spawning American shad migrate into the Cabot Station vicinity in late April or early May. Female shad broadcast eggs in open water in a variety of habitats. After spawning, spent shad swim back downstream during June and July. Eggs are planktonic and passively drift downstream with river currents, and hatch in 3-12 days, depending on water temperature. Post yolk-sac larvae are further transported by currents into areas of lower velocity, where they begin to feed on plankton. Although some young-of-year (YOY) may move actively downstream at other times, the seaward migration out of the Connecticut River occurs in September through November.

American shad prefer areas dominated by runs, 3-18 feet deep for spawning purposes, and have been observed to spawn over a variety of substrates but prefer sand and gravel bottom with sufficient water velocity to eliminate silt deposits (Collette and Klein-MacPhee 2002; Stier and Crance 1985). This type of habitat most closely corresponds to the runs and glides occurring downstream from Cabot Station but is very limited in the bypass reach. Approximately 77% of mesohabitat below Cabot Station is run; glides are less than 3% of the total habitat below Cabot Station. Hightower et al. (2011) noted that dissolved oxygen levels lower than 5.0 mg/l were unsuitable for spawning, and that optimal spawning water velocity ranges from approximately 2-3 feet/sec; optimal depths range from approximately 6.6-11.5 feet, and that gravel/cobble/boulder substrates are preferred to silt/sand or clay.

Juveniles are pelagic filter feeders and therefore habitat generalists; they are attracted to areas with concentrations of plankton and suitable water quality (Stier and Crance 1985). As weak swimmers, low-velocity mesohabitats such as pool and backwater may be inherently more attractive than riffles and fast moving runs. Pool and backwater habitats occur in about 57% of the bypass reach (Table 3) and 19% of the reach below Cabot Station (Table 5).

4.3 Blueback Herring

Pre-spawning blueback herring enter the Connecticut River at about the same time as American shad and may utilize the study area for spawning and rearing. Blueback herring broadcast spawn on hard substrate in swift-flowing tributaries to the lower Connecticut River. Presumably, some spawning also occurs in the mainstem Connecticut River, where swift-flowing habitats with hard substrate are available (Collette and Klein-MacPhee 2002). Adults migrate back downstream immediately after spawning. Eggs are adhesive when first deposited, but drift downstream after becoming water-hardened. The larvae continue to drift downstream as development proceeds. Juveniles remain in the river, feeding on zooplankton, until fall of the year of hatching, they then emigrate to the sea. Juvenile blueback begin their seaward migration slightly earlier and at higher water temperatures (peaking at 14-15ºC) than American shad (Collette and Klein-MacPhee 2002).

Active spawning occurs over a wide range of water velocities. Blueback herring are reported to spawn in both swift-flowing, deeper stretches and in slower-flowing tributaries and flooded low-lying areas adjacent to the main stream; substrates may vary from coarse to fine materials (Pardue 1983). These conditions describe the uppermost segments of the study area where most riffles are located (Appendix A) but are also representative of runs that are well distributed throughout the study area, including portions of the bypass reach. However most of the runs featuring the requisite hard substrates (i.e., cobble, gravel) can be found in the first 14 miles of river below Cabot Station. Fines such as sand predominate as substrates in the remaining downstream reaches. As tributary spawners, blueback herring may also utilize habitat in the lower Deerfield River, a significant tributary that enters the study area a short distance below the Cabot tailrace.

Eggs are initially demersal but become planktonic. Pardue (1983) reports that larvae in Chesapeake Bay remain near or slightly downstream of presumed spawning areas, and in Nova Scotia are associated with relatively shallow (depth < 6.6 feet), sandy, warm areas within and near areas of observed spawning. The most strategic spawning areas are runs/riffles with hard substrates that are a short distance upstream from runs, pools with finer substrates.

Assuming that suitable plankton and water quality exists downstream from the Cabot Station, this reach should provide extensive, suitable habitat for this species especially in the transition area between cobble/gravel and finer substrates. Pardue (1983) notes that the species is tolerant of turbidity and juveniles exhibit a diel response to light intensity.

4.4 American Eel

American eels spawn in the marine environment, and migrate to inland waters to mature. Immature eels entering the Connecticut River may spend three to 18 years in freshwater before migrating to marine spawning grounds. Larval/juvenile eels initially move into estuaries and tidal freshwater. After inhabiting fresh water for some time, they gain pigment and gradually move upstream. Upstream movement may continue during the first few years of residence in freshwater. At maturation, the species undergoes another color change to the silver eel stage and migrates downstream, usually at night during fall.

Eels recruited to the study area will have matured beyond the leptocephalus and glass eel (elver) life stage to that of an immature pre-adult “yellow” phase, which occurs approximately 2 years after hatching (USFWS 2005). The timing and duration of upstream migration is watershed specific, and upstream migration may occur during most months of the year (ASMFC 2000).

Yellow eel are habitat generalists; USFWS (2005) reports that *“Feeding and growth of yellow eels occur in estuaries and freshwaters over a period of many years (including offshore, mid-water, and bottom areas of lakes, estuaries, and large streams).”* Depending on where they cease their upstream migration, some yellow eel reach the extreme upper portions of the rivers while others stay behind in the brackish areas (ASMFC 2000). Density-dependent factors may serve as recruitment mechanisms to the study area; according to USFWS (2007), density-dependent competition induces young eels to disperse into less crowded areas. Larger individuals farther upstream tend to become more sedentary and occupy territories, densities of eels decline, and females predominate.

As habitat generalists, eels would not be expected to demonstrate a pronounced preference or avoidance for any particular type of mesohabitat that exists in the bypass reach or downstream of Cabot Station. Rather, factors such as relative density of other eel and abundance of suitable forage would affect their choice of habitat. Juvenile eels would be expected to inhabit these mesohabitats throughout the year. Detailed information about microhabitat preference (i.e., depth, velocity and substrates) are not available, however, given that eels have adapted to a wide range of habitat throughout a very broad range of geography, climate and ecosystems strongly indicates a wide tolerance to such variables.

5 SUMMARY

Mesohabitat throughout a total of approximately three miles of river channel in the bypass reach of the Project and 33 miles of the Connecticut River below Cabot Station was surveyed under summer low flow conditions. The bypass reach, which is bedrock controlled, is dominated by pool, followed by run and backwater. Substrates are composed of bedrock and large boulder, along with cobble that originated as broken bedrock material. River embankments are high and steep-sided.

The reach below Cabot Station passes through alluvial geology within a broad floodplain, and has lower banks and finer substrates than that of the bypass reach. Mesohabitat in this reach is dominated by runs and pools with generally gradual transitions between boundaries. Riffles are limited and scarce, primarily concentrated in the reach immediately downstream from Cabot Station.

Diadromous species may utilize habitat within the study area for spawning and/or rearing. Adult sturgeon, shad and herring adults migrate upstream and broadcast spawn during the spring months and then exit downstream. Eggs and fry are generally planktonic and are passively transported downstream until becoming large and well-formed enough to volitionally swim. YOY shad and herring occupy riverine habitats until the fall when they emigrate to the marine environment where they live until maturity. Thus these species do not occupy the study area between late fall through early or mid spring. American eel ascend the Connecticut River as juveniles and may dwell in the study area year round for as much as 18 years until attaining sexual maturity and departing for the sea.

The assessment provides the necessary data to support and focus other relicensing activities needed to assess Project effects on riverine resources.

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APPENDIX A – PHOTOGRAPHS

BYPASS REACH

PHOTO 1. Upstream end of bypass reach. View looking downstream from Gill-Turners Falls Bridge. Note tributary inflow at right, alluvial island in center, and riffle/run mesohabitat boundary at pool outlets on river right and river left of island, and steep, bedrock controlled embankments

PHOTO 2. Detail of pool outlet/run mesohabitat boundary, river right channel

PHOTO 3. Detail of pool outlet/riffle mesohabitat boundary, river left channel

PHOTO 4. Substrate detail, ledge control of pool outlet (right) and riffle (left)

PHOTO 5. Bedrock riffle below large pool view looking upstream

PHOTO 6. Riverine pool above Turners Falls Rd bridge. Note bedrock/ledge channel control and steep embankment

PHOTO 7. Riverine pool, transition to run, looking downstream. Note bedrock/ledge channel control

PHOTO 8. Run/riffle mesohabitat below Turners Falls Rd bridge, looking downstream

PHOTO 9. Riffle mesohabitat below Turners Falls Rd Bridge, looking downstream

PHOTO 10. Riffle mesohabitat below Turners Falls Rd Bridge, looking downstream

PHOTO 11. Pool upstream from "rock dam" looking downstream

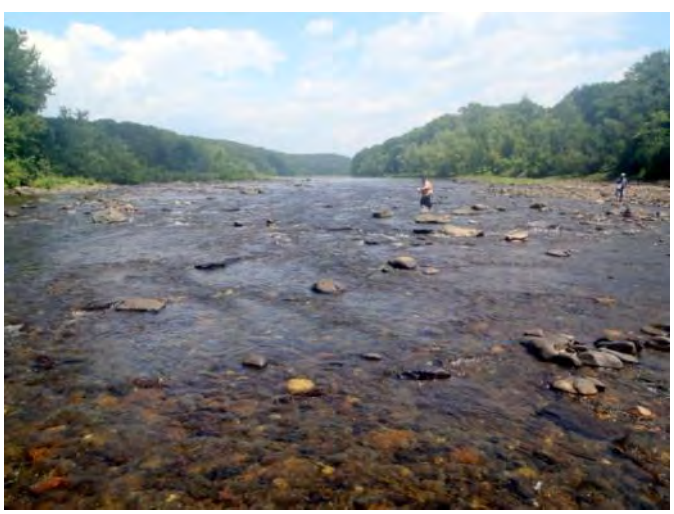


Photo 12. Cobble riffle upstream from "rock dam" looking upstream

PHOTO 13. View looking upstream of hydraulic control at "rock dam"

PHOTO 14. View looking downstream at head of backwater, as seen from "rock dam." Note alluvial geomorphology

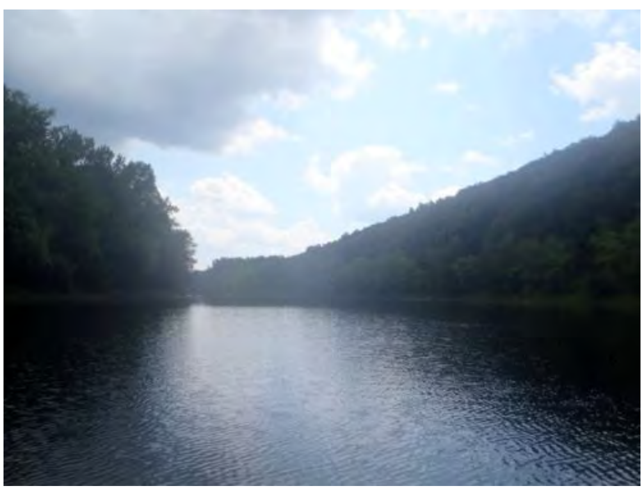


PHOTO 15. View looking downstream within backwater. Note alluvial geomorphology

PHOTO 16. View looking downstream at confluence of backwater with Cabot Station tailrace

Photo 17. Detail of un-embedded cobble substrate in tailrace area

CONNECTICUT RIVER BELOW CABOT STATION

Photo 18. Outlet of tailwater. At low flow this is a run, but becomes a riffle at higher flow

Photo 19. View looking upstream from hydraulic control directly underneath the General Pierce Bridge. Wetted area at left is a side arm; area at far right is the tailwater pool outlet seen in Photo 16

Photo 20. View looking upstream from pool toward ledge hydraulic control from Photo 17 *(exposed ledge can be seen under left chord of the General Pierce Bridge)*

Photo 21. Typical pool habitat below Cabot Station. Location is at former railroad bridge, Montague City

Photo 22. Typical river channel and shoreline characteristic between East Deerfield and Sunderland

