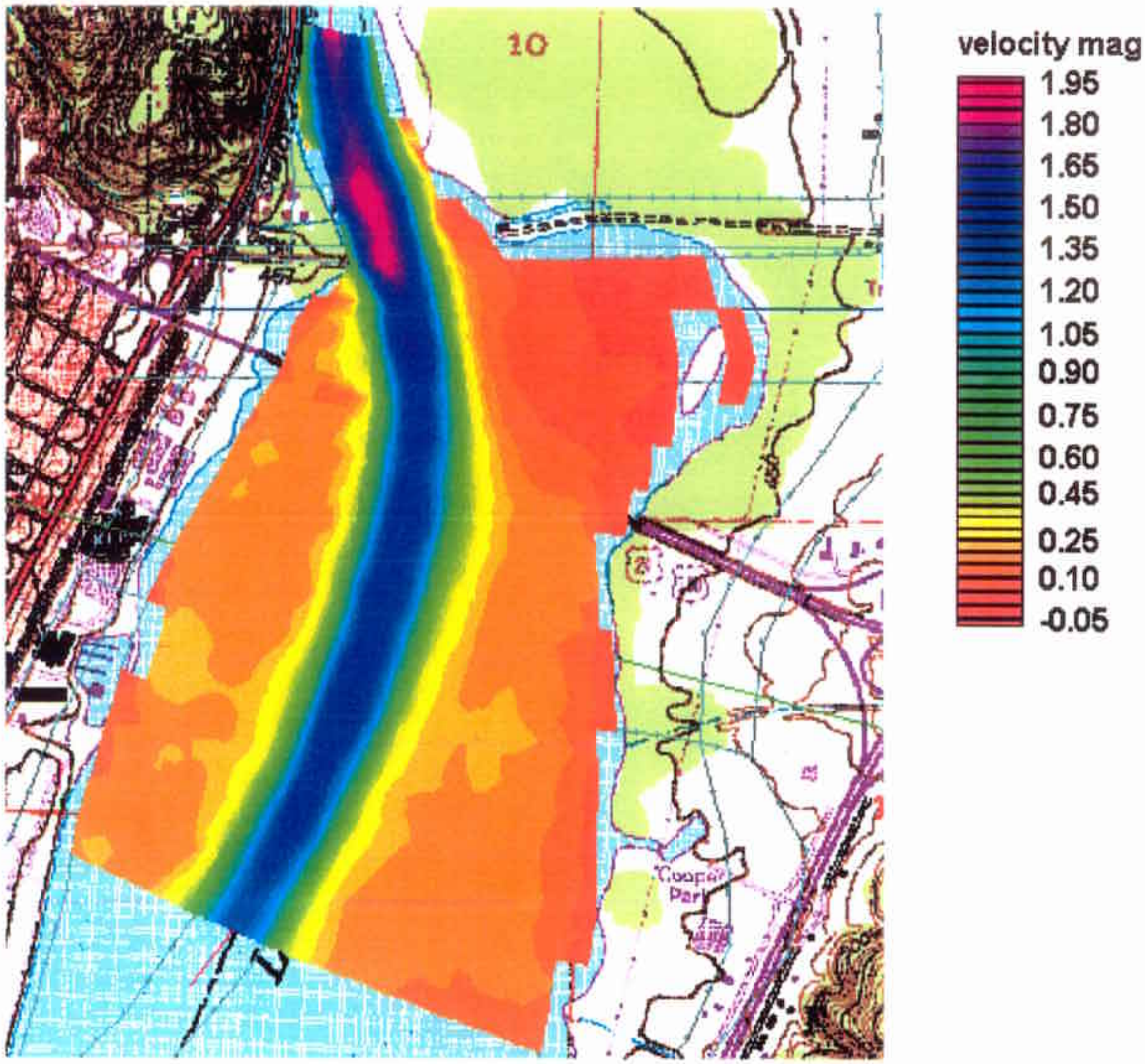

Figure 43. Velocity Variations for a flow of 15,000 cfs

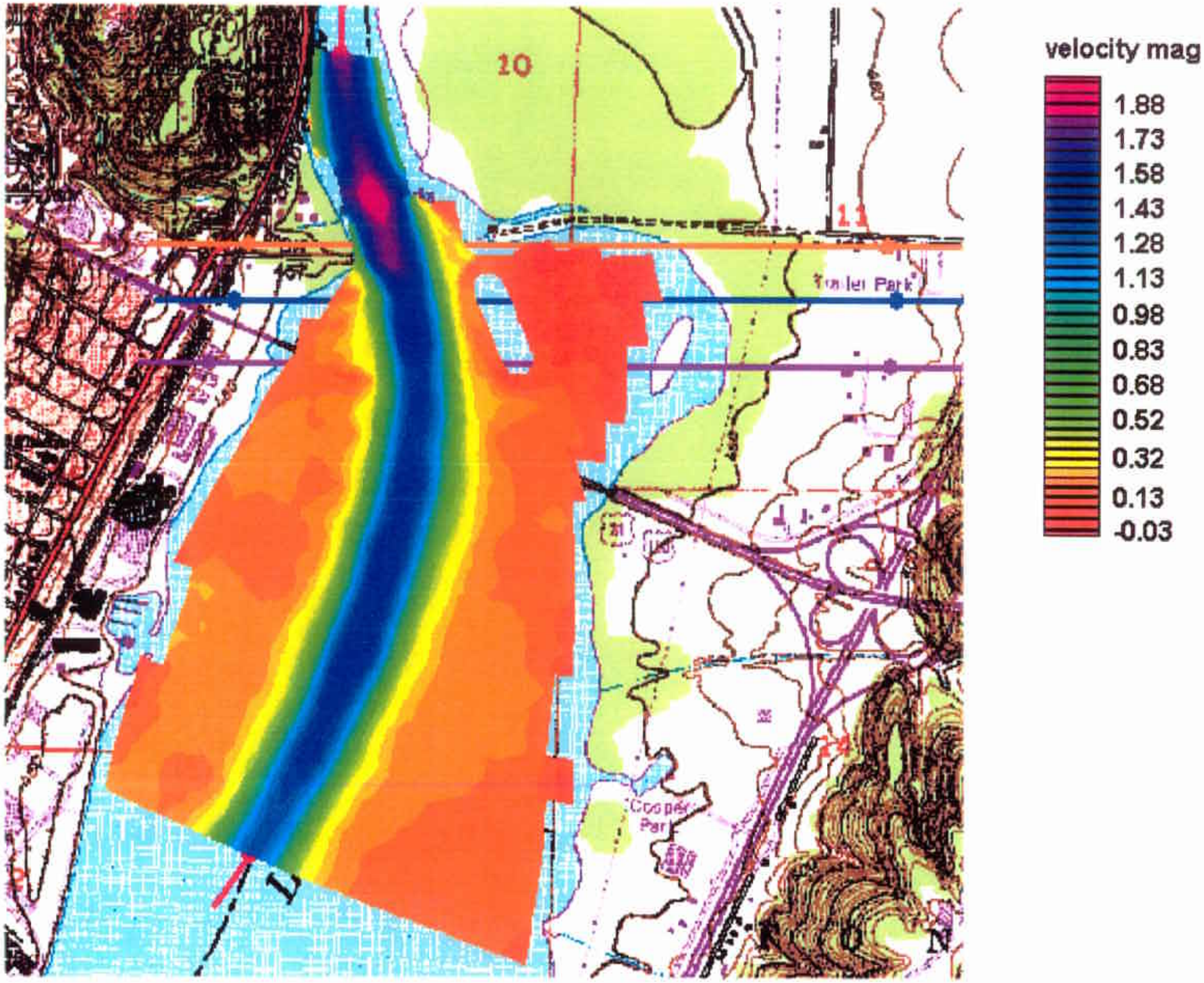

Figure 44. The Spatial Velocity Distribution for Alternative 1 for a flow of 15,000 cfs

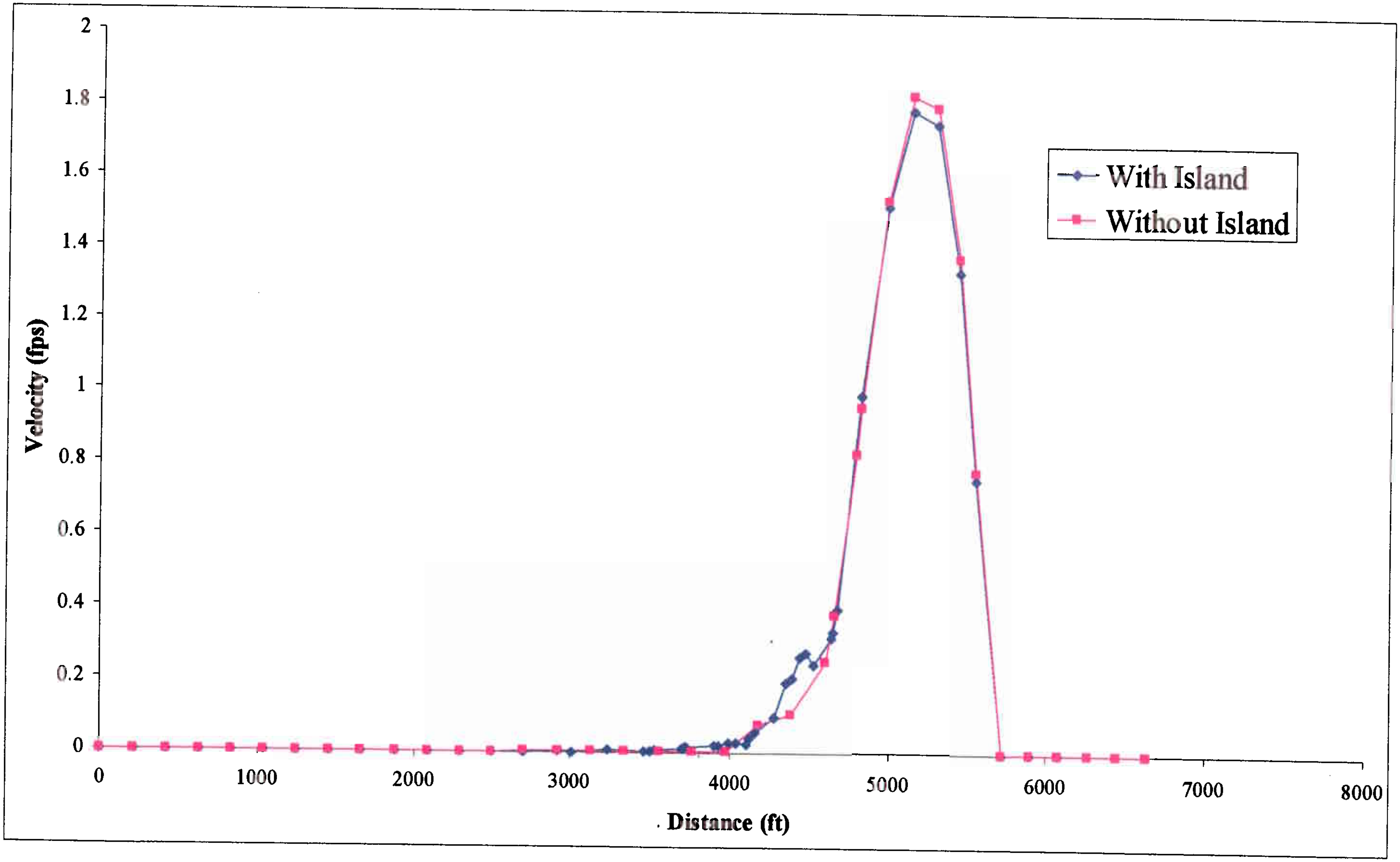

Figure 45. Lateral Velocity Distribution at Cross-Section 1, Qw = 15,000 cfs, Alternative 1

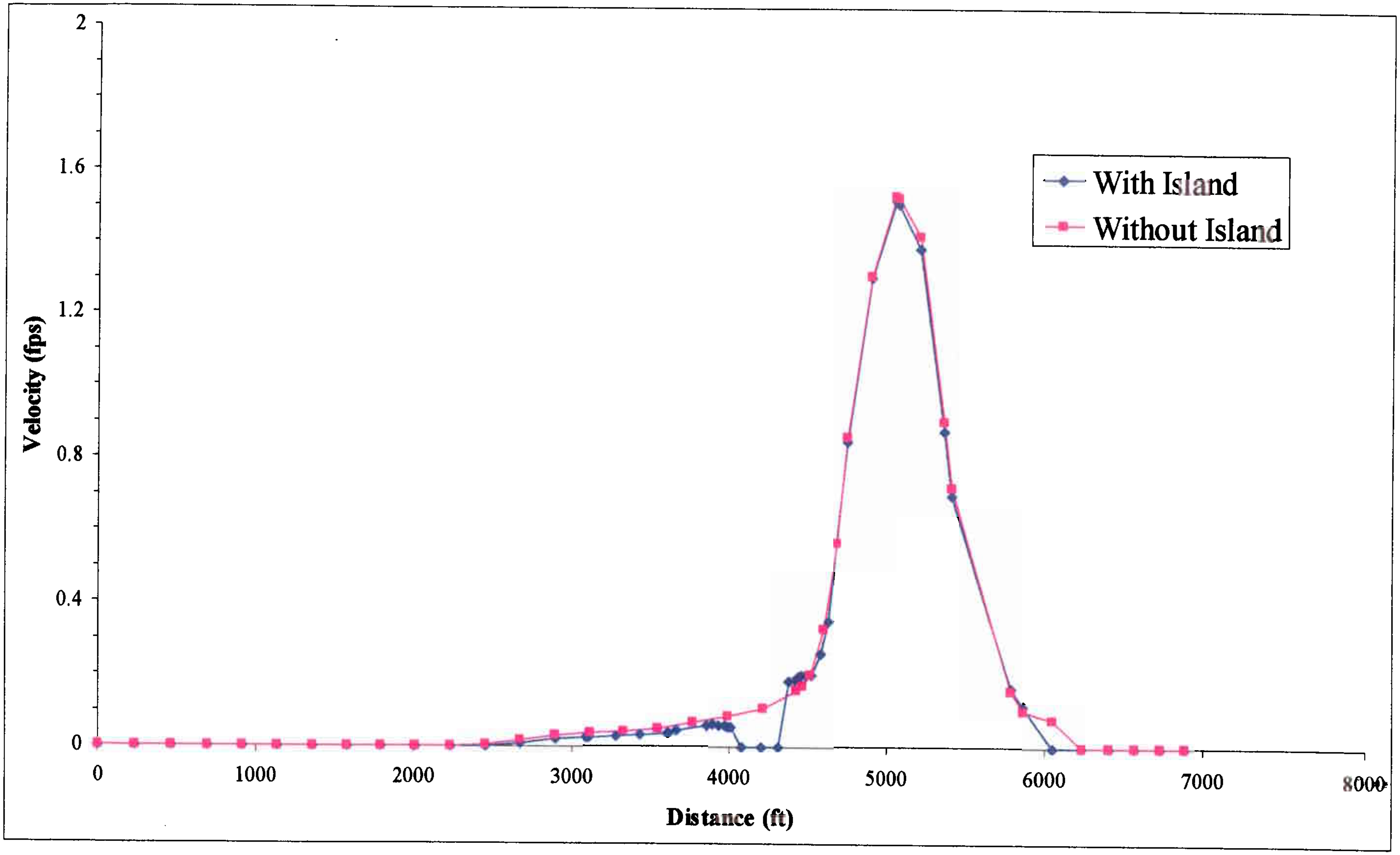

Figure 46. Lateral Velocity Distribution at Cross-Section 2, Qw = 15,000 cfs, Alternative 1

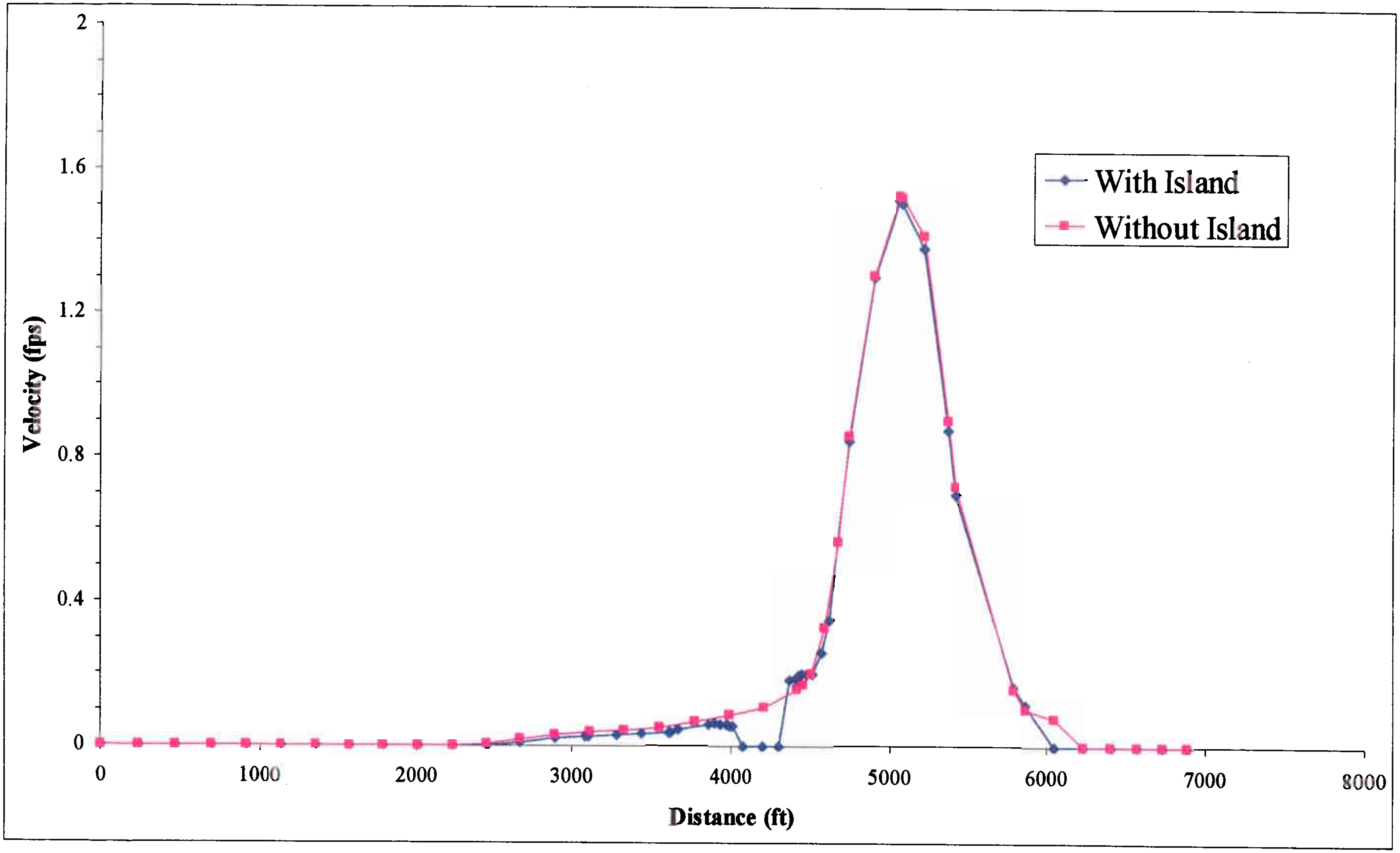

Figure 47. Lateral Velocity Distribution at Cross-Section 3, Qw = 15,000 cfs, Alternative 1

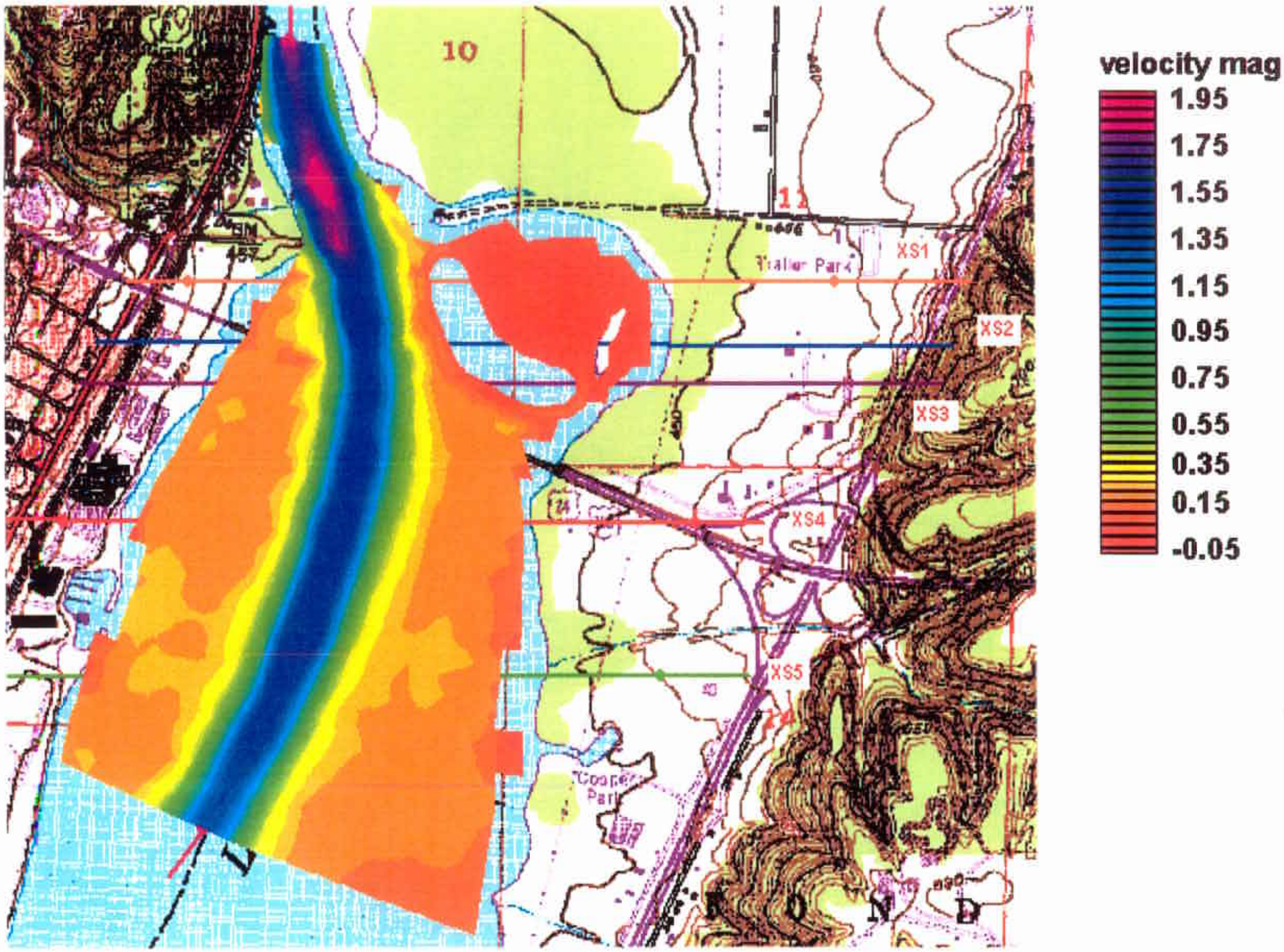

Figure 48. Spatial Velocity Distribution, Qw = 15,000 cfs, Alternative 2

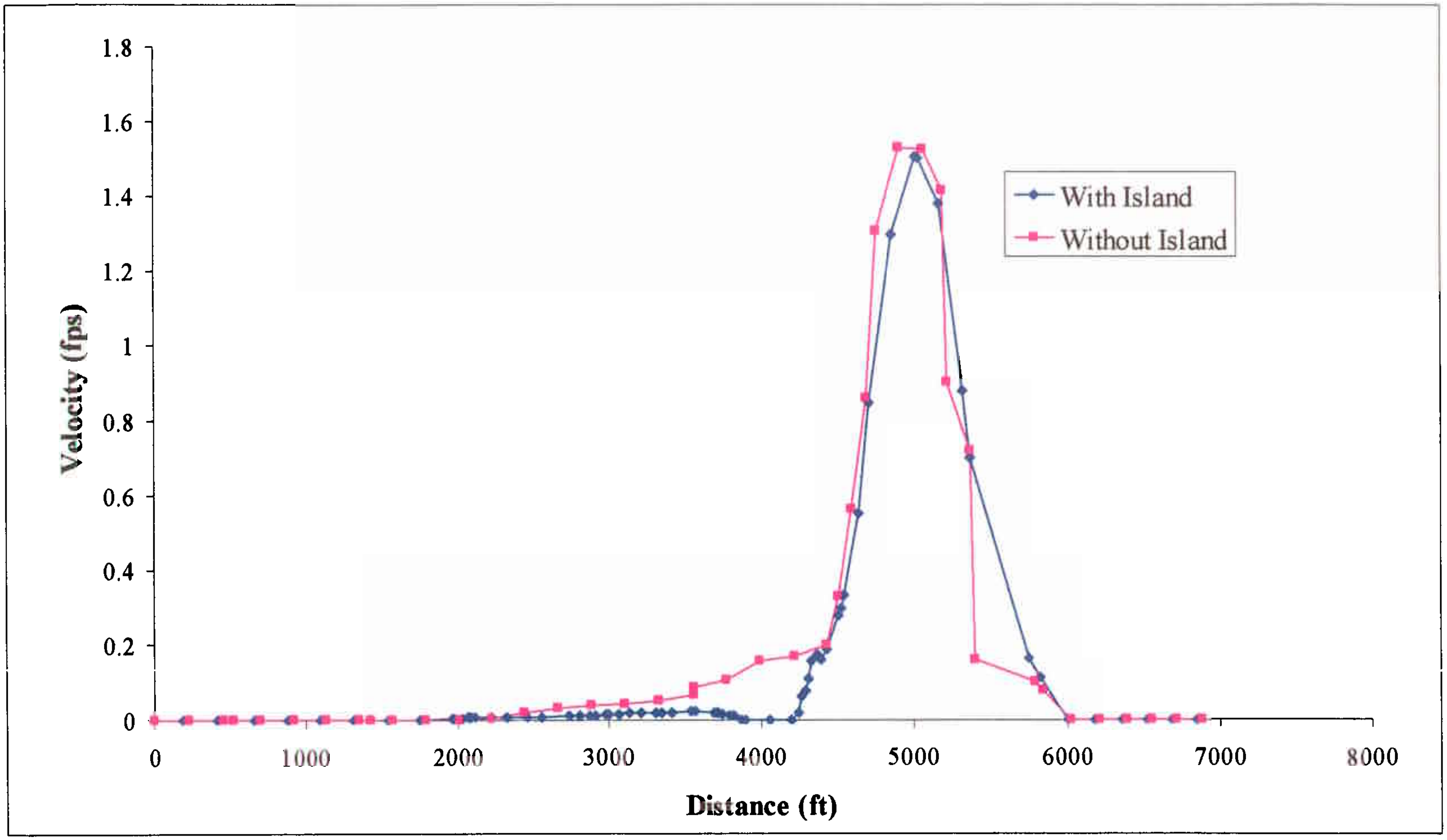

Figure 49. Lateral Velocity Distribution at Cross-Section 1, Qw = 15,000, Alternative 2

