UPPER OHIO NAVIGATION STUDY, PENNSYLVANIA
ENVIRONMENTAL APPENDIX

Hydroacoustic Survey

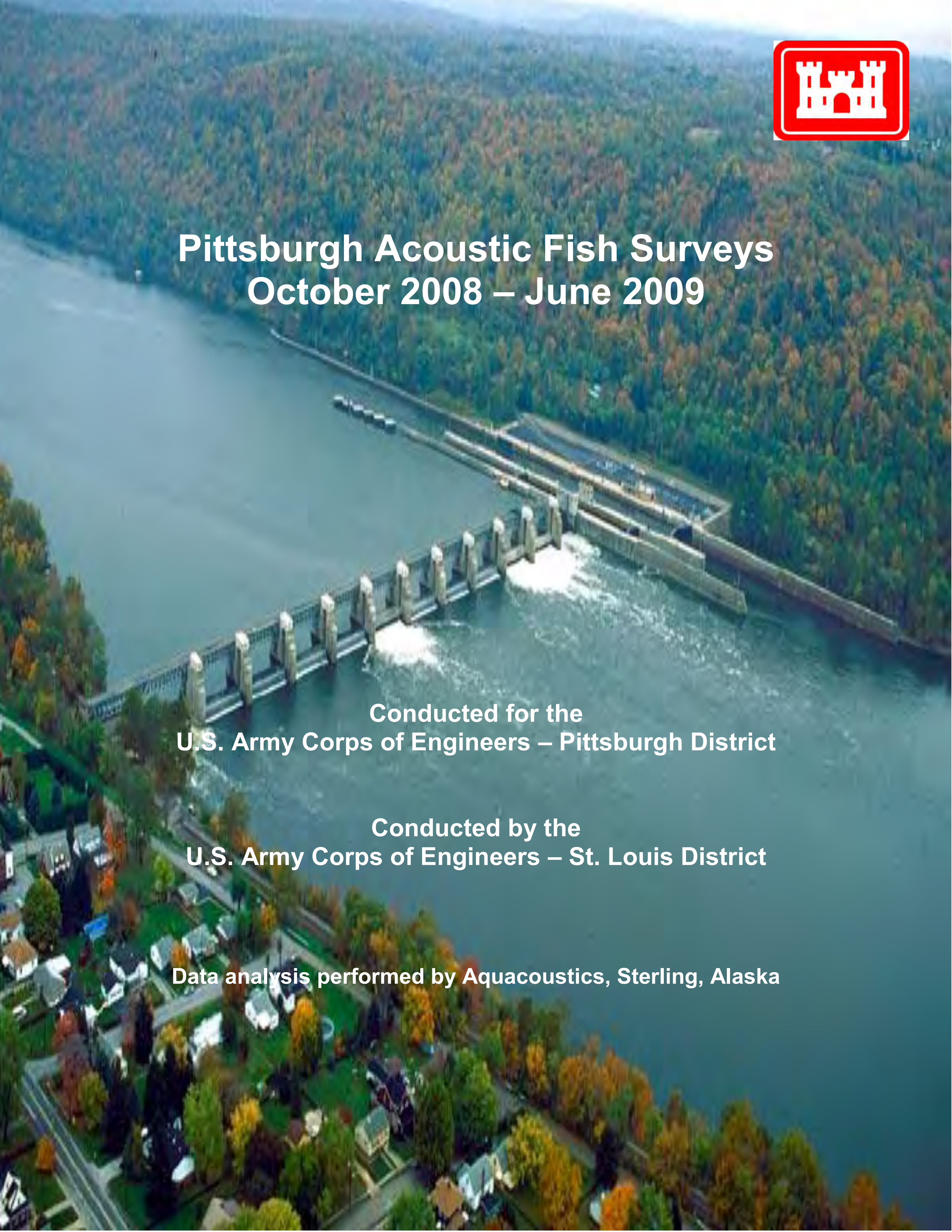
Pittsburgh Acoustic Fish Surveys
October 2008 – June 2009

Note to Reader:

These initial surveys may be considered cursory in that they were a first look at fish aggregations in the tailwaters of Emsworth, Dashields, and Montgomery Dams. This was undertaken to support planning for potential fish passage structures at these navigation facilities. The specific survey dates (April 21-22, June 02-03, Oct 28-29) were at the surveyor's convenience within seasonal ranges. Further surveys will be necessary should further planning for fish passage structures to optimize results based on seasonal flow and temperature conditions associated with upriver fish movement on the upper Ohio River.

Aerial images of dams and locks used as background in figures in this report date from 07 April 1993 and *do not represent actual gate openings or river conditions during these three surveys*. Approximate gate openings, and approximate and measured flows (cfs) are provided for each site per survey (see text regarding "gate openings" and Tables 5, 10, and 15). Gate numbering sequences (in ascending order; gate #1, 2, 3…) at both Emsworth and Montgomery start at the navigation locks and proceed across the entire river (Dashields is a fixed-crest dam, i.e., without gates). Actual dam gate openings are somewhat apparent and portrayed by figures providing Acoustic Doppler Current Profiles (ADCP; see: Figs. 9-12, 21-24, and 33-36).

Relatively few fish were detected below any site, with most detected below Montgomery Dam. These preliminary surveys did not reveal fish using specific areas in any of the three tail-waters; rather, ADCP results indicate that fish were seeking areas of lower velocity with changing flows.



Pittsburgh Acoustic Fish Surveys October 2008 – June 2009

Conducted for the
U.S. Army Corps of Engineers – Pittsburgh District

Conducted by the
U.S. Army Corps of Engineers – St. Louis District

Data analysis performed by Aquacoustics, Sterling, Alaska

Pittsburgh Acoustic Fish Surveys October 2008 – June 2009

Introduction

Improving upriver fish passage through dams is recognized as an important way to restore river ecosystems. Some of the dams in the system may impose complete barriers to upriver fish passage except through the navigation locks. Opportunity for upriver fish passage through the navigation dams depends on hydraulic conditions at the dams, fish behavior and fish swimming abilities. Downriver fish passage can occur through the locks and the gated sections of the dams.

The general goal of the fish passage project is to increase opportunity for upriver fish passage at Emsworth Main Channel Locks and Dam, Emsworth Back Channel Dam, Dashields Locks and Dam, and Montgomery Locks and Dam. Increasing access to upriver habitats should result in a proliferation in the size and distribution of native migratory fish populations. Migratory fishes are defined as a species that have major annual movements to spawning, foraging, or wintering habitats within the river system.

This report describes the results of preconstruction fish surveys performed in fiscal year 2009, the first year of study, at Emsworth Main Channel Locks and Dam, Emsworth Back Channel Dam, Dashields Locks and Dam, and Montgomery Locks and Dam. The purpose of these surveys is to provide background information on fish location, abundance and size distribution in an area designated for future fish passage improvements. Background aerial photos in the figures are dated April 7, 1993, and do not represent the actual gate openings or river conditions transpiring during the fish surveys.

Realities and Constraints of Monitoring

The problem of fish passage is systemic. The projects at Emsworth Main Channel Locks and Dam, Emsworth Back Channel Dam, Dashields Locks and Dam, and Montgomery Locks and Dam would contribute to the alleviation of serial disconnectivity, but by themselves would not fix the problem and eliminate the need for systemic fish passage. Systemic monitoring of fish populations goes beyond the scope of the monitoring effort in fiscal year 2009.

Objectives for measuring success of the fish passageways needs to be identified through informed discussion between river resource managers and fisheries biologists. The strongest bioresponse indicator would likely be identified through monitoring. Preconstruction monitoring utilizing mobile hydroacoustic sampling methods can show the abundance and distribution of aggregations of fishes in the tailwaters. Changes in these aggregations would be quantified at various times of the year. This purported change in abundance could be used to establish the baseline condition for change by which the fish passage alternative's effectiveness could be measured.

Fiscal Year 2009 Scope of Work

Preconstruction monitoring activities in fiscal year 2009 involved hydroacoustic monitoring in tailwater areas. Determining the locations in tailwaters where fishes aggregate is important in situating fishway entrances and in identifying feasible alternatives. The locations, numbers, and relative size structure of fish aggregations in the tailwater areas were surveyed using mobile hydroacoustic equipment. The species composition and size structure of the fish aggregations were not determined. Hydraulic conditions were sampled concurrently with the hydroacoustic fish surveys using an acoustic Doppler current profiler (ADCP) system. Mobile hydroacoustic fish surveys, coupled with ADCP, provide spatially explicit information about where fish aggregate in the tailwaters for use in designing fishway entrances. Information about the species and length frequency of fish aggregations in the tailwater is needed to supplement the hydroacoustic survey information that provides only numbers and relative size of fish.

Methods

Preconstruction hydroacoustic fish surveys were conducted by the St. Louis District for the Pittsburgh District in October 2008, April 2009, and June 2009. All hydroacoustic data were collected from the *Motor Vessel Boyer (M/V Boyer).*

Fish survey data were only collected downstream of the dams. These data were analyzed by Aquacoustics, Inc. of Kenai, Alaska. All acoustic data were collected with a BioSonics DTX system with a 200 kHz split-beam transducer at 10 pps, 0.3 msec pulse width, and -70dB threshold.

Acoustic data were processed with SonarData EchoView software. Fish tracks (i.e. groups of echoes returned by an individual fish) were detected with EchoView's implementation of the α,β-tracking algorithm. Fish tracks were displayed on the echogram, reviewed and edited where necessary (e.g., echoes were added or removed, partial tracks belonging to one fish were merged, merged tracks of more than one fish were split). After the review was completed, a fish database was exported that contained target strength (TS), positional information (geographic coordinates and depth) and transect segment ID for each individual fish that was detected. In addition, a transect segment database was exported with the geographic coordinates of the midpoint of each 10-m segment.

For each transect segment, fish density values were calculated as follows: Each observed fish was weighted by the (nominal) width of the beam at the range of the fish. The weighted fish count was then summed over each segment and divided by the segment length:

$$D_i = \frac{\sum_j \frac{1}{b_j}}{l_i}$$

where D_i is the fish density (fish/m^2) of segment i, the summation is over all fish j observed in segment i, b_j is the beam diameter (m) at range of fish j, and l_i is the length (m) of segment i.

ArcView was used to map transect segments and their density values. The survey area was divided into strata based on fish density distribution patterns and physical structures (e.g., lock chamber, walls). Segments belonging to the same stratum were pooled to calculate an overall fish density estimate and confidence intervals for each stratum. Certain strata were not investigated during all surveys as water conditions in some areas were too shallow to accommodate the *M/V Boyer*.

Fish size information needs to be interpreted with caution, given the absence of data on the relationship between the physical size and the acoustics size of the species detected. With a split-beam system, the acoustic size (target strength) of fish relates primarily to the fish size, however the relationship can differ by species. Love's any aspect equation:

$$\text{Fish length (cm)} = 10^{((TS+69.23)/20)}$$

was used to convert fish acoustic size to length, where TS is the mean acoustic target strength for all targets from a fish. The length was then converted from centimeters (cm) to inches for this report. Fish with a converted length equal to or greater than 40 inches were reported as 40 inches because these sizes of fish lay outside the bounds of Love's regression.

Pool and tailwater stages were obtained online from RiverGages.com data mining. Water temperature was measured during the hydroacoustic surveys. Gate openings and flows (cfs) were obtained from the USACE Pittsburgh District.

Results

28-29 October 2008

The surveys conducted on 28-29 October 2008 showed low densities at all survey locations and strata. Densities were below 1 fish per 10 hectares at all sites. Emsworth Main Channel fish were concentrated in the tailwater spillway (strata 2) near the left descending bank (Figure 1), while fish at Emsworth Back Channel were dispersed downriver along the right descending bank (strata 3) (Figure 2). Fish at the Dashields Locks and Dam were concentrated in the mid-channel tailwater (strata 2) as well as along the right descending bank (strata 5) (Figure 3), and those at Montgomery Locks and Dam were concentrated in the tailwater spillway along the right descending bank (strata 2) as well as the downstream area of the right descending bank (strata 5) and the mid-channel (strata 4) (Figure 4). Fish abundance and spatial distributions are shown in Tables 1 – 4 and Figures 1 – 4.

The fish size distribution is shown in Figures 5 - 8. Most fish at the Emsworth sites are 20-30 inches and smaller, while those at the Montgomery and Dashields tailwater locations are greater than 20 inches.

Acoustic Doppler Current Profile (ADCP) displays showing velocity distribution for each dam are shown in Figures 9 –12. Water conditions for each dam are shown in

Table 5. Dam gate openings at the time of the surveys were as follows: Emsworth Main Channel Locks and Dam 3' (0-0-0-1-1-0-0-1); Emsworth Back Channel 2' (1-0-0-0-0-1) (10/28/2008); Dashields Locks and Dam (no gates); Montgomery Locks and Dam 4' (0-0-0-0-2-2-0-0-0-0).

Table 1. Emsworth Main Channel Locks and Dam tailwater fish population estimate October 2008.

Strata	Location	Hectares	Mean density (fish/m²)	Lower CI	Upper CI	Population estimate	Lower 95%	Upper 95%
1	lock	1.08	0.008	0.000	0.017	87	0	184
2	spill	6.09	0.098	0.034	0.199	5,969	2,071	12,120
3	spill shallow	1.16	0.000	0.000	0.000			
4	left bank	1.75	0.009	0.000	0.035	157	0	611
5	left bank shallow	1.98	0.000	0.000	0.000			
6	mid-channel	8.74	0.004	0.001	0.010	350	87	874
7	mid-channel shallow	1.48	0.000	0.000	0.000			
8	right bank	3.70	0.005	0.000	0.011	185	0	407
		25.98				**6,747**		

Table 2. Emsworth Back Channel Dam tailwater fish population estimate October 2008.

Strata	Location	Hectares	Mean density (fish/m²)	Lower CI	Upper CI	Population estimate	Lower 95%	Upper 95%
1	spill	2.98	0.002	0.000	0.008	60	0	238
2	shallow bar	3.39	0.000	0.000	0.000			
3	downriver	8.79	0.016	0.006	0.032	1,406	527	2,812
		15.15				**1,466**		

Table 3. Dashields Locks and Dam tailwater fish population estimate October 2008.

Strata	Location	Hectares	Mean density (fish/m²)	Lower CI	Upper CI	Population estimate	Lower 95%	Upper 95%
1	lock	1.07	0.016	0.000	0.047	172	0	505
2	spill	7.62	0.040	0.018	0.067	3,048	1,372	5,106
3	left bank	4.19	0.000	0.000	0.000	0	0	0
4	mid-channel	17.93	0.001	0.000	0.002	179	0	359
5	right bank	4.65	0.033	0.000	0.089	1,535	0	4,139
		35.47				**4,934**		

Table 4. Montgomery Locks and Dam tailwater fish population estimate October 2008.

Strata	Location	Hectares	Mean density (fish/m^2)	Lower CI	Upper CI	Population estimate	Lower 95%	Upper 95%
1	lock	0.61	0.000	0.000	0.000	0	0	0
2	spill	6.92	0.092	0.048	0.158	6,371	3,324	10,941
3	left bank	5.41	0.002	0.000	0.005	108	0	270
4	mid-channel	19.87	0.013	0.007	0.022	2,583	1,391	4,371
5	right bank	5.63	0.054	0.022	0.102	3,038	1,238	5,739
		38.43				**12,100**		

Table 5. Water conditions at the locks and dams 28-29 October 2008. Pool and tailwater stages were obtained online from RiverGages.com data mining.

Date	Pool Stage	Tailwater Stage	Flow (cfs)	Water Temperature (ºF)
		Emsworth Main Channel Locks & Dam		
10/28/08	16.8’	13.6’	9,000 (est)	53
10/29/08	16.9’	13.8’	10,000 (est)	53
		Dashields Locks & Dam		
10/28/08	13.8'	12.8'	9,000	53
10/29/08	14.0’	12.9’	10,000	53
		Montgomery Locks & Dam		
10/28/08	12.4’	13.2’	10,500 (est.)	53
10/29/08	12.5’	13.1’	11,500 (est.)	53

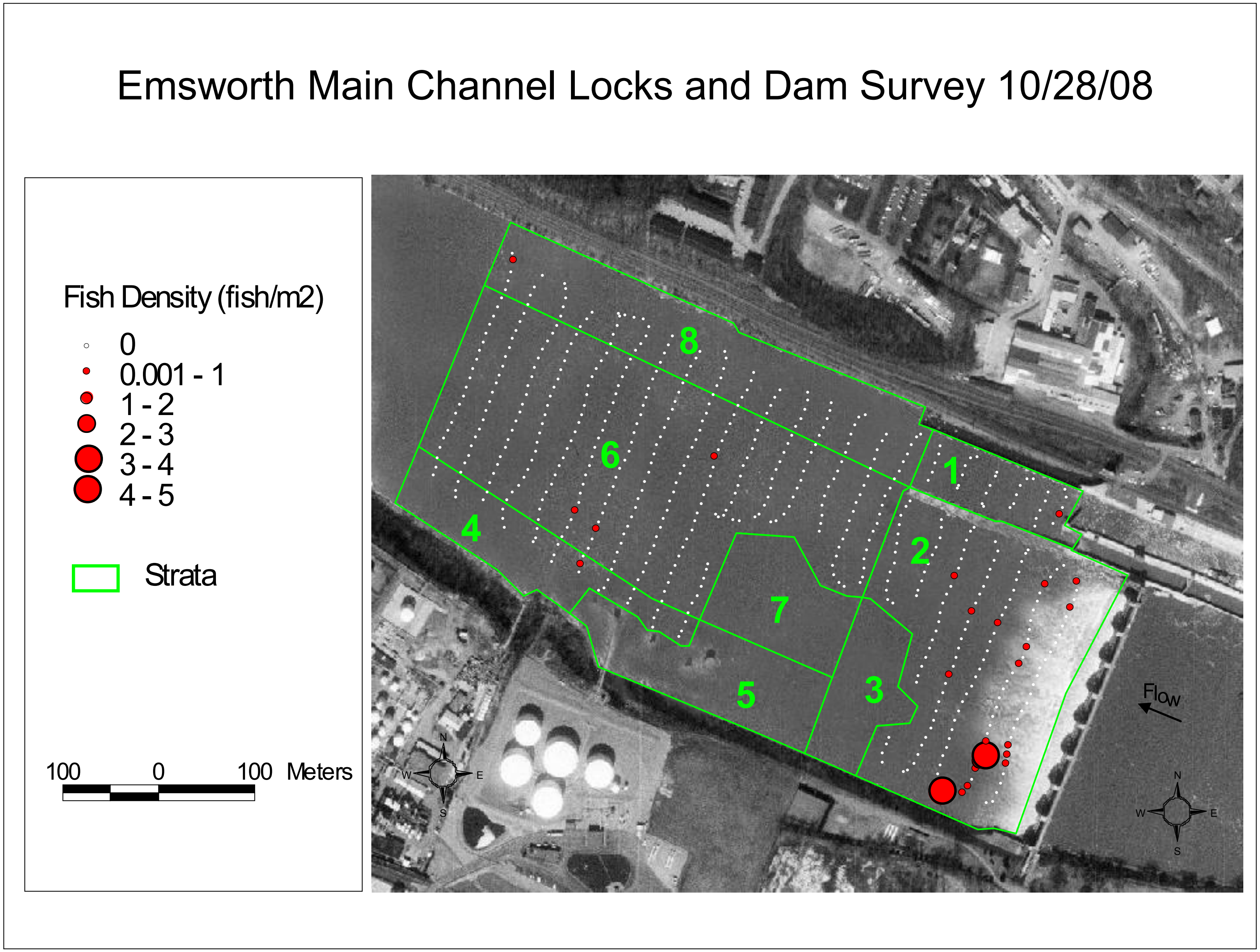


Figure 1. Emsworth Main Channel Locks and Dam fish density distribution 28 October 2008.

