NAVPAT Application to Winfield Pool, Kanawha River, and Evaluation of NAVPAT Habitat Relationships

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Stephen Maynord, Jack Killgore, Barry Payne,
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ABSTRACT: NAVPAT evaluates the effects of commercial navigation traffic on riverine fish habitat. On the Winfield Pool of the Kanawha River, NAVPAT was used to evaluate changes in fish habitat as a result of lock improvements at the Winfield Lock and Dam made during the 1990's. Fifteen species/life stages were evaluated at a range of traffic levels. The Winfield Pool was divided into 127 longitudinal reaches and each reach was divided into lateral cells having similar depth, velocity, and substrate size. Without traffic habitat quality is determined based on ambient depth, velocity, substrate size, and available structure. Without traffic habitat is degraded by tow traffic as a result of velocity change, substrate scour, and propeller entrainment. NAVPAT results on Winfield Pool showed three different responses to navigation traffic. Seven of the fifteen species/life stages showed no effects of navigation traffic on riverine fish habitat at any of the traffic levels tested on Winfield Pool. Four of the fifteen species/life stages showed effects of navigation traffic but no difference as a result of the lock improvements made during the 1990's. The last four of the fifteen species/life stages, swiftwater spawners, showed not only effects of navigation but also differences in habitat quality as a result of the lock improvements. Evaluation of the existing NAVPAT habitat relationships suggests using a guild approach to promote a more community level approach to habitat assessment.

Contents

Conversion Factors, Non-SI to SI Units of Measurement viii

Preface ix

1—Introduction 1

2—NAVPAT Description 4

3—NAVPAT Version Used for Winfield 9

4—Program Changes to NAVPAT 11

5—Flow Windows for Species/Life Stages 14

6—Description of NAVPAT Input 17

- Bathymetry/Cell File 17
- Bathymetry 17
- Substrate 31
- Cell Limits 31
- Structure 31
- In-Channel Structure Data 40
- Roughness Parameter 41
- Traffic 42
- Sailing Lines and Tow Positions 46
- Tow Position Frequency 46
- Stage and Discharge Files 47

7—Example Application 53

8—NAVPAT Results 58

9—Evaluation of NAVPAT Habitat Relationships 87

- Ecological Guild 87
- Species Response to Navigation Traffic 90
- Recommendations for Improved Habitat Models 98

10—Analysis of Results 100

11—Display of NAVPAT Input/Output in GIS 103

- Conversion of NAVPAT Cells to GIS Polygons 103
- Example Display in GIS 105

12—Summary and Conclusions 107

References 109
Appendix A: Review Certification A1
SF 298

List of Figures

Figure 1. Flow chart of NAVPAT model 7
Figure 2. Comparison of 20 identical cross sections for effect of seed, 5-day simulation, species number 1 16
Figure 3. Comparison of 20 identical cross sections for effect of seed, 5- to 100-day simulations, species number 1 16
Figure 4. Example cross-section/cell input file 19
Figure 5. Navigation Chart No. 7 showing NAVPAT cross sections 22
Figure 6. Navigation Chart No. 8 showing NAVPAT cross sections 23
Figure 7. Navigation Chart No. 9 showing NAVPAT cross sections 24
Figure 8. Navigation Chart No. 10 showing NAVPAT cross sections 25
Figure 9. Navigation Chart No. 11 showing NAVPAT cross sections 26
Figure 10. Navigation Chart No. 12 showing NAVPAT cross sections 27
Figure 11. Navigation Chart No. 13 showing NAVPAT cross sections 28
Figure 12. Navigation chart No. 14 showing NAVPAT cross sections 29
Figure 13. Navigation Chart No. 15 showing NAVPAT cross sections 30
Figure 14. Cumulative number of tows versus Julian day for Traffic Year 1996 43
Figure 15. Cumulative number of tows versus Julian day for Traffic Year 2000 43
Figure 16. Cumulative number of tows versus Julian days 154-178 for Traffic Year 2000, Species 2 44
Figure 17. Stage file for Winfield..49

Figure 18. Winfield discharge file 52

Figure 19. Cross section, cell limits, navigable limits, and five tow positions used in example application of NAVPAT 54

Figure 20. Variation of ambient velocity, without tow SI, and with tow average SI across cross section 55

Figure 21. Variation of SI due to tow impacts at cell 6 during flow window and average SI due to tow traffic....55

Figure 22. Variation of peak velocity disturbance across section for tow on Julian day 124.4 56

Figure 23. 300-sec time-history of velocity computed in NAVPAT for cells 1 and 6 for tow on Julian day 124.4 56

Figure 24. Propeller entrainment parameters for tow passage on Julian day 124.4 57

Figure 25. Variation of SI over flow window for emerald shiner fry index resulting from propeller entrainment....78

Figure 26. Habitat units for species 1 – emerald shiner (spawning)....79

Figure 27. Habitat units for species 2 – emerald shiner (fry index) 79

Figure 28. Habitat units for species 3 – paddlefish (spawning)....80

Figure 29. Habitat units for species 4 – paddlefish (larval)....80

Figure 30. Habitat units for species 5 – freshwater drum (food index)....81

Figure 31. Habitat units for species 6 – freshwater drum (egg/larval) 81

Figure 32. Habitat units for species 7 – sauger (spawning)....82

Figure 33. Habitat units for species 8 – sauger (larval) 82

Figure 34. Habitat units for species 9 – channel catfish (young of year)....83

Figure 35. Habitat units for species 10 – black crappie (spawning)....83

Figure 36. Habitat units for species 11 – black crappie (fry food) 84

Figure 37. Habitat units for species 12 – black crappie (juvenile food) 84

Figure 38. Habitat units for species 13 – black crappie (adult food)....85

Figure 39. Habitat units for species 14 – spotted bass (spawning)....85

Figure 40. Habitat units for species 15 – spotted bass (juvenile food) 86

Figure 41. SI modifier V1 versus ambient velocity for species 14, spotted bass spawning 94

Figure 42. SI modifier V2 versus depth for species 14, spotted bass spawning 94

Figure 43. SI modifier V3 versus substrate size for species 14, spotted bass spawning 95
Figure 44. SI modifier V4 versus velocity disturbance modifier for species 14, spotted bass spawning 95
Figure 45. SI modifier VI versus water depth for species 15, spotted bass juvenile food 96
Figure 46. SI modifier V2 versus percent of structure in cell for species 15, spotted bass juvenile food 96
Figure 47. SI modifier V3 versus ambient velocity for species 15, spotted bass juvenile food 97
Figure 48. SI modifier V4 versus substrate size for species 15, spotted bass juvenile food 97
Figure 49. SI modifier V5 versus substrate disturbance for species 15, spotted bass juvenile food 98
Figure 50. Schematic of NAVPAT cells and GIS polygons 104
Figure 51. GIS display of ambient velocity at reaches represented by cross sections 41.27, 41.555, and 41.744 105
Figure 52. GIS display of SI values for the without project condition, which is the 1996 traffic, for cross sections 41.27, 41.555, and 41.744 106
Figure 53. GIS display of SI values for the with project condition, which is the 2000 traffic, for cross sections 41.27, 41.555, and 41.744 106

List of Tables

Table 1. Flow Windows in 1992 Marmet Simulations 15
Table 2. Representative Cross Sections Used in NAVPAT Analysis 20
Table 3. McClane (2004) Structure Reaches Correlated to NAVPAT Reaches 33
Table 4. Structure Percentages 40
Table 5. Manning’s Coefficient Versus Substrate Size 41
Table 6. Manning’s Coefficient Versus Structure 41
Table 7. Manning’s Coefficient Versus Vegetation Parameter 41
Table 8. Tow Frequency Distribution for Tows Near the Center of the Channel 47

Table 9. Tow Frequency Distribution for Tows Near the Right Bank of the Channel 47

Table 10. Tow Frequency Distribution for Tows Near the Left Bank of the Channel 47

Table 11. Summary of NAVPAT Results 59

Table 12. Effects of Project 78

Table 13. Species Guilds for Fishes of the Lower Mississippi River and Ohio River Basins 88

Conversion Factors, Non-SI to SI Units of Measurement

Non-SI units of measurement used in this report can be converted to SI units as follows:

Multiply	**By**	**To Obtain**
acres	4,046.873	square meters
acre-feet	1,233.489	cubic meters
feet	0.3048	meters
horsepower (550 foot-pounds force per second)	745.69999	watts
inches	25.4	millimeters
square feet	0.09290304	square meters

Preface

The work reported herein was conducted for the U.S. Army Engineer District, Huntington, by the U.S. Army Engineer Research and Development Center (ERDC), Vicksburg, MS. The main goal of the study reported herein was to evaluate the effects of lock improvements at Winfield Lock and Dam on riverine fish habitat.

This study was conducted in ERDC's Coastal and Hydraulics Laboratory (CHL) and Environmental Laboratory (EL) and the Huntington District. This report was written by Dr. Stephen T. Maynord, CHL, Drs. Jack Killgore and Barry Payne and Mr. Scott Bourne, EL, and Ms. Janet Cote, Huntington District. The work was conducted under the direction of Mr. Thomas A. Richardson, Director, CHL.

An independent technical review (ITR) of the study reported herein was conducted by the U.S. Army Engineer District, Nashville, and the West Virginia Field Office of the U.S. Fish and Wildlife Service. The signed ITR certification is included as Appendix A.

Dr. James R. Houston was Director, COL James R. Rowan was Commander of ERDC.

1 Introduction

The **Nav**igation **P**redictive **A**nalysis **T**echnique (NAVPAT) was developed by the U.S. Army Engineer District (USAED), Louisville, in the 1980's to evaluate potential impacts of changes in commercial traffic on selected aquatic organisms. Updates and revisions continued in the 1990's. The Louisville District and the U.S. Army Engineer Research and Development Center (ERDC) developed the physical forces relationships used in NAVPAT. Some of the physical forces relationships used in NAVPAT are described in Maynord (1990). The Louisville District developed the traffic model and completed all computer programming. The Louisville District and the U.S. Fish and Wildlife Service (USFWS) developed the habitat relationships used in NAVPAT. NAVPAT evaluates quality and quantity of fish habitat for various fleet configurations and traffic levels. The habitat relationships in NAVPAT were developed by an interdisciplinary team composed primarily of biologists. The original model is documented in USAED, Louisville (1995), and additional information is provided herein. (The study documented in the 1995 report was conducted in 1991 and reflects the NAVPAT version of 1991). The 1995 report states "...(NAVPAT), provides quantitative values of projected environmental effects of various navigation proposals at one or more time intervals in units that are habitat-based and are essentially 'habitat units'. The model was developed to assess individual tow movement on specific cells or points in a river cross section. NAVPAT was also developed as an overall summary for multiple river reaches for numerous tow passages." The 1995 report also states, "It has not been possible to verify predicted NAVPAT model results for biological change, since no long-term monitoring data exists for the biological system of most rivers. The biological system of Pool 13 of the Upper Mississippi River (and all other rivers) is being modified and will continue to be modified by human actions, including commercial navigation traffic. Changes may be observed through long-term field monitoring of biological systems, but linking such changes directly to commercial navigation traffic, among a host of other influencing factors, will be difficult at best."

The Fish and Wildlife Coordination Act Report (pg 14-15) prepared by the USFWS for the Marmet Lock Project acknowledges that NAVPAT should not be viewed as a "predictor of absolute impacts, but rather a planning level tool" used to rank alternatives (USFWS 1993). It is said to give trend and magnitude of potential impacts, or to assess net benefits of certain mitigation measures.

In planning the Winfield Locks improvement project during 1984, the U.S Army Engineer District, Huntington, evaluated the indirect effects from projected navigation changes for several alternative lock improvements using the Energy

Flow Model (EFM). The Huntington District determined that no significant impacts to the fish populations would occur should the navigation industry re-fleet and increase tonnage on that system, as was anticipated with several of the alternatives. The West Virginia Department of Natural Resources and the USFWS raised concerns about the EFM's ability to analyze tow effects on fish populations. A rigorous comment/response fostered under the National Environmental Policy Act planning process confirmed the validity of the EFM's simulations, and planners concluded that EFM offered an acceptable range of tolerance for modeling methodology at the time. Nevertheless, the Corps committed to revisit the modeling effort as techniques improved and were applied to pending Kanawha River project improvements. Specifically, in September of 1986 the Corps committed to re-examine the EFM conclusions using a developing modeling technique, NAVPAT. The Corps committed to apply the NAVPAT technique to the Winfield planning horizon should significant impacts be found using the NAVPAT technique for a similar project at Marmet Locks and Dam. Significant impacts were found using the NAVPAT model for Marmet. To fulfill this obligation, in 2004 the Huntington District, with the guidance and assistance of ERDC in Vicksburg, MS, analyzed data from the Winfield Pool using the NAVPAT computer model.

The main goal of the study reported herein is to consider the potential for indirect adverse effects from navigation changes in the Winfield Pool related to lock improvements carried out at Winfield Locks and Dam during the 1990's. The focus of this evaluation is for riverine habitat changes for fishes. Winfield Pool is located between River Miles 31.1 and 67.7 on the Kanawha River. Normal pool elevation at Winfield is 566.0 ft as referenced to mean sea level. The width of the water surface at normal pool elevation is typically 600 to 900 ft.[1] Depth in the navigable portion of the channel varies from a low of about 11 ft in the upper reaches of the pool to over 30 ft in the lower reaches of the pool. The Winfield Pool passes through one large city, Charleston, and major tributaries entering the Kanawha River in the Winfield Pool are the Pocatalico, Coal, and Elk Rivers.

The 15 fish species/life stages used in the Winfield NAVPAT evaluation are:

No.	Species/Life Stage
1	Emerald shiner spawning
2	Emerald shiner fry
3	Paddlefish spawning
4	Paddlefish larval
5	Freshwater drum food index
6	Freshwater drum egg/larval
7	Sauger spawning
8	Sauger larval
9	Channel catfish young of year
10	Black crappie spawning

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[1] Table of conversion factors is located on page viii.

11 Black crappie fry food
12 Black crappie juvenile food
13 Black crappie adult food
14 Spotted bass spawning
15 Spotted bass juvenile food

The NAVPAT simulations described herein compare two different project conditions. The without project condition for Winfield Pool, designated “1996,” represents the fleet configuration on the Kanawha River when the original lock at Winfield, measuring 56 ft by 360 ft, was in service. The with project condition or “2000” condition characterizes the fleet after the improvements, which enlarged the lock to 110 ft by 800 ft, were completed. As a result of these modifications, the average tow size increased from 6.0 barges per tow in 1990 to 8.7 barges per tow in 1998.

The objectives of this report are to describe and document the NAVPAT model, compare the current application to earlier models, evaluate the habitat relationships models used in NAVPAT, and present results of the Winfield NAVPAT simulation using the existing version of the model. A secondary objective of the Winfield study is to present NAVPAT cell information in a geographic information system (GIS) framework for ease of viewing both input and output.

2 NAVPAT Description

NAVPAT input describes the waterway by cross sections, breaks each cross section into cells having common habitat, and computes a suitability index (SI) for each cell for conditions with and without traffic. The SI describes habitat quality and varies from 0 (no habitat value) to 1.0 (optimum habitat value); these values were developed by an interagency team of biologists and engineers. Without traffic habitat quality is determined by habitat relationships that depend on one or more of the following variables:

- Cell depth.
- Cell ambient water velocity.
- Cell substrate size.
- Cell structure.

NAVPAT reduces habitat quality based on two different types of tow effects:

- Tow-induced velocity (species/life stage 1, 3, 14), substrate scour (species/life stage 5, 9, 11, 12, 13, 15), or both velocity and scour (species/life stage 7, 10), or
- Propeller entrainment (species/life stage 2, 4, 6, 8).

SI recovers between tow events for the velocity/scour tow effects, but does not recover between tows for propeller entrainment. As will be discussed subsequently, the duration of the simulation can be important for the propeller entrainment species. NAVPAT evaluates the effects of every tow on habitat quality during the period of interest, but does not address cumulative impacts on populations, communities, or trophic dynamics.

The SI is converted to either area habitat units by multiplying cell SI by cell channel bottom area (units are SI × acres) or volume habitat units by multiplying cell SI by cell volume (units are SI × acre ft). Analysis and conclusions in this report are based on area habitat units. Volume habitat units are presented for information purposes only.

A flow chart of the NAVPAT model is shown in Figure 1. Additional comments on the code are as follows:

a. Subroutine PKZONE. This subroutine picks which of the five zones the tow is located in by using a random number generator and the probabilities given in the tow position frequency input file.

b. Subroutine DECAY. The objective of this subroutine is to compute the percentage of the channel that is undisturbed by propeller entrainment. The percentages are called EGGL, EGGC, and EGGR and correspond to the portion of the channel left of the left limit of navigation, the center portion between the left and right limits of navigation, and the portion right of the right limit of navigation. Subroutine DECAY first computes the volume of water entrained by both props in 1 ft of travel of the tow and compares it to the volume of a 1-ft-long reach of the channel region between the left and right navigation limits. The channel region is broken up into five zones. If the tow is in one of the three inside zones, entrainment only occurs in the channel region and EGGL and EGGR are equal to 100 percent. If the tow is in one of the two outside zones, both the channel region and the side nearest the tow have entrainment. Ratios of channel and tow areas are used to define the undisturbed percentages EGGL, EGGC, and EGGR.

c. Subroutine CELTRN. The objective of this subroutine is to compute the percentage of the cell entrained in the propeller jet. The channel is separated into six paired points of channel area measured from the left bank and undisturbed percentage. The six area points and the corresponding percentage points are:

(1) A(1) = 0, E(1) = 100. Point 1 is on the left bank.

(2) A(2) = area left of channel - 0.5, E(2) = maximum of 2 × EGGL - 100 or EGGC. Point 2 is slightly left of the left navigation limit.

(3) A(3) = area left of channel, E(3) = EGGC. Point 3 is on the left navigation limit.

(4) A(4) = area left of channel + channel area, E(4) = EGGC. Point 4 is on the right navigation limit.

(5) A(5) = A(4) + 0.5, E(5) = maximum of 2 × EGGR - 100 or EGGC. Point is slightly right of the right navigation limit.

(6) A(6) = A(4) + area right of channel, E(6) = 100. Point 6 is on the right bank.

Subroutine CELTRN uses the area left of the left side of the cell and interpolates the undisturbed percentage from the six paired points. The same thing is done for the right side of the cell. The undisturbed percentage from the left and right sides of the cell are averaged to provide an undisturbed percentage for the cell. The undisturbed percentage for the cell is subtracted from 100 to define the percentage of the cell entrained in the propeller jet.

d. Subroutines CALVEL and WAVE. These subroutines evaluate the six sources of tow-induced velocity that can negatively impact habitat. The six sources are bow wave, displacement flow, return flow, propeller jet, wake flow, and wave-induced velocity at shallow shoreline cells. Wave velocities are calculated only if the minimum depth in the cell is less than or equal to 2.0 ft. Each of the six components is evaluated over a 300-sec time-history. If two or more velocity sources are occurring at the same time, their velocities are added together and stored as a 300-sec time-history of tow-induced velocity from all sources.

e. Subroutine SSDISP. This subroutine uses the time-history of velocity from CALVEL and WAVE to compute the depth that the substrate is disturbed in the cell.

f. With the exception of propeller entrainment, the SI value for nine of the fifteen species is allowed to recover based on the time between tows. The recovery rate is the number of days it takes for the SI to recover from zero to the SI value without traffic.

g. The SIFUN habitat relationships define the without traffic habitat quality (SI) and effects of tows on habitat quality (SI). Only three tow effects are used: peak tow-induced velocity, substrate scour, and propeller entrainment. Some species/life stage habitat degrades only in response to one of the three tow effects. Others respond to a combination of peak tow-induced velocity and substrate scour.

h. Model output has two options that are hardwired into NAVPAT. The with tow SI can be expressed as the average over a flow window or the SI at the end of the flow window. The version of NAVPAT received from the Louisville District had the variable "kswit" set equal to 2, which causes the program to output the average SI over the flow window.

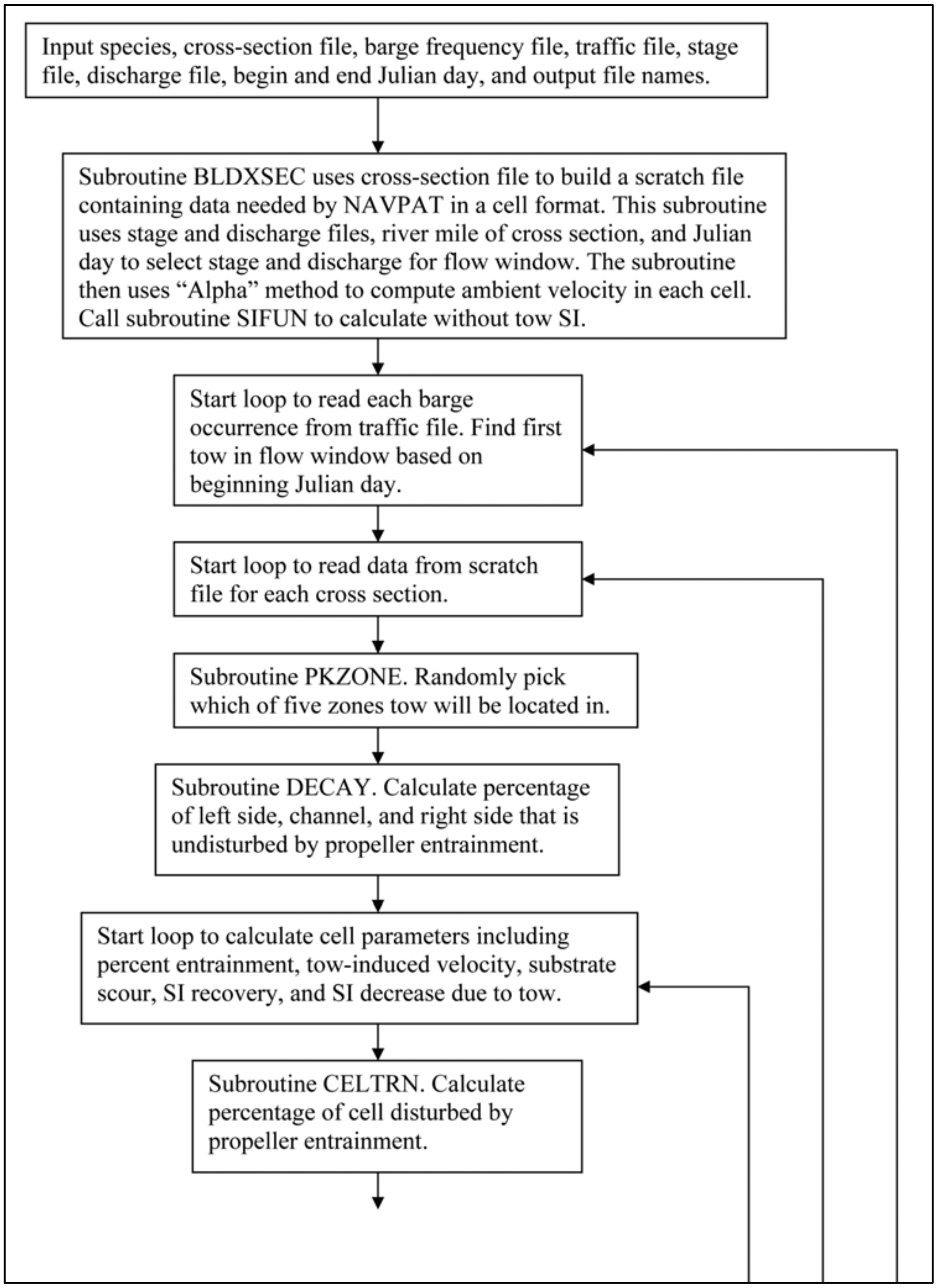


Figure 1. Flow chart of NAVPAT model (Continued)