PHOTO 23. Typical run downstream from Sunderland

PHOTO 24. Glide/riffle boundary below Sunderland, looking upstream

PHOTO 25. Glide/riffle boundary below Sunderland, looking downstream

PHOTO 26. Typical run/pool habitat between Hadley and Northampton, MA

PHOTO 27. Typical pool habitat in vicinity of Mount Tom, MA

PHOTO 28. Backwater habitat in The Oxbow, Northampton MA

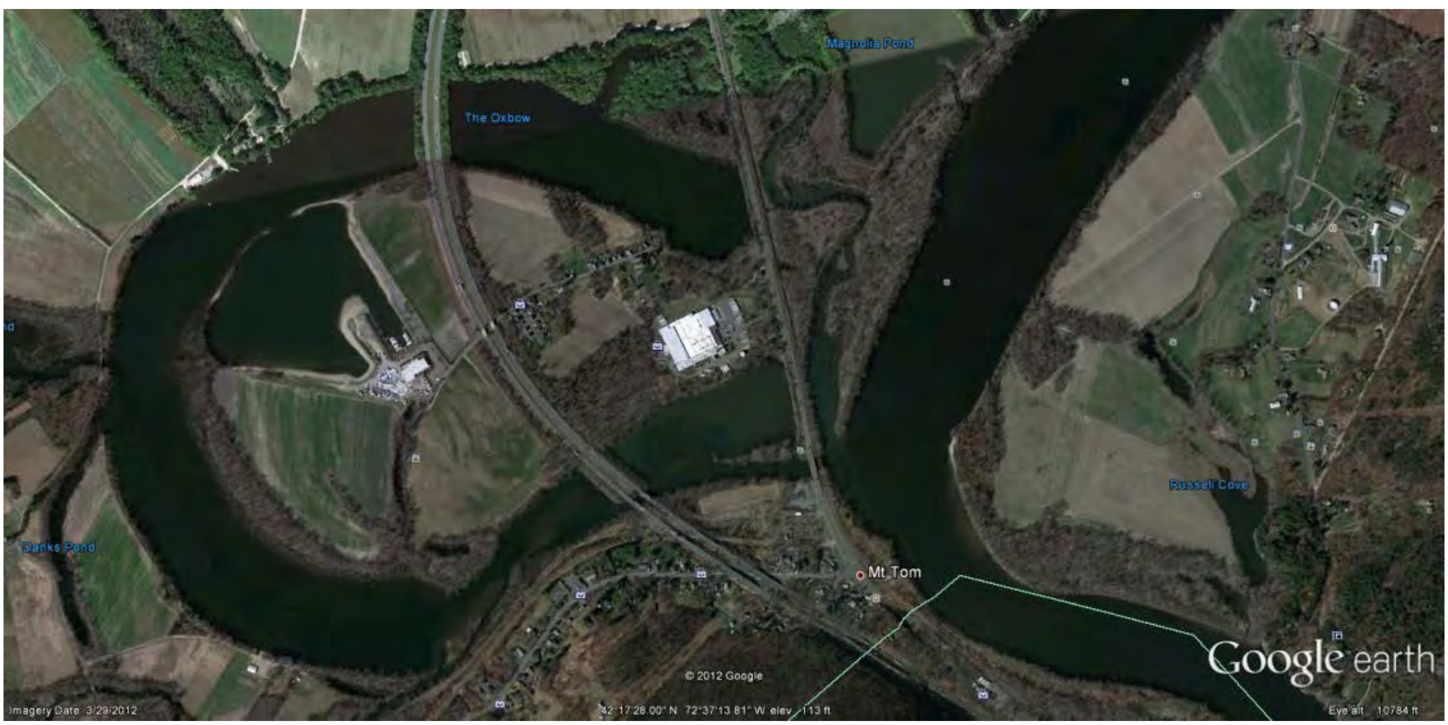
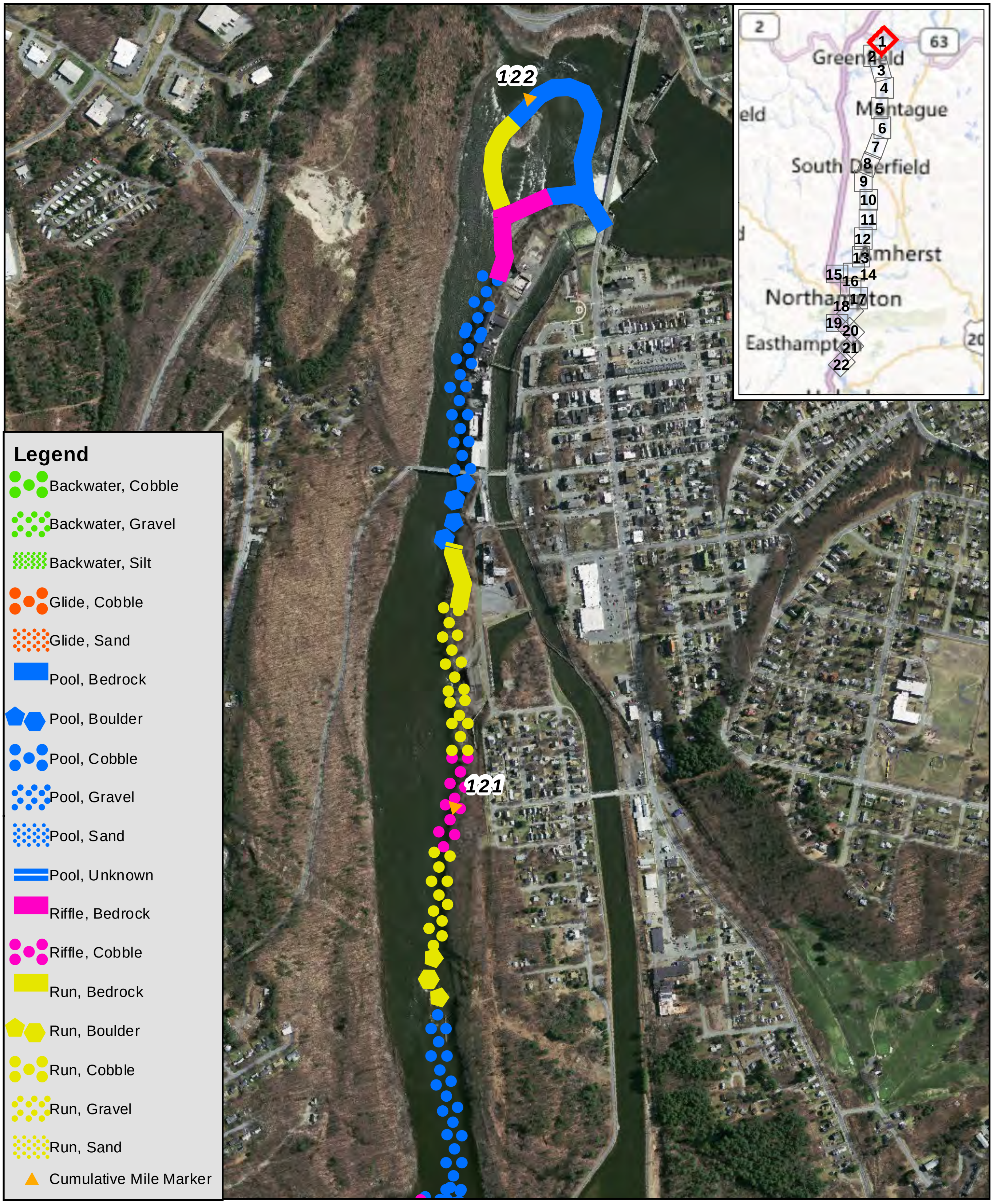


PHOTO 29. Aerial view of The Oxbow, Northampton MA (*Google Earth*)

APPENDIX B – MESOHABITAT MAPS



FIRSTLIGHT POWER RESOURCES

AQUATIC HABITAT MAPPING STUDY

Downstream Mesohabitat
Linear Habitat Classification

Figure # 1

N

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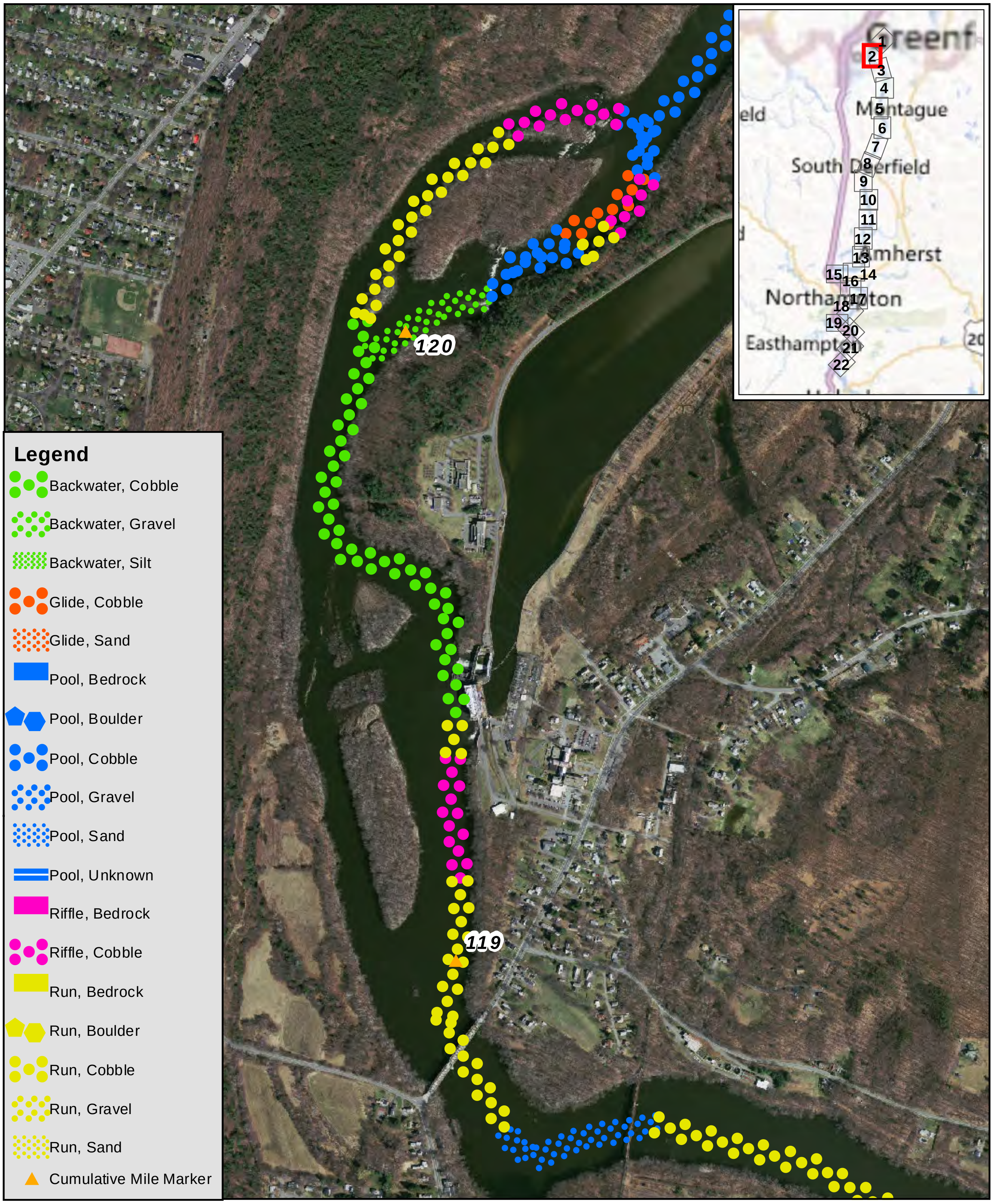

FIRSTLIGHT POWER RESOURCES

AQUATIC HABITAT MAPPING STUDY

Downstream Mesohabitat
Linear Habitat Classification

Figure # 2

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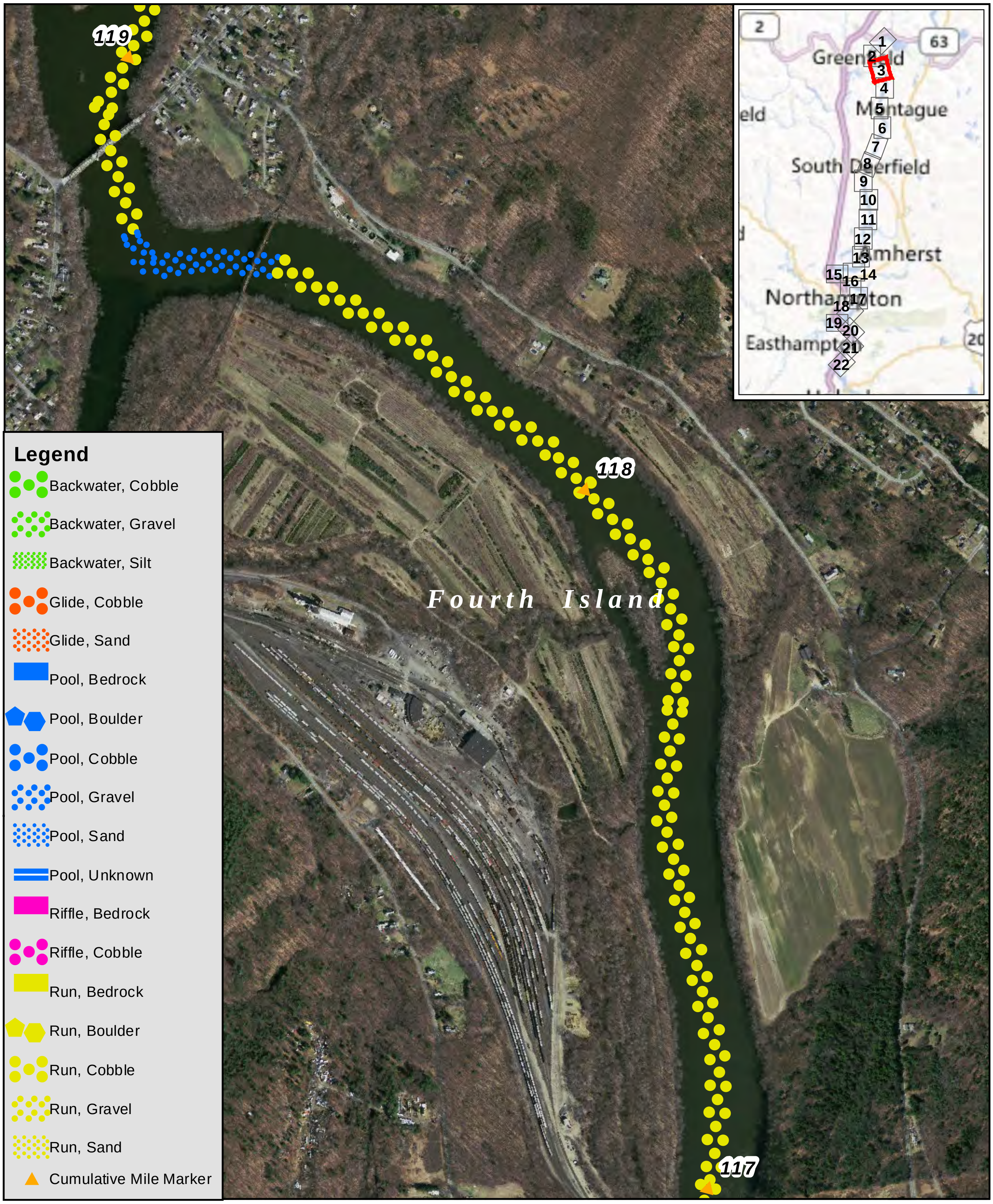