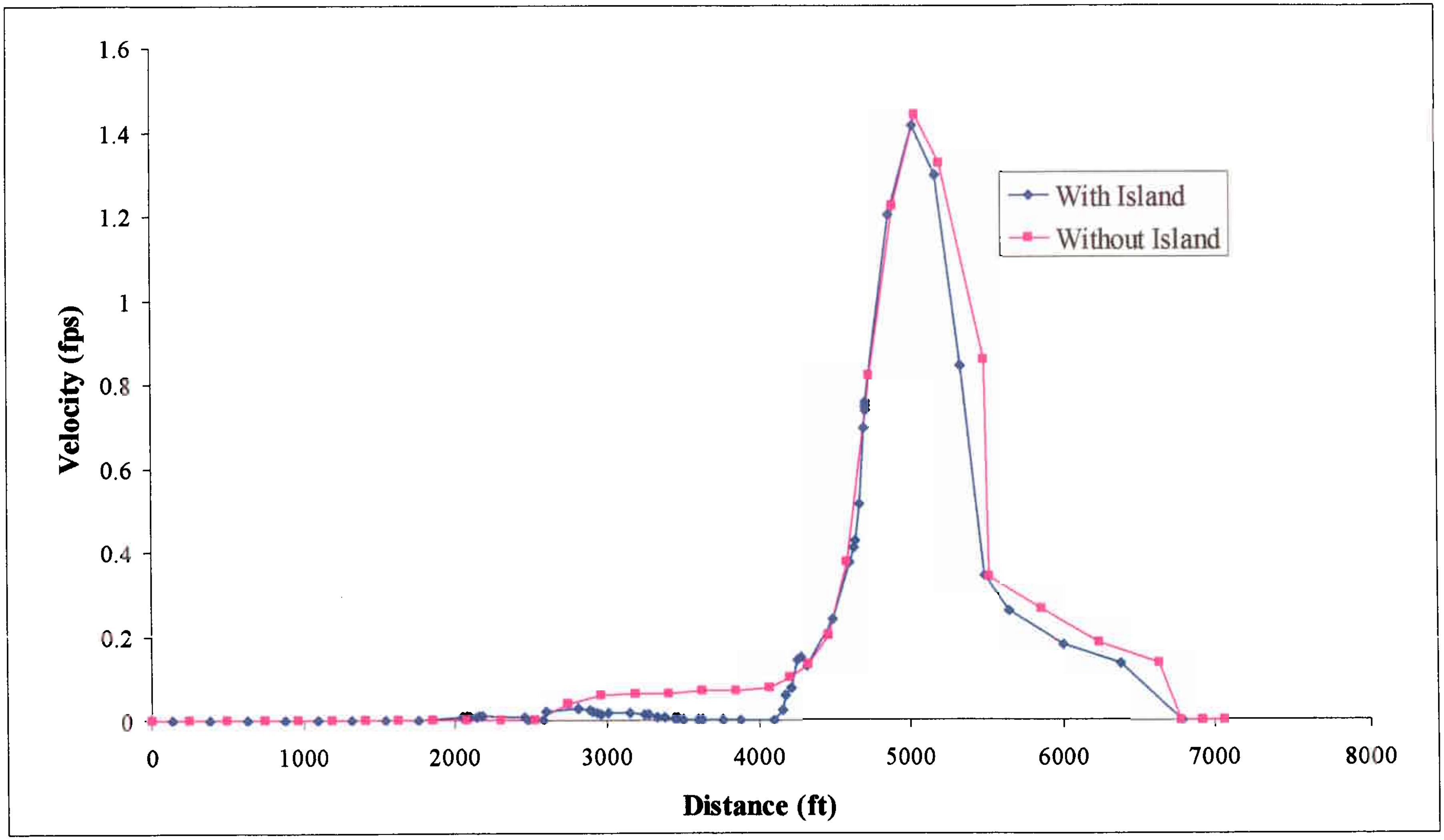

Figure 50. Lateral Velocity Distribution at Cross-Section 2, Qw = 15,000, Alternative 2

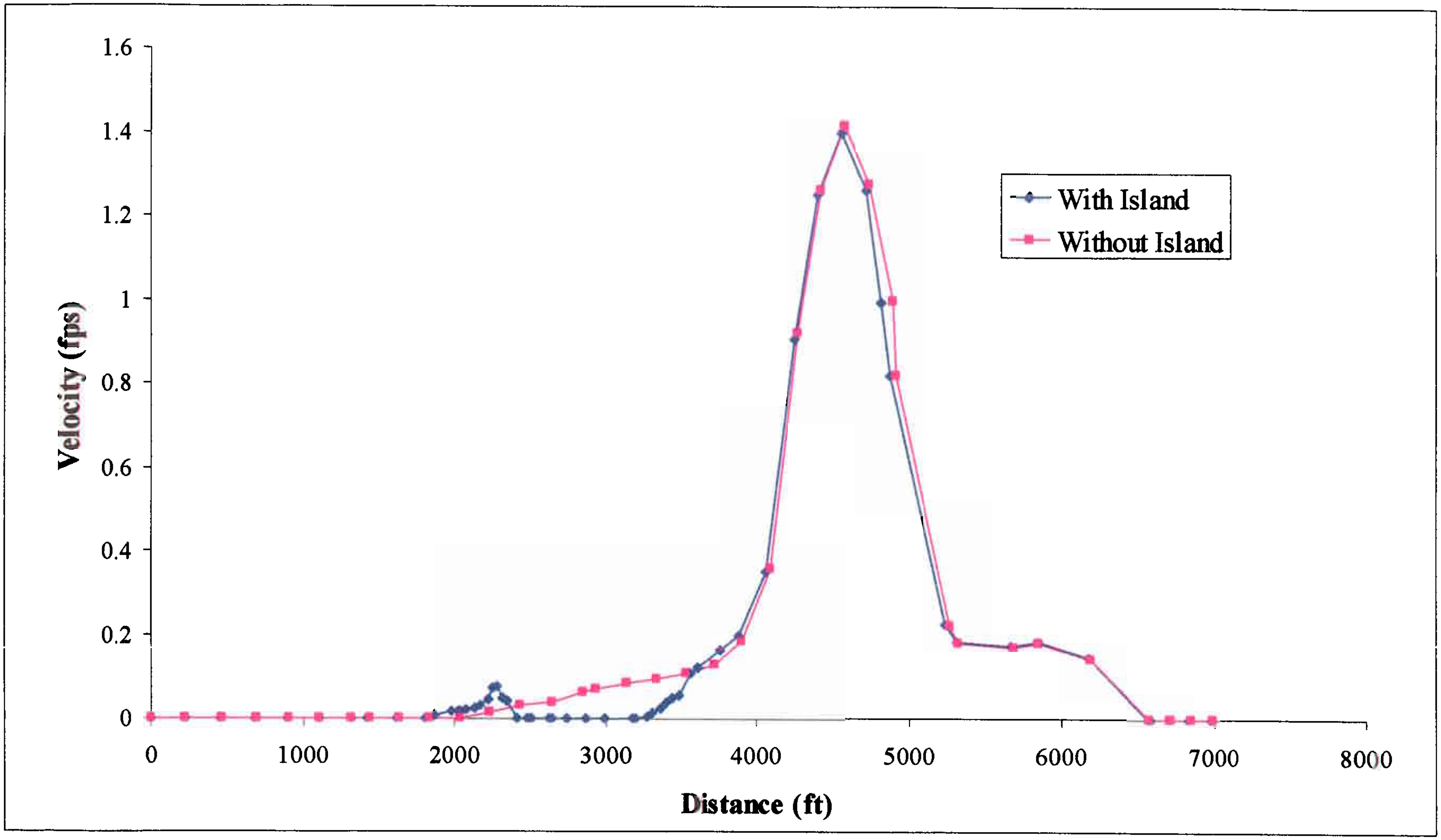

Figure 51. Lateral Velocity Distribution at Cross-Section 3, Qw = 15,000, Alternative 2

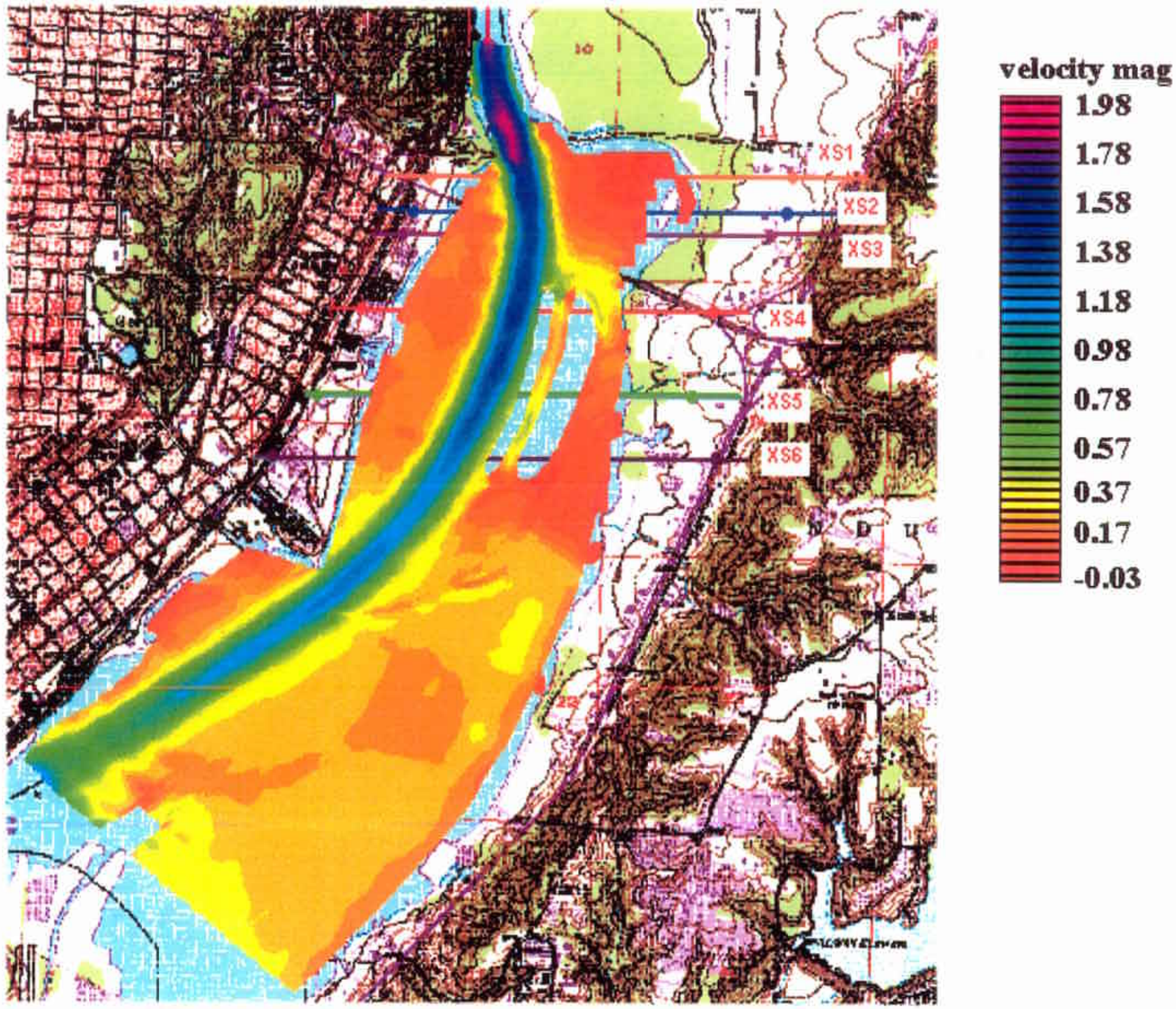

Figure 52. Spatial Velocity Distribution, Qw = 15,000 cfs, Alternative 3

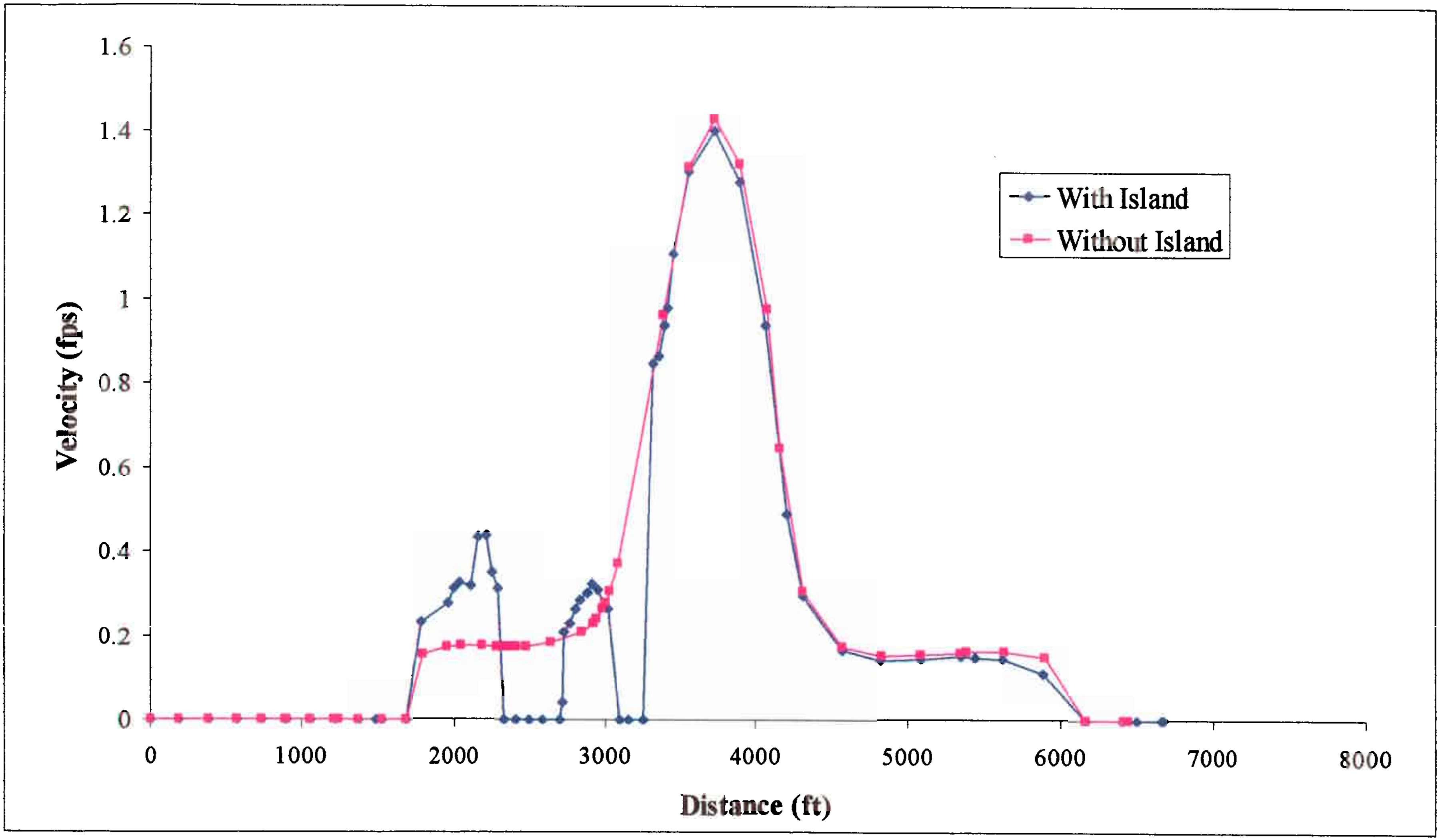

Figure 53. Lateral Velocity Distribution at Cross-Section 1, Qw = 15,000, Alternative 3

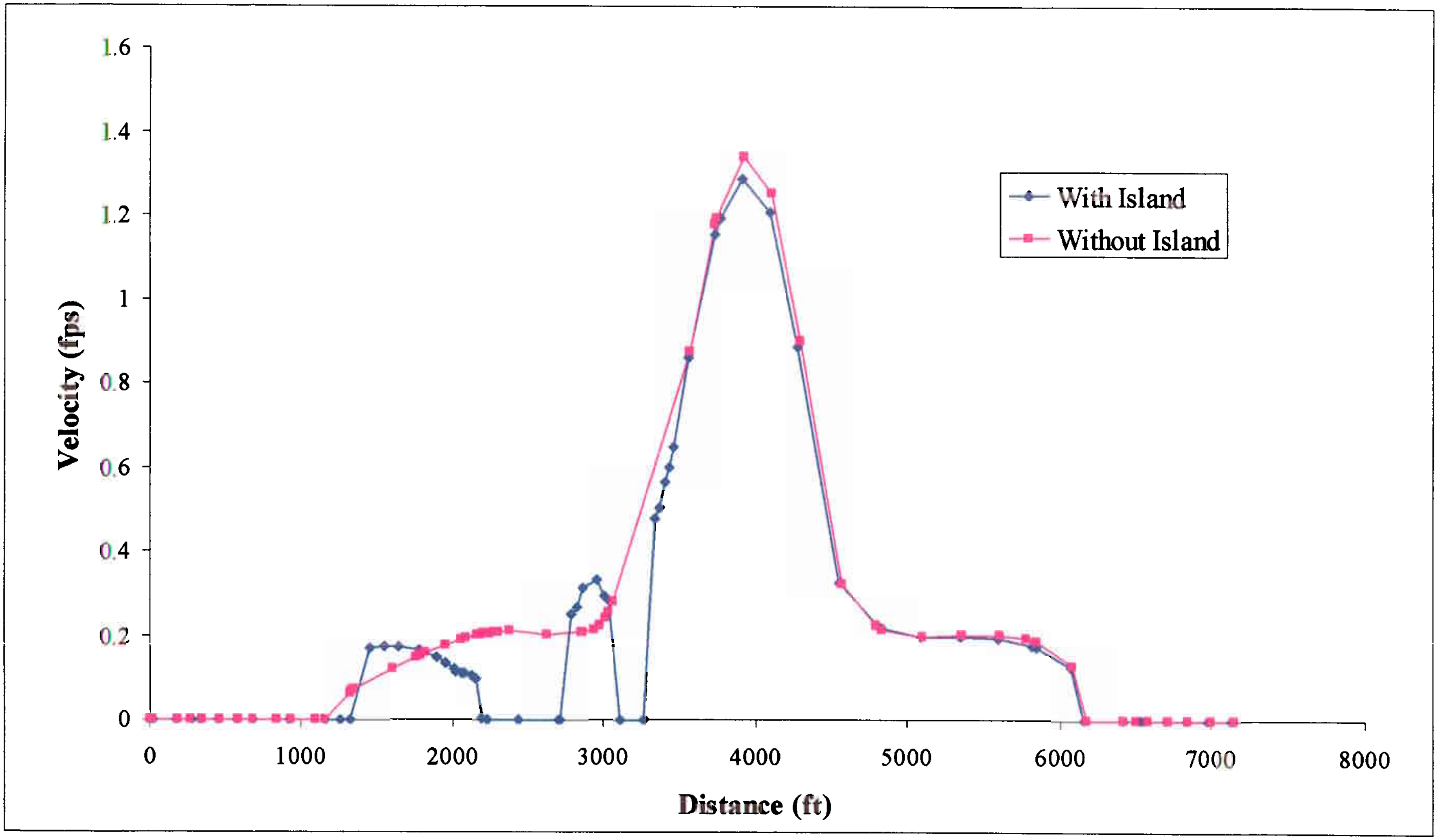

Figure 54. Lateral Velocity Distribution at Cross-Section 2, Qw = 15,000, Alternative 3

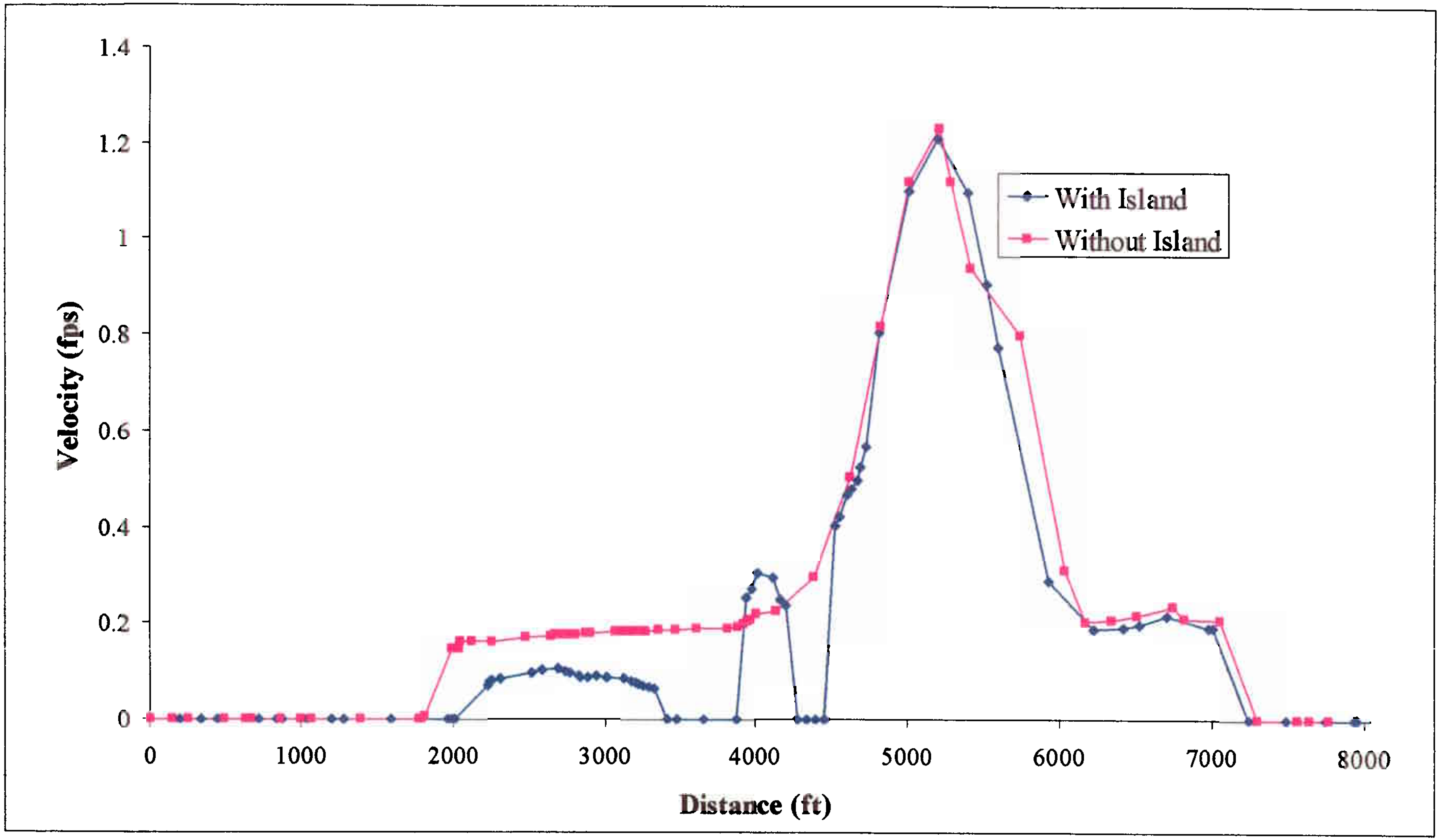

Figure 55. Lateral Velocity Distribution at Cross-Section 3, Qw = 15,000, Alternative 3