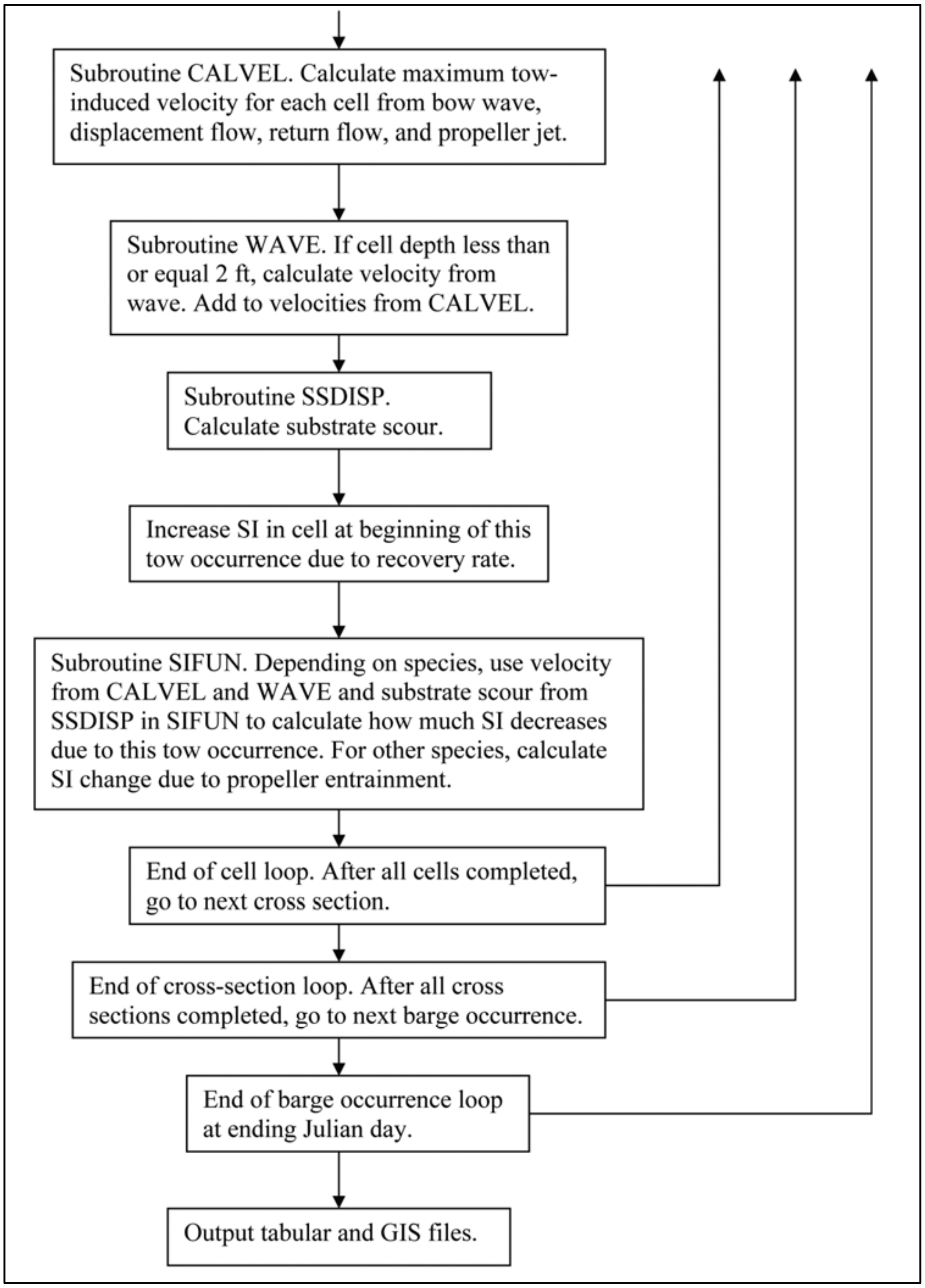


Figure 1. (Concluded)

3 NAVPAT Version Used for Winfield

The objective of this section is to compare an earlier application of NAVPAT on the Marmet Pool, which is the next pool upstream on the Kanawha River, to the current version being used for the Winfield Pool study. The Marmet study was conducted around 1992 but documentation for the study has not been found except for the output files. NAVPAT has two basic parts. The first part, referred to as NAVPAT, is the cross section and cell manipulation, traffic data processing, and tow-induced water motions. The second part, referred to as SIFUN, contains the habitat relationships. The 1992 Marmet output files show that the NAVPAT version used in 1992 was version 2.21 with a date of 7/22/1992. The SIFUN module is shown in the 1992 Marmet Pool output files as version 3.21 without any date. Neither NAVPAT 2.21 nor SIFUN 3.21 source codes have been located. The Louisville District provided the latest version of the NAVPAT source code shown as version 5.10 with a date of 4/28/99. The SIFUN module in the current code is version 3.30, also with a date of 4/28/99.

A version of NAVPAT was found that stated, "PROGRAM MODIFICATIONS 4/21/92 BY TERRY SIEMSEN - CEORLPD-R MODS INCLUDE KANAWHA RIVER TEMPS FOR VISCOSITY CALCULATIONS AND USES ORL BIOLOGICAL MODELS -- MODIFIED FOR USE ON KANAWHA RIVER BUT INCLUDES ALL ORL OPTIMIZATIONS AND ASSUMPTIONS." This program was named "KPAT220.for" and was version 2.20 dated 04/21/92. Version 2.20 was compared to the most recent version 5.10. All subroutines that contain the hydraulic and entrainment routines were the same in versions 2.20 and 5.10. Both versions 2.20 and 5.10 had a problem with the number of tows being incorrect because of a program error that subtracted 1 from variable "begday," an operation that had already been completed earlier in the program. Both versions were corrected. Corrected versions 2.20 and 5.10 were run with the same input data, and identical results were obtained. The remaining question is how does version 2.21 used in the Marmet simulations compare to versions 2.20 or 5.10? The Marmet data was searched to try to establish the cross section, traffic, and tow position input files that correspond to a specific output file in order to make comparative runs with available output files from version 2.21 and version 5.10. While the correct bathymetry/cell file could be found, the correct traffic and tow position frequency files could not be identified.

An SIFUN module was found that stated in the beginning comment lines, "KSIFUN MODELS FOR KANAWHA RIVER STUDY OF MARMET L&D BASED ON WORK BY HOFFMAN (USFWS) ET AL., NOVEMBER 1988. KSIFUN FUNCTION MODELS (VERSION 1.20 05/28/90) BY TERRY SIEMSEN, LOUISVILLE DISTRICT, NAVIGATION PLANNING SUPPORT CENTER (CEORL-PD-C)." Version 2.10 of NAVPAT states about this SIFUN module, "MODIFICATIONS 1/23/91 BY TERRY SIEMSEN FOR ORHPD STAFF-- MODS INCLUDE CONTINUED USE OF ORH/FWS BIO MODELS WHICH HAVE QUESTIONABLE VARIABLES." There is no evidence that SIFUN version 1.20 was used on Marmet because all output files refer to SIFUN version 3.21. An SIFUN module having a version number of 3.20 and date of 1/31/91 was found and compared to the latest version 3.30 dated 4/28/99. The only difference between 3.20 and 3.30 was that 3.20 had the following equation for emerald shiner SI without tow effects:

$$SI = (V1 \times V2 \times V3) \times 0.333333$$

Version 3.30 had the equation as:

$$SI = (V1 \times V2 \times V3)^{0.333333}$$

The equation in version 3.30 agrees with USAED, Louisville (1995), and the equation in version 3.20 is not a standard technique for combining variables. In conclusion, the habitat relationships in SIFUN currently being used appear to be the most recent version 3.30, which is identical to version 3.20 (except for one error in 3.20) that preceded version 3.21 used in the Marmet simulations. For the Winfield application, the most recent versions of NAVPAT and SIFUN were used in the Winfield simulations reported herein. SIFUN was converted to a subroutine in NAVPAT.

4 Program Changes to NAVPAT

Several changes were made prior to running NAVPAT for the Winfield project. As stated previously, a problem was found in the code that resulted in the number of tows being simulated not being equal to the number of tows in the traffic file. (Note that the traffic input files run from day 0 to day 364.) For example, when a species is run for a beginning Julian day (variable "begday") of 124, day 123 is read from the traffic file. The statement in the Fortran code "if(time.lt.begday-1) go to 100" did not result in the correct number of tow events being simulated. The variable begday had already been reduced by 1 previously in the program to account for the numbering system in the traffic file. The second reduction of begday in the above "if" statement caused the problem with the incorrect number of tows. The "if" statement was changed to "if(time.lt.begday) go to 100" and the number of tows used in the simulation was correct.

Two other problems were corrected but had little impact on the resulting output. The two changes were:

(1) Under the section where variables "kwavel" and "kwaver" are checked for wave activity, the original code had waves only at the cell numbers equal to kwavel and kwaver. The code was changed to compute waves at cells on the left bank less than or equal to kwavel and cells greater than or equal to kwaver. In the original code waves were computed in one cell having minimum cell depth of 2 ft. In the revised code, waves are computed in cells having minimum cell depth of 2 ft or less. This change likely has minimal impact on the final output because waves are generally only computed in the first and last cells that are on the shoreline because these are generally the only cells having depth less than 2 ft.

(2) In the subroutine to calculate substrate displacement, the equation for determining TMIN contained $\log_{10}(30 \times Y/AKS)$. Y in NAVPAT is the distance from the tow. The log equation should have used depth rather than distance from the tow and was corrected to $\log_{10}(11.1 \times \text{Depth}/AKS)$. This correction should result in only minor changes in the output because TMIN is the minimum shear and is exceeded in all cases where tow effects are significant.

Other changes were made to input formatting to simplify running and allow display of input with GIS and spreadsheet software as follows:

(1) The input bathymetry/cell file was changed to a free field format described subsequently.

(2) The previous version of NAVPAT required that the lateral variation of ambient velocity across the cross section be determined in a separate program called BLDVEL that contained the "Alpha" program for velocity determination given in EM 1110-2-1601 (Headquarters, U.S. Army Corps of Engineers 1991). The alpha method is simply a division of the total discharge through the cross section based on the conveyance of each subsection or cell in the case of NAVPAT. Each run of BLDVEL required an input discharge and stage. NAVPAT was changed to read stage and discharge from two files that contain stage and discharge as a function of river mile and Julian day. The stage and discharge files for NAVPAT were developed from data provided by the Louisville District and will be discussed subsequently. The program BLDVEL was added to NAVPAT as a subroutine. The new NAVPAT simulation uses the input beginning and ending Julian days to determine an average Julian day for the simulation. The river mile and average Julian day are used with the stage and discharge files to determine a stage and discharge for the simulation period (also called flow window). The selected stage and discharge are used as input in the BLDVEL subroutine to determine the lateral variation of ambient velocity required in NAVPAT. The computed ambient velocities are part of the revised output of the NAVPAT program.

The output file formats were also changed. The program keeps the two output files, one for GIS output and one containing a tabular output. The GIS output file contains the following values (described later in this report):

a. River mile/cell number. This entry is expressed as a number = river mile times 100000 plus cell number. Cell number 7 at river mile 31.425 becomes 3142507.

b. Depth at middle of cell, ft.

c. Ambient velocity in cell, ft/sec. This value is calculated in NAVPAT.

d. Substrate size for cell, mm. Riprap = 1999.

e. Percent of structure in cell.

f. Added roughness value for cell.

g. Cell SI without traffic, SIMAX. Based on one or more ambient conditions of depth, ambient velocity, substrate size, and percent structure, depending on species.

h. Cell habitat units based on area without traffic = SIMAX × reach length × cell perimeter. Note that cell perimeter is measured across the channel.

i. Cell habitat units based on volume without traffic = SIMAX × reach length × cell width × cell depth.

j. Cell SI with traffic, SIVAL. Based on tow changes of either velocity change and/or substrate scour or propeller entrainment.

k. Cell habitat units based on area with traffic = SIVAL × reach length × cell perimeter. Note that cell perimeter is measured across the channel.

l. Cell habitat units based on volume with traffic = SIVAL × reach length × cell width × cell depth.

The second output file, the tabular file, was changed and contains the following:

a. Header information including species, input and output file names, time period of simulation.

b. Without tow results:

  (1) River mile, average cross-section SI based on plan area, average cross-section SI based on volume, habitat units for cross section based on plan area, habitat units for cross section based on volume, SI for each cell.

  (2) For the same river mile in (1) above, cell depth, area, perimeter, width, ambient velocity, substrate D50, percentage structure, and roughness parameter.

  (3) For the same river mile in (1) above, discharge and pool elevation.

  (4) Total sum of without traffic habitat units for entire reach based on plan view area and volume.

c. Number of tows during selected beginning and ending Julian days.

d. With tow results:

  (1) River mile, average cross-section SI based on plan area, average cross-section SI based on volume, habitat units for cross section based on plan area, habitat units for cross section based on volume, SI for each cell.

  (2) Total sum of with traffic habitat units for entire reach based on plan view area and volume.

5 Flow Windows for Species/Life Stages

Flow windows are the Julian days used in NAVPAT to evaluate vessel effects during selected portions of the entire period of interest for a given species/life stage. For example, the 1995 report shows emerald shiner spawning to occur between Julian days 163 and 260. To prevent running the entire period, four 9-day flow windows of 168-176, 189-197, 228-236, and 247-255 were selected that represent the probable spawning season of emerald shiner. The flow windows used in the Marmet study are shown in Table 1. These same flow windows were used for Winfield. The flow windows are combined by using a weighted average of the number of days in each window. If all windows are equal in number of days (as in Table 1), the result is simply an arithmetic average of all flow windows.

NAVPAT was run to look at the effects of the "flow windows" used to evaluate the different species. The number of tows in the selected flow window must be large enough or the random selection of tow position used in the program will lead to variations in the outcome. In addition, the position of the cross section in the file will result in a different seed value that is used in the random generation of tow position. For example, NAVPAT was run with 20 identical cross sections (RM 31.15 in Winfield Pool) in a file for various numbers of tows and various days of simulations. Figure 2 shows results of a 5-day flow window for two different traffic levels for the 20 identical cross sections. The variations are the result of different seed values in the random tow selection as each subsequent cross section is encountered. Figure 3 shows the effect of a larger flow window that is simply increasing the sample size. As number of tows increases in the selected flow window, the variations due to the random selection of tow position are reduced. The 5-day flow window used in the 1992 Marmet simulations will lead to some variation in results due to the relatively small sample size. To some extent, this problem is alleviated by the combination of the three or more flow windows shown in Table 1.

Table 1
Flow Windows in 1992 Marmet Simulations

Species	Flow Windows, Julian Days			
	Winter	Spring	Summer	Autumn
1 - Emerald shiner spawning		124-128, 134-138, 144-148		
2 - Emerald shiner fry		154-158, 164-168, 174-178		
3 - Paddlefish spawning		110-114, 120-124, 130-134		
4 - Paddlefish larval		124-128, 134-138, 144-148		
5 - Freshwater drum food index	14-18, 44-48, 73-77	124-128, 134-138, 144-148	196-200, 226-230, 257-261	288-292, 318-322, 349-353
6 - Freshwater drum egg/larval		140-144, 150-154, 160-164		
7 - Sauger spawning		84-88, 94-98, 104-108		
8 - Sauger larval		110-114, 120-124, 130-134		
9 - Channel catfish young of year		154-158, 164-168, 174-178		
10 - Black crappie spawning		124-128, 134-138, 144-148		
11 - Black crappie fry food		140-144, 150-154, 160-164		
12 - Black crappie juvenile food	14-18, 44-48, 73-77	124-128, 134-138, 144-148	196-200, 226-230, 257-261	288-292, 318-322, 349-353
13 - Black crappie adult food	14-18, 44-48, 73-77	124-128, 134-138, 144-148	196-200, 226-230, 257-261	288-292, 318-322, 349-353
14 - Spotted bass spawning		124-128, 134-138, 144-148		
15 - Spotted bass juvenile food		124-128, 134-138, 144-148	196-200, 226-230, 257-261	288-292, 318-322, 349-353

Figure 2. Comparison of 20 identical cross sections for effect of seed, 5-day simulation, species number 1

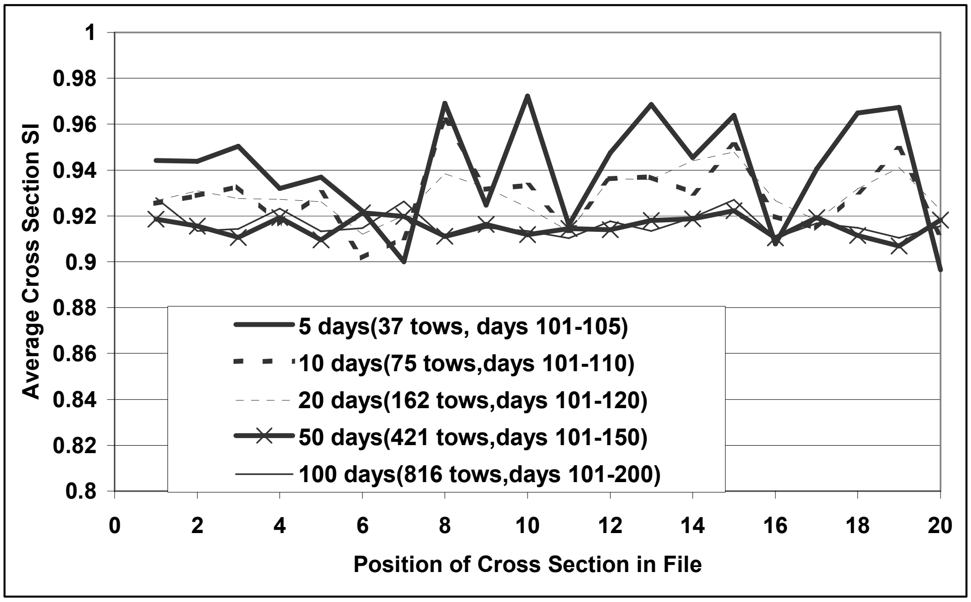


Figure 3. Comparison of 20 identical cross sections for effect of seed, 5- to 100-day simulations, species number 1

6 Description of NAVPAT Input

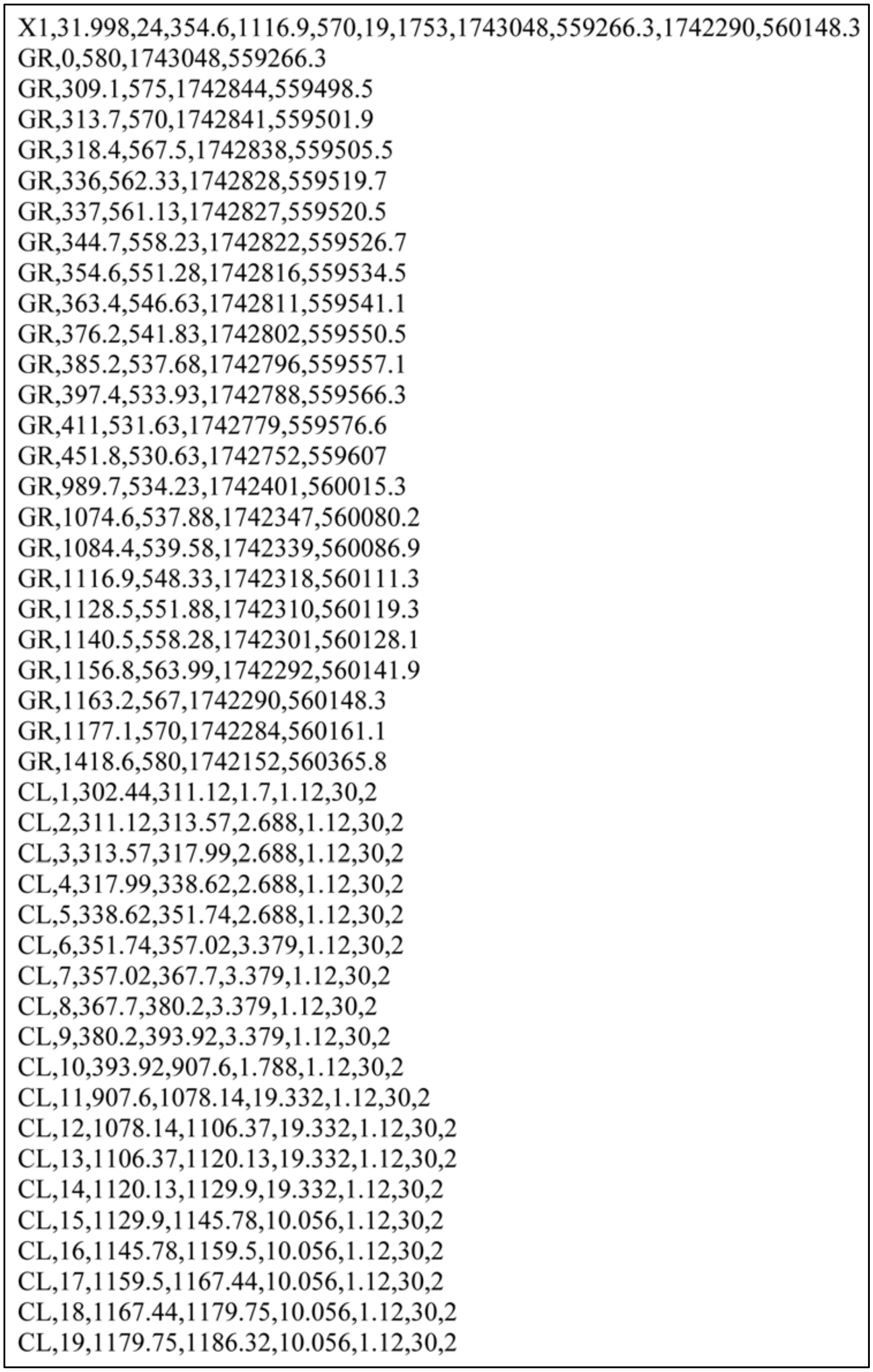
Bathymetry/Cell File

As stated under changes to NAVPAT, the bathymetry/cell file was changed to a free field format with each variable separated by a comma. Use of this format was selected because it is easy to import this format into popular spreadsheet programs and plot out the input data such as cross section, cell location, and left and right limits of navigation. An example input file is shown in Figure 4. The X1 header line contains the river mile, number of GR (bathymetry) points, left and right limits of the navigation channel in feet from left bank, pool elevation (not used because this value is now read from an input file), number of cells, reach length in feet along channel that this section represents, and two pairs of xy coordinates. The first pair are the xy coordinates of the origin of the measurements from the left bank that are used in both the GR lines and the CL (cell) lines. The second pair of xy coordinates is a point along the cross section that provides orientation of the cross section. The next lines in the bathymetry/cell file are the coordinates defining the cross section. Note that each GR line contains a single point having distance from left bank in feet, elevation in feet, and two numbers that are not used in the simulation but are state plane coordinates in the Winfield Pool input file. The CL lines define the cells that are the basis of the NAVPAT calculations and output. Each line contains cell number, distance of left side of cell from left bank (looking downstream) in feet, distance of right side of cell from left bank in feet, substrate D50 in millimeters, velocity in feet per second (not used because this is calculated by NAVPAT), percentage of structure in cell, and roughness parameter.

Bathymetry

Bathymetry for the Winfield Pool was provided in XYZ format with data collected along cross sections that were approximately 500 ft apart along the entire length of the Winfield Pool. Each cross section was described by about 150 points. As a general rule these data extended up to about elevation 564 to 565 (elevations in feet) or about 1 to 2 ft below the Winfield normal pool elevation of 566. Above the normal pool, the Louisville District provided digital terrain data files that generally contained data at 5-ft contour intervals such as 570, 575, etc. These data were used to define the bathymetry above the underwater

XYZ data. Connecting the underwater XYZ data to the 570 contour line resulted in some cases where the shallow bench near the shoreline was not accurately described. Typical bench widths and slopes were determined from data in Hagerty et al. (1995) and from unpublished data provided by Mr. Michael Spoor of the Huntington District. These typical bench widths were used with the underwater XYZ data and the digital terrain contours to better model benches along the Winfield Pool. The bathymetry data was loaded into the Surface Modeling System to view contour plots. The contour plots were used to identify reaches along the channel having a relatively constant cross section. The representative reaches are shown in Table 2 and Figures 5-13 and define the representative cross sections used in the NAVPAT model of Winfield. The Winfield Pool is described by 127 reaches having reach lengths varying from about 400 to 3,000 ft and averaging about 1,500 ft.