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AQUATIC HABITAT MAPPING STUDY

Downstream Mesohabitat
Linear Habitat Classification

Figure # 3

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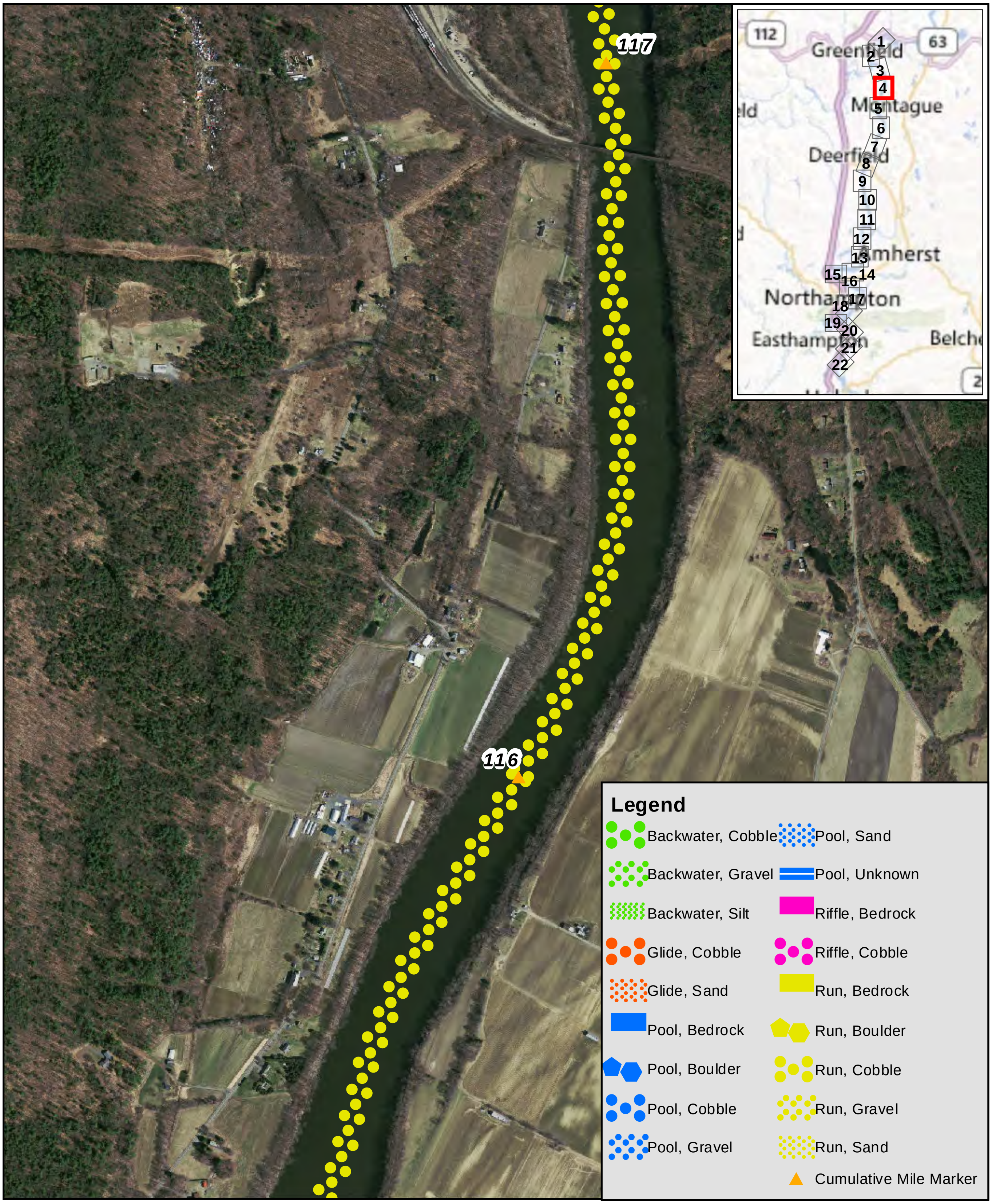

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AQUATIC HABITAT MAPPING STUDY

Downstream Mesohabitat
Linear Habitat Classification

Figure # 4

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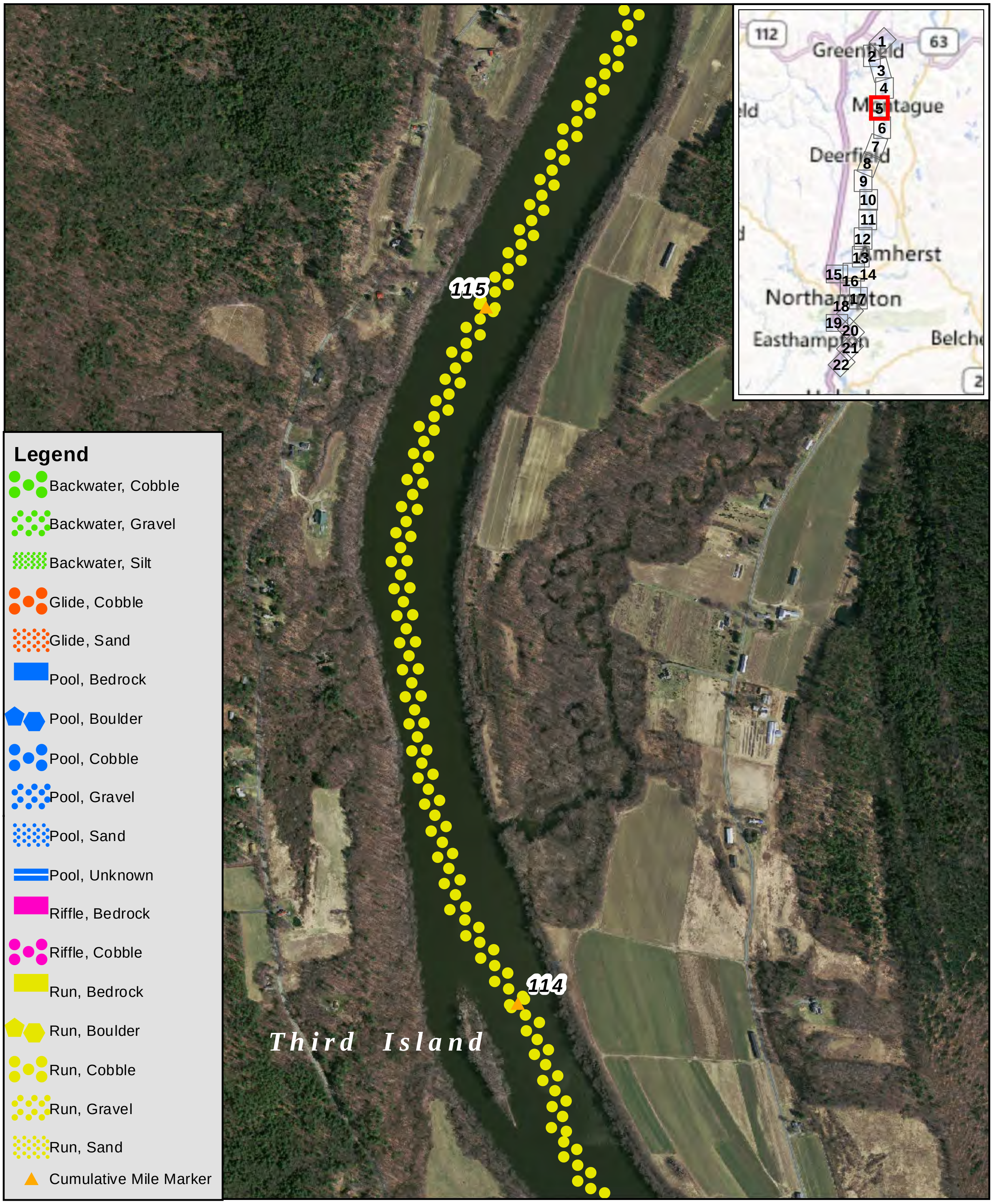

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AQUATIC HABITAT MAPPING STUDY

Downstream Mesohabitat
Linear Habitat Classification

Figure # 5

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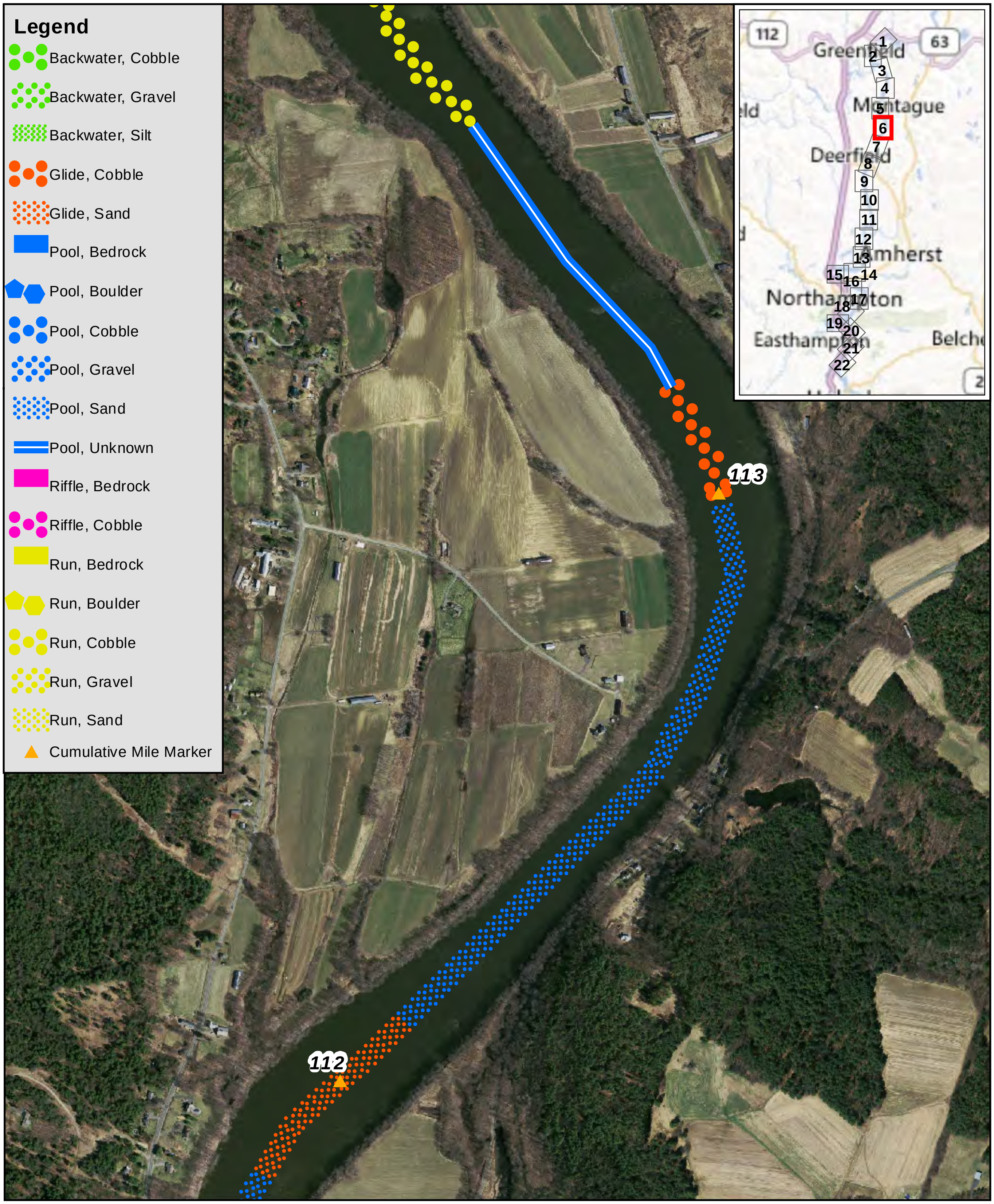