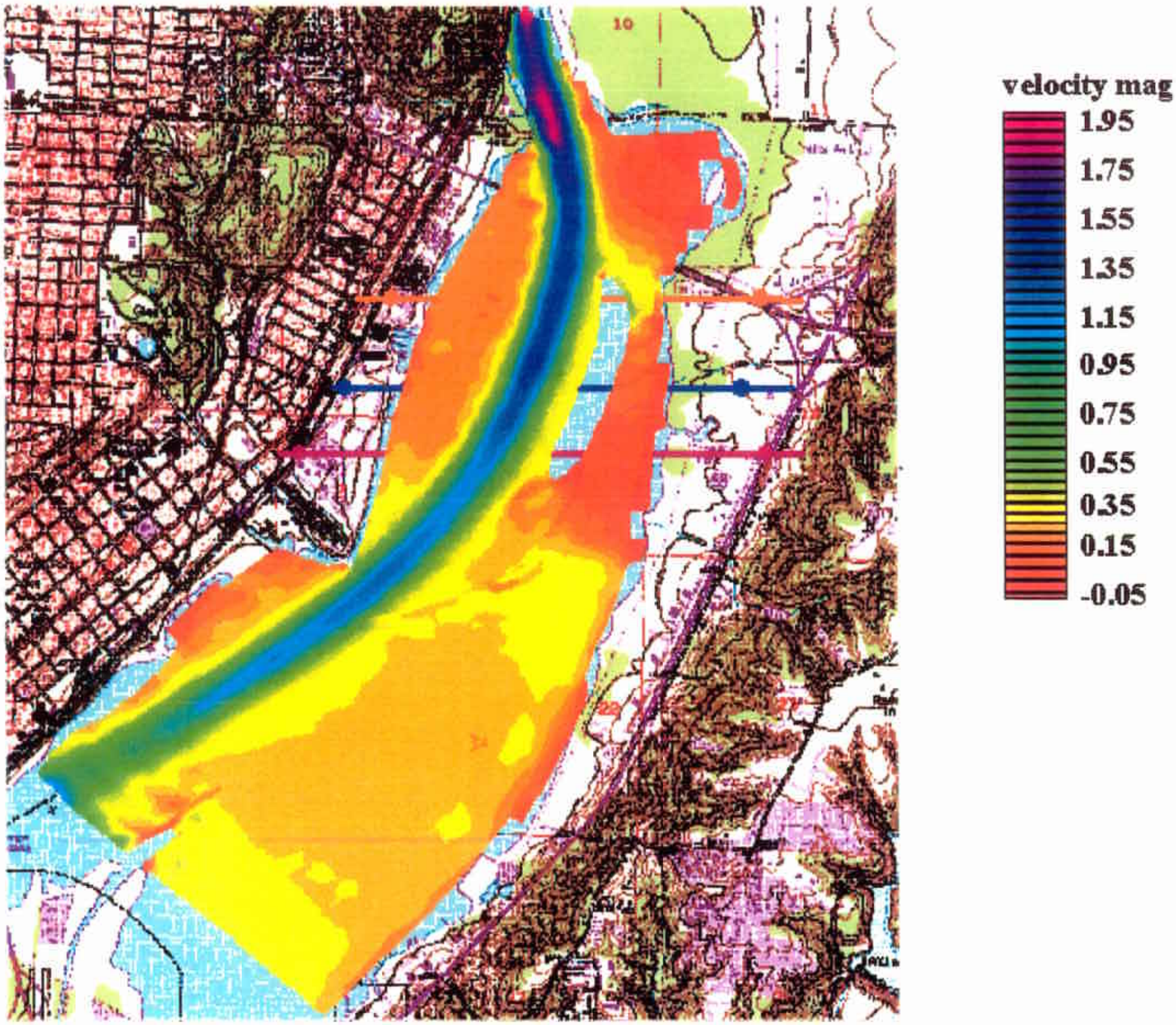

Figure 56. Spatial Velocity Distribution , Qw = 15,000, Alternative 4

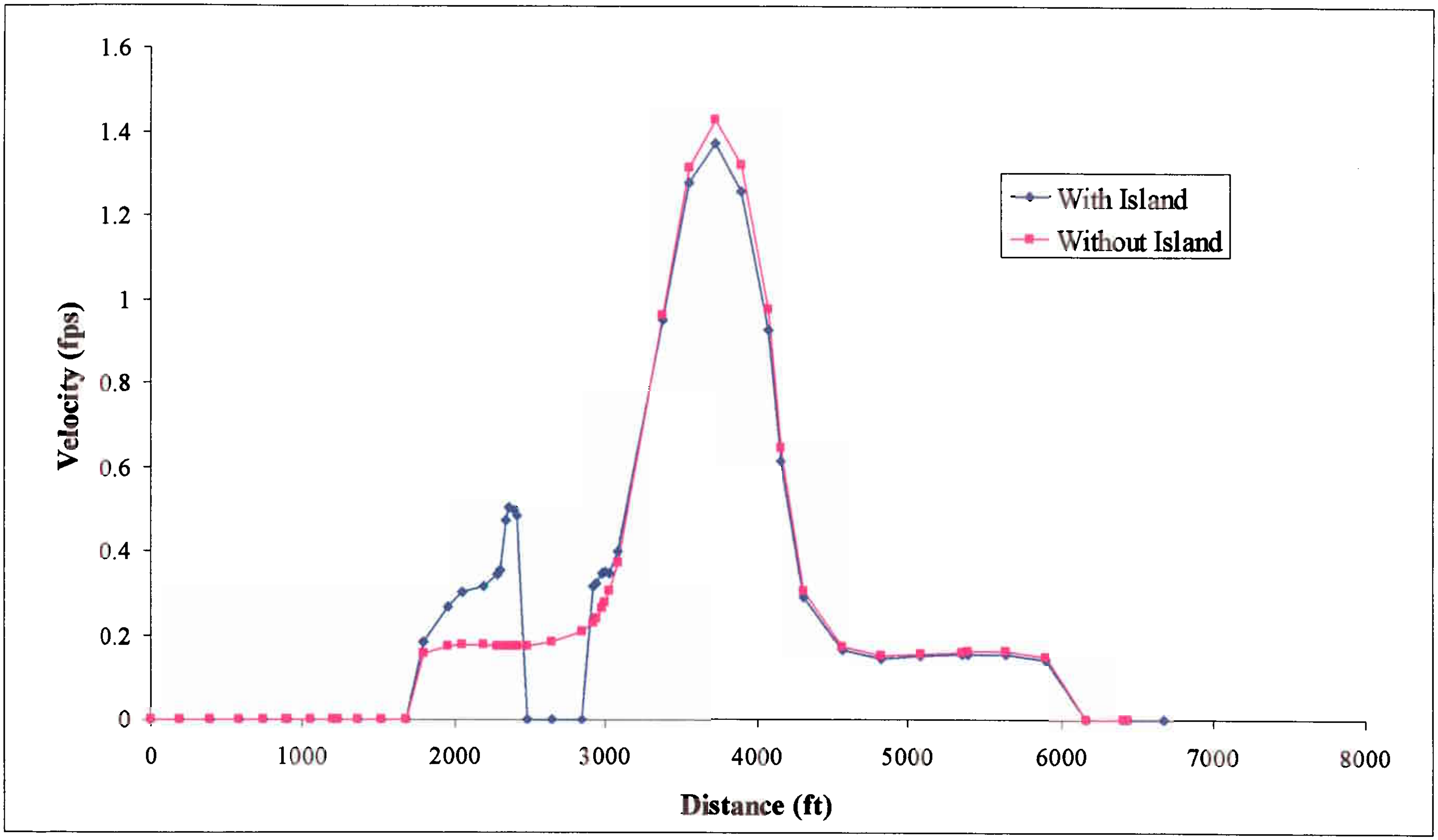

Figure 57. Lateral Velocity Distribution at Cross-Section 1, Qw = 15,000, Alternative 4

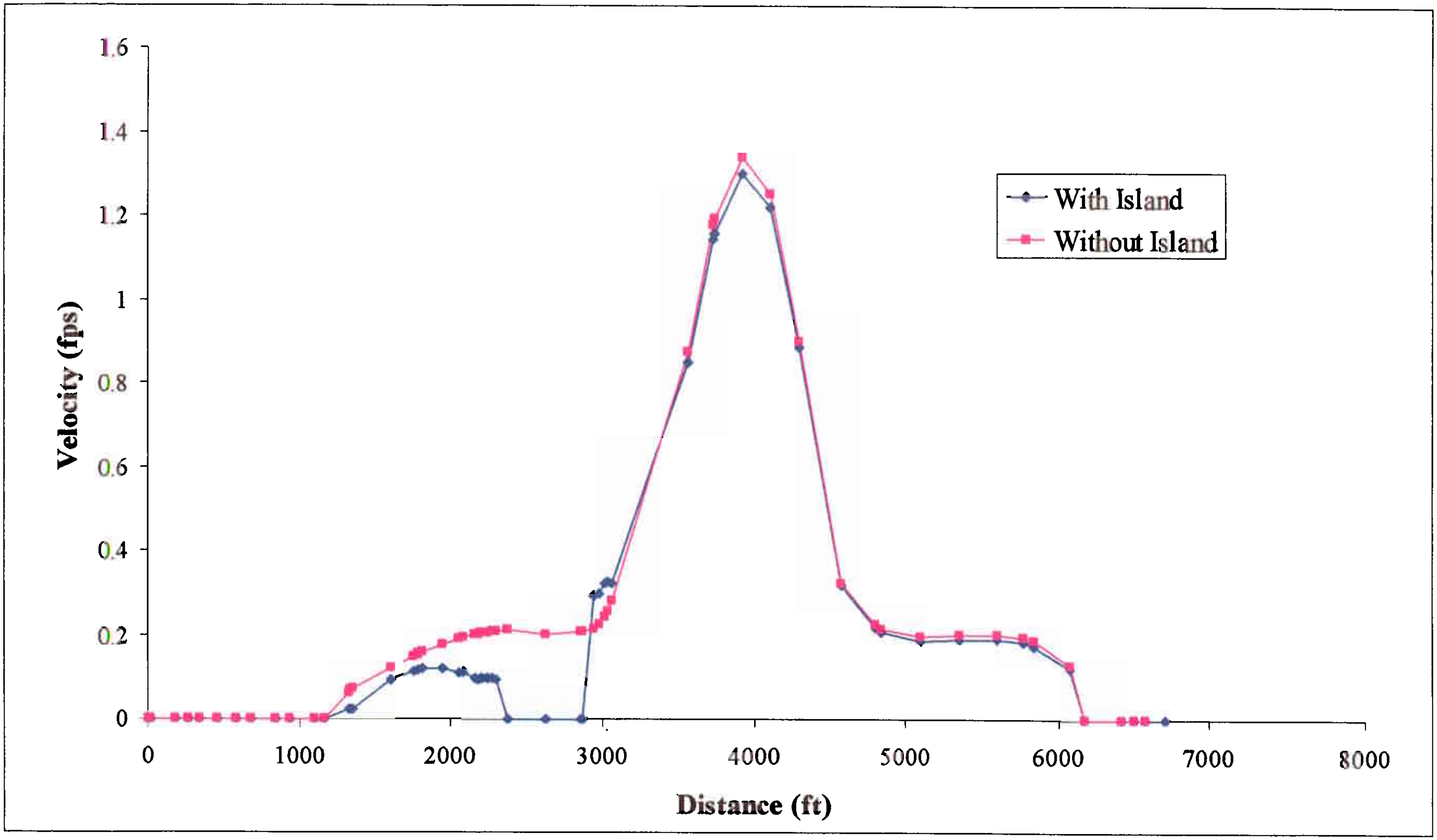

Figure 58. Lateral Velocity Distribution at Cross-Section 2, Qw = 15,000, Alternative 4

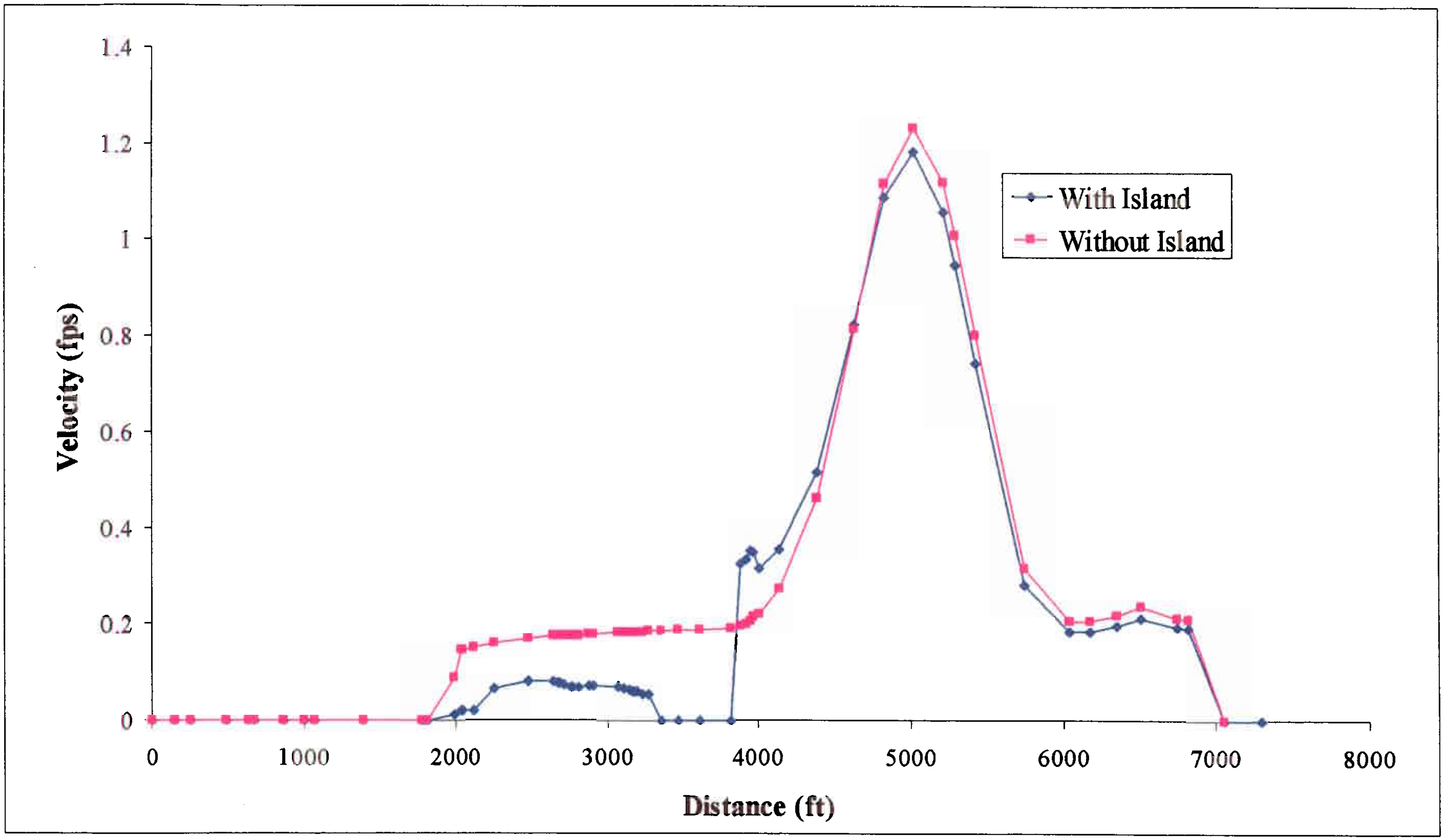

Figure 59. Lateral Velocity Distribution at Cross-Section 3, Qw = 15,000, Alternative 4

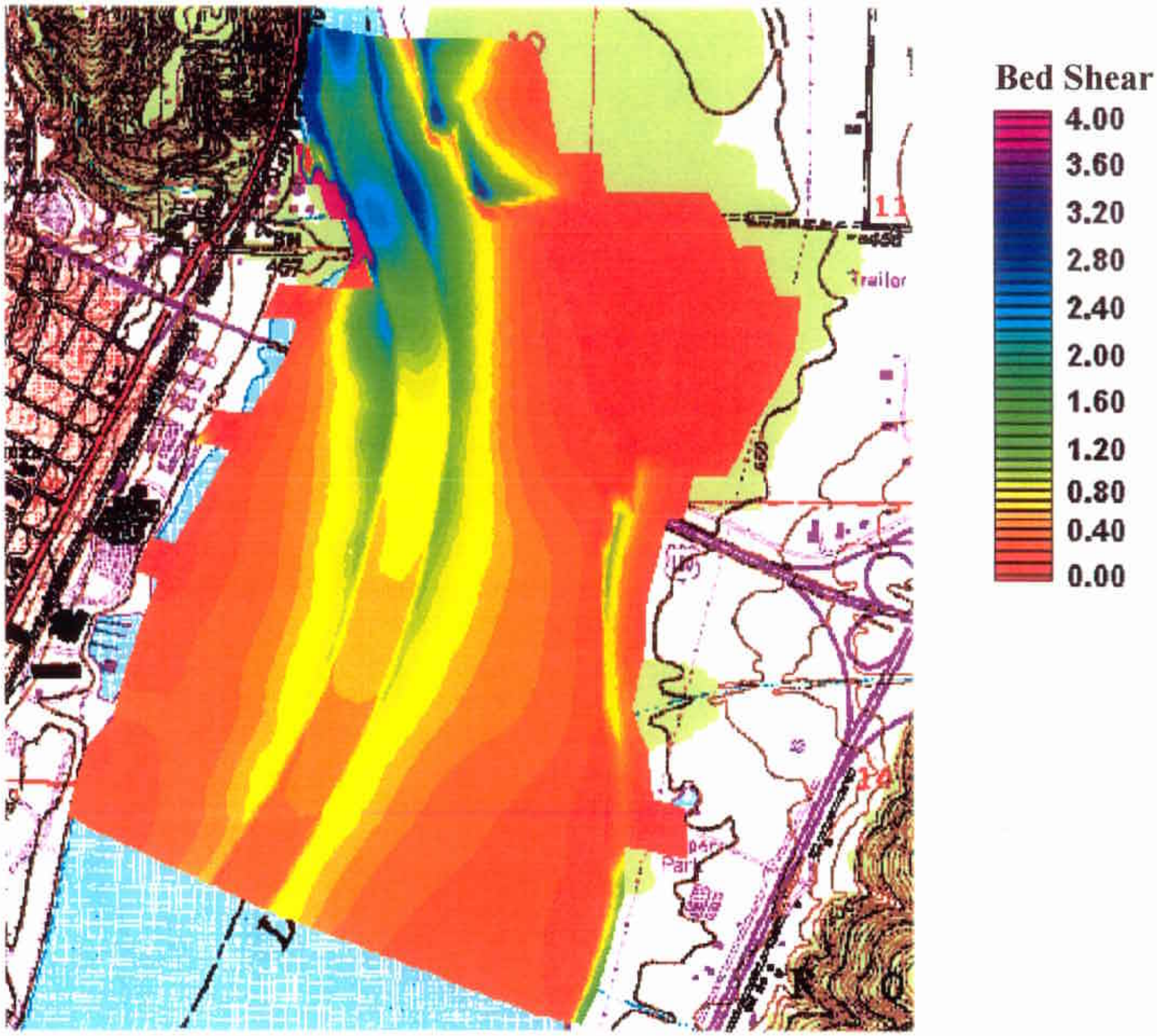

Figure 60. Spatial Shear Stress Distribution for Ambient Conclition for a flow of 45,000 cfs

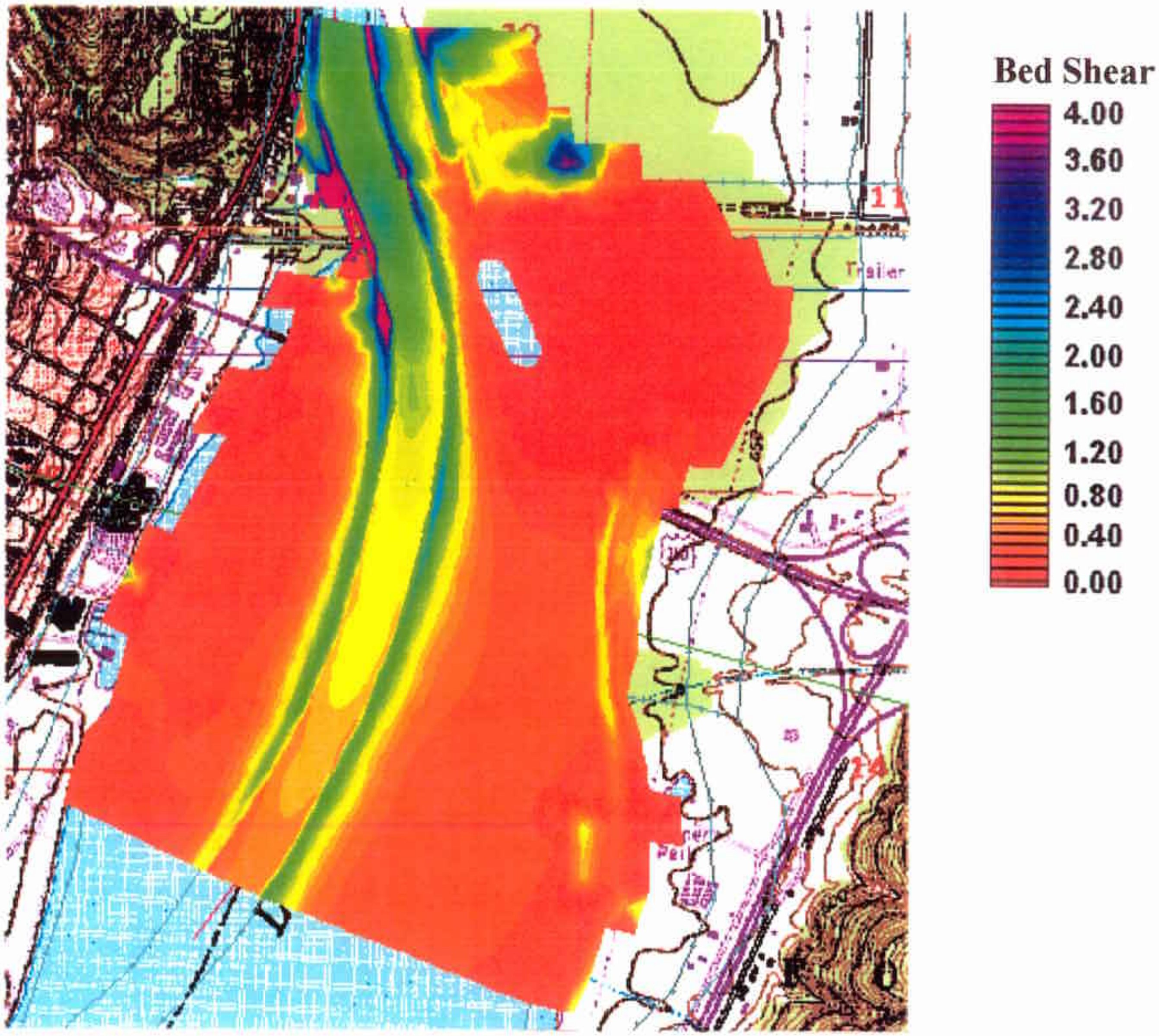

Figure 61. Spatial Shear Stress Distribution for Alternative 1 for a flow of 45,000 cfs

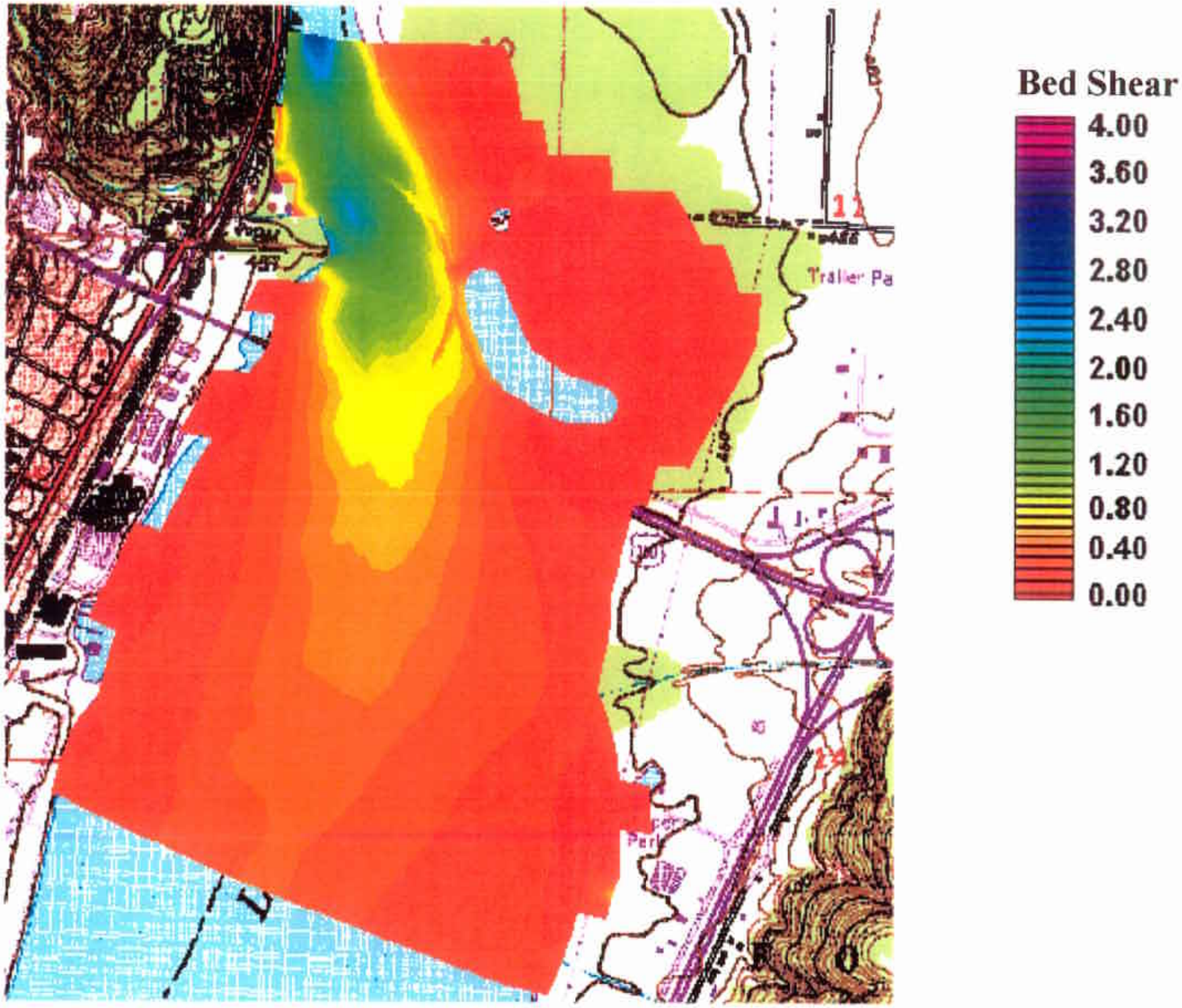

Figure 62. Spatial Shear Stress Distribution for Alternative 2 for a flow of 45,000 cfs

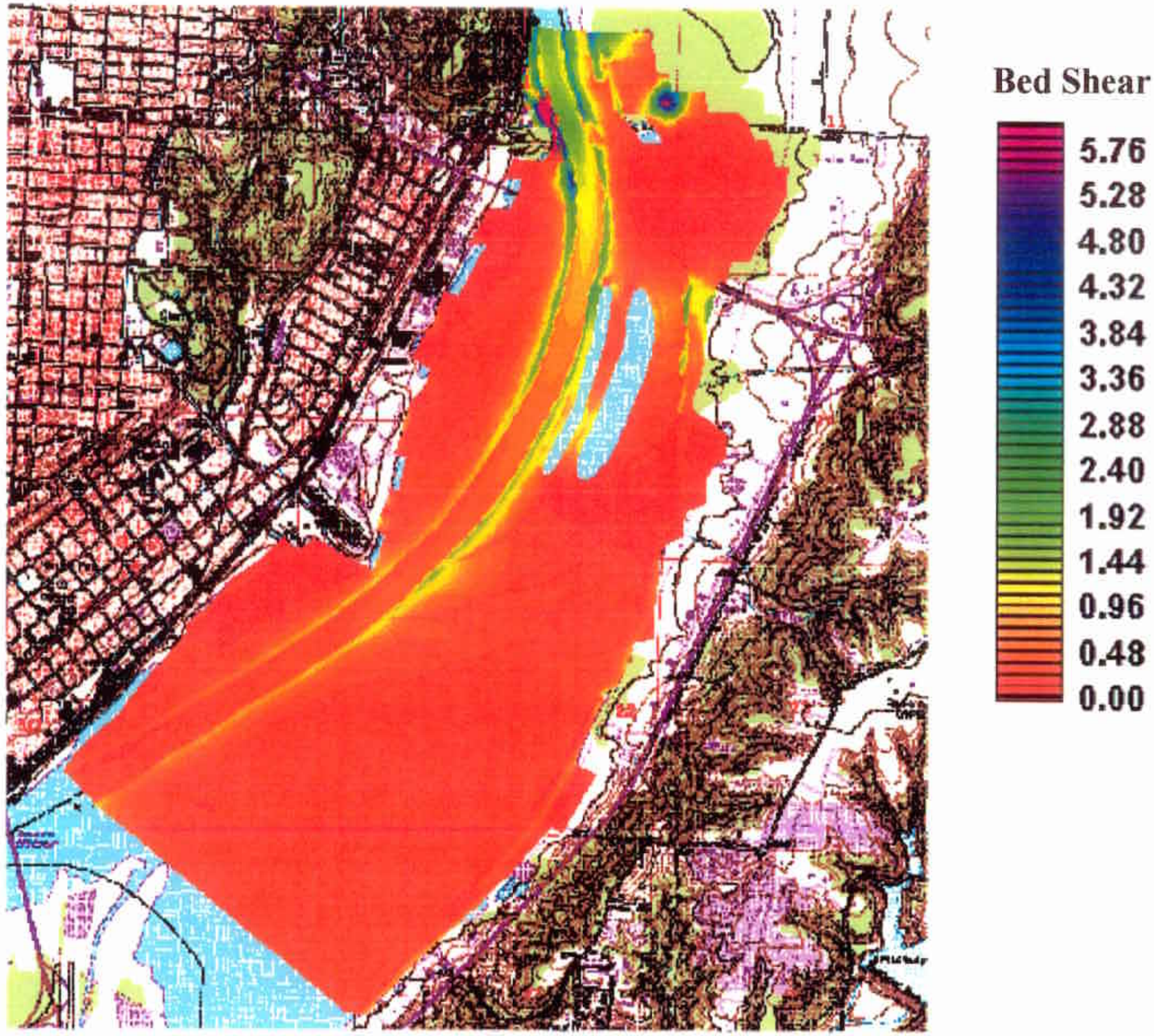

Figure 63. Spatial Shear Stress Distribution for Alternative 3 for a flow of 45,000 cfs