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CL,12,1078.14,1106.37,19.332,1.12,30,2
CL,13,1106.37,1120.13,19.332,1.12,30,2
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```

Figure 4. Example cross-section/cell input file

Table 2
Representative Cross Sections Used in NAVPAT Analysis

Reach	Representative River Mile	Beginning River Mile	Ending River Mile	Total reach length, ft	Downstream reach length, ft	Upstream reach length, ft	Dominant Left bank Structure from Photo	Representative River Mile	Spoor Left Bank	Spoor % of reach	Dominant Right bank Structure from Photo	Spoor Right Bank	Spoor % of reach
1	31.425	31.33	31.567	1251.36	501.6	749.76	TH	31.420	RR	52	RR		0
2	31.711	31.567	31.807	1267.2	760.32	506.88	TM	31.710	Height over 15 ft	47	RR	RR	19
3	31.998	31.807	32.139	1752.96	1008.48	744.48	TM	32.000	RR	37	RR	RR	33
4	32.28	32.139	32.469	1742.4	744.48	997.92	RR	32.280	RR	74	TM	RR	55
5	32.566	32.469	32.751	1488.96	512.16	976.8	BA	32.570	RR	8	RR	RR	25
6	32.843	32.751	32.938	987.36	485.76	501.6	RR	32.840	RR	77	TM	RR	26
7	33.124	32.938	33.316	1995.84	982.08	1013.76	TM,RR	33.120	RR	34	BR	Height over 15 ft	24
8	33.407	33.316	33.6	1499.52	480.48	1019.04	TM	33.410		0	BR	Height over 15 ft	53
9	33.694	33.6	33.884	1499.52	496.32	1003.2	TH	33.690	RR	43	TM		0
10	33.985	33.884	34.08	1034.88	533.28	501.6	DV			0	TM,DV		0
11	34.172	34.08	34.363	1494.24	485.76	1008.48	DV	34.170	RR	99	DV		0
12	34.55	34.363	34.645	1488.96	987.36	501.6	DV			0	TM		0
13	34.742	34.645	34.93	1504.8	512.16	992.64	DV,TM	34.930	RR	68	DV		0
14	35.118	34.93	35.26	1742.4	992.64	749.76	TM			0	TM		0
15	35.401	35.26	35.638	1995.84	744.48	1251.36	TM	35.400	RR	65	TM		0
16	35.781	35.638	35.971	1758.24	755.04	1003.2	TM	35.780		0	TM		0
17	36.161	35.971	36.445	2502.72	1003.2	1499.52	DV	36.160		0	1/3DV,2/3B	RR	56
18	36.633	36.445	36.917	2492.16	992.64	1499.52	DV	36.630		0	DV	RR	42
19	37.107	36.917	37.204	1515.36	1003.2	512.16	DV,TM			0	TM		0
20	37.391	37.204	37.575	1958.88	987.36	971.52	RR,TM	37.200		0	TM	RR	23
21	37.671	37.575	37.861	1510.08	506.88	1003.2	TM			0	TM,DV		0
22	37.955	37.861	38.14	1473.12	496.32	976.8	TM	37.860	Height 5 to15 ft	30	TM	RR	44
23	38.235	38.14	38.324	971.52	501.6	469.92	TM	38.240	RR	100	TM		0
24	38.419	38.324	38.514	1003.2	501.6	501.6	BA	38.420	RR	45	BA,TM	RR	33
25	38.703	38.514	38.989	2508	997.92	1510.08	BA	38.700		0	DV	RR	58
26	39.277	38.989	39.512	2761.44	1520.64	1240.8	BA,MC(2/3)	39.280	RR	22	RR	RR	36
27	39.746	39.512	39.946	2291.52	1235.52	1056	BA,MC	39.750	RR	6	RR	MC	36
28	40.037	39.946	40.137	1008.48	480.48	528	BA,MC(1/2)	40.040	MC	68	TM	RR	40
29	40.23	40.137	40.417	1478.4	491.04	987.36	TM	40.230	MC	58	BR,MC		0
30	40.699	40.417	40.985	2999.04	1488.96	1510.08	TM	40.700	MC	62	BR,RR		0
31	41.081	40.985	41.175	1003.2	506.88	496.32	TM,MC(1/2	41.080		0	RR,TM		0
32	41.27	41.175	41.41	1240.8	501.6	739.2	TM	41.270		0	BA,RR	RR	13
33	41.555	41.41	41.648	1256.64	765.6	491.04	TM	41.560		0	BA	RR	42
34	41.744	41.648	41.941	1547.04	506.88	1040.16	RR	41.740	RR	69	RR	RR	58
35	42.113	41.941	42.308	1937.76	908.16	1029.6	RR	42.110	RR	40	RR	RR	24
36	42.4	42.308	42.539	1219.68	485.76	733.92	RR	42.400	RR	84	RR,MC(1/2)		0
37	42.678	42.539	42.864	1716	733.92	982.08	RR	42.860	RR	69	RR	RR	28
38	43.052	42.864	43.242	1995.84	992.64	1003.2	RR			0	BR,MC		0
39	43.434	43.242	43.717	2508	1013.76	1494.24	TM	43.430		0	BR	RR	22
40	43.812	43.717	43.996	1473.12	501.6	971.52	TM	43.810		0	BR		0
41	44.192	43.996	44.375	2001.12	1034.88	966.24	RR	44.190	MC	18	DV	RR	42
42	44.661	44.375	44.753	1995.84	1510.08	485.76	BR	44.760	MC	22	DV	RR	75
43	44.943	44.753	45.17	2201.76	1003.2	1198.56	RR			0	DV		0
44	45.311	45.17	45.452	1488.96	744.48	744.48	RR,MC	45.310		0	DV	RR	98
45	45.596	45.452	45.692	1267.2	760.32	506.88	RR	45.600	RR	20	DV	RR	100
46	45.791	45.692	45.978	1510.08	522.72	987.36	DV	45.790	RR	64	RR	RR	98
47	46.161	45.978	46.351	1969.44	966.24	1003.2	BA,FD	46.350	RR	87	DV	RR	89
48	46.543	46.351	46.728	1990.56	1013.76	976.8	RR			0	RR		0
49	46.92	46.728	47.059	1747.68	1013.76	733.92	RR	46.920	RR	97	RR	RR	49
50	47.202	47.059	47.393	1763.52	755.04	1008.48	BA	47.390	RR	26	RR	RR	51
51	47.578	47.393	47.772	2001.12	976.8	1024.32	BA,RR			0	DV		0
52	47.956	47.772	48.149	1990.56	971.52	1019.04	BR	48.050		0	RR	RR	33
53	48.337	48.149	48.431	1488.96	992.64	496.32	BR			0	RR,MC		0
54	48.527	48.431	48.718	1515.36	506.88	1008.48	TM	48.530		0	RR	RR	98
55	48.813	48.718	48.999	1483.68	501.6	982.08	BR	48.810		0	RR	RR	99
56	49.283	48.999	49.564	2983.2	1499.52	1483.68	RR	49.280	RR	54	BR,MC(1/2)	RR	99
57	49.853	49.564	50.087	2761.44	1525.92	1235.52	RR	49.850	RR	64	BR		0
58	50.236	50.087	50.33	1283.04	786.72	496.32	RR,VW	50.240	RR	63	RR,BA,VW		0
59	50.426	50.33	50.615	1504.8	506.88	997.92	RR	50.430	RR	84	RR	RR	49
60	50.89	50.615	51.18	2983.2	1452	1531.2	RR	50.890	RR	70	DV	RR	83
61	51.275	51.18	51.461	1483.68	501.6	982.08	RR	51.460	RR	63	RR	RR	99

(Continued)

Table 2 (Concluded)

62	51.554	51.461	51.79	1737.12	491.04	1246.08	RR			0	RR		0
63	52.018	51.79	52.206	2196.48	1203.84	992.64	RR	52.020	RR	72	DV	RR	99
64	52.304	52.206	52.352	770.88	517.44	253.44	RR	52.300	RR	74	RR	RR	99
65	52.494	52.352	52.731	2001.12	749.76	1251.36	RR	52.490	RR	68	DV	RR	98
66	52.877	52.731	53.112	2011.68	770.88	1240.8	RR	52.880	RR	66	RR,MC	RR	100
67	53.254	53.112	53.397	1504.8	749.76	755.04	RR	53.250	RR	26	RR	RR	96
68	53.444	53.397	53.545	781.44	248.16	533.28	RR	53.440	RR	97	TM	RR	37
69	53.733	53.545	53.919	1974.72	992.64	982.08	RR	53.730	RR	66	RR	MC	99
70	54.018	53.919	54.209	1531.2	522.72	1008.48	RR	54.020	RR	87	BR,MC	MC	48
71	54.304	54.209	54.441	1224.96	501.6	723.36	RR,MC(1/4	54.300	RR	80	RR	MC	87
72	54.485	54.441	54.5	311.52	232.32	79.2	RR	54.490	RR	98	TM		0
73	54.578	54.5	54.6	528	411.84	116.16	RR	54.580	RR	100	BR		0
74	54.662	54.6	54.763	860.64	327.36	533.28	RR	54.660	RR	60	BR		0
75	54.859	54.763	55.056	1547.04	506.88	1040.16	DV	54.860	RR	86	RR,TM(1/3)		0
76	55.145	55.056	55.246	1003.2	469.92	533.28	RR	55.150	RR	85	RR	RR	85
77	55.336	55.246	55.386	739.2	475.2	264	RR	55.340	RR	72	TM	RR	99
78	55.435	55.386	55.528	749.76	258.72	491.04	RR	55.440	RR	97	RR,TM	RR	37
79	55.73	55.528	55.9	1964.16	1066.56	897.6	RR	55.730	RR	86	RR	RR	30
80	55.919	55.9	56.019	628.32	100.32	528	RR	55.920	RR	46	RR	RR	65
81	56.105	56.019	56.192	913.44	454.08	459.36	BA	56.100		0	RR	RR	70
82	56.287	56.192	56.385	1019.04	501.6	517.44	RR	56.290	RR	29	RR	RR	57
83	56.485	56.385	56.626	1272.48	528	744.48	RR	56.490	RR	99	RR	RR	100
84	56.766	56.626	56.861	1240.8	739.2	501.6	RR,VW,M	56.770	RR	99	RR	RR	100
85	56.959	56.861	57.051	1003.2	517.44	485.76	RR	56.960	RR	99	RR	RR	99
86	57.143	57.051	57.239	992.64	485.76	506.88	RR	57.140	RR	81	RR	RR	99
87	57.335	57.239	57.426	987.36	506.88	480.48	RR	57.330		0	RR	RR	100
88	57.526	57.426	57.594	887.04	528	359.04	RR	57.530		0	RR	RR	104
89	57.705	57.594	57.808	1129.92	586.08	543.84	RR,BA	57.710	RR	53	BA,RR	RR	66
90	57.901	57.808	57.996	992.64	491.04	501.6	RR	57.900	RR	90	RR	RR	66
91	58.088	57.996	58.281	1504.8	485.76	1019.04	RR	58.090	RR	60	RR	RR	81
92	58.372	58.281	58.561	1478.4	480.48	997.92	RR	58.370	RR	77	RR	RR	78
93	58.751	58.561	58.985	2238.72	1003.2	1235.52	RR	58.750	RR	92	RR	RR	79
94	59.125	58.985	59.31	1716	739.2	976.8	RR	59.130	RR	84	RR	RR	84
95	59.409	59.31	59.597	1515.36	522.72	992.64	RR	59.410	RR	95	RR	RR	79
96	59.787	59.597	59.976	2001.12	1003.2	997.92	DV	59.790	RR	100	RR	RR	83
97	60.167	59.976	60.309	1758.24	1008.48	749.76	RR	60.170	RR	100	RR	RR	88
98	60.451	60.309	60.64	1747.68	749.76	997.92	RR,BA	60.450	RR	97	RR	RR	100
99	60.733	60.64	60.923	1494.24	491.04	1003.2	DV	60.730	RR	99	RR	RR	100
100	61.021	60.923	61.111	992.64	517.44	475.2	RR,FD	61.020	RR	98	RR	RR	78
101	61.208	61.111	61.392	1483.68	512.16	971.52	BA	61.210	RR	71	RR	RR	61
102	61.489	61.392	61.537	765.6	512.16	253.44	RR,FD	61.490	RR	96	RR,BR	RR	15
103	61.681	61.537	61.774	1251.36	760.32	491.04	RR,BA(1/3	61.680	RR	99	RR	RR	44
104	61.867	61.774	61.96	982.08	491.04	491.04	BA	61.870	RR	97	BA	RR	76
105	62.052	61.96	62.244	1499.52	485.76	1013.76	RR	62.050	RR	94	RR		0
106	62.334	62.244	62.38	718.08	475.2	242.88	DV,BR	62.330	RR	104	RR		0
107	62.425	62.38	62.52	739.2	237.6	501.6	RR	62.420	RR	96	RR		0
108	62.707	62.52	62.993	2497.44	987.36	1510.08	BA	62.710	RR	98	RR		0
109	63.085	62.993	63.23	1251.36	485.76	765.6	BA	63.080	RR	94	RR		0
110	63.281	63.23	63.381	797.28	269.28	528	BA	63.280	RR	93	RR		0
111	63.56	63.381	63.807	2249.28	945.12	1304.16	RR,BA(1/3	63.560	RR	99	BA,RR	RR	15
112	63.953	63.807	64.043	1246.08	770.88	475.2	RR	63.950	RR	57	RR,BA	RR	21
113	64.14	64.043	64.236	1019.04	512.16	506.88	RR,FD	64.140	RR	71	BA		0
114	64.333	64.236	64.516	1478.4	512.16	966.24	RR	64.330	RR	24	BA,RR(2/3)	RR	22
115	64.609	64.516	64.657	744.48	491.04	253.44	RR,BA	64.610	RR	54	RR	RR	48
116	64.704	64.657	64.848	1008.48	248.16	760.32	RR	64.700	RR	60	RR	RR	75
117	64.897	64.848	64.988	739.2	258.72	480.48	RR			0	RR		0
118	65.174	64.988	65.32	1752.96	982.08	770.88	RR	65.170	RR	70	RR	RR	43
119	65.367	65.32	65.46	739.2	248.16	491.04	RR	65.370	RR	46	RR	RR	49
120	65.646	65.46	65.883	2233.44	982.08	1251.36	RR	65.650	RR	43	RR		0
								65.900	RR	15		RR	23
121	66.12	65.883	66.4	2729.76	1251.36	1478.4	RR	66.120	RR	42	BA(brush in water)		0
122	66.495	66.4	66.587	987.36	501.6	485.76	RR	66.500	RR	34	BA		0
123	66.684	66.587	66.822	1240.8	512.16	728.64	RR	66.680	RR	29	BA		0
124	66.869	66.822	66.961	733.92	248.16	485.76	RR	66.870		0	BA		0
125	66.961	66.961	67.057	506.88	0	506.88	BA	66.980	RR	59	BA		0
126	67.138	67.057	67.238	955.68	427.68	528	BA	67.140	RR	91	BA		0
127	67.34	67.238	67.436	1045.44	538.56	506.88	RR	67.340	RR	77	BA,RR		0

RR = riprap
TH = trees/brush heavy
TM = trees/brush medium
BR = brush
BA = bench, berm, and bar
VW = vertical wall
FD = floating dock
MC = mooring cells
DV = developed, banks frequently riprap, docks, vertical walls