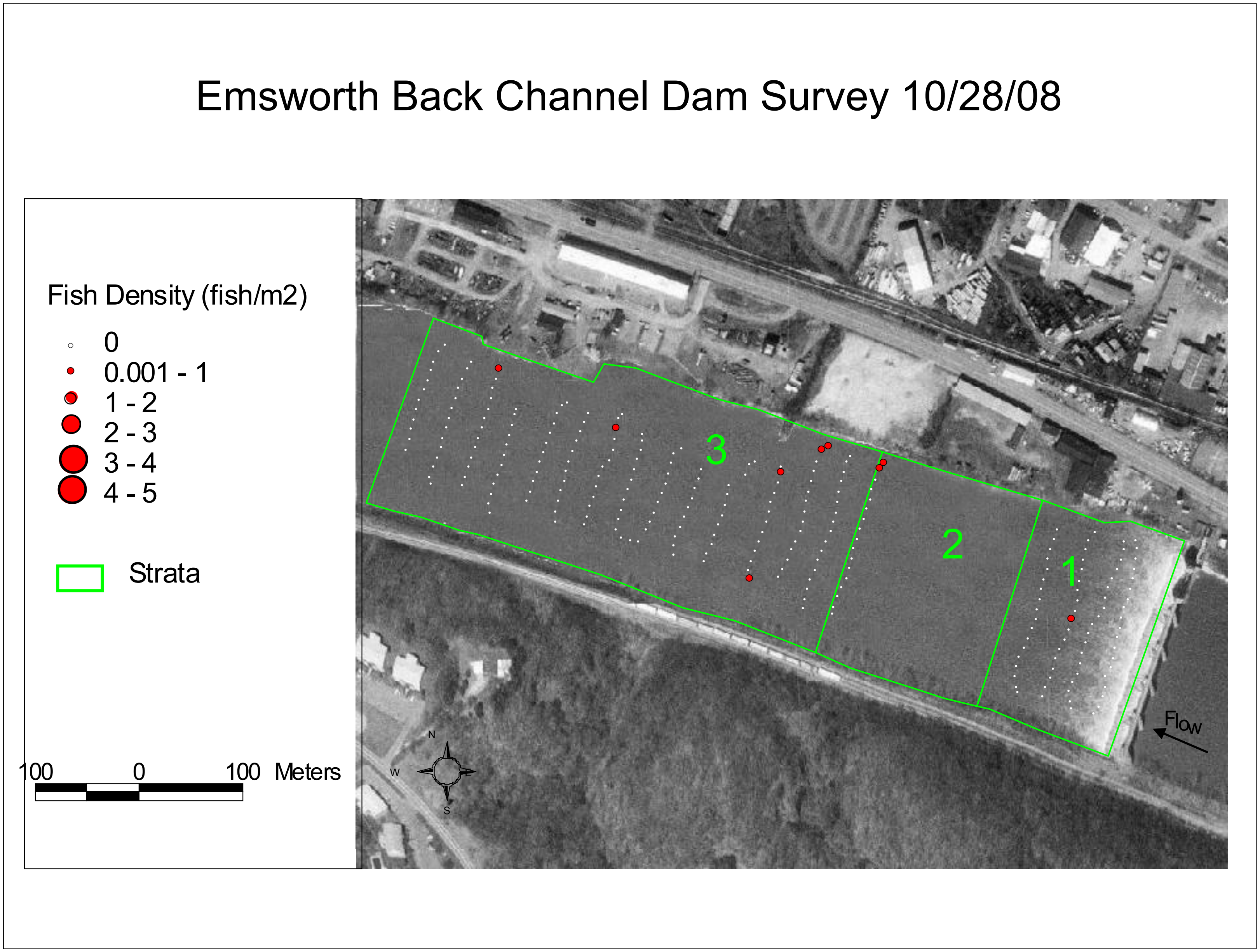


Figure 2. Emsworth Back Channel Dam fish density distribution 28 October 2008.

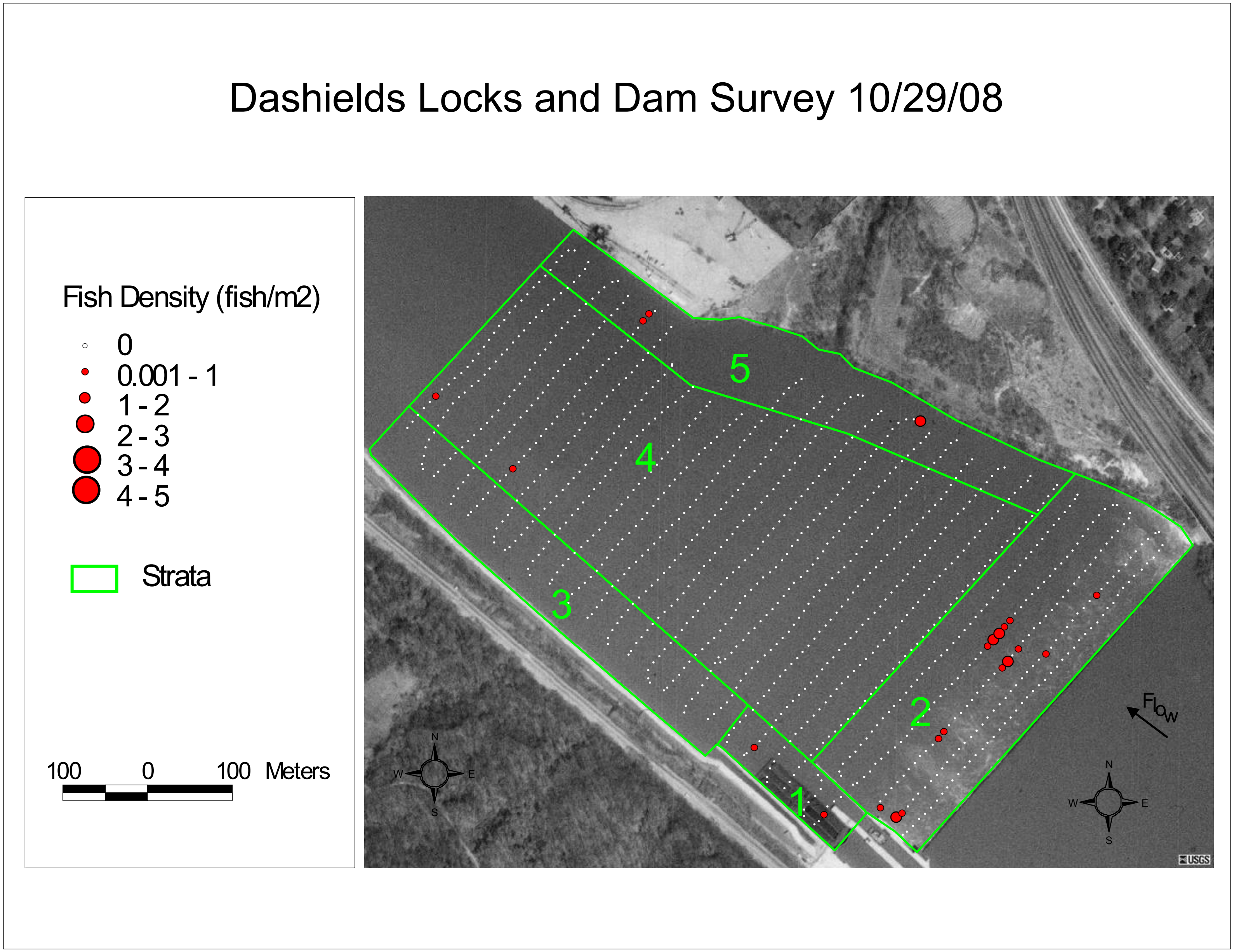


Figure 3. Dashields Locks and Dam fish density distribution 29 October 2008.

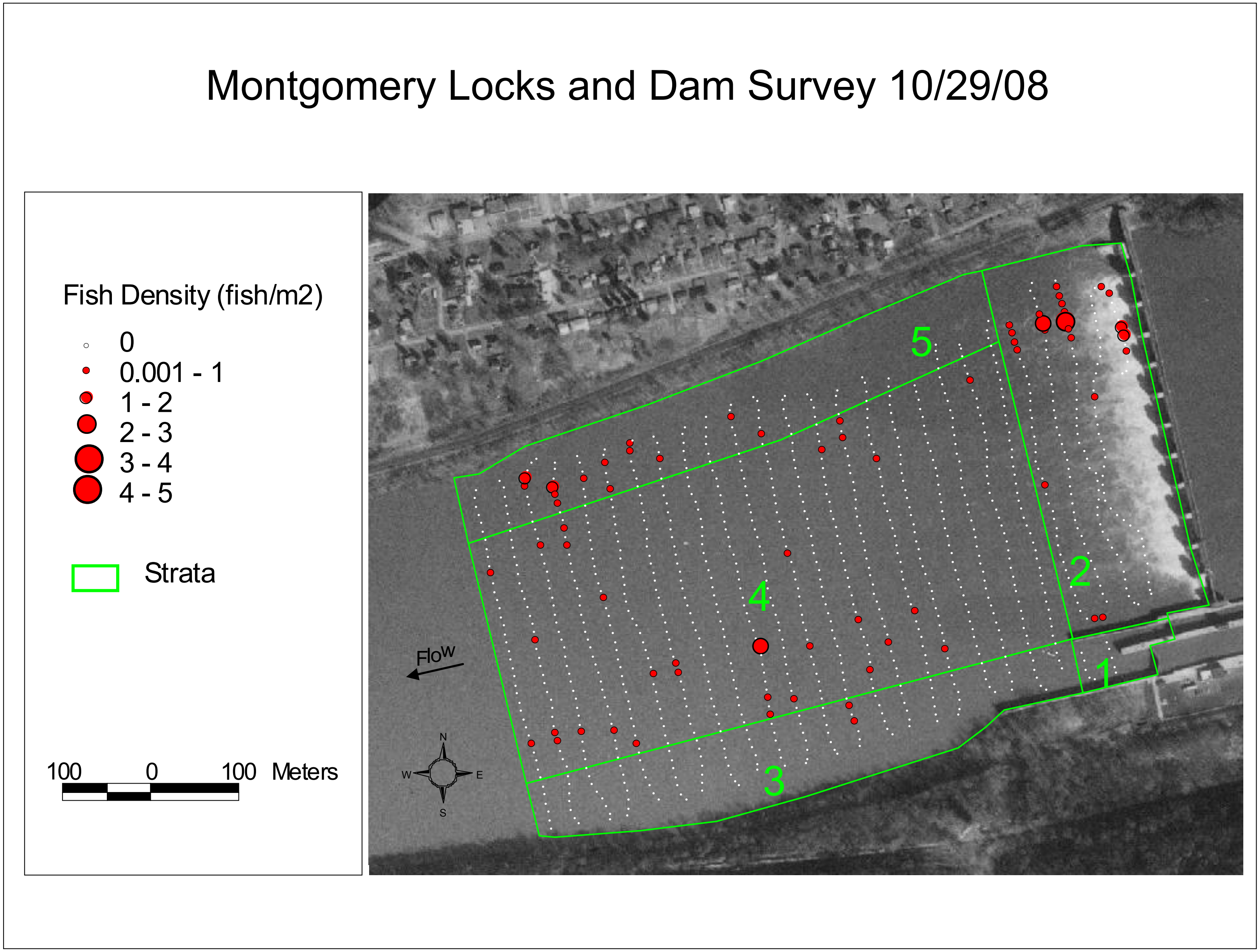


Figure 4. Montgomery Locks and Dam fish density distribution 29 October 2008.

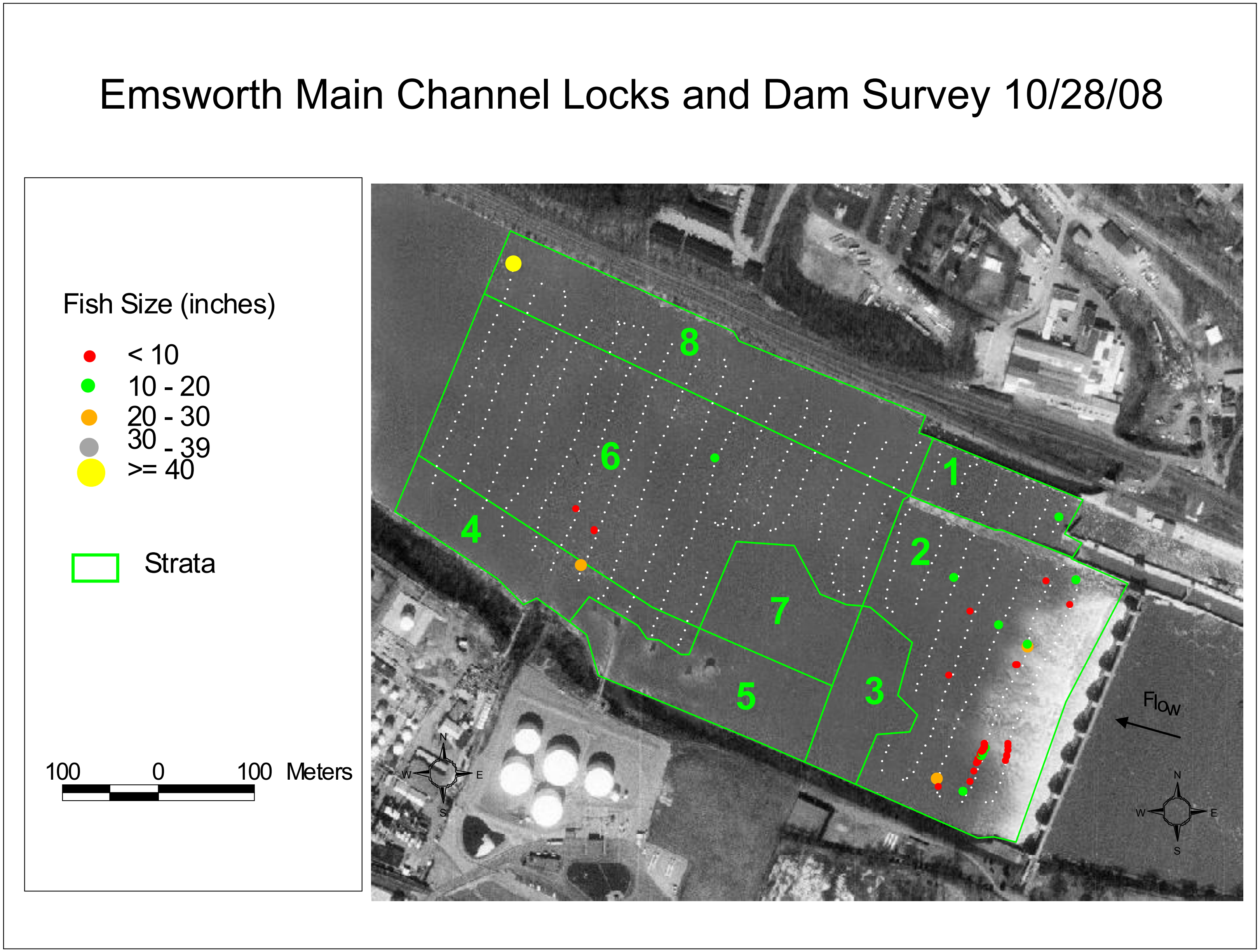


Figure 5. Emsworth Main Channel Locks and Dam fish sizes 28 October 2008.

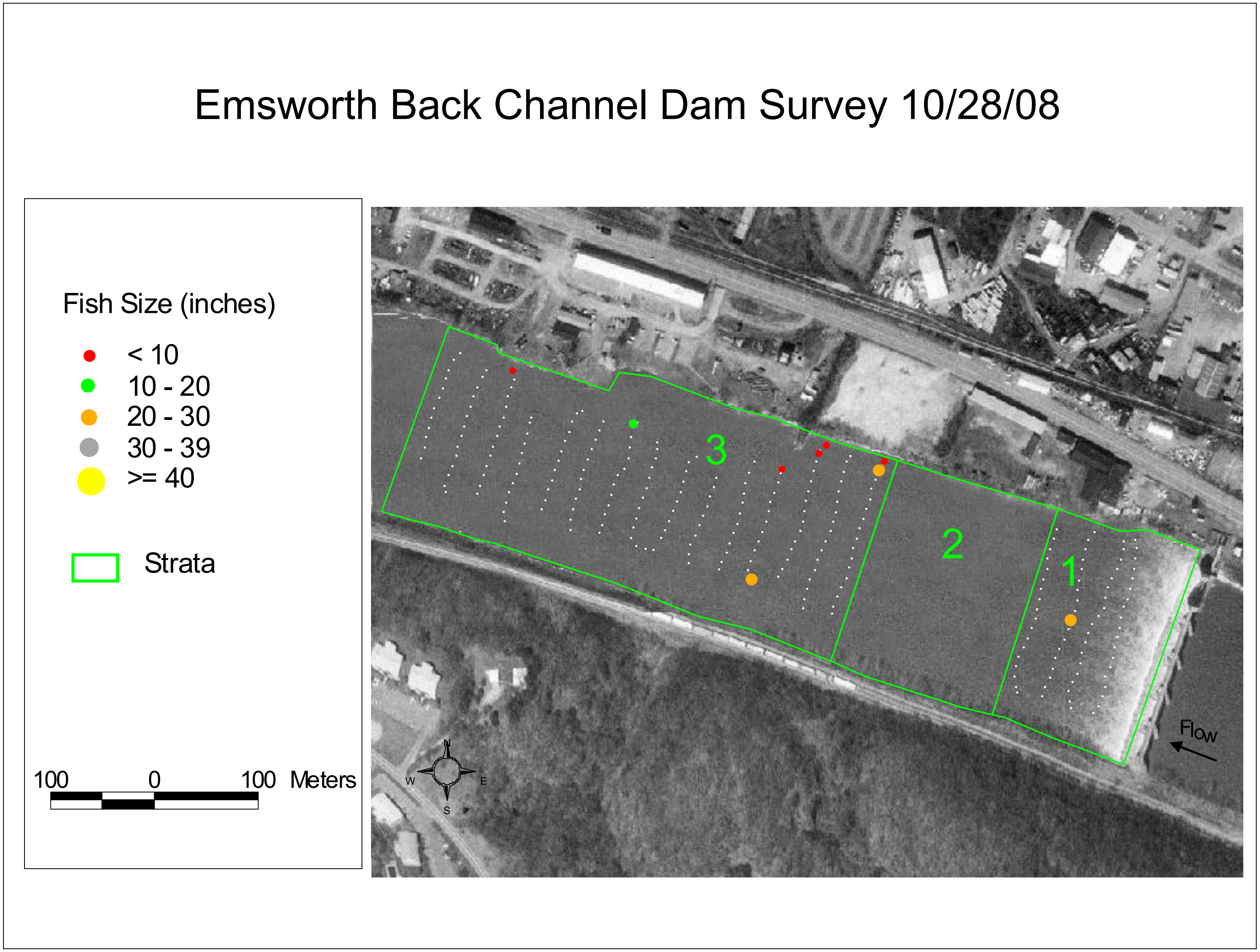


Figure 6. Emsworth Back Channel Dam fish sizes 28 October 2008.

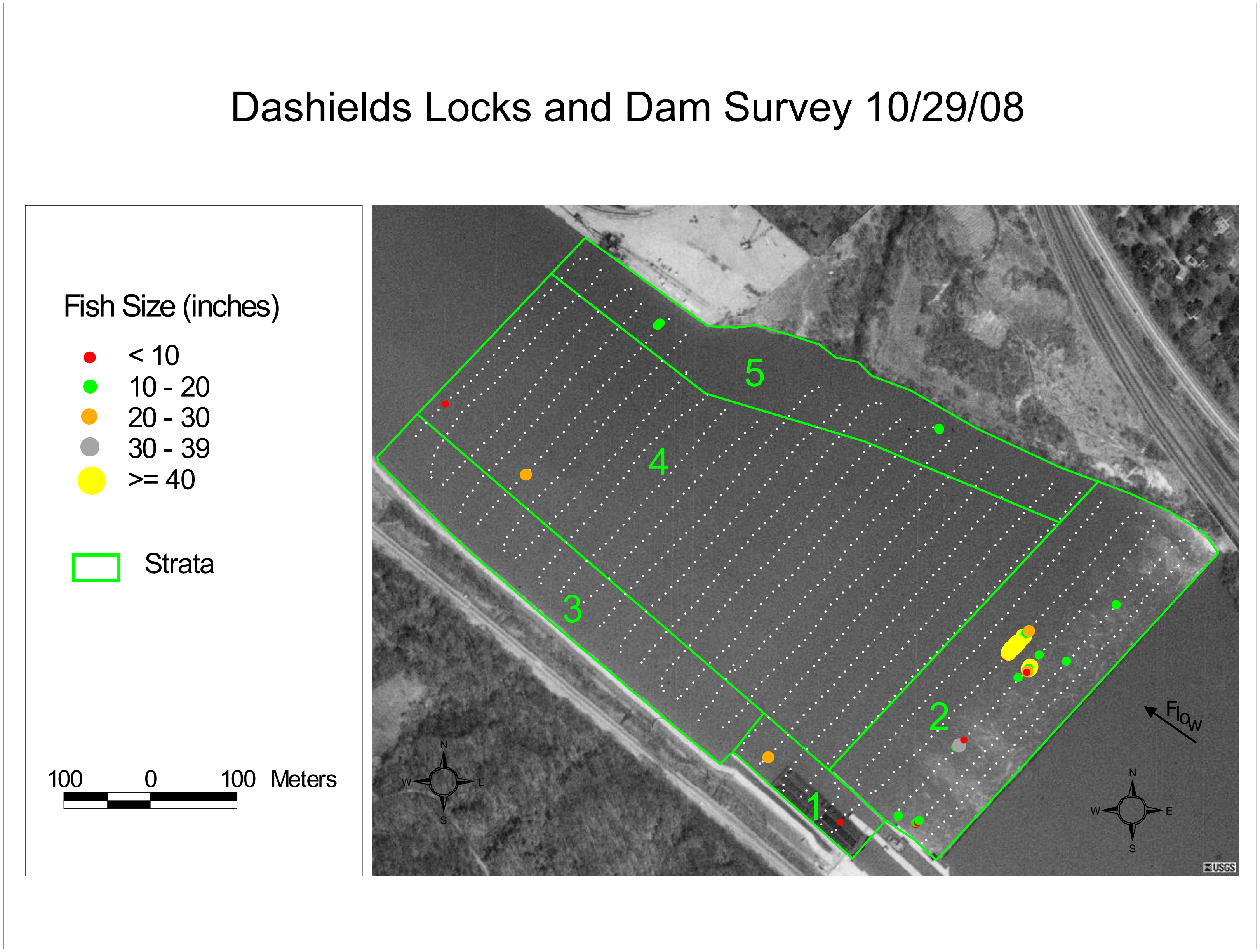


Figure 7. Dashields Locks and Dam fish sizes for 29 October 2008.