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AQUATIC HABITAT MAPPING STUDY

Downstream Mesohabitat
Linear Habitat Classification

Figure # 6

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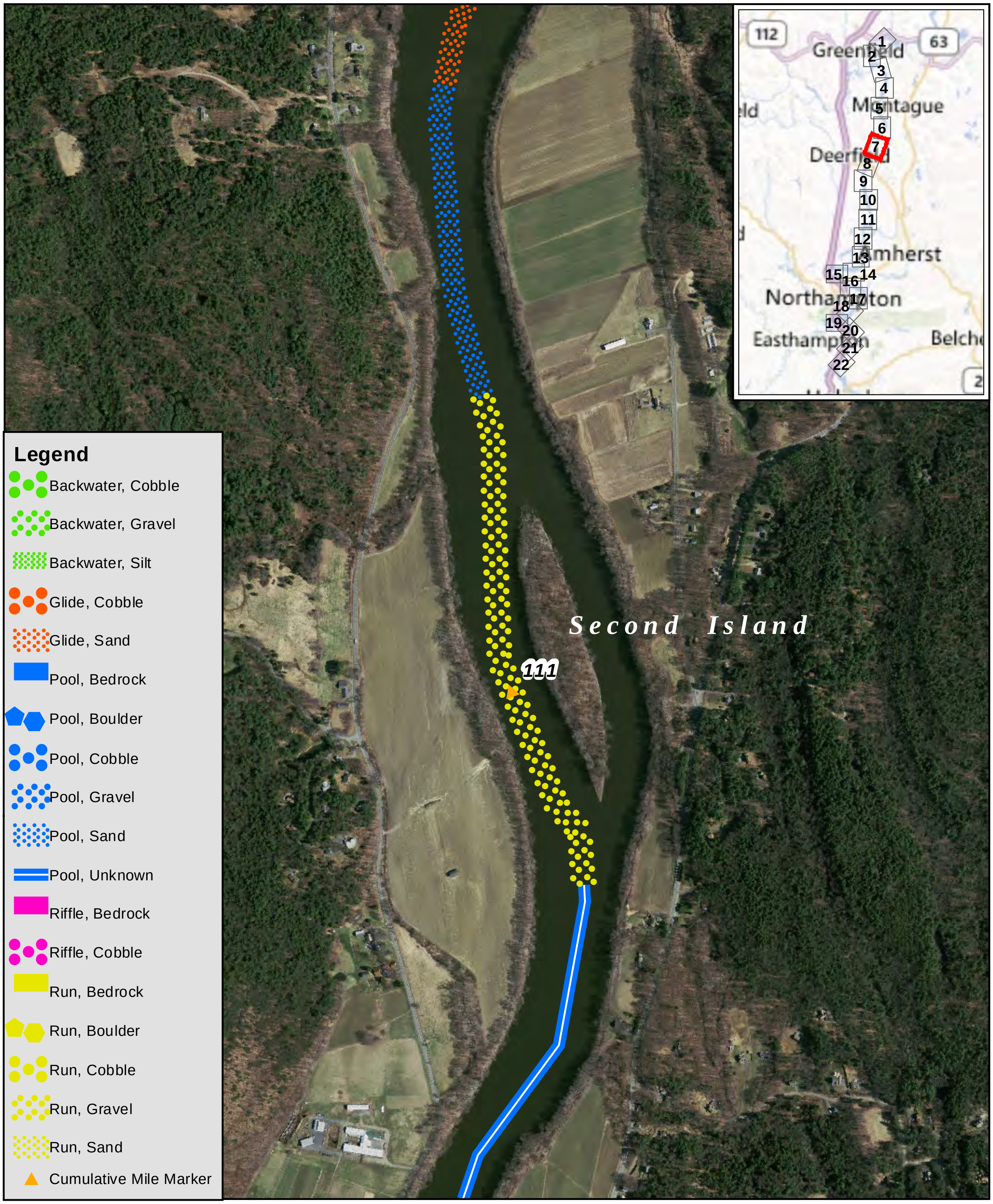

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AQUATIC HABITAT MAPPING STUDY

Downstream Mesohabitat
Linear Habitat Classification

Figure # 7

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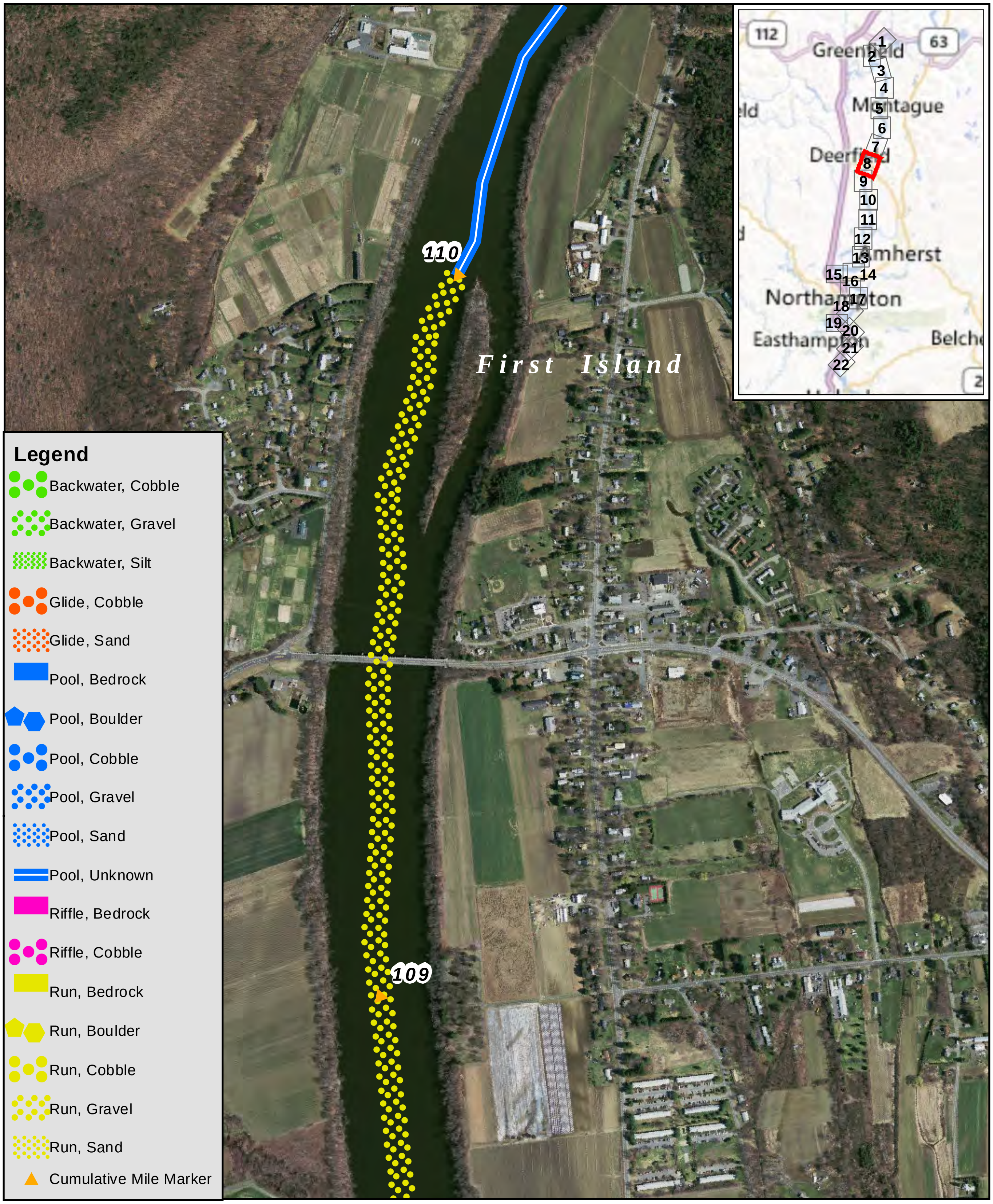

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AQUATIC HABITAT MAPPING STUDY

Downstream Mesohabitat
Linear Habitat Classification

Figure # 8

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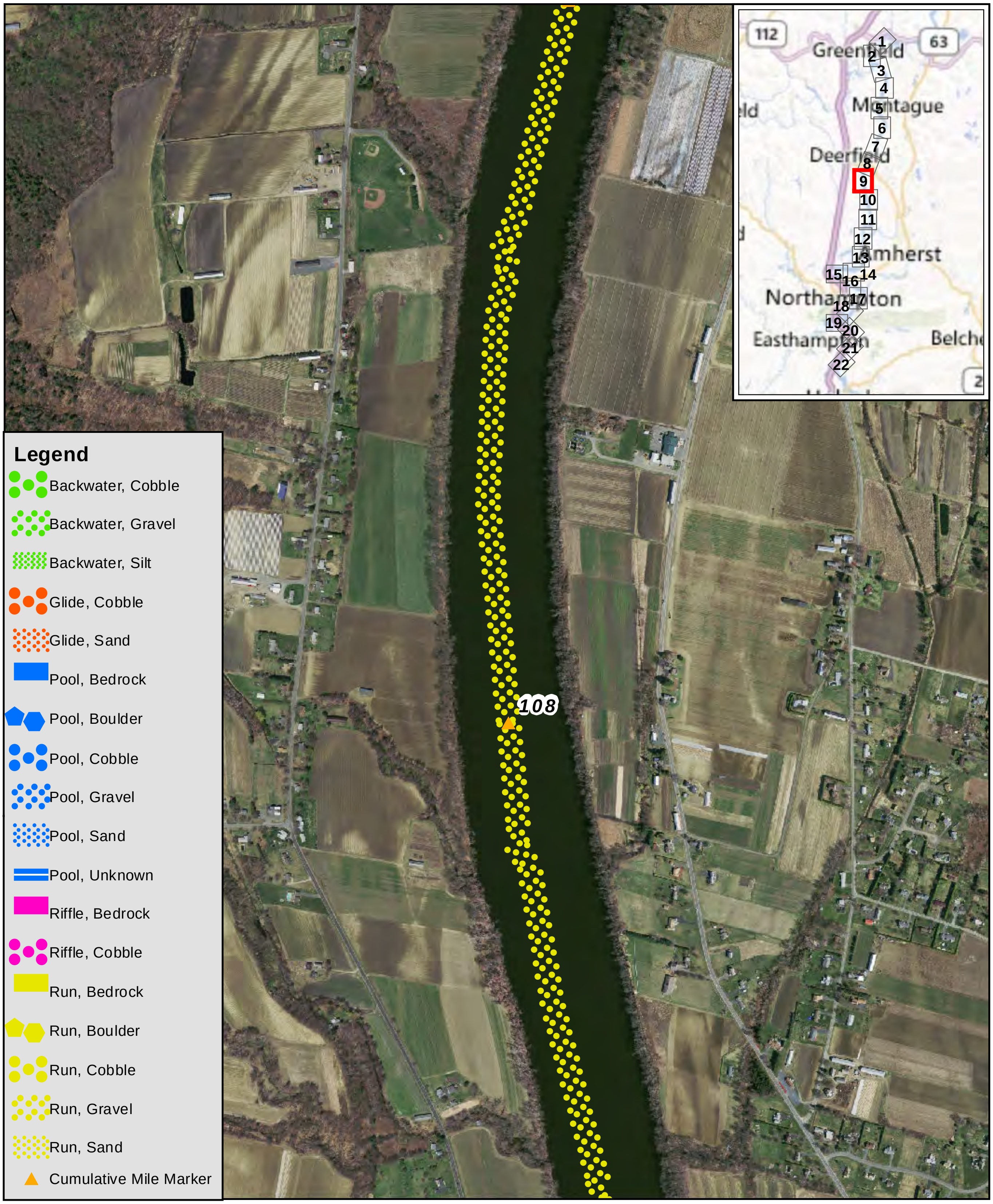

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AQUATIC HABITAT MAPPING STUDY