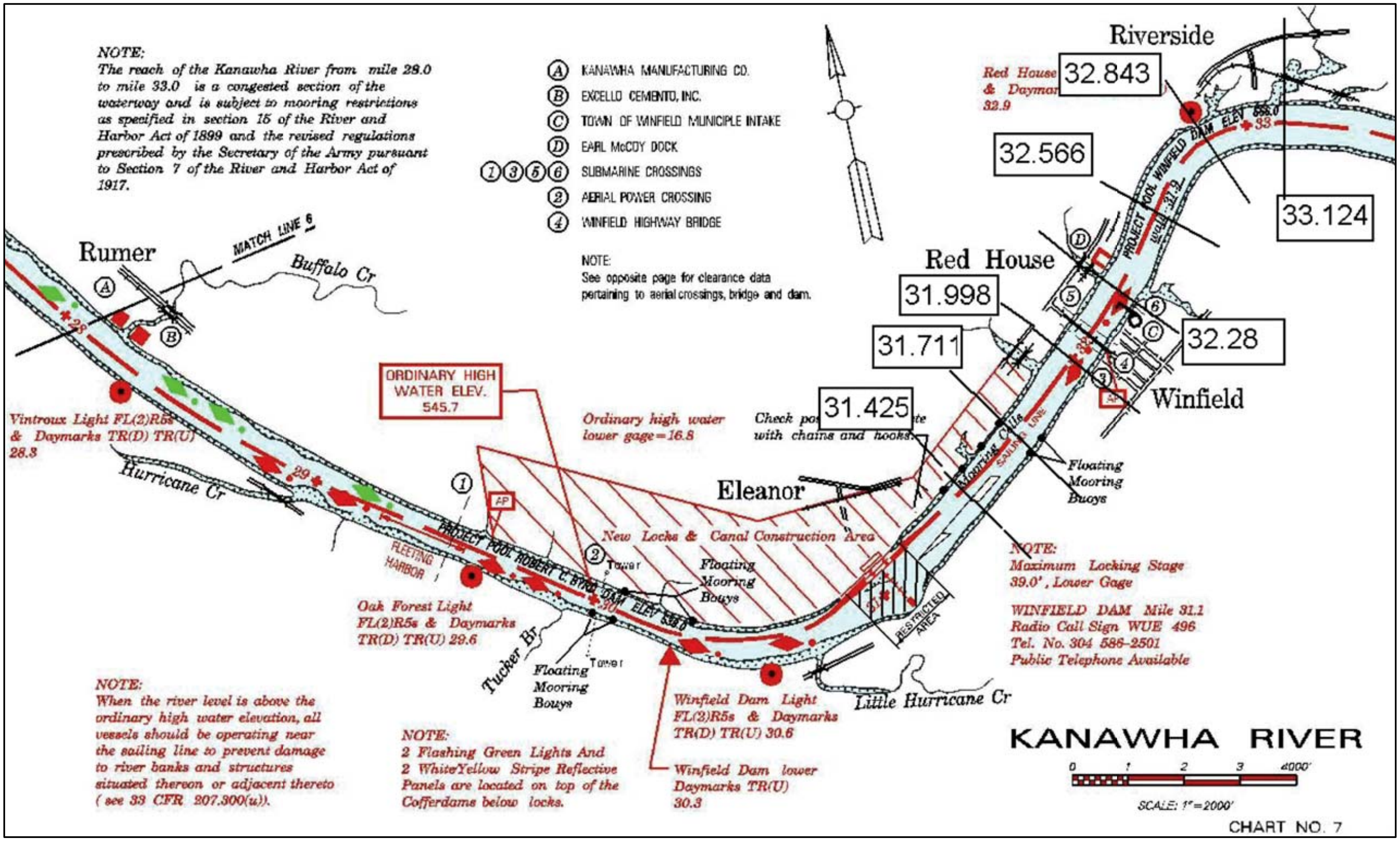


Figure 5. Navigation Chart No. 7 showing NAVPAT cross sections

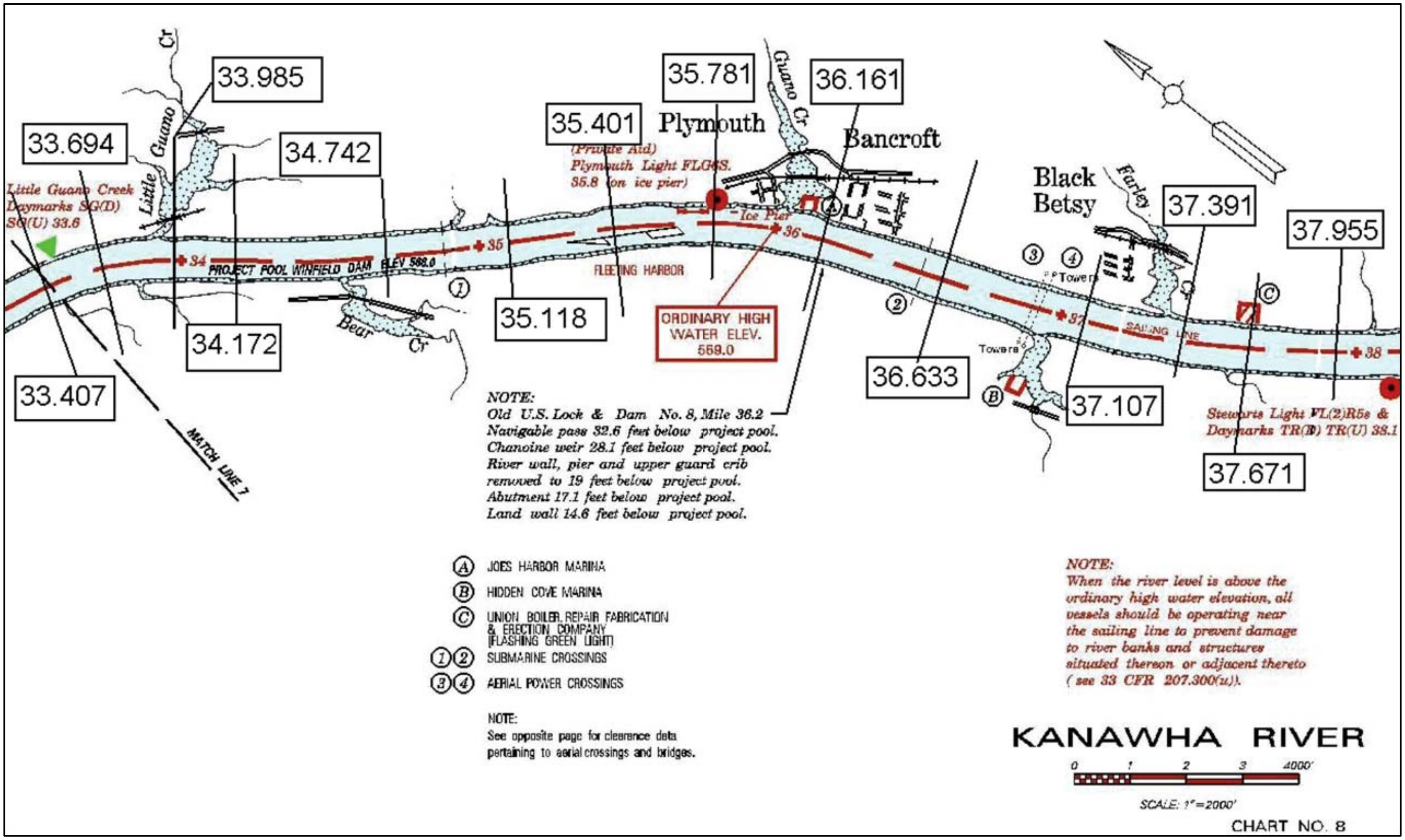


Figure 6. Navigation Chart No. 8 showing NAVPAT cross sections

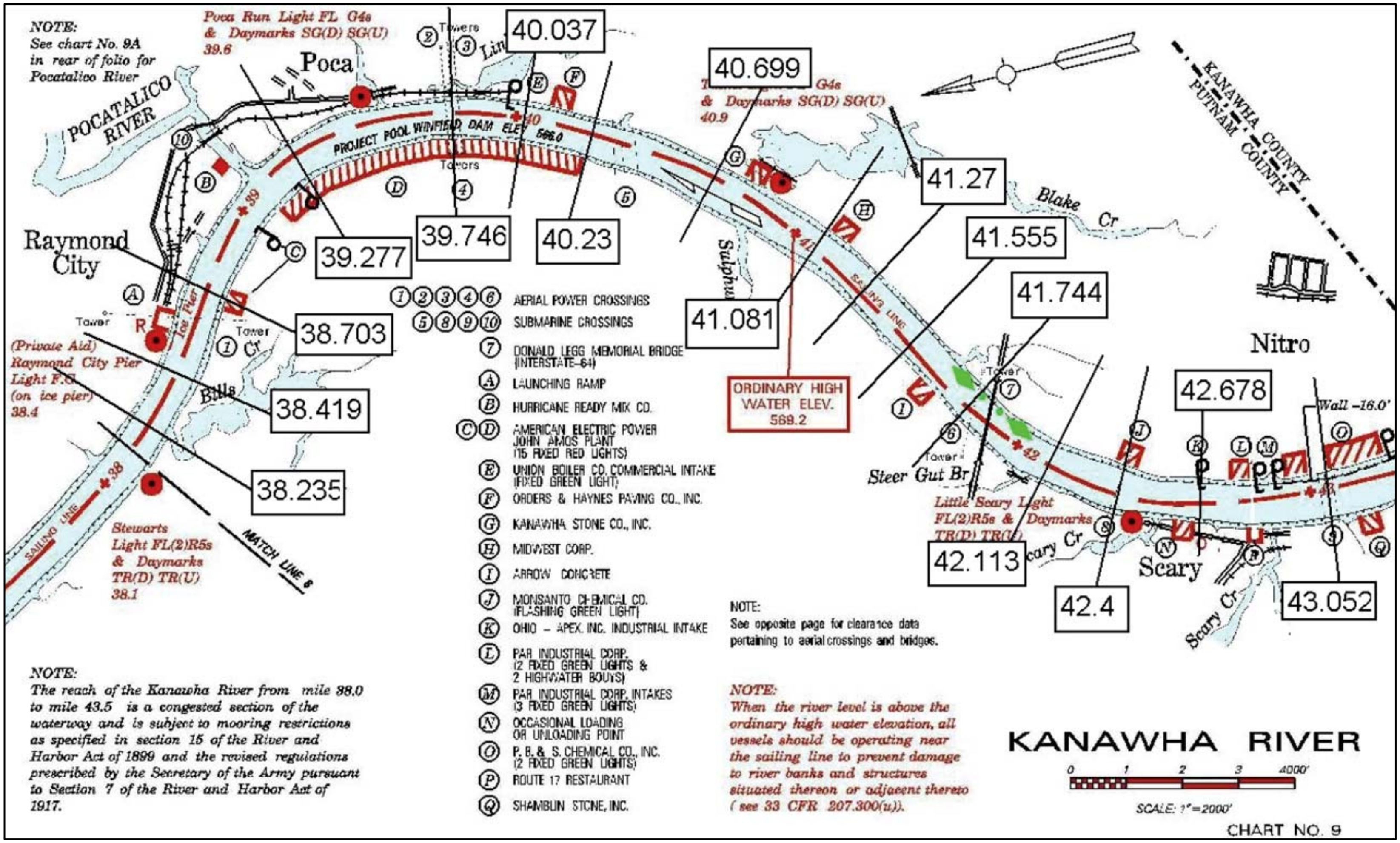


Figure 7. Navigation Chart No. 9 showing NAVPAT cross sections

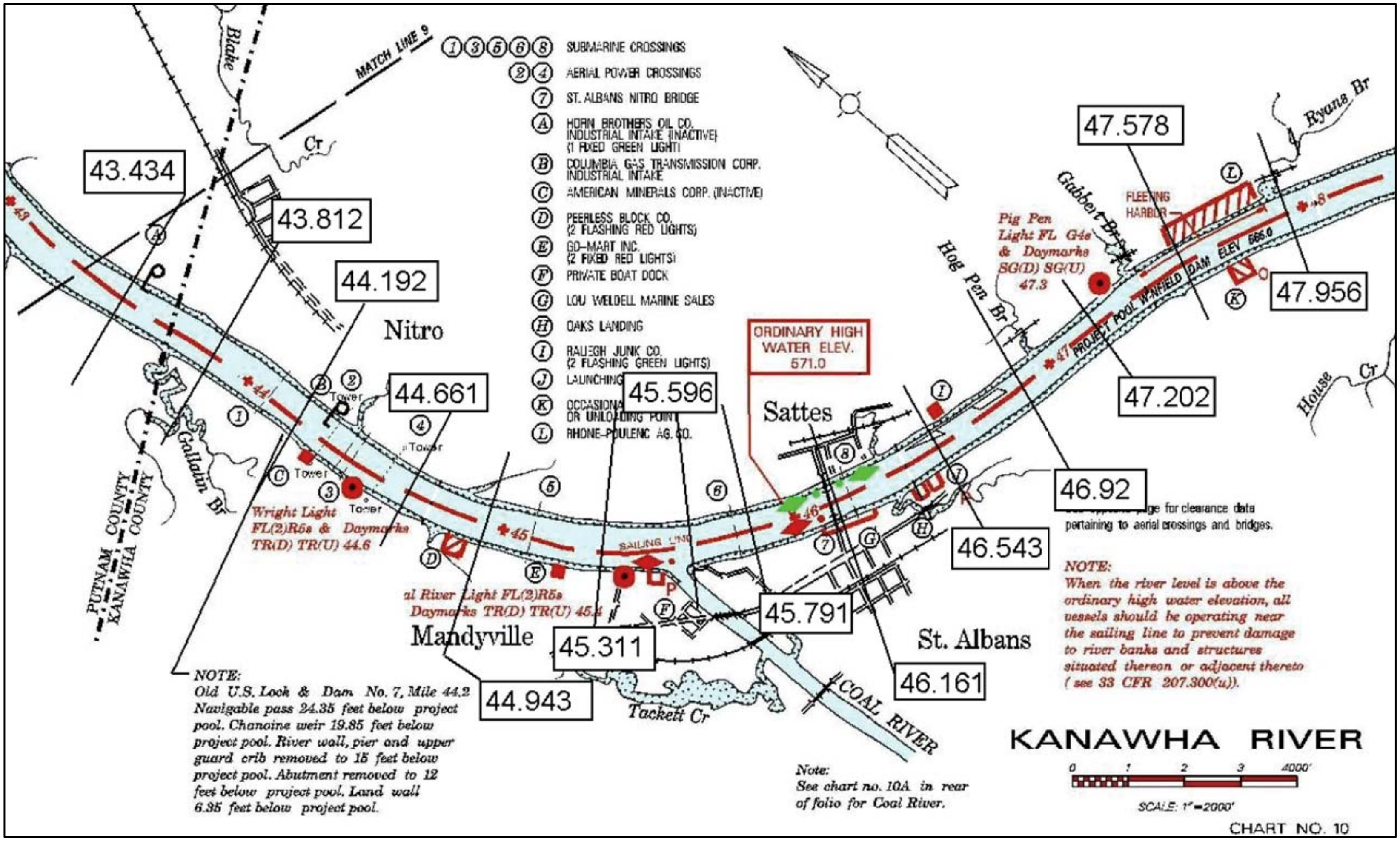


Figure 8. Navigation Chart No. 10 showing NAVPAT cross sections

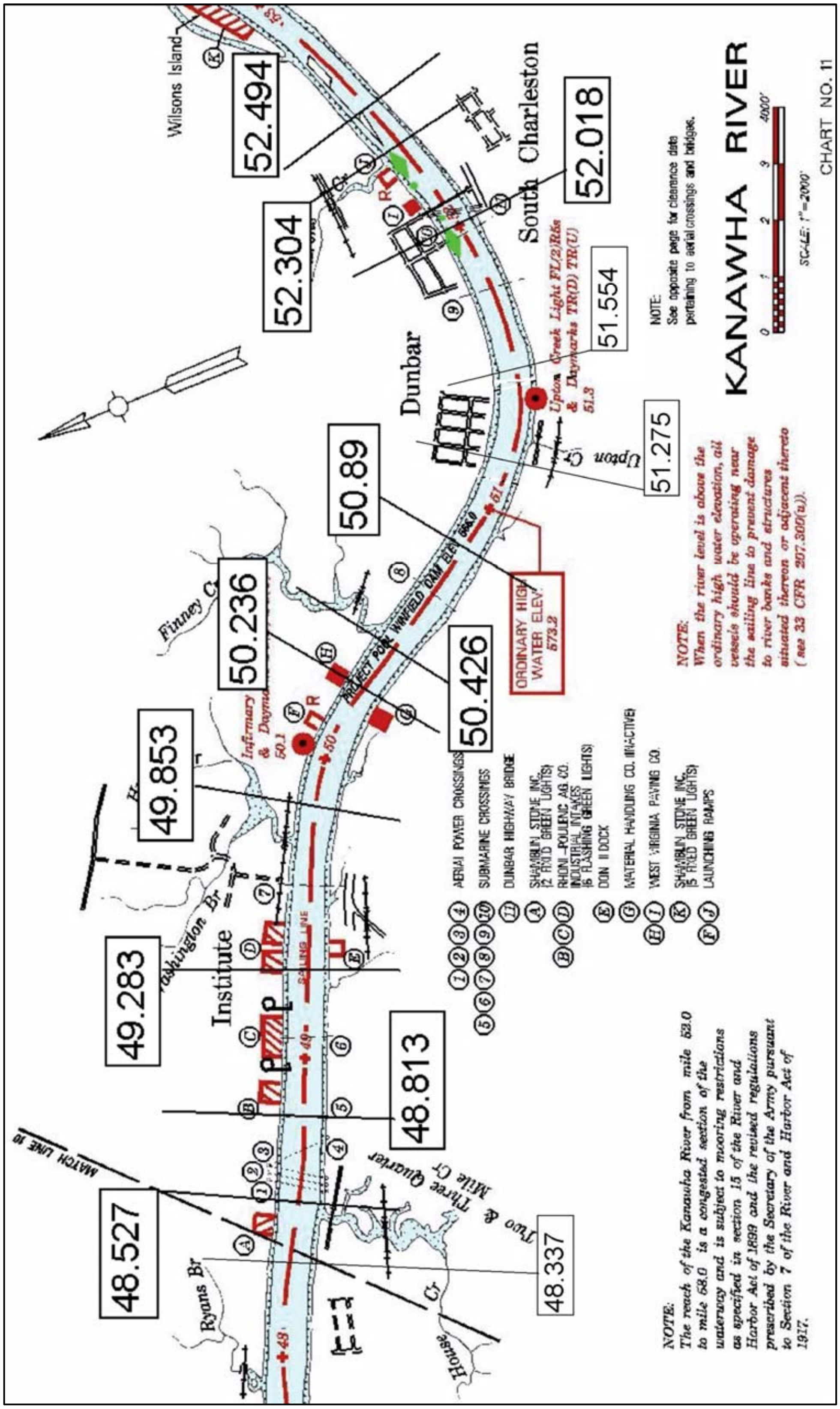


Figure 9. Navigation Chart No. 11 showing NAVPAT cross sections

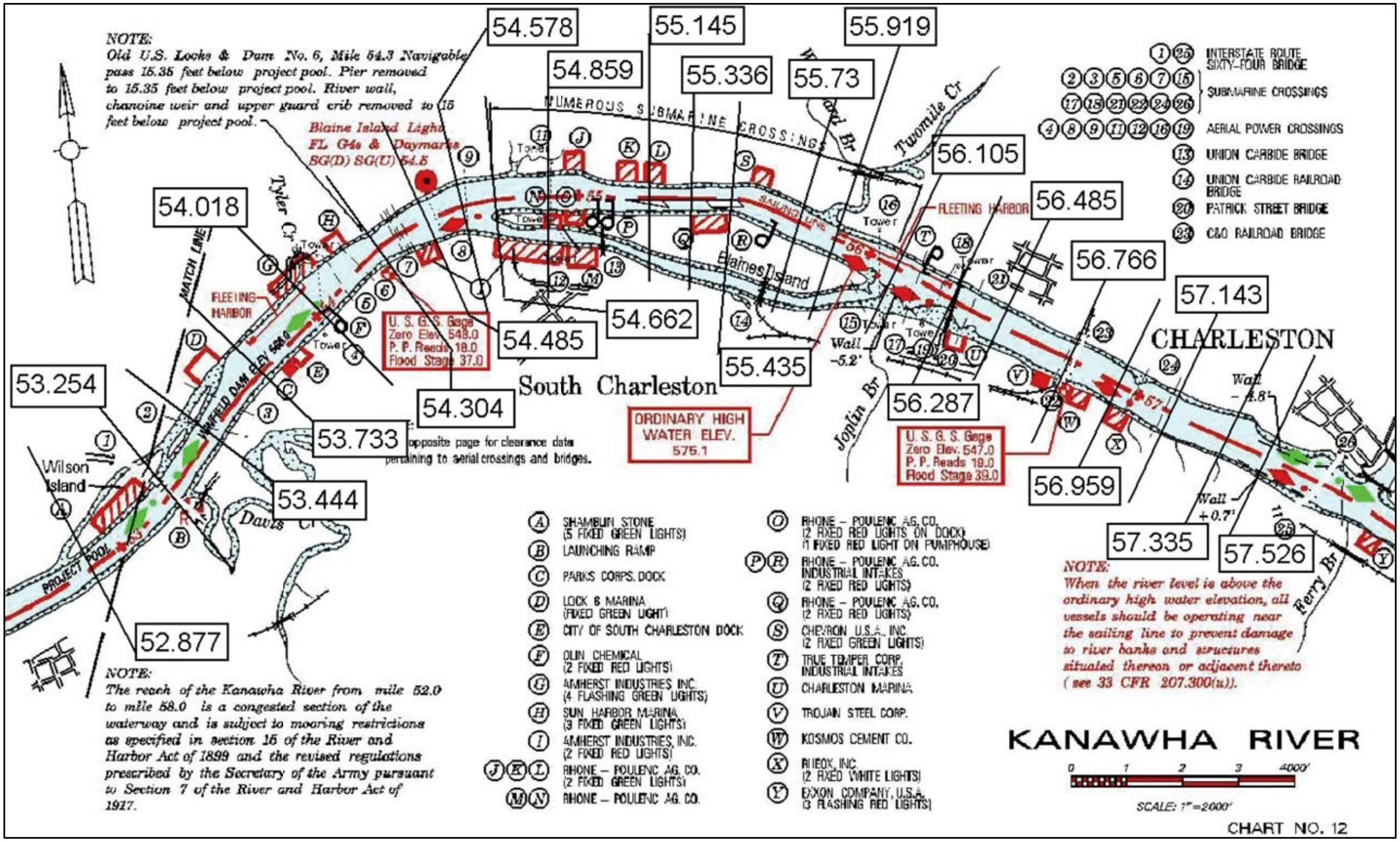


Figure 10. Navigation Chart No. 12 showing NAVPAT cross sections

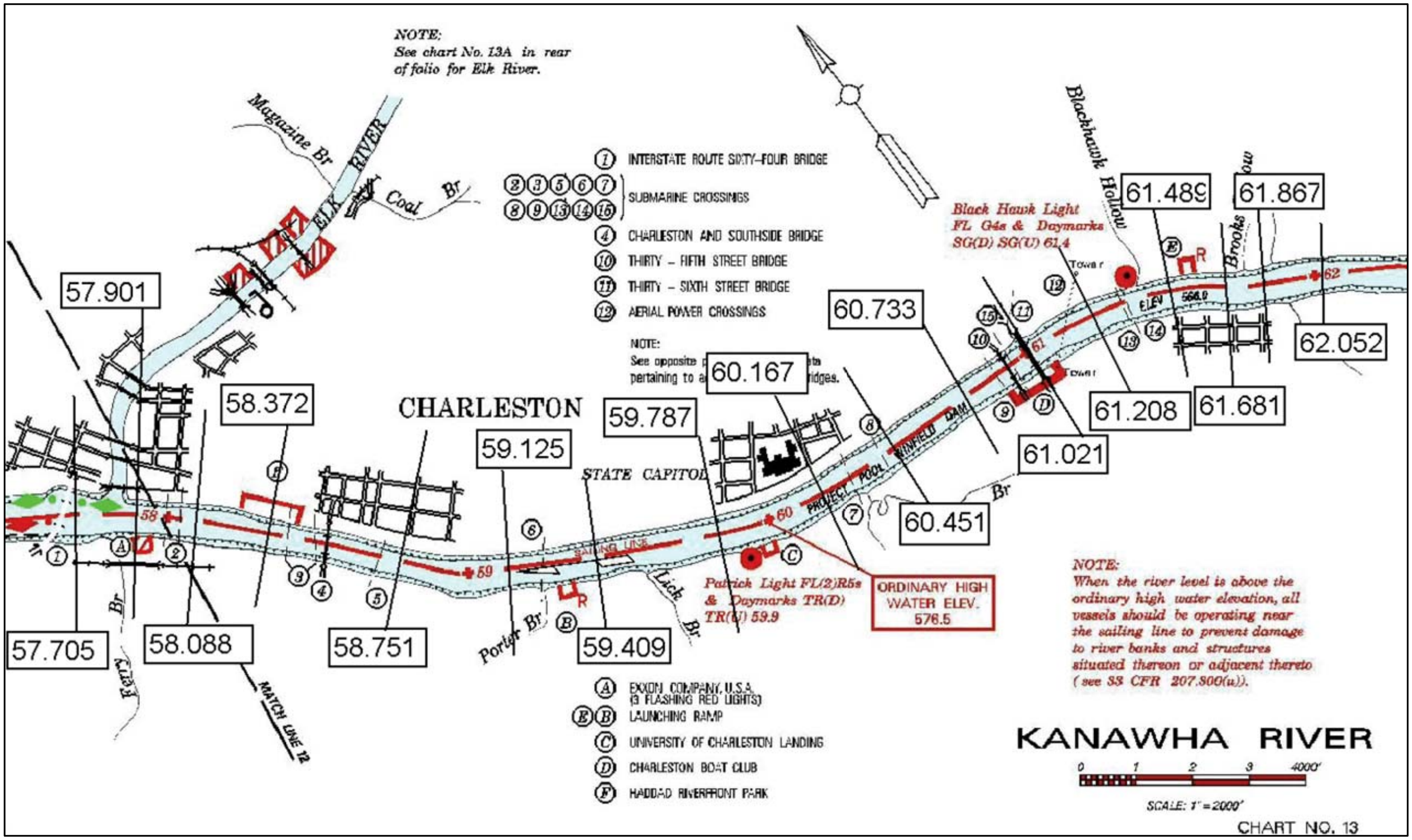


Figure 11. Navigation Chart No. 13 showing NAVPAT cross sections

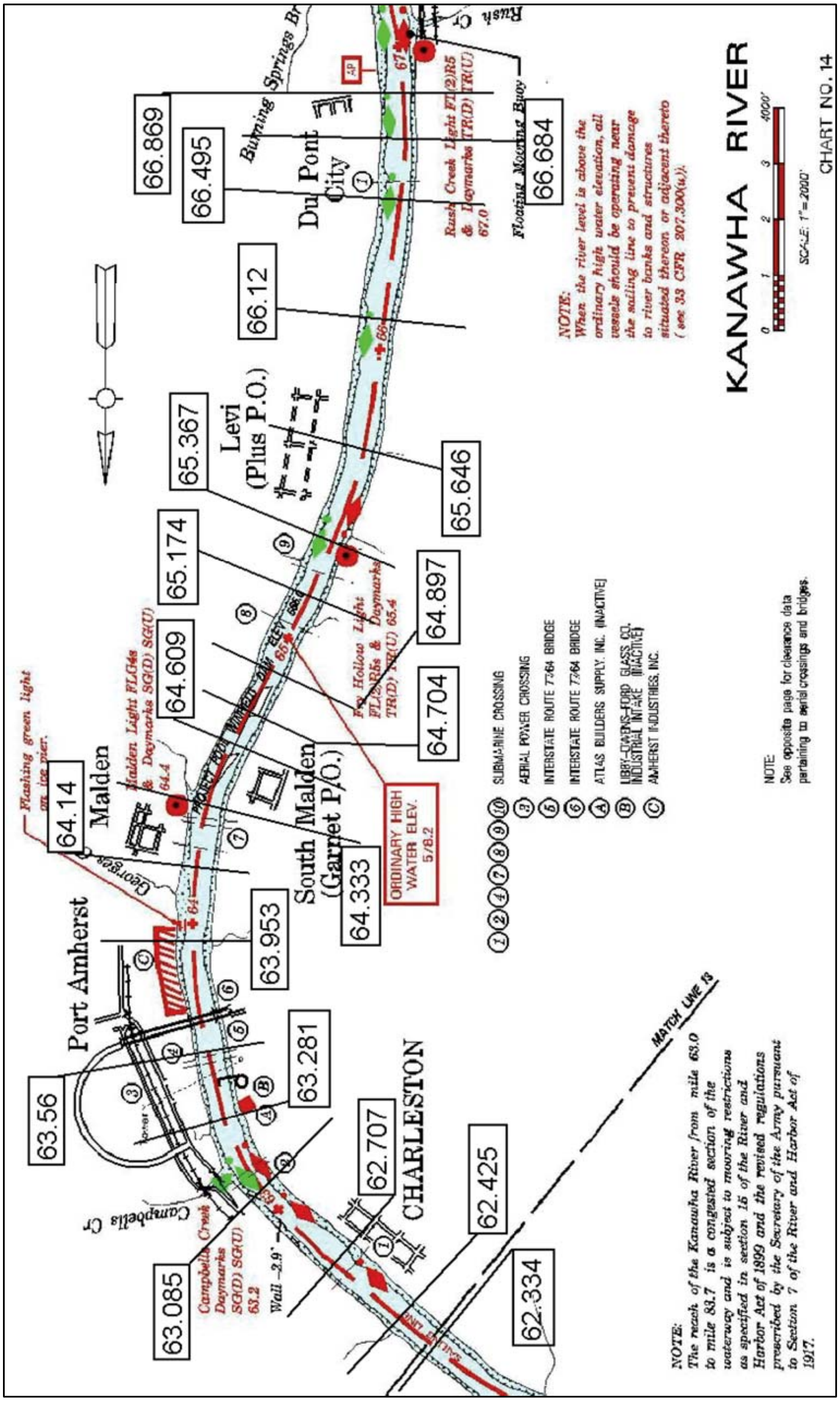


Figure 12. Navigation Chart No. 14 showing NAVPAT cross sections

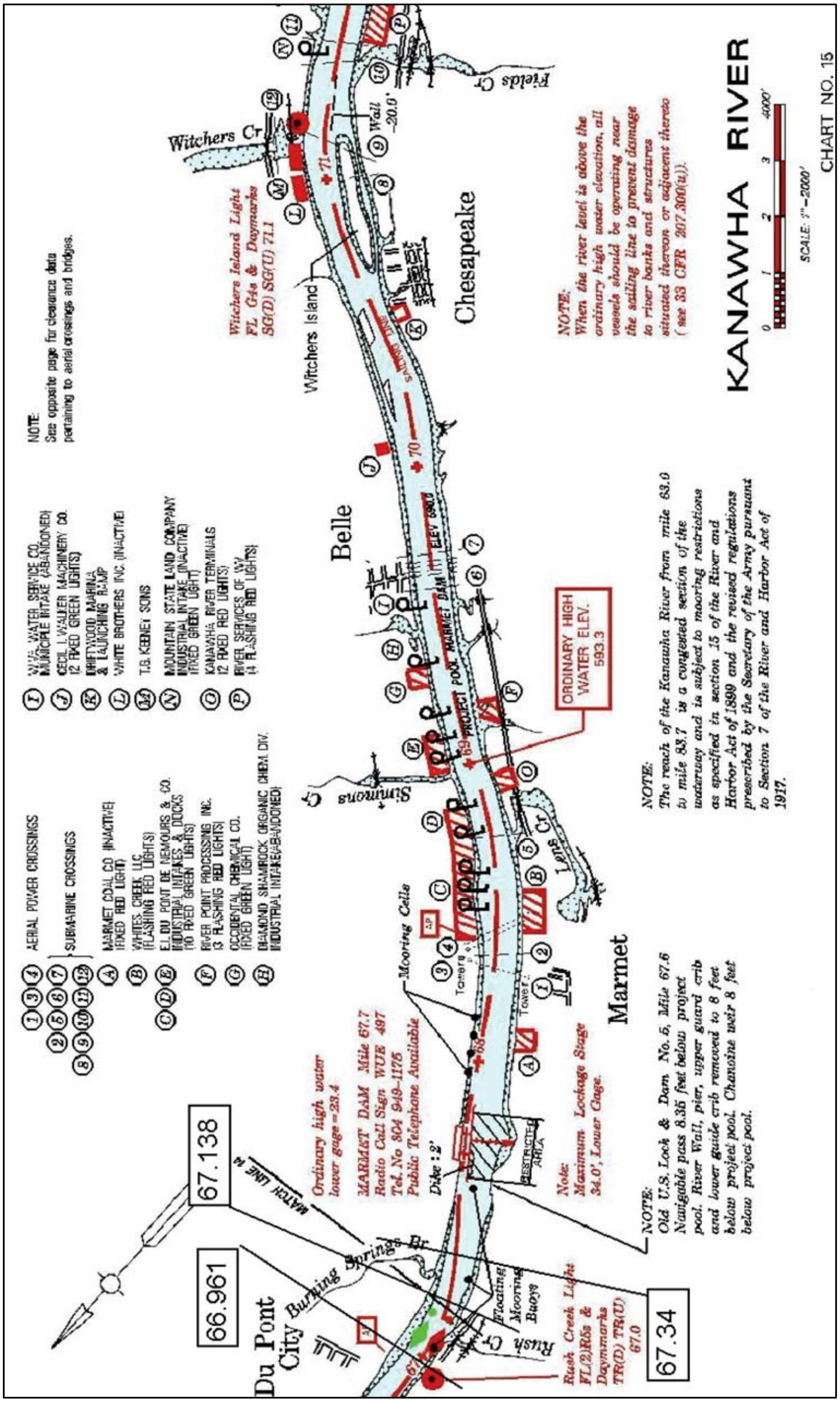


Figure 13. Navigation Chart No. 15 showing NAVPAT cross sections

Substrate

The Winfield Pool substrate-type data were prepared from side scan sonar images acquired in a survey conducted 1-3 Nov 1998. A Sea Scan PC Side Scan Sonar (Marine Sonic Technology, Ltd. – White Marsh, VA) and a differential global positioning system (GPS) instrument were linked to a computer system onboard the 22-ft closed-cabin survey vessel. The computer digitally recorded the high-resolution sonar images along with positional data from the GPS.

The sonar images were used to identify substrate "polygons" based on the relationship between sonar images and an extensive series of river bottom grab samples that were collected in a ground-truthing exercise in an upper Ohio River pool (Normandeau Associates, Inc. 1997). These polygons represent areas of similar substrate composition, which, in turn, are classified as percentages of grain sizes that are present (i.e., 20 percent fine sand, 30 percent gravel, and 50 percent cobble boulder, for example). The sonar images containing the substrate-type polygons were mosaiced together and georeferenced to a river basemap in order to create the GIS coverage.