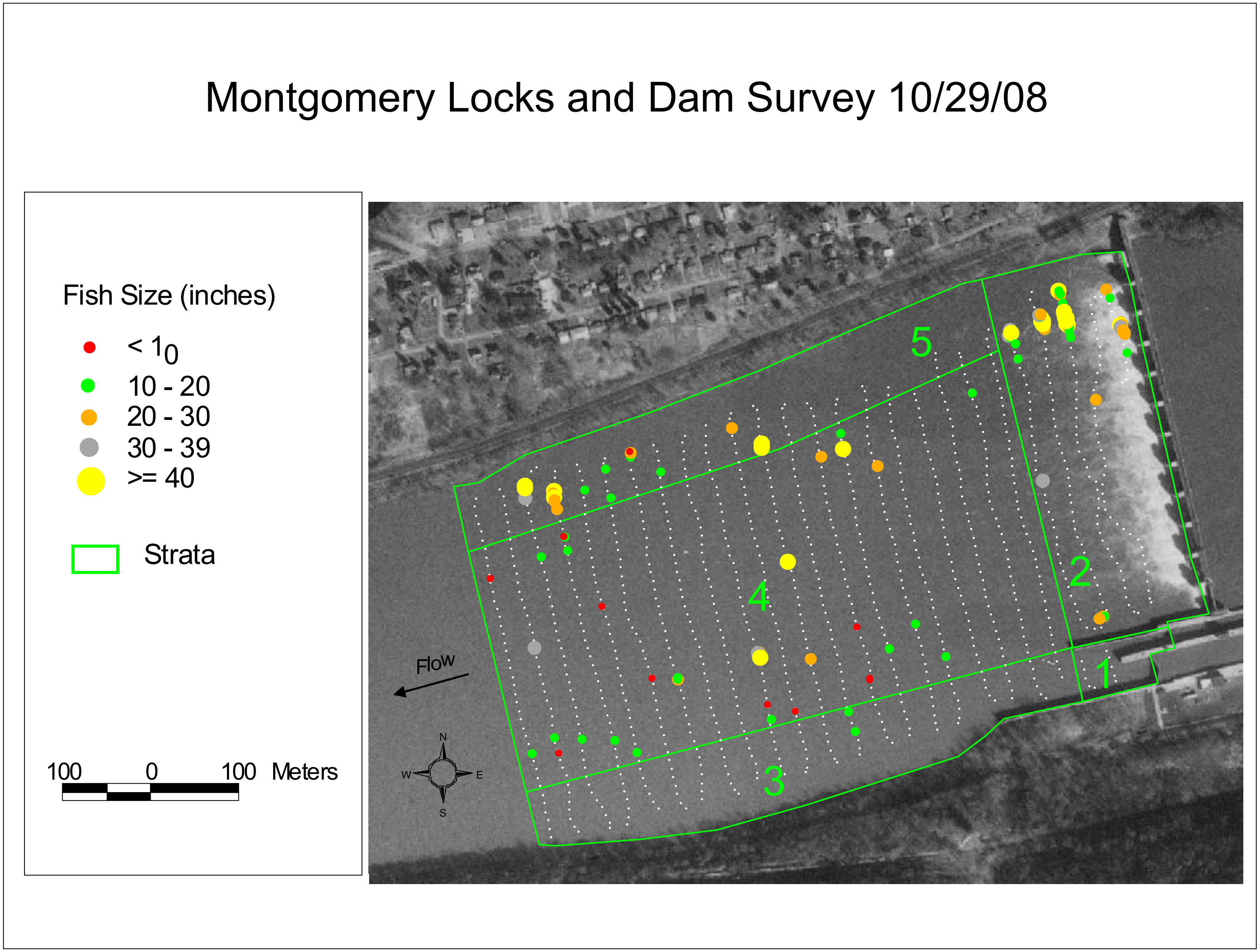


Figure 8. Montgomery Locks and Dam fish sizes 29 October 2008.

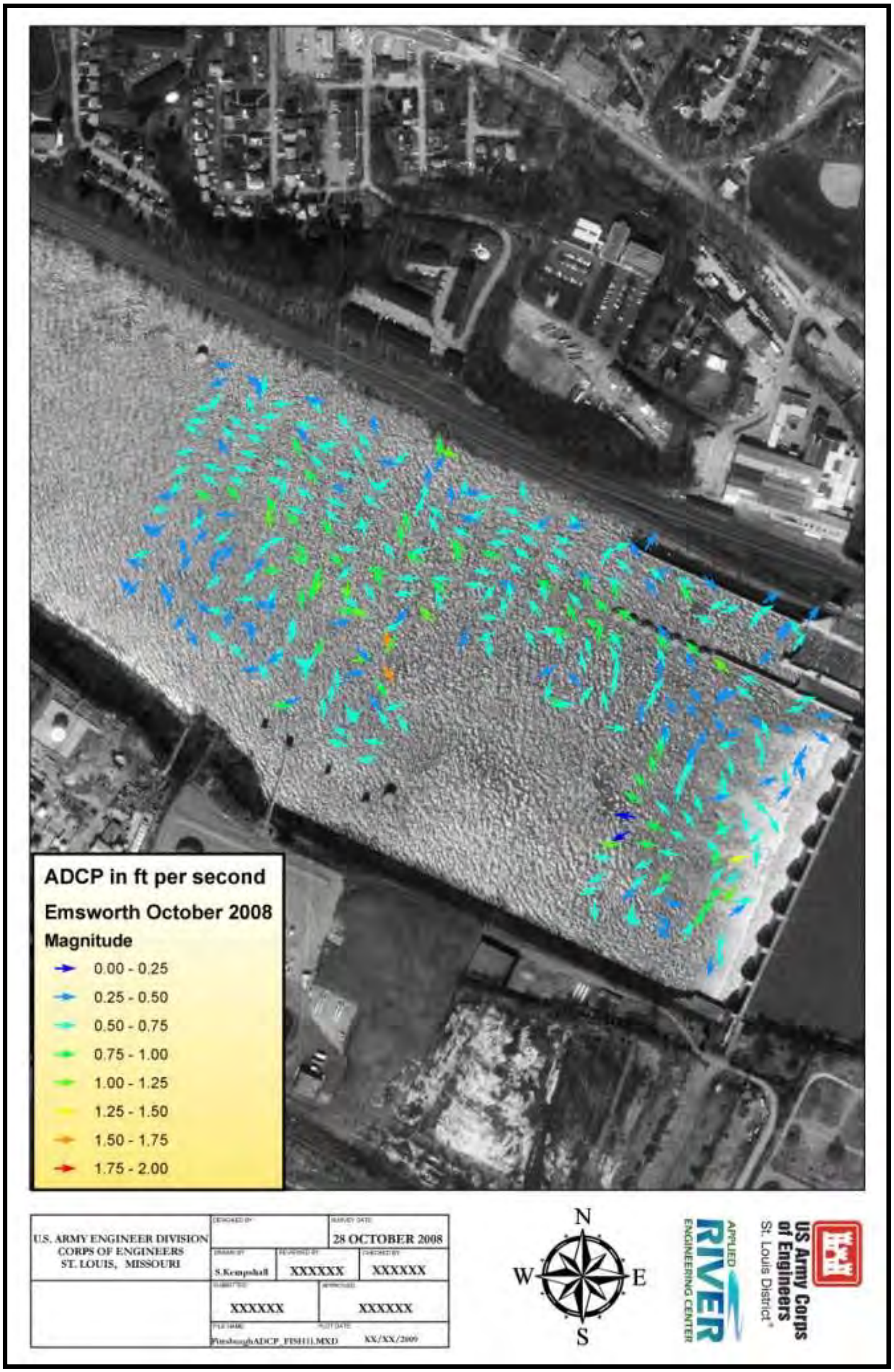


Figure 9. Acoustic Doppler Current Profile of Emsworth Main Channel Locks and Dam 28 October 2008.

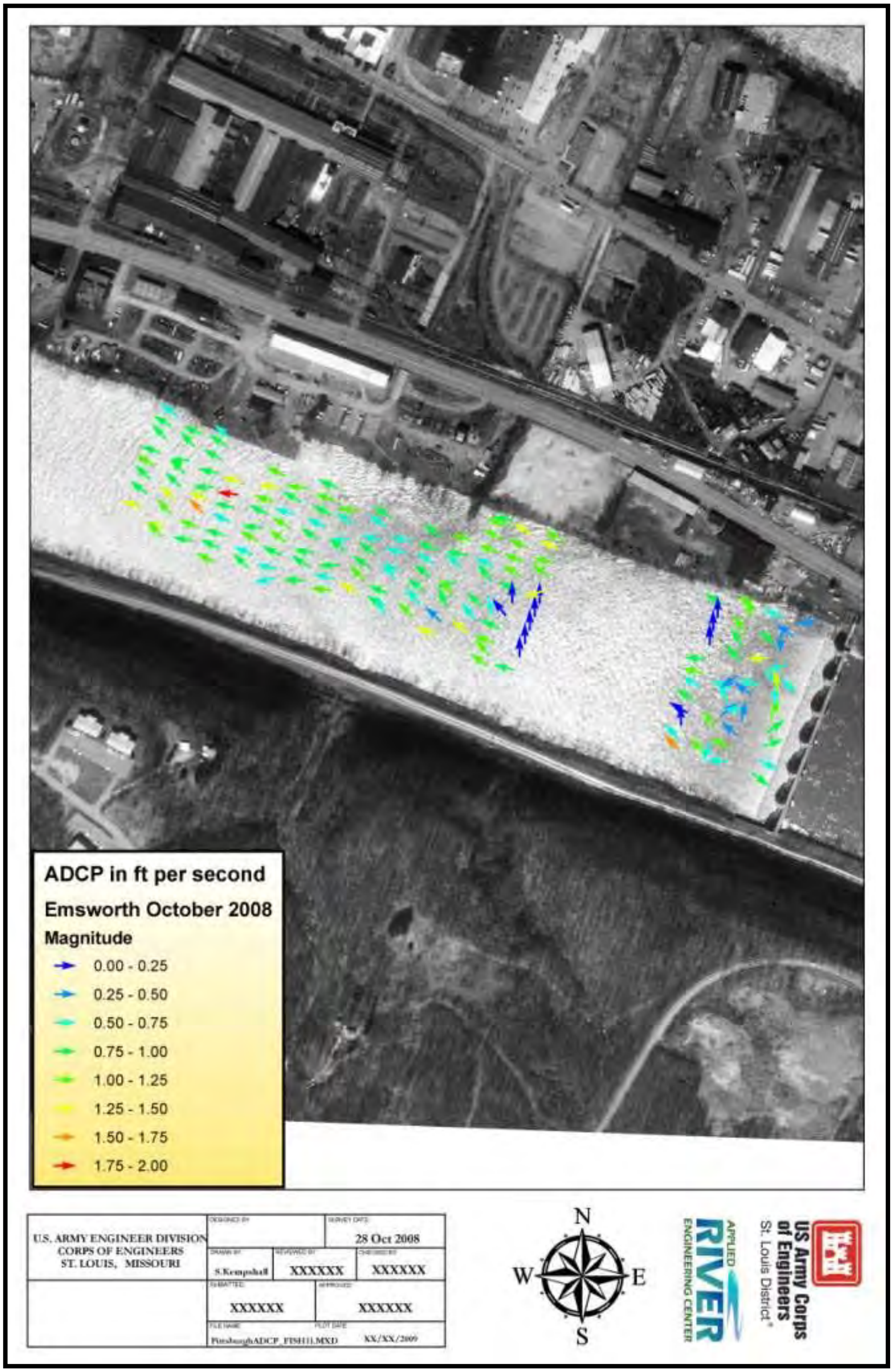


Figure 10. Acoustic Doppler Current Profile of Emsworth Back Channel Dam 28 October 2008.

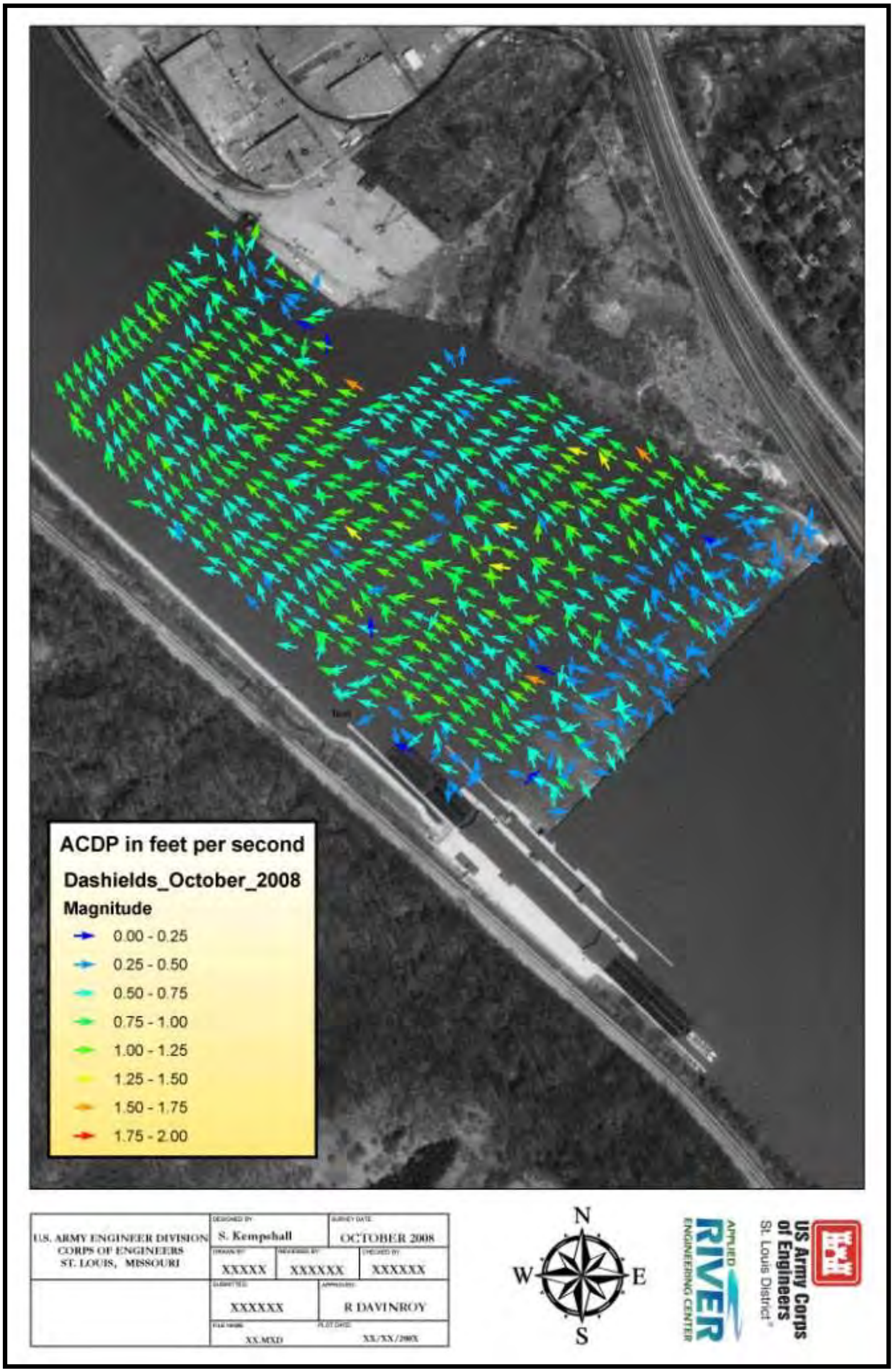


Figure 11. Acoustic Doppler Current Profile of Dashields Locks and Dam 29 October 2008.

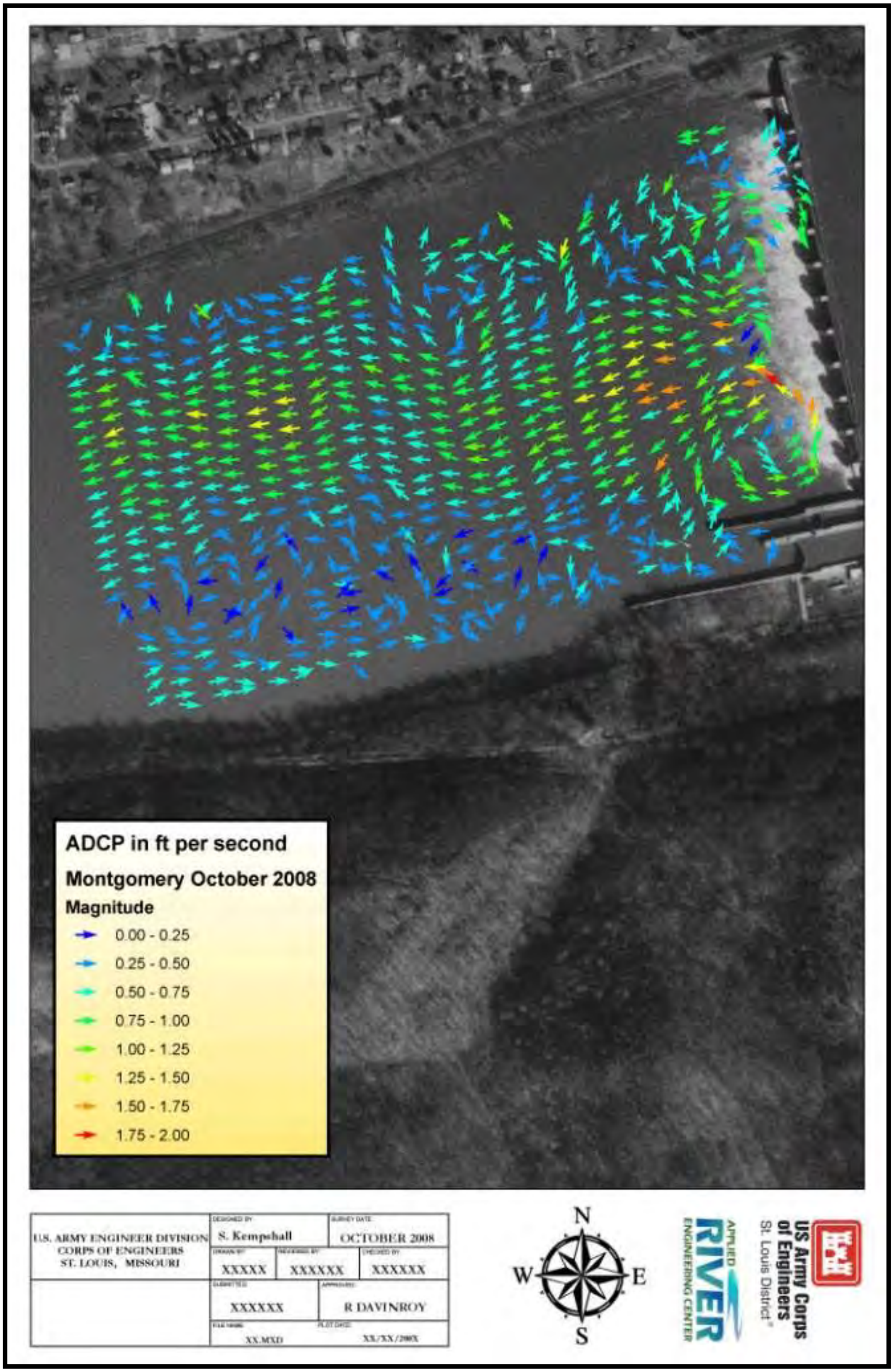


Figure 12. Acoustic Doppler Current Profile of Montgomery Locks and Dam 29 October 2008.

21-22 April 2009

Sampling locations in April 2009 were similar to October 2008 surveys, although some survey transects extended outside the preliminary strata boundaries established in October. These strata boundaries will be altered to reflect the sampling areas after additional surveys are completed. Other strata surveyed in October were not surveyed in April due to inaccessibility, such as the spillway area of the Emsworth Back Channel Dam site. Fish abundance and spatial distributions are shown in Tables 6 – 9 and Figures 13 – 17.

Few fish were detected at any of the four sites; Emsworth Main Channel Locks and Dam, Emsworth Back Channel Dam, and Dashields Locks and Dam had three, eight, and seven fish respectively, while Montgomery Locks and Dam had 90 fish. Population estimates for the four survey sites were lower in April 2009 than in the October 2008 estimates.

Fish at Emsworth Main Channel Locks and Dam were located primarily at the downstream end of the survey site along the right descending bank (strata 8) (Figure 13), while fish at the Emsworth Back Channel Dam site were located downriver (strata 3) (Figure 14). Fish at the Dashields Locks and Dam site were found along the right (strata 5) and left descending banks (strata 3), as well as near the lock (strata 1) (Figure 15). At the Montgomery Locks and Dam location, fish were disbursed primarily along the right descending bank (strata 5) and the mid-channel (strata 4) (Figure 16).