Downstream Mesohabitat
Linear Habitat Classification

Figure # 9

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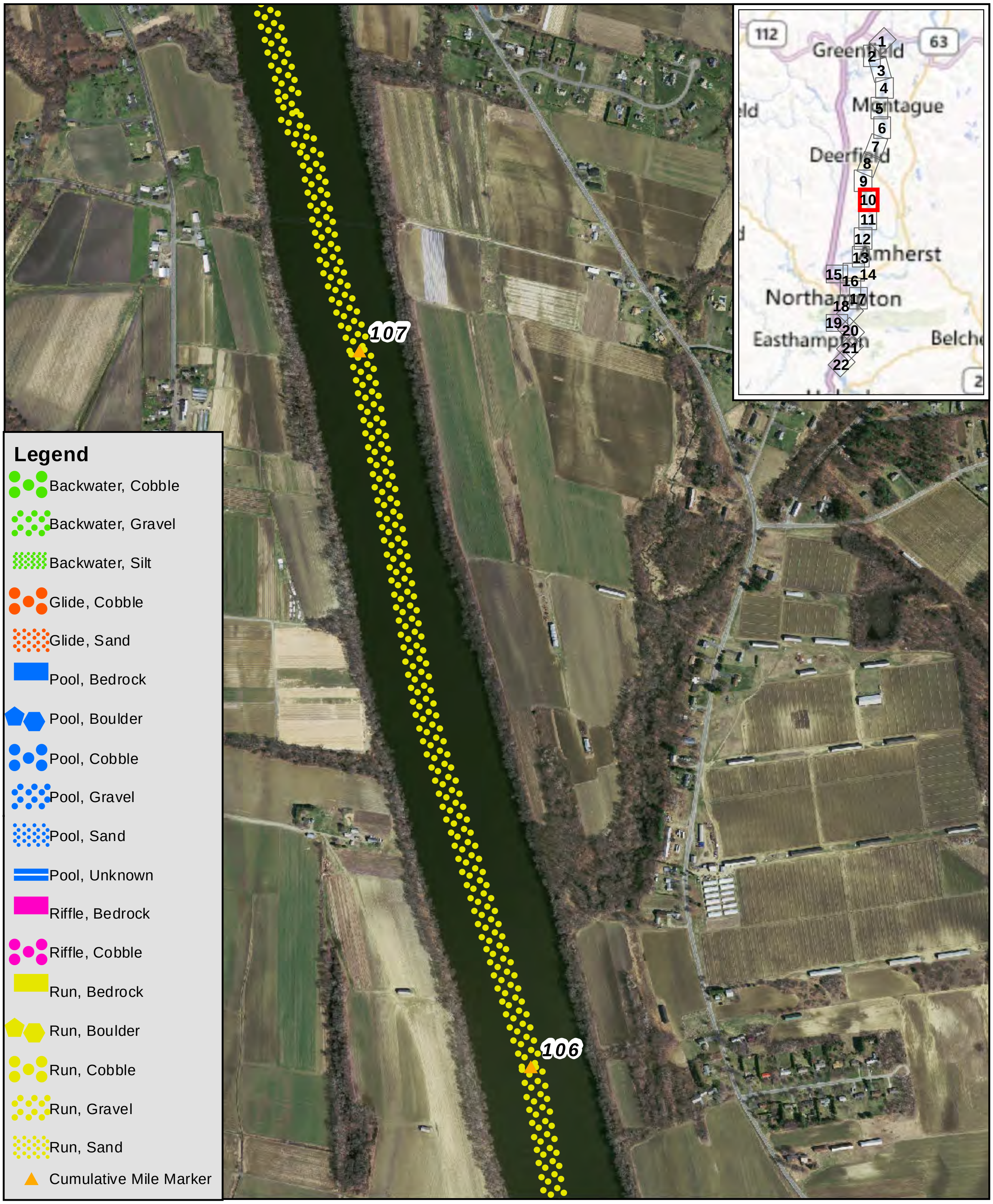

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AQUATIC HABITAT MAPPING STUDY

Downstream Mesohabitat
Linear Habitat Classification

Figure # 10

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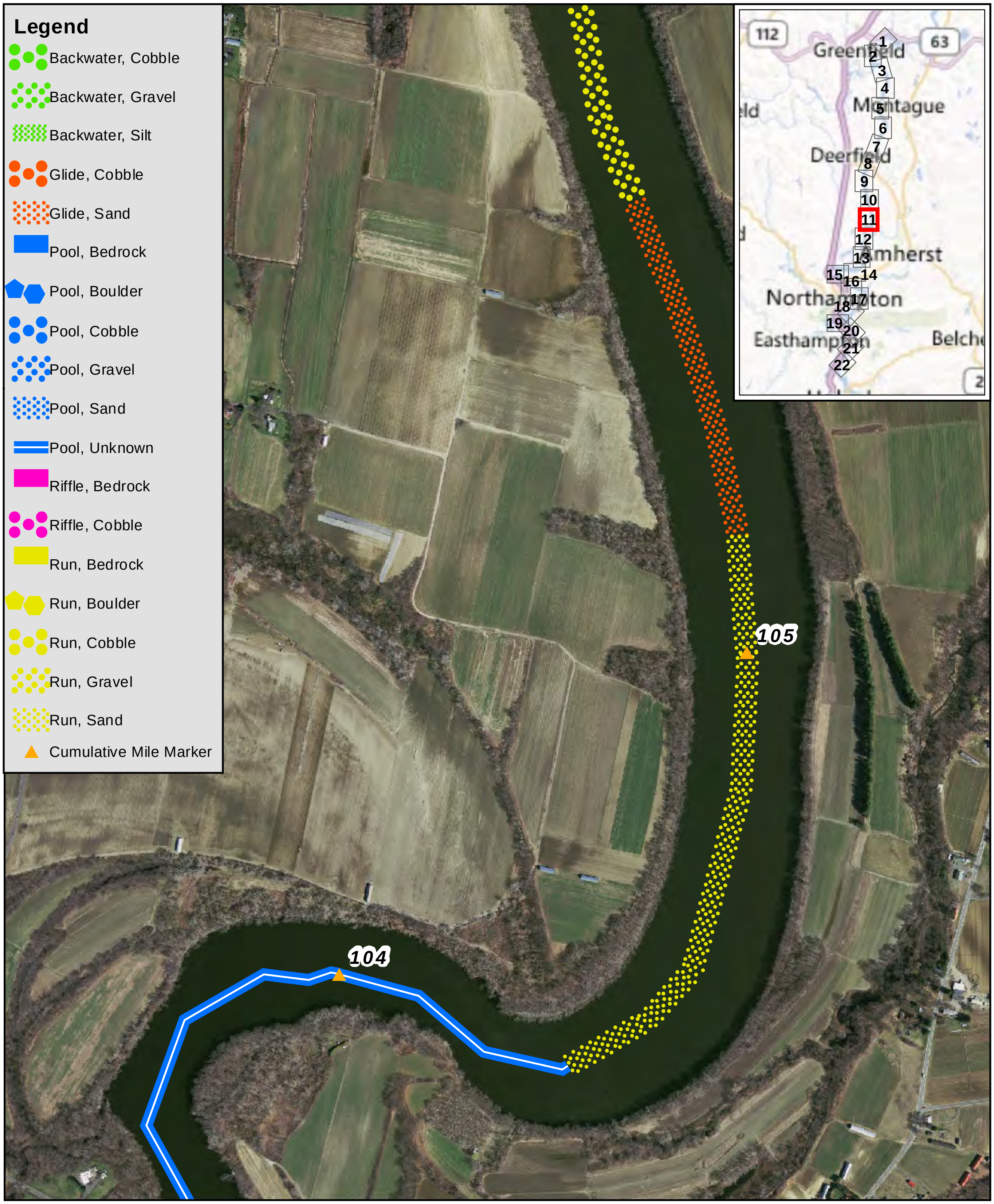

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AQUATIC HABITAT MAPPING STUDY

Downstream Mesohabitat
Linear Habitat Classification

Figure # 11

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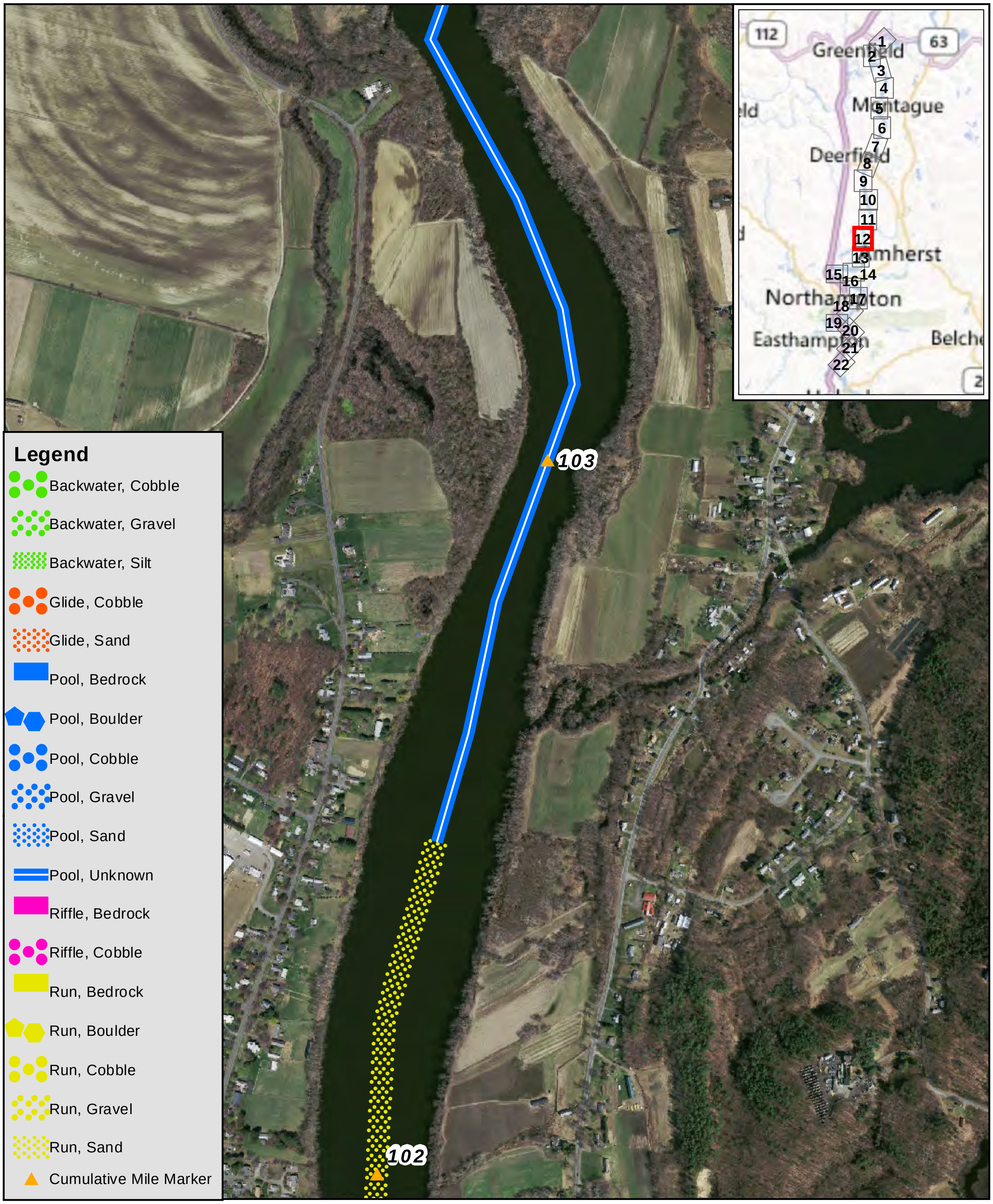

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AQUATIC HABITAT MAPPING STUDY