The cross-section reach length limits based on bathymetry were checked against the substrate data to ensure that the substrate size was relatively constant along the length of the reaches. The left and right cell limits were selected to maintain a constant substrate size for each cell, and minimize depth variation across the cell. Substrate D50 in millimeters was recorded in the NAVPAT bathymetry/cell input file.

Cell Limits

Left and right cell limits were established based on several factors. As stated under "Bathymetry" above, reach lengths (longitudinal cell limits) were set to maintain similar depth along the length of the cell. As stated under "Substrate" above, lateral cell limits were set to maintain a constant substrate within the cell. Cell sizes were further refined in the near bank region and other parts of the channel where depths were changing rapidly or where needed to define structure.

Structure

Structure can be beneficial for reasons including refuge from high velocity, provision of feeding areas by providing stable material for colonization by invertebrates, and provision of an overhead canopy to provide shade and reduce predation by birds. The NAVPAT model uses structure for the following six of the fifteen species/life stages used in the Marmet NAVPAT analysis:

- Channel catfish young of year index (SI structure = 0.67-1.0).
- Black crappie spawning index (SI structure = 0.67-1.0).
- Black crappie fry food index (SI structure = 0.79-1.0).
- Black crappie juvenile food index (SI structure = 0.79-1.0).

- Black crappie adult food index (SI structure = 0.50-1.0).
- Spotted bass juvenile food index (SI structure = 0.67-1.0).

The percentage of structure in each cell is the most difficult parameter to define in NAVPAT input because it is almost completely subjective. Fortunately, the percentage of structure has a limited impact on the results. In the above list, the lower and upper SI structure values are for 0 and 100 percent structure, respectively. As shown in the range of values, 0 percent structure does not mean habitat having SI = 0. The significance of this uncertainty in the structure input for the Winfield results is discussed later in this report in Chapter 10, Analysis of Results.

As part of this study, McClane (2004) documented shoreline conditions above the water level based on field evaluation. McClane provided photographs and field note descriptions for 469 reaches along the banks of the Winfield Pool. The relationship of river mile used herein and the McClane reaches and photographs are shown in Table 3. Also shown is an evaluation of the bank structure by Mr. Michael Spoor of the Huntington District. The percentages in the table were used to determine which McClane reach or reaches to use in selecting structure for the NAVPAT reaches. Shoreline photographs and bank profiles were used to infer the structure and vegetation in the subaqueous cells adjacent to the shoreline. The values used herein are based on considering the surface area of the cell affected. After both a field trip and viewing hundreds of shoreline photographs in the Winfield Pool, the fundamental assumption used herein is that the shoreline information can be used to infer underwater conditions for only the first 15 ft from the shoreline. Shoreline conditions dictate the selection of percent structure in the 15-ft-wide zone next to the bank. The rules used in establishing shoreline structure are provided in Table 4. During the first attempt to develop these rules, riprap was assigned a small percentage of habitat because it provides stable substrate and interstitial spaces used by fish. Some of the correspondence on the Marmet study suggested that hardened banks were given no structure value. That approach was followed herein and riprap banks were given structure percentages of zero. As will be discussed in Chapter 10, the uncertainty in structure value had little impact on conclusions regarding impacts.

Table 3
McClane (2004) Structure Reaches Correlated to NAVPAT Reaches

Left Bank RM	Reach-field #	Photo#	Length, ft	%bank	Right Bank RM	Reach-field #	Photo#	Length, ft	%bank
31.42	WIN-041	Same	428	26	31.42	WIN-040	Same	1334	100
31.42	WIN-042	Same	860	53					
31.42	WIN-043	Same	295	18					
31.42	WIN-044	Same	1303	2					
31.71	WIN-044	Same	1270	73	31.71	WIN-040	Same	1491	100
31.71	WIN-045	Same	479	27					
32	WIN-045	Same	158	10	32	WIN-040	Same	587	42
32	WIN-046	Same	889	58	32	WIN-039	Same	803	57
32	WIN-047	Same	479	31					
32.28	WIN-047	Same	1259	87	32.28	WIN-038	Same	535	35
32.28	WIN-048	Same	190	13	32.28	WIN-037	Same	785	52
					32.28	WIN-036	Same	199	13
32.57	WIN-048	Same	335	22	32.57	WIN-036	Same	149	9
32.57	WIN-049	Same	1111	74	32.57	WIN-035	Same	960	61
32.57	WIN-050	Same	58	4	32.57	WIN-034	Same	474	30
32.84	WIN-050	Same	178	15	32.84	WIN-034	Same	1133	62
32.84	WIN-051	Same	1034	85	32.84	WIN-033	Same	540	29
					32.84	WIN-032	Same	165	9
33.12	WIN-053	Same	435	33	33.12	WIN-029	Same	581	39
33.12	WIN-052	Same	616	46	33.12	WIN-030	Same	891	61
33.12	WIN-051	Same	278	21					
33.41	WIN-054	Same	900	66	33.41	WIN-028	Same	639	37
33.41	WIN-053	Same	470	34	33.41	WIN-029	Same	1069	63
33.69	WIN-056	Same	755	38	33.69	WIN-026	Same	477	22
33.69	WIN-055	Same	1241	62	33.69	WIN-027	Same	769	36
					33.69	WIN-028	Same	889	42
33.985	WIN-056	Same		100	33.985	WIN-026		400	39
					33.985	WIN-024		635	61
34.17	WIN-058	Same	497	33	34.17	WIN-024	Same	1494	100
34.17	WIN-057	Same	538	36					
34.17	WIN-056	Same	460	31					
34.55	WIN-058	Same		100	34.55	WIN-024	Same	195	13
					34.55	WIN-023	Same	1294	87
34.742	WIN-058	Same	800	53	34.742	WIN-022	Same	1127	75
34.742	WIN-059	Same	708	47	34.742	WIN-021	Same	380	25
35.118	WIN-059	Same	2034	100	35.118	WIN-020	Same	140	8
					35.118	WIN-021	Same	1603	92
35.4	WIN-059	Same	2408	100	35.4	WIN-018	Same	968	41
					35.4	WIN-019	Same	680	29
					35.4	WIN-020	Same	708	30
35.78	WIN-059	Same	2022	100	35.78	WIN-016	Same	590	29
					35.78	WIN-017	Same	456	22
					35.78	WIN-018	Same	1004	49
36.16	WIN-060	Same	1222	54	36.16	WIN-012	Same	243	11
36.16	WIN-059	Same	1038	46	36.16	WIN-013	Same	908	41
					36.16	WIN-014	Same	529	24
					36.16	WIN-015	Same	195	9
					36.16	WIN-016	Same	355	16
36.63	WIN-062	Same	438	15	36.63	WIN-010	Same	1361	48
36.63	WIN-061	Same	2286	80	36.63	WIN-012	Same	1448	52
36.63	WIN-060	Same	144	5					
37.107	WIN-065	Same	591	39	37.107	WIN-009	Same	1294	85
37.107	WIN-064	Same	600	39	37.107	WIN-010	Same	231	15
37.107	WIN-063	Same	178	12					
37.107	WIN-062	Same	156	10					
37.391	WIN-067	Same	807	41	37.391	WIN-006	Same	1087	55
37.391	WIN-066	Same	1046	54	37.391	WIN-007	Same	449	23
37.391	WIN-065	Same	100	5	37.391	WIN-008	Same	173	9
					37.391	WIN-009	Same	250	13
37.671	WIN-070	Same	223	15	37.671	WIN-006	Same	880	58
37.671	WIN-069	Same	332	22	37.671	WIN-004	Same	639	42
37.671	WIN-068	Same	955	63					
37.955	WIN-071	Same	1235	84	37.955	WIN-003	Same	1473	100
37.955	WIN-070	Same	237	16					

(Sheet 1 of 7)

Table 3 (Continued)

Left Bank RM	Reach-field #	Photo#	Length, ft	%bank	Right Bank RM	Reach-field #	Photo#	Length, ft	%bank
38.24	WIN-073	Same	46	3	38.24	WIN-002	Same	797	56
38.24	WIN-072	Same	563	36	38.24	WIN-003	Same	636	44
38.24	WIN-071	Same	959	61					
38.42	WIN-075	Same	554	43	38.42	WIN-001	Same	614	50
38.42	WIN-074	Same	403	31	38.42	WIN-002	Same	610	50
38.42	WIN-072	Same	13	1					
38.42	WIN-073	Same	313	24					
38.7	WIN-077	Same	277	12	38.7	WIN-126	Same	553	24
38.7	WIN-076	Same	1799	78	38.7	WIN-127	Same	251	11
38.7	WIN-075	Same	232	10	38.7	WIN-128	Same	789	34
					38.7	WIN-129	Same	753	32
39.28	WIN-081	Same	141	5	39.28	WIN-121	Same	705	24
39.28	WIN-080	Same	1991	68	39.28	WIN-122	Same	454	16
39.28	WIN-079	Same	454	16	39.28	WIN-123	Same	938	32
39.28	WIN-078	Same	135	5	39.28	WIN-125	Same	396	14
39.28	WIN-077	Same	192	7	39.28	WIN-126	Same	394	14
39.75	WIN-081	Same	1846	100	39.75	WIN-119	Same	976	48
					39.75	WIN-120	Same	508	25
					39.75	WIN-121	Same	569	28
40.04	WIN-082	Same	800	70	40.04	WIN-117	Same	455	36
40.04	WIN-081	Same	337	30	40.04	WIN-118	Same	554	44
					40.04	WIN-119	Same	257	20
40.23	WIN-083	Same	733	43	40.23	WIN-116	Same	442	24
40.23	WIN-082	Same	971	57	40.23	WIN-117	Same	1411	76
40.7	WIN-085	Same	31	1	40.7	WIN-111	Same	92	4
40.7	WIN-084	Same	538	26	40.7	WIN-112	Same	158	7
40.7	WIN-083	Same	1529	73	40.7	WIN-113	Same	307	13
					40.7	WIN-114	Same	367	15
					40.7	WIN-115	Same	1040	44
					40.7	WIN-116	Same	407	17
41.08	WIN-086	Same	590	40	41.08	WIN-108	Same	594	38
41.08	WIN-085	Same	902	60	41.08	WIN-109	Same	710	45
					41.08	WIN-110	Same	257	16
					41.08	WIN-111	Same	13	1
41.27	WIN-086	Same	1216	100	41.27	WIN-106	Same	97	7
					41.27	WIN-105	Same	44	3
					41.27	WIN-107	Same	797	53
					41.27	WIN-108	Same	560	38
41.56	WIN-086	Same	775	53	41.56	WIN-104	Same	210	17
41.56	WIN-087	Same	697	47	41.56	WIN-106	Same	39	3
					41.56	WIN-105	Same	1007	80
41.74	WIN-089	Same	671	48	41.74	WIN-102	Same	611	35
41.74	WIN-088	Same	243	17	41.74	WIN-103	Same	632	37
41.74	WIN-087	Same	491	35	41.74	WIN-104	Same	483	28
42.11	WIN-089	Same	1950	100	42.11	WIN-100	Same	683	39
					42.11	WIN-101	Same	863	49
					42.11	WIN-102	Same	222	13
42.4	WIN-092	Same	559	27	42.4	WIN-098	Same	180	9
42.4	WIN-091	Same	148	7	42.4	WIN-099	Same	779	40
42.4	WIN-090	Same	287	14	42.4	WIN-100	Same	1011	51
42.4	WIN-089	Same	1066	52					
42.678	WIN-092	Same		15	42.678	WIN-096	Same		41
42.678	WIN-093	Same		85	42.678	WIN-097	Same		32
					42.678	WIN-098	Same		27
43.052	WIN-093	Same		50	43.052	WIN-095	Same		100
43.052	WIN-094	Same		50					
43.43	WIN-152	Same	1324	52	43.43	WIN-146	Same	174	7
43.43	WIN-151	Same	1170	46	43.43	WIN-147	Same	1342	53
43.43	WIN-094	Same	50	2	43.43	WIN-148	Same	396	16
					43.43	WIN-150	Same	605	24
43.81	WIN-152	Same	1878	100	43.81	WIN-143	Same	412	20
					43.81	WIN-144	Same	185	9
					43.81	WIN-145	Same	438	21
					43.81	WIN-146	Same	1059	51

(Sheet 2 of 7)

Table 3 (Continued)

Left Bank RM	Reach-field #	Photo#	Length, ft	%bank	Right Bank RM	Reach-field #	Photo#	Length, ft	%bank
44.19	WIN-155	Same	390	15	44.19	WIN-139	Same	46	2
44.19	WIN-154	Same	410	15	44.19	WIN-140	Same	539	22
44.19	WIN-153	Same	769	29	44.19	WIN-141	Same	164	7
44.19	WIN-152	Same	1077	41	44.19	WIN-142	Same	1183	49
					44.19	WIN-143	Same	493	20
44.661	WIN-155	Same	756	44	44.661	WIN-138	Same		20
44.661	WIN-156	Same	973	56	44.661	WIN-139	Same		80
44.943	WIN-156	Same	466	26	44.943	WIN-139	Same		100
44.943	WIN-157	Same	962	54					
44.943	WIN-158	Same	364	20					
45.31	WIN-161	Same	771	33	45.31	WIN-136	Same	654	31
45.31	WIN-160	Same	569	24	45.31	WIN-137	Same	250	12
45.31	WIN-159	Same	833	36	45.31	WIN-138	Same	1229	58
45.31	WIN-158	Same	167	7					
45.6	WIN-162	Same	359	46	45.6	WIN-133	Same	67	6
45.6	WIN-161	Same	423	54	45.6	WIN-134	Same	535	50
					45.6	WIN-135	Same	283	27
					45.6	WIN-136	Same	177	17
45.79	WIN-169	Same	949	46	45.79	WIN-131	Same	76	4
45.79	WIN-168	Same	193	9	45.79	WIN-132	Same	1661	89
45.79	WIN-167	Same	210	10	45.79	WIN-133	Same	131	7
45.79	WIN-166	Same	211	10					
45.79	WIN-165	Same	265	13					
45.79	WIN-164	Same	251	12					
46.161	WIN-169	Same	554	35	46.161	WIN-195	Same	414	27
46.161	WIN-171	Same	456	29	46.161	WIN-130	Same	1100	73
46.161	WIN-172	Same	393	25					
46.161	WIN-174	Same	168	11					
46.543	WIN-196	Same	404	25	46.543	WIN-130	Same	1131	76
46.543	WIN-197	Same	992	60	46.543	WIN-131	Same	351	24
46.543	WIN-198	Same	246	15					
46.92	WIN-198	Same	3214	100	46.92	WIN-192	Same	1713	63
					46.92	WIN-193	Same	655	24
					46.92	WIN-194	Same	309	11
					46.92	WIN-195	Same	26	1
47.202	WIN-200	Same	722	50	47.202	WIN-189	Same	1610	100
47.202	WIN-199	Same	700	50					
47.578	WIN-199	Same	900	53	47.578	WIN-191	Same	377	26
47.578	WIN-198	Same	797	47	47.578	WIN-192	Same	1064	74
47.956	WIN-202	Same	1500	100	47.956	WIN-185	Same	152	9
					47.956	WIN-186	Same	1276	79
					47.956	WIN-187	Same	188	12
48.337	WIN-202	Same	1126	75	48.337	WIN-188	Same	564	38
48.337	WIN-201	Same	367	25	48.337	WIN-189	Same	920	62
48.53	WIN-204	Same	474	25	48.53	WIN-182	Same	155	7
48.53	WIN-203	Same	546	28	48.53	WIN-183	Same	930	42
48.53	WIN-202	Same	910	47	48.53	WIN-184	Same	759	35
					48.53	WIN-185	Same	345	16
48.81	WIN-204	Same	2344	100	48.81	WIN-179	Same	483	25
					48.81	WIN-180	Same	116	6
					48.81	WIN-181	Same	1138	59
					48.81	WIN-182	Same	193	10
49.28	WIN-206	Same	43	2	49.28	WIN-175	Same	758	27
49.28	WIN-205	Same	262	10	49.28	WIN-176	Same	354	13
49.28	WIN-204	Same	2388	89	49.28	WIN-177	Same	564	20
					49.28	WIN-178	Same	662	24
					49.28	WIN-179	Same	470	17
49.85	WIN-206	Same	2589	100	49.85	WIN-175	Same	2551	100
50.24	WIN-211	Same	166	11	50.24	WIN-247	Same	29	2
50.24	WIN-210	Same	194	12	50.24	WIN-248	Same	404	25
50.24	WIN-209	Same	256	16	50.24	WIN-249	Same	187	12
50.24	WIN-208	Same	341	22	50.24	WIN-250	Same	894	56
50.24	WIN-207	Same	378	24	50.24	WIN-175	Same	71	4
50.24	WIN-206	Same	217	14					
50.43	WIN-212	Same	1827	98	50.43	WIN-244	Same	409	25
50.43	WIN-211	Same	36	2	50.43	WIN-245	Same	465	28
					50.43	WIN-246	Same	446	27
					50.43	WIN-247	Same	335	20

(Sheet 3 of 7)

Table 3 (Continued)

Left Bank RM	Reach-field #	Photo#	Length, ft	%bank	Right Bank RM	Reach-field #	Photo#	Length, ft	%bank
50.89	WIN-214	Same	2272	80	50.89	WIN-239	Same	242	9
50.89	WIN-213	Same	319	11	50.89	WIN-240	Same	715	27
50.89	WIN-212	Same	240	8	50.89	WIN-241	Same	274	10
					50.89	WIN-242	Same	188	7
					50.89	WIN-243	Same	423	16
					50.89	WIN-244	Same	816	31
51.275	WIN-214	Same	1611	100	51.275	WIN-238	Same	1163	100
51.554	WIN-215	Same	897	57	51.554	WIN-239	Same	1734	100
51.554	WIN-216	Same	668	43					
52.02	WIN-216	Same	1253	54	52.02	WIN-238	Same	1530	69
52.02	WIN-217	Same	543	23	52.02	WIN-237	Same	536	24
52.02	WIN-218	Same	546	23	52.02	WIN-236	Same	141	6
52.3	WIN-218	Same	555	43	52.3	WIN-236	Same	21	2
52.3	WIN-219	Same	259	20	52.3	WIN-235	Same	1079	98
52.3	WIN-220	Same	488	37					
52.49	WIN-220	Same	39	2	52.49	WIN-235	Same	44	3
52.49	WIN-221	Same	1531	98	52.49	WIN-234	Same	1481	97
52.88	WIN-221	Same	2227	100	52.88	WIN-234	Same	545	26
					52.88	WIN-233	Same	296	14
					52.88	WIN-232	Same	1251	60
53.25	WIN-221	Same	898	60	53.25	WIN-232	Same	562	25
53.25	WIN-222	Same	84	6	53.25	WIN-231	Same	944	43
53.25	WIN-223	Same	515	34	53.25	WIN-227	Same	256	12
					53.25	WIN-228	Same	199	9
					53.25	WIN-226	Same	250	11
53.44	WIN-223	Same	1299	100	53.44	WIN-227	Same	348	11
					53.44	WIN-228	Same	334	11
					53.44	WIN-226	Same	736	23
					53.44	WIN-229	Same	542	17
					53.44	WIN-230	Same	541	17
					53.44	WIN-225	Same	248	8
					53.44	WIN-224	Same	401	13
53.73	WIN-223	Same	348	24	53.73	WIN-224	Same	1035	69
53.73	WIN-301	298	242	17	53.73	WIN-300	297	468	31
53.73	WIN-302	299	322	22					
53.73	WIN-303	300	105	7					
53.73	WIN-304	301	448	31					
54.02	WIN-304	301	83	6	54.02	WIN-300	297	134	8
54.02	WIN-305	302	237	16	54.02	WIN-299	296	330	21
54.02	WIN-306	303	187	13	54.02	WIN-298	295	758	47
54.02	WIN-307	304	181	12	54.02	WIN-296	293	378	24
54.02	WIN-308	305	410	28					
54.02	WIN-309	306	350	24					
54.3	WIN-309	306	184	15	54.3	WIN-296	293	486	40
54.3	WIN-310	307	255	20	54.3	WIN-295	292	169	14
54.3	WIN-311	308	519	41	54.3	WIN-294	291	95	8
54.3	WIN-312	309	300	24	54.3	WIN-293	290	468	38
54.49	WIN-312	309	705	100	54.49	WIN-292	289	516	65
					54.49	WIN-291	288	126	16
					54.49	WIN-290	287	147	19
54.58	WIN-312	309	136	18	54.58	WIN-290	287	66	13
54.58	WIN-313	310	411	54	54.58	WIN-289	286	134	27
54.58	WIN-327	324	213	28	54.58	WIN-288	285	170	34
					54.58	WIN-286	283,284	131	26
54.66	WIN-313	310	424	27	54.66	WIN-286	283,284	52	6
54.66	WIN-315	312	492	32	54.66	WIN-285	282	810	94
54.66	WIN-327	324	171	11					
54.66	WIN-325	322	466	30					
54.86	WIN-329	326	107	3	54.86	WIN-281	278	371	30
54.86	WIN-330	327	391	11	54.86	WIN-283	280	456	36
54.86	WIN-328	325	330	9	54.86	WIN-284	281	428	34
54.86	WIN-316	313	319	9					
54.86	WIN-313	310	388	11					
54.86	WIN-315	312	844	23					
54.86	WIN-325	322	1225	34					

(Sheet 4 of 7)

Table 3 (Continued)

Left Bank RM	Reach-field #	Photo#	Length, ft	%bank	Right Bank RM	Reach-field #	Photo#	Length, ft	%bank
55.15	WIN-331	328	1060	26	55.15	WIN-280	277	1236	99
55.15	WIN-330	327	339	8					
55.15	WIN-319	316	940	23					
55.15	WIN-318	315	312	8					
55.15	WIN-317	314	165	4					
55.15	WIN-325	322	1268	31					
55.34	WIN-331	328	176	11	55.34	WIN-279	276	606	87
55.34	WIN-319	316	666	40	55.34	WIN-280	277	89	13
55.34	WIN-324	321	403	24					
55.34	WIN-323	320	183	11					
55.34	WIN-325	322	225	14					
55.44	WIN-323	320	964	100	55.44	WIN-278	none	638	52
					55.44	WIN-279	276	598	48
55.73	WIN-323	320	1259	100	55.73	WIN-275	273	148	11
					55.73	WIN-276	274	559	42
					55.73	WIN-277	275	399	30
					55.73	WIN-278	none	226	17
55.92	WIN-334	331	98	4	55.92	WIN-273	271	866	78
55.92	WIN-333	330	573	21	55.92	WIN-274	272	237	21
55.92	WIN-320	317	474	17					
55.92	WIN-321	318	580	21					
55.92	WIN-322	319	175	6					
55.92	WIN-323	320	859	31					
56.1	WIN-338	Same	113	10	56.1	WIN-272	270	696	79
56.1	WIN-337	Same	89	8	56.1	WIN-273	271	188	21
56.1	WIN-336	333	56	5					
56.1	WIN-335	332	250	22					
56.1	WIN-334	331	553	48					
56.1	WIN-322	319	83	7					
56.29	WIN-340	Same	662	64	56.29	WIN-269	267	352	33
56.29	WIN-339	Same	211	20	56.29	WIN-270	268,269	234	22
56.29	WIN-338	Same	166	16	56.29	WIN-272	270	479	45
56.49	WIN-342	Same	119	9	56.49	WIN-268	259	1257	98
56.49	WIN-341	Same	922	69	56.49	WIN-269	267	22	2
56.49	WIN-340	Same	295	22					
56.77	WIN-346	Same	403	30	56.77	WIN-268	259	1207	100
56.77	WIN-345	Same	258	19					
56.77	WIN-344	Same	121	9					
56.77	WIN-343	Same	234	17					
56.77	WIN-342	Same	334	25					
56.96	WIN-349	Same	79	7	56.96	WIN-268	259	986	100
56.96	WIN-348	Same	245	23					
56.96	WIN-347	Same	186	17					
56.96	WIN-346	Same	553	52					
57.14	WIN-349	Same	1133	100	57.14	WIN-268	259	970	100
57.33	WIN-349	Same	1004	100	57.33	WIN-267	266	317	32
57.53	WIN-350	Same	374	32	57.33	WIN-268	259	677	68
57.53	WIN-349	Same	800	68	57.53	WIN-267	266	1016	100
57.71	WIN-352	Same	28	3	57.71	WIN-264	263	156	19
57.71	WIN-351	Same	515	51	57.71	WIN-265	264	155	19
57.71	WIN-350	Same	469	46	57.71	WIN-266	265	446	54
					57.71	WIN-267	266	72	9
57.9	WIN-352	Same	1003	100	57.9	WIN-263	259	834	100
58.09	WIN-352	Same	1293	100	58.09	WIN-262	Same	165	13
					58.09	WIN-263	259	1095	87
58.37	WIN-352	Same	1979	100	58.37	WIN-259	Same	1061	54
					58.37	WIN-260	260,261	539	27
					58.37	WIN-262	Same	365	19
58.75	WIN-352	Same	2022	100	58.75	WIN-259	Same	1970	100
59.13	WIN-356	Same	212	11	59.13	WIN-259	Same	1695	100
59.13	WIN-355	Same	308	17					
59.13	WIN-354	Same	665	36					
59.13	WIN-353	Same	534	29					
59.13	WIN-352	Same	140	8					

