Rio Grande silvery minnow
Rescue and Salvage – 2009

Prepared For:
Middle Rio Grande Endangered Species Act Collaborative Program

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Executive Summary

This report documents efforts during 2009 to reduce the mortality of post-larval Rio Grande silvery minnow (RGSM, *Hybognathus amarus*) when flow in the Middle Rio Grande became intermittent. In January of 2007, New Mexico Fish and Wildlife Conservation Office (NMFWCO) assumed responsibility for salvage operations for RGSM. Initially, we formulated a new salvage protocol to more effectively manage the salvage activities. This included defining criteria for how and when salvage of RGSM would occur. These criteria were defined using field experience (regarding air temperature and secondary fish health), and review of tolerances of RGSM to environmental variables developed by K. Buhl, USGS Ecotoxicology Research Center in Yankton, South Dakota. Handling and transport protocols initiated in 2007 based on research conducted by Dr. Colleen Caldwell, New Mexico State University, were continued in 2009. Results indicate that efforts undertaken in 2007 improved survival of RGSM that had been subjected to poor habitat and water quality conditions during intermittency and handling during salvage.

Between 16 July and 20 October 2009, a total of 20.0 miles of the main channel of the Middle Rio Grande dried, all in the San Acacia Reach. An estimated total of 18,473 RGSM were salvaged from isolated pools in 2009. Of these, 17,199 were transported and released alive within flowing sections of the San Acacia Reach. The death of 1,694 RGSM was attributed to water operations in the Middle Rio Grande during the 2009 irrigation season and assigned as incidental take. This level of observed incidental take was well below the limits established under the amended Biological Opinion of 22,242 individuals. The death of 1,646 RGSM was attributed to U.S. Fish and Wildlife Service permit activities.

Introduction

Until the 1950s, RGSM was distributed throughout many of the larger order streams of the Rio Grande Basin upstream of Brownsville, Texas to points in northern New Mexico primarily below 5,500 ft elevation (1,676 m). This elevation coincides with the approximate vicinities of Abiquiu on the Chama River, Velarde on the Rio Grande, and Santa Rosa on the Pecos River. Today, absent from much of its historic range, RGSM is restricted to a variably perennial reach of the Rio Grande in New Mexico, from the vicinity of Algodones downstream to the headwaters of Elephant Butte Reservoir, a distance that fluctuates as the size of the pool of water in storage in Elephant Butte Reservoir changes, but is approximately 150 river miles (241 km).

RGSM is currently listed as endangered by the State of New Mexico, having first been listed May 25, 1979 as an endangered endemic population of the Mississippi silvery minnow (*Hybognathus nuchalis*; New Mexico Department of Game and Fish, 1988). The species is also listed as endangered by the State of Texas (Sections 65.171 - 65.184 of Title 31 T.A.C.) and the Republic of Mexico (Secretaria de Desarrollo Social, 1994). On July 20, 1994, the U. S. Fish and Wildlife Service (Service) published a final rule to list RGSM as a Federal endangered species with proposed critical habitat. In 2003, the Service designated critical habitat for RGSM in the Middle Rio Grande. The critical habitat designation extends from Cochiti Dam downstream about 157 mi (252 km) to the utility line crossing the Rio Grande in Socorro County. This location is at 4,450 feet of elevation (1,356 m), corresponding to the elevation of the spillway crest for Elephant Butte Dam. The lateral limits (width) of critical habitat extend between the existing levees or, in areas without levees, the riparian zone, extending 300 feet (91.4 m) laterally from each side of the bankfull stage of the Middle Rio Grande. Portions of the Pueblos of Santo Domingo, Santa Ana, Sandia, and Isleta fall within the broader area designated as critical habitat, but the Pueblos are specifically excluded from the critical habitat designation.

Every year since 2001, with the exception of 2008, salvage activities have been conducted on intermittent sections of the Rio Grande for RGSM (Smith 2001, Smith and Munoz 2002, Smith and Basham 2003, US Fish and Wildlife 2005b, 2006b, Remshardt 2008). These activities have been conducted under a variety of protocols and management actions. On March 17, 2003, the Service issued a Biological Opinion on the effects of actions associated with the, "Programmatic Biological Assessment of Bureau of Reclamation's Water and River Maintenance Operations, Army Corps of Engineers' Flood Control Operation, and Related Non-Federal Actions on the Middle Rio Grande, New Mexico," (U.S. Fish and Wildlife Service, 2003). The consultation involved two federal agencies, U. S. Bureau of Reclamation and the Army Corps of Engineers, and two non-federal entities. The Service concluded that water operations and river maintenance activities in the Middle Rio Grande, as proposed (Reclamation and Corps, 2003), were likely to jeopardize the continued existence of RGSM along with the southwestern willow flycatcher (*Empidonax traillii extimus*; flycatcher) and adversely modify critical habitat of RGSM (U.S. Fish and Wildlife Service, 2003). The March 17, 2003 BO describes a Reasonable and Prudent Alternative, Reasonable and Prudent Measures, and Conservation Measures that serve in part to secure baseline conditions for RGSM and flycatcher. As part of the March 17, 2003 BO, the Service established the annual incidental take limit for RGSM for water operations in the Middle Rio Grande. That limit was amended in 2005(U.S. Fish and Wildlife Service, 2005a) and again on June 15, 2006 (U.S. Fish and Wildlife Service, 2006a) incorporating a formula that includes October standard monitoring data, habitat conditions during the spawn (spring runoff), and

augmentation. Action agencies are apprised of the limit for incidental take by April 1 each year. Estimates of incidental take in the field are derived from surveys in which observed mortality is multiplied by 50, based on the assumption that the probability of observing a single mortality is 0.02. This value was an estimated value determined by USFWS Biologists. The August 15, 2005 amendment also specified that the incidental take statement applies to RGSM greater than 30 mm standard length. The amended incidental take limit for the 2009 irrigation season was 3,624,985 and is equivalent to 72,500 RGSM that are observed dead. This report documents efforts during 2009 to reduce the mortality of post-larval RGSM when flow in the Middle Rio Grande became intermittent.

Methods

The Middle Rio Grande below Cochiti Dam is designated by four divisions/reaches defined by locations of mainstream irrigation diversion dams. The Cochiti Reach extends from Cochiti Dam to Angostura Diversion Dam. The reach from Angostura Diversion Dam to Isleta Diversion Dam is called the Angostura Reach. The Isleta Reach is bounded upstream by Isleta Diversion Dam and downstream by San Acacia Diversion Dam. Finally, the reach below San Acacia Diversion Dam to the headwaters of Elephant Butte Reservoir is the San Acacia Reach.

Determination of Incidental Take

RGSM mortality can occur with channel drying resulting from excessive drought conditions, and conditions resulting from federal mediated water operations. In the recent past, intermittent conditions have existed in significant portions (e.g., up to 68.0 miles – approximately 45 percent of the RGSM's contemporary range) of the river between Isleta Diversion Dam and Elephant Butte Reservoir. Efforts to salvage RGSM from intermittent reaches of river are intended to reduce RGSM mortality that occurs with channel drying resulting from water operations and drought conditions. In addition, salvage is meant to reduce the probability that mortality associated with water operations will exceed the limit for incidental take.

RGSM rescue operations progressed in synchrony with river recession, with priority given to river reaches in which the death of RGSM due to federal water operations would result in incidental take. Drying due to federal water operations might include but is not limited to changes in diversion rate, while drying that follows a rewetting event caused by rainstorms would not necessarily be defined as due to federal water operations. Incidental take of post embryonic RGSM is defined for two size classes, i.e., for those shorter than or equal to 30 mm SL and those longer than 30 mm SL. All smaller sized post embryonic RGSM ($\leq$ 30 mm SL) are presumed to be taken as a result of federal water operations when the river dries downstream of Isleta Diversion (U. S. Fish and Wildlife Service, 2003), but no limit on the amount of incidental take is calculated.

Determination of incidental take of the larger size class of post embryonic RGSM (> 30 mm SL) was conditional. Mortality of the larger sized post embryonic RGSM that occurs in portions of the river that are rewetted due to forces that are not directly or indirectly related to the operations of the Action Agencies was not considered to be incidental take under the March 17, 2003 BO (U. S. Fish and Wildlife Service, 2003). In contrast, rewetting and subsequent re-drying of river reaches that were previously dried in violation of the BO and was directly or indirectly related to the operations of the Action Agencies was regarded as incidental take. RGSM mortality,

involving the larger sized individuals, that occurred outside of the active river channel was generally not considered to be incidental take under the March 17, 2003 BO (U. S. Fish and Wildlife Service, 2003); the exception to this generalization involves areas outside of the active channel that are wetted as a consequence of federal water pumping operations (i.e., water pumped from the low flow conveyance channel in an effort to maintain specified flows in the river) or river maintenance activities. Finally, the larger sized RGSM that are "rescued" and that die in transit to relocation sites were not considered to be incidental take. Likewise RGSM that exhibited advanced clinical signs of poor health were deemed not salvageable and also (e.g., lethargy and hemorrhagic lesions) were not considered incidental take.

Rescue of RGSM

Transport tanks equipped with water-tight lids were filled with water to near capacity with water from flowing sections prior to the day's salvage. Salt (NaCl) was added to water in hauling vessels at the rate of 1.2 % NaCl solution, and Stress Coat was added at the rate of 0.26 ml/liter (1 ml/gallon) (Appendix A).

Using seines of various sizes, fish were collected from isolated pools that formed as flow in the Middle Rio Grande becomes discontinuous. Prior to handling RGSM, personnel washed their hands to remove the residue of lotions (e.g., suntan lotions and mosquito repellant). Fish were handled with care using wetted hands. RGSM that exhibited advanced clinical signs of poor health (e.g., lethargy and hemorrhagic lesions) were not salvaged. Salvaged RGSM were immediately placed into five-gallon buckets filled with transport tank water and subsequently transferred to 30-gallon transport tanks attached to utility terrain vehicles.

Pure oxygen was supplied to transport tanks through micro-bubble oxygen diffusers. Flow of oxygen was adjusted with varying water temperatures and loading rates of fish to maintain dissolved oxygen levels at or above 100% saturation. Rescued RGSM were transported to the nearest section of perennial flow within their reach of origin and released to the river. Prior to releasing RGSM into the river, water in the transport tanks was tempered (by slowly adding river water to the transport tanks) until it was within 1° C of the water temperature of the river at the release site. Daily counts of salvaged RGSM rescued were made. Other species of fishes encountered while salvaging RGSM were returned to isolated pools.

Once a location was identified as a potential salvage site, a set of primary and secondary biological criteria were applied to determine whether salvage should occur. These criteria were defined using field experience (water quality parameters) and tolerance limits of RGSM to environmental variables (secondary water quality, K. Buhl, unpublished data). Documentation of conditions, incidental take (if appropriate), and preservation of individuals followed.

Criteria for Salvaging

Primary (Water Quality)	1. Water temperature < 34°C 2. Dissolved Oxygen > 2.0 mg/liter 3. pH < 9.0
Secondary (Fish Health)	1. No Dead fish (any species) in pool 2. No lethargy and/or hemorrhagic lesions noticed from fish (any species) in pool

In the instances where salvage was deemed necessary and feasible, every effort was made to ensure that any fish to be moved had the highest probability of survival.

Monitoring Activities

During salvage, a variety of data were collected to document the conditions at the pools, including those data necessary to determine whether or not salvage would occur. These parameters included estimated size of pool, species composition, water quality parameters, documentation of FWS permit take, and the presence of VIE-marked hatchery fish. These activities included the documentation and preservation of mortalities and/or salvaged when these pools otherwise met the criteria. Preserved specimens were returned to the lab for verification. Preserved specimens were processed similar to methods described for enumeration of incidental take.

Results

Documentation of Incidental Take of RGSM

Incidental take of RGSM (larger than 30 mm SL) that occurred as a result of water operations in the Middle Rio Grande was documented and evaluated under limitations established in the March 17, 2003 BO (U. S. Fish and Wildlife Service, 2003) and as determined on April 22, 2009 (U. S. Fish and Wildlife Service, 2009). Channel drying resulted in the incidental take of 1,694 RGSM (Figure 1; Tables 1,2,3). This level of incidental take was below the limit established in 2009 irrigation season.