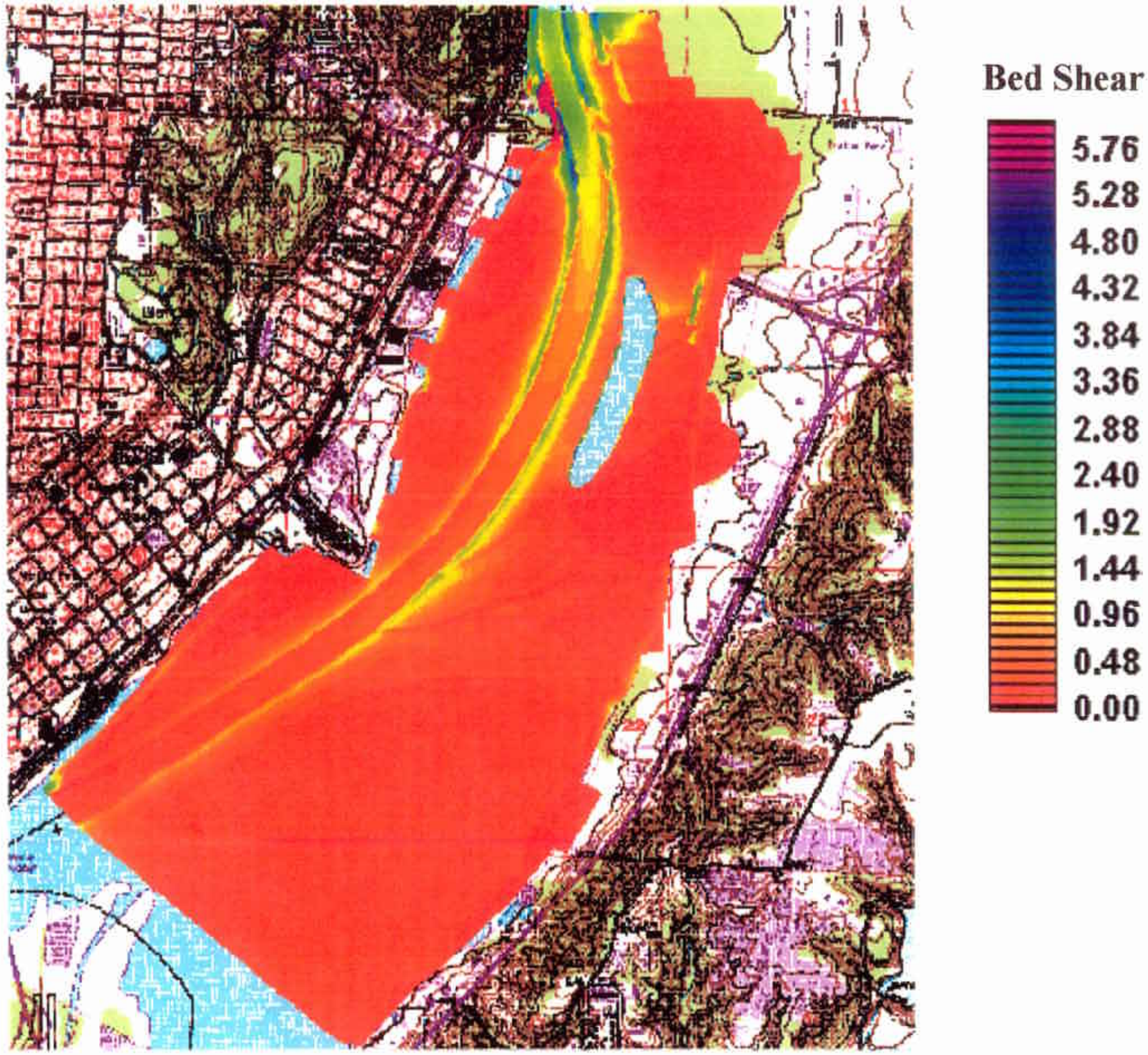

Figure 64. Spatial Shear Stress Distribution for Alternative 4 for a flow of 45,000 cfs

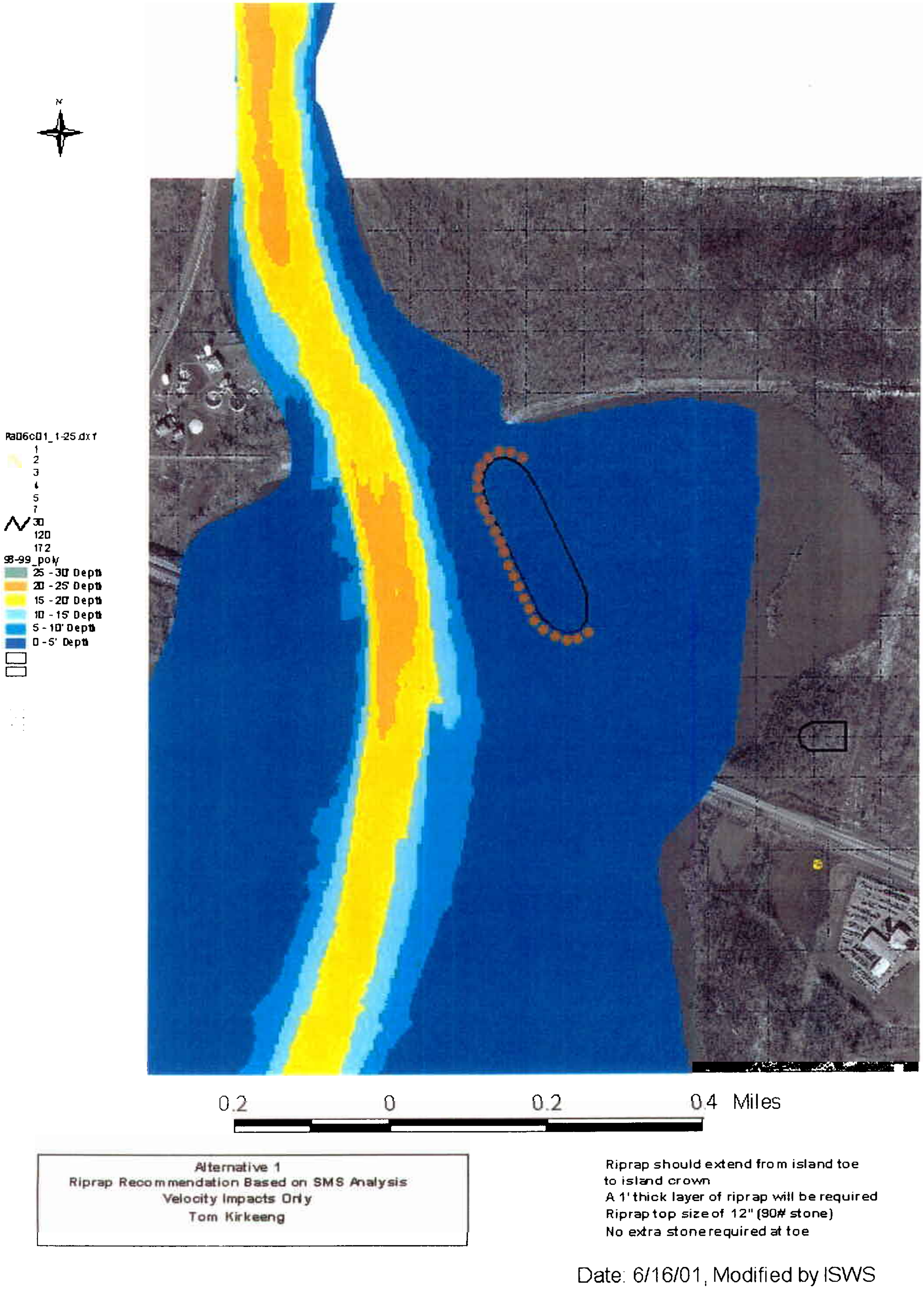

Figure 65. Alternative 1, Zones of Suggested Bank Stabilization Work

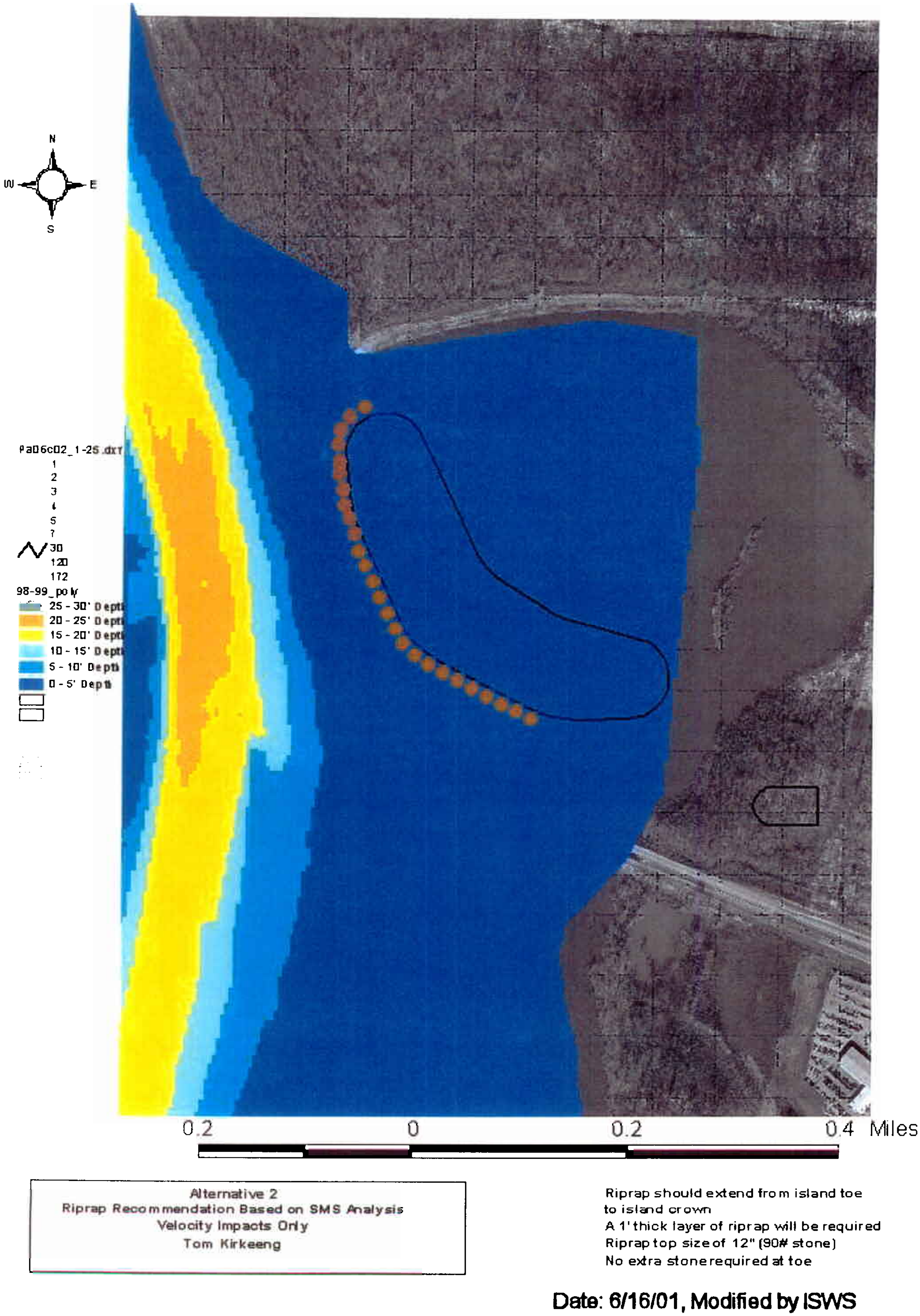

Figure 66. Alternative 2. Zones of Suggested Bank Stabilization Work

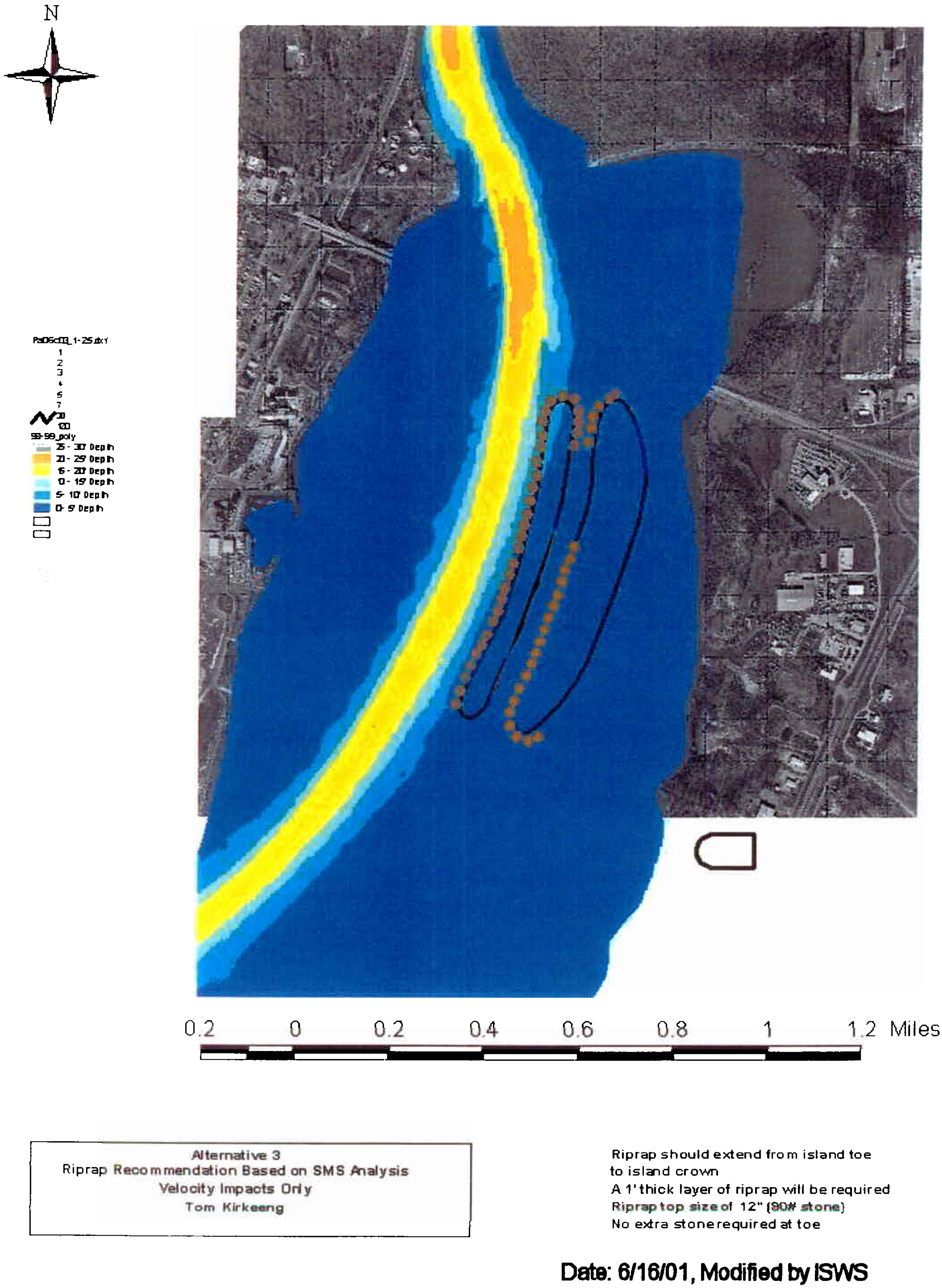

Figure 67. Alternative 3, Zones of Suggested Bank Stabilization Work

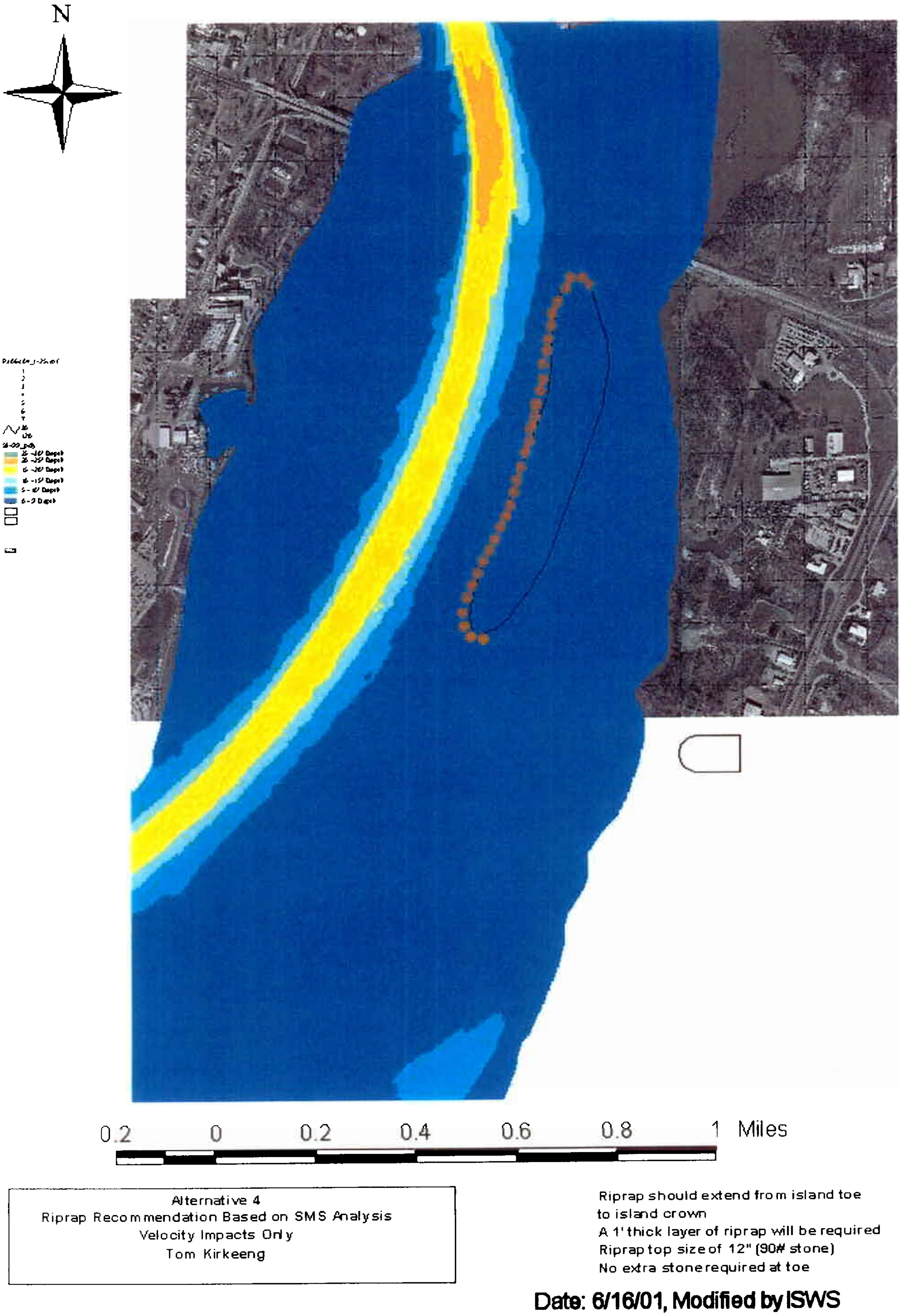

Figure 68. Alternative 4, Zones of Suggested Bank Stabilization Work

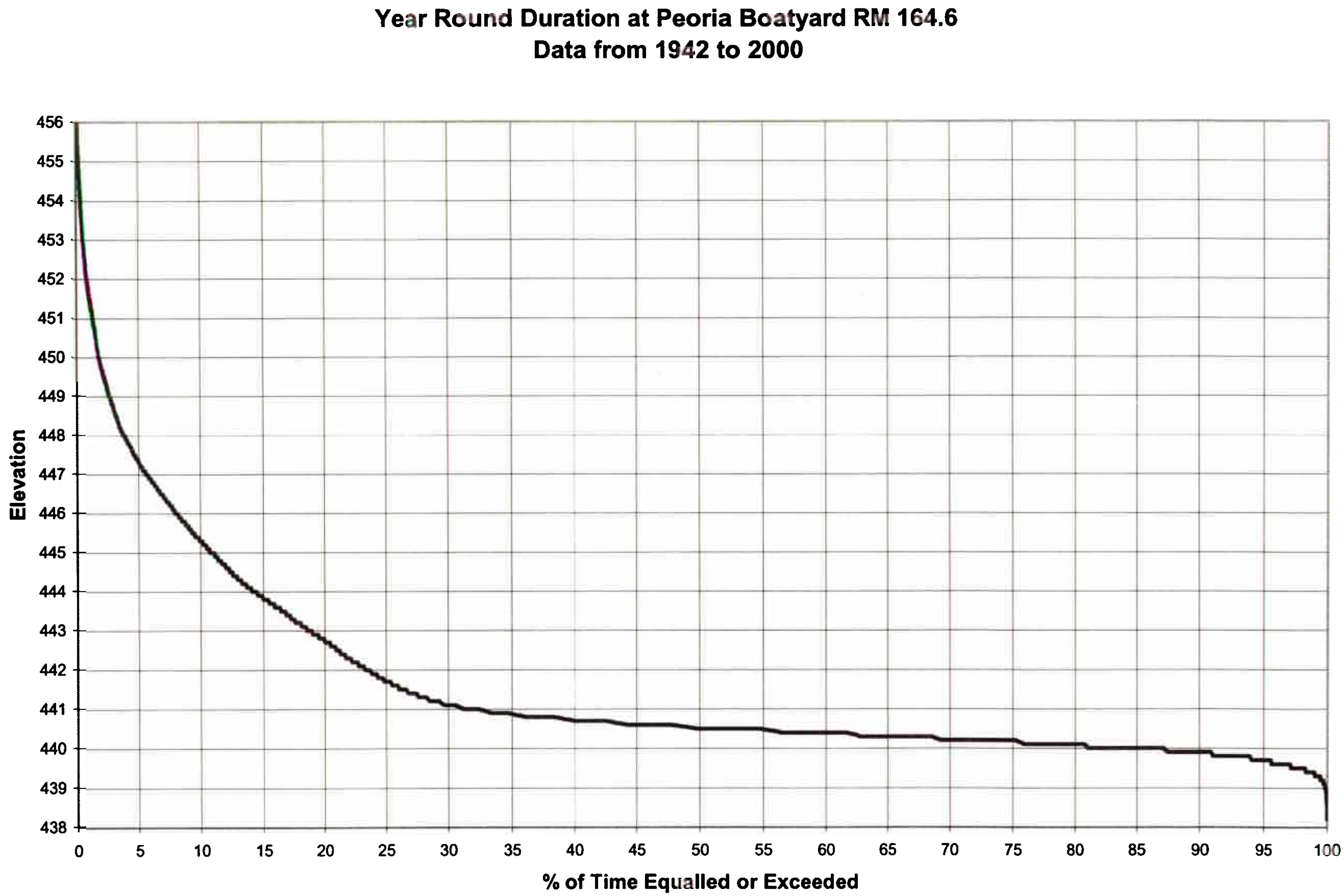

Figure 69. Year Round Duration of Water Surface Elevation Variations at Peoria Boatyard, RM 164.6. Data from 1942 to 2000. (Personal Communications, USA COE, 2001)

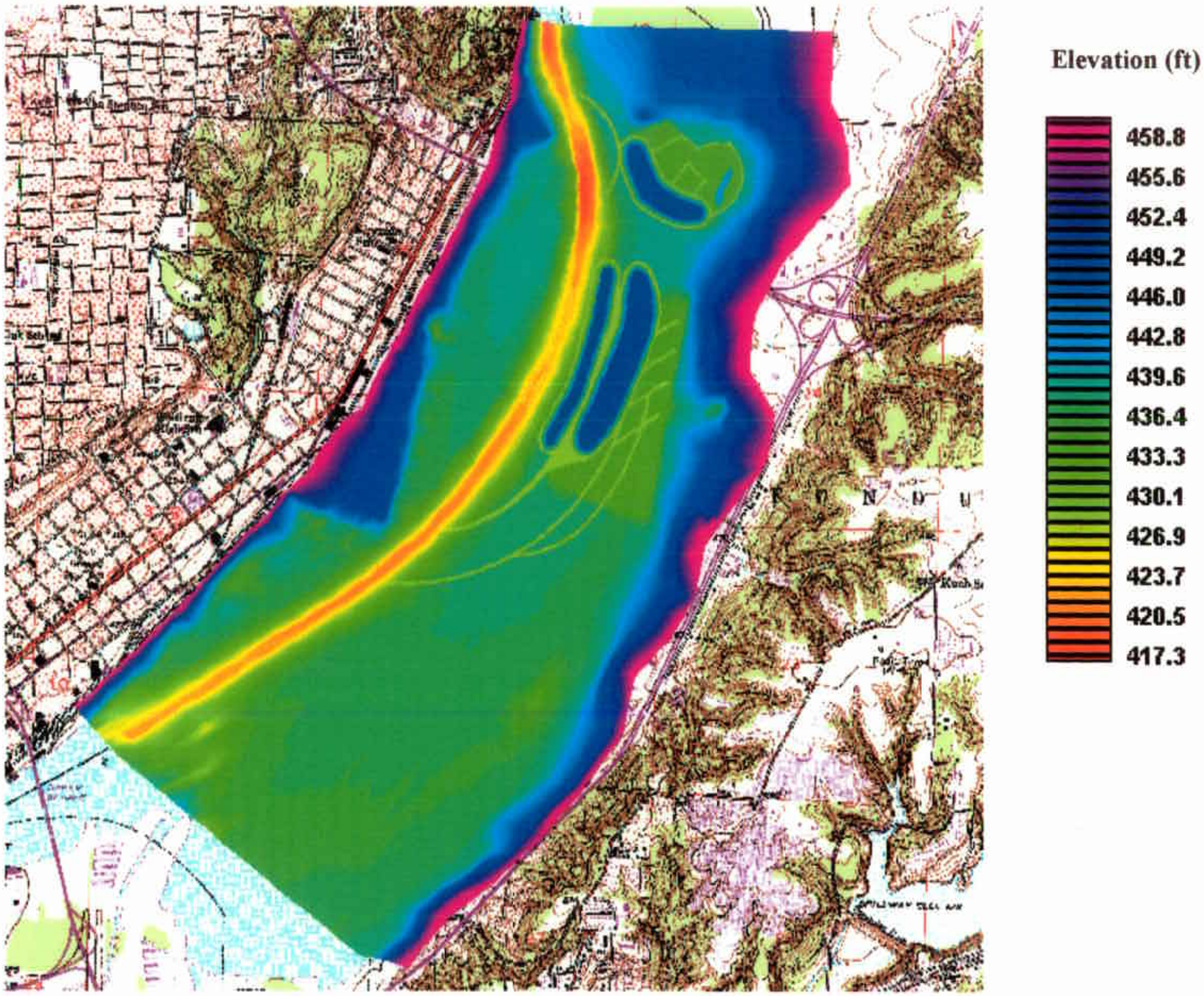

Figure 79. Elevation Variations for Alternatives 2 and 3

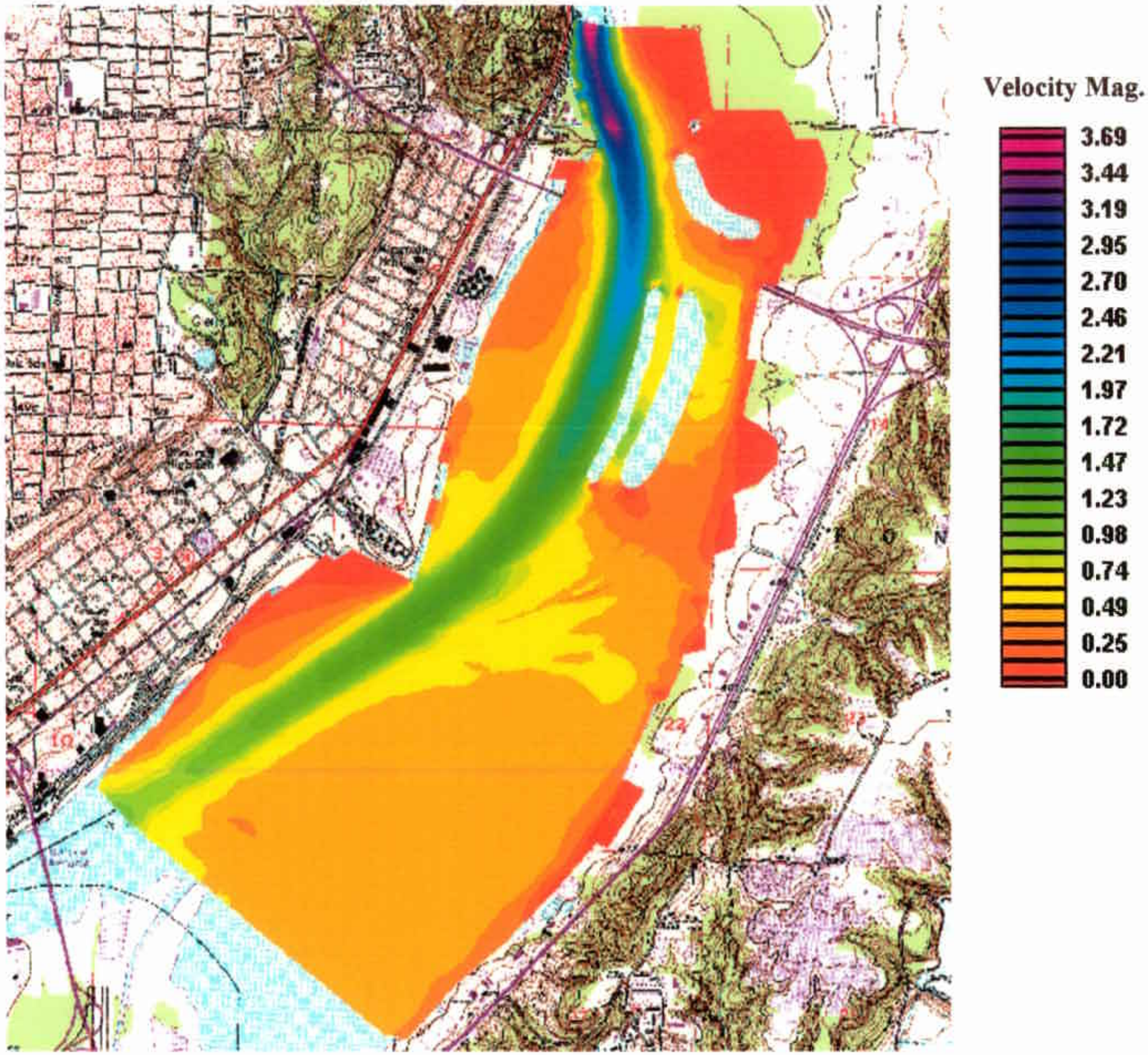

Figure 80. Spatial Velocity Distributions for Alternatives 2 and 3 for a flow of 45,000 cfs.