(Sheet 5 of 7)

Table 3 (Continued)

Left Bank RM	Reach-field #	Photo#	Length, ft	%bank	Right Bank RM	Reach-field #	Photo#	Length, ft	%bank
59.41	WIN-358	Same	234	12	59.41	WIN-259	Same	1730	100
59.41	WIN-357	Same	394	20					
59.41	WIN-356	Same	1391	69					
59.79	WIN-360	Same	1294	57	59.79	WIN-259	Same	1945	100
59.79	WIN-359	Same	489	21					
59.79	WIN-358	Same	501	22					
60.17	WIN-362	Same	571	32	60.17	WIN-259	Same	1718	100
60.17	WIN-361	Same	923	51					
60.17	WIN-360	Same	303	17					
60.45	WIN-366	Same	287	19	60.45	WIN-259	Same	1498	100
60.45	WIN-364	Same	224	15					
60.45	WIN-365	Same	573	37					
60.45	WIN-363	Same	261	17					
60.45	WIN-362	Same	194	13					
60.73	WIN-369	Same	247	16	60.73	WIN-259	Same	1510	100
60.73	WIN-368	Same	433	27					
60.73	WIN-366	Same	250	16					
60.73	WIN-367	Same	659	41					
61.02	WIN-370	Same	132	11	61.02	WIN-256	Same	807	63
61.02	WIN-369	Same	1099	89	61.02	WIN-257	Same	162	13
					61.02	WIN-258	Same	300	23
61.21	WIN-371	Same	688	59	61.21	WIN-255	Same	205	16
61.21	WIN-370	Same	486	41	61.21	WIN-256	Same	1109	84
61.49	WIN-373	Same	648	53	61.49	WIN-252	Same	396	30
61.49	WIN-372	Same	249	20	61.49	WIN-253	Same	330	25
61.49	WIN-371	Same	322	26	61.49	WIN-254	Same	346	26
					61.49	WIN-255	Same	253	19
61.68	WIN-375	Same	222	21	61.68	WIN-414	Same	42	4
61.68	WIN-374	Same	320	31	61.68	WIN-415	Same	17	2
61.68	WIN-373	Same	498	48	61.68	WIN-251	Same	519	52
					61.68	WIN-252	Same	427	42
61.87	WIN-378	Same	19	2	61.87	WIN-410	Same	131	13
61.87	WIN-376	Same	1004	92	61.87	WIN-411	Same	328	32
61.87	WIN-375	Same	69	6	61.87	WIN-412	Same	148	14
					61.87	WIN-413	Same	226	22
					61.87	WIN-414	Same	190	19
62.05	WIN-378	Same	1323	100	62.05	WIN-410	Same	1345	100
62.33	WIN-379	Same	825	79	62.33	WIN-410	Same	929	100
62.33	WIN-378	Same	216	21					
62.42	WIN-380	Same	62	2	62.42	WIN-410	Same	1078	37
62.42	WIN-379	Same	909	34					
62.71	WIN-381	Same	219	8	62.71	WIN-410	Same	1810	63
62.71	WIN-380	Same	1450	55					
63.08	WIN-382	Same	825	57	63.08	WIN-408	Same	229	15
63.08	WIN-381	Same	613	43	63.08	WIN-409	Same	191	12
					63.08	WIN-410	Same	1148	73
63.28	WIN-386	Same	768	62	63.28	WIN-404	Same	461	32
63.28	WIN-384	Same	173	14	63.28	WIN-405	Same	295	21
63.28	WIN-382	Same	306	25	63.28	WIN-406	Same	188	13
					63.28	WIN-407	Same	488	34
63.56	WIN-391	Same	245	12	63.56	WIN-402	Same	358	20
63.56	WIN-390	Same	581	29	63.56	WIN-403	Same	433	24
63.56	WIN-388	Same	248	12	63.56	WIN-404	Same	1014	56
63.56	WIN-387	Same	429	22					
63.56	WIN-386	Same	482	24					
63.95	WIN-394	Same	324	20	63.95	WIN-398	Same	285	17
63.95	WIN-393	Same	884	55	63.95	WIN-399	Same	174	10
63.95	WIN-392	Same	368	23	63.95	WIN-400	Same	400	23
63.95	WIN-391	Same	33	2	63.95	WIN-401	Same	202	12
					63.95	WIN-402	Same	650	38
64.14	WIN-395	Same	640	55	64.14	WIN-396	Same	653	57
64.14	WIN-394	Same	518	45	64.14	WIN-397	Same	215	19
					64.14	WIN-398	Same	277	24

(Sheet 6 of 7)

Table 3 (Concluded)

Left Bank RM	Reach-field #	Photo#	Length, ft	%bank	Right Bank RM	Reach-field #	Photo#	Length, ft	%bank
64.33	WIN-415	Same	680	61	64.33	WIN-466	Same	470	38
64.33	WIN-395	Same	437	39	64.33	WIN-467	Same	98	8
					64.33	WIN-468	Same	191	15
					64.33	WIN-469	Same	299	24
					64.33	WIN-396	Same	178	14
64.61	WIN-418	Same	220	23	64.61	WIN-465	Same	273	26
64.61	WIN-417	Same	244	26	64.61	WIN-466	Same	770	74
64.61	WIN-416	Same	476	51					
64.7	WIN-419	Same	584	74	64.7	WIN-464	Same	215	29
64.7	WIN-418	Same	210	26	64.7	WIN-465	Same	524	71
65.17	WIN-425	Same	1003	78	65.17	WIN-458	Same	329	27
65.17	WIN-424	Same	188	15	65.17	WIN-459	Same	281	23
65.17	WIN-423	Same	62	5	65.17	WIN-462	Same	611	50
65.17	WIN-421	Same	36	3					
65.37	WIN-427	Same	763	58	65.37	WIN-457	Same	161	14
65.37	WIN-426	Same	121	9	65.37	WIN-458	Same	1024	86
65.37	WIN-425	Same	409	31					
65.65	WIN-429	Same	846	42	65.65	WIN-454	Same	1175	60
65.65	WIN-428	Same	178	9	65.65	WIN-455	Same	296	15
65.65	WIN-427	Same	989	49	65.65	WIN-456	Same	314	16
					65.65	WIN-457	Same	179	9
65.9	WIN-423	Same	22	2	65.9	WIN-462	Same	248	19
65.9	WIN-421	Same	260	21	65.9	WIN-463	Same	905	69
65.9	WIN-420	Same	831	68	65.9	WIN-464	Same	160	12
65.9	WIN-419	Same	118	10					
66.12	WIN-431	Same	469	21	66.12	WIN-450	Same	474	17
66.12	WIN-430	Same	581	26	66.12	WIN-451	Same	1235	44
66.12	WIN-429	Same	1226	54	66.12	WIN-452	Same	402	14
					66.12	WIN-453	Same	327	12
					66.12	WIN-454	Same	350	13
66.5	WIN-432	Same	320	21	66.5	WIN-447	Same	165	10
66.5	WIN-431	Same	1186	79	66.5	WIN-449	Same	271	17
					66.5	WIN-450	Same	1186	73
66.68	WIN-433	Same	83	7	66.68	WIN-447	Same	1025	100
66.68	WIN-432	Same	1115	93					
66.87	WIN-433	Same	706	100	66.87	WIN-446	Same	356	44
					66.87	WIN-447	Same	447	56
66.98	WIN-436	Same	146	19	66.98	WIN-444	Same	139	21
66.98	WIN-435	Same	121	16	66.98	WIN-445	Same	446	66
66.98	WIN-434	Same	324	42	66.98	WIN-446	Same	88	13
66.98	WIN-433	Same	163	21					
67.14	WIN-437	Same	1129	100	67.14	WIN-444	Same	987	100
67.34	WIN-441	Same	233	15	67.34	WIN-443	Same	849	55
67.34	WIN-439	Same	466	31	67.34	WIN-444	Same	704	45
67.34	WIN-438	Same	274	18					
67.34	WIN-437	Same	550	36					

(Sheet 7 of 7)

Table 4
Structure Percentages

Shoreline Feature	Percentage of Structure	Roughness Parameter (for velocity calculations only)
Riprap/rubble	0	0 - additional roughness of riprap handled by substrate size. All riprap substrate = 1,999 mm which gives a Manning's n value of 0.040.
Vertical walls	5% in NAVPAT cell containing wall (based on 15-ft-wide cell). Walls away from shoreline = 10%	0
Trees/brush - heavy	75% in first 15 ft	4
Trees/brush - medium	50% in first 15 ft	3
Brush	20% in first 15 ft	2
Floating docks	Estimate area of docks/area of NAVPAT cell, estimate distance from shore and place in correct cell	0
Mooring cells/pile clusters	Estimate area of mooring cells × 3/area of NAVPAT cell, estimate distance from shore and place in correct cell	3
Bench, berm, bar	20%	1
Developed - generally RR bank, usually docks	20%	0

In-Channel Structure Data

The NAVPAT model integrates in-channel structure information into the analysis. In-channel structures, which are utilized by some fish species, include such features as sunken trees, rocks, old lock walls, and vessel wrecks. Two pieces of in-channel structural information can be added to the data files.

The first is the percentage of structure present within each cell. In order to determine these percentages within the Winfield Pool, ArchView software was used to map cell boundaries and the locations of major river structures including mooring cells, submerged walls, and ice breakers. Side scan sonar images were then added to the maps. The images were analyzed manually to determine the amount of structural coverage per cell.

The second input is a roughness score assigned to the available structure. This score is used by NAVPAT to establish the ambient water velocity. Unlike structures located within shallow waters, in-channel structure has little effect on water velocity due to its relatively small height when compared to the depth of the water column. Therefore, within the Winfield project, all in-channel structure was assigned a roughness parameter of "0."

Roughness Parameter

The roughness parameter is a required input for each cell to calculate ambient velocity using Manning's equation. It essentially defines how vegetation or other factors affect the Manning's roughness coefficient of the cell. The base value of the Manning's coefficient depends on both the substrate size and the percent of structure. Table 5 shows the relationship of Manning's coefficient versus substrate size. Table 6 shows the relationship of Manning's coefficient versus structure. Table 7 shows the relationship of Manning's coefficient versus the roughness/vegetation parameter. Table 4 shows the rules used to establish the roughness/vegetation parameter. The overall Manning's coefficient used in NAVPAT velocity calculations is the sum of the Manning's coefficients from substrate, structure, and vegetation parameter.

Table 5
Manning's Coefficient Versus Substrate Size

Substrate size, mm	Manning's Coefficient
Less than or equal 0.065	0.018
0.175	0.014
0.375	0.020
0.75	0.022
4.0	0.024
12	0.026
32	0.028
128	0.030
1,999	0.040
2,000	0.040

Note: Linear interpolation used for substrate sizes between values in the table.

Table 6
Manning's Coefficient Versus Structure

Percent structure	Manning's Coefficient
Less than 15%	0.0
15% to less than 45%	0.010
45% to less than 75%	0.025
Greater than or equal 75%	0.050

Table 7
Manning's Coefficient Versus Vegetation Parameter

Vegetation parameter	Manning's Coefficient
0	0.0
1	0.01
2	0.02
3	0.0375
4	0.075

Traffic

The NAVPAT program uses a traffic file that contains the individual tow characteristics for the projected fleet that will occur over an entire year for each traffic scenario. Figures 14 and 15 show the cumulative number of tows for the 1996 and 2000 traffic scenarios used in this study of Winfield. While this approach has the strength of simulating an actual traffic year, it has a weakness of the selected traffic scenario being only one of a large number of traffic scenario possibilities. An example of this is shown in Figure 16 showing the Julian days 154-178 (year 2000) used for species 2, emerald shiner fry that are subject to propeller entrainment. While the traffic files for 35 and 40 million tons (MT) reflect that level of tonnage for the year, the two scenarios have variations during the year that can cause variations in output when comparing results from an average of three 5-day flow windows of 154-158, 164-168, and 174-178 used for species 2. The number of tows for each of these flow windows are as follows:

Year	**Tonnage, MT**	**# Tows for Indicated Julian Days**		
		154-158	**164-168**	**174-178**
1996	35	114	95	110
1996	40	124	121	138
2000	35	90	72	67
2000	40	81	57	90

Note that in 1996, the three flow windows have an average increase in number of tows of 20 percent when comparing 40 MT to 35 MT. In year 2000, the three flow windows have an average number of tows in 35 and 40 MT that is essentially unchanged. One factor that does change in year 2000 is the distribution of tows in the three flow windows. The 35 MT traffic scenario has more tows during 154-158 and 164-168, whereas the 40-MT scenario has more tows during 174-178. This difference in distribution is important because the earlier Julian day flow windows have less impact on emerald shiner fry habitat because flows, and thus ambient velocities, are higher than in the later flow windows. The intent of this discussion is to show that variation of NAVPAT output is directly attributed to variations in the traffic file. Thus, focusing on a single traffic scenario can be misleading.

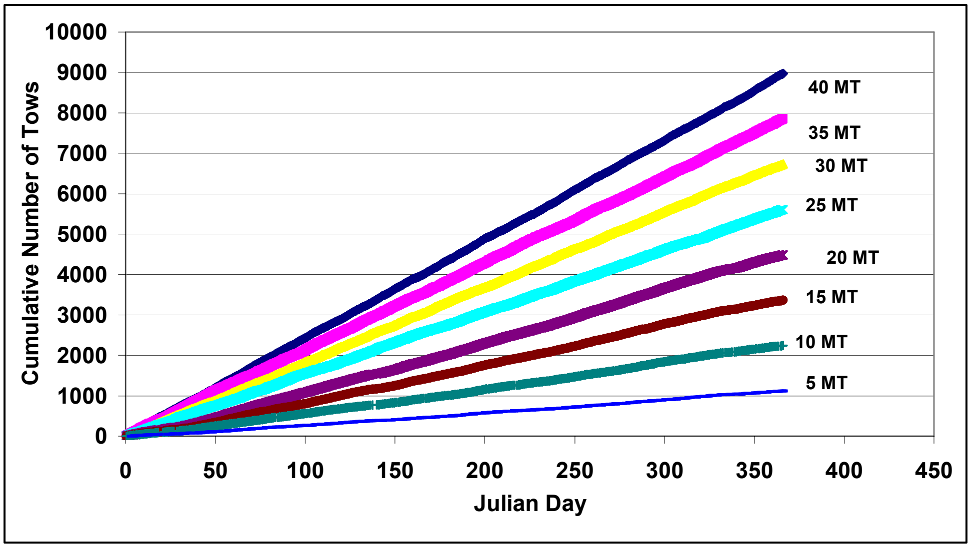


Figure 14. Cumulative number of tows versus Julian day for Traffic Year 1996

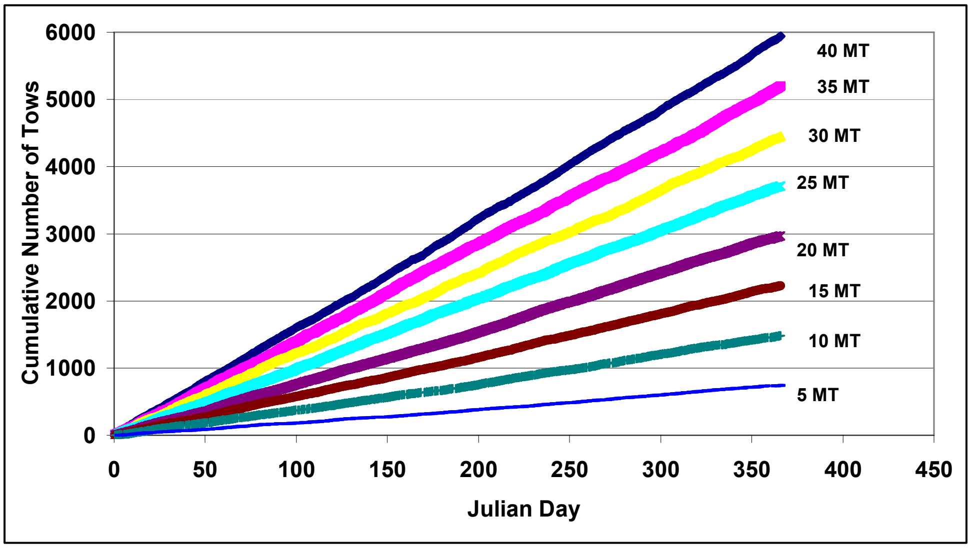


Figure 15. Cumulative number of tows versus Julian day for Traffic Year 2000

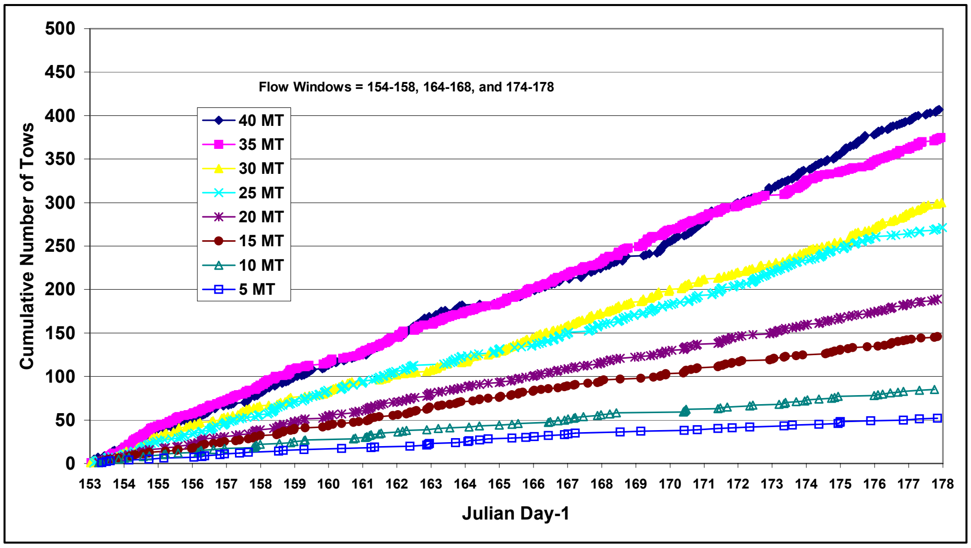


Figure 16. Cumulative number of tows versus Julian days 154-178 for Traffic Year 2000, Species 2

Traffic files contain one line describing each tow passage with the following data:

1) Julian day at time of passage
2) Towboat class 1-8 corresponding to <1,200 hp, 1,200-1,400 hp, 1,400-1,800 hp, 1,800-2,300 hp, 2,300-3,400 hp, 3,400-5,000 hp, 5,000-5,600 hp, and > 5600 hp. These classes correspond to the classes used in the Louisville District's economics model.
3) U = upbound, D = downbound
4) E = empty, L = loaded
5) Total length of barges, ft
6) Total beam of barges, ft
7) Draft of barges, ft
8) Tow speed relative to ground, ft/sec
9) Propeller diameter, in.
10) Propeller pitch, in.
11) Propeller speed, rpm
12) Y = Kort nozzle, N = open wheel propellers

The District provided items 1-8 in the traffic files. Items 9-12, propeller diameter, propeller pitch, propeller speed, and whether the propeller had a Kort nozzle or an open wheel configuration, had to be determined to complete the NAVPAT input. Based on unpublished data from the Ohio River, propeller diameter (D_p) in inches can be estimated from installed towboat horsepower using

$$D_p = 5.8\ \text{hp}^{0.34} \qquad (1)$$

Propeller diameter was estimated using the upper end of the 8 towboat horsepower ranges used in the traffic files. Using the same Ohio River data, propeller pitch is determined from

$$\text{Pitch} = 24.8 \exp\left(0.0136 \times D_p\right) \qquad (2)$$

A Kort nozzle is a streamlined cylinder around the propeller that improves propeller performance at low speeds typical of inland tows. Analysis of tow traffic by the Louisville District showed that towboat classes 5 and above had mostly Kort nozzles and classes 4 and below were predominately open wheel configurations. In the NAVPAT study of Winfield, all towboats in classes 4 and below were open wheel propellers and classes 5 and above were Kort nozzles.

As part of the Upper Mississippi River-Illinois Waterway (UMR-IWW) Navigation Feasibility Study, techniques were developed to define propeller speed as a function of all the other parameters in the traffic file plus several parameters that had to be assumed. The techniques are presented in Maynord (2000). Assumptions used in applying the techniques were required because the traffic file does not vary from cross section to cross section, and some of the parameters such as local depth vary. The assumptions used in applying Maynord (2000) were as follows:

1) Kinematic viscosity of water = 0.00001 ft^2/sec.
2) Roughness allowance $\Delta_{cf} = 0.0005$
3) Local depth = 20 ft
4) Semi-integrated tow
5) Minimum tow speed = 3 mph. A small percentage of the tows in the traffic file had ground speeds of less than 3 mph that appear unrealistic.
6) Speed over ground was converted to speed through the water using a current speed of 1.3 ft/sec. This ambient velocity was an average over the length of the pool that varied from 0.5 ft/sec just above the Winfield Pool to 2 ft/sec just below the Marmet Pool.
7) Pressure coefficient = 0.1
8) One of the inputs to the Maynord (2000) techniques for propeller rpm is the return velocity and drawdown in the channel. A typical Winfield cross section of 600 ft wide and 14,000 ft^2 area was used in the UMR-IWW model for return velocity and drawdown (Maynord 1996) and resulted in the following regression equation for return velocity V_r in ft/sec,

$$V_r = 0.000305\, V_w^{0.9} \left(\text{beam} \times \text{draft}\right)^{0.9} \qquad (3)$$

where V_w is tow speed relative to water, in ft/sec, and beam and draft are in feet. The regression equation for drawdown z, in feet, is

$$z = 0.0000052\, V_w^{2.08} \left(\text{beam} \times \text{draft}\right)^{0.94} \tag{4}$$

Sailing Lines and Tow Positions

One of the inputs to the X1 line in the NAVPAT bathymetry/cell file is the left and right channel limits. These limits depend on many factors including available depth, channel alignment, presence of structures like bridges, etc. ERDC made an estimate of the channel limits based on the navigation charts (Figures 5-13) and provided those to the Louisville District. Distance between left and right limits varied from 250 to 400 ft. The Louisville District reviewed the limits and provided revisions that were incorporated into the input files. The distance between the left and right channel limits defines the width of the navigation channel. This width is divided into five segments representing five possible lateral tow positions. Calculations in NAVPAT are based on the tow being in the center of one of the five segments. For example, assume left and right channel limits on the X1 line are 300 and 500 ft, respectively, from the left bank. Each segment has a width of (500 – 300)/5 = 40 ft. Since the tow is in the middle of the segment, the position of the tow centerline closest to the left bank will be at 300 + 40/2 = 320 ft from the left bank. The other four tow centerline positions will be 360, 400, 440, and 480 ft from the left bank.

Tow Position Frequency

For each tow in the traffic file, NAVPAT uses a random number generator to select which of the five tow positions to use in the calculations of tow effects. For a given tow, the random selection of position is repeated for each cross section. Consequently, a tow can be in position 1 at one cross section and in position 5 at the next upstream cross section. This presents no problem because after all tows are simulated, their distribution of position will equal the distribution specified in the tow position frequency file. (This is strictly true for large numbers of tows and becomes less true for smaller numbers of tows.) The tow position frequency file contains a frequency distribution of the lateral tow position for each cross section used in the analysis. The distribution varies with towboat class (1 through 8) with large towboats confined to a narrow portion of the channel and small towboats allowed to occupy a wider width. For Winfield, three distributions (Tables 8-10) of centered sailing line, sailing line close to left bank, and sailing line close to the right bank were used to describe the tow positions and were based on the position of the sailing line from the navigation charts. NAVPAT does not directly address passing or meeting tows by computing physical effects at two locations in the cross section while the tows are at the same river mile for a short period of time. The effects of passing and meeting tows can be indirectly handled in NAVPAT using sufficiently wide left and right limits of navigation and a tow position frequency file that assigns a low frequency of occurrence to the outer (#1 and #5) tow positions.