Downstream Mesohabitat
Linear Habitat Classification

Figure # 12

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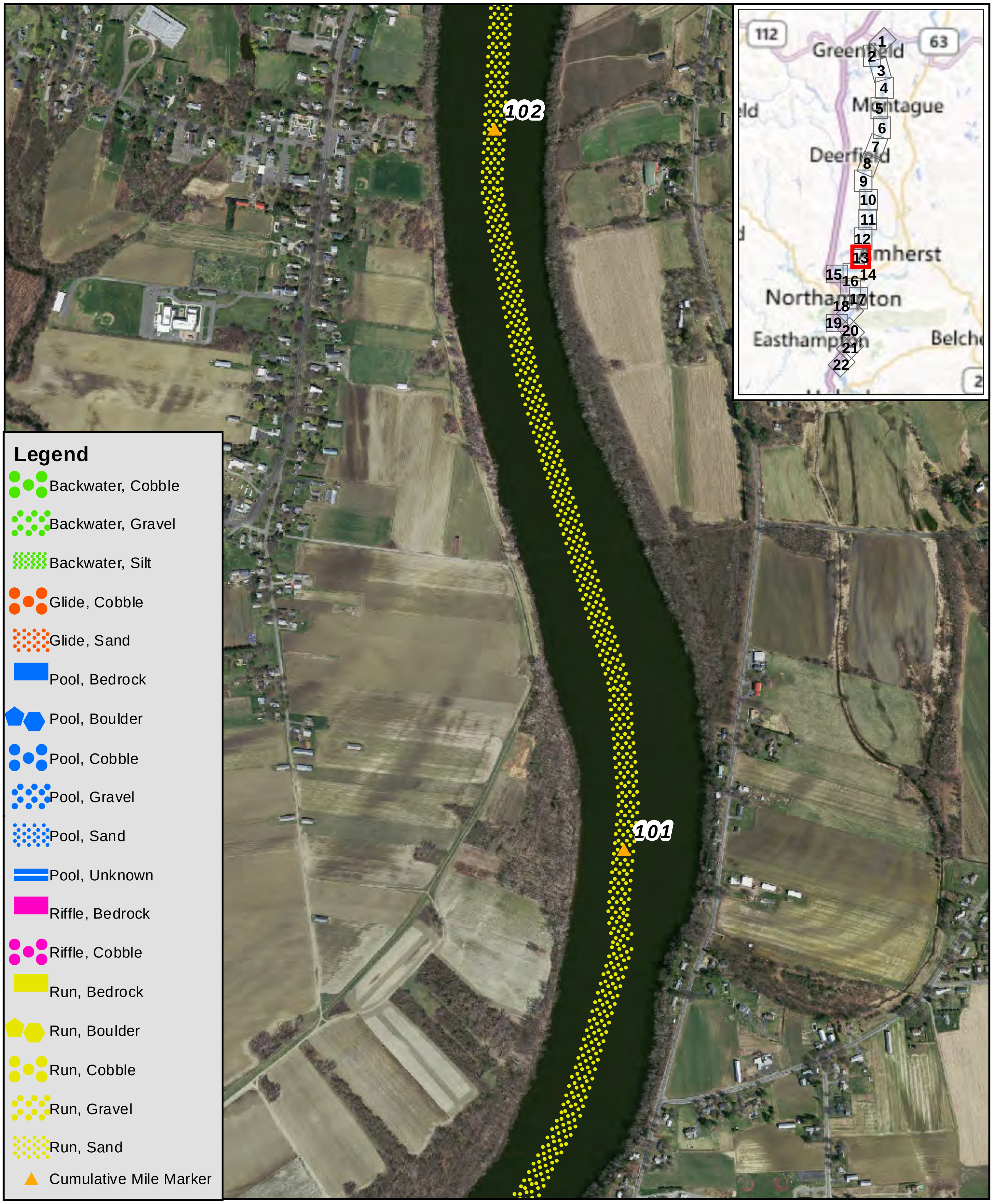

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AQUATIC HABITAT MAPPING STUDY

Downstream Mesohabitat
Linear Habitat Classification

Figure # 13

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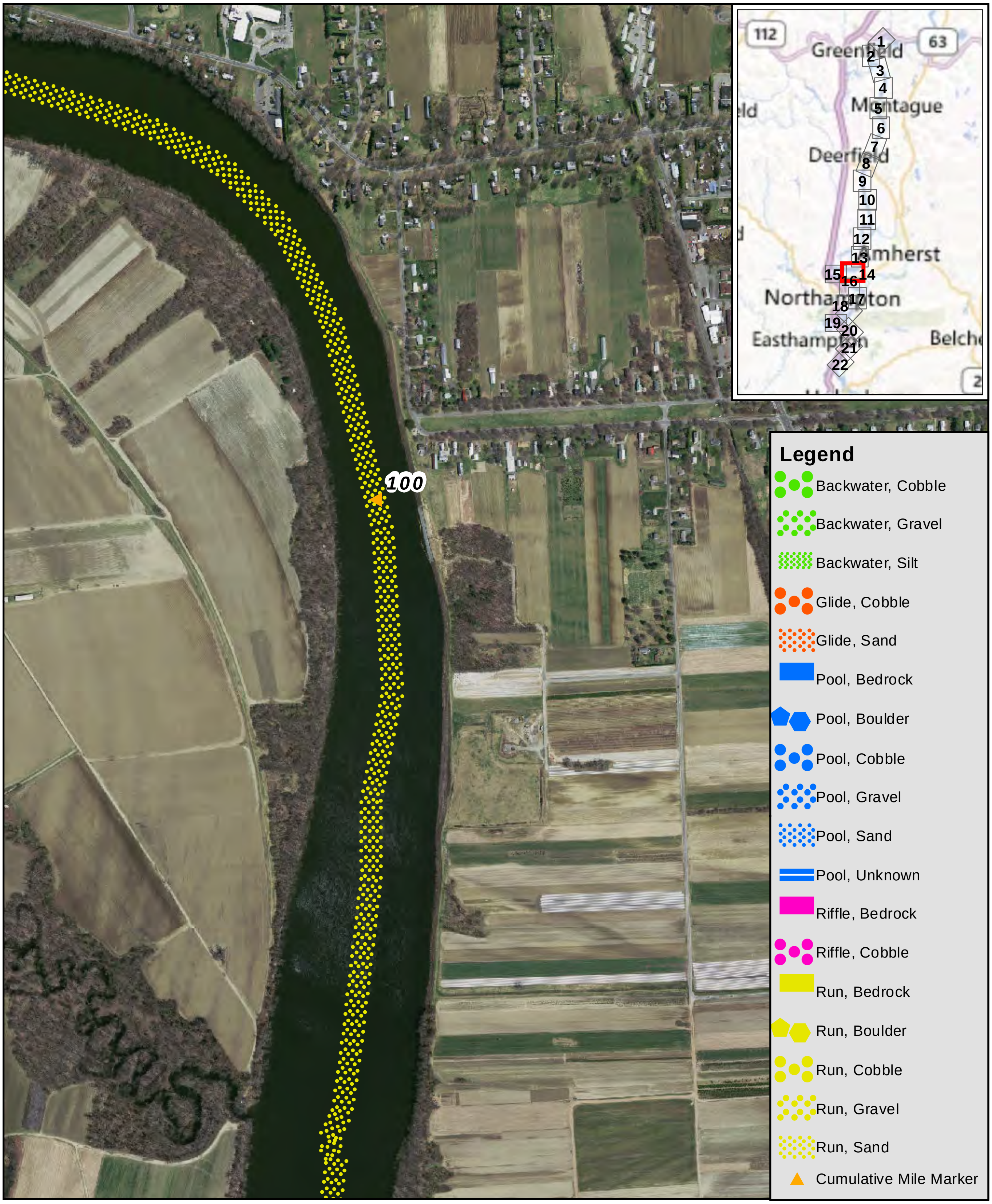

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AQUATIC HABITAT MAPPING STUDY

Downstream Mesohabitat
Linear Habitat Classification

Figure # 14

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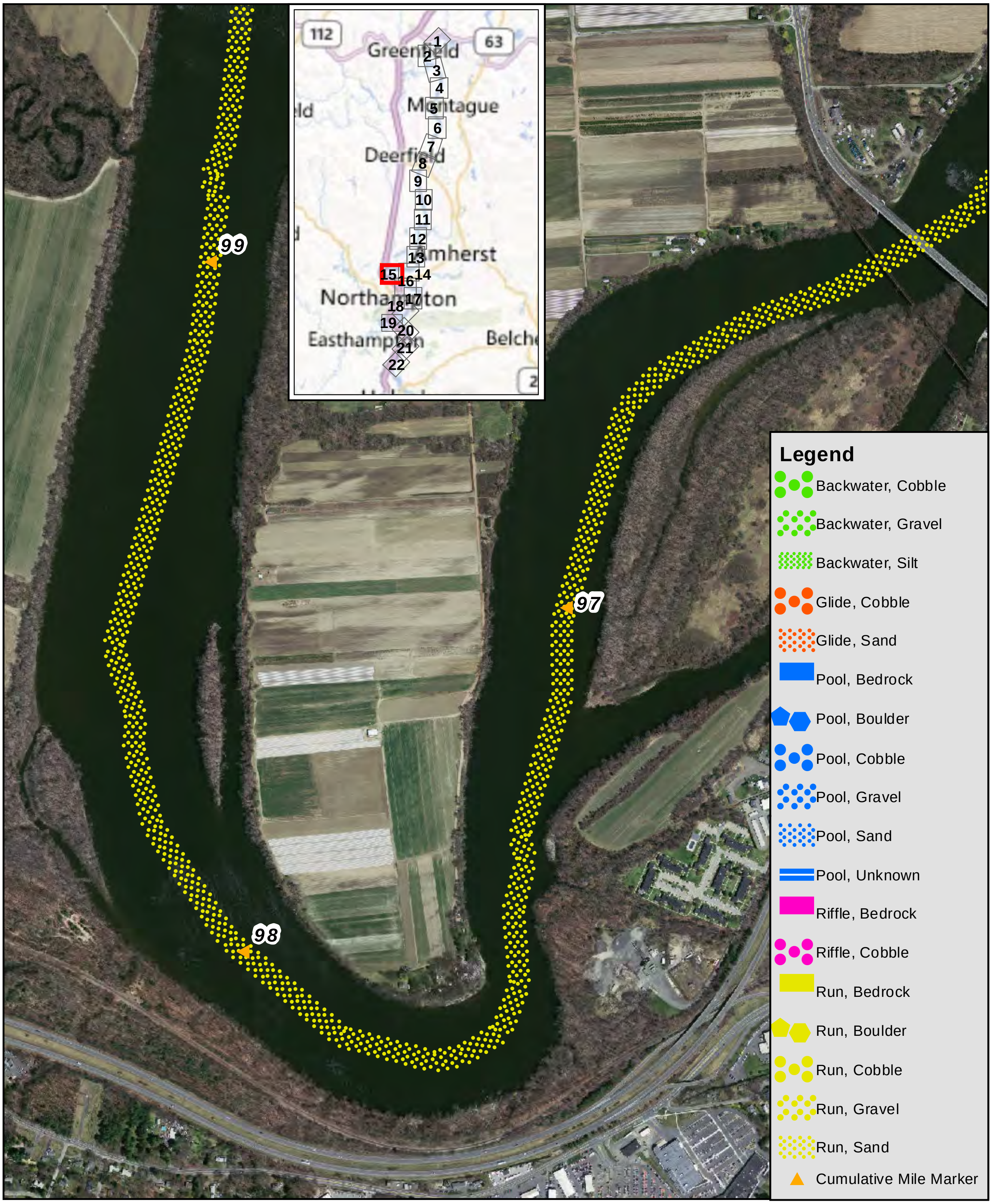

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AQUATIC HABITAT MAPPING STUDY

Downstream Mesohabitat
Linear Habitat Classification

Figure # 15

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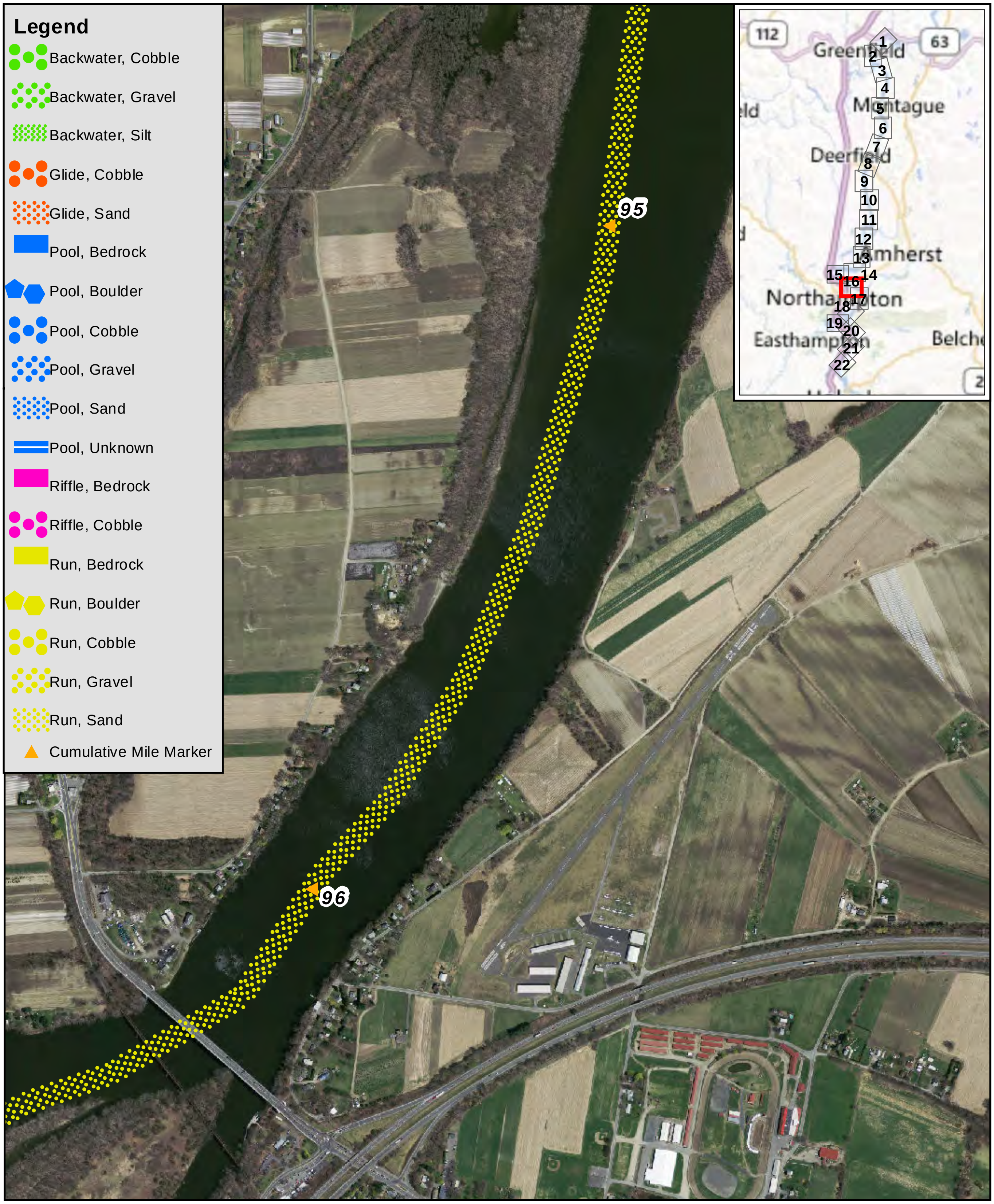