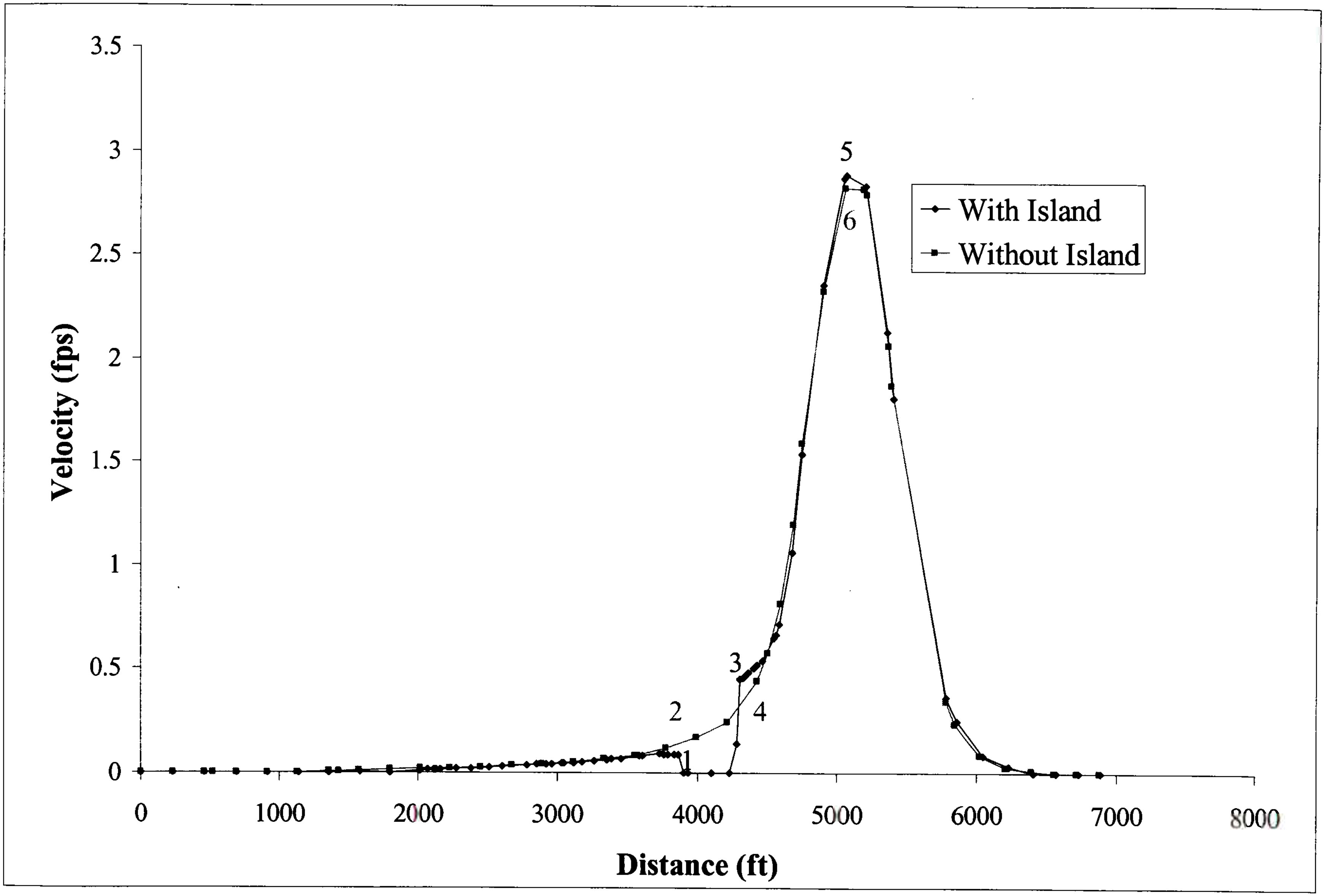

Figure 81. Lateral Velocity Distributions at Cross-section 1 (see Figure 70) for a flow of 45,000 cfs for Alternatives 2 and 3

X-1, 45K

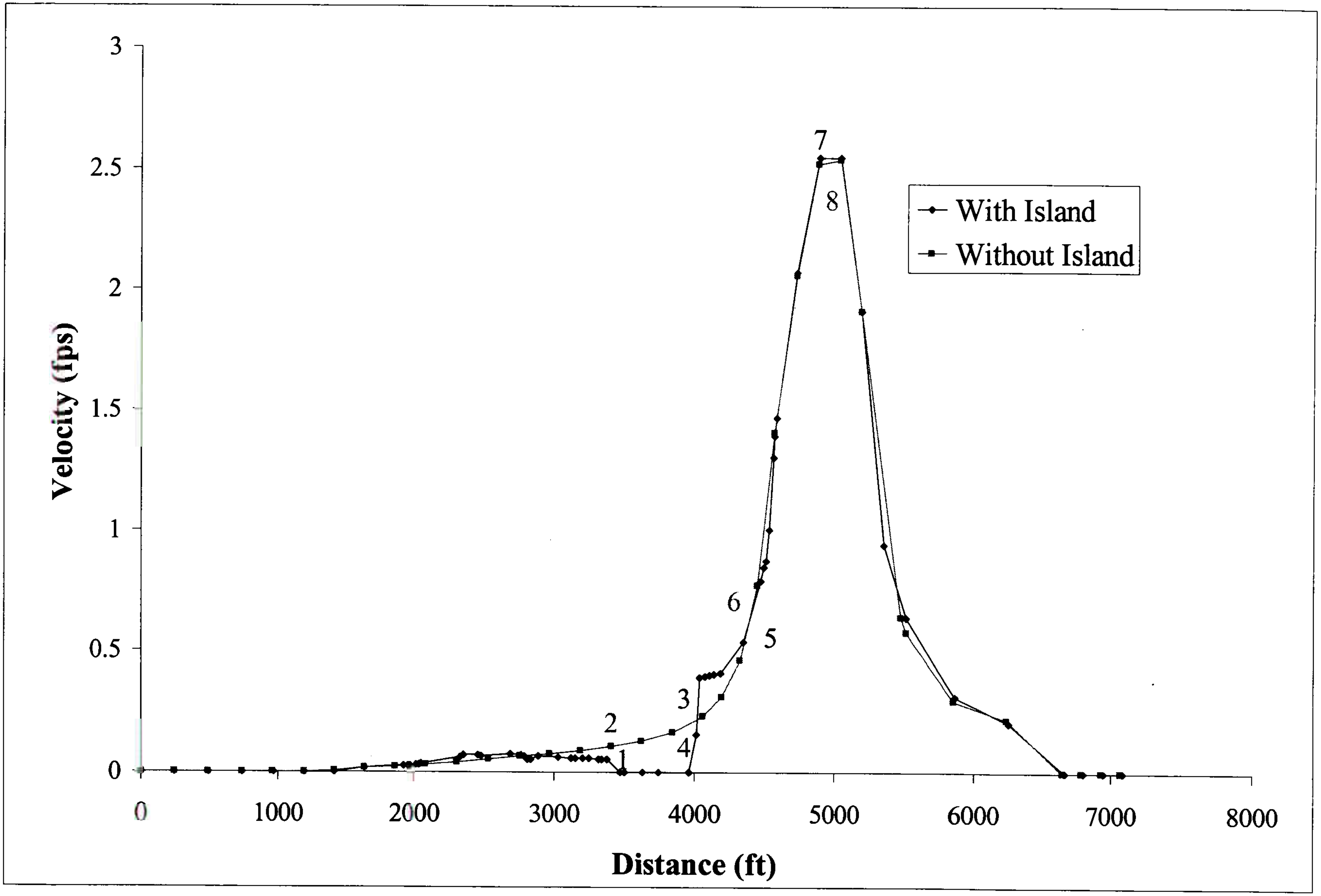

Figure 82. Lateral Velocity Distributions at Cross-section 2 (see Figure 70) for a flow of 45,000 cfs for Alternatives 2 and 3

X- 2, 45K

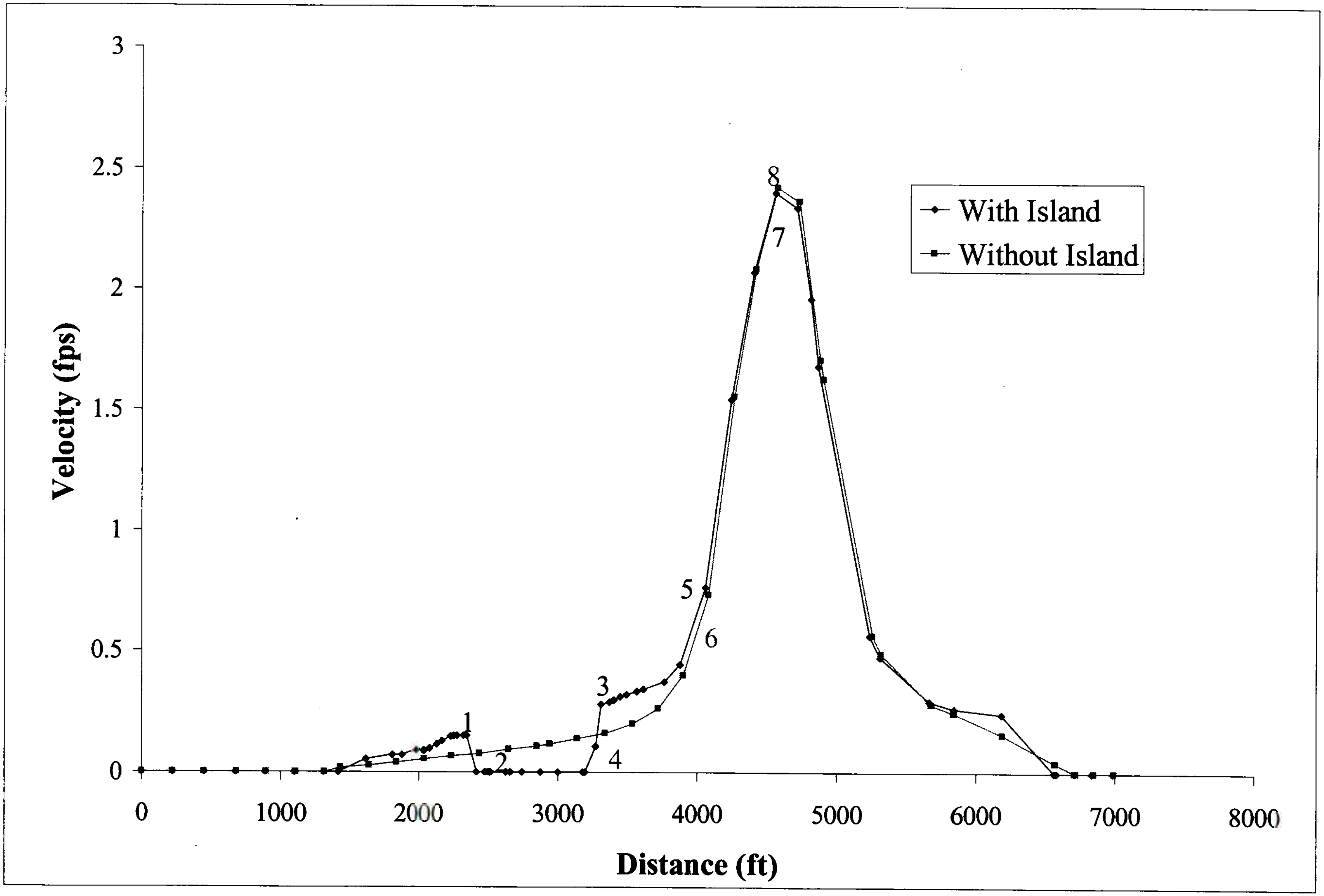

Figure 83. Lateral Velocity Distributions at Cross-section 3 (see Figure 70) for a flow of 45,000 cfs for Alternatives 2 and 3

V-3, 45K

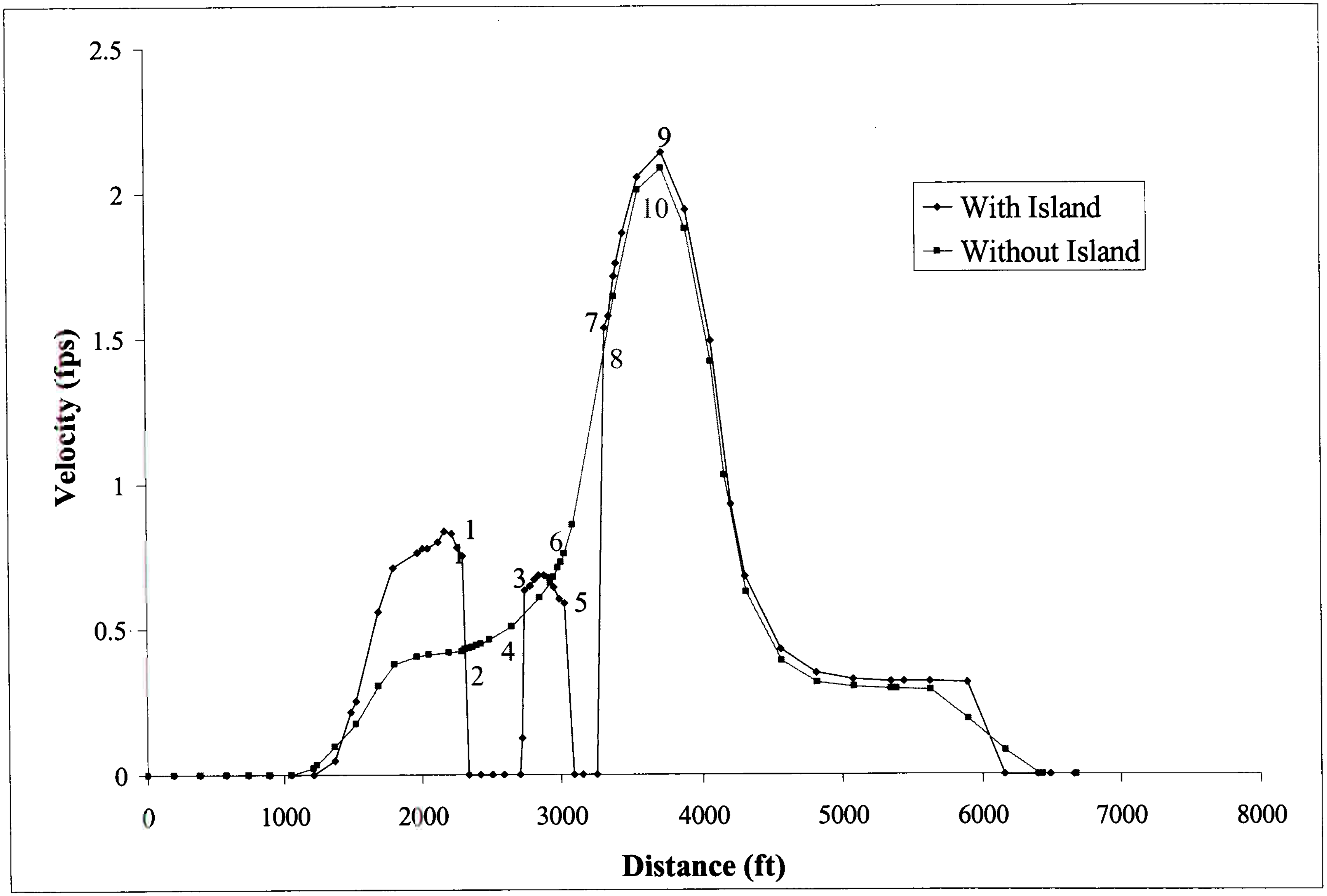

Figure 84. Lateral Velocity Distributions at Cross-section 4 (see Figure 70) for a flow of 45,000 cfs for Alternatives 2 and 3

Y. 4 45K

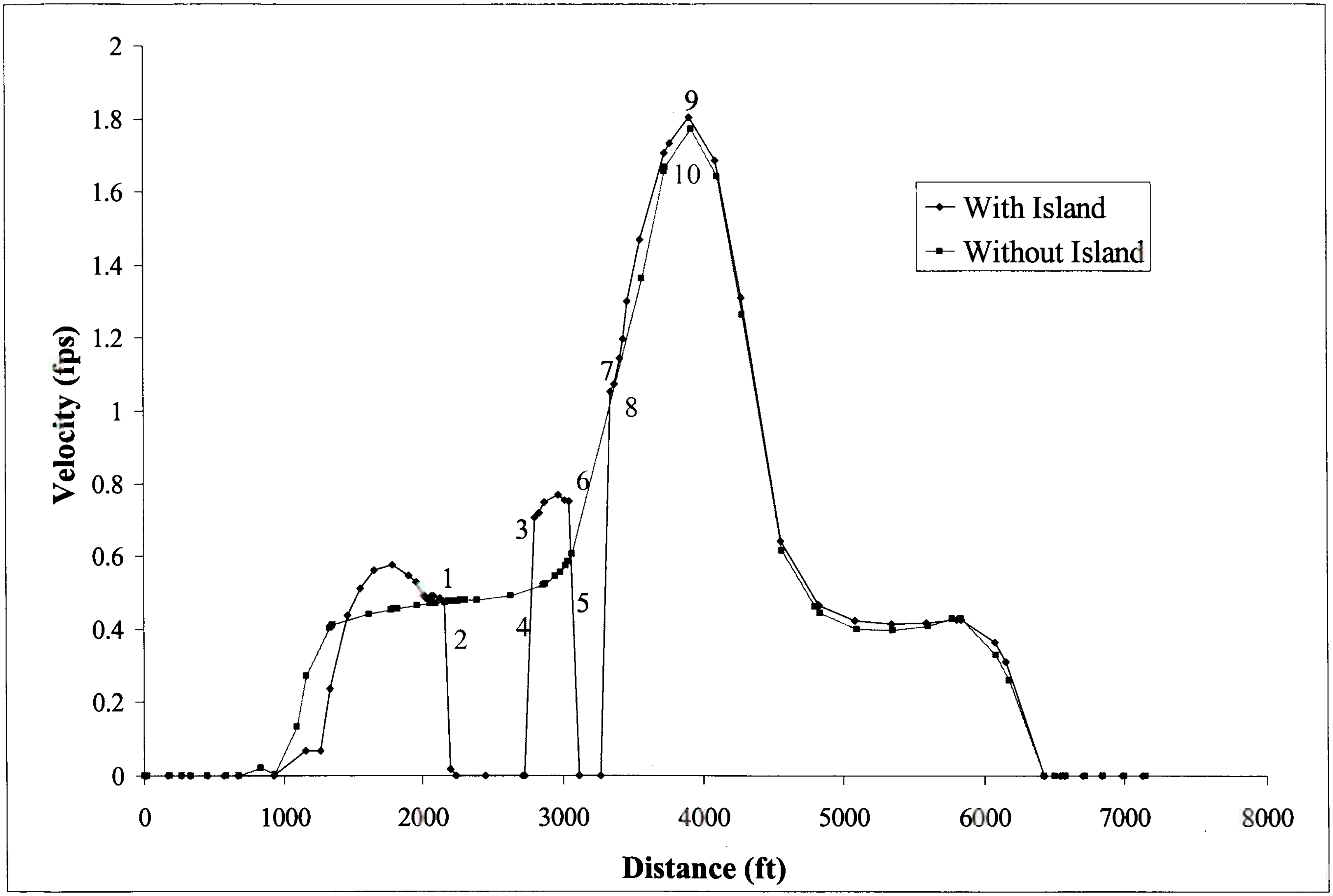

Figure 85. Lateral Velocity Distributions at Cross-section 5 (see Figure 70) for a flow of 45,000 cfs for Alternatives 2 and 3

x. 5, 45K

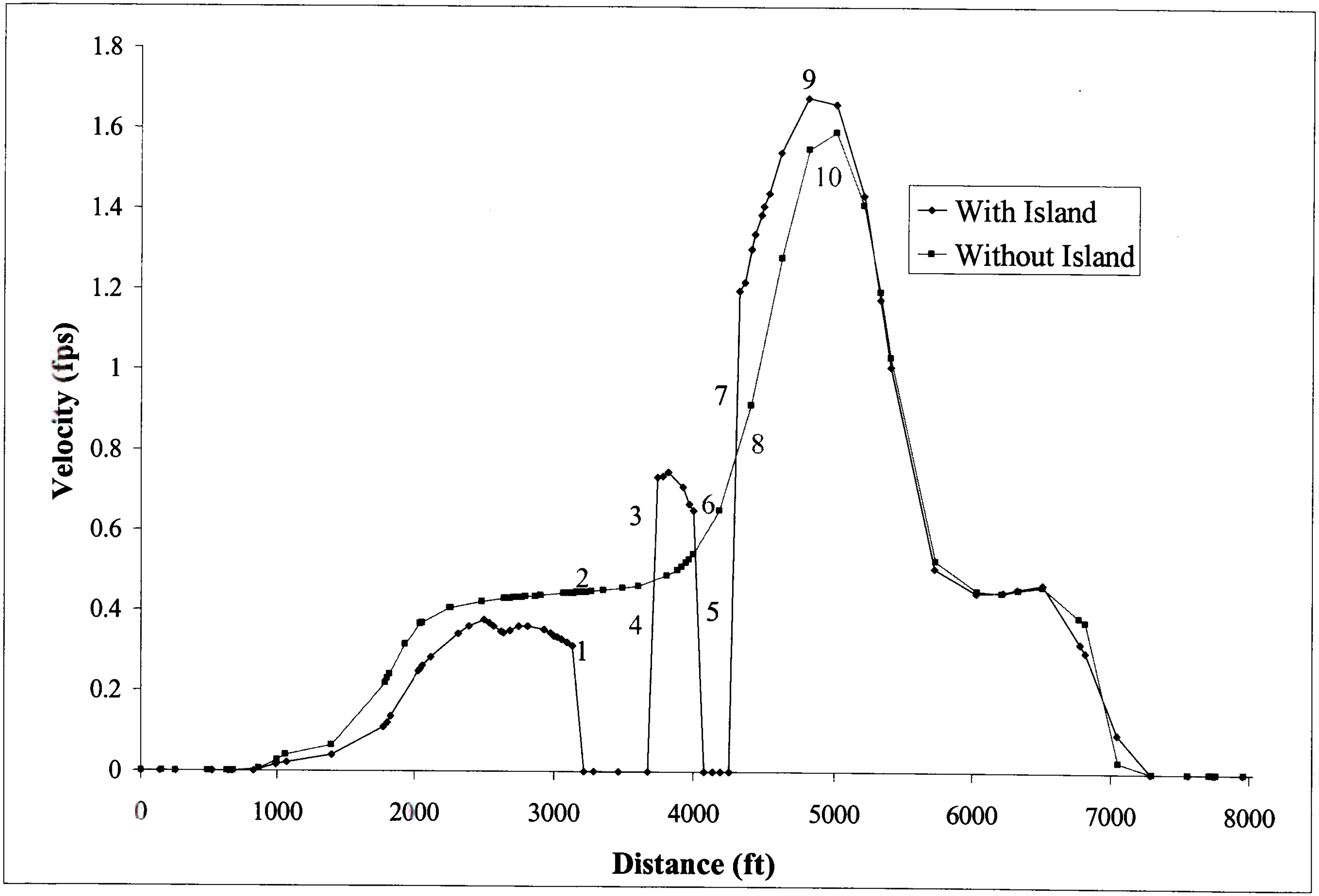

Figure 86. Lateral Velocity Distributions at Cross-section 6 (see Figure 70) for a flow of 45,000 cfs for Alternatives 2 and 3