Table 8
Tow Frequency Distribution for Tows Near the Center of the Channel

X1	36.633	8			
1	15	22.5	25	22.5	15
2	10	25	30	25	10
3	10	25	30	25	10
4	10	25	30	25	10
5	5	30	30	30	5
6	5	30	30	30	5
7	5	25	40	25	5
8	0	25	50	25	0

Table 9
Tow Frequency Distribution for Tows Near the Right Bank of the Channel

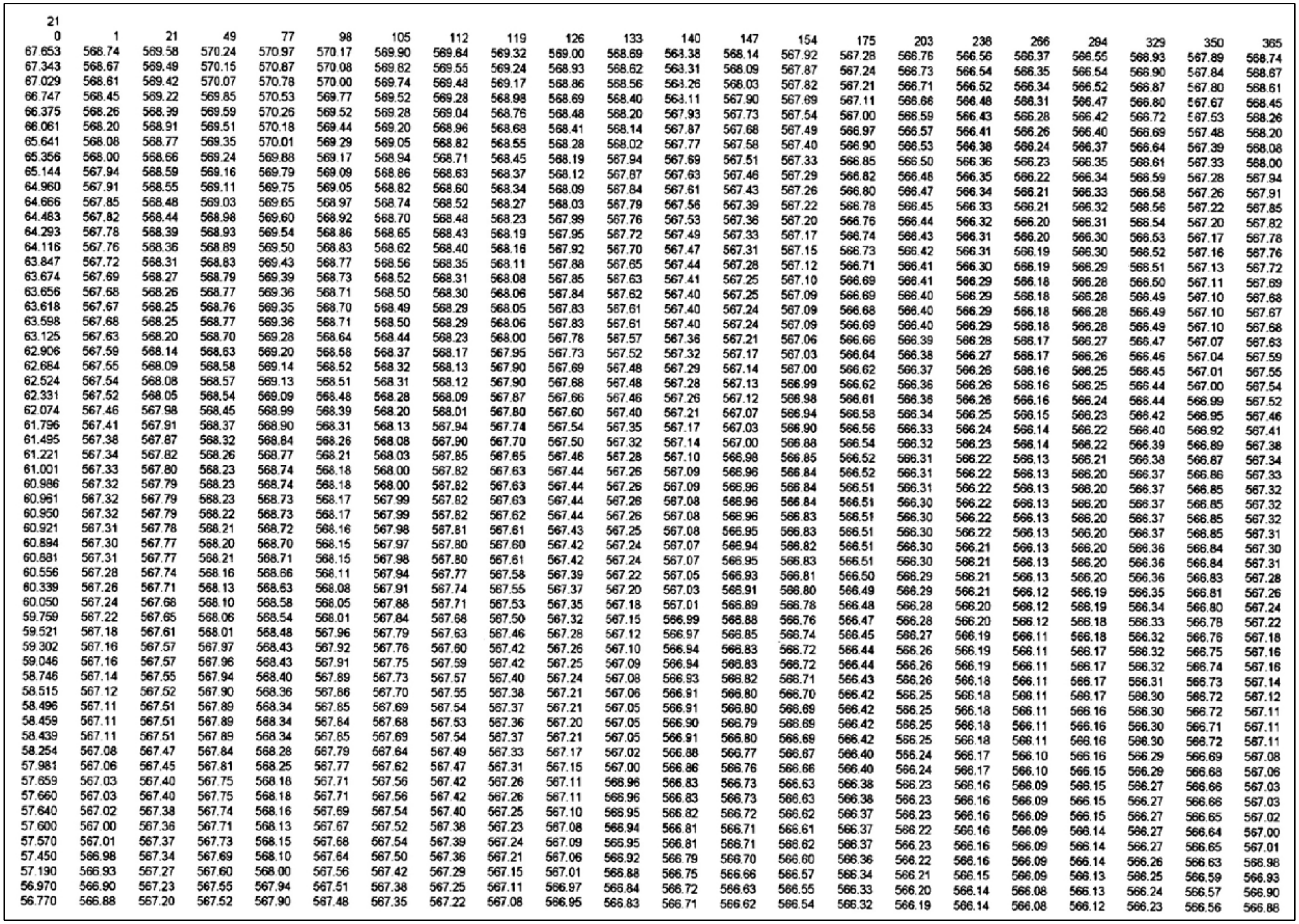
X1	54.304	8			
1	17.5	25	25	20	12.5
2	12.5	29	28.5	22.5	7.5
3	12.5	29	28.5	22.5	7.5
4	12.5	29	28.5	22.5	7.5
5	7.5	33	29.5	27.5	2.5
6	7.5	33	29.5	27.5	2.5
7	7.5	28	39.5	22.5	2.5
8	0	27.5	50	22.5	0

Table 10
Tow Frequency Distribution for Tows Near the Left Bank of the Channel

X1	32.843	8			
1	12.5	20	25	25	17.5
2	7.5	22.5	28.5	29	12.5
3	7.5	22.5	28.5	29	12.5
4	7.5	22.5	28.5	29	12.5
5	2.5	27.5	29.5	33	7.5
6	2.5	27.5	29.5	33	7.5
7	2.5	22.5	39.5	28	7.5
8	0	22.5	50	27.5	0

Stage and Discharge Files

As stated under program changes to NAVPAT, stage and discharge files were added to facilitate the determination of ambient velocity in NAVPAT. The file is comma delimited to facilitate data entry and ease of plotting in spreadsheet programs. The file is composed of columns of discharge corresponding to Julian days. The rows define discharge as a function of river mile. The first entry in the file is the number of columns of Julian day discharge that is equal to the total number of columns minus 1. Julian days must increase from left to right and river miles must decrease from top to bottom. The stage file is set up with the same format. The range of river miles in the Stage and discharge files needs to be slightly greater than the range of river miles in the bathymetry/cell file. The Winfield files are shown in Figures 17 and 18.



```
     21
      0       1      21      49      77      98     105     112     119     126     133     140     147     154     175     203     238     266     294     329     350     365
 67.653  568.74  569.58  570.24  570.97  570.17  569.90  569.64  569.32  569.00  568.69  568.38  568.14  567.92  567.28  566.76  566.56  566.37  566.55  566.93  567.89  568.74
 67.343  568.67  569.49  570.15  570.87  570.08  569.82  569.55  569.24  568.93  568.62  568.31  568.09  567.87  567.24  566.73  566.54  566.35  566.54  566.90  567.84  568.67
 67.029  568.61  569.42  570.07  570.78  570.00  569.74  569.48  569.17  568.86  568.56  568.26  568.03  567.82  567.21  566.71  566.52  566.34  566.52  566.87  567.80  568.61
 66.747  568.45  569.22  569.85  570.53  569.77  569.52  569.28  568.98  568.69  568.40  568.11  567.90  567.69  567.11  566.66  566.48  566.31  566.47  566.80  567.67  568.45
 66.375  568.26  568.99  569.59  570.26  569.52  569.28  569.04  568.76  568.48  568.20  567.93  567.73  567.54  567.00  566.59  566.43  566.28  566.42  566.72  567.53  568.26
 66.061  568.20  568.91  569.51  570.18  569.44  569.20  568.96  568.68  568.41  568.14  567.87  567.68  567.49  566.97  566.57  566.41  566.26  566.40  566.69  567.48  568.20
 65.641  568.08  568.77  569.35  570.01  569.29  569.05  568.82  568.55  568.28  568.02  567.77  567.58  567.40  566.90  566.53  566.38  566.24  566.37  566.64  567.39  568.08
 65.356  568.00  568.66  569.24  569.88  569.17  568.94  568.71  568.45  568.19  567.94  567.69  567.51  567.33  566.85  566.50  566.36  566.23  566.35  566.61  567.33  568.00
 65.144  567.94  568.59  569.16  569.79  569.09  568.86  568.63  568.37  568.12  567.87  567.63  567.46  567.29  566.82  566.48  566.35  566.22  566.34  566.59  567.28  567.94
 64.960  567.91  568.55  569.11  569.75  569.05  568.82  568.60  568.34  568.09  567.84  567.61  567.43  567.26  566.80  566.47  566.34  566.21  566.33  566.58  567.26  567.91
 64.666  567.85  568.48  569.03  569.65  568.97  568.74  568.52  568.27  568.03  567.79  567.56  567.39  567.22  566.78  566.45  566.33  566.21  566.32  566.56  567.22  567.85
 64.483  567.82  568.44  568.98  569.60  568.92  568.70  568.48  568.23  567.99  567.76  567.53  567.36  567.20  566.76  566.44  566.32  566.20  566.31  566.54  567.20  567.82
 64.293  567.78  568.39  568.93  569.54  568.86  568.65  568.43  568.19  567.95  567.72  567.49  567.33  567.17  566.74  566.43  566.31  566.20  566.30  566.53  567.17  567.78
 64.116  567.76  568.36  568.89  569.50  568.83  568.62  568.40  568.16  567.92  567.70  567.47  567.31  567.15  566.73  566.42  566.31  566.19  566.30  566.52  567.16  567.76
 63.847  567.72  568.31  568.83  569.43  568.77  568.56  568.35  568.11  567.88  567.65  567.44  567.28  567.12  566.71  566.41  566.30  566.19  566.29  566.51  567.13  567.72
 63.674  567.69  568.27  568.79  569.39  568.73  568.52  568.31  568.08  567.85  567.63  567.41  567.25  567.10  566.69  566.41  566.29  566.18  566.28  566.50  567.11  567.69
 63.656  567.68  568.26  568.77  569.36  568.71  568.50  568.30  568.06  567.84  567.62  567.40  567.25  567.09  566.69  566.40  566.29  566.18  566.28  566.49  567.10  567.68
 63.618  567.67  568.25  568.76  569.35  568.70  568.49  568.29  568.05  567.83  567.61  567.40  567.24  567.09  566.68  566.40  566.29  566.18  566.28  566.49  567.10  567.67
 63.598  567.68  568.25  568.77  569.36  568.71  568.50  568.29  568.06  567.83  567.61  567.40  567.24  567.09  566.69  566.40  566.29  566.18  566.28  566.49  567.10  567.68
 63.125  567.63  568.20  568.70  569.28  568.64  568.44  568.23  568.00  567.78  567.57  567.36  567.21  567.06  566.66  566.39  566.28  566.17  566.27  566.47  567.07  567.63
 62.906  567.59  568.14  568.63  569.20  568.58  568.37  568.17  567.95  567.73  567.52  567.32  567.17  567.03  566.64  566.38  566.27  566.17  566.26  566.46  567.04  567.59
 62.684  567.55  568.09  568.58  569.14  568.52  568.32  568.13  567.90  567.69  567.48  567.29  567.14  567.00  566.62  566.37  566.26  566.16  566.25  566.45  567.01  567.55
 62.524  567.54  568.08  568.57  569.13  568.51  568.31  568.12  567.90  567.68  567.48  567.28  567.13  566.99  566.62  566.36  566.26  566.16  566.25  566.44  567.00  567.54
 62.331  567.52  568.05  568.54  569.09  568.48  568.28  568.09  567.87  567.66  567.46  567.26  567.12  566.98  566.61  566.36  566.26  566.16  566.24  566.44  566.99  567.52
 62.074  567.46  567.98  568.45  568.99  568.39  568.20  568.01  567.80  567.60  567.40  567.21  567.07  566.94  566.58  566.34  566.25  566.15  566.23  566.42  566.95  567.46
 61.796  567.41  567.91  568.37  568.90  568.31  568.13  567.94  567.74  567.54  567.35  567.17  567.03  566.90  566.56  566.33  566.24  566.14  566.22  566.40  566.92  567.41
 61.495  567.38  567.87  568.32  568.84  568.26  568.08  567.90  567.70  567.50  567.32  567.14  567.00  566.88  566.54  566.32  566.23  566.14  566.22  566.39  566.89  567.38
 61.221  567.34  567.82  568.26  568.77  568.21  568.03  567.85  567.65  567.46  567.28  567.10  566.98  566.85  566.52  566.31  566.22  566.13  566.21  566.38  566.87  567.34
 61.001  567.33  567.80  568.23  568.74  568.18  568.00  567.82  567.63  567.44  567.26  567.09  566.96  566.84  566.52  566.31  566.22  566.13  566.20  566.37  566.86  567.33
 60.986  567.32  567.79  568.23  568.74  568.18  568.00  567.82  567.63  567.44  567.26  567.09  566.96  566.84  566.51  566.31  566.22  566.13  566.20  566.37  566.85  567.32
 60.961  567.32  567.79  568.23  568.73  568.17  567.99  567.82  567.63  567.44  567.26  567.08  566.96  566.84  566.51  566.30  566.22  566.13  566.20  566.37  566.85  567.32
 60.950  567.32  567.79  568.22  568.73  568.17  567.99  567.82  567.62  567.44  567.26  567.08  566.96  566.83  566.51  566.30  566.22  566.13  566.20  566.37  566.85  567.32
 60.921  567.31  567.78  568.21  568.72  568.16  567.98  567.81  567.61  567.43  567.25  567.08  566.95  566.83  566.51  566.30  566.22  566.13  566.20  566.37  566.85  567.31
 60.894  567.30  567.77  568.20  568.70  568.15  567.97  567.80  567.60  567.42  567.24  567.07  566.94  566.82  566.51  566.30  566.21  566.13  566.20  566.36  566.84  567.30
 60.881  567.31  567.77  568.21  568.71  568.15  567.98  567.80  567.61  567.42  567.24  567.07  566.95  566.83  566.51  566.30  566.21  566.13  566.20  566.36  566.84  567.31
 60.556  567.28  567.74  568.16  568.66  568.11  567.94  567.77  567.58  567.39  567.22  567.05  566.93  566.81  566.50  566.29  566.21  566.13  566.20  566.36  566.83  567.28
 60.339  567.26  567.71  568.13  568.63  568.08  567.91  567.74  567.55  567.37  567.20  567.03  566.91  566.80  566.49  566.29  566.21  566.12  566.19  566.35  566.81  567.26
 60.050  567.24  567.68  568.10  568.58  568.05  567.88  567.71  567.53  567.35  567.18  567.01  566.89  566.78  566.48  566.28  566.20  566.12  566.19  566.34  566.80  567.24
 59.759  567.22  567.65  568.06  568.54  568.01  567.84  567.68  567.50  567.32  567.15  566.99  566.88  566.76  566.47  566.28  566.20  566.12  566.18  566.33  566.78  567.22
 59.521  567.18  567.61  568.01  568.48  567.96  567.79  567.63  567.46  567.28  567.12  566.97  566.85  566.74  566.45  566.27  566.19  566.11  566.18  566.32  566.76  567.18
 59.302  567.16  567.57  567.97  568.43  567.92  567.76  567.60  567.42  567.26  567.10  566.94  566.83  566.72  566.44  566.26  566.19  566.11  566.17  566.32  566.75  567.16
 59.046  567.16  567.57  567.96  568.43  567.91  567.75  567.59  567.42  567.25  567.09  566.94  566.83  566.72  566.44  566.26  566.19  566.11  566.17  566.32  566.74  567.16
 58.746  567.14  567.55  567.94  568.40  567.89  567.73  567.57  567.40  567.24  567.08  566.93  566.82  566.71  566.43  566.26  566.18  566.11  566.17  566.31  566.73  567.14
 58.515  567.12  567.52  567.90  568.36  567.86  567.70  567.55  567.38  567.21  567.06  566.91  566.80  566.70  566.42  566.25  566.18  566.11  566.17  566.30  566.72  567.12
 58.496  567.11  567.51  567.89  568.34  567.85  567.69  567.54  567.37  567.21  567.05  566.91  566.80  566.69  566.42  566.25  566.18  566.11  566.16  566.30  566.72  567.11
 58.459  567.11  567.51  567.89  568.34  567.84  567.68  567.53  567.36  567.20  567.05  566.90  566.79  566.69  566.42  566.25  566.18  566.11  566.16  566.30  566.71  567.11
 58.439  567.11  567.51  567.89  568.34  567.85  567.69  567.54  567.37  567.21  567.05  566.91  566.80  566.69  566.42  566.25  566.18  566.11  566.16  566.30  566.72  567.11
 58.254  567.08  567.47  567.84  568.28  567.79  567.64  567.49  567.33  567.17  567.02  566.88  566.77  566.67  566.40  566.24  566.17  566.10  566.16  566.29  566.69  567.08
 57.981  567.06  567.45  567.81  568.25  567.77  567.62  567.47  567.31  567.15  567.00  566.86  566.76  566.66  566.40  566.24  566.17  566.10  566.15  566.29  566.68  567.06
 57.659  567.03  567.40  567.75  568.18  567.71  567.56  567.42  567.26  567.11  566.96  566.83  566.73  566.63  566.38  566.23  566.16  566.09  566.15  566.27  566.66  567.03
 57.660  567.03  567.40  567.75  568.18  567.71  567.56  567.42  567.26  567.11  566.96  566.83  566.73  566.63  566.38  566.23  566.16  566.09  566.15  566.27  566.66  567.03
 57.640  567.02  567.38  567.74  568.16  567.69  567.54  567.40  567.25  567.10  566.95  566.82  566.72  566.62  566.37  566.23  566.16  566.09  566.15  566.27  566.65  567.02
 57.600  567.00  567.36  567.71  568.13  567.67  567.52  567.38  567.23  567.08  566.94  566.81  566.71  566.61  566.37  566.22  566.16  566.09  566.14  566.27  566.64  567.00
 57.570  567.01  567.37  567.73  568.15  567.68  567.54  567.39  567.24  567.09  566.95  566.81  566.71  566.62  566.37  566.23  566.16  566.09  566.14  566.27  566.65  567.01
 57.450  566.98  567.34  567.69  568.10  567.64  567.50  567.36  567.21  567.06  566.92  566.79  566.70  566.60  566.36  566.22  566.16  566.09  566.14  566.26  566.63  566.98
 57.190  566.93  567.27  567.60  568.00  567.56  567.42  567.29  567.15  567.01  566.88  566.75  566.66  566.57  566.34  566.21  566.15  566.09  566.13  566.25  566.59  566.93
 56.970  566.90  567.23  567.55  567.94  567.51  567.38  567.25  567.11  566.97  566.84  566.72  566.63  566.55  566.33  566.20  566.14  566.08  566.13  566.24  566.57  566.90
 56.770  566.88  567.20  567.52  567.90  567.48  567.35  567.22  567.08  566.95  566.83  566.71  566.62  566.54  566.32  566.19  566.14  566.08  566.12  566.23  566.56  566.88
```

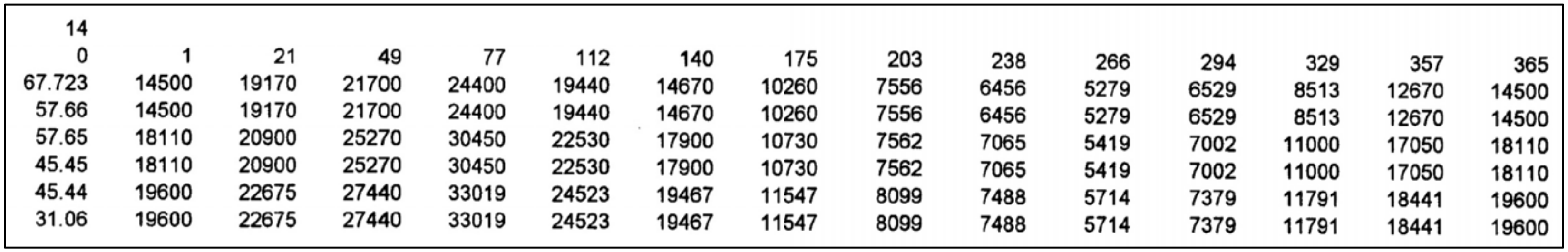
Figure 17. Stage file for Winfield. Number of Julian day columns in 1st line. River miles in column 1. Julian days across row 2. River miles must decrease. River miles do not have to correspond to river miles in cross section/cell file. (Stage in feet above MSL.) (continued)