The fish size distribution is shown in Figures 17 – 20. Fish sizes in the Montgomery Locks and Dam tailwater vary in size, but most fish at the other sites are less than 10 inches.

Water conditions for each dam are shown in Table 10. Acoustic Doppler Current Profile (ADCP) displays showing velocity distribution for each dam are shown in Figures 21 – 24. Dam gate openings at the time of the surveys were as follows: Emsworth Main Channel Locks and Dam – six gates up two feet, two gates up one foot; Emsworth Back Channel – all gates up one foot; Dashields Locks and Dam – no gates; Montgomery Locks and Dam – all gates up two feet, then shut gate 1 completely at 11:00 a.m. during the survey.

Table 6. Emsworth main Channel Locks and Dam tailwater fish population estimate April 2009.

Strata	Location	Hectares	Mean density (fish/m^2)	Lower CI	Upper CI	Population estimate	Lower 95%	Upper 95%
1	lock	1.08	0.000	0.000	0.000	0	0	0
2	spill	6.09	0.000	0.000	0.000	0	0	0
3	spill shallow	1.16	0.000	0.000	0.000			
4	left bank	1.75	0.005	0.000	0.020	87	0	349
5	left bank shallow	1.98	0.000	0.000	0.000			
6	mid-channel	8.74	0.000	0.000	0.000	0	0	0
7	mid-channel shallow	1.48	0.000	0.000	0.000			
8	right bank	3.70	0.005	0.000	0.011	185	0	407
		25.98				**272**		

Table 7. Emsworth Back Channel Dam tailwater fish population estimate April 2009.

Strata	Location	Hectares	Mean density (fish/m^2)	Lower CI	Upper CI	Population estimate	Lower 95%	Upper 95%
1	spill	2.98						
2	shallow bar	3.39	0.000	0.000	0.000	0	0	0
3	downriver	8.79	0.008	0.003	0.017	703	264	1,494
		15.15				**703**		

Table 8. Dashields Locks and Dam tailwater fish population estimate April 2009.

Strata	Location	Hectares	Mean density (fish/m^2)	Lower CI	Upper CI	Population estimate	Lower 95%	Upper 95%
1	lock	1.07	0.016	0.000	0.045	172	0	484
2	spill	7.62	0.000	0.000	0.000	0	0	0
3	left bank	4.19	0.003	0.000	0.011	126	0	461
4	mid-channel	17.93	0.000	0.000	0.001	0	0	179
5	right bank	4.65	0.005	0.000	0.012	233	0	558
		35.47				**530**		

Table 9. Montgomery Locks and Dam tailwater fish population estimate April 2009.

Strata	Location	Hectares	Mean density (fish/m^2)	Lower CI	Upper CI	Population estimate	Lower 95%	Upper 95%
1	lock	0.61	0.005	0.000	0.011	30	0	67
2	spill	6.92	0.000	0.000	0.000	0	0	0
3	left bank	5.41	0.007	0.002	0.014	379	108	757
4	mid-channel	19.87	0.009	0.006	0.014	1,788	1,192	2,782
5	right bank	5.63	0.097	0.022	0.256	5,458	1,238	14,404
		38.43				**7,655**		

Table 10. Water conditions at the locks and dams 21-22 April 2009. Pool and tailwater stages were obtained online from RiverGages.com data mining.

Date	Upper Gage	Lower Gage	Flow (cfs)	Water Temperature (ºF)
		Emsworth Main Channel Locks & Dam		
4/21/09	16.5	15.5	36,000 (est.)	50
4/22/09	16.3	16.0	41,000 (est.)	50
		Dashields Locks & Dam		
4/21/09	15.5	14.3	36,000	50
4/22/09	15.7	14.2	41,000	50
		Montgomery Locks & Dam		
4/21/09	12.5	14.0	43,000 (est.)	50
4/22/09	12.5	14.3	49,000 (est.)	50

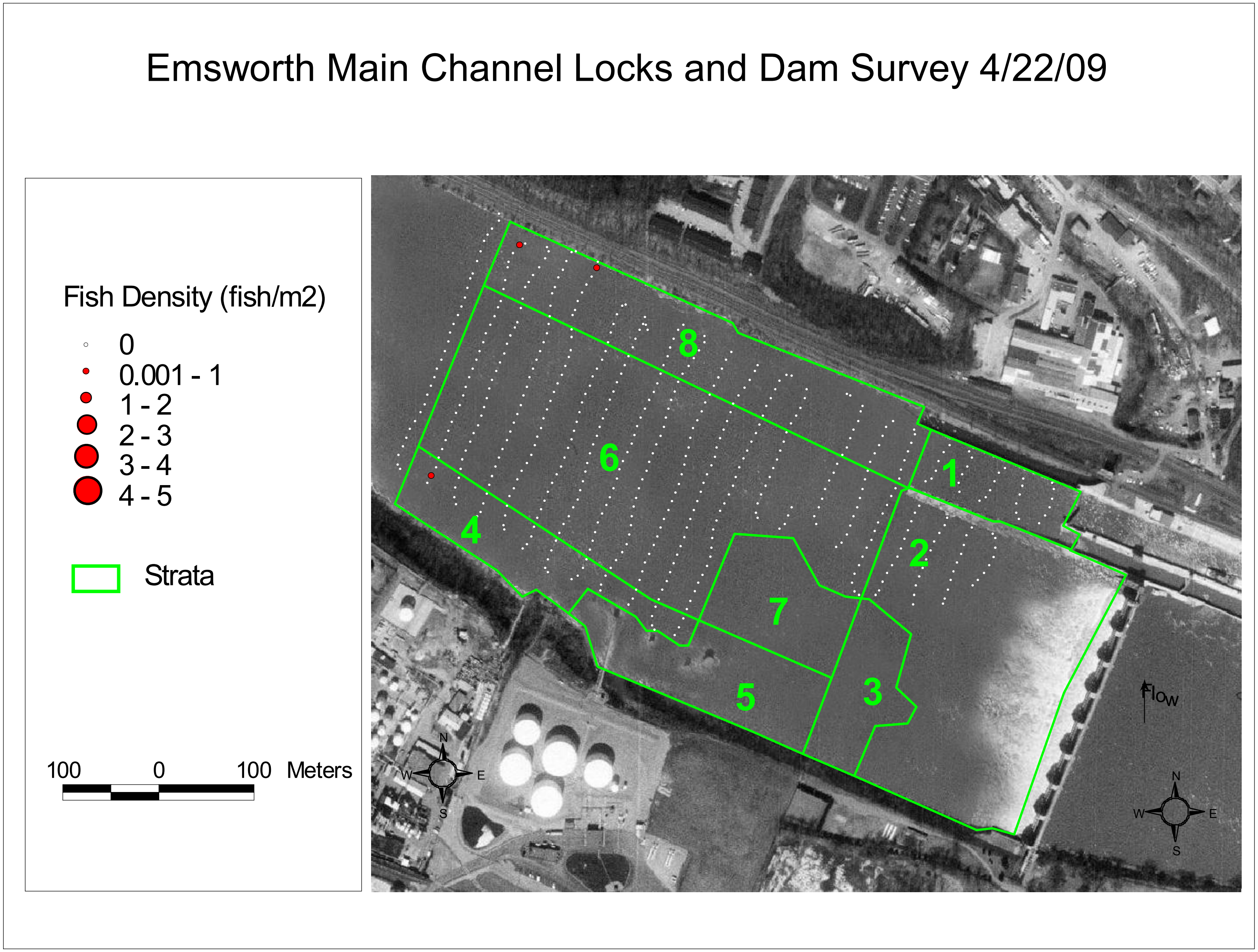


Figure 13. Emsworth Main Channel Locks and Dam fish density distribution 22 April 2009.

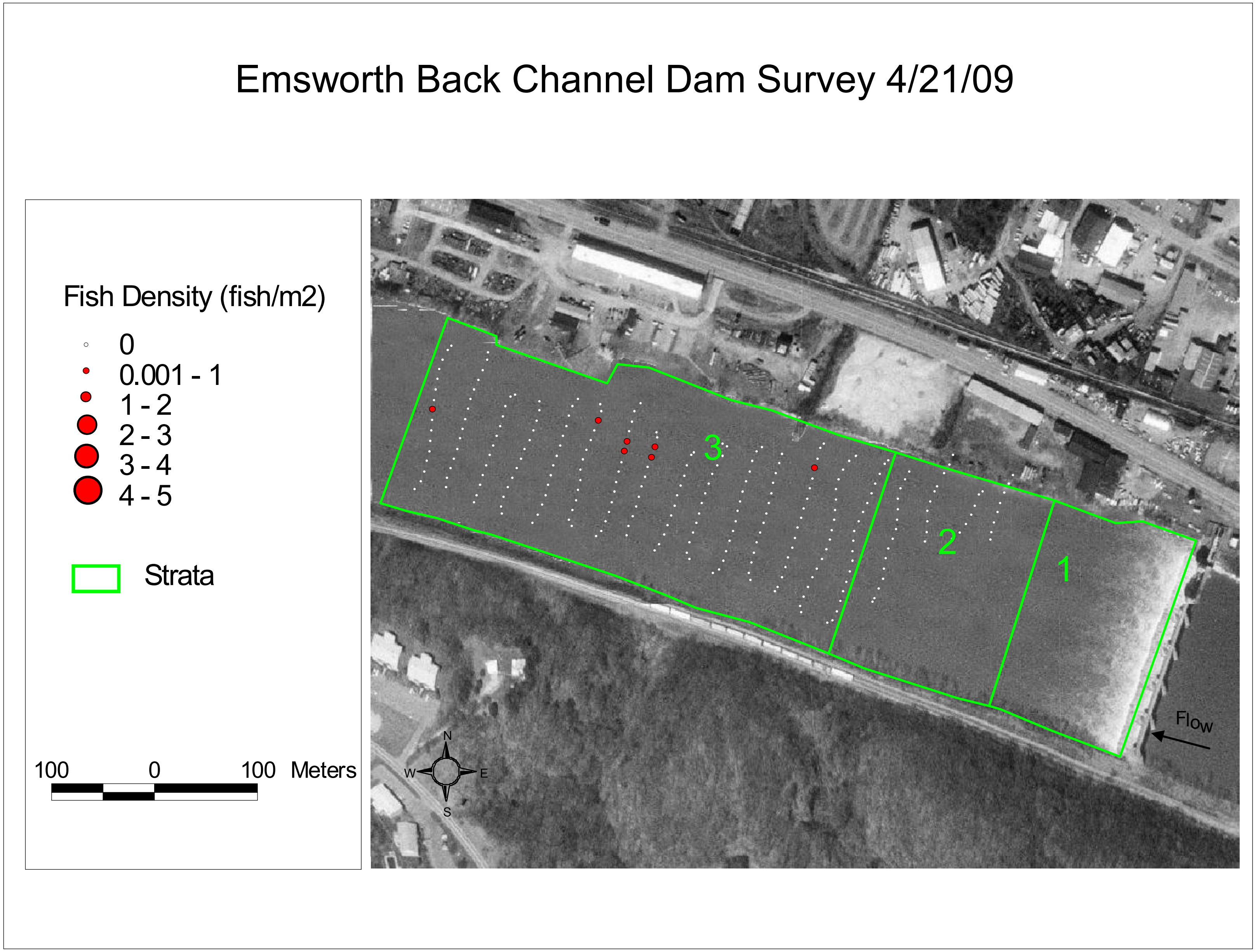


Figure 14. Emsworth Back Channel Dam fish density distribution 21 April 2009.

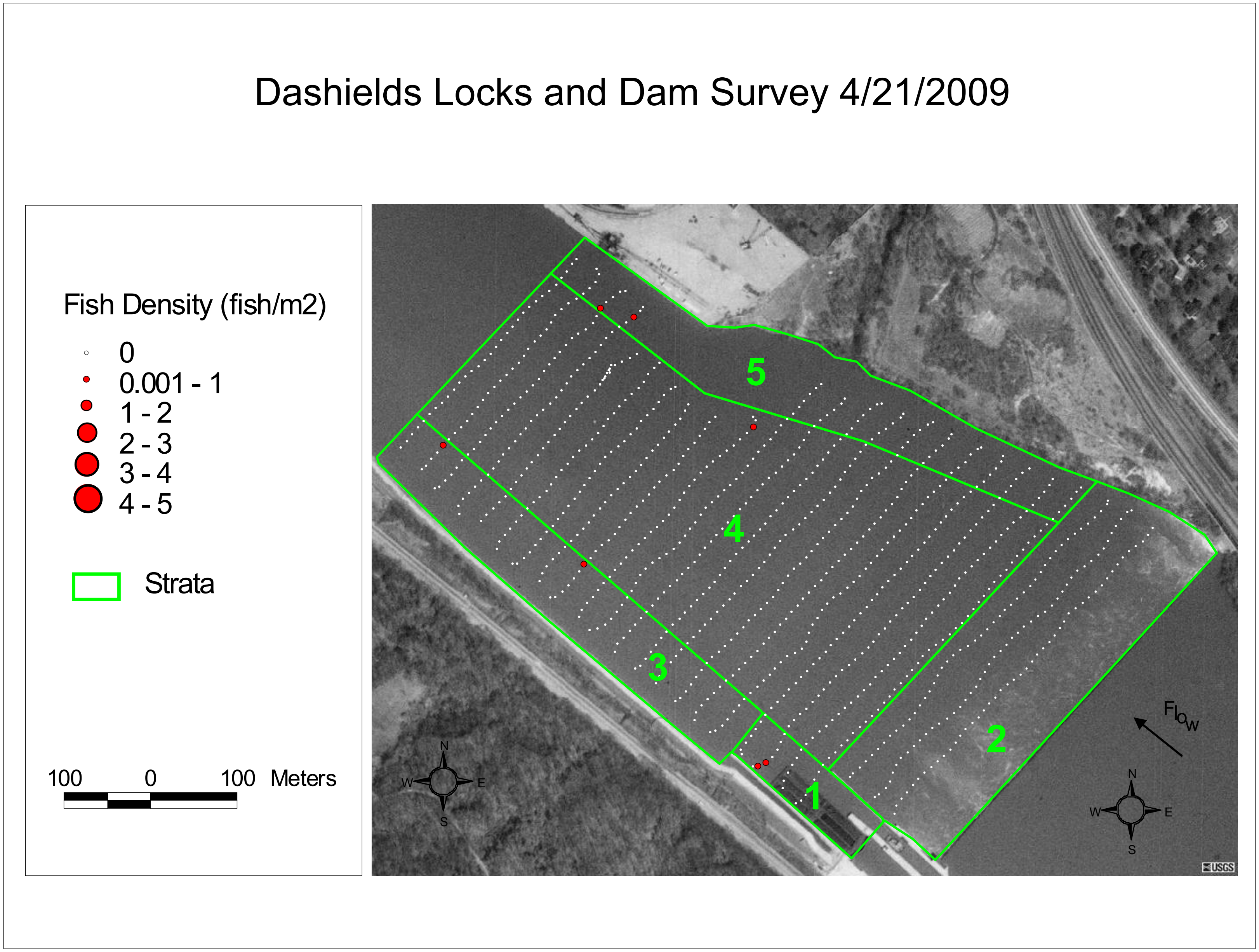


Figure 15. Dashields Locks and Dam fish density distribution 21 April 2009.

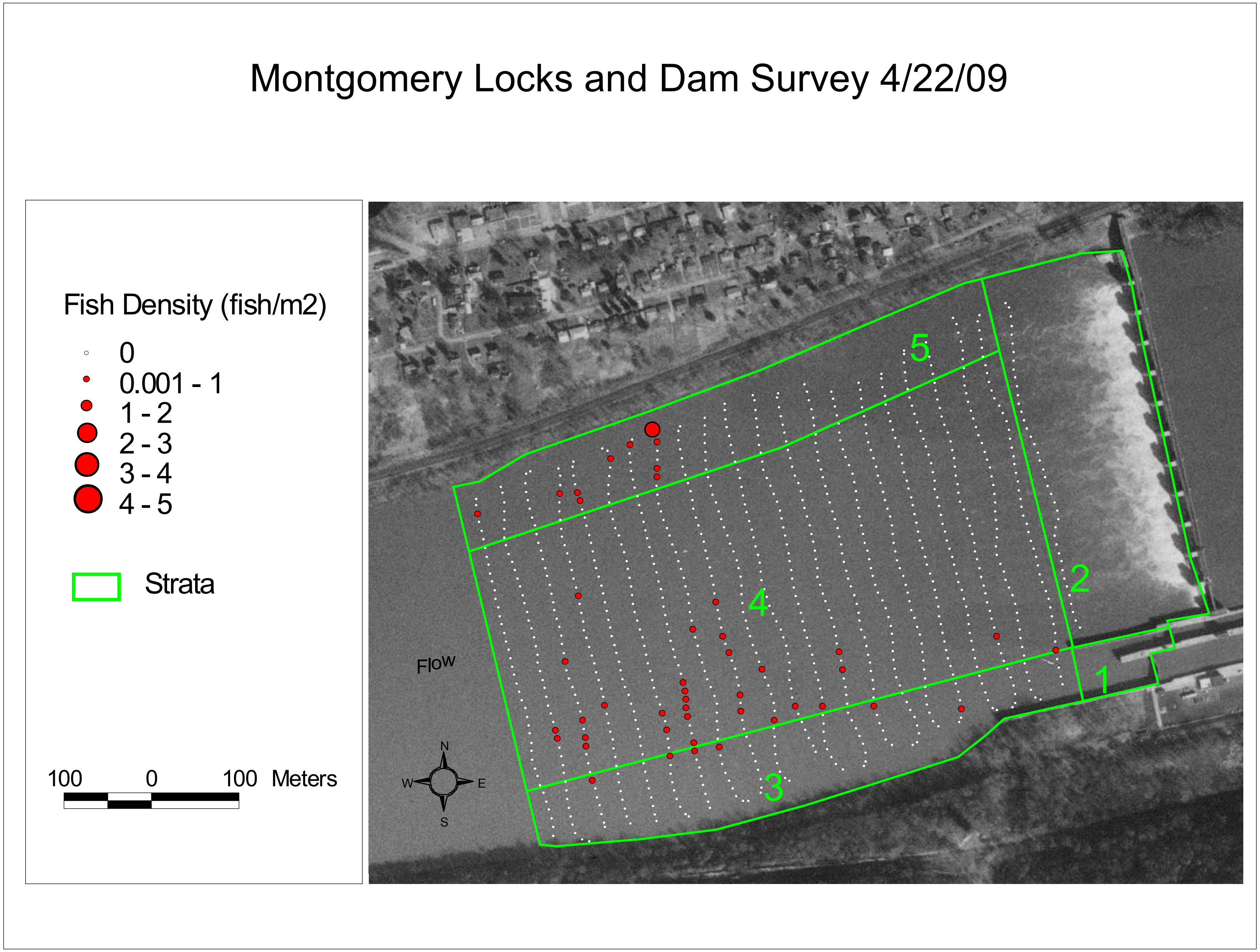


Figure 16. Montgomery Locks and Dam fish density distribution 22 April 2009.

Figure 17. Emsworth Main Channel Locks and Dam fish sizes 22 April 2009.

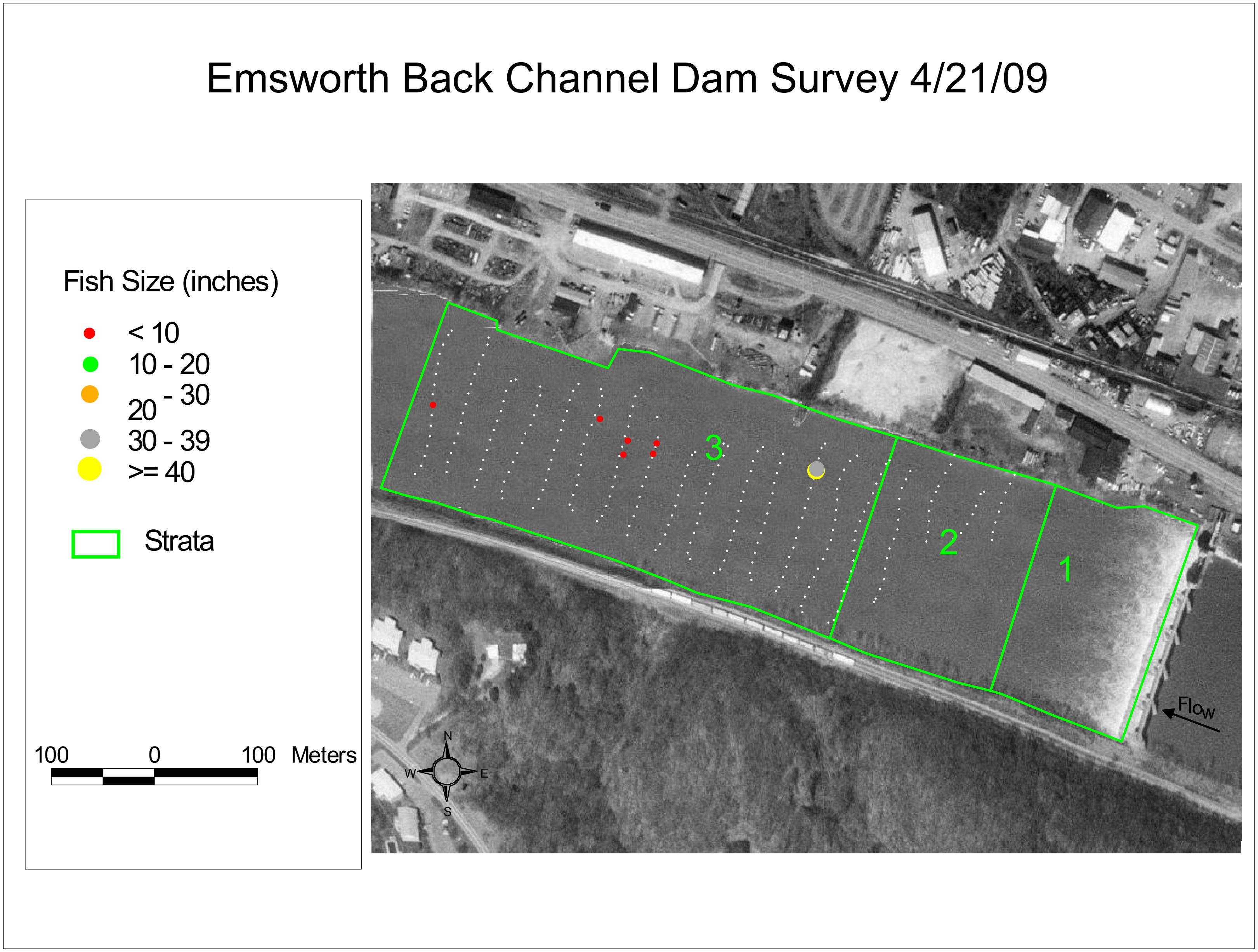


Figure 18. Emsworth Back Channel Dam fish sizes 21 April 2009.