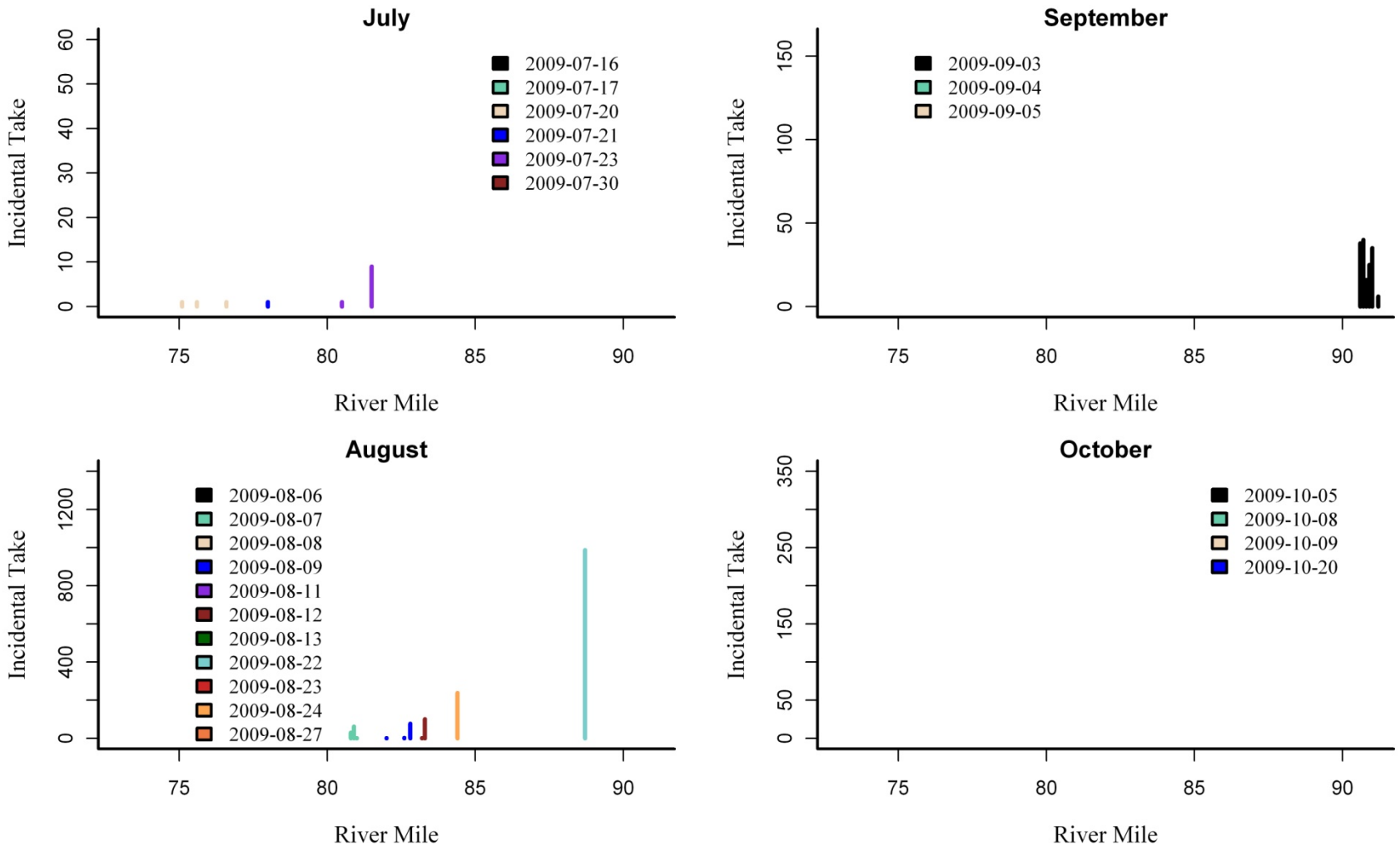

Figure 1. Incidental take of Rio Grande silvery minnow by date and river mile.

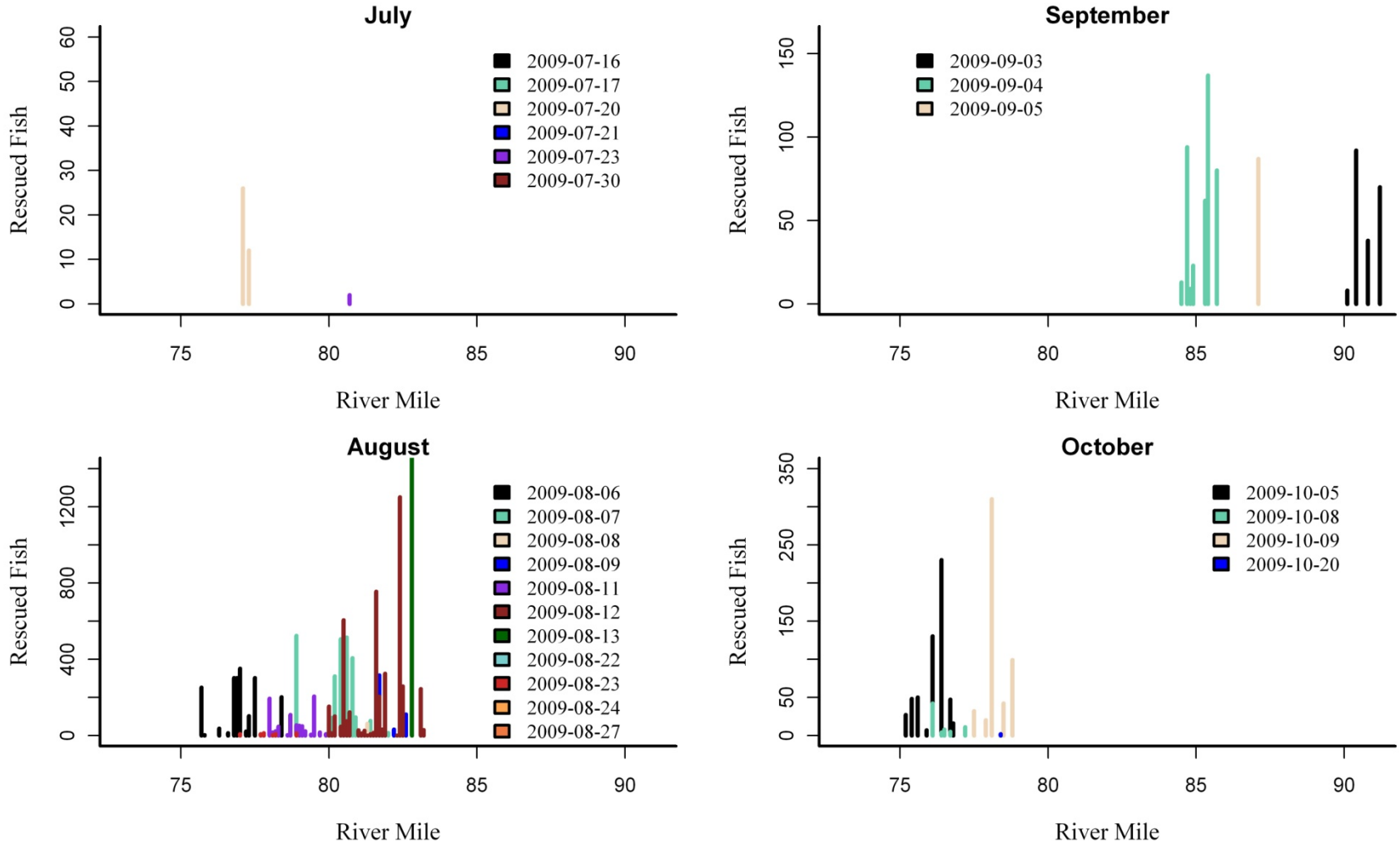

Figure 2. Total Rio Grande silvery minnows rescued by date and river mile.

Rescue of Rio Grande silvery minnow

RGSM rescue operations generally progressed in synchrony with river recession over the course of the 2009 irrigation season in main channel habitats. Ultimately, 20.0 miles of the main channel of the Middle Rio Grande were dried, all in the San Acacia Reach (Figures 5 through 22). The Isleta Reach remained continuous throughout irrigation. Discontinuous main channel segments of the San Acacia Reach of the Middle Rio Grande occurred between Neil Cupp's and the south boundary of Bosque Del Apache Wildlife Refuge during the 2009 irrigation season.

Rescue operations were conducted 24 days during the 2009 irrigation season. Rescue operations were restricted to main channel pools during the period of 16 July 2009 to 20 October 2009 (Figure 1), though many subsections re-wetted and were subsequently re-salvaged. In total, 65.0 river miles were salvaged in the San Acacia reach from July to October (Table 4).

A total of 18,473 RGSM was captured in isolated pools within the river. Of these 17,199 were transported to flowing sections within the same reach and released alive (Figure 2). In 2009, the release location was approximately 1 mile downstream of San Acacia Diversion Dam. The average daily longitudinal extent of aquatic habitat involved in rescue operations per day was at or below the 8.0 miles/day rate allowed in the March 17, 2003 BO; U. S. Fish and Wildlife Service, 2003), as modified on June 15, 2006 (U. S. Fish and Wildlife Service, 2006a).

All RGSM were captured in the San Acacia Reach. This relates to an estimated 860 salvaged RGSM/ river mile dried. This number is over a tenfold increase from that recorded in the last year of salvage for this reach in 2007. Age 0 fish (> 30 mm SL) represented the majority (92%) of salvaged fish in the San Acacia Reach, but were primarily observed after the August 8, 2009. This date is similar to salvage data for Age 0 fish in 2007. Age 1 fish were observed during the entire salvage season. The reality is that many fish in the San Acacia Reach likely perished when drying occurred during July before reaching the minimum size of 30 mm SL to be considered for salvage or counted towards incidental take.

Monitoring Activities

A total of 259 unique pools were surveyed at least one time, with a sum of 523 pool surveys. Of the isolated pools, 411 (78.6%) were actively sampled to salvage RGSM and 112 were not salvaged. Mean size of isolated pools was 226 m^2 (Min. 0.1 m^2, Max. 10,000 m^2). Mean dissolved oxygen in isolated pools was 6.5 mg/liter (Min. 0.5 mg/liter, Max. 15.5 mg/liter). Of the 112 pools not salvaged, 21 (19%) failed for not meeting the criterion for dissolved oxygen (> 2.0 mg/liter), and nine (8%) failed for not meeting the criterion for temperature (<34.0° C). Variation in dissolved oxygen in isolated pools was predictable and proportion to the logarithm of estimated size of isolated pool (Figure 3, $F_{1,440} = 5.082$, $P = 0.025$). Low critical levels of dissolved oxygen were rarely observed and these instances were all in pools less than 400 m^2. Mean water temperature of isolated pools was 23.6 ° C (Min. 8.0, Max. 36.7). Mean water temperature of isolated pools decreased over the course of the irrigation season. Critical values were exceeded rarely and only before 1 September (Figure 4).

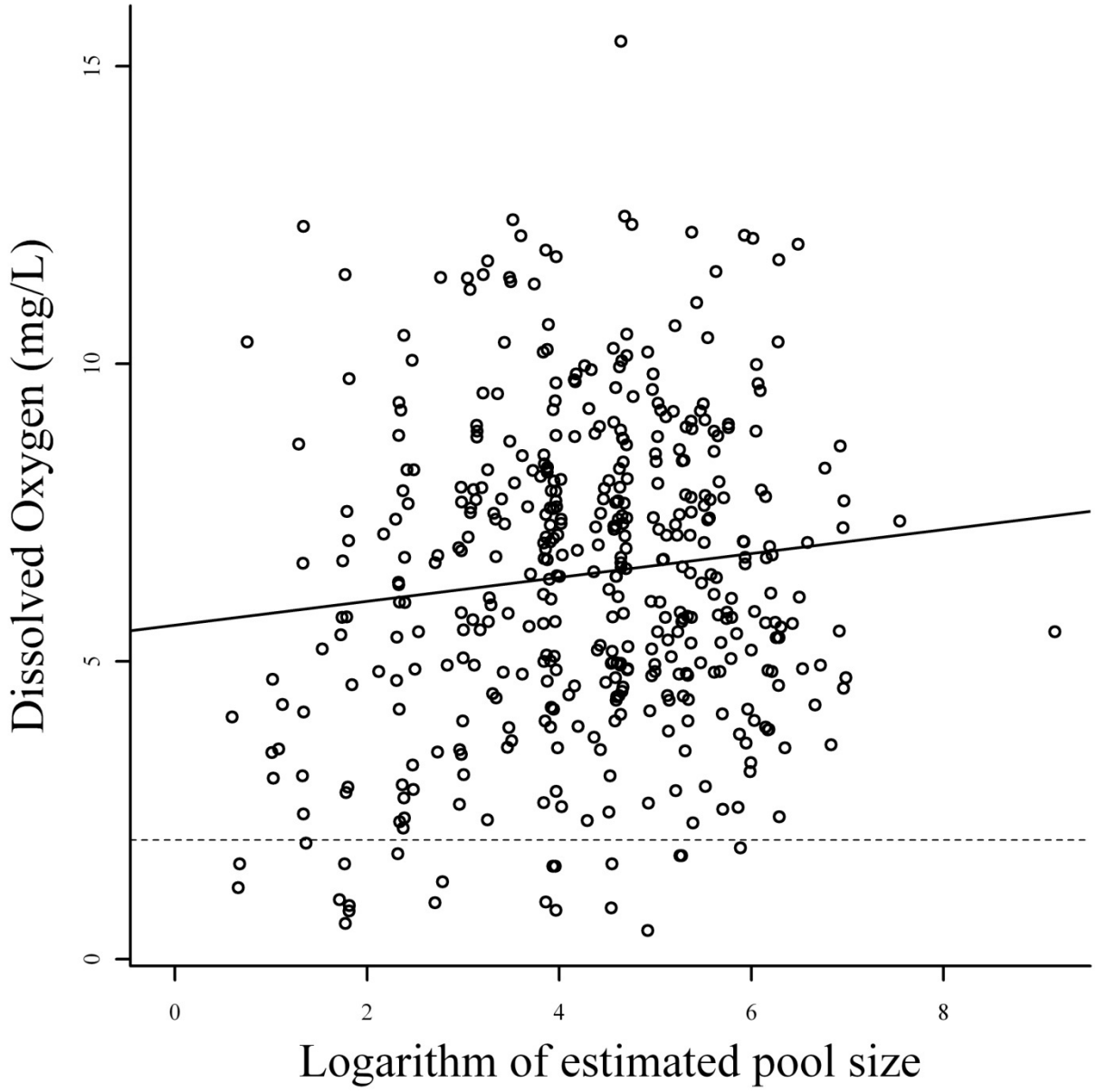

Figure 3. Relation between pool surface area (m^2) and dissolved oxygen content in isolated pools. Dotted line indicates lower critical oxygen limit. Equation of best fit Y = 5.61 (±0.40) + 0.20 (±0.09) * logarithm of estimated pool size (solid line).