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AQUATIC HABITAT MAPPING STUDY

Downstream Mesohabitat
Linear Habitat Classification

Figure # 16

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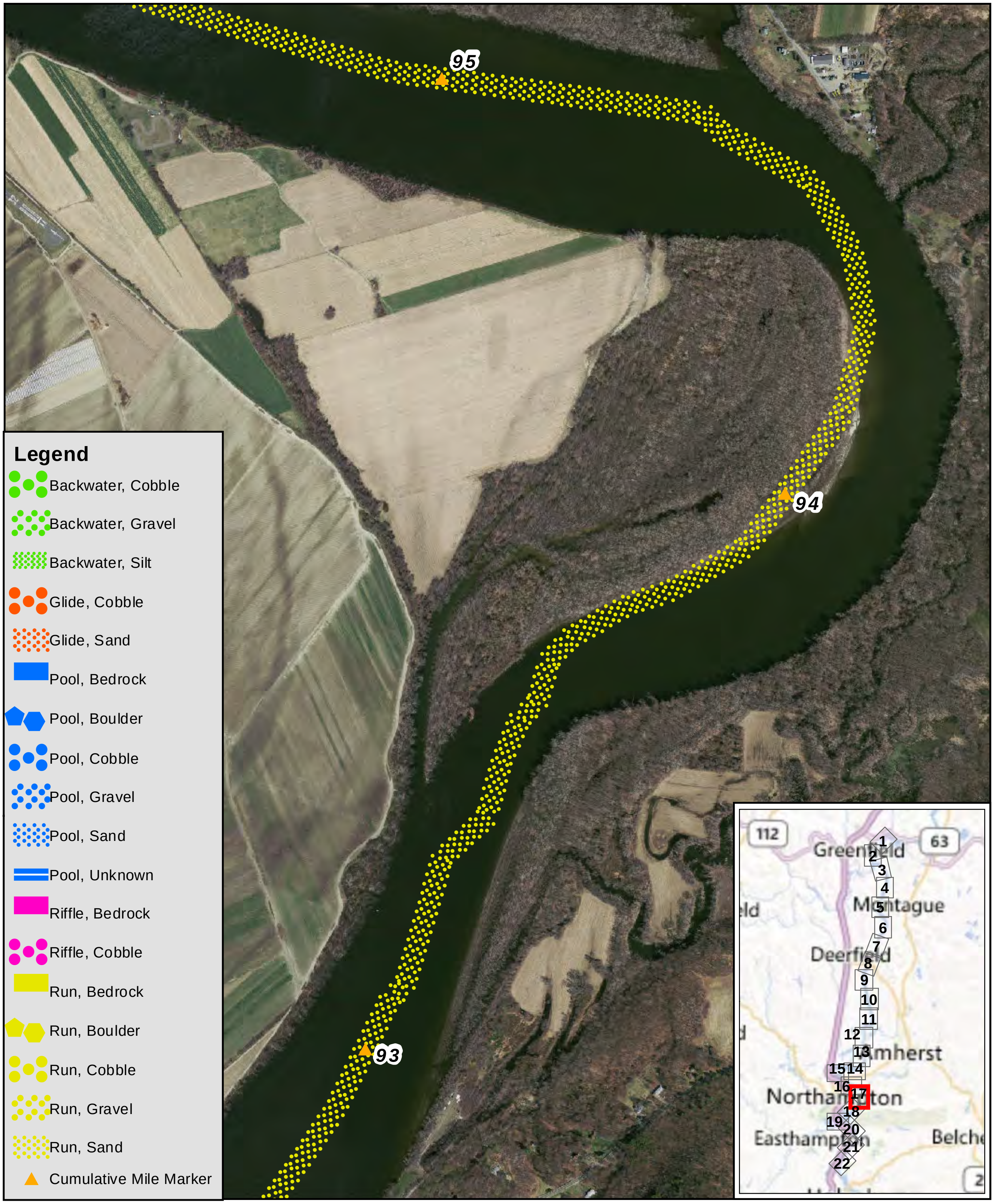

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AQUATIC HABITAT MAPPING STUDY

Downstream Mesohabitat
Linear Habitat Classification

Figure # 17

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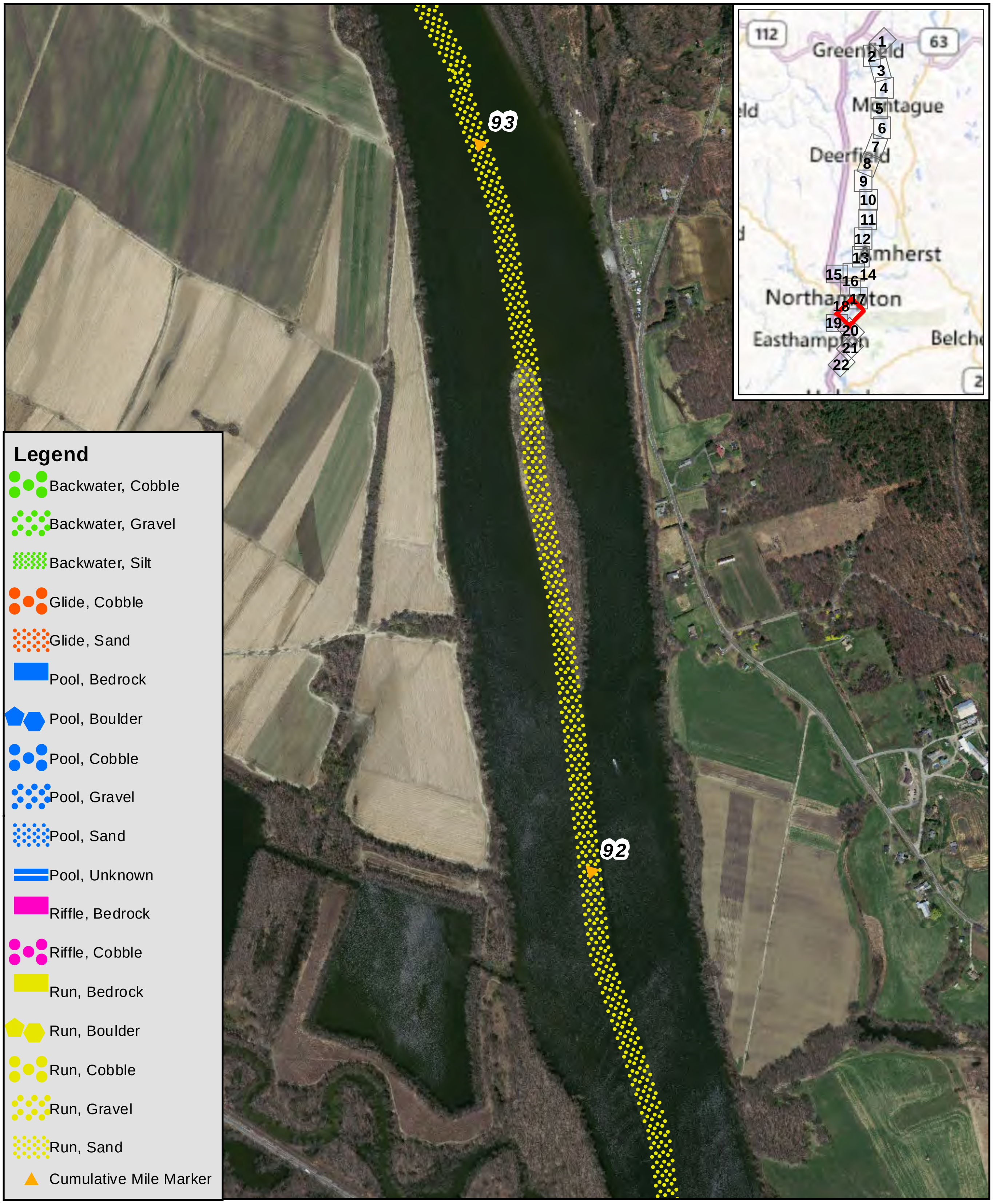

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AQUATIC HABITAT MAPPING STUDY

Downstream Mesohabitat
Linear Habitat Classification

Figure # 18

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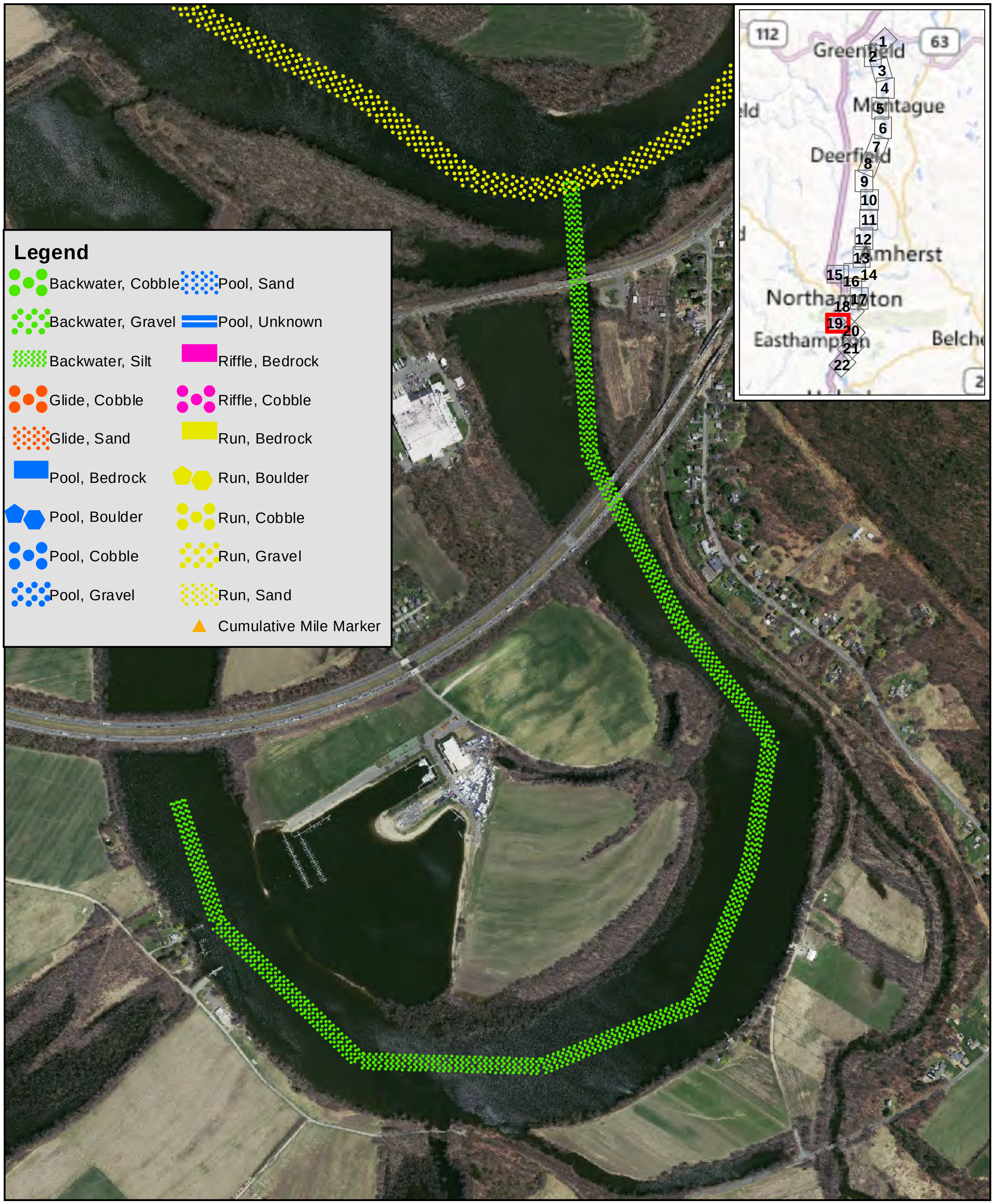