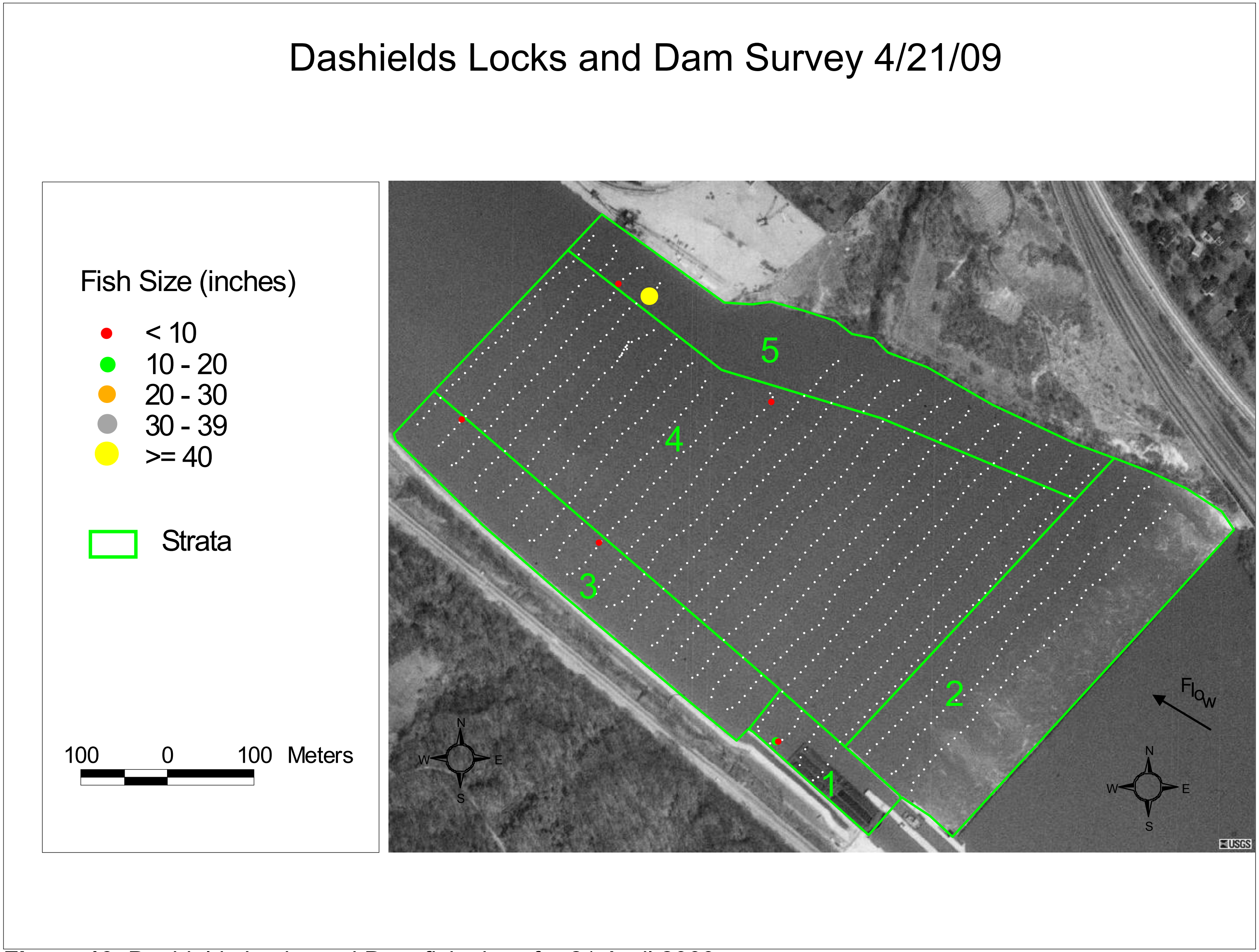


Figure 19. Dashields Locks and Dam fish sizes for 21 April 2009.

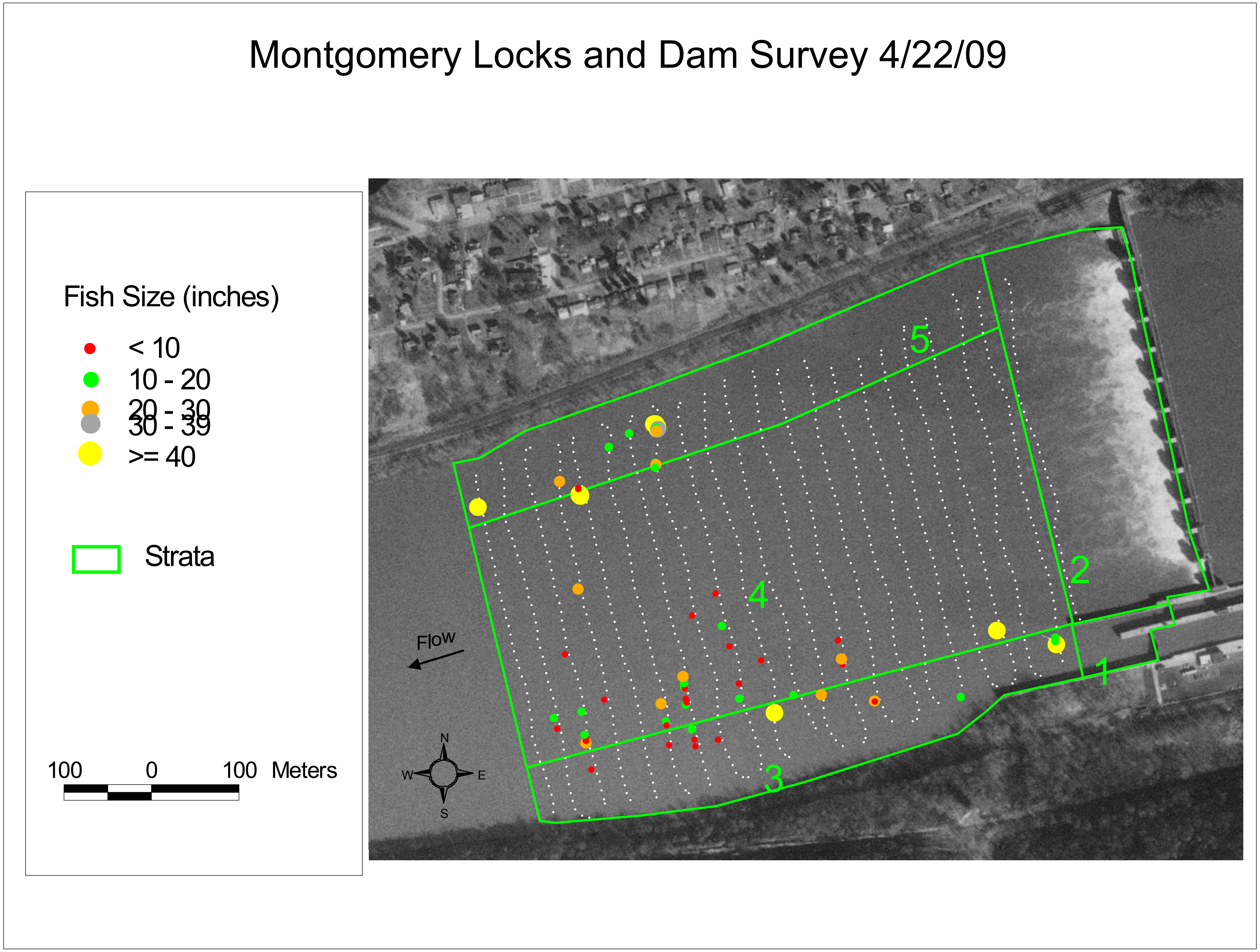


Figure 20. Montgomery Locks and Dam fish sizes 22 April 2009.

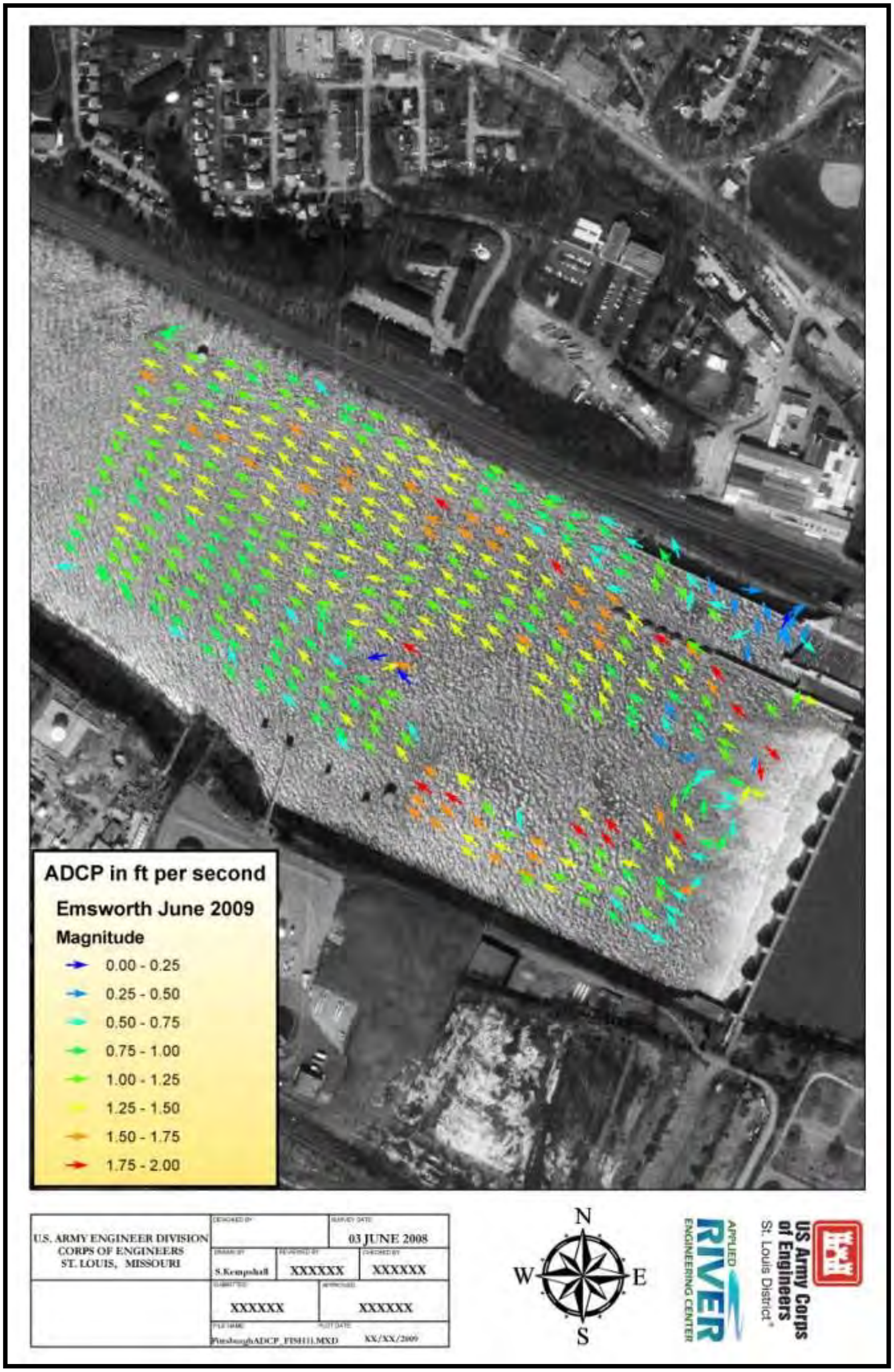


Figure 21. Acoustic Doppler Current Profile of Emsworth Main Channel Locks and Dam 22 April 2009.

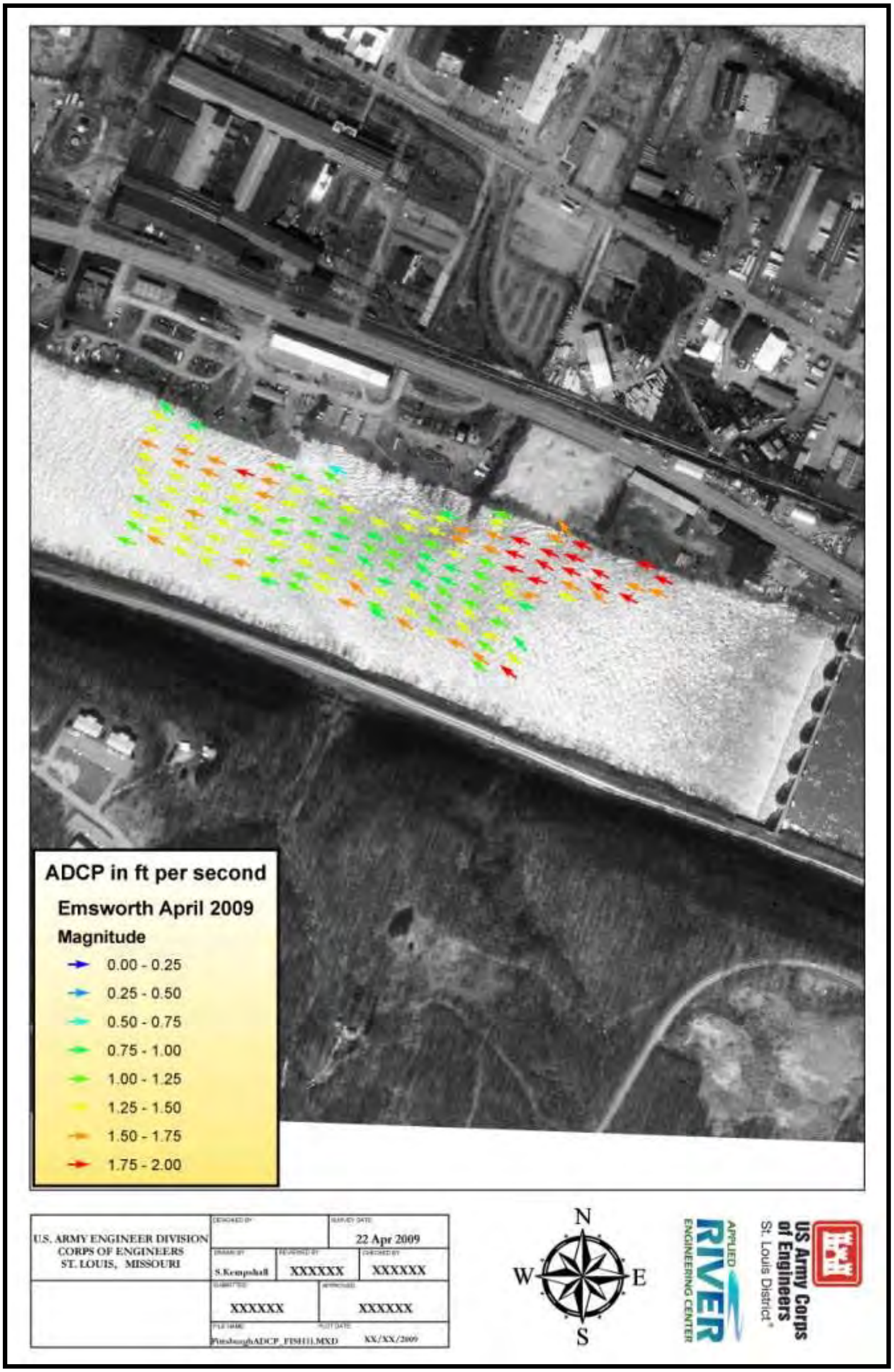


Figure 22. Acoustic Doppler Current Profile of Emsworth Back Channel Dam 21 April 2009.

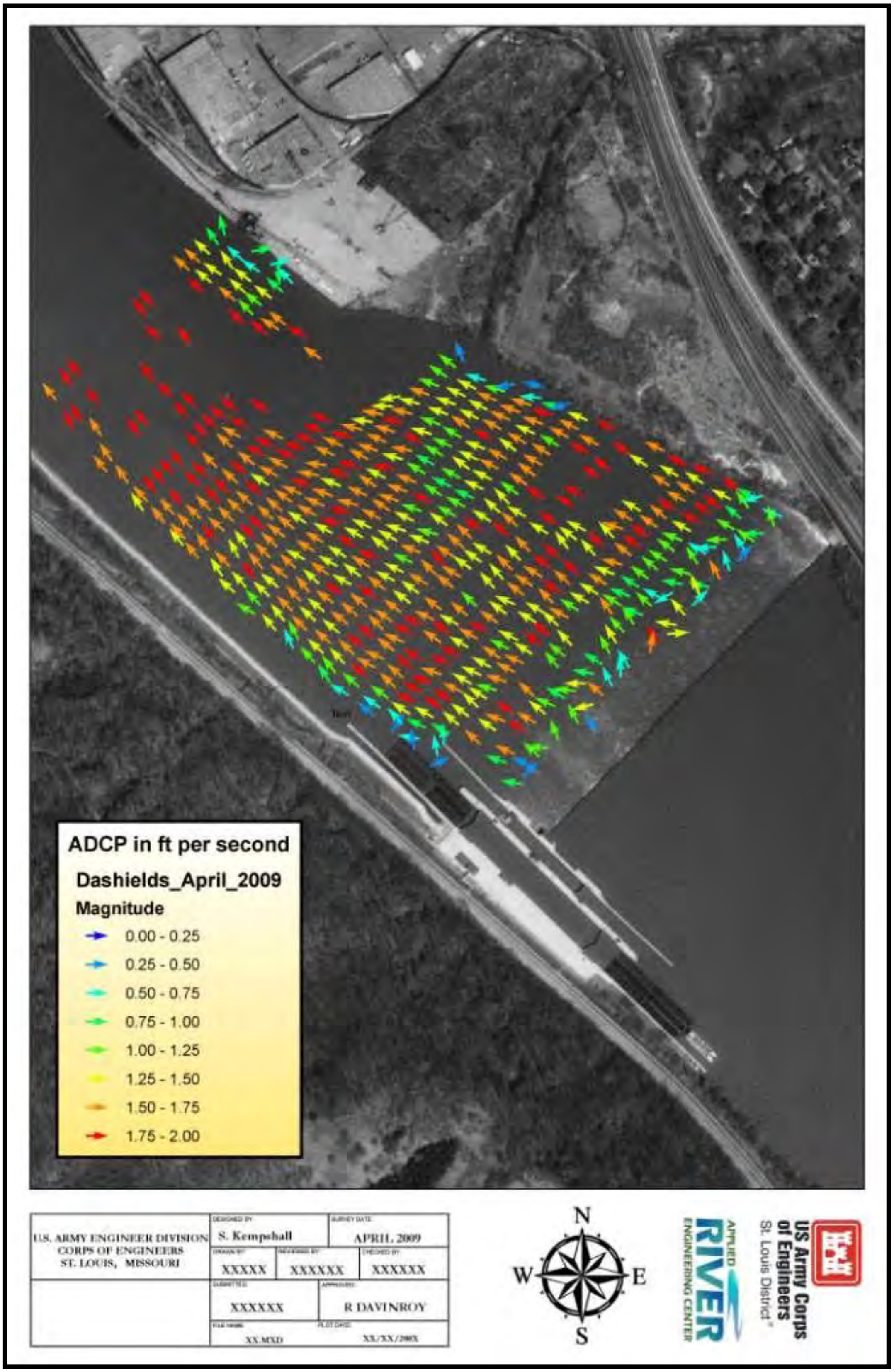


Figure 23. Acoustic Doppler Current Profile of Dashields Locks and Dam 21 April 2009.