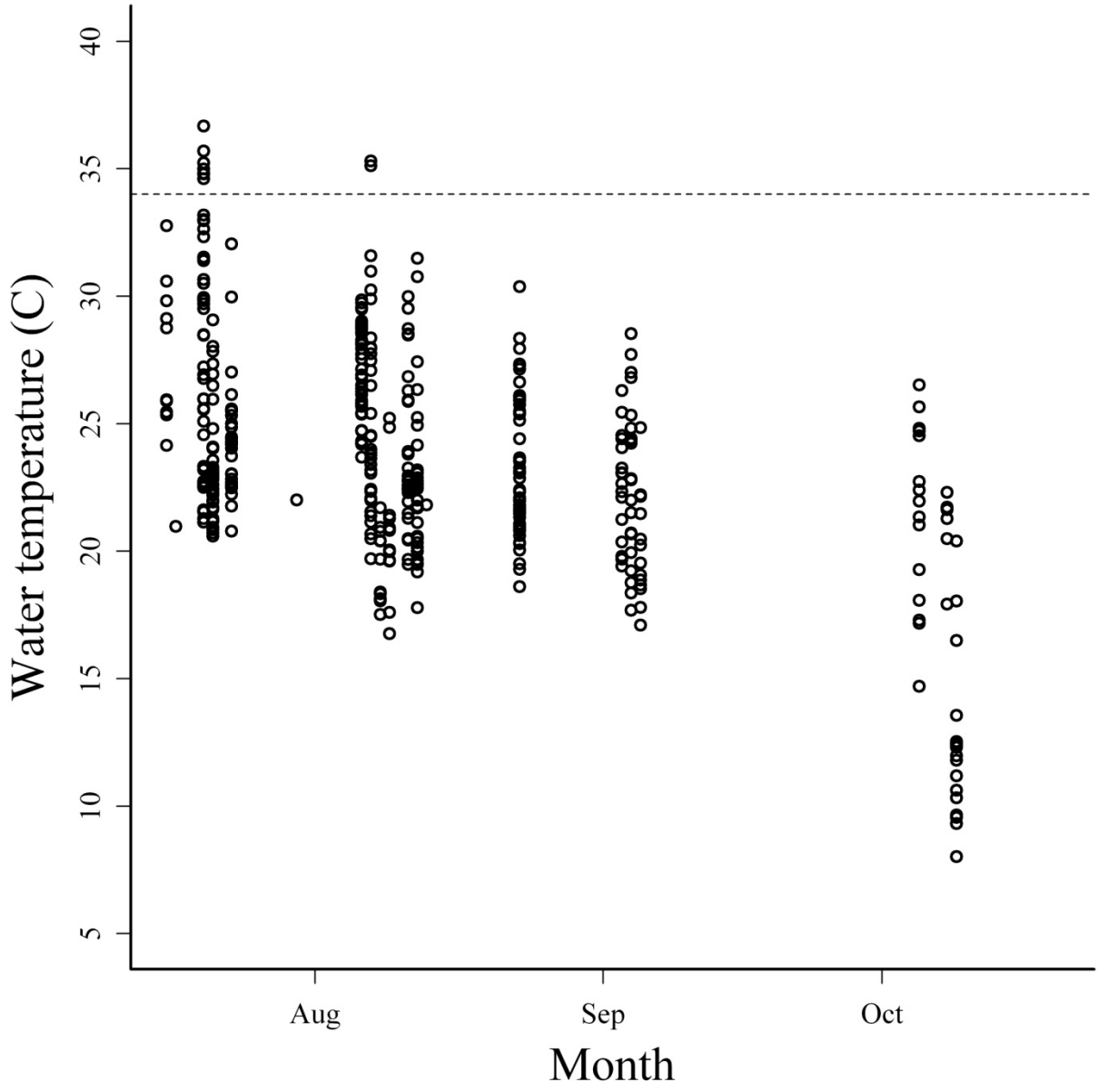

Figure 4. Water temperature in isolated pools by date. Dotted line indicates upper critical temperature limit for RGSM.

A total of 1,646 Rio Grande silvery minnow was counted towards the FWS permit (Tables 1,2). These individuals included those that perished between the act of salvage and when they were to be released back to the river, were preserved for salvage research, and those that were deemed not salvageable based on the criteria mentioned previously.

Discussion

In 2009, we were able to identify pool characteristics and seasonal timeframe that equated to better water quality conditions. Generally, after September 1, water conditions remained favorable in pools that maintained surface areas of over 1000 m^2. Unfortunately, the critical time for intermittency occurs prior to this, occasionally as early as June 15. This critical period also coincides with the early life stages of RGSM, when fish less than 30 mm SL are often abundant. These individuals are more susceptible to extreme water quality conditions and have little chance of surviving the stress of salvage, so are generally left to perish.

Since 2007, the adoption of a new rescue and salvage protocol allowed us to more effectively manage the effort to salvage RGSM. The total number of salvaged RGSM was likely lower than would have been estimated in previous years but we feel that current salvage numbers more accurately reflect the number of fish that could be and were rescued. By prioritizing our efforts and the quality of fish that were salvaged, we believe there were higher survival rates after fish were released back in secure sections of the river. In addition to the higher survival rates and benefit to the species achieved by our efforts, we also were able to cut down on workforce needs and expenses.

Acknowledgments

The Middle Rio Grande Endangered Species Collaborative Program supported this work under Interagency Agreement 06-AA-40-2491 as administered by the Bureau of Reclamation. There were in excess of 10 people that contributed directly to the rescue effort, notably including personnel associated with the U.S. Fish and Wildlife Service and the U.S. Army Corps of Engineers. The contributions of everyone are greatly appreciated. Success in RGSM operations during 2009 can be attributed to the tremendous cooperation and the professionalism of all involved.

Personnel of the New Mexico Fish and Wildlife Conservation Office served to plan and coordinate rescue operations, and represented the core of the rescue workforce, including Adam Valdez, Andrew ElkShoulder, Thomas Archdeacon, Tristan Austring, Weston Furr, Evan Anderson, and Dustin Myers. Field assistance was provided by Army Corps of Engineers staff including Sarah Beck, Don Gallegos, Justin Reale, and Phillip Alarcon. Special thanks to Bosque Del Apache National Wildlife Refuge for providing housing and logistical support.

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Table 1. Chronological order of Rio Grande silvery minnow salvage in 2009.

Note: FWS permit includes those found dead that could not be attributed to Incidental Take including fish not salvaged due to health criteria, those sacrificed for research, or died prior to release.

16 July 2009	San Acacia Reach	WJR09-863
Rio Grande silvery minnow – Salvaged>30mm		23 (23)
Rio Grande silvery minnow – FWS permit		0
Rio Grande silvery minnow – Incidental Take		0

16 July 2009	San Acacia Reach	TPA09-2009
Rio Grande silvery minnow – Salvaged		0
Rio Grande silvery minnow – FWS permit		0
Rio Grande silvery minnow – Incidental Take		0

17 July 2009	San Acacia Reach	EBA09-046
Rio Grande silvery minnow – Salvaged		0
Rio Grande silvery minnow – FWS permit		0
Rio Grande silvery minnow – Incidental Take		0

20 July 2009	San Acacia Reach	WJR09-864
Rio Grande silvery minnow – Salvaged		121 (81)
Rio Grande silvery minnow – FWS permit		0
Rio Grande silvery minnow – Incidental Take		3

21 July 2009	San Acacia Reach	EBA09-047
Rio Grande silvery minnow – Salvaged		35 (35)
Rio Grande silvery minnow – FWS permit		0
Rio Grande silvery minnow – Incidental Take		0

21 July 2009	San Acacia Reach	TPA09-101
Rio Grande silvery minnow – Salvaged		25 (25)
Rio Grande silvery minnow – FWS permit		0
Rio Grande silvery minnow – Incidental Take		1

23 July 2009	San Acacia Reach	WJR09-865
Rio Grande silvery minnow – Salvaged		33 (32)
Rio Grande silvery minnow – FWS permit		0
Rio Grande silvery minnow – Incidental Take		10

30 July 2009	San Acacia Reach	TJA09-057
Rio Grande silvery minnow – Salvaged		1 (1)
Rio Grande silvery minnow – FWS permit		0
Rio Grande silvery minnow – Incidental Take		0

6 August 2009	San Acacia Reach	TPA09-109
Rio Grande silvery minnow – Salvaged		3,074 (47)
Rio Grande silvery minnow – FWS permit		0
Rio Grande silvery minnow – Incidental Take		0

7 August 2009	San Acacia Reach	WJR09-869
Rio Grande silvery minnow – Salvaged		4,209 (80)
Rio Grande silvery minnow – FWS permit		898
Rio Grande silvery minnow – Incidental Take		94

8 August 2009	San Acacia Reach	TPA09-110
Rio Grande silvery minnow – Salvaged		551 (20)
Rio Grande silvery minnow – FWS permit		21
Rio Grande silvery minnow – Incidental Take		0

9 August 2009	San Acacia Reach	WJR09-870
Rio Grande silvery minnow – Salvaged		540 (40)
Rio Grande silvery minnow – FWS permit		0
Rio Grande silvery minnow – Incidental Take		81

11 August 2009	San Acacia Reach	WJR09-871
Rio Grande silvery minnow – Salvaged		1,002 (64)
Rio Grande silvery minnow – FWS permit		4
Rio Grande silvery minnow – Incidental Take		0

12 August 2009	San Acacia Reach	WJR09-872
Rio Grande silvery minnow – Salvaged		4,374 (152)
Rio Grande silvery minnow – FWS permit		136
Rio Grande silvery minnow – Incidental Take		101

13 August 2009	San Acacia Reach	WJR09-873
Rio Grande silvery minnow – Salvaged		2,100 (100)
Rio Grande silvery minnow – FWS permit		0
Rio Grande silvery minnow – Incidental Take		0

22 August 2009	San Acacia Reach	WJR09-874
Rio Grande silvery minnow – Salvaged		0 (0)
Rio Grande silvery minnow – FWS permit		0
Rio Grande silvery minnow – Incidental Take		987

23 August 2009	San Acacia Reach	WJR09-875
Rio Grande silvery minnow – Salvaged		89 (29)
Rio Grande silvery minnow – FWS permit		3
Rio Grande silvery minnow – Incidental Take		0

24 August 2009	San Acacia Reach	WJR09-876
Rio Grande silvery minnow – Salvaged		0 (0)
Rio Grande silvery minnow – FWS permit		93
Rio Grande silvery minnow – Incidental Take		238

27 August 2009	San Acacia Reach	WJR09-877
Rio Grande silvery minnow – Salvaged		5 (5)
Rio Grande silvery minnow – FWS permit		0
Rio Grande silvery minnow – Incidental Take		0

3 September 2009	San Acacia Reach	TPA09-119A
Rio Grande silvery minnow – Salvaged		354 (295)
Rio Grande silvery minnow – FWS permit		0
Rio Grande silvery minnow – Incidental Take		179

4 September 2009	San Acacia Reach	TPA09-120A
Rio Grande silvery minnow – Salvaged		510 (83)
Rio Grande silvery minnow – FWS permit		210
Rio Grande silvery minnow – Incidental Take		00

5 September 2009	San Acacia Reach	TPA09-121A
Rio Grande silvery minnow – Salvaged		122 (112)
Rio Grande silvery minnow – FWS permit		43
Rio Grande silvery minnow – Incidental Take		0

5 October 2009	San Acacia Reach	WJR09-878
Rio Grande silvery minnow – Salvaged		621 (90)
Rio Grande silvery minnow – FWS permit		121
Rio Grande silvery minnow – Incidental Take		0

6 October 2009	San Acacia Reach	WJR09-880
Rio Grande silvery minnow – Salvaged		0 (0)
Rio Grande silvery minnow – FWS permit		0
Rio Grande silvery minnow – Incidental Take		0

8 October 2009	San Acacia Reach	WJR09-881
Rio Grande silvery minnow – Salvaged		71(15)
Rio Grande silvery minnow – FWS permit		55
Rio Grande silvery minnow – Incidental Take		0

9 October 2009	San Acacia Reach	WJR09-882
Rio Grande silvery minnow – Salvaged		610 (23)
Rio Grande silvery minnow – FWS permit		62
Rio Grande silvery minnow – Incidental Take		0

20 October 2009	San Acacia Reach	
Rio Grande silvery minnow – Salvaged		3 (2)
Rio Grande silvery minnow – FWS permit		0
Rio Grande silvery minnow – Incidental Take		

16 July – 20 October	**Rio Grande**	**2009 Totals**
Rio Grande silvery minnow – Salvaged		**18,473 (1,354)**
Rio Grande silvery minnow – FWS permit		**1,646**
Rio Grande silvery minnow – Incidental Take		**1,694**

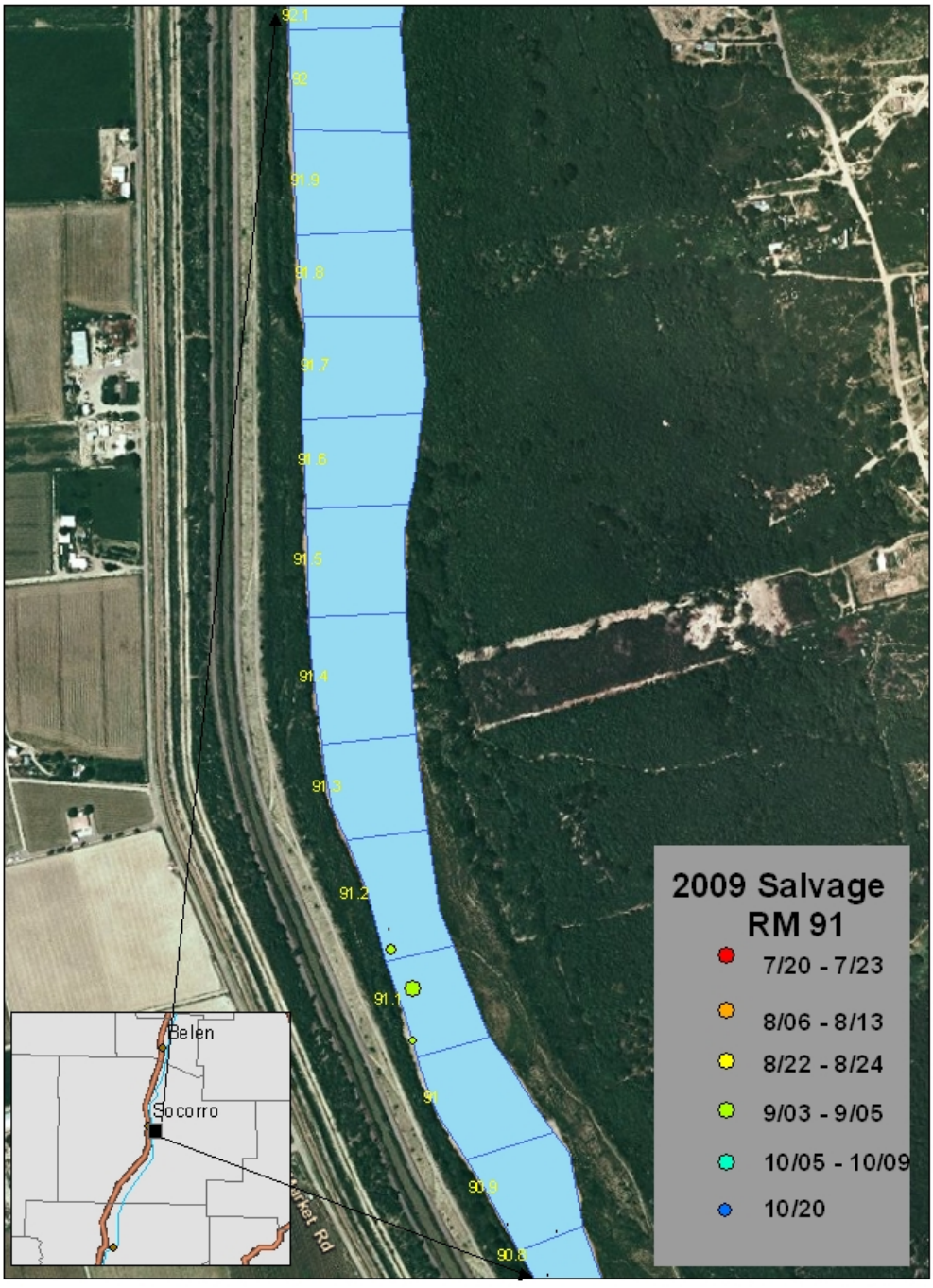

Figure 5. 2009 River Mile 91 map. Locations on map note different salvage dates and relative size of pool.