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AQUATIC HABITAT MAPPING STUDY

Downstream Mesohabitat
Linear Habitat Classification

Figure # 19

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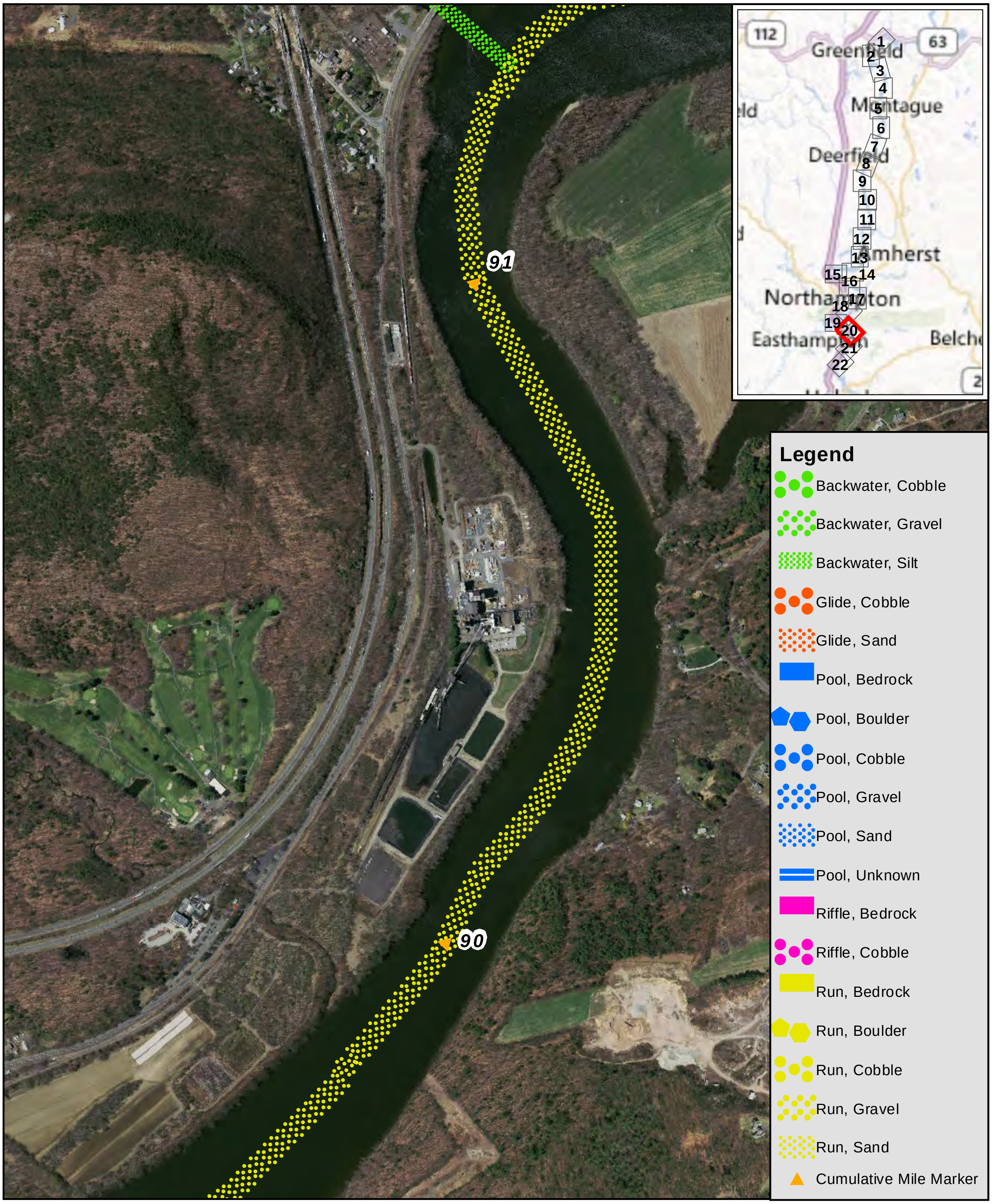

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AQUATIC HABITAT MAPPING STUDY

Downstream Mesohabitat
Linear Habitat Classification

Figure # 20

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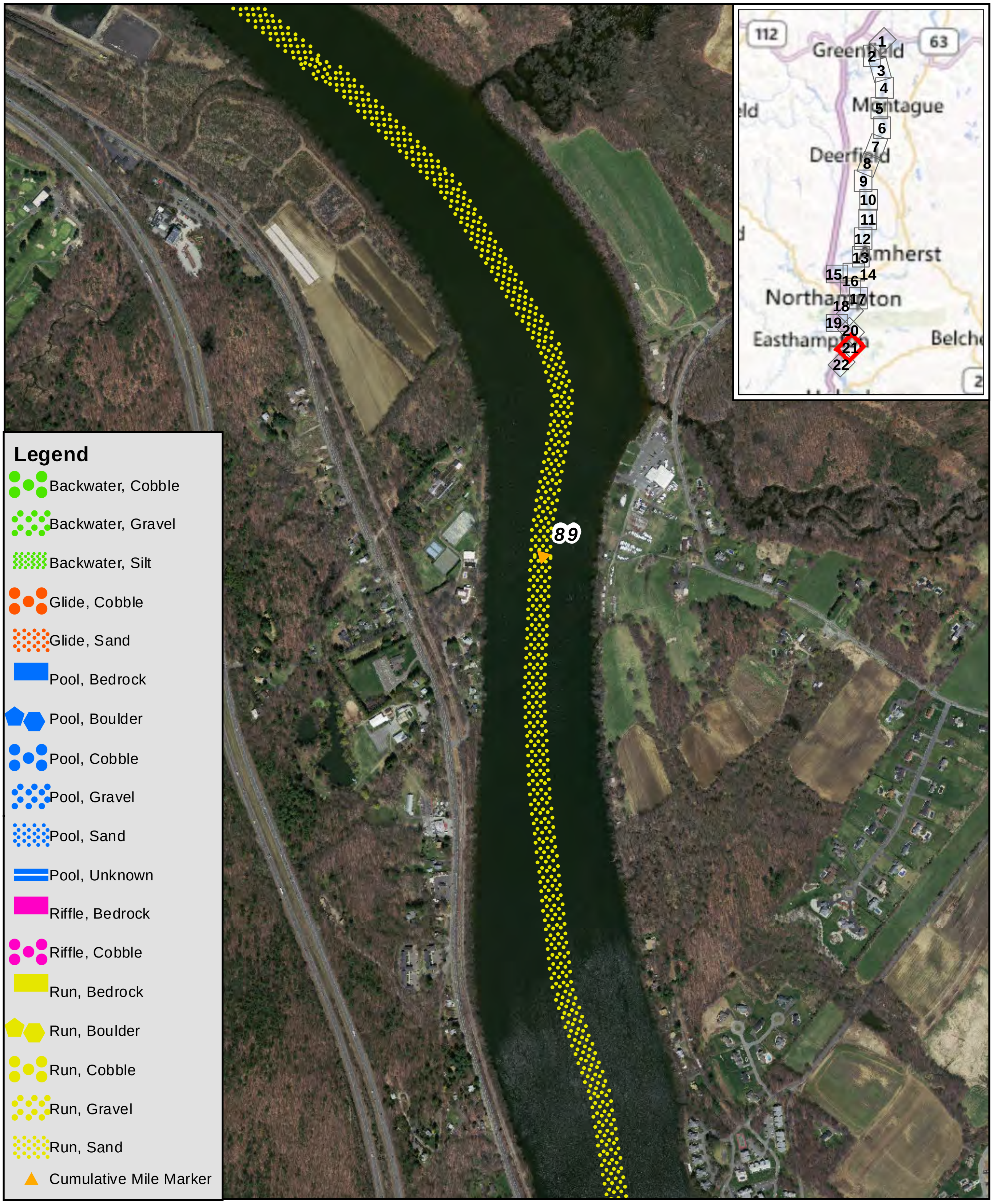

FIRSTLIGHT POWER RESOURCES

AQUATIC HABITAT MAPPING STUDY

Downstream Mesohabitat
Linear Habitat Classification

Figure # 21

FirstLight Power Resources GDF SUEZ

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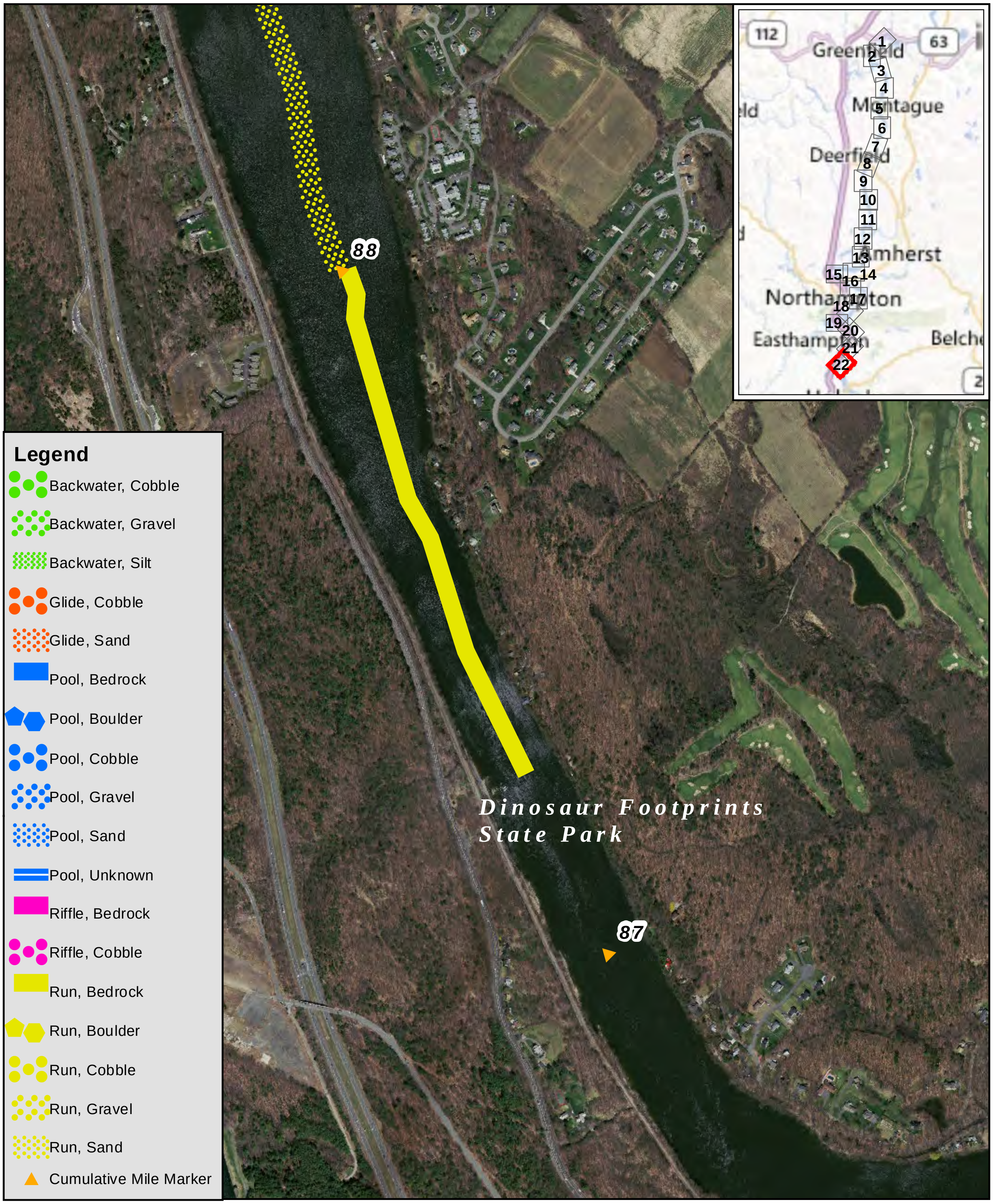

FirstLight Power Resources
GDF SUEZ

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FIRSTLIGHT POWER RESOURCES

AQUATIC HABITAT MAPPING STUDY

Downstream Mesohabitat
Linear Habitat Classification

Figure # 22

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