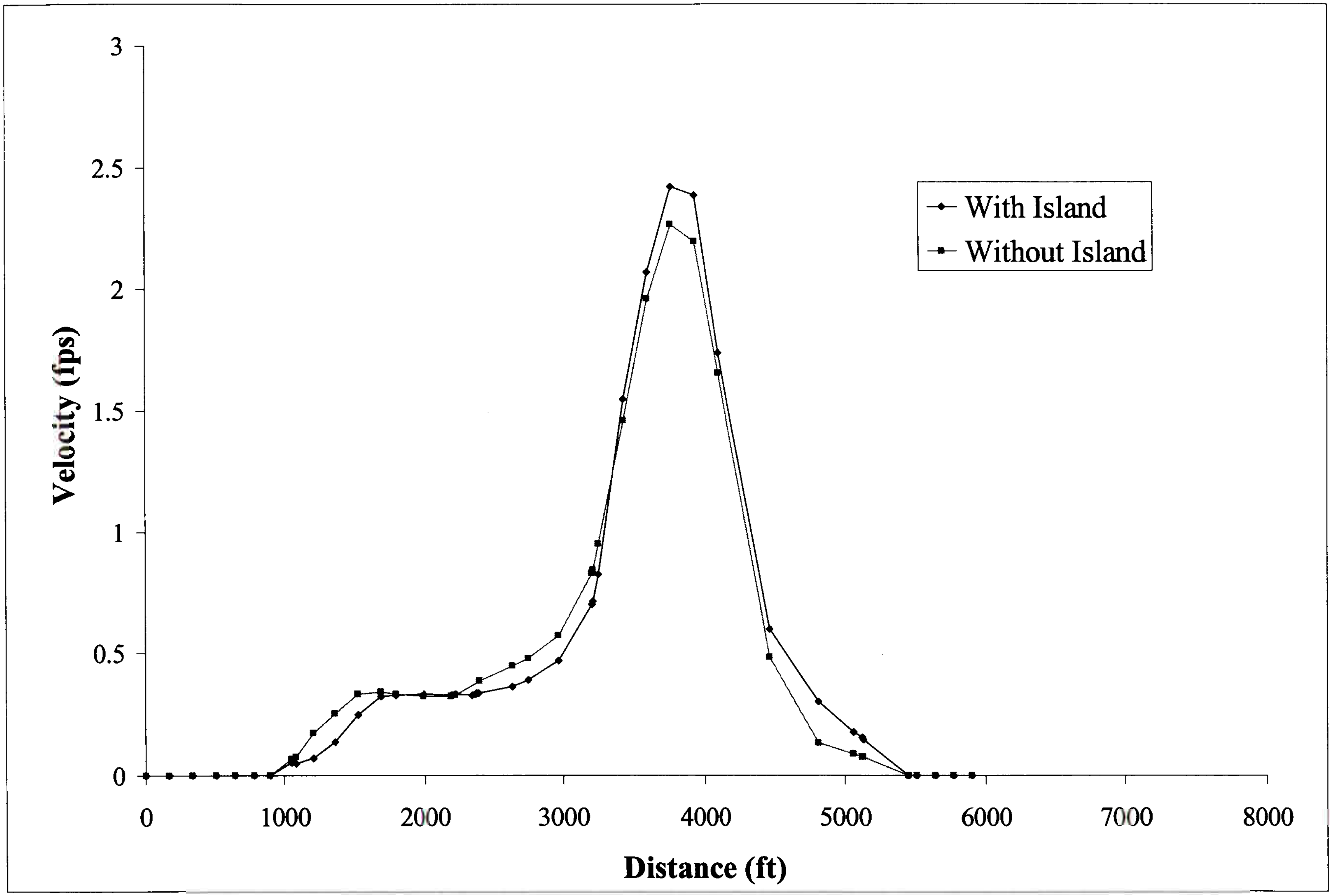

Figure 87. Lateral Velocity Distributions at Cross-section 7 (see Figure 70) for a flow of 45,000 cfs for Alternatives 2 and 3

X-7 45K

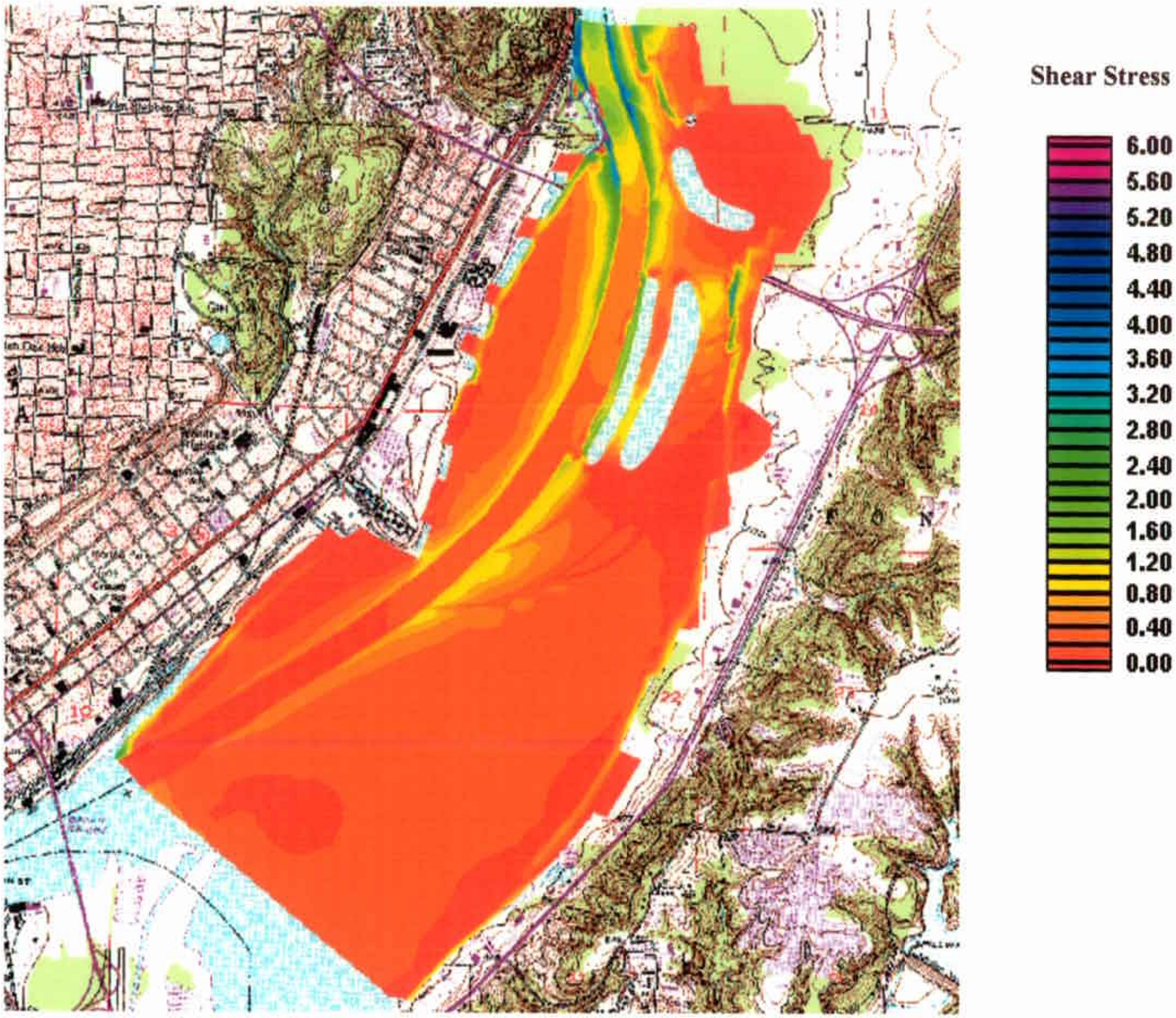

Figure 88. Shear Stress Distributions for Alternatives 2 and 3 for a flow of 45,000 cfs.

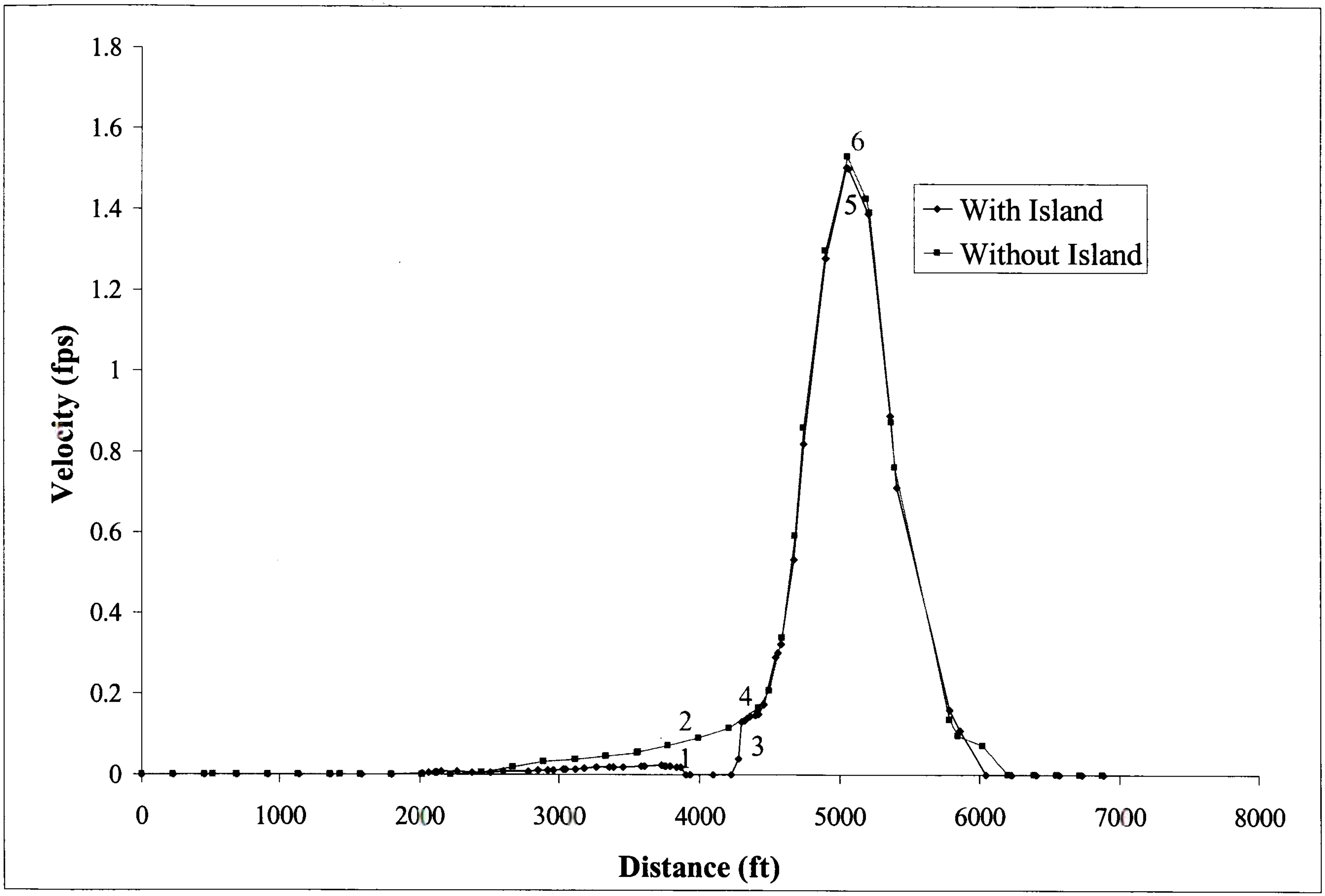

Figure 89. Lateral Velocity Distributions at Cross-section 1 (see Figure 70) for a Flow of 15,000 cfs, for Alternatives 2 and 3.

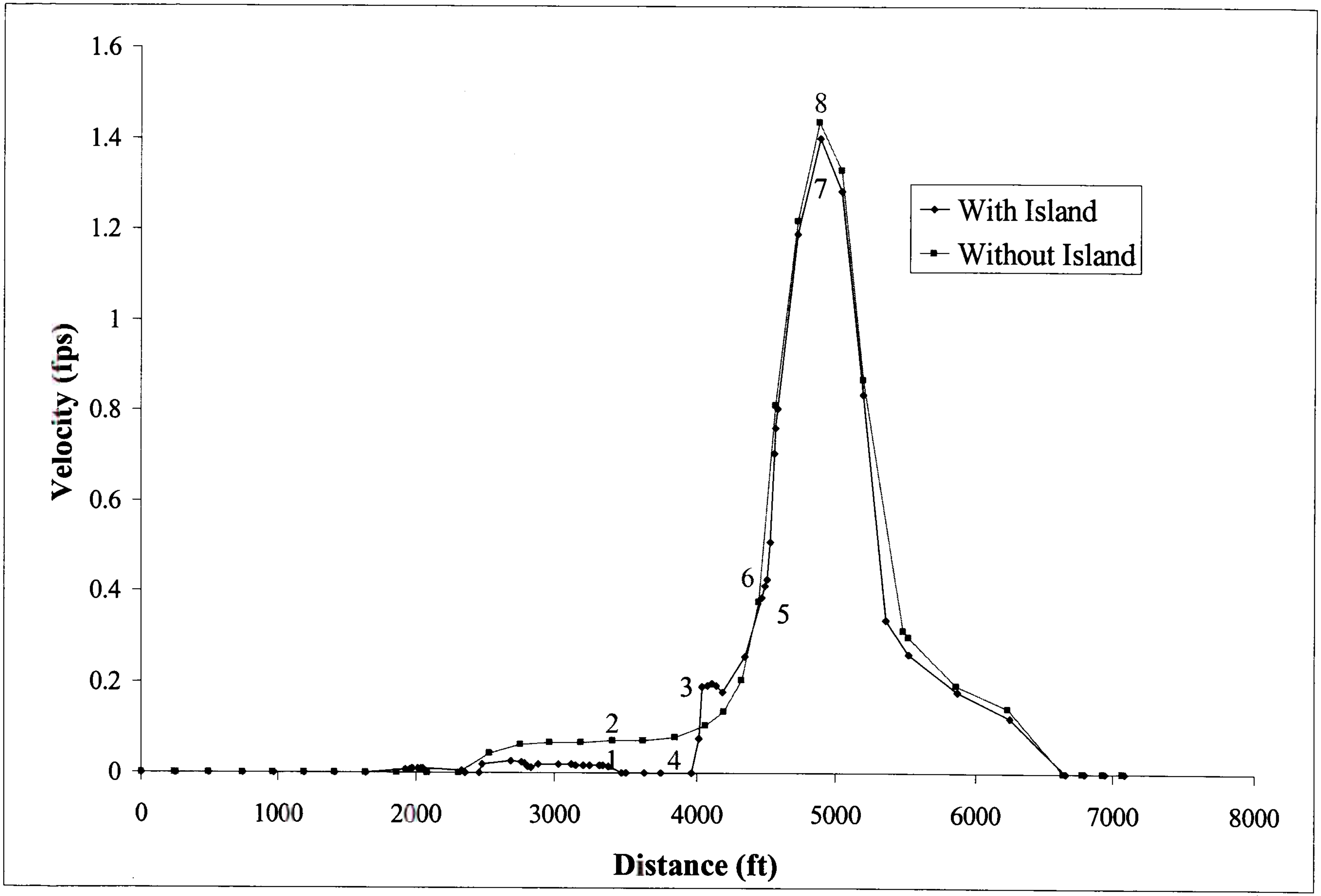

Figure 90. Lateral Velocity Distributions at Cross-section 2 (see Figure 70) for a Flow of 15,000 cfs, for Alternatives 2 and 3.

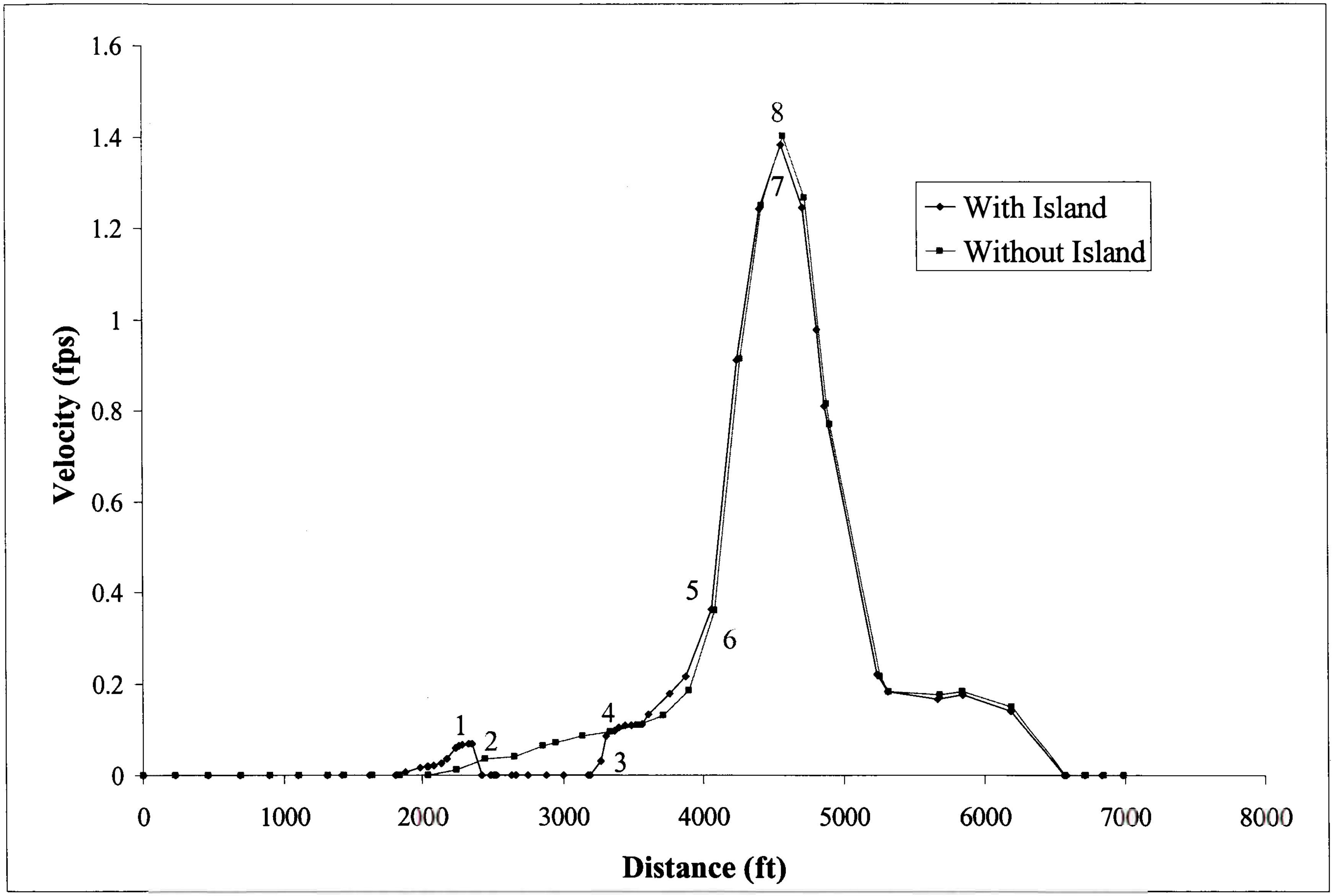

Figure 91. Lateral Velocity Distributions at Cross-section 3 (see Figure 70) for a Flow of 15,000 cfs, for Alternatives 2 and 3.

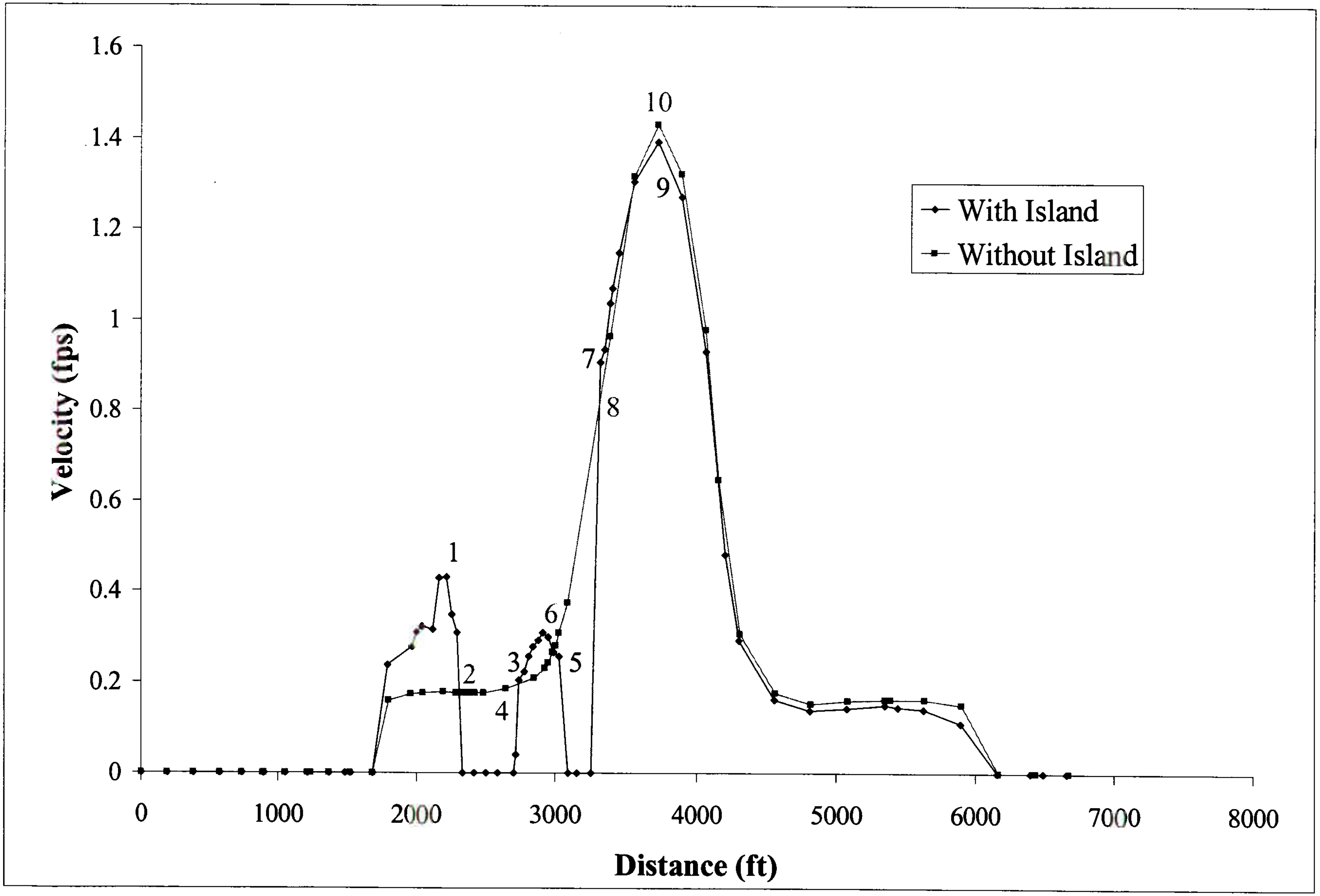

Figure 92. Lateral Velocity Distributions at Cross-section 4 (see Figure 70) for a Flow of 15,000 cfs, for Alternatives 2 and 3.

15K
X-4

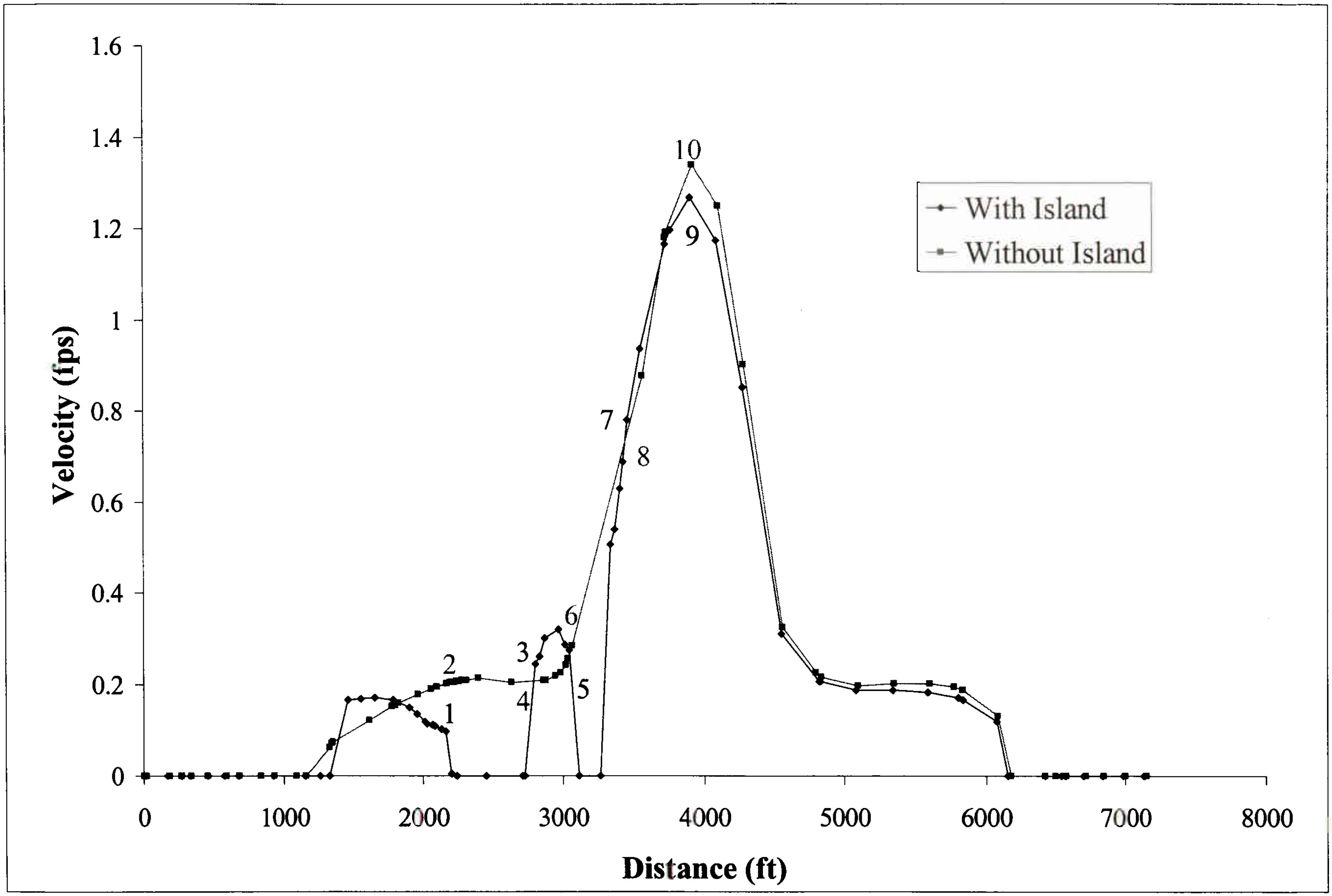

Figure 93. Lateral Velocity Distributions at Cross-section 5 (see Figure 70) for a Flow of 15,000 cfs, for Alternatives 2 and 3.