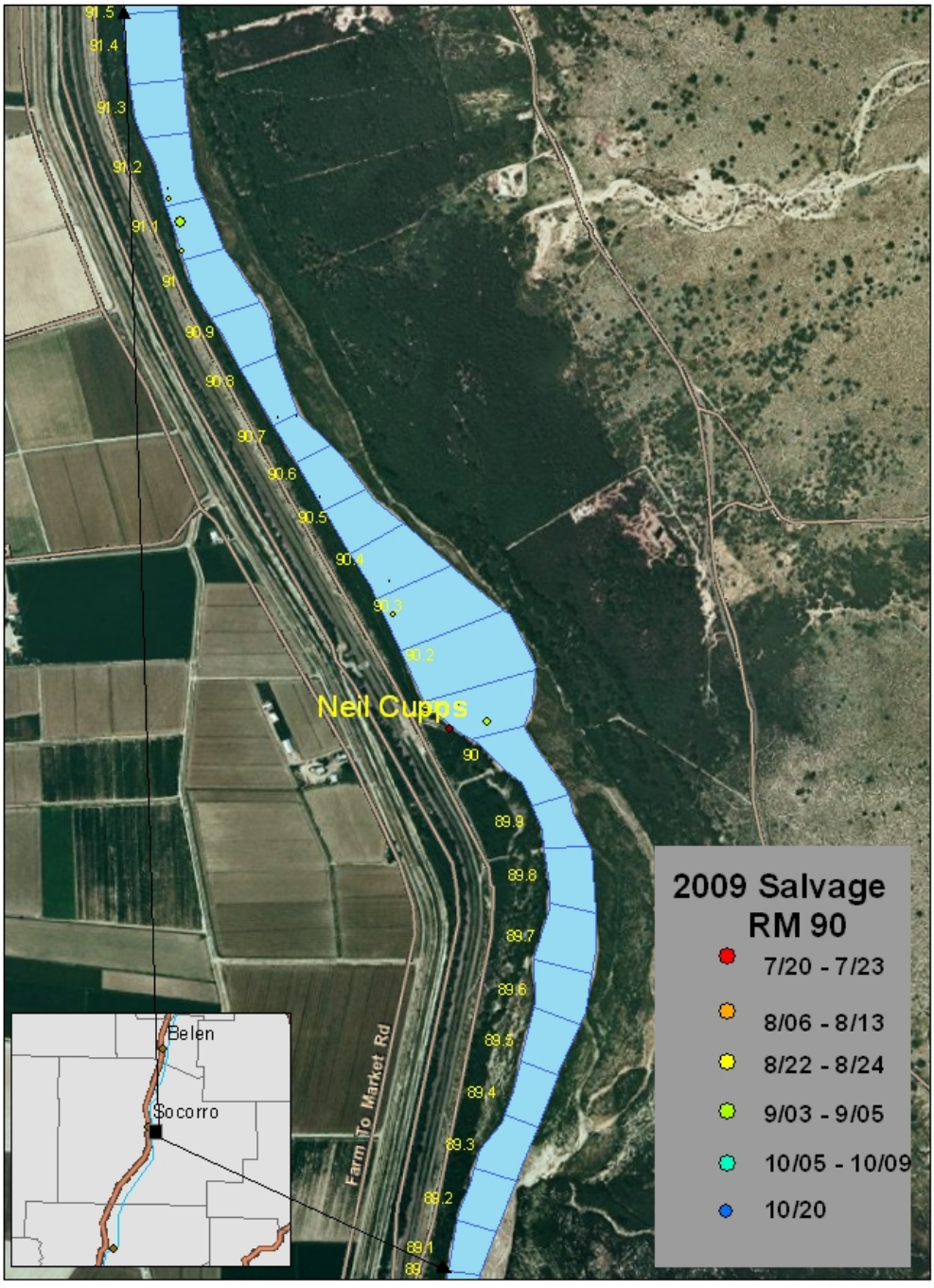

Figure 6. 2009 River Mile 90 map. Locations on map note different salvage dates and relative size of pool.

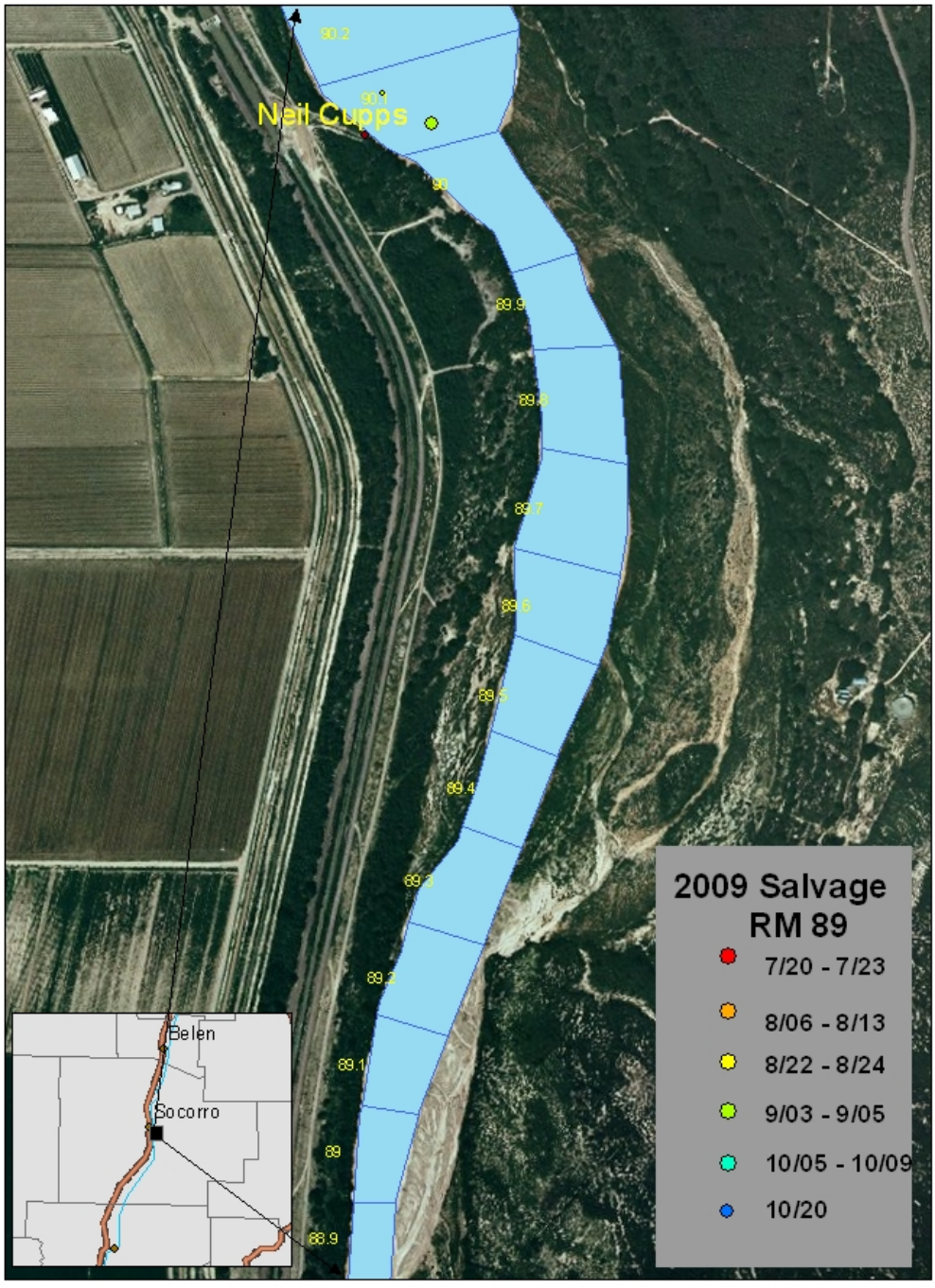

Figure 7. 2009 River Mile 89 map. Locations on map note different salvage dates and relative size of pool.

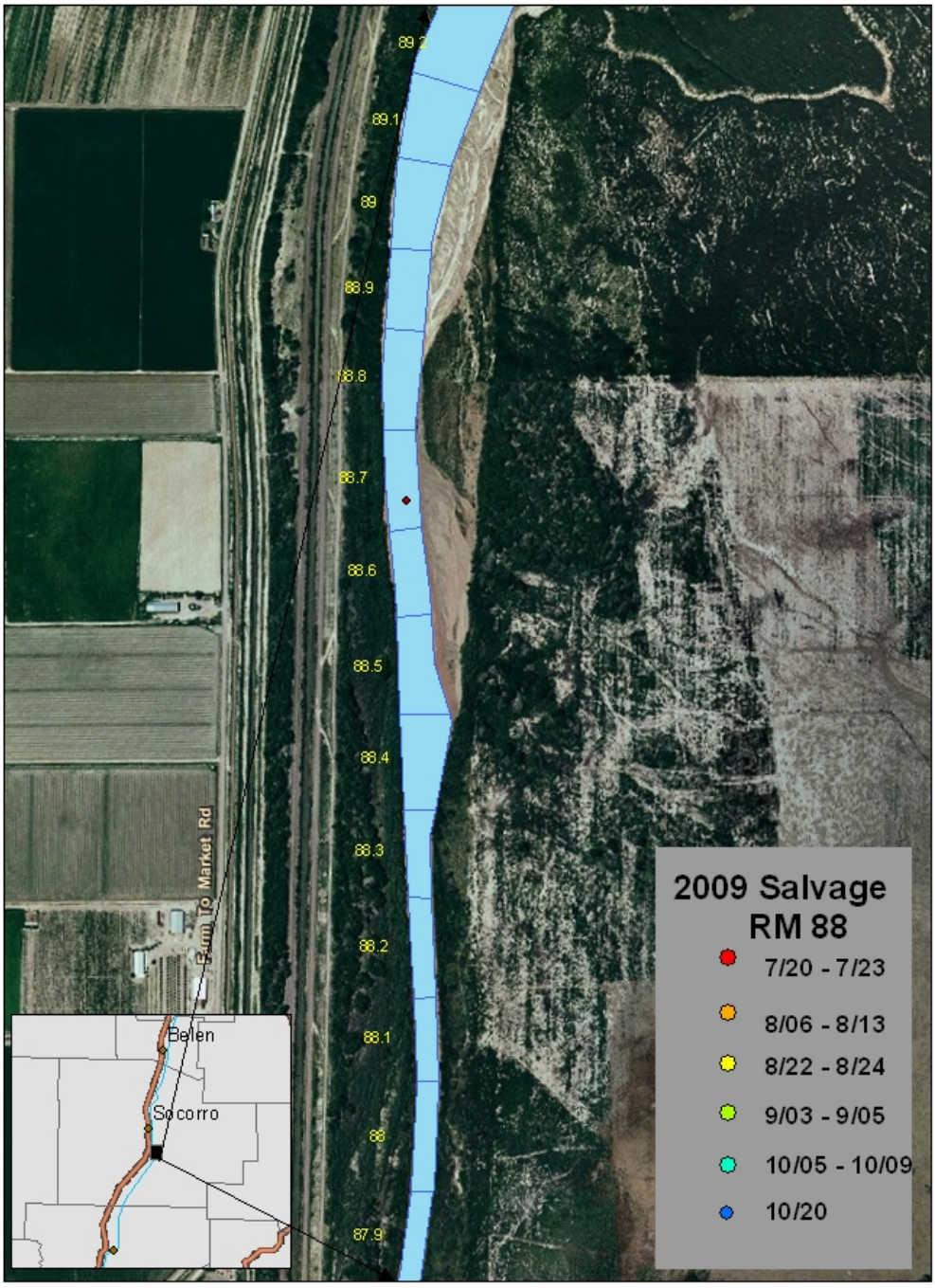

Figure 8. 2009 River Mile 88 map. Locations on map note different salvage dates and relative size of pool.