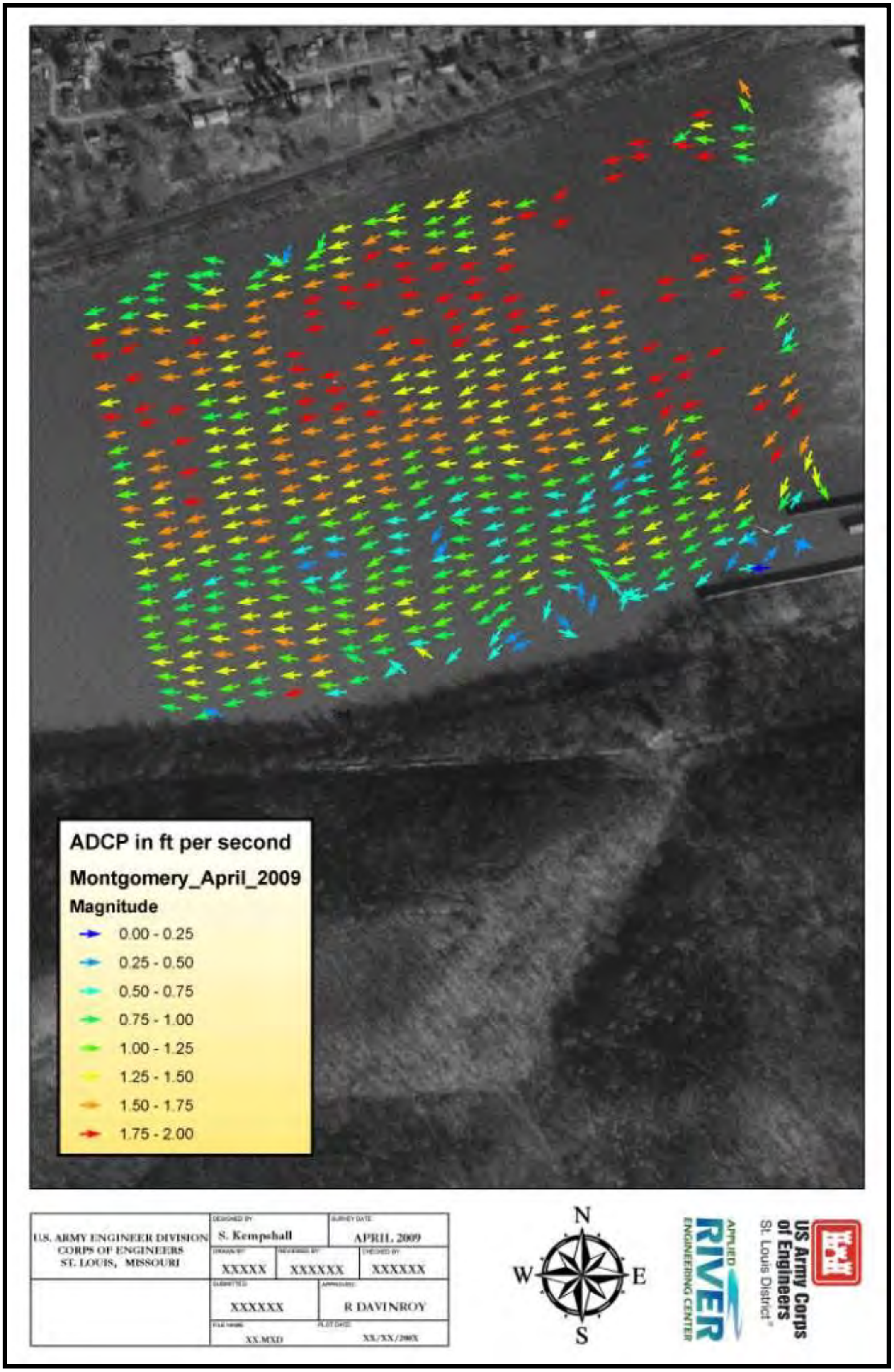


Figure 24. Acoustic Doppler Current Profile of Montgomery Locks and Dam 22 April 2009.

June 2-3, 2009

Sampling locations in June 2009 were similar to October 2008 and April 2009 surveys. Fish abundance and spatial distributions are shown in Tables 11 – 14 and Figures 25 – 28.

Twenty-three fish were counted in the Emsworth Main Channel Locks and Dam tailwater, nine in the Emsworth Back Channel Dam tailwater, 11 in Dashields Locks and Dam tailwater, and 22 in Montgomery Locks and Dam tailwater. Population estimates for the four survey sites were lower in June 2009 than in the October 2008 estimates, but higher than the April 2009 estimates, except at Montgomery (Table 16).

At Emsworth Main Channel Locks and Dam, fish were located primarily in the mid-channel (strata 6), the tailwater spillway (strata 2), and the shallow area of the left descending bank (strata 5) (Figure 25). At the Emsworth Back Channel Dam fish were located primarily in the downriver area (strata 3) near the right descending bank (Figure 26). Fish were disbursed along the right and left descending banks (strata 5 and 3) at Dashields Locks and Dam (Figure 27), as well as at Montgomery Locks and Dam (strata 5 and 3) (Figure 28).

The fish size distribution is shown in Figures 29 – 32. Larger fish were observed at the Emsworth Main Channel Locks and Dam and Montgomery Locks and Dam tailwaters than in the Dashields Locks and Dam or Emsworth Back Channel Dam locations.

Water conditions for each dam are shown in Table 15. Acoustic Doppler Current Profile (ADCP) displays showing velocity distribution for each dam are shown in Figures 33 – 36. Dam gate openings at the time of the surveys were as follows: Emsworth Main Channel Locks and Dam – all gates up one foot; Emsworth Back Channel – all gates up one foot; Dashields Locks and Dam – no gates; Montgomery Locks and Dam – gates 1, 2, 10 on sill, others open two feet.

Table 11. Emsworth Main Channel Locks and Dam tailwater fish population estimate June 2009.

Strata	Location	Hectares	Mean density (fish/m^2)	Lower CI	Upper CI	Population estimate	Lower 95%	Upper 95%
1	lock	1.08	0.000	0.000	0.000	0	0	0
2	spill	6.09	0.007	0.002	0.015	426	122	914
3	spill shallow	1.16	0.000	0.000	0.000	0	0	0
4	left bank	1.75	0.010	0.000	0.025	175	0	436
5	left bank shallow	1.98	0.016	0.000	0.031	316	0	613
6	mid-channel	8.74	0.009	0.002	0.019	787	175	1,661
7	mid-channel shallow	1.48	0.000	0.000	0.000	0	0	0
8	right bank	3.70	0.003	0.000	0.009	111	0	333
		25.98				**1,815**		

Table 12. Emsworth Back Channel Dam tailwater fish population estimate June 2009.

Strata	Location	Hectares	Mean density (fish/m^2)	Lower CI	Upper CI	Population estimate	Lower 95%	Upper 95%
1	spill	2.98	0.000	0.000	0.000	0	0	0
2	shallow bar	3.39	0.000	0.000	0.000	0	0	0
3	downriver	8.79	0.008	0.003	0.015	703	264	1,318
		15.15				**703**		

Table 13. Dashields Locks and Dam tailwater fish population estimate June 2009.

Strata	Location	Hectares	Mean density (fish/m^2)	Lower CI	Upper CI	Population estimate	Lower 95%	Upper 95%
1	lock	1.07	0.015	0.000	0.029	161	0	312
2	spill	7.62	0.002	0.000	0.005	152	0	381
3	left bank	4.19	0.005	0.000	0.010	210	0	419
4	mid-channel	17.93	0.001	0.000	0.003	179	0	538
5	right bank	4.65	0.014	0.000	0.035	651	0	1,628
		35.47				**1,354**		

Table 14. Montgomery Locks and Dam tailwater fish population estimate June 2009.

Strata	Location	Hectares	Mean density (fish/m^2)	Lower CI	Upper CI	Population estimate	Lower 95%	Upper 95%
1	lock	0.61	0.000	0.000	0.000			
2	spill	6.92	0.000	0.000	0.000	0	0	0
3	left bank	5.41	0.006	0.002	0.013	325	108	703
4	mid-channel	19.87	0.001	0.000	0.003	199	0	596
5	right bank	5.63	0.014	0.002	0.027	788	113	1,519
		38.43				**1,311**		

Table 15. Water conditions at the locks and dams 2-3 June 2009. Pool and tailwater stages were obtained online from RiverGages.com data mining.

Date	Upper Gage	Lower Gage	Flow (cfs)	Water Temperature (ºF)
Emsworth Main Channel Locks & Dam				
6/2/09	16.5	15.5	30,000 (est.)	67
6/3/09	16.5	15.4	30,000 (est.)	67
Dashields Locks & Dam				
6/2/09	15.3	13.8	30,000	67
6/3/09	15.3	14.0	30,000	67
Montgomery Locks & Dam				
6/2/09	12.5	12.8	32,000 (est.)	67
6/3/09	12.5	13.4	32,500 (est.)	67

Table 16. Fish population estimates by survey and location.

Location	Oct 2008	April 2009	June 2009
Emsworth Main Channel Locks & Dam	6,747	272	1,815
Emsworth Back Channel Dam	1,466	703	703
Dashields Locks & Dam	4,934	530	1,354
Montgomery Locks & Dam	12,100	7,655	1,311

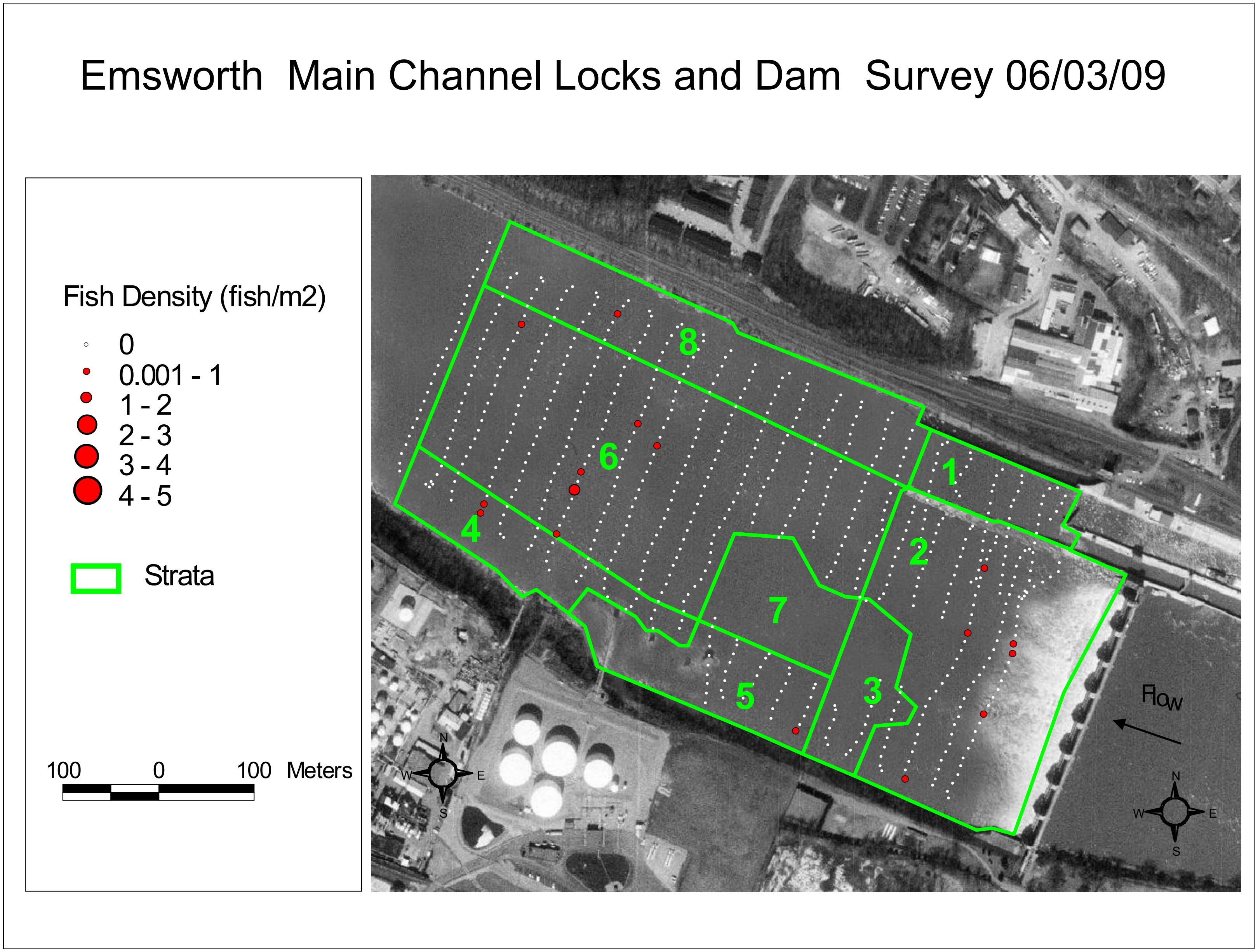


Figure 25. Emsworth Main Channel Locks and Dam fish density distribution 3 June 2009.

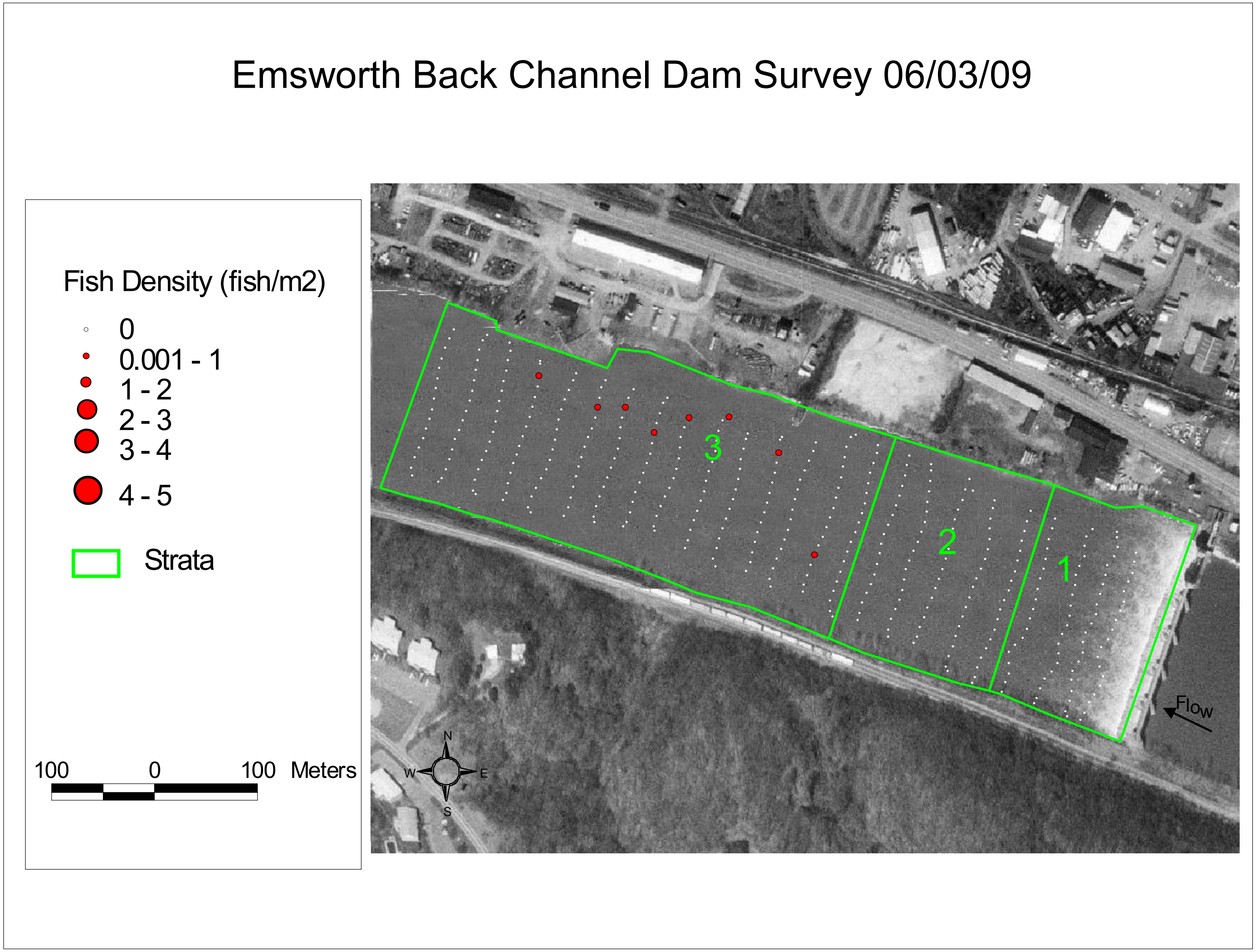


Figure 26. Emsworth Back Channel Dam fish density distribution 3 June 2009.

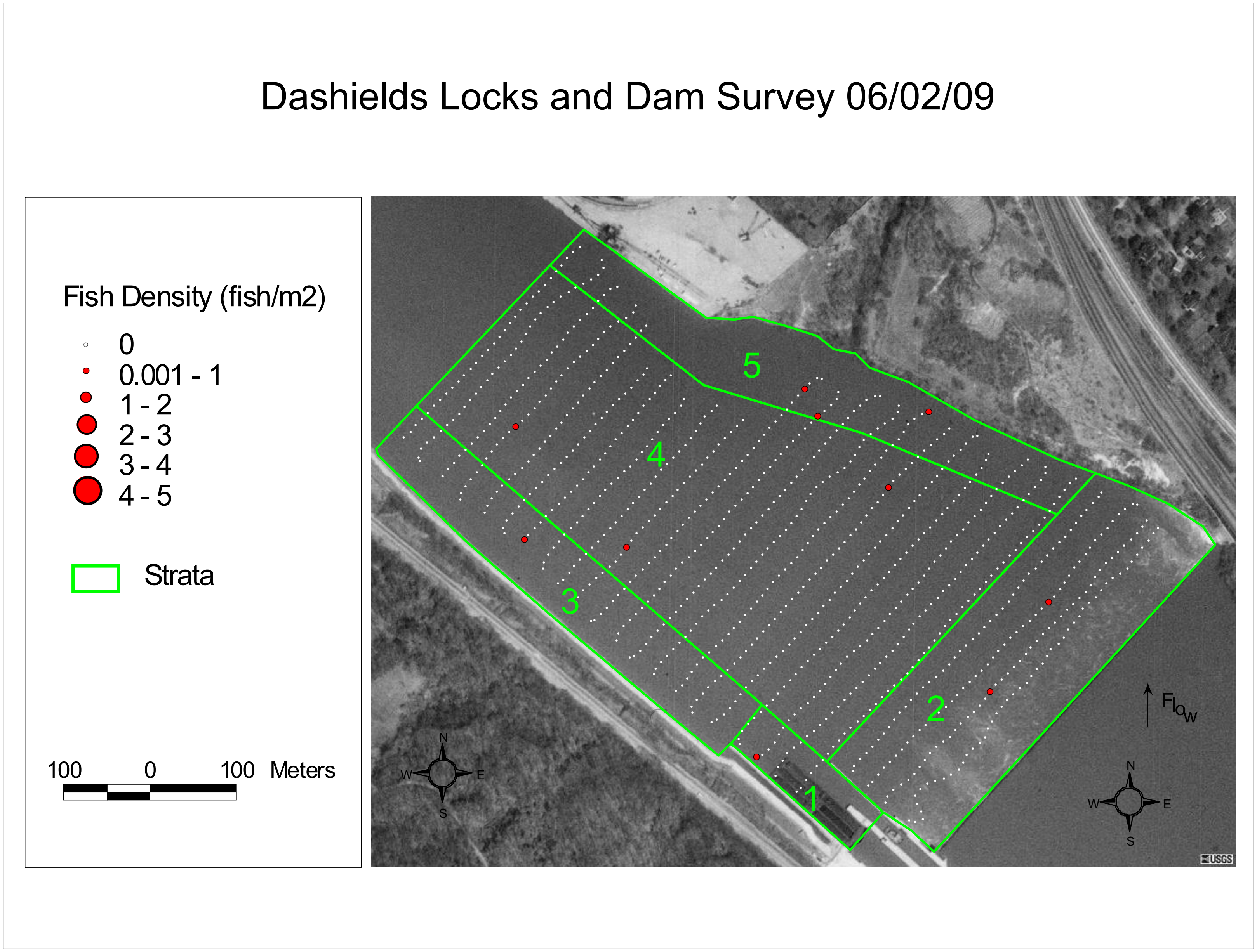


Figure 27. Dashields Locks and Dam fish density distribution 2 June 2009.