15K
4-5

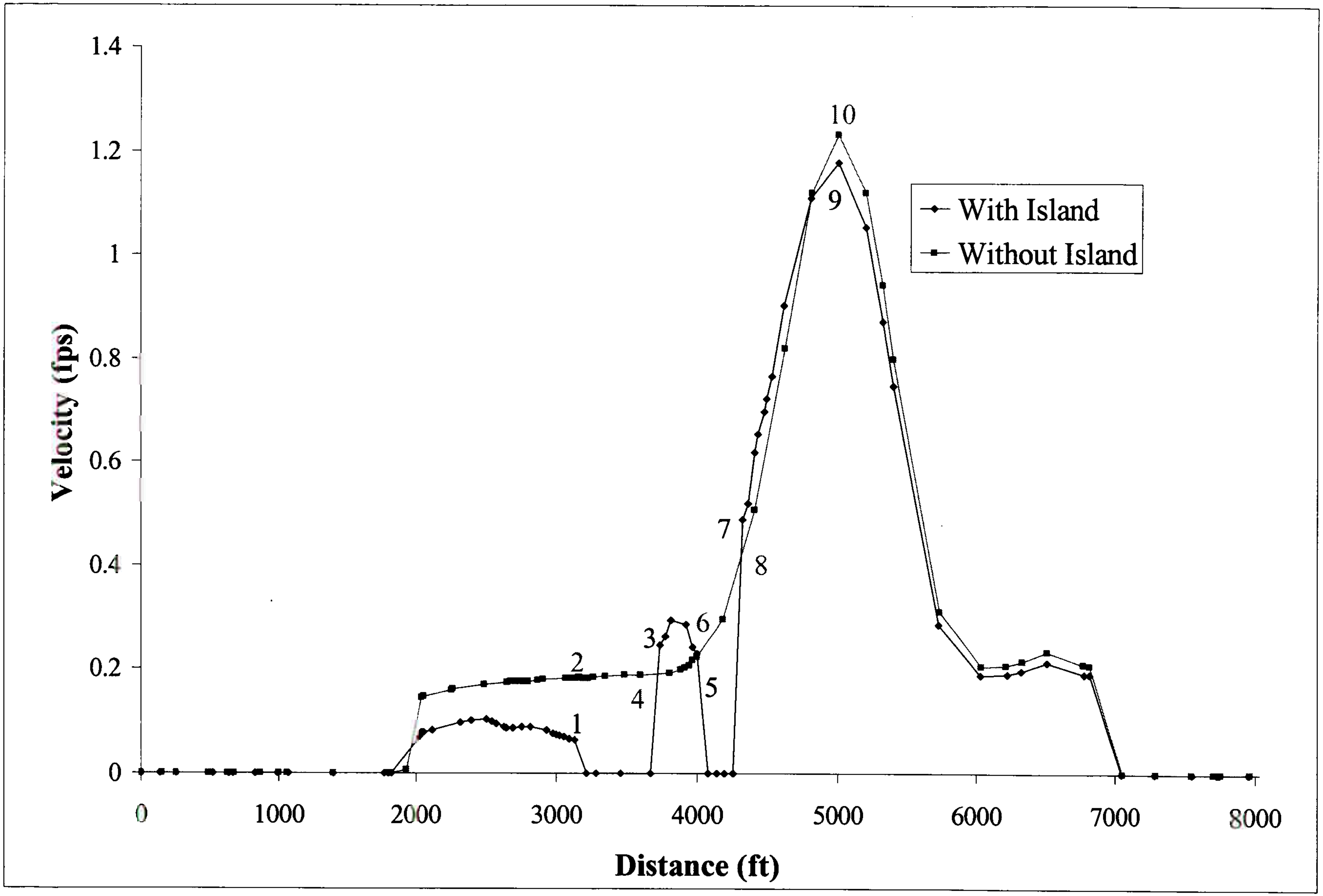

Figure 94. Lateral Velocity Distributions at Cross-section 6 (see Figure 70) for a Flow of 15,000 cfs, for Alternatives 2 and 3.

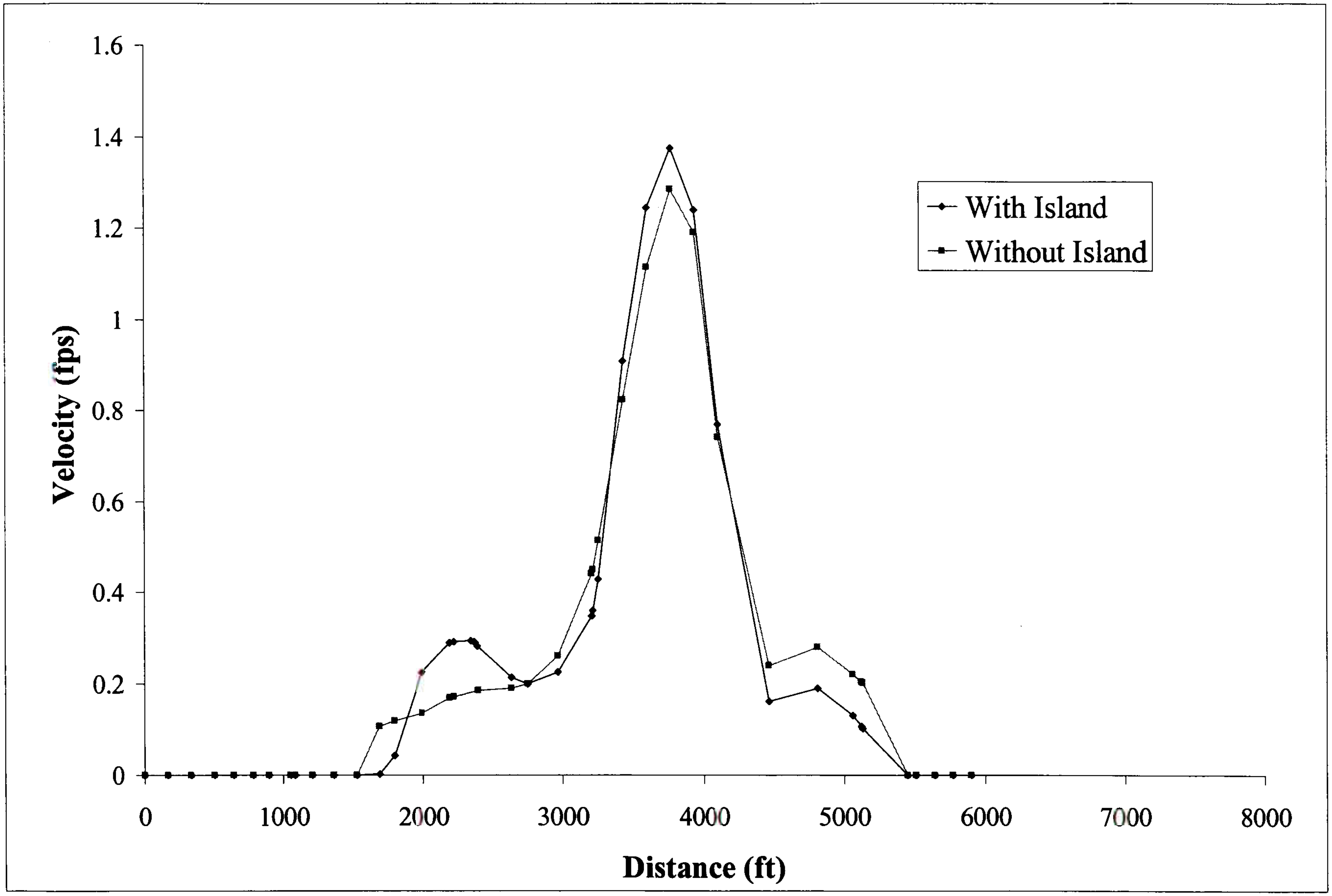

Figure 95. Lateral Velocity Distributions at Cross-section 7 (see Figure 70) for a Flow of 15,000 cfs, for Alternatives 2 and 3.

ILLINOIS DEPARTMENT OF NATURAL RESOURCES

Illinois State Water Survey

Main Office • 2204 Griffith Drive • Champaign, IL 61820-7495 • *Tel (217) 333-2210* • *Fax (217) 333-6540*
Peoria Office • P.O. Box 697 • Peoria, IL 61652-0697 • *Tel (309) 671-3196* • *Fax (309) 671-3106*

SWS

September 12, 2001

Brad Thompson
Mike Tarpey
U.S. Army Corps of Engineers
Rock Island District
Rock Island, IL 61204

Reference: Letter Report: Hydrodynamic Modeling for Artificial Island Construction
Within the Lower Peoria Lake

Dear Brad and Mike:

Enclosed please find the final draft copy of the Letter Report on the Peoria Lake Hydrodynamic Modeling work.

We have modified the report that was sent to you on July 30, 2001. Please note that we have provided quite a few illustrations and figures that were not needed for this letter report. Comments by Tom Kirkeen and others have also been incorporated. We also decided that it was not necessary for us to alter the outline of the report as was suggested in one of the e-mails. We believe the present report incorporates all the comments; written, verbal or through telephone discussions over the last 2 years from various members of the Interagency Committee working on the Peoria Lake Front Development Project.

We want to thank Jim Mick, John Marlin, both of you, and all the technical and support staff from the Rock Island District of the COE for their support and help during this project. We are looking forward please send the latest revision to many other joint projects for years to come. If you need any additional materials or information, please do not hesitate to give us a call.

Thank you very much.

Sincerely,

Nani

Nani G. Bhowmik, Ph.D, P.E.
Principal Scientist
Watershed Science Section
Phone: (217) 333-6775
Email: nbhowmik@uiuc.edu

cc: Mike Demissie
John Marlin (WMRC)
Jim Mick (IDNR)

10 Aug 2001

Comments from Tom Kirkeeng regarding ISWS SMS Analysis:

Reference:

(1) Memo and transmittal of 30 July 2001 from ISWS to MVR

(2) "Letter Report: Hydrodynamic Modeling for Artificial Construction Within the Lower Peoria Lake" (Draft)

(3) e-mail correspondence from Brad Thompson to ILDNR "Peoria ILDNR SMS Report" 29 May 2001

(4) Memo of 31 Aug 2000 for ILDNR and ISWS "Proposal of Detailed Information to be provided by the ISWS regarding the SMS Modeling

✓ Pg 9 second paragraph

State vintage of hydrographic data (1998-1999) – see clarification

✓ Pg 9 second paragraph

Specify location of gages that were used for calibration – see text

✓ Pg 11 2nd par

Better description of how 15,000 cfs was chosen for analysis – see text

Analysis of sediment data to show which flow moves the most sediment – No sediment modeling results

✓ Pg 13 1st par

What is the significance of the 6000 cfs? – Taken out

✓ Pg 15 2nd para

"flows do not stay attached" could you describe "attached" – see changes

✓ pg 15 4th bullet

would you feel comfortable sketching what you suspect the future island may look like, what is the scope of this predicted elongation – Not in the Report.

✓ pg 16

middle paragraph

referring to figures 15-17

we have discussed this before, project indicates a lower velocity in the main channel as compared to base condition, I don't believe Alt 2-4 show this – is this an anomaly or is there a bust in the computations or grid generation, etc? Please see the text.

✓ pg 18 4th bullet

flow confined near the nav channel

Do you see any impact to the navigation? see revised plots

✓ Pg 19 3rd bullet

The "cyclic variations" that are discussed – can you provide a better description – is this a computer model phenomena or will this happen in the prototype? see revised Text.

✓ Pg 20 bullet #7

"may last a relatively longer time" – can a stronger or more definitive statement be made? see revised text

Pg 23 Alternative 1 – 2nd paragraph

The velocity increases mentioned – is this increase enough to make a difference re: sediment deposition

Pl. see text

Pg 26 Remarks

I don't understand the point of the second sentence Pl. see changes

Pg 30 last paragraph

The first sentence states that it is clear that some bank protection would be needed even if not considering waves and velocity turbulence. But I understood that the material can withstand 3.0 fps and the most the model put out was 2.0 fps.

not clear

Pl. see changes

Pg 31 middle paragraph

Refers to fig 62-65 I think that these figures are what MVR provided to ISWS – I think ISWS edited them to reflect their opinion but those edits don't show up on my copy.

Pl. see text.

Pg 33 3rd paragraph

"Only the zones between the islands in Alternative 3 are expected to be impacted by the water velocities or waves generated by recreational traffic." Does this mean that bank protection is needed in these zones.

Pl. see changes.

Figure 10

Legend – would be helpful if a contour interval was chosen using numbers without using as many decimal places (for instance – use 0.1 fps as a contour interval rather than 0.057fps) Also, please consider using a standard contour interval and max min values for all plots for a given flow.

Figure 15

Points 1-6 could these locations be identified on a map

Pl. see figures.

Hydrodynamic Modeling for Artificial Island Construction Within the Lower Peoria Lake

By

Nani G. Bhowmik, Principal Scientist
Mike Demissie, Principal Scientist and Head
Watershed Science Section
Illinois State Water Survey
Champaign, Illinois State Water Survey

Introduction

This letter report summarizes the work conducted by the Illinois State Water Survey in support of the potential artificial island construction within the Lower Peoria Lake by utilizing the dredged lake bed sediments. As part of the Peoria lakefront study, the state of Illinois, Department of Natural Resources and the US Army Corps of Engineers, Rock Island District are jointly working to develop feasible alternatives to place dredged sediment from the Peoria Lake. It was decided that the feasibility of constructing artificial island with dredged materials within the Lower Peoria Lake will be one of the major emphasis in the immediate future.

Lower Peoria Lake offers an opportunity and option to locate, build and maintain artificial islands with dredged materials. Moreover, not only the location or locations are suitable from a hydrodynamic and hydraulic point of view, but they also could be constructed on lake bed that is owned by the state of Illinois.

Construction of artificial islands with dredged materials within Peoria Lake is neither new nor novel. The US Army Corps of Engineers with direct support from the state of Illinois, have already constructed two barrier islands within the Upper Peoria Lake near Chilliocothe on the east side of the river. The barrier island closer to the main navigation channel was constructed by clem-shell type dredging operation using only the top soft sediment layer. It was assumed that this barrier island will be washed away by the Illinois River flow. Since its construction, the island did not get washed away and is still in existence providing important terrestrial and shoreline habitats.

The other barrier island constructed parallel to the barrier island closer to the main channel, was constructed on the east side of the island with soft sediment. This island was constructed by relatively hard sediment that was also dredged by clem-shell type dredging. These sediments were dredged from the Lake below the top soft sediments. This barrier island on the east side has stayed very stable, and vegetation, etc. have grown heavily and presently is an important Illinois River migratory bird habitat. The dredged channel from where the sediments were taken, are still in very good shape after being left alone for five to six years.

These two examples from the Upper Peoria Lake illustrate the viability and the sustainability of constructing artificial islands with dredged materials. It is quite clear that the

Peoria Lake sediment can and should be able to sustain itself within the lake environment if those are used to construct artificial island or islands. The sustainability of the dredged channel as a deep water habitat if properly oriented, sized and built next to the artificial island could also be sustained.

The work being reported here was undertaken to determine the appropriate location or locations of artificial islands within the lower Peoria Lake.

Historical Sedimentation Problems

The Peoria Lake is located upstream of the Peoria Lock and Dam at RM 157.6 and extends approximately up to Chillicothe, RM 180. Peoria Lake is also called the bottomland lake of the Illinois River and has been subjected to extensive sediment deposition. The profile of the Illinois River shown in Figure 1 indicates that the river also changes its slope to a much flatter gradient within the Peoria Pool. This flatter slope within the Peoria Lake also accelerated the deposition of sediments over the years.

Many researchers worked on the Illinois River and the problems associated with the excessive sediment deposition. Some of the original research on the sedimentation problems of the Peoria lake and Illinois River and the backwater lakes can be found in Demissie and Bhowmik (1985), Bhowmik et. al (1993), Demissie et. al (1992), Bhowmik and Demissie (1989). Initial research on mathematical modeling for the construction of artificial islands within the Peoria Lake was also done in 1988 by Demissie et. al (1988). Recently Bhowmik and Demissie (2001) completed a project on the historical sediment deposition at or near the mouths of five tributary deltas of the Peoria Lake. These are: Richland Creek, Partridge Creek, Blue Creek, Dickison Run and Farm Creek.

Management of excessive sediment load within the Peoria Lake must be done at two geographical locations. These are: a) at the watershed level, and b) within the lake environment. Just a pure control of the sediment input from the watershed will not show any substantial sediment reduction to the lake for many years to come. At the same time, trying to manage the sediment within the lake environment without controlling the input of the sediments from the watershed will also not be a very successful operation.

As part of the Peoria Lakefront Development project of the State of Illinois and the U.S. Army Corps of Engineers, it was agreed that one option for sediment placement would be to build artificial island or islands within the Lower Peoria Lake by utilizing the sediment that have already been deposited within the lake environment. As previously mentioned this is not a new concept. The original conceptual idea and mathematical modeling work was done by Demissie et. al (1988). After the publication of that report several artificial islands of various shapes and sizes with a varied degree of objectives have been built within the Upper Mississippi River. The barrier islands near Chillicothe were also built within the Upper Peoria Lake.

Study Purpose, Goals, and Rationale

After extensive discussions between the State of Illinois, U.S. Army Corps of Engineers, and local interested citizens, agency representatives and others it was decided that:

- Attempts will be made to build one of more artificial islands within the Peoria Lake,
- Before any such island is built, a thorough hydrodynamic analysis supported by the state-of-the-art modeling work will be done,
- The modeling work will be conducted for the Lower Peoria Lake below the narrows where higher potential exist to build one or two islands in the immediate future.
- The results from the hydrodynamic model will be used as a guide to determine the size, shape, orientation and locations of potential island or islands,
- The modeling results will be used to identify the zones or areas of the island(s) where protective blankets may be needed to withstand the erosive forces of the water or the potential effects of high wave activities, and
- The final selection of the islands will be made by joint deliberation of the state, federal, and interested parties,
- The modeling results will also be used as a guide to determine the viability of the deep water channels that will be created to remove the sediments from the lake bed.

Mathematical models are great tools if used properly to postulate what could happen if an action such as building of artificial islands within the Peoria Lake is completed. It provides an opportunity to test various sizes and shapes of islands with a multitude of orientation, top elevation and also at numerous locations. Mathematical modeling work can also be done within a relatively shorter period of time initially to eliminate various options, which are not feasible because of a variety of constraints and/or reasons. Some of these are: hydraulic instability, impracticability due to excessive generations of high velocities, significant changes in the water surface elevations during flood, potential of river bank erosion, significant modifications of the flows away from the main navigation channel, and simple impracticability of building island or islands at certain locations.

Initially, various island options were discussed, rough sketches drawn, debated based on the expert knowledge of the river and then either rejected or accepted for modeling purposes. It was also decided that the Surface Water Modeling System, RMA-2 will be used to test the hydraulic viability of building island or islands within the Lower Peoria Lake.

SMS Model Description

The model used for this project is the Surface Water Modeling System (SMS) which is a two-dimensional finite element model in plane coordinates. It was developed by the Engineering Computer Graphics Laboratory at the Brigham Young University in close cooperation with U.S. Army Waterways Experiment Station (WES) and the U.S. Federal Highway Administration (FHWA).

For the Peoria Lake, the hydrographic data collected by the U.S. Army Corps of Engineers from the Rock Island District in 1998-99 were used in the creation of the finite element grid. Where overbank elevation data were not collected, those gaps were filled by utilizing the contour elevations from the U.S. Geological Survey 1:24,000 Quad maps. The Manning roughness values were assigned for six different zones along the cross-section which included main channel, channel border, shallow areas and areas near the one percent flood elevations. Other parameters were assigned based on hydrodynamic properties of an alluvial river. The model was calibrated utilizing stage data collected at the Peoria Lock and Dam, Boatyard and Chillicothe. Calibration and verification was also done for three flow events, one high flow event in February 1997, two medium flow events one each in February-March of 1997, and another one in May-June of 1996, and two low flow events once each in August 1996, and November 1995.

Recently US Army Corps of Engineers from the Rock Island District (Personal Communications) made available to the Water Survey the 2-dimensional Acoustic Doppler Current Profiler (ADCP) velocity measurements data at several locations within the Lower Peoria Lake. The measured velocity data were provided in vector forms across the width of the river. The flow for which these velocity data were collected varied from about 23,000 cfs to 25,000 cfs. Several sets of the lateral velocity data collected from about the same location do not match with one another. One cross-section, designated here as Cross-Section 1 is located at approximately River Mile (RM) 163.7 provided a very good lateral velocity distribution, which was used as a verification tool for the RMA-2 model.

The model was ran for a flow of 25,000 cfs and lateral velocity distribution at RM 163.7 was plotted. The simulated lateral velocity distribution and the measured velocity distribution at Cross-Section 1 is plotted in Figure 2. A visual comparison will show that the simulated and measured velocities are quite close indicating an excellent fit.

Flows Modeled

The flow data available at various locations and analysed by the US Army Corps of Engineers (1992) for RM 80 to 290 along the Illinois River was used to determine the flows and stages along the Peoria Lake. For example, a flow having a frequency of occurrence of one percent (1%) is also termed as 100 year flood or flow. The flow frequencies and corresponding flows and stages at Peoria Lock and Dam, and Chillicothe based on the US Army Corps of Engineers (1992) are shown in Tables 1and 2 These values were used to run the RMA-2 model for various flows.

Normally all open channel hydraulic geometries are analyzed and/or determined based on a flow having a frequency of occurrence of about 2.33 years which is also termed as bankful discharge or dominant discharge. However, when the Illinois River flows through the Peoria Lake it is not flowing through an ordinary and normal river channel. The Peoria Lake is quite unique, it is very broad and wide and has a tremendous amount of storage capacity. This uniqueness of the Peoria Lake makes it extremely difficult to categorize it into a standard river geometrical pattern. This is quite amply illustrated in Tables 1 and 2.

Table 1 shows the flows at various frequencies at Chillicothe, which is upstream of the Peoria Lake. Table 2 shows similar values at Peoria Lock and Dam which is downstream of Chillicothe. Consequently, drainage areas at Peoria Lock and Dam is slightly higher than that at Chillicothe. However, the flows for various frequency of occurrences at Chillicothe is higher than those at Peoria Lock and Dam. This amply illustrates the fact that the storage of the Peoria Lake is quite significant and it plays a dominant role in the estimation of flows between the upstream and downstream cross-sections of the Peoria Lake.

Subsequent sections will illustrate the results obtained after the RMA 2 model was ran for various flows and several island options. It should be pointed out here that the readers should keep in mind that the Peoria Lake has a tremendous amount of storage and as such the measured flows from the upstream to downstream sections may vary within the same day depending upon whether or not the stages are increasing or falling at any particular time.

Two flows were selected by the USA-COE, RID (Personal Communications, 2001) to show what would happen to the velocity structure with and without any islands. One of the flows is low flow and the other has a frequency occurrence of 2 years. Results from these two flows, 15,000 cfs and 45,000 cfs, will now be illustrated. The 45,000 cfs is the 2-year flow at Chillicothe, Table 1. This was used as a surrogate for the bankful discharge, which normally has a frequency of occurrence of 2 years. The decision to use 2-year flow as the design flow was made by the Interagency Committee based on the concept of "bankful discharge".

Alternatives Modeled

Results from four (4) separate island shape, orientation and locations are given below. These possible islands sites are either located upstream or downstream of the McClugge Bridge. As mentioned previously, these sites are suitable for island construction because of the hydraulics of the flows and the availability of deposited sediments. Several alternatives were tested, altered, changed, modeled and discussed before the four final alternatives were selected. The fundamental and basic considerations behind these alternatives are their suitability and sustainability against 2-year flow events. Also, considerations were given whether or not excessive scour or sediment are expected because of the flows around these islands.

All the islands were somewhat stream lined. Figures 3 and 4 show these four alternatives within the Lower Peoria Lake. Alternatives 1 and 2 are located upstream of the McClugge Bridge and Alternatives 3 and 4 are located below McClugge Bridge. Modeling results to be included in the next section will show how these islands, if constructed, would alter the flow patterns for a flow of 15,000 cfs and 45,000 cfs.

Table 1 and 2 showed that at both the Chillicothe and Peoria Lock and Dam, the stages for a 2-year flow is 448.4 ft-msl and 447.2 ft-msl, respectively. In order to assure that the islands would not be completely flooded for 2-year flow, the interagency committee recommended the top elevations of all the islands to be kept at 450 ft-msl. With this height, the terrestrial plants and animals will survive a 2-year flood. All subsequent model runs were completed assuming all the islands have a top elevation of 450 ft-msl.

Modeling Results

The modeling results to be shown are for islands that are suggested for final consideration. Engineering design or geotechnical analyses are neither included nor completed for this specific component of the project. Because an extensive amount of plots and figures are included with this letter report, all the figures are given at the end of the report.

Flows Modeled

The modeling work was completed for flows of 15,000 cfs, 25,000 cfs and 45,000 cfs. As mentioned previously, detailed modeling work was done only for flows of 15,000 cfs and 45,000 cfs.

No Island

SMS was initially run for the entire Peoria Lake without any island at any location to determine the undisturbed flow conditions. Results from this modeling work were used to determine the initial boundary conditions for that segment of the river from the constriction at about RM 166.3 through RM 165.2. This spatial extent of the model covered the areal extent of the four island options that have been selected for further analyses. The elevation variations for the modeled area are shown in Figure 5.

Twenty-five Thousand Cubic Feet per Second (25,000 cfs)

The spatial velocity distribution for a flow of 25,000 cfs is shown in Figure 6. Again the maximum velocity is near the constriction between the upper and lower Peoria Lake, which approaches a value of about 2.6 fps. Again, the majority of the flow is confined within the main channel with some spreading as the water moves in the downstream direction. This velocity structure generated based on this flow was used to calibrate the model results with the measured velocity data provided by the USA-COE, RID, (Personal Communications 2001), see Figure 2. The lateral measured velocity data that were used for calibration is at a cross-section shown in this figure.

Forty-five Thousand Cubic Feet per Second (45,000 cfs)

The spatial velocity distribution without any island and also for a flow of 45,000 cfs are shown in Figure 7. The maximum velocity near the constriction is about 3.50 fps. The flow does spread out even though most of the flow is confined within the navigation channel.

Alternative 1

Figure 8 shows the Elevation Map or Topographic Map of the Lower Peoria Lake with the proposed Alternative 1 island. The top elevation of the island is 450 ft-msl. The normal pool elevation of the Peoria Lake is 440 ft-msl. The flow in this figure is from top to bottom. The main channel is on the right side or west side of the river. Left and right sides are determined based on an observer standing on the middle of the river and looking downstream. The lightly shaded areas around the proposed island are the zones where dredging will be performed to create deep water habitats. The lines shown in light colors are the proposed deep water channel.