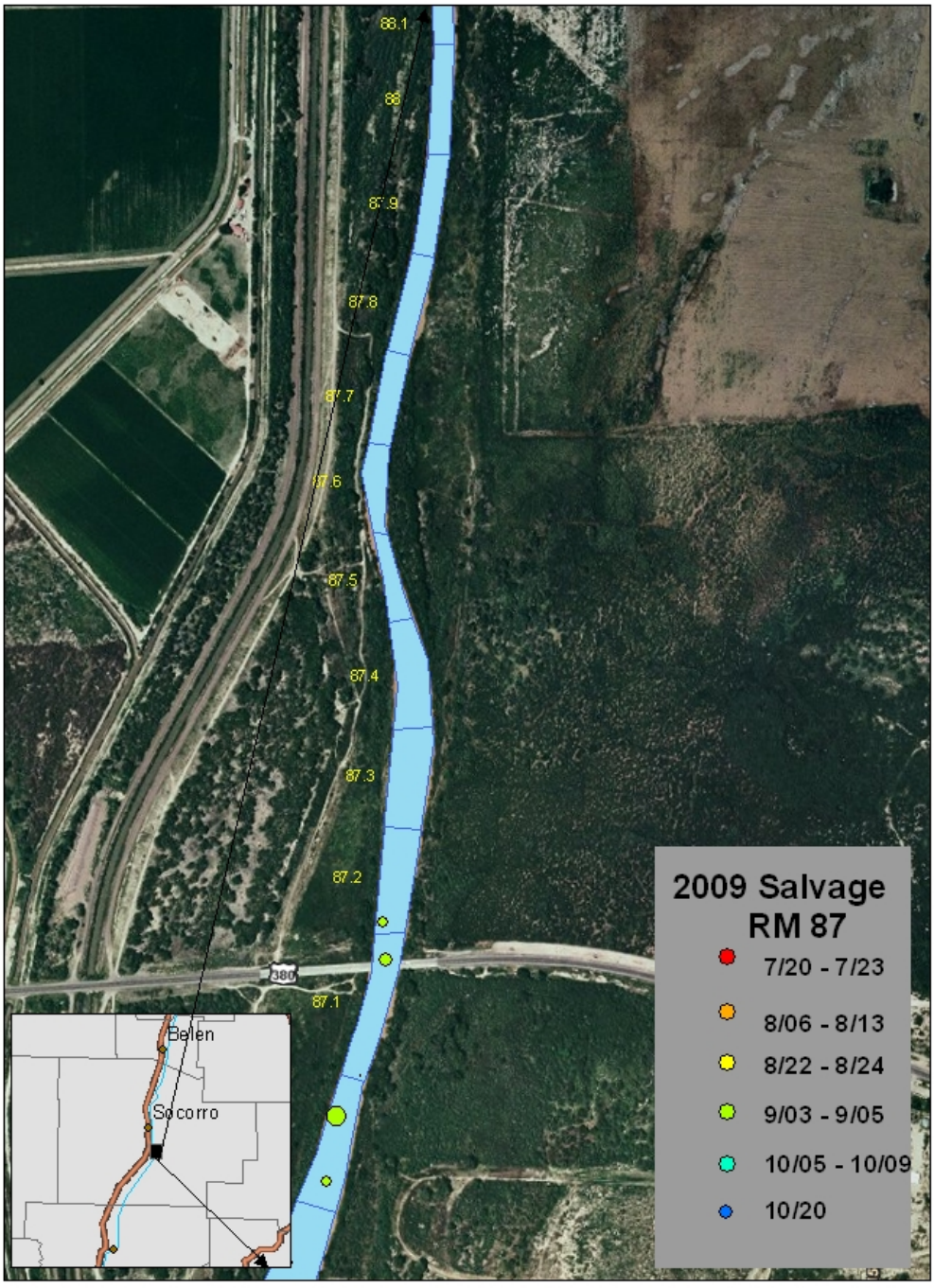

Figure 9. 2009 River Mile 87 map. Locations on map note different salvage dates and relative size of pool.

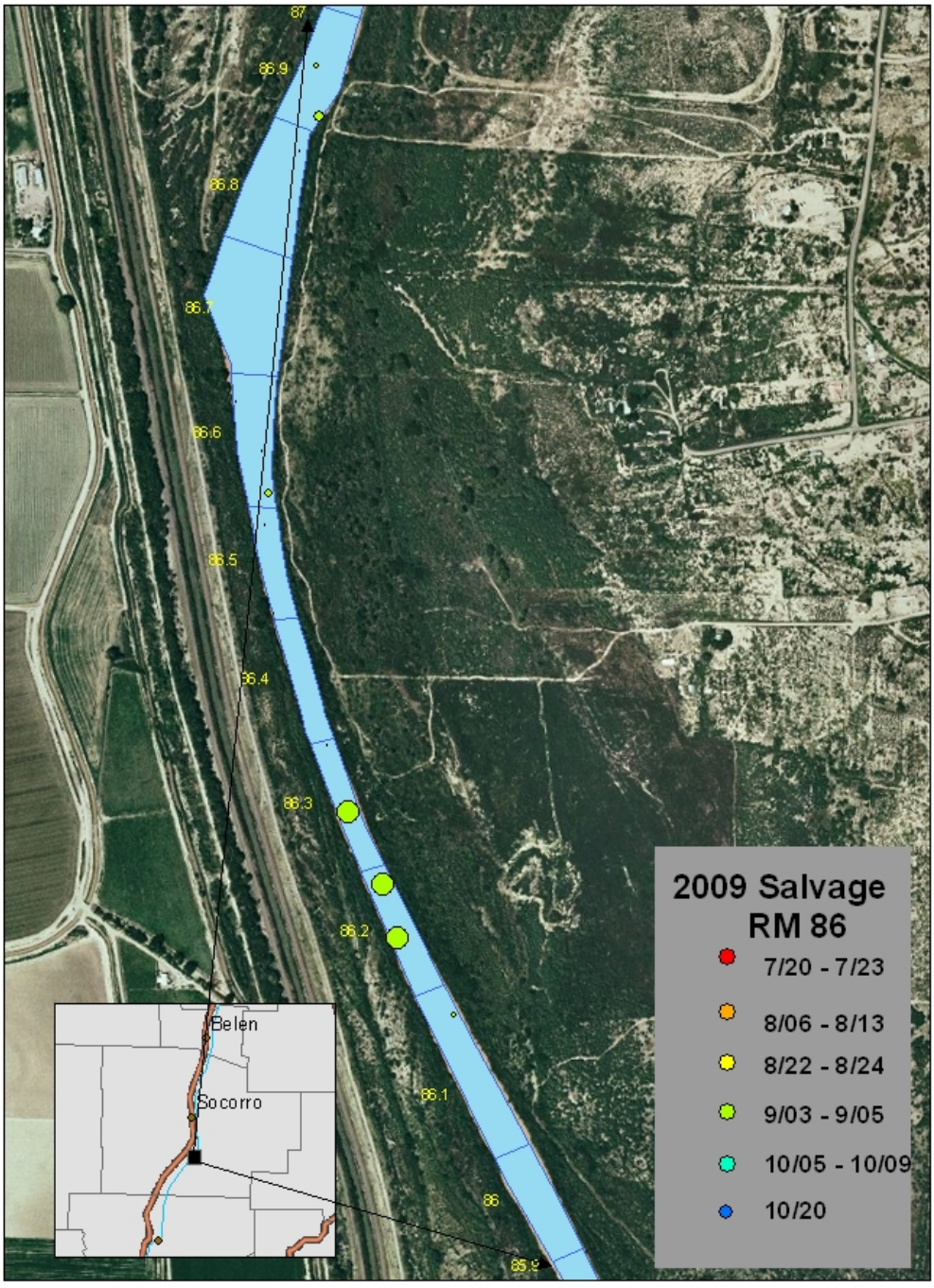

Figure 10. 2009 River Mile 86 map. Locations on map note different salvage dates and relative size of pool.

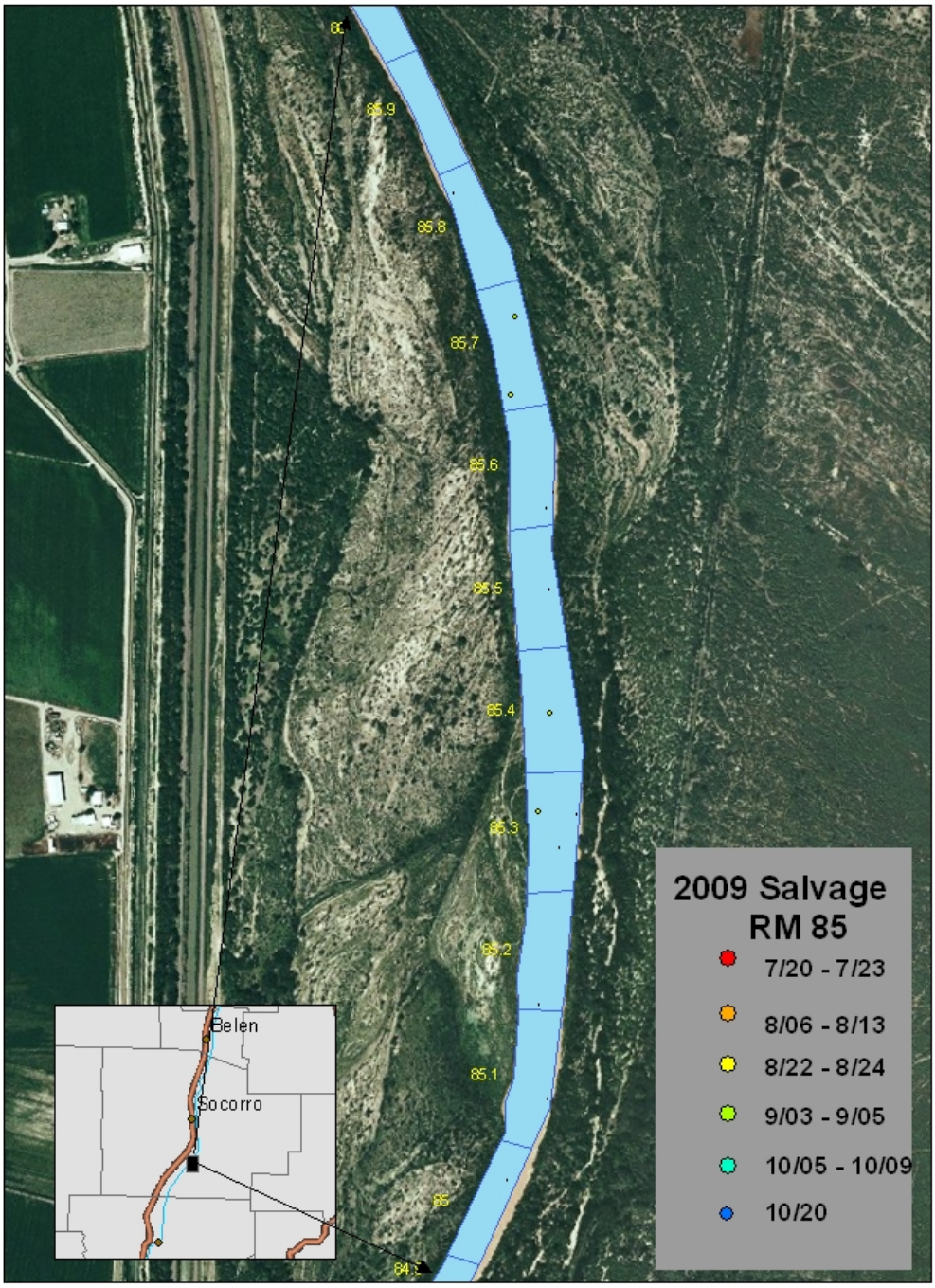

Figure 11. 2009 River Mile 85 map. Locations on map note different salvage dates and relative size of pool.

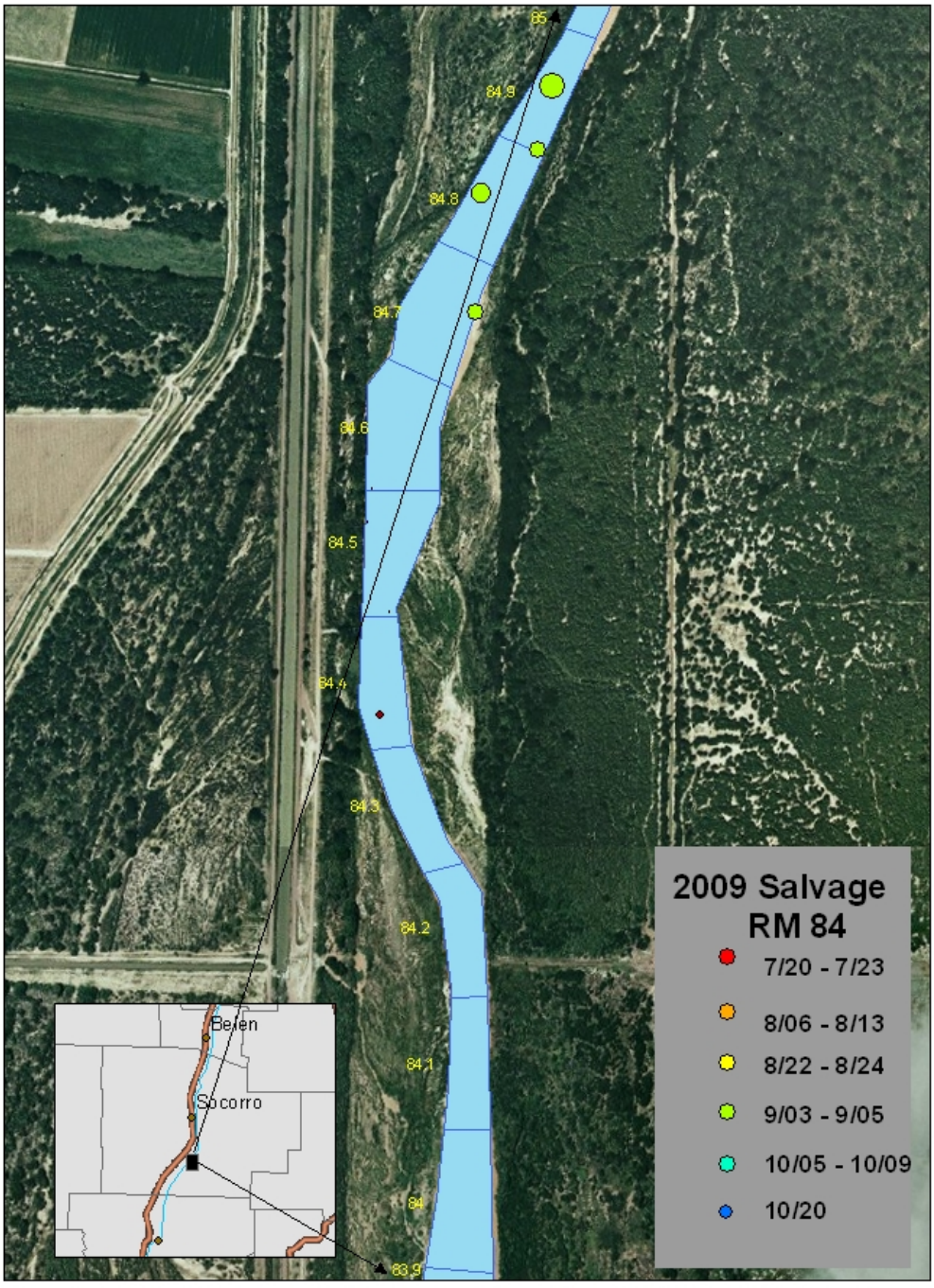

Figure 12. 2009 River Mile 84 map. Locations on map note different salvage dates and relative size of pool.