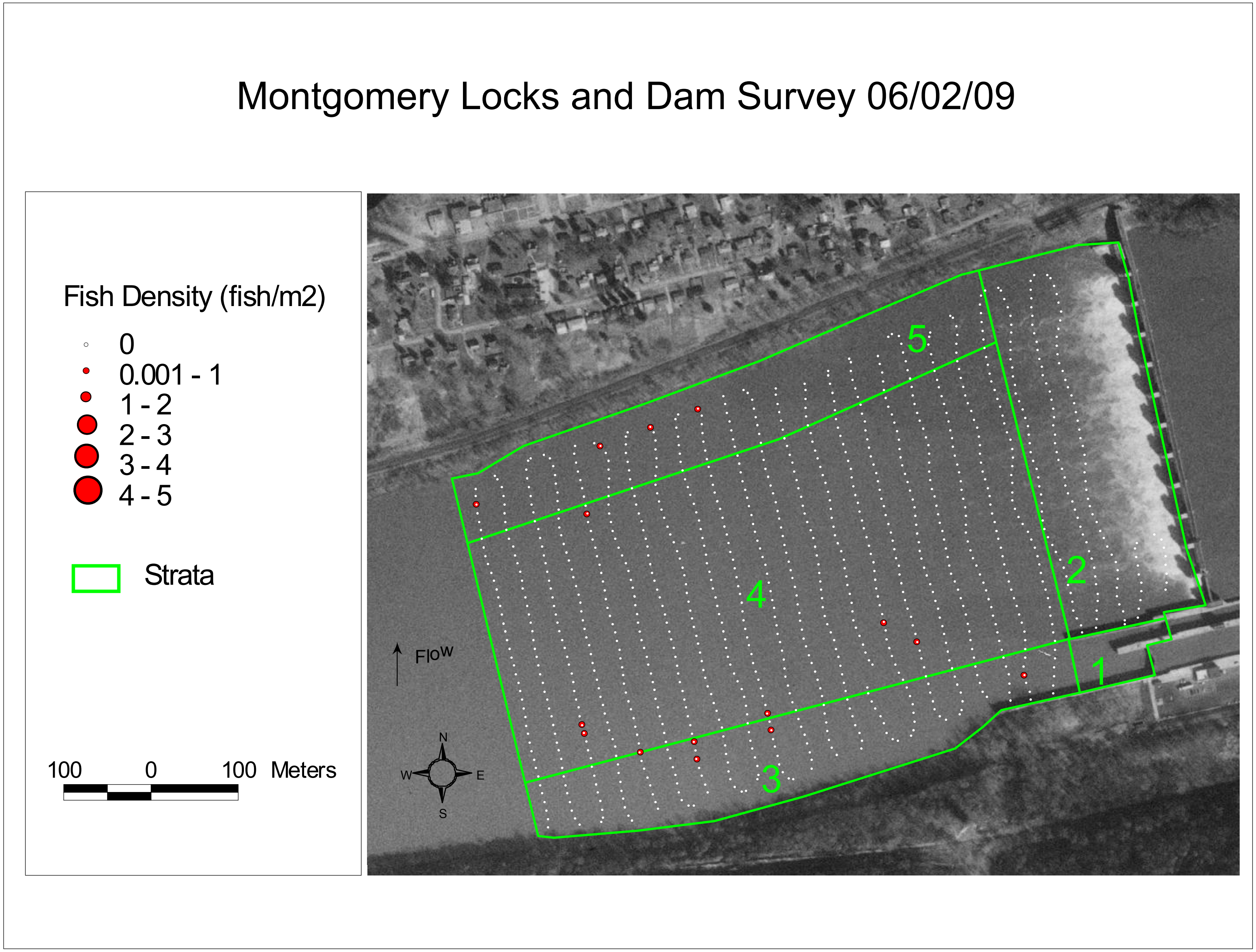


Figure 28. Montgomery Locks and Dam fish density distribution 2 June 2009.

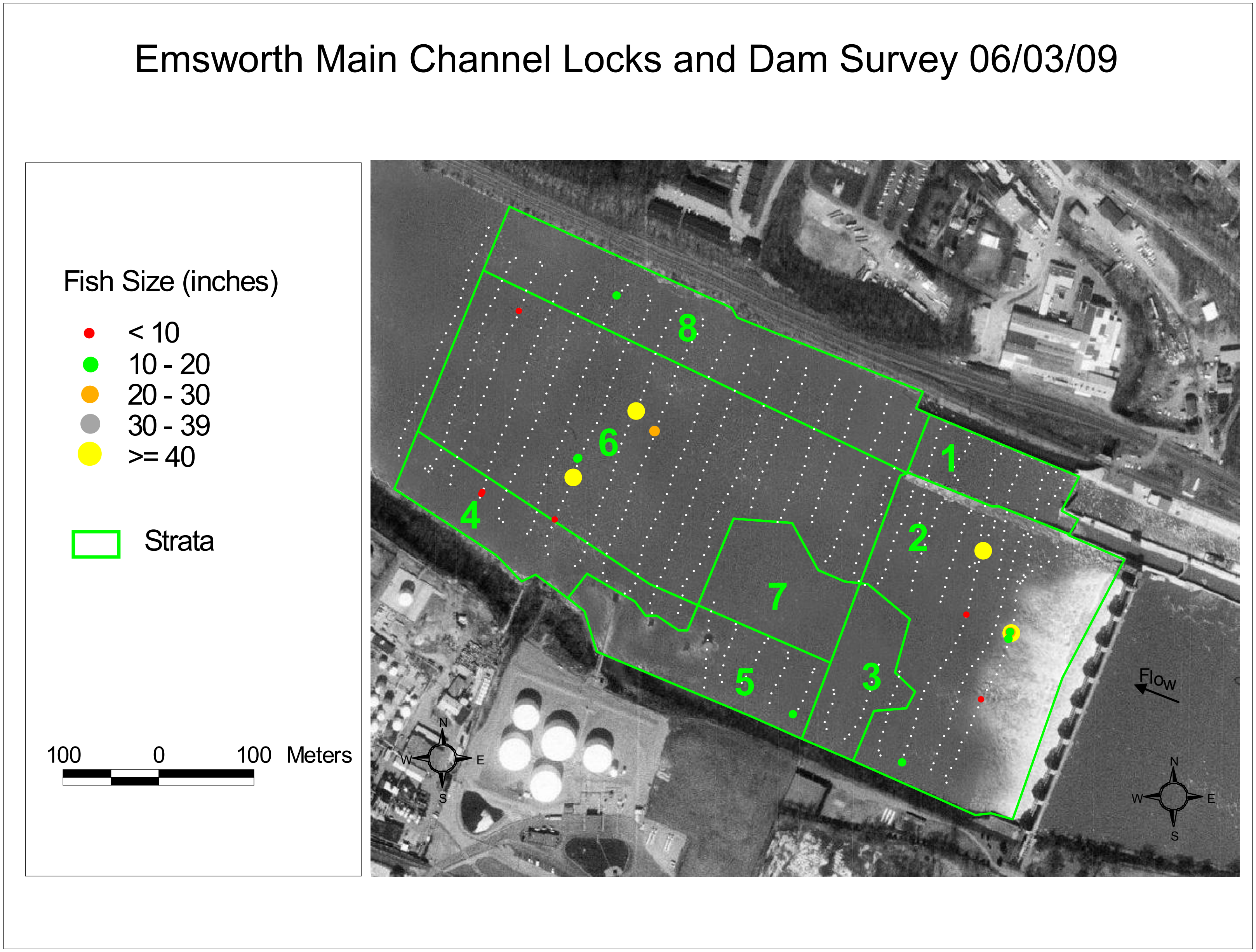


Figure 29. Emsworth Main Channel Locks and Dam fish sizes June 3, 2009.

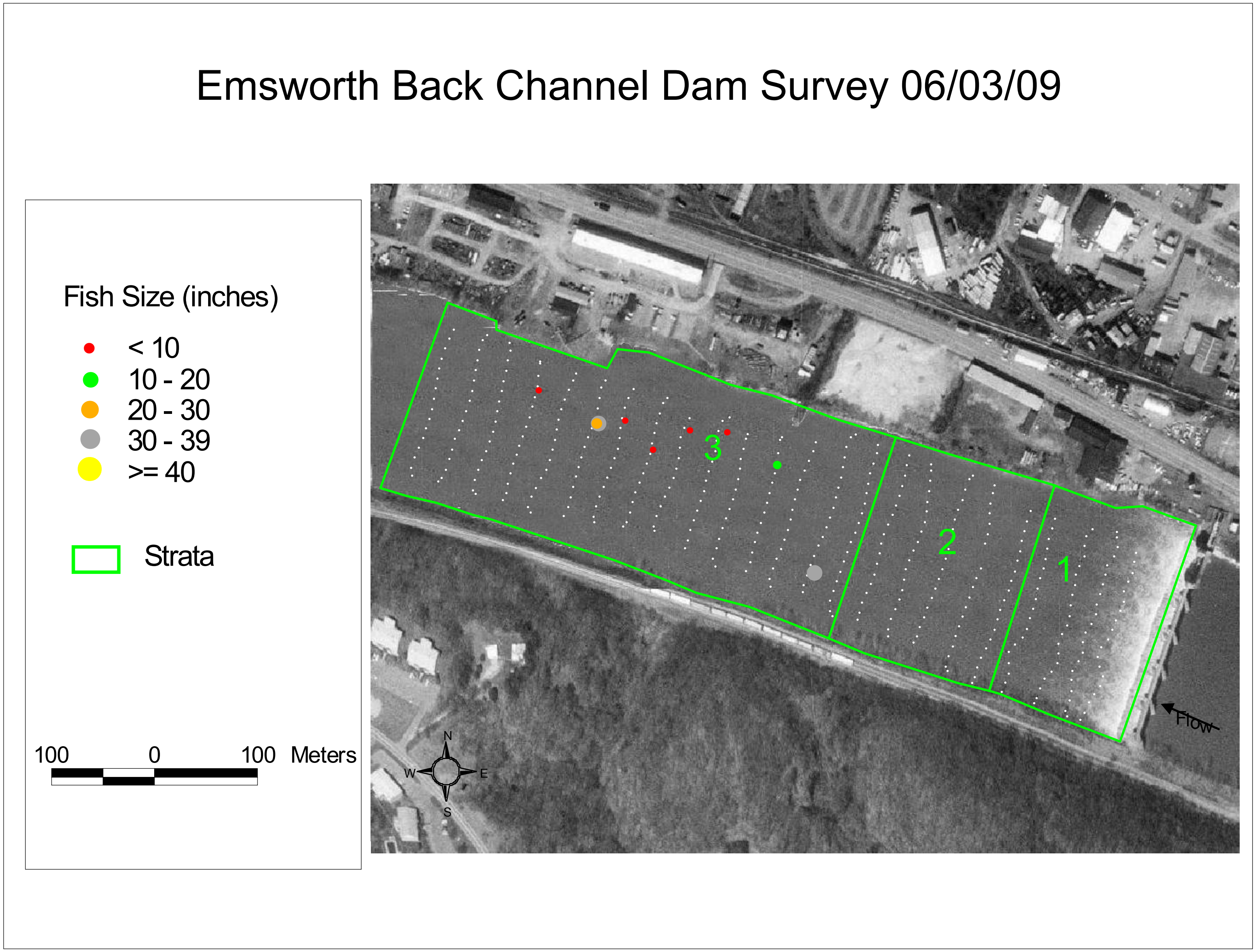


Figure 30. Emsworth Back Channel Dam fish sizes June 3, 2009.

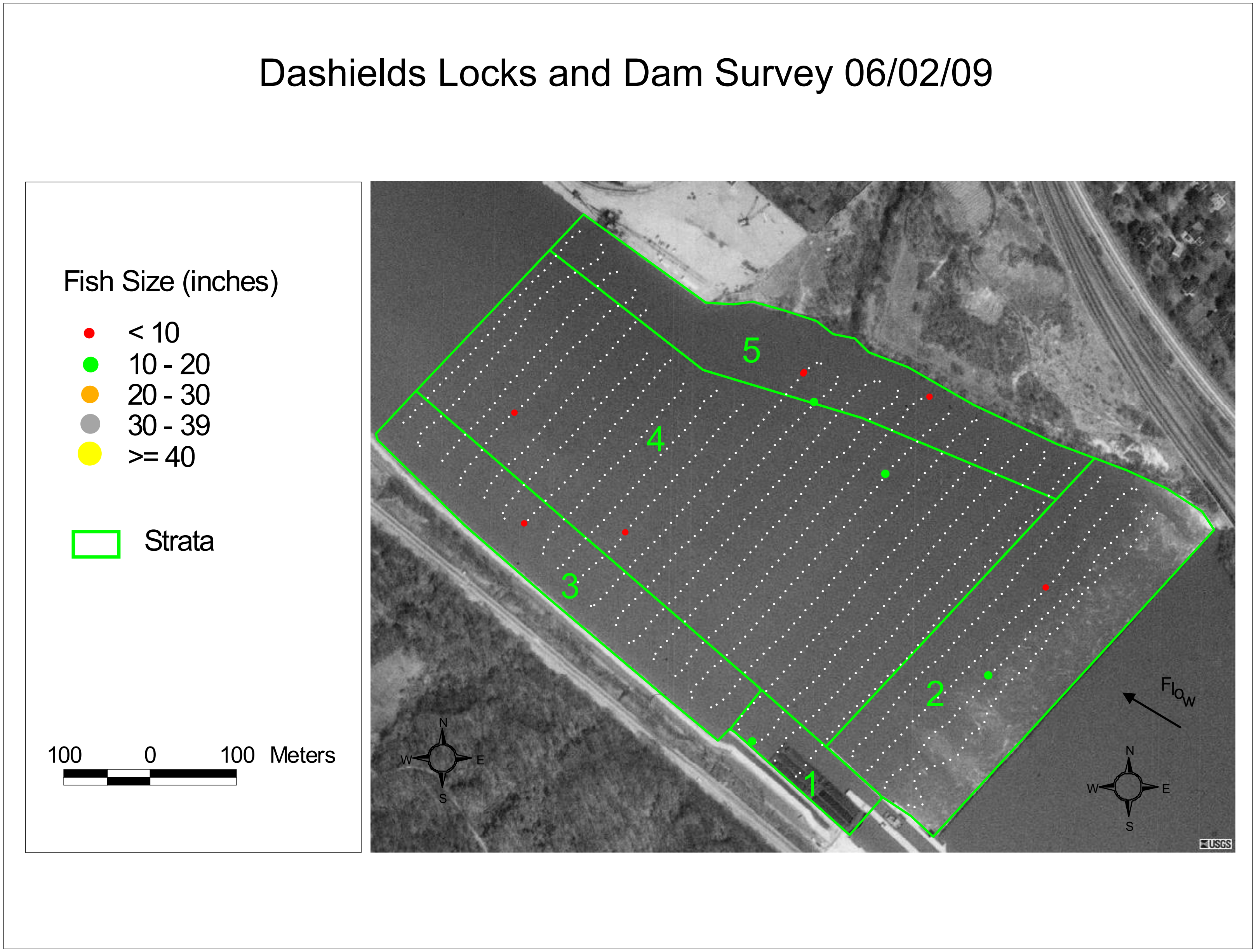


Figure 31. Dashields Locks and Dam fish sizes for June 2, 2009.

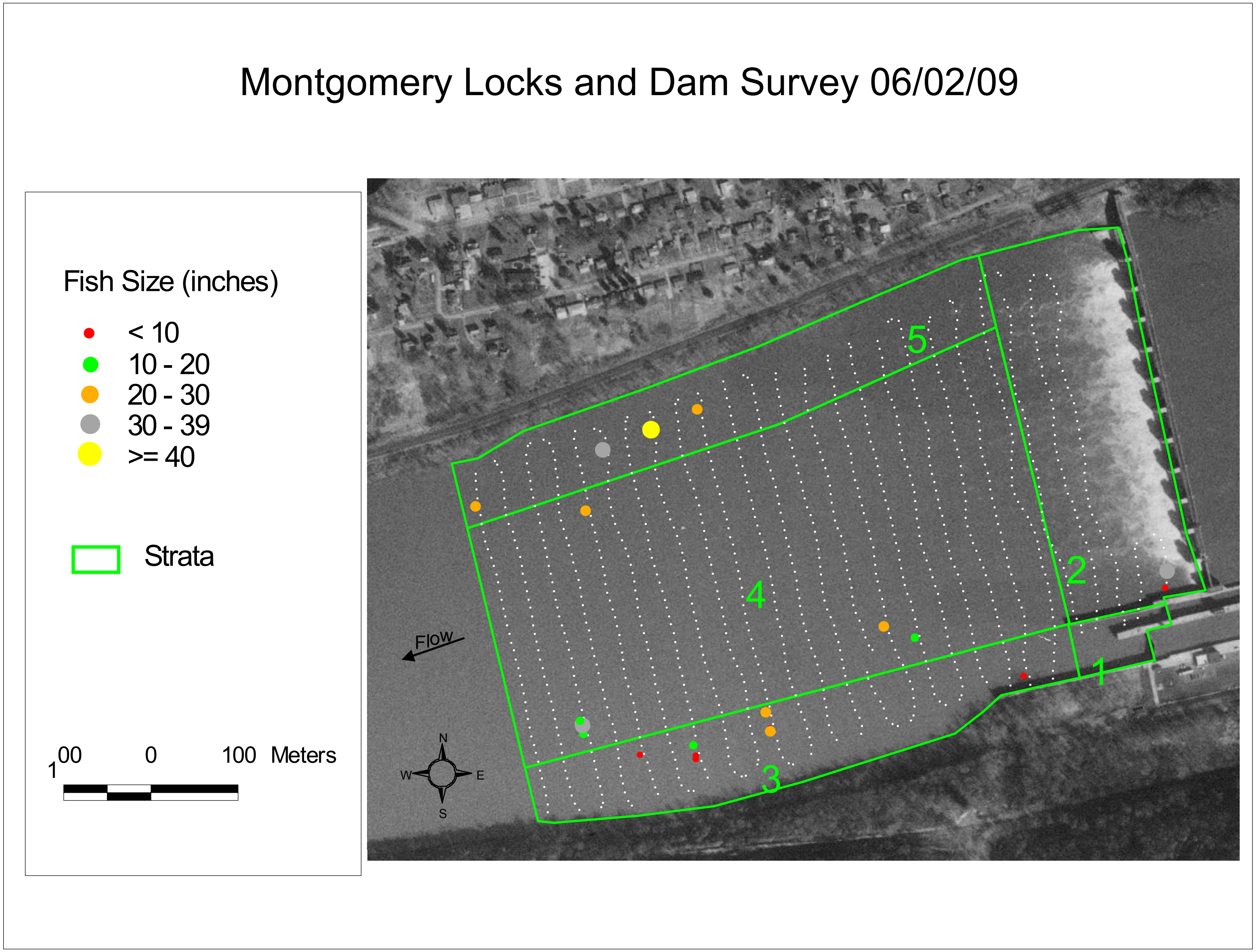


Figure 32. Montgomery Locks and Dam fish sizes June 2, 2009.

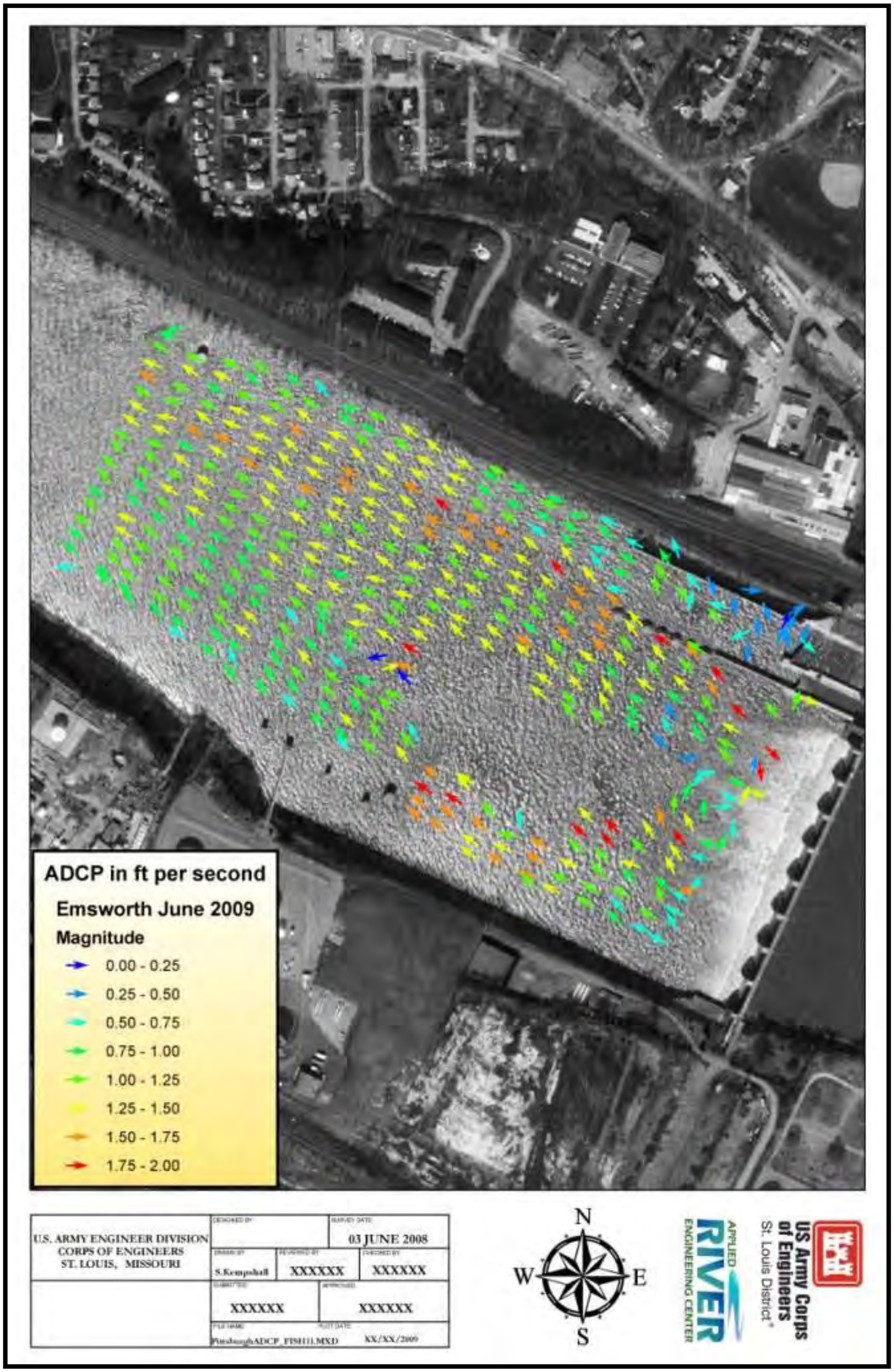


Figure 33. Acoustic Doppler Current Profile of Emsworth Main Channel Locks and Dam 3 June 2009.