This illustration also shows the three lateral cross-sections where lateral velocity distributions will be analyzed subsequently. In this illustration, cross-sections are identified from upstream to downstream direction. This will be true for all subsequent illustrations. Flow is again from top to bottom.

The SMS model was run for a flow of 45,000 cfs. The lateral depth integrated velocities thus obtained are depicted in Figure 9. Some general observations from this figure are :

- As suspected, because of the semicircular shape of the island at the leading and tail ends, flow velocities at these locations become close to zero.
- The velocity at this zone is either negligible or very low.
- At the upper top right hand edge (looking downstream), it is quite possible that additional sediment will be deposited in the future making this end of the island elongated. A portion of this elongated stretch will stay below normal pool level and apportion very close to the proposed island may extend above normal pool level in the future.
- The middle portion of the tail end of the island may also experience similar fate in the future because of the existence of extremely low velocities. It is suspected that ultimately and also in the long run, the tail end of the island may be elongated assuming a shape similar to an air foil.

The velocity structure has further been analyzed by constructing lateral velocity profiles at three cross-sections as shown in Figured 8 and 9, and these are shown in Figures 10, 11 and 12. The location of these cross sections are given in Figures 8 and 9.

All the cross-sectional velocity distributions for all the alternatives have been plotted looking downstream (i.e. for the Peoria Lake), the left hand side of the plots are on the east side of the navigation channel. At all the cross-sections, the depth integrated average velocities at the verticals at the dredged channel next to the main channel and on the west side of the island, do increase as a result of the construction of the island.

These changes in velocities are given in Table 3. All the points (such as 1, 2, etc.) shown in Table 3 are also identified in Figures 10, 11 and 12. Points 1, 3 and 5 are associated with the constructed island and points 2, 4 and 6 are associated with the ambient flow conditions.

A close examination of Table 3 and Figures 10, 11, and 12 will show that velocities do increase next to the island for this flow of 45,000 cfs. This increase in velocities at the deep channel next to the island is obviously desirable for the future maintenance of these newly created deep water channels. The maximum increase is for cross-section No. 2, on the main channel side, i.e. right side (looking downstream) of the island where the velocities increased from about 0.44 fps to 0.52 fps.

Figures 13, 14, and 15 show the lateral vertical velocity distributions and the river cross-sections at cross-sections 1, 2, and 3, respectively for Alternative 1.

It must be pointed out that the lateral velocities shown in all the figures are the depth integrated average velocities at each vertical in the lateral direction.

Alternative 2

For Alternative 2, again an island above the McClugge Bridge is proposed. The plan form of this proposed island including the sediment removal area and the deep water channels are shown in Figure 16. Figure 17 shows the depth integrated spatial vertical velocity distribution around this island. Again, the top of the island is at 450 ft-msl and the normal pool elevation of the lake is 440 ft-msl. The flow is from top to bottom.

An examination of this figure will show that:

- There is a very low velocity zone at the tip of the island on the right hand side (looking down-stream). This indicates that there is a good probability that sediment may accumulate at this zone elongating the island somewhat in the upstream direction.
- The velocities on the inside of the island (left hand side) is either negligible or close to zero.
- The velocities near the upstream edge on the navigation channel side (right side of the island) may be somewhat high indicating that some protective measures may be needed.
- The velocities near the lower right hand side of the island are quite low. This may enhance the sediment deposition at this location extending the island in the downstream side. This indicates that the deep water channel at this location (lower right side of the island) may silt up at a higher rate than at other locations.
- The final shape of the island with time, especially the lower right side may be different than the constructed one.
- The changes in velocities are given in the next several illustrations.

Figures 16 and 17 also show the locations of three cross-sections where the lateral velocity distributions with and without the island have been determined. Figures 18, 19 and 20 show the velocity distributions at these three cross-sections. A close examination of Figures 18, 19 and 20 will show that the velocities do not change significantly on both sides of the island after the construction of the island. The velocities with and without the island are given in Table 4.

An examination of Figures 18, 19, 20 and Table 4 will show:

- Velocities do not change significantly next to the island except at cross-section 3 where an increase in velocities on the east side of the island is observed.
- This increase in velocities would enhance the relative maintenance of the deep water area.
- Velocities within navigations channel at cross-section 3 increase as a result of the construction of the island.

Figures 21, 22 and 23 show the lateral velocity distributions and the river profiles at the three cross-sections shown in Figures 16 and 17 for Alternative 2.

During recent discussion with the USA-COE, RID, it was felt that it would be appropriate to determine the changes in velocities if any in the downstream region once an island alternative such as Alternative 2 is in place. In order to determine such changes, lateral velocity distributions at cross-sections 4 and 5, Figure 24 was plotted with and without the island in place. Cross-sections 4 and 5 are located below McClugge Bridge. These two plots of the lateral velocity distributions are given in Figure 25 and 26. An examination of these figures will show that very little or no changes do occur in velocities downstream of the McClugge Bridge if an island as shown in Alternative 2 is built above the McClugge Bridge.

Alternative 3

Figure 27 shows Alternative 3 with a pair of islands below the McClugge Bridge. This illustration also shows the sediment removal areas where deep water habitats are to be created. These areas are shown with a geometric patterns with light shades. This illustration also shows the variations in elevations at various locations.

Figure 28 shows the spatial distribution of the depth integrated velocities for a flow of 45,000 cfs. Areas shaded dark red are the areas where the velocities are computed to be very low. An examination of this illustration will show:

- Velocities are very low at the tips and tail ends of both the islands.
- These low velocities may enhance the sediment deposition at these locations.
- However, the extension of the island due to sediment deposition next to the navigation channel will be smaller compared to the larger island.
- The tail end of the larger island may extend in the downstream direction within the areas shown in dark red.
- The velocities along the right side (next to the navigation channel) of the smaller island will be relatively higher.
- The velocities between both the islands are expected to be higher than the ambient flow condition.
- There is an area on the left side of the larger island near the upstream zones where velocities are also going to be relatively high.
- Higher velocities on both sides of both the islands indicate that the newly created deep water channel may be relatively stable.
- Subsequent illustrations will show that the maximum velocities within the main channel do increase after the construction of the islands.

Figures 27 and 28 showed the locations of the three cross-sections where the lateral velocity distributions have been determined with and without any islands. The three plots for three cross-sections are given in Figures 29, 30 and 31. Examination of these three illustrations will substantiate the observations made previously. The velocities at different locations with and without islands are given in Table 5. In all locations, the velocities within the navigation channel increase with the islands in place compared to the ambient conditions.

The lateral velocity distributions and the lateral river cross-sections at those three cross-sections shown in Figures 27 and 28 are given in Figures 32, 33 and 34.

Alternative 4

The last alternative tested is Alternative 4, which is shown in Figure 35. For this option a single island is proposed below the McClugge's Bridge. The elevations, the island, proposed deep water habitat areas, and the three cross-section locations are also shown also shown in this figure.

Figure 36 shows the spatial velocity distributions for a flow of 45,000 cfs with the island in place. An examination of this illustration will show that:

- There are low velocity zones at the tip and tail end of the island. Thus these areas are expected to have some sediment deposition in the future. The areas of expected sediment deposition at the tail end would be larger than at the tip of the island.
- The velocities are expected to be higher on both sides of the island and also for most of its length compared to ambient flow conditions and also at the same location.
- The inside shore (next to the navigation channel) is also expected to be subjected to higher velocities compared to the ambient flow conditions. This is especially true near the upstream inside shore of the island.

Lateral velocity distributions were computed at three different cross-sections. These cross-sectional plots with and without islands are given in Figures 37, 38 and 39. Table 6 shows the velocities at selected six locations with and without the islands. An examination of these three illustrations and Table 6 will again substantiate the observations made previously. In almost all cases, the velocities next to the island increase somewhat compared to the ambient flow conditions. The velocity in the navigation channel also shows either no change or some increase in magnitudes.

The last three illustrations for Alternative 4, Figures 40, 41 and 42 show the lateral velocity profiles and the river cross sections at those three cross-sections

Low Flows

Model was also run for a flow of 15,000 cfs. The following discussions are based on the results obtained for a flow of 15,000 cfs.

Base Condition: No Island

The RMA-2 model was ran for 15,000 cfs without any island in place. Figure 43 shows the depth integrated lateral velocity distribution for this flow. The velocity ranges from negligible to about 1.9 fps or a little higher. The higher velocities are located within the main channel and close to the constriction between the upper and lower Peoria Lake.

Alternative 1

For this alternative, the spatial velocity distribution for a flow of 15,000 cfs is given in Figure 44. An examination of this figure will show that there is a small zone of very low velocity at the upper river side edge and also at the downstream edge of the island. These areas again could experience sediment deposition in the long term. The river side areas of the island do have slightly elevated velocities compared to the ambient conditions. This is amply illustrated in the next three illustrations.

Figures 45, 46 and 47 show the lateral velocity distributions at the three cross-sections shown in Figure 44 starting at the upstream area. At all three cross-sections, velocities on the river side of the island increase compared to the ambient conditions. The maximum velocities within the main channel remains essentially unchanged on at least two cross-sections and at the upstream section, it drops slightly.

Alternative 2

The spatial velocity distribution for Option 2 for a flow of 15,000 cfs is shown in Figure 48. Again the velocity ranged from negligible to about 1.9 fps. There are some areas close to the river especially on the upper tip and lower one-third to one-half of the island, where velocities are extremely low. Again, these are the areas where sediment deposition is expected to occur in the future.

The lateral velocity distribution at all three cross-sections are given in Figures 49, 50 and 1.

Alternative 3

The spatial velocity distribution for Alternative 3 and also for a flow of 15,000 cfs is shown in Figure 52. An examination of this figure will show that except for a zone near the upstream end of the wider island, and the downstream tip of the narrow island, the velocities do not change significantly next to the islands. In general, velocities are extremely low on the east side (left hand side looking downstream) of the larger island, which is expected for this area.

Figures 53, 54 and 55 show the lateral velocity distribution for cross-sections 1, 2 and 3 respectively, for Alternative 3 and a flow of 15,000 cfs. An examination of all these figures will show that the velocities between the two islands do increase compared to the ambient velocities. This was found to be true for a flow of 45,000 cfs. This indicates that the rate of sediment deposition in between these two islands may be lower compared to the ambient conditions.

Alternative 4

Modeling results for Alternative 4 and also for 15,000 cfs are shown in Figure 56. The spatial velocity distribution is given here. In general and also for this flow, the velocities do not approach zero on the west side of the island indicating that at this low flow period, the velocities may be high enough to keep this area relatively clean from the deposition of fine sediments. The maximum velocity is within the mail channel also in the upper most area of the main channel.

The lateral distributions of the velocities at cross-sections 1,2, and 3 are shown in Figure 57, 58 and 59, respectively. At all three cross-sections, there is a very small decrease in the maximum velocities within the main channel. However, these minor changes should not impact in the scour and deposition of the sediments.

At Section 1, Figure 57, it is quite clear that the velocities on the east side of the island, or left hand side looking downstream do increase substantially from about 0.22 fps to about 0.57 fps. This is a substantial increase, which probably was caused by the constricted flow area between the island and the east shore of the lake (Figure 56). As the flow areas between the island and the east shore increase in the downstream direction, the velocities between the island and the east shore decrease, Figure 56.

Remarks

The velocity distributions shown above for flows of 45,000 cfs and 15,000 cfs can be used to estimate the stability of these islands against potential scour at those two flows. Evaluation of all the alternatives with associated velocity distributions indicates that all of these alternatives are feasible for construction. Biologically, per personally communications with RID, COE and other Biologists, Alternative 2 and 3 may be superior to the other two alternatives.

Sediment Modeling

Initially it was felt that some sediment modeling work may be needed to determine the future potential sediment deposition at or near the islands. The model that was tried is called SED2D. SED2D is coupled with the SMS. A brief description of this model is as follows.

SMS includes a general computer program (SED2D) for two-dimensional, vertically averaged sediment transport in open channel flows. The initial code development was accomplished by Ariathurai (1974), then the two-dimensional model in the horizontal plan was extended to included the vertical plane by Ariathurai, MacArthur, and Krone (1977).

SED2D can be applied to clay or sand bed where flow velocities can be considered two-dimensional in the horizontal plane. It is useful for both deposition and erosion studies. SED2D treats two categories of sediment: (1) noncohesive referred to as sand, and (2) cohesive referred to as clay.

Both clay and sand may be analyzed, but he model considers a single, effective grain size during each run. Therefore, a separate run is required for each effective grain size. Fall velocity must be prescribed along with the water surface elevation, x-velocity, y-velocity, diffusion coefficients, bed density, critical shear stress for erosion, erosion rate constants, and critical shear stress for deposition.

SED2D does not compute water surface elevations or velocities; these data must be provided from RMA2. An implicit assumption of the SED2D is that the changes in the bed elevation due to erosion and /or deposition do not significantly affect the flow field. When the bed change calculated by SED2D does become significant, the flow field calculated by RMA2 is no longer valid. Thus, the SED2D run should be stopped, a new flow field calculation should be made using the new channel bathymetry generated by SED2D, and the SED2D run should be restarted with the new flow field as input. This is a major limitation of SED2D, especially for the Peoria Lake where long term variation in bed is expected due to sediment deposition. These bed changes will alter the flow-field thus making the SED2D results essentially invalid.

SED2D can only be run after having initially run RMA2. As mentioned above, this is because SED2D uses the flow solutions computed by RMA2 to compute suspended sediment concentration in kilograms per cubic meters at the nodes, and the total bed change in meter form the start of the run. After SMS successfully reads in the boundary condition file, the SED2D menu will be enabled. To prepare for a SED2D run, the first is to define the bed type of the mesh. Either a sand or clay bed can be specified, but not both at the same time.

Attempts were made to run the SED2D for a 1% flow of 105,000 cfs with an initial input of sediment concentration equal to 0.5 kg/m^3. All computations in SED2D are performed with metric units.

Results of these runs showed how a certain sediment concentration when introduced at the upstream end will distribute and dissipate over the lake after a certain time period. This type of analyses does not portray the changes in the bed elevation over a period of 10, 15, or 20 years when the inflow sediment transport of any river consists of suspended load and bed load. Moreover, the particle size distribution of these particles could and would vary from sand to silt or clay. Illinois River at Peoria Lake is not an exception to this normal sediment transport characteristic of an alluvial river.

Long-term goal of any sediment transport modeling within the Peoria Lake would be to estimate the spatial distribution of the sediment deposition patterns with and without the presence of the proposed island. These types of modeling exercise will require a constant input of suspended sediment loads whose concentration and particle size distributions would vary with time and also spatially. The model also had to run for a period of 10, 15, or 20 years. The SED2D model as it is formulated presently does not have that capability.

The simplest method to estimate the sediment deposition would be to review the old hydrographic data including the recent data collected by the Rock Island District of the U.S. Army Corps of Engineers. Once this analysis is done, then the rate of past sediment deposition can be extrapolated to make an estimate of the future sedimentation rate. This type of specific analysis is being done now by the Rock Island District of the U.S. Army Corps of Engineers.

Another model that could be used is the HEC-6 model of the U.S. Army Corps of Engineers. The HEC-6 model is a one dimensional steady flow model, which will give an estimate of the sediment deposition and scour over a time period. This type of modeling work would not provide any kind of quantification of the lateral variabilities in the sediment deposition patterns.

Shear Stress

Even though SED2D did not provide the necessary tools to estimate the long term bed changes in two dimensions due to sediment scour and or deposition, still this modeling exercise was utilized to estimate the spatial distribution of shear stresses for a flow of 45,000 cfs. The spatial shear stresses thus obtained for the ambient conditions and also for all four alternatives are given in Figures 60 through 64, respectively. The shear stress values shown are in SI units and they are given in Kg force per square meter. The conversion factor from Kg force/square meter to pounds per square feet (# force/ft^2) is 0.205.

An examination of all of these figures will show that the shear stresses at or near the two underwater banks of the navigation channel are relatively higher. Theoretically, this is what is expected for an open channel flow field where with a change in bank slope, a relative increase in shear stress in expected.

Islands: Bankline Stabilization

The modeling work performed so far can be used to make an estimate of the potential shoreline erosion of the island(s) due to the movement of the water after the islands are built. This type of analysis will only show the potential of erosion due to water movement only. In order to arrive at an estimated area or zones of the island shores where bank stabilization would be needed, the concept of the critical shear or tractive force as it is called or the concept of permissible velocities can be used. There are many textbooks where these values for different particle sizes are given. Table 7 shows some of these values (after Chow 1959). There are other analyses where the critical shear stresses are normally related to the median particle diameter of the bed materials. One such relationship is given by Equation 1 (after Highway Research Board, 1970).

$$\tau_c = 4d_{50} \qquad (1)$$

where τ_c is the critical shear stress in #/ft^2, and d_{50} is in ft.

In engineering design, normally a factor of safety is used to estimate the stable particle size. Factors such as gradation, maximum and minimum sizes, and need of a fitter blanket must also be considered in the design of riprap particles.

The maximum velocities computed for 45,000 cfs next to the islands are in the range of 3 fps. This shows that at some locations, some bank protection work will be needed especially o the side of the island next to the main channel and upstream ends of the island. However, effects of the waves generated by the wind or navigation traffic could finally dictate the need of bank protection work (Bhowmik et. al 1982, Bhowmik 1976, and Bhowmik et. al 1981). Bhowmik et at (1982) computed wind generated wave heights for a sustained wind duration of 6 hours having a frequency of occurrence of 50 years. That analysis for four sites on the Illinois and Mississippi Rivers showed that highest significant wave heights occurred in the month of March and ranged about 0.9 ft for 2-yr wind frequency and 1.6 ft for 50 year wind frequency. Therefore, it is suspected that similar wind waves can be expected also for the Peoria Lake.

Based on this analysis and a knowledge of the expected waves created by commercial and recreational boats, it is almost certain that the right hand side of the islands looking downstream will be subjected to high wave activities either generated by wind or river traffic. In order to protect against such wave activities and also against the zones of high velocities, it is suggested that protective bank stabilization work be installed on all four options at the locations shown in Figures 65, 66, 67, and 68, respectively. These areas or zones of potential protection were agreed on by the USA COE RI and the Water Survey Scientists based on a telephone discussion. In order to determine the approximate height for which the bank stabilization work along the island shores should be installed, an examination of the long-term water surface changes within the Peoria Lake was performed by the U.S. Army Corps of Engineers (USA COE, Rock Island District (Personal Communication). The USACOE provided the frequency distribution plots of the water surface elevations for the period 1942 through 2000. These frequency plots were developed on a monthly basis and for the 12-month period. The yearly and the Period of Record (POR) frequency plot is shown in Figure 69.

An examination of Figure 69 will show that if the shore lines of the islands as shown in Figures 65 to 68, are stabilized from an elevation of about 439 ft-msl to 443 ft-msl, then the shore lines will be stable against a water surface variation for up to about 82 percent of the time. This means that for about 18 percent of the time, the shorelines will be subjected to water surface activities, which will not have any kind of artificial protective works. It is suggested that the protective works be installed for this zone between elevation variations of 439 ft-msl to 443 ft-msl.

There are numerous techniques that could be used to stabilize the lakeshores, which would be applicable for these islands. These could vary from structural techniques such as rock riprap, gabions, inter-locking blocks, geotubes and others. Non-structural techniques employing Bioengineering should also be suitable for some zones of the island shores. The USACOE will perform the engineering design for the shore stabilization work.

It would be worthwhile to repeat here that in almost all cases, it is expected that the stability of the islands, whether it is at the front ends, or on the west side, will depend on the wave activities whether from wind or river traffic.

Summary

This letter report has summarized the hydrodynamic modeling work performed by the Illinois State Water Survey in support of the selection of Proposed Artificial Island Construction Sites within the Lower Peoria Lake. Previous studies and new hydrographic data collected by the U.S. Army Corps of Engineers have shown that the Peoria Lake has lost a significant amount of its capacity due to sediment deposition. There are several alternatives for the creation of deep-water habitats including the removal of the deposited sediments and placing them at appropriate locations. One of the alternatives is to create artificial islands with the sediments removed from the lakebed. This technique will not only create the needed deep-water habitats outside of the navigation channel, but it will also assist in the placement of dredged materials. Moreover, creation of artificial islands will also recreate terretrial habitats and zones of lake surface with minimum wave activities which could enhance the reduction of turbidity in those protected areas.

The Illinois State Water Survey in close consultation of the USACOE, Illinois Department of Natural Resources (IDNR) conducted this mathematical hydrodynamic modeling work. The model selected is the two dimensional hydrodynamic unsteady modeling system called RMA 2. This model was calibrated and applied for the entire Peoria Lake with a special emphasis on the Lower Peoria Lake. The Interagency Committee selected the Lower Peoria Lake in and around the McClugge Bridge and on the east side of the navigation channel to be the site where the initial or sets of islands could be built.

The modeling work was done for two flows, one having a frequency of occurrence of 2-years with a flow of 45,000 cfs. The other was a low flow condition of 15,000 cfs. All model runs were completed for 2-year flow, various alternatives were tested and a final selection of four (4) alternatives were made. Two of these alternatives had islands just upstream of the McClugge Bridge and two below the McClugge Bridge. All proposed islands are located on the east side of the navigation channel.

Modeling work was also completed for a flow of 15,000 cfs with each individual island in place. For all the runs, both for the flows of 45,000 cfs and 15,000 cfs, spatial velocity distributions in two dimensions have been developed and included in this report. A comparative analysis of the lateral velocity distributions at three-cross-sections, with and without the islands in place, has also been done and the plots included with this report. It was observes that in general, there is some increase in velocities next to the islands along the newly created deep-water channel. The maximum velocities within the main navigation channel do increase in most cases when the island or islands are in place. In one case, some minor decreases in the velocities were observed when the island was in place.

The height of all the islands was selected to be 450 ft-msl. This will allow top of the islands to be about 3 ft above a 2-year flow. However, for a one percent flow, all the islands will be submerged.

The spatial velocity distributions with the islands in place were reviewed to determine the zones of higher velocities which may require artificial shoreline stabilization work. A review of the wind generated and river traffic generated waves showed that the bank stabilization work will be needed in some areas essentially against the waves rather than the island induced velocities. Based on a review of the historical water surface variations analyzed by the USACOE, it is suggested that the stabilization work be extended from about 439 ft-msl to 443 ft-msl.

It is suggested that a combination of structural and nonstructural means be considered for stabilizing the selected shore lines against wind and or river traffic generated wave activities and in some cases against the flow induced velocities. The four selected alternatives with deep water channels should enhance aquatic habitats and terrestrial habitats by having a portion of the island(s) above the 2-year stage. Anyone of these islands, if built should also enhance the overall aquatic habitat within the Lower Peoria Lake.

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Table 1. Flow Frequencies, Flows and Stages at Chillicothe, After USACOE (1992) RM180

Flow Frequencies		Flow	Stages
Percent Time	Years	*Cfs*	Ft-msl
0.2	500	125,000	461.8
0.5	200	114,000	460.2
1.0	100	105,000	459.0
2.0	50	100,000	457.8
4.0	25	85,000	456.4
10.0	10	75,000	454.4
20.0	5	65,000	452.1
50.0	2	45,000	448.4

Table 2. Flow Frequencies, Flows and Stages at Peoria Lock and Dam; After USACOE (1992)

Flow Frequency		Flow	Stages
Percent Time	Years	Cfs	Ft-msl
0.2%	500	103,000	460.4
0.5%	200	92,000	459.0
1.0%	100	85,000	457.8
2.0%	50	80,000	456.6
4.0%	25	72,000	455.3
10.0%	10	63,000	453.2
20.0%	5	54,000	451.0
50.0%	2	40,000	447.2

Table 3. Velocity Changes Due to the Construction of the Island, Alternative 1, Q=45,000 cfs

	Velocities, fps					
Locations	With Island 1	Without Island 2	With Island 3	Without Island 4	With Island 5	Without Island 6
Cross-section 1	0.08	0.1	0.22	0.21	3.25	3.26
Cross-section 2	0.19	0.19	0.52	0.44	2.77	2.81
Cross-section 3	0.12	0.15	0.32	0.24	2.5	2.51

Table 4. Velocity Changes Due to the Construction of the Island, Alternative 2, Q=45,000 cfs

	Velocities, fps					
Locations	**With Island 1**	**Without Island 2**	**With Island 3**	**Without Island 4**	**With Island 5**	**Without Island 6**
Cross-section 1	0.09	0.14	0.42	0.58	2.77	2.8
Cross-section 2	0.08	0.09	0.36	0.32	2.5	2.51
Cross-section 3	0.16	0.09	0.2	0.21	2.45	2.42

Table 5. Velocity Changes Due to the Construction of the Islands, Alternative 3, Q=45,000 cfs

	Velocities, fps					
Locations	**With Island 1**	**Without Island 2**	**With Island 3**	**Without Island 4**	**With Island 5**	**Without Island 6**
Cross-section 1	0.77	0.43	0.65	0.55	0.6	0.76
Cross-section 2	0.5	0.47	0.73	0.5	0.77	0.61
Cross-section 3	0.34	0.44	0.75	0.47	0.67	0.54
Locations	**With Island 7**	**Without Island 8**	**With Island 9**	**Without Island 10**		
Cross-section 1	1.48	1.47	2.15	2.09		
Cross-section 2	0.97	1.01	1.79	1.77		
Cross-section 3	1	0.81	1.68	1.59		

Table 6. Velocity Changes Due to Construction of An Island, Alternative 4, Q=45,000 cfs

	Velocities, fps					
Locations	With Island 1	Without Island 2	With Island 3	Without Island 4	With Island 5	Without Island 6
Cross-section 1	0.85	0.45	0.72	0.66	2.05	2.09
Cross-section 2	0.50	0.47	0.68	0.54	1.80	1.77
Cross-section 3	0.32	0.44	0.79	0.49	1.67	1.59

Table 7. Maximum Permissible Velocities Recommended by Fortier and Scobey and the Corresponding Unit-Tractive-Force Values Converted by the U.S. Bureau of Reclamation

(For straight channels of small slope, after aging), See Chow (1959)

Material	Clear Water		Water transporting colloidal silts	
	V, fps	τo, lb/ft^2	V, fps	$\tau 0$, lb/ft^2
Fine sand, colloidal	1.50	0.027	2.50	0.075
Sandy loam, noncolloidal	1.75	0.037	2.50	0.075
Silt loam, noncolloidal	2.00	0.048	3.00	0.11
Alluvial silts, noncolloidal	2.00	0.048	3.50	0.15
Ordinary firm loam	2.50	0.075	3.50	0.15
Volcanic ash	2.50	0.075	3.50	0.15
Stiff clay, very colloidal	3.75	0.26	5.00	0.46
Alluvial silts, colloidal	3.75	0.26	5.00	0.46
Shales and hardpans	6.00	0.67	6.00	0.67
Fine gravel	2.50	0.075	5.00	0.32
Graded loam to cobbles when noncolloidal	3.75	0.38	5.00	0.66
Graded silts to cobbles when colloidal	4.00	0.43	5.50	0.80
Coarse gravel, noncolloidal	4.00	0.30	6.00	0.67
Cobbles and shingles	5.00	0.91	5.50	1.10