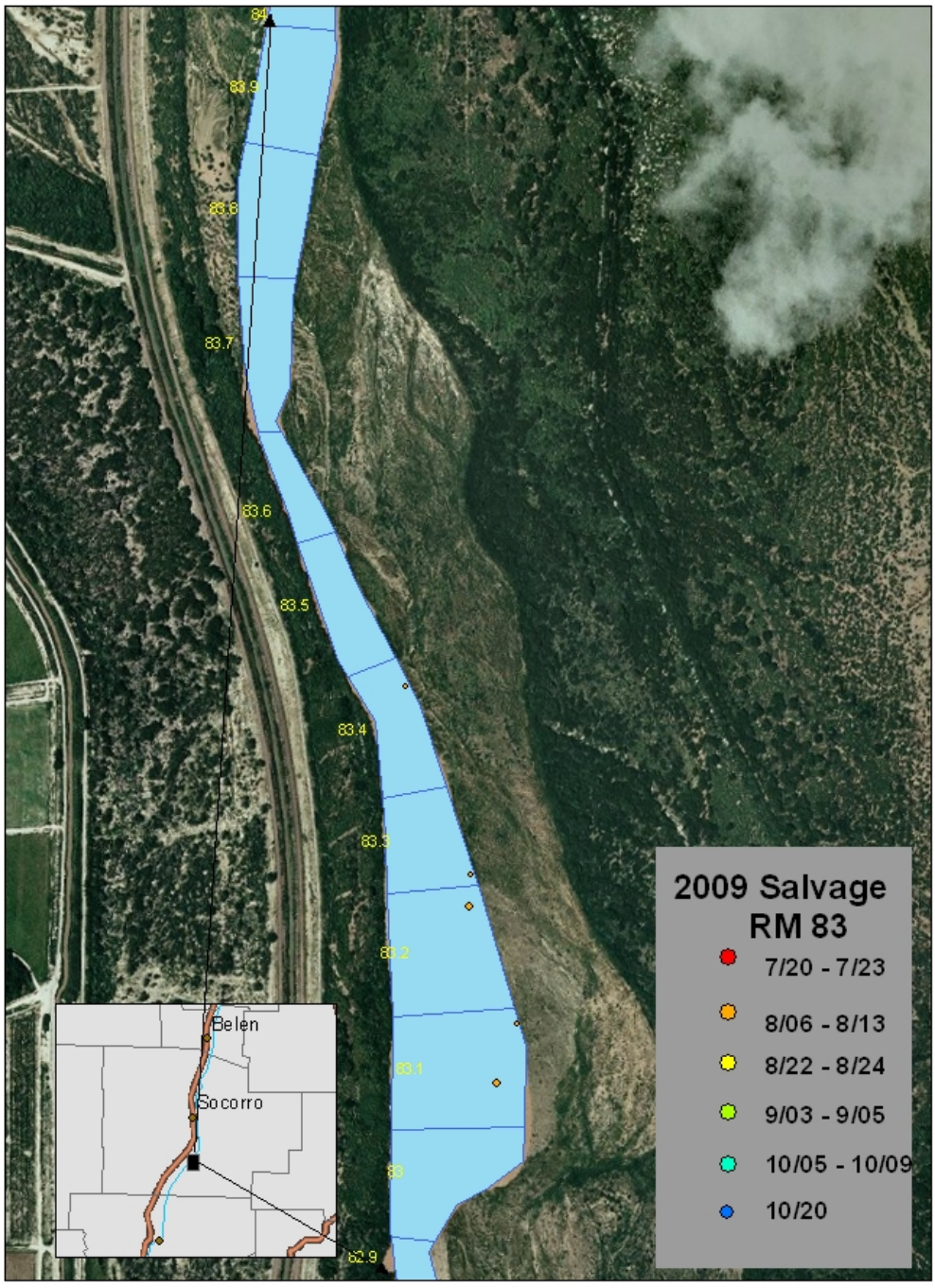

Figure 13. 2009 River Mile 83 map. Locations on map note different salvage dates and relative size of pool.

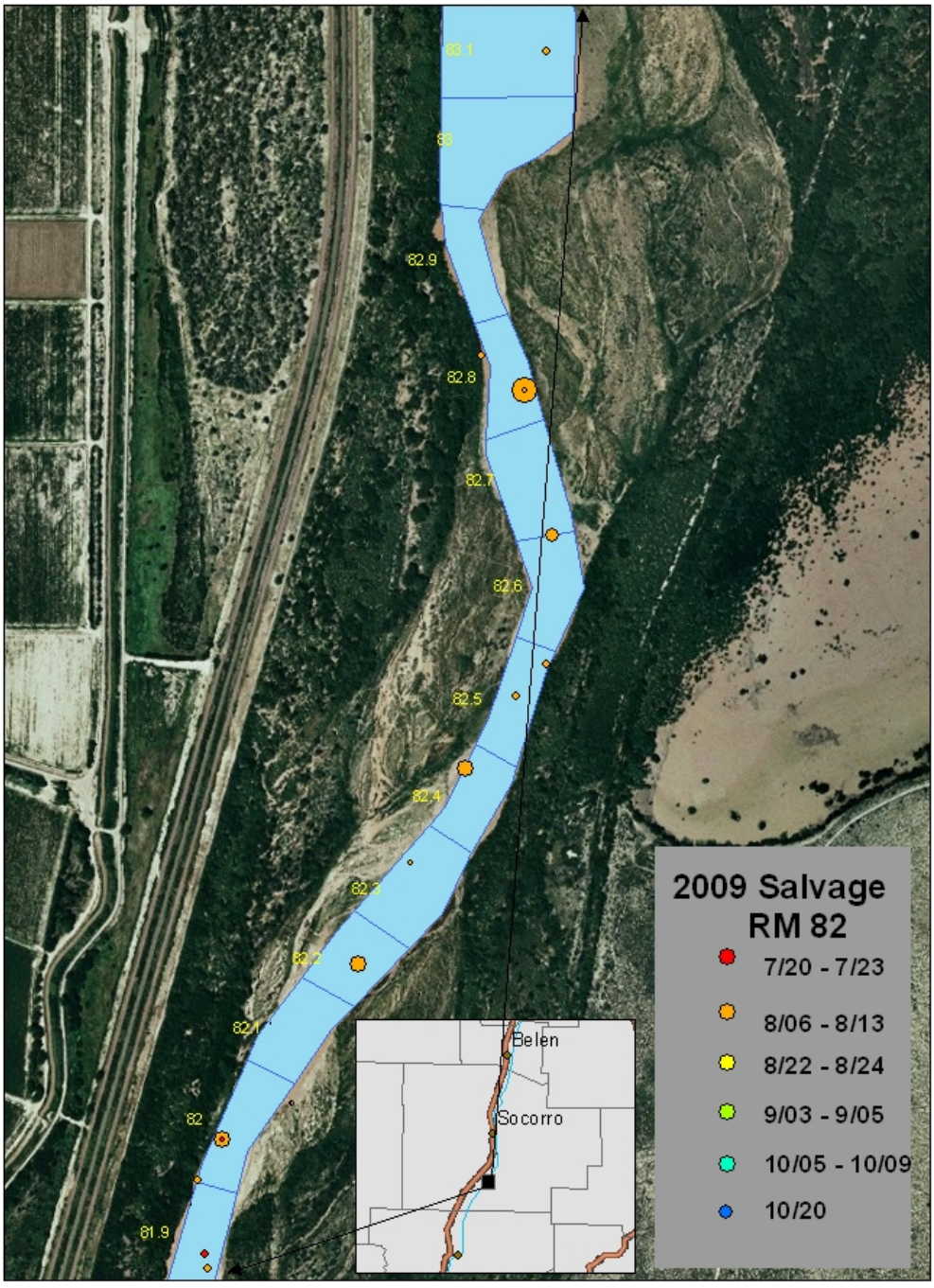

Figure 14. 2009 River Mile 82 map. Locations on map note different salvage dates and relative size of pool.

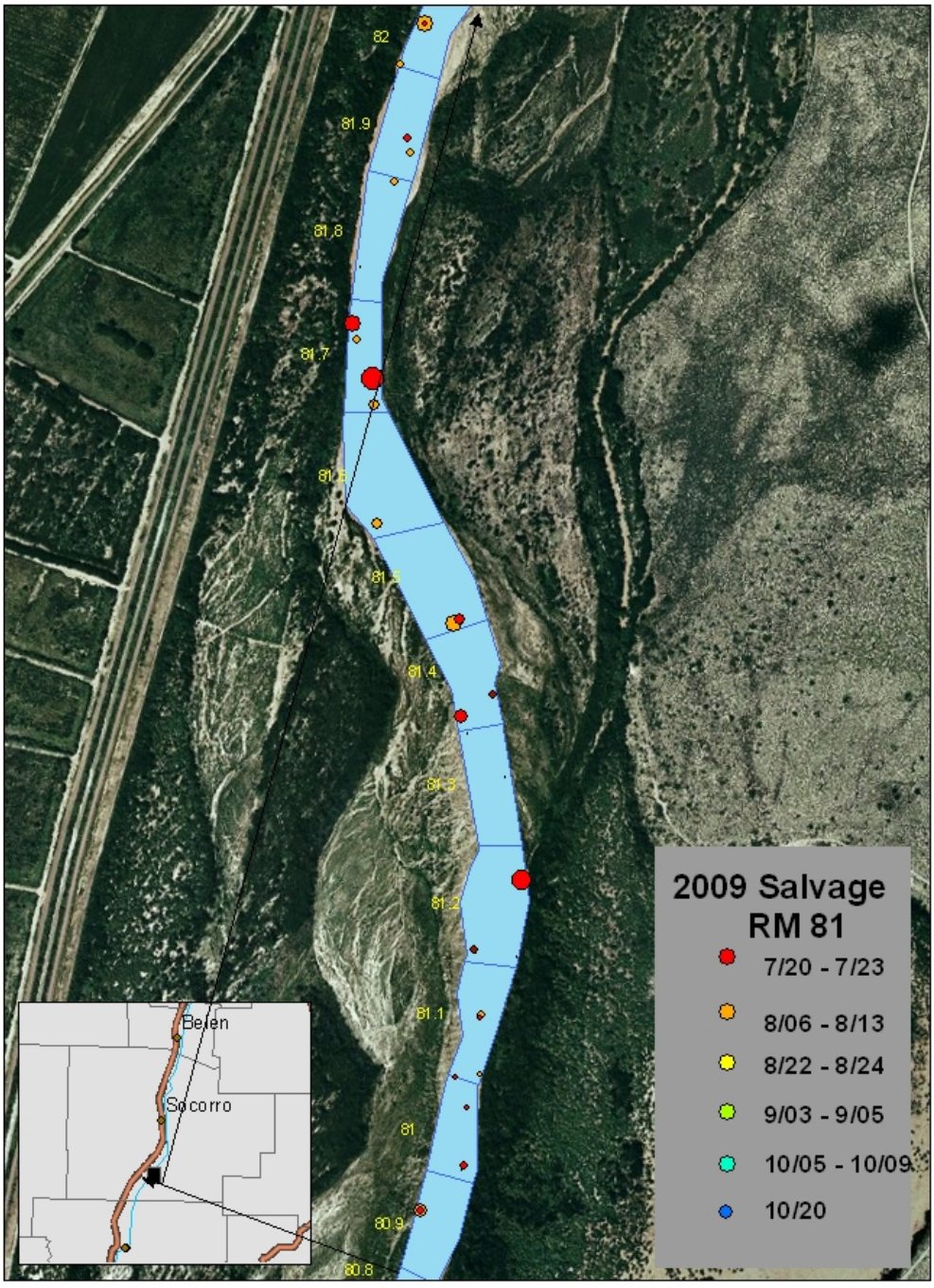

Figure 15. 2009 River Mile 81 map. Locations on map note different salvage dates and relative size of pool.