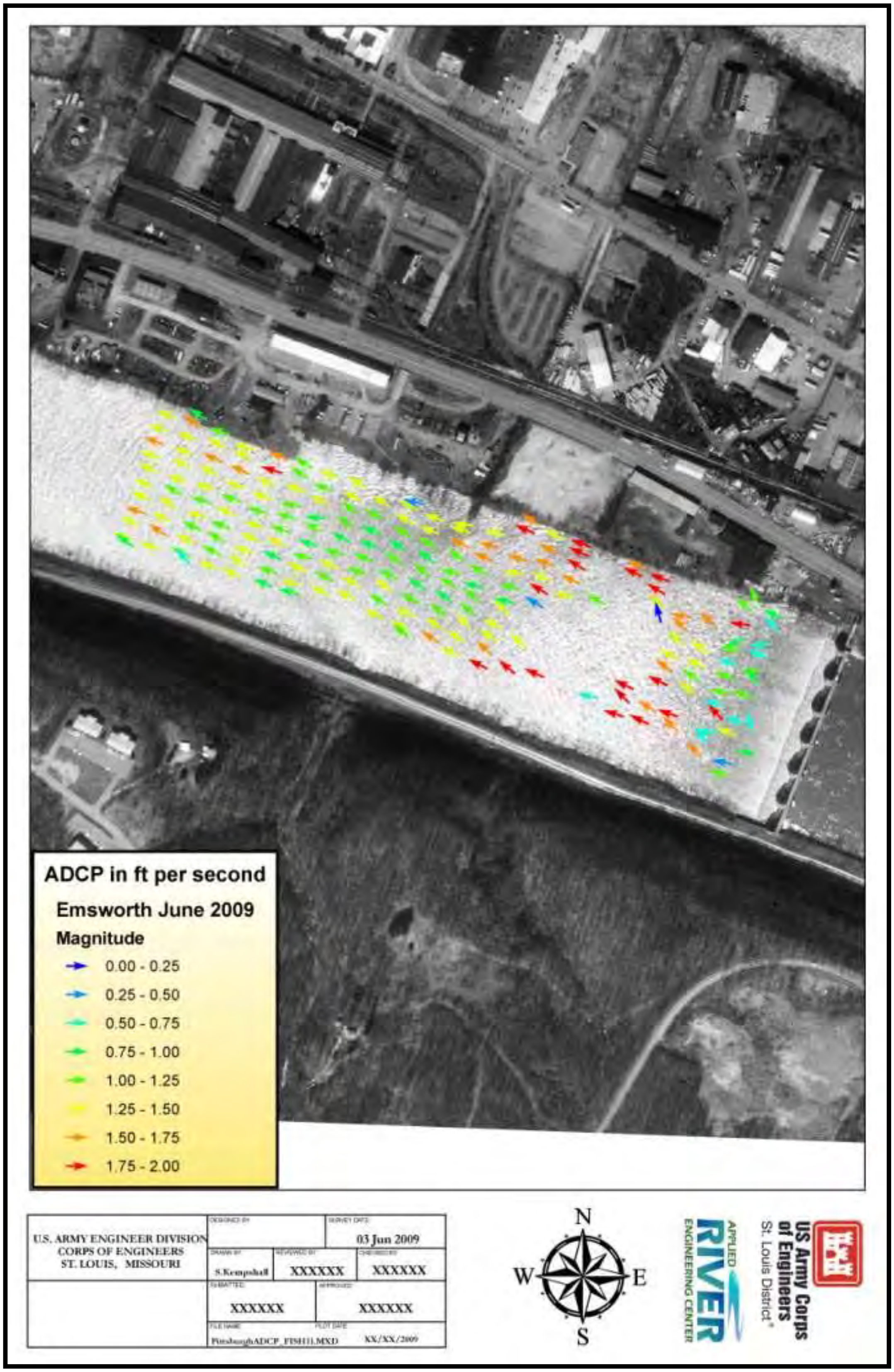


Figure 34. Acoustic Doppler Current Profile of Emsworth Back Channel Dam 3 June 2009.

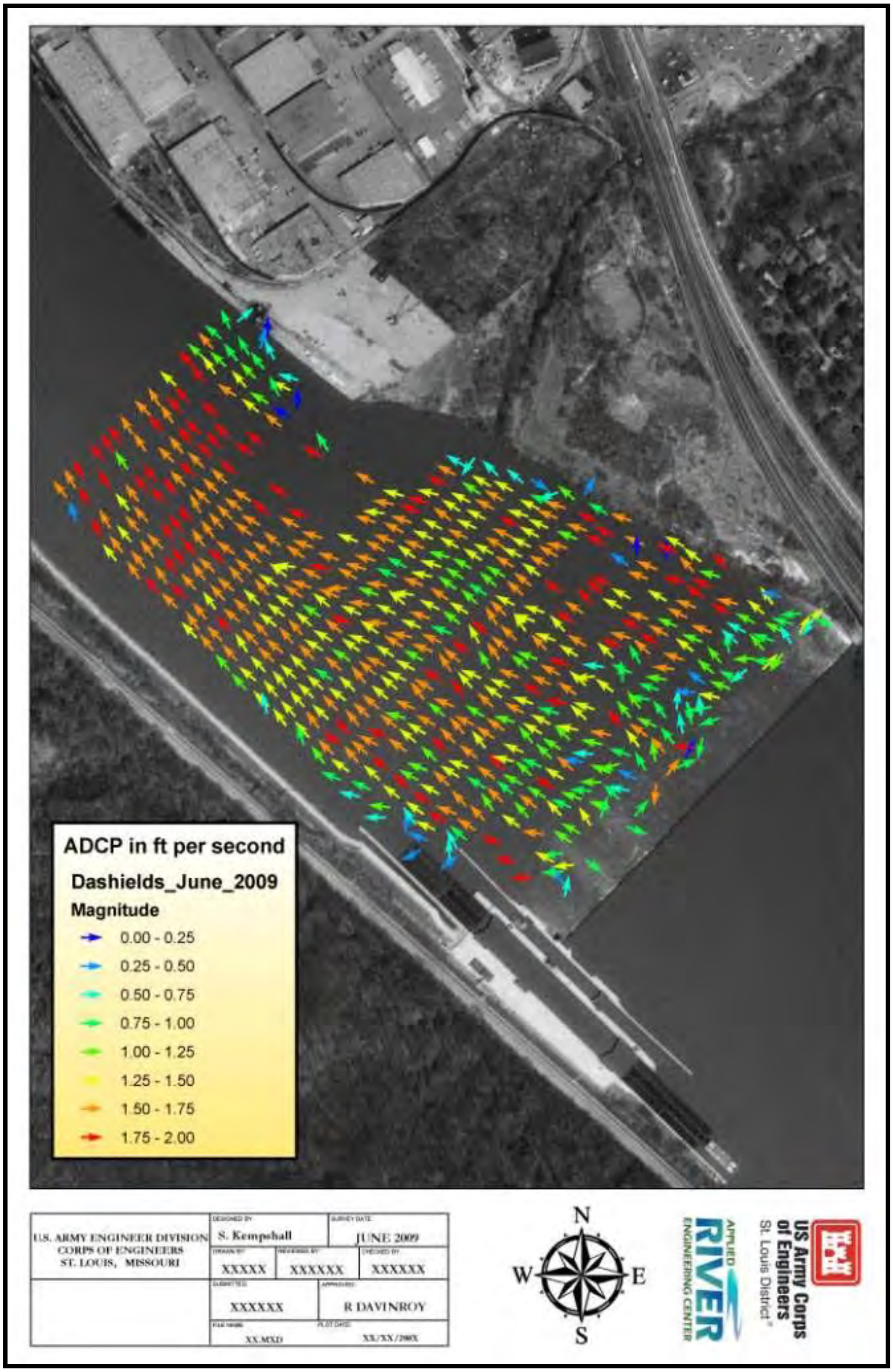


Figure 35. Acoustic Doppler Current Profile of Dashields Locks and Dam 2 June 2009.

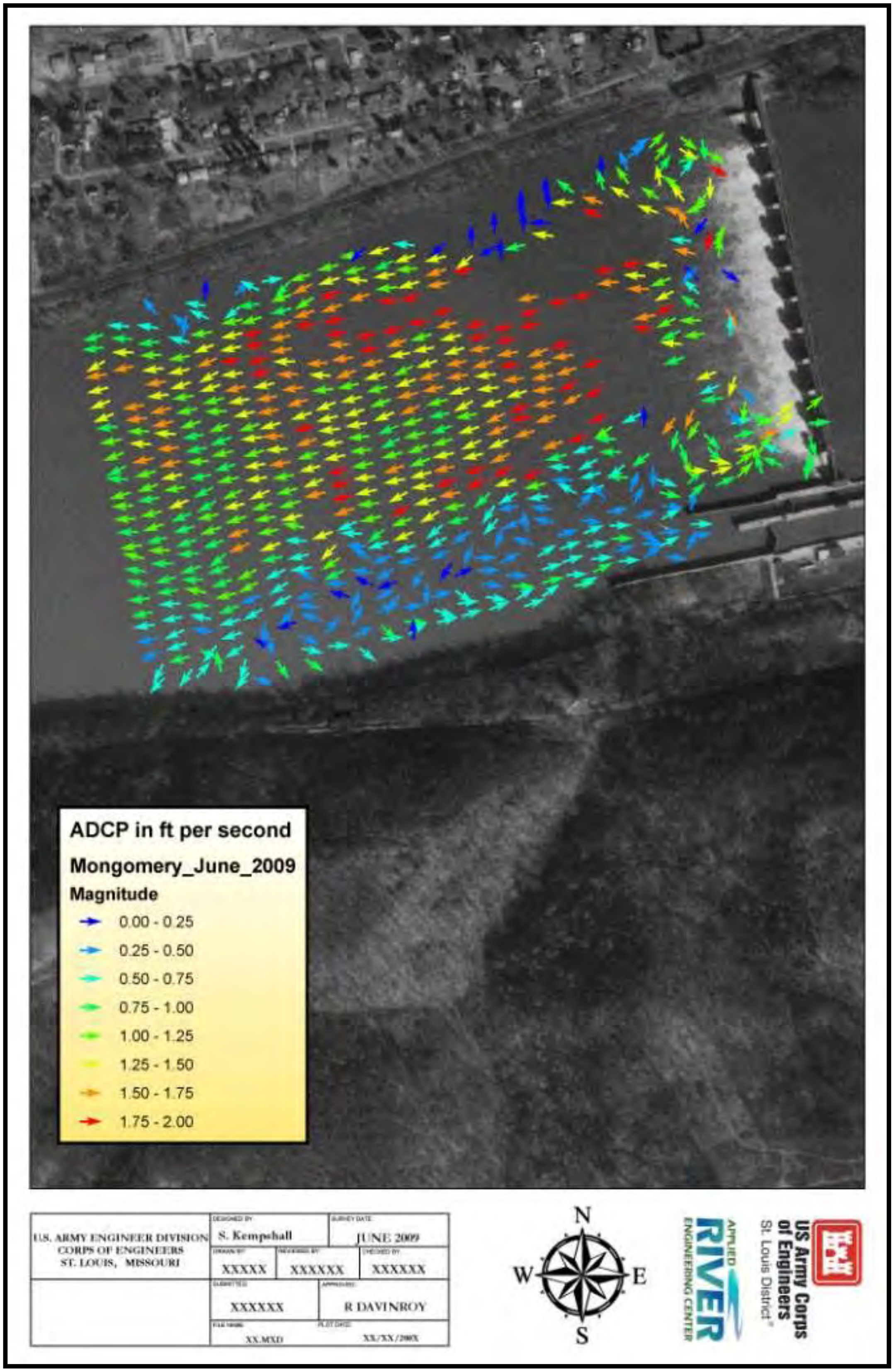


Figure 36. Acoustic Doppler Current Profile of Montgomery Locks and Dam 2 June 2009.

Discussion

This report presents initial fish monitoring efforts at Emsworth Main Channel Locks and Dam, Emsworth Back Channel Dam, Dashields Locks and Dam, and Montgomery Locks and Dam. Additionally, basic information on fish movement, general effect of dams on fish migration, and general fish passage information is also provided.

River ecosystems are complex systems of energy, water and material flows interacting with a diverse set of organisms. These ecosystems can be characterized by lateral (river/floodplain), longitudinal (upstream/downstream), vertical and temporal relationships. A "healthy" river maintains its connectivity as determined by the geomorphologic characteristics of the watershed. These physical connections allow river ecosystems to be resilient to external stresses within a certain range of natural variation, maintaining a self-sustaining condition of the ecosystem. Disruption of these relations can lead to degradation of the river ecosystem. Dams on the Ohio River and its tributaries disrupt the longitudinal connectivity of the river corridor and alter the distribution and abundance of many river organisms including migratory fish.

Before dam construction, migratory fishes moved upstream in large spawning groups to the upper river and tributaries. With the completion of each dam, the longitudinal connectivity of the formerly free-flowing river that fishes had adapted to was further fragmented. Thus, over time, migratory fishes were denied access to sections of the river and adjacent tributaries that they used for spawning, foraging, Overwintering, and shelter. Connectivity affects the turnover, or movement of species between habitat patches and ultimately the number of species in a region. Local biotic communities in rivers are in dynamic equilibrium and are often altered by disturbance events such as floods and droughts. Lack of connection between habitats has significant implications for redistribution, recolonization, and local extinctions of fish and other biota within rivers. The fish communities of tributaries are also influenced by seasonal influx of spawning fish from the larger rivers. Migratory fishes provide concentrations of biomass for fish eating birds and mammals and the eggs, larvae and juveniles of seasonal migratory fishes greatly affect the trophic structure of tributary communities. Additionally, fish migrations are important in maintaining genetic diversity of fish populations. High genetic diversity makes populations resilient to disturbances. Sufficient inter-pool movement of most fishes may still occur to prevent genetic isolation, although opportunity for upriver gene flow is limited.

Numerous native fishes have life history requirements that involve upstream and downstream migratory movements. Improvements in fish passage would benefit both common and uncommon species. In addition to the purely ecological benefits, economic benefits from mussel and fish harvest have been important for centuries. Removing barriers in the river system is the ideal solution, creating a higher water quality and connecting different habitat types are key aides to restoring the longitudinal ecosystems that rivers provide. In the case of the Ohio River, this could mean connecting several pools in sequence or connecting a pool with all of its blocked tributaries with fish passage structures, depending on the needs of the specific species being targeted for improvement.

To ensure that fish can find the fishway, it is imperative to place the structure in a location where fish are present or in an area which can attract fish. The location of fishways at Locks and Dams must be situated in an area where fish congregate and in a location which minimizes impact to navigation and the operation and maintenance of the dam. Other factors involved with the layout of the structures included minimizing ice and debris damage by using existing structures as deflection devices, reducing costs by minimizing fill material required or reducing the amount of sheet pile used in the structure. Additionally, dam safety is a significant concern when making modifications to the dam gates or the spillways. The closer a fishway recreates the natural habitat of a species, the greater the likelihood that species will be able to use the fishway. Velocities should be similar to that of natural river conditions so that fishes will be able to use the fishway as if it was part of the original river. Larger fishways would be a benefit to the project. A larger fishway could pass more fish, could have greater attracting flows, and could be less likely to behaviorally deter fishway usage due to crowding. A smaller fishway could form a bottleneck for fish and could make the fish vulnerable to predation by birds. A review of successful fishways (including small alpine rivers and larger lowland rivers) has found that around 10% of the minimum flow of the river passes through the fishways. These fishway projects passed a variety of fish species with different migration behaviors and swimming performance. However, Northcote (1998) identified several realities for fish passage projects. These include 1) the biological enormity of the problem cannot be define, 2) fish passage facilities do not accommodate the multidirectional (lateral, upstream and downstream – only upstream) movement of migratory fishes, 3) information on migratory behavior and swimming performance of many fish species is still lacking, 4) a fish passage facility can be an important contribution in the life cycle of migratory fish, but it addresses only one aspect of that cycle.

The purpose of the proposed fish passage projects is to restore free access for migratory fishes to upstream habitat in the Ohio River system. Ultimately this restored access should lead to a healthier re-connected river system and an increase in the size and distribution of native migratory fish populations. However, many additional questions need to be addressed before the fishways are proposed, located, and designed for each site. These questions include:

- Is fish passage needed?
- Would construction and operation of a fishway adversely affect navigation at the Locks and Dams?
- What species and sizes of fish presently aggregate in the tailwaters of the Locks and Dams?
- Where do fish presently aggregate in the tailwaters of the Locks and Dams?
- How many more fish will pass through the Locks and Dams with fishways in place?
- What type of fishways can pass all the migratory fish species that occur in the Ohio River?

- How big (width, depth, flow) do the fishways at the Locks and Dams need to be?
- What are the design criteria for internal hydraulic conditions in the fishways?
- Will fish enter and pass through the fishways?
- When do the fishways need to be available for fish passage?
- Are upstream control structures on fishways needed?
- What is the range of river discharge and stage in the pool and tailwater at the Locks and Dams?
- Can the dam gates be all raised out of the water (open river condition) to enable upriver fish passage?
- How many fish presently pass upriver through the Locks?
- How many more fish can be induced to pass upriver through the Locks?

In order to answer many of these questions, further monitoring is required. In addition to mobile hydroacoustic surveys, other methods may include stationary hydroacoustic surveys, fish tagging and telemetry studies, high-resolution three dimensional numerical hydraulic modeling, and fish capture.

The mobile hydroacoustic monitoring conducted in October 2008, April 2009, and June 2009 provided preliminary information on the relative size and distribution of fishes below Emsworth Main Channel Locks and Dam, Emsworth Back Channel Dam, Dashields Locks and Dam, and Montgomery Locks and Dam. Overall, relatively few fishes were detected at each site. Fish population estimates were highest during October 2008 as one would expect if fish were congregating below the dams during the fall to migrate to upriver overwintering sites. Fish population estimates were also highest at Montgomery Locks and Dam.

Comparing ADCP results with fish distributions indicated that fishes at each of the sites were seeking low velocity areas (blue arrows) during the October 2008 surveys. During the April 2009 surveys, velocities were much higher (yellow, orange and red arrows), which may have prevented fishes from congregating in the area even if they were attempting to migrate upriver to spawning sites. The fishes that were present did seek low velocity areas if they were available. Fishes at Emsworth Back Channel were located in medium velocity sites (green arrows) since low velocity sites were not available. Overall velocity profiles were intermediate during the June 2009 surveys compared to October 2008 and April 2009. Fishes were avoiding high velocity locations at each of the survey sites, and seemed to be seeking primarily low velocity areas. Some fishes at Emsworth Main Channel Locks and Dam were located in medium velocity areas.

Fish distribution at Emsworth Main Channel Locks and Dam varied over time. Fishes were found primarily in strata 2, 5, 6, and 8. Fish distribution at Emsworth Back Channel was consistent over time, occurring primarily in strata 3. At Dashields Locks and Dam, fishes were detected primarily in strata 3 and 5, and once each in strata 1 and 2. Montgomery Locks and Dam fishes were located primarily in strata 4 and 5, and once each in strata 2 and 3. This information, in combination with the ADCP results discussed above, indicates that the fishes are not using specific areas of the sampling sites, but seem to be seeking out areas of low velocity refuge. Thus, tailwater river levels, flow conditions, and gate openings appear to have an effect on fish distribution. Additional surveys taken during differing flow conditions over an extended time period should be conducted to corroborate these findings.

In order to determine fish species associated with the relative size classes, fish capture would need to occur shortly after mobile hydroacoustic surveys are conducted.

Literature Cited

Northcote, T. G. (1998). "Migratory behavior of fish and its significance to movement through riverine fish passage facilities," *Fish migration and fish bypasses*. M. Jungwirth, S. Schmutz, and S. Wiess, eds., Fishing News Books, Blackwell Science Ltd. Oxford, U.K., 3-18.