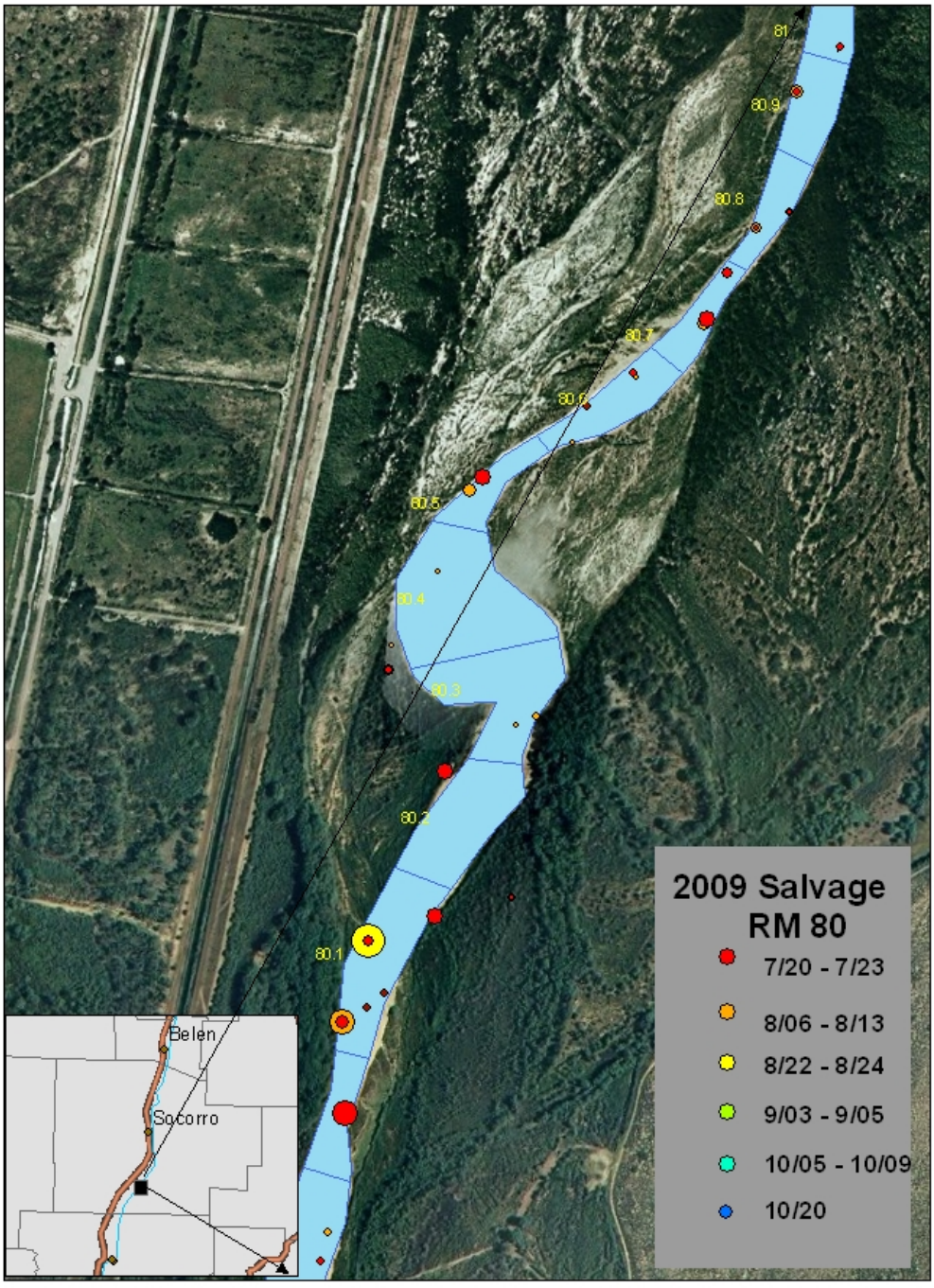

Figure 16. 2009 River Mile 80 map. Locations on map note different salvage dates and relative size of pool.

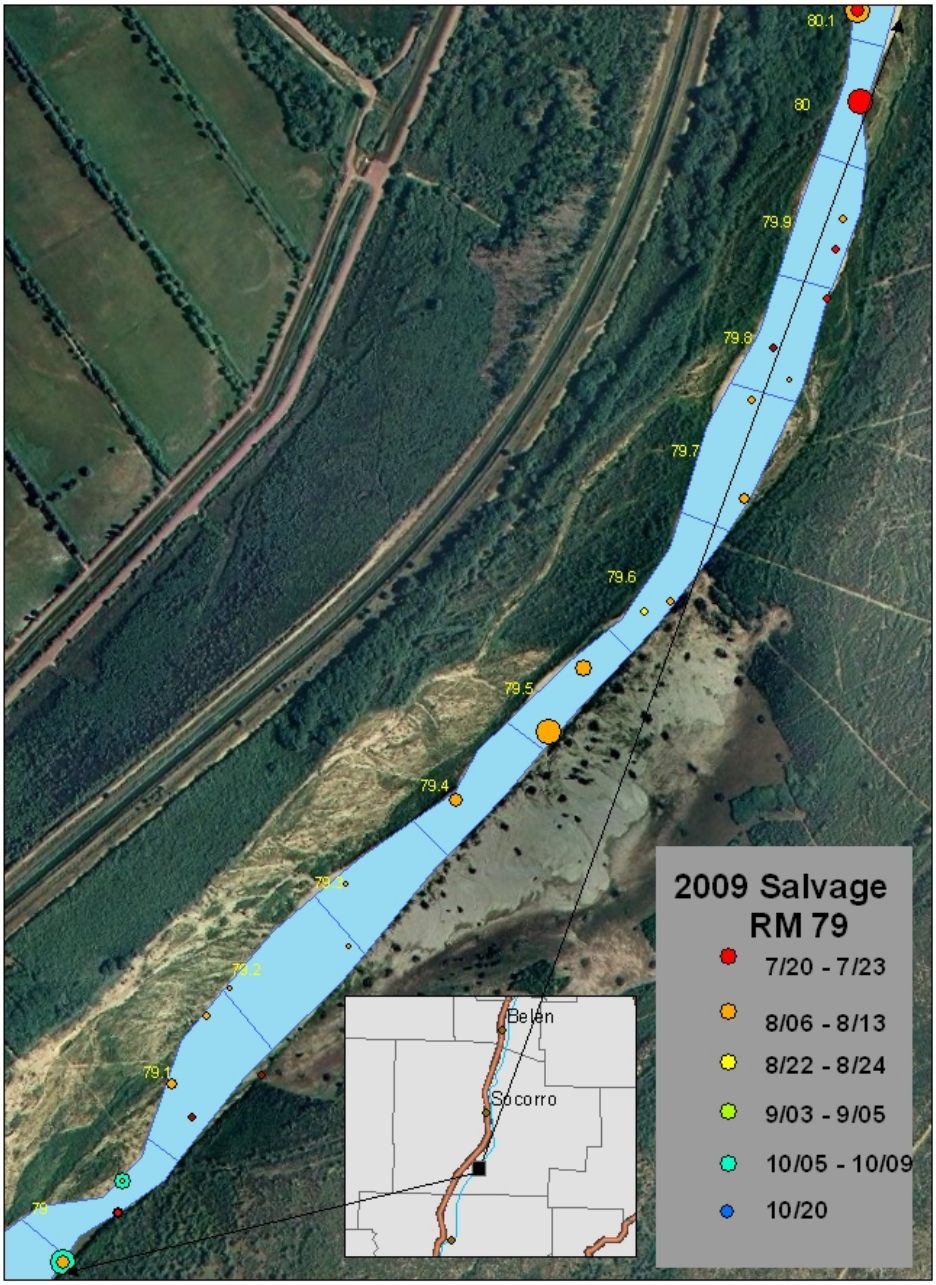

Figure 17. 2009 River Mile 79 map. Locations on map note different salvage dates and relative size of pool.

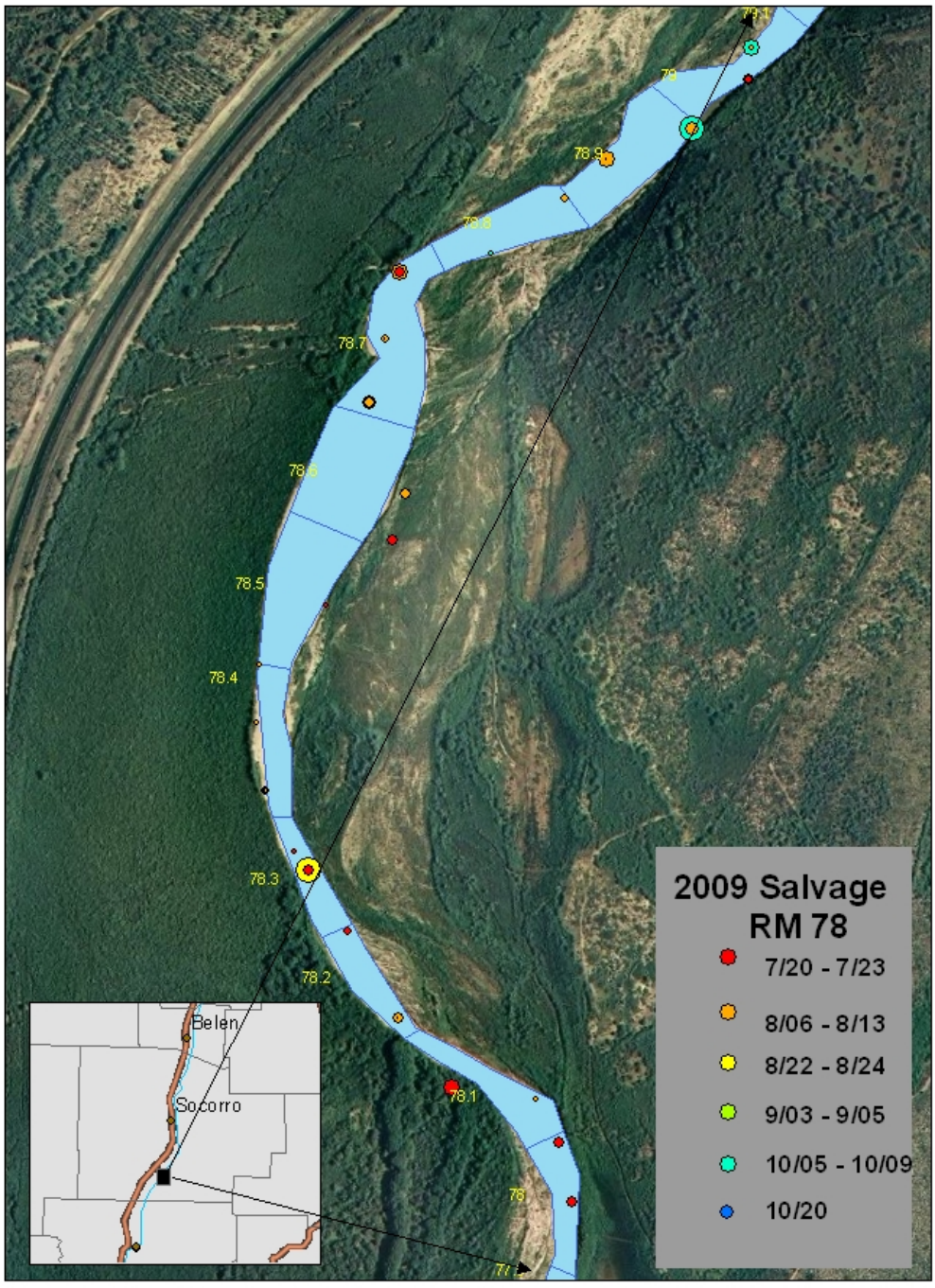

Figure 18. 2009 River Mile 78 map. Locations on map note different salvage dates and relative size of pool.

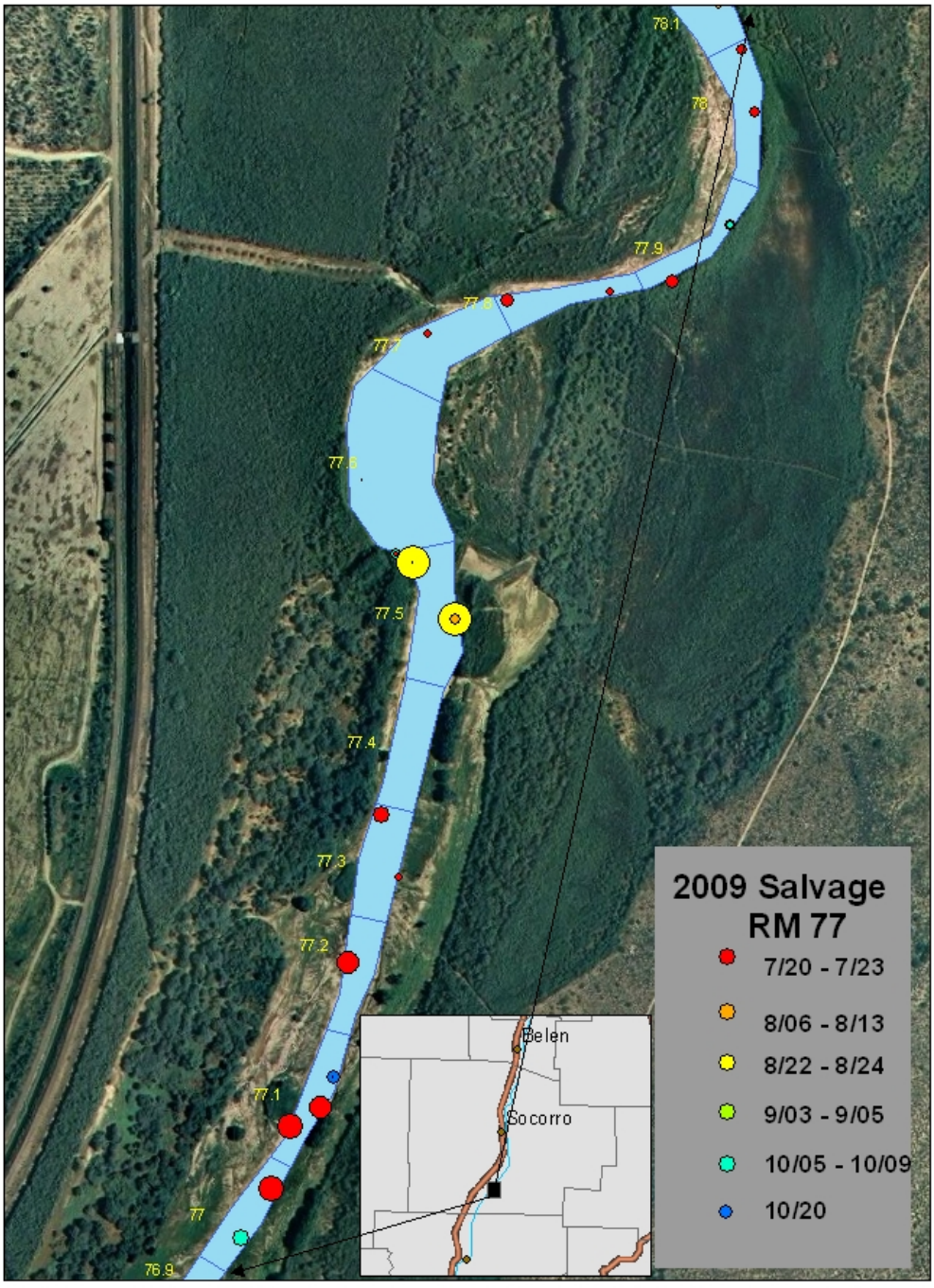

Figure 19. 2009 River Mile 77 map. Locations on map note different salvage dates and relative size of pool.

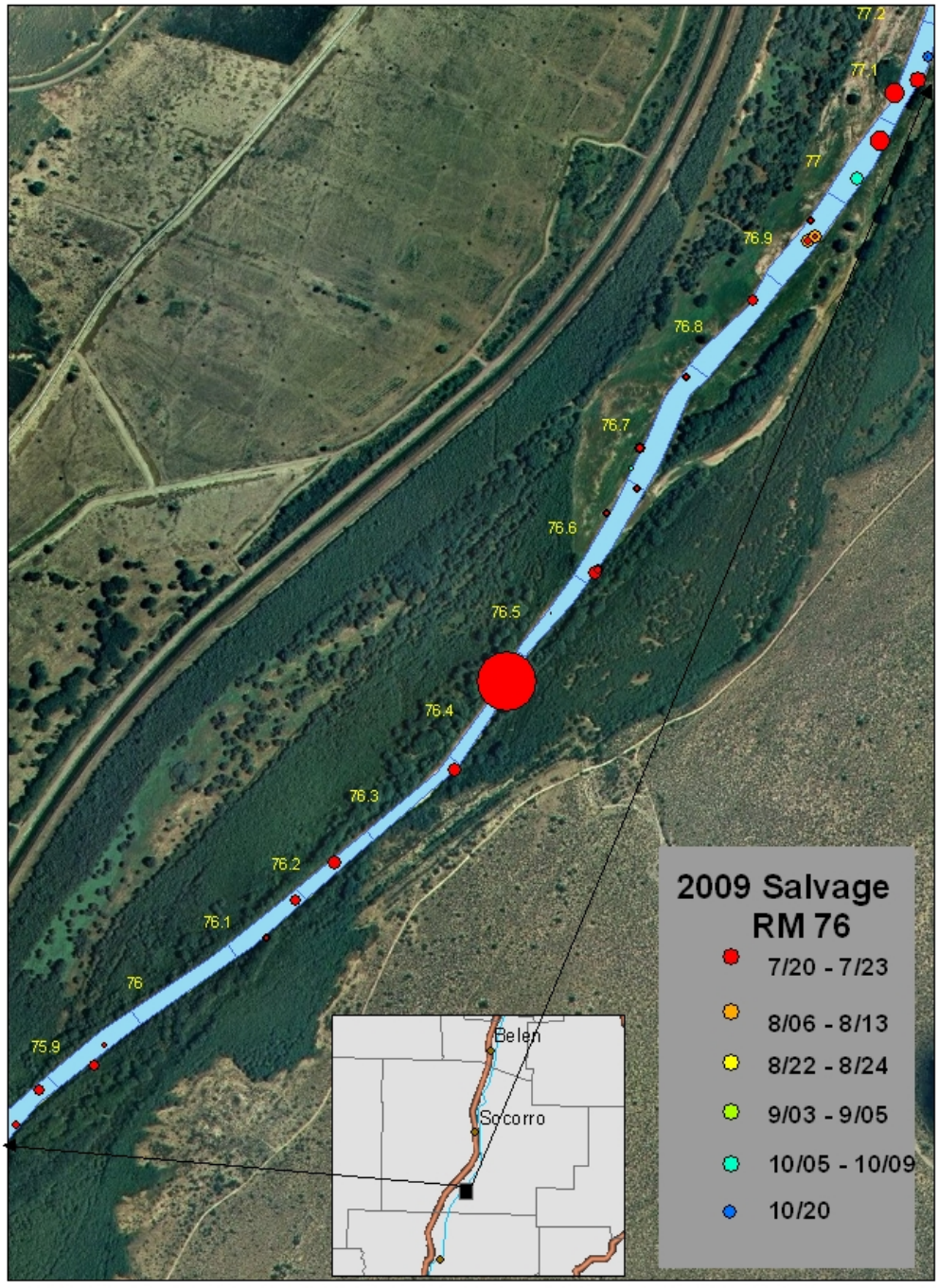

Figure 20. 2009 River Mile 76 map. Locations on map note different salvage dates and relative size of pool.

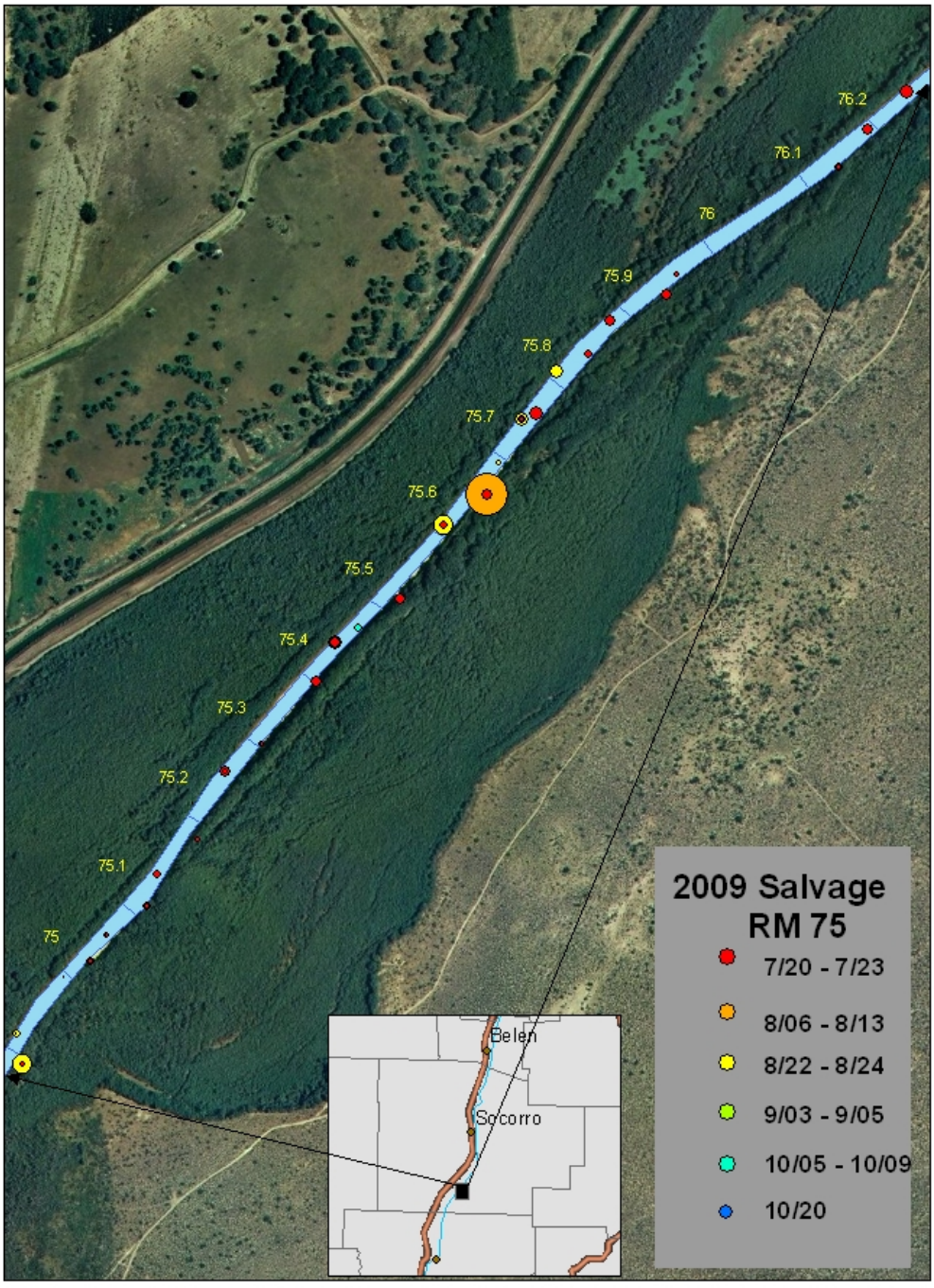

Figure 21. 2009 River Mile 75 map. Locations on map note different salvage dates and relative size of pool.

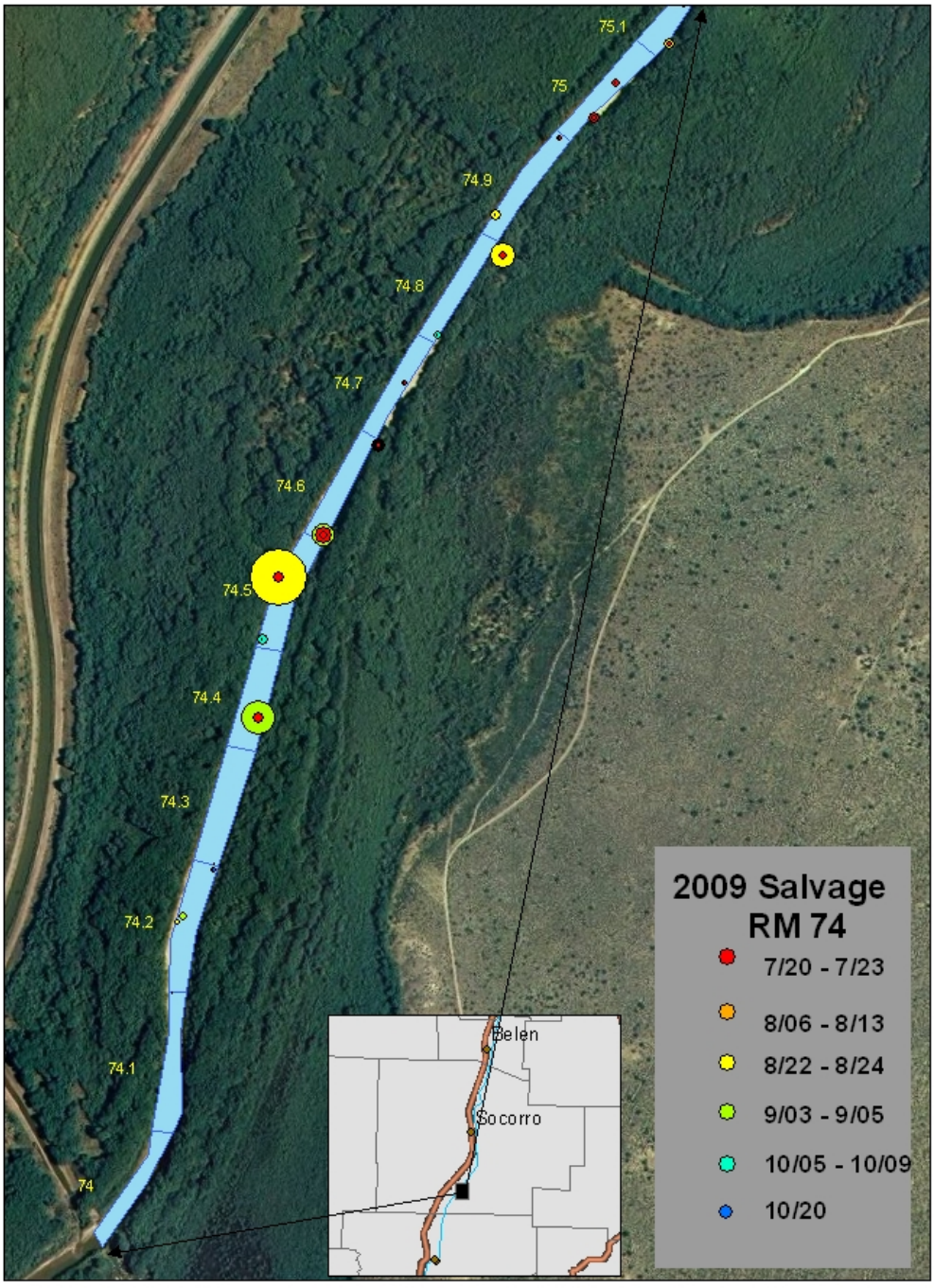

Figure 22. 2009 River Mile 74 map. Locations on map note different salvage dates and relative size of pool.

Appendix A. Water Conditioning Formulations for Transport Tanks

Water Conditioning Formulations for Transport Tanks

Large Transport Tank:

Each half holds 211.2 liters (55.80 gallons) of water.
To render this volume a 1.2 percent salt solution requires 2,534 grams (2.5 kg) of NaCl, which volumetrically equals about 1 ¾ cups.
The prescribed amount of stress coat is 0.26 ml/liter (1.00 ml/gallon), with 56.00 ml (or approximately 0.25 cups) of stress coat added to each half of the large tank.
Optimal fish density for 211.2 liters @ 10 g/liter = 2,112 g. 4,000 young-of-year (35 mm TL = 0.5 g), or 700 adult (65 mm TL = 3.0 g)

Small Transport Tank:

The tank holds 138.2 liters (36.50 gallons) of water.
To render this volume a 1.2 percent salt solution requires 1,658 grams (1.6 kg) of NaCl, which volumetrically equals about 3/4 cup.
The prescribed amount of stress coat is 0.26 ms/liters (1 ml/gallon) and 36.00 ml (or approximately 0.12 cups) of stress coat will be added to the small tank.
Optimal fish density for 138.2 liters @ 10 grams/liters = 1,382 g. 2750 young-of-year (35 mm TL = 0.5 g), or 450 adult (65 mm TL = 3.0 g)

Bags:

Bags will be filled with river water to approximately 0.66 of bag capacity (approximately 3.00 liters; 0.80 gallons).
To render this volume a 1.2 percent salt solution requires 36 grams of NaCl, which volumetrically equals about 3 teaspoons.
The prescribed amount of stress coat is 0.26 ml/liter (1.00 ml/gallon) and 1.00 ml of stress coat will be added to each bag.
Optimal fish density for 3 liters @ 10 grams/liter = 30 g. 60 young-of-year (35 mm TL = 0.5 g), or 10 adult (65 mm TL = 3.0 g)