56.760	566.87	567.19	567.51	567.89	567.47	567.34	567.21	567.07	566.94	566.82	566.70	566.61	566.53	566.32	566.19	566.14	566.08	566.12	566.23	566.55	566.87
56.720	566.87	567.19	567.50	567.88	567.46	567.33	567.20	567.07	566.94	566.81	566.70	566.61	566.53	566.32	566.19	566.14	566.08	566.12	566.23	566.55	566.87
56.700	566.87	567.19	567.50	567.88	567.47	567.33	567.21	567.07	566.94	566.82	566.70	566.61	566.53	566.32	566.19	566.14	566.08	566.12	566.23	566.55	566.87
56.520	566.84	567.15	567.45	567.82	567.41	567.29	567.16	567.03	566.90	566.78	566.67	566.59	566.51	566.30	566.18	566.13	566.08	566.12	566.22	566.53	566.84
56.340	566.81	567.11	567.40	567.77	567.37	567.24	567.12	566.99	566.87	566.76	566.65	566.57	566.49	566.29	566.18	566.12	566.07	566.11	566.21	566.51	566.81
56.320	566.80	567.10	567.40	567.76	567.36	567.24	567.12	566.99	566.87	566.75	566.64	566.56	566.49	566.29	566.17	566.12	566.07	566.11	566.21	566.51	566.80
56.280	566.79	567.09	567.38	567.74	567.34	567.22	567.10	566.98	566.85	566.74	566.63	566.55	566.48	566.28	566.17	566.12	566.07	566.11	566.21	566.50	566.79
56.270	566.79	567.08	567.38	567.74	567.34	567.22	567.10	566.97	566.85	566.74	566.63	566.55	566.48	566.28	566.17	566.12	566.07	566.11	566.21	566.50	566.79
56.060	566.80	567.09	567.38	567.74	567.35	567.22	567.11	566.98	566.86	566.74	566.64	566.56	566.48	566.29	566.17	566.12	566.07	566.11	566.21	566.50	566.80
55.730	566.76	567.04	567.33	567.67	567.29	567.17	567.06	566.94	566.82	566.71	566.61	566.53	566.46	566.27	566.16	566.12	566.07	566.10	566.20	566.48	566.76
55.650	566.75	567.03	567.31	567.66	567.28	567.16	567.05	566.93	566.81	566.70	566.60	566.53	566.45	566.27	566.16	566.11	566.07	566.10	566.19	566.47	566.75
55.370	566.68	566.93	567.19	567.51	567.16	567.05	566.95	566.84	566.73	566.63	566.54	566.47	566.41	566.24	566.14	566.10	566.06	566.09	566.17	566.43	566.68
55.050	566.67	566.92	567.18	567.50	567.15	567.04	566.94	566.83	566.73	566.63	566.54	566.47	566.40	566.24	566.14	566.10	566.06	566.09	566.17	566.42	566.67
55.030	566.67	566.92	567.18	567.49	567.15	567.04	566.94	566.83	566.72	566.63	566.53	566.47	566.40	566.24	566.14	566.10	566.06	566.09	566.17	566.42	566.67
54.810	566.65	566.89	567.14	567.45	567.11	567.01	566.91	566.80	566.70	566.60	566.52	566.45	566.39	566.23	566.14	566.10	566.06	566.09	566.17	566.40	566.65
54.530	566.62	566.86	567.10	567.39	567.07	566.97	566.87	566.77	566.67	566.58	566.50	566.43	566.37	566.22	566.13	566.09	566.05	566.08	566.16	566.39	566.62
54.340	566.61	566.84	567.07	567.37	567.05	566.95	566.85	566.75	566.66	566.57	566.49	566.42	566.36	566.22	566.13	566.09	566.05	566.08	566.16	566.38	566.61
54.010	566.59	566.81	567.04	567.32	567.01	566.92	566.82	566.73	566.63	566.55	566.47	566.41	566.35	566.21	566.12	566.09	566.05	566.08	566.15	566.37	566.59
53.790	566.57	566.78	567.00	567.28	566.98	566.89	566.80	566.70	566.61	566.53	566.45	566.39	566.34	566.20	566.12	566.08	566.05	566.08	566.14	566.35	566.57
53.530	566.54	566.74	566.95	567.22	566.93	566.84	566.76	566.66	566.58	566.50	566.43	566.37	566.32	566.19	566.11	566.08	566.05	566.07	566.14	566.33	566.54
53.230	566.51	566.71	566.91	567.16	566.89	566.80	566.72	566.63	566.55	566.48	566.41	566.35	566.30	566.18	566.11	566.08	566.04	566.07	566.13	566.32	566.51
53.210	566.51	566.71	566.91	567.16	566.89	566.80	566.72	566.63	566.55	566.48	566.41	566.35	566.30	566.18	566.11	566.08	566.04	566.07	566.13	566.32	566.51
53.170	566.51	566.70	566.90	567.15	566.88	566.80	566.72	566.63	566.55	566.47	566.40	566.35	566.30	566.18	566.11	566.07	566.04	566.07	566.13	566.32	566.51
53.150	566.51	566.70	566.90	567.15	566.88	566.79	566.71	566.63	566.55	566.47	566.40	566.35	566.30	566.18	566.11	566.07	566.04	566.07	566.13	566.31	566.51
52.960	566.49	566.68	566.87	567.12	566.85	566.77	566.69	566.61	566.53	566.46	566.39	566.34	566.29	566.17	566.10	566.07	566.04	566.07	566.12	566.30	566.49
52.710	566.48	566.66	566.85	567.09	566.83	566.75	566.67	566.59	566.51	566.44	566.38	566.33	566.28	566.17	566.10	566.07	566.04	566.06	566.12	566.30	566.48
52.400	566.47	566.64	566.83	567.06	566.81	566.73	566.66	566.58	566.50	566.43	566.37	566.32	566.28	566.16	566.10	566.07	566.04	566.06	566.12	566.29	566.47
52.120	566.45	566.62	566.80	567.03	566.78	566.71	566.63	566.56	566.49	566.42	566.36	566.31	566.27	566.16	566.09	566.07	566.04	566.06	566.11	566.28	566.45
52.100	566.45	566.62	566.80	567.02	566.78	566.70	566.63	566.55	566.48	566.42	566.35	566.31	566.27	566.16	566.09	566.07	566.04	566.06	566.11	566.28	566.45
52.090	566.45	566.62	566.79	567.02	566.77	566.70	566.63	566.55	566.48	566.41	566.35	566.31	566.26	566.15	566.09	566.06	566.04	566.06	566.11	566.28	566.45
52.060	566.45	566.62	566.80	567.02	566.78	566.70	566.63	566.55	566.48	566.42	566.35	566.31	566.26	566.16	566.09	566.07	566.04	566.06	566.11	566.28	566.45
51.690	566.43	566.60	566.77	566.99	566.75	566.68	566.61	566.54	566.47	566.40	566.34	566.30	566.26	566.15	566.09	566.06	566.04	566.06	566.11	566.27	566.43
51.550	566.43	566.59	566.76	566.98	566.74	566.67	566.60	566.53	566.46	566.40	566.34	566.29	566.25	566.15	566.09	566.06	566.04	566.06	566.11	566.26	566.43
51.270	566.41	566.56	566.73	566.93	566.71	566.64	566.57	566.50	566.44	566.38	566.32	566.28	566.24	566.14	566.08	566.06	566.03	566.05	566.10	566.25	566.41
51.080	566.40	566.55	566.71	566.91	566.69	566.62	566.56	566.49	566.43	566.37	566.31	566.27	566.23	566.14	566.08	566.06	566.03	566.05	566.10	566.25	566.40
50.920	566.39	566.54	566.70	566.90	566.69	566.62	566.56	566.49	566.43	566.37	566.31	566.27	566.23	566.14	566.08	566.06	566.03	566.05	566.10	566.24	566.39
50.730	566.38	566.53	566.69	566.88	566.67	566.60	566.54	566.48	566.42	566.36	566.30	566.26	566.23	566.13	566.08	566.06	566.03	566.05	566.10	566.24	566.38
50.610	566.39	566.53	566.69	566.89	566.67	566.61	566.54	566.48	566.42	566.36	566.31	566.27	566.23	566.13	566.08	566.06	566.03	566.05	566.10	566.24	566.39
50.450	566.38	566.53	566.68	566.88	566.66	566.60	566.54	566.47	566.41	566.35	566.30	566.26	566.22	566.13	566.08	566.06	566.03	566.05	566.09	566.24	566.38
50.350	566.37	566.51	566.66	566.86	566.65	566.58	566.52	566.46	566.40	566.35	566.29	566.26	566.22	566.13	566.08	566.05	566.03	566.05	566.09	566.23	566.37
50.240	566.37	566.51	566.66	566.85	566.64	566.58	566.52	566.46	566.40	566.34	566.29	566.25	566.22	566.13	566.08	566.05	566.03	566.05	566.09	566.23	566.37
50.090	566.36	566.50	566.65	566.84	566.64	566.57	566.51	566.45	566.39	566.34	566.29	566.25	566.22	566.13	566.07	566.05	566.03	566.05	566.09	566.23	566.36
49.910	566.36	566.49	566.64	566.82	566.62	566.56	566.51	566.44	566.39	566.33	566.28	566.25	566.21	566.12	566.07	566.05	566.03	566.05	566.09	566.22	566.36
49.820	566.35	566.48	566.62	566.80	566.61	566.55	566.49	566.43	566.38	566.32	566.27	566.24	566.20	566.12	566.07	566.05	566.03	566.05	566.09	566.21	566.35
49.700	566.34	566.47	566.61	566.79	566.59	566.54	566.48	566.42	566.37	566.32	566.27	566.23	566.20	566.12	566.07	566.05	566.03	566.04	566.08	566.21	566.34
49.590	566.34	566.47	566.60	566.78	566.59	566.53	566.48	566.42	566.36	566.31	566.27	566.23	566.20	566.12	566.07	566.05	566.03	566.04	566.08	566.21	566.34
49.470	566.33	566.46	566.59	566.77	566.58	566.52	566.47	566.41	566.36	566.31	566.26	566.23	566.20	566.11	566.07	566.05	566.03	566.04	566.08	566.20	566.33
49.310	566.33	566.46	566.59	566.76	566.58	566.52	566.47	566.41	566.36	566.31	566.26	566.23	566.19	566.11	566.07	566.05	566.03	566.04	566.08	566.20	566.33
49.140	566.32	566.45	566.58	566.75	566.57	566.51	566.46	566.40	566.35	566.30	566.26	566.22	566.19	566.11	566.07	566.05	566.03	566.04	566.08	566.20	566.32
48.950	566.32	566.44	566.57	566.73	566.55	566.50	566.45	566.39	566.34	566.30	566.25	566.22	566.19	566.11	566.06	566.05	566.03	566.04	566.08	566.20	566.32
48.750	566.31	566.43	566.56	566.72	566.54	566.49	566.44	566.39	566.34	566.29	566.25	566.21	566.18	566.11	566.06	566.04	566.03	566.04	566.08	566.19	566.31
48.480	566.30	566.42	566.54	566.70	566.53	566.48	566.43	566.37	566.33	566.28	566.24	566.21	566.18	566.10	566.06	566.04	566.02	566.04	566.07	566.19	566.30
48.200	566.29	566.40	566.52	566.68	566.51	566.46	566.41	566.36	566.32	566.27	566.23	566.20	566.17	566.10	566.06	566.04	566.02	566.04	566.07	566.18	566.29
47.940	566.29	566.40	566.52	566.67	566.50	566.45	566.41	566.36	566.31	566.27	566.23	566.20	566.17	566.10	566.06	566.04	566.02	566.04	566.07	566.18	566.29
47.680	566.28	566.39	566.50	566.65	566.49	566.44	566.40	566.35	566.30	566.26	566.22	566.19	566.16	566.10	566.06	566.04	566.02	566.04	566.07	566.17	566.28
47.400	566.27	566.37	566.48	566.63	566.47	566.43	566.38	566.34	566.29	566.25	566.21	566.18	566.16	566.09	566.05	566.04	566.02	566.03	566.07	566.17	566.27
47.110	566.26	566.36	566.47	566.61	566.46	566.41	566.37	566.32	566.28	566.24	566.21	566.18	566.15	566.09	566.05	566.04	566.02	566.03	566.06	566.16	566.26
46.890	566.25	566.35	566.45	566.59	566.44	566.40	566.36	566.31	566.27	566.23	566.20	566.17	566.15	566.09	566.05	566.04	566.02	566.03	566.06	566.16	566.25
46.650	566.25	566.34	566.44	566.57	566.43	566.39	566.35	566.31	566.27	566.23	566.20	566.17	566.14	566.08	566.05	566.03	566.02	566.03	566.06	566.15	566.25
46.360	566.24	566.33	566.43	566.56	566.42	566.38	566.34	566.30	566.26	566.22	566.19	566.16	566.14	566.08	566.05	566.03	566.02	566.03	566.06	566.15	566.24

Figure 17. Continued

46.120	566.23	566.32	566.42	566.54	566.41	566.37	566.33	566.29	566.25	566.22	566.18	566.16	566.14	566.08	566.05	566.03	566.02	566.03	566.06	566.14	566.23
46.110	566.23	566.32	566.41	566.54	566.40	566.36	566.33	566.29	566.25	566.22	566.18	566.16	566.14	566.08	566.05	566.03	566.02	566.03	566.06	566.14	566.23
46.080	566.23	566.32	566.41	566.54	566.40	566.36	566.33	566.29	566.25	566.21	566.18	566.16	566.13	566.08	566.05	566.03	566.02	566.03	566.06	566.14	566.23
46.060	566.23	566.32	566.42	566.54	566.41	566.37	566.33	566.29	566.25	566.22	566.18	566.16	566.14	566.08	566.05	566.03	566.02	566.03	566.06	566.14	566.23
45.790	566.22	566.31	566.41	566.53	566.40	566.36	566.32	566.28	566.24	566.21	566.18	566.15	566.13	566.08	566.05	566.03	566.02	566.03	566.06	566.14	566.22
45.450	566.22	566.30	566.39	566.51	566.38	566.34	566.31	566.27	566.23	566.20	566.17	566.15	566.13	566.07	566.04	566.03	566.02	566.03	566.05	566.13	566.22
45.450	566.22	566.30	566.39	566.51	566.38	566.34	566.31	566.27	566.23	566.20	566.17	566.15	566.13	566.07	566.04	566.03	566.02	566.03	566.05	566.13	566.22
45.190	566.21	566.28	566.37	566.48	566.36	566.33	566.29	566.26	566.22	566.19	566.16	566.14	566.12	566.07	566.04	566.03	566.02	566.03	566.05	566.13	566.21
44.900	566.20	566.27	566.36	566.46	566.35	566.31	566.28	566.25	566.21	566.18	566.16	566.14	566.12	566.07	566.04	566.03	566.02	566.02	566.05	566.12	566.20
44.630	566.19	566.27	566.35	566.45	566.34	566.31	566.28	566.24	566.21	566.18	566.15	566.13	566.11	566.07	566.04	566.03	566.02	566.02	566.05	566.12	566.19
44.360	566.19	566.26	566.34	566.44	566.33	566.30	566.27	566.23	566.20	566.18	566.15	566.13	566.11	566.06	566.04	566.03	566.02	566.02	566.05	566.12	566.19
44.140	566.18	566.25	566.33	566.43	566.32	566.29	566.26	566.23	566.20	566.17	566.15	566.13	566.11	566.06	566.04	566.03	566.02	566.02	566.05	566.11	566.18
43.880	566.18	566.25	566.32	566.42	566.31	566.28	566.25	566.22	566.19	566.17	566.14	566.12	566.10	566.06	566.04	566.02	566.01	566.02	566.04	566.11	566.18
43.640	566.17	566.24	566.31	566.40	566.30	566.27	566.24	566.21	566.19	566.16	566.14	566.12	566.10	566.06	566.03	566.02	566.01	566.02	566.04	566.11	566.17
43.350	566.17	566.23	566.30	566.39	566.29	566.26	566.23	566.21	566.18	566.15	566.13	566.11	566.10	566.06	566.03	566.02	566.01	566.02	566.04	566.10	566.17
43.130	566.16	566.22	566.29	566.37	566.28	566.25	566.23	566.20	566.17	566.15	566.13	566.11	566.09	566.05	566.03	566.02	566.01	566.02	566.04	566.10	566.16
42.780	566.15	566.21	566.27	566.35	566.27	566.24	566.21	566.19	566.16	566.14	566.12	566.10	566.09	566.05	566.03	566.02	566.01	566.02	566.04	566.09	566.15
42.350	566.15	566.20	566.26	566.34	566.26	566.23	566.21	566.18	566.16	566.14	566.12	566.10	566.09	566.05	566.03	566.02	566.01	566.02	566.04	566.09	566.15
41.890	566.14	566.19	566.25	566.33	566.24	566.22	566.20	566.17	566.15	566.13	566.11	566.09	566.08	566.05	566.03	566.02	566.01	566.02	566.03	566.09	566.14
41.880	566.14	566.19	566.25	566.32	566.24	566.22	566.19	566.17	566.15	566.13	566.11	566.09	566.08	566.05	566.03	566.02	566.01	566.02	566.03	566.08	566.14
41.850	566.14	566.19	566.25	566.32	566.24	566.22	566.19	566.17	566.15	566.13	566.11	566.09	566.08	566.05	566.03	566.02	566.01	566.02	566.03	566.08	566.14
41.830	566.14	566.19	566.25	566.32	566.24	566.22	566.19	566.17	566.15	566.13	566.11	566.09	566.08	566.05	566.03	566.02	566.01	566.02	566.03	566.08	566.14
41.430	566.13	566.18	566.23	566.30	566.23	566.20	566.18	566.16	566.14	566.12	566.10	566.09	566.07	566.04	566.03	566.02	566.01	566.02	566.03	566.08	566.13
41.130	566.12	566.16	566.21	566.28	566.21	566.19	566.17	566.15	566.13	566.11	566.09	566.08	566.07	566.04	566.02	566.02	566.01	566.02	566.03	566.07	566.12
40.720	566.11	566.15	566.20	566.26	566.20	566.18	566.16	566.14	566.12	566.10	566.09	566.08	566.07	566.04	566.02	566.02	566.01	566.01	566.03	566.07	566.11
40.370	566.10	566.14	566.19	566.25	566.18	566.17	566.15	566.13	566.11	566.10	566.08	566.07	566.06	566.04	566.02	566.01	566.01	566.01	566.03	566.06	566.10
39.940	566.10	566.14	566.18	566.23	566.18	566.16	566.14	566.12	566.11	566.09	566.08	566.07	566.06	566.03	566.02	566.01	566.01	566.01	566.02	566.06	566.10
39.730	566.09	566.13	566.17	566.22	566.16	566.15	566.13	566.12	566.10	566.09	566.07	566.06	566.05	566.03	566.02	566.01	566.01	566.01	566.02	566.06	566.09
39.130	566.09	566.13	566.16	566.21	566.16	566.14	566.13	566.11	566.10	566.08	566.07	566.06	566.05	566.03	566.02	566.01	566.01	566.01	566.02	566.06	566.09
38.950	566.09	566.12	566.16	566.20	566.15	566.14	566.12	566.11	566.09	566.08	566.07	566.06	566.05	566.03	566.02	566.01	566.01	566.01	566.02	566.05	566.09
38.520	566.08	566.11	566.15	566.19	566.14	566.13	566.12	566.10	566.09	566.08	566.06	566.06	566.05	566.03	566.02	566.01	566.01	566.01	566.02	566.05	566.08
38.150	566.08	566.11	566.14	566.18	566.14	566.12	566.11	566.10	566.08	566.07	566.06	566.05	566.05	566.03	566.02	566.01	566.01	566.01	566.02	566.05	566.08
37.720	566.07	566.10	566.13	566.17	566.13	566.12	566.11	566.09	566.08	566.07	566.06	566.05	566.04	566.03	566.02	566.01	566.01	566.01	566.02	566.05	566.07
37.310	566.07	566.09	566.12	566.16	566.12	566.11	566.10	566.09	566.07	566.06	566.05	566.05	566.04	566.02	566.01	566.01	566.01	566.01	566.02	566.04	566.07
36.880	566.06	566.09	566.12	566.15	566.11	566.10	566.09	566.08	566.07	566.06	566.05	566.04	566.04	566.02	566.01	566.01	566.01	566.01	566.02	566.04	566.06
36.440	566.06	566.08	566.11	566.14	566.11	566.09	566.08	566.07	566.06	566.06	566.05	566.04	566.04	566.02	566.01	566.01	566.01	566.01	566.01	566.04	566.06
36.050	566.05	566.07	566.10	566.13	566.10	566.09	566.08	566.07	566.06	566.05	566.04	566.04	566.03	566.02	566.01	566.01	566.00	566.01	566.01	566.03	566.05
35.660	566.05	566.07	566.09	566.11	566.09	566.08	566.07	566.06	566.05	566.05	566.04	566.03	566.03	566.02	566.01	566.01	566.00	566.01	566.01	566.03	566.05
35.260	566.04	566.06	566.08	566.11	566.08	566.07	566.06	566.06	566.05	566.04	566.04	566.03	566.03	566.02	566.01	566.01	566.00	566.01	566.01	566.03	566.04
34.790	566.04	566.06	566.07	566.09	566.07	566.06	566.06	566.05	566.04	566.04	566.03	566.03	566.02	566.01	566.01	566.01	566.00	566.01	566.01	566.02	566.04
34.350	566.04	566.05	566.07	566.08	566.06	566.06	566.05	566.05	566.04	566.03	566.03	566.02	566.02	566.01	566.01	566.01	566.00	566.00	566.01	566.02	566.04
33.890	566.03	566.04	566.06	566.07	566.06	566.05	566.05	566.04	566.03	566.03	566.03	566.02	566.02	566.01	566.01	566.00	566.00	566.00	566.01	566.02	566.03
33.440	566.03	566.04	566.05	566.06	566.05	566.04	566.04	566.03	566.03	566.03	566.02	566.02	566.02	566.01	566.01	566.00	566.00	566.00	566.01	566.02	566.03
33.020	566.02	566.03	566.04	566.06	566.04	566.04	566.03	566.03	566.03	566.02	566.02	566.02	566.01	566.01	566.01	566.00	566.00	566.00	566.01	566.01	566.02
32.750	566.02	566.03	566.04	566.05	566.04	566.03	566.03	566.03	566.02	566.02	566.02	566.01	566.01	566.01	566.00	566.00	566.00	566.00	566.01	566.01	566.02
32.510	566.02	566.02	566.03	566.04	566.03	566.03	566.02	566.02	566.02	566.02	566.01	566.01	566.01	566.01	566.00	566.00	566.00	566.00	566.00	566.01	566.02
32.250	566.02	566.02	566.03	566.04	566.03	566.03	566.02	566.02	566.02	566.02	566.01	566.01	566.01	566.01	566.00	566.00	566.00	566.00	566.00	566.01	566.02
32.090	566.02	566.02	566.03	566.04	566.03	566.02	566.02	566.02	566.02	566.01	566.01	566.01	566.01	566.01	566.00	566.00	566.00	566.00	566.00	566.01	566.02
32.070	566.01	566.02	566.03	566.03	566.02	566.02	566.02	566.02	566.02	566.01	566.01	566.01	566.01	566.01	566.00	566.00	566.00	566.00	566.00	566.01	566.01
32.050	566.01	566.02	566.02	566.03	566.02	566.02	566.02	566.02	566.02	566.01	566.01	566.01	566.01	566.01	566.00	566.00	566.00	566.00	566.00	566.01	566.01
32.030	566.01	566.02	566.03	566.03	566.03	566.02	566.02	566.02	566.02	566.01	566.01	566.01	566.01	566.01	566.00	566.00	566.00	566.00	566.00	566.01	566.01
31.570	566.01	566.02	566.02	566.03	566.02	566.02	566.02	566.01	566.01	566.01	566.01	566.01	566.01	566.00	566.00	566.00	566.00	566.00	566.00	566.01	566.01
31.130	566.01	566.01	566.01	566.02	566.01	566.01	566.01	566.01	566.01	566.01	566.01	566.01	566.01	566.00	566.00	566.00	566.00	566.00	566.00	566.01	566.01
31.100	566.00	566.00	566.00	566.00	566.00	566.00	566.00	566.00	566.00	566.00	566.00	566.00	566.00	566.00	566.00	566.00	566.00	566.00	566.00	566.00	566.00
31.060	541.69	542.47	543.18	544.00	543.11	542.83	542.54	542.23	541.92	541.61	541.31	541.07	540.83	540.17	539.76	539.57	539.38	539.53	539.90	540.91	541.69

Figure 17. Concluded



```
      14
       0      1     21     49     77    112    140    175    203    238    266    294    329    357    365
  67.723  14500  19170  21700  24400  19440  14670  10260   7556   6456   5279   6529   8513  12670  14500
   57.66  14500  19170  21700  24400  19440  14670  10260   7556   6456   5279   6529   8513  12670  14500
   57.65  18110  20900  25270  30450  22530  17900  10730   7562   7065   5419   7002  11000  17050  18110
   45.45  18110  20900  25270  30450  22530  17900  10730   7562   7065   5419   7002  11000  17050  18110
   45.44  19600  22675  27440  33019  24523  19467  11547   8099   7488   5714   7379  11791  18441  19600
   31.06  19600  22675  27440  33019  24523  19467  11547   8099   7488   5714   7379  11791  18441  19600
```

Figure 18. Winfield discharge file. Number of Julian day columns in 1st position. River miles in decreasing order in column 1. Julian days in row 2. Discharge in cubic feet per second

7 Example Application

This section provides a detailed example of using NAVPAT. Figure 19 shows the cross section at Winfield river mile 41.555 with cells and left and right limits of navigation. Figure 20 shows the without and with tow average SI for emerald shiner spawning (species/life stage 1) along with the ambient velocity computed by NAVPAT. The with-tow SI is averaged over the flow window of Julian days 124-128. From the habitat equations in NAVPAT, emerald shiner spawning uses most substrates because this stage has pelagic eggs, prefers depths greater than 2 ft, and prefers low ambient velocity. For ambient velocity less than 0.22 ft/sec, without tow SI = 1.0. For ambient velocity greater than 1.2 ft/sec, without tow SI = 0.0. The ambient velocity and SI plot show that the without tow SI is 0.0 in the center where the ambient velocity exceeds 1.2 ft/sec. The SI plot also shows greater tow effects on the left side of the channel because the sailing line is closer to the left bank. Greatest tow effects are found where the without and with tow SI curves depart the greatest. Based on the habitat relationships in NAVPAT, emerald shiner spawning habitat is only affected by velocity disturbance. Cell 6, having a cell center located 149 ft from the left bank, has the SI plotted in Figure 21 over the duration of the flow window during which 78 tows passed the section. Note that the curve begins the flow window at the without tow SI = 0.465 calculated for cell 6. The portions of the line that slope upward are doing so based on the recovery rate. The sharp drops are the tow occurrences that produce a velocity disturbance great enough to cause the SI to fall below the current SI. The sharp drop at time 124.4 was the result of a tow-induced velocity disturbance of 2.0 ft/sec. At time 124.5, another tow produced a velocity disturbance of 1.5 ft/sec. However, this occurrence did not produce an effect (i.e. drop) since the current SI was low due to the prior event at 124.4. This demonstrates how critical the timing of large tow events is to the output from NAVPAT. Figure 21 also shows the average SI value over the flow window of 0.38 at cell 6 that is the representative value used in most NAVPAT applications to describe the tow event. Figure 21 demonstrates a fundamental assumption used in NAVPAT for species/life stages subject to velocity change and/or substrate scour and then recovery. That fundamental assumption is that the tow can only degrade the habitat if the amount of degradation from the tow is greater than the present SI. The present SI is equal to the last tow to cause a drop in SI plus any recovery. NAVPAT calculates this approach by making the starting point for the effects from each tow equal to the SI without any traffic. The starting point for each tow is not the SI from the previous tow. The maximum the habitat SI can be degraded (the minimum SI) along the Figure 21 curve is equal to the SI from the single worst tow.

Detailed output from a single tow is presented to show some of the parameters used in NAVPAT. A large tow occurred on Julian day 124.4 (123.4 in traffic file) and resulted in a peak velocity disturbance as shown in Figure 22 for the river mile 41.555 cross section. The tow was upbound and 105 ft wide, 9 ft draft, 660 ft long, and traveling at about 6 mph relative to the water. This tow was on the sailing zone closest to the left bank and 180 ft from the left bank. The peak velocity plot shows a large spike on the left bank (cell 1) that is due to surface waves in shallow water. Figure 23 shows the 300-sec-long time-history of velocity at cells 1 and 6. Near the tow at cell 6, surface waves do not contribute but the propeller jet velocity is significant. Away from the tow at the shoreline cell 1, the propeller jet has no impact but surface-wave-induced velocity is significant. The time-histories are used in NAVPAT to compute the peak tow velocity disturbance and to compute substrate scour. Depending on species and life stage, peak tow velocity, substrate scour, or both are used in the habitat relationships.

Figure 24 shows various propeller entrainment parameters for a single tow passage. The selected tow passed the cross section at river mile 41.555 on Julian day 124.4. EGGL, EGGC, and EGGR are the percentages of the left, center, and right sides of the channel that are undisturbed by propeller entrainment. EGGL, EGGC, and EGGR are used to determine the percentage of each cell that is entrained in the propeller jet. Figure 24 also shows the percentages of each cell for the tow passage on Julian day 124.4. Regardless of which of the five zones the tow is located in, any cell whose complete width is in the navigation channel will have percent entrained of 100 - EGGC. Figure 25 shows the variation of SI emerald shiner fry index (species 2) over the flow window of 124-128 for cells 1 and 6. Shoreline cell 1 is excellent habitat for emerald shiner fry index and is unaffected by propeller entrainment. Cell 6 is poor habitat even without tows because of the high ambient velocity as indicated by the beginning SI of 0.1. Cell 6, which is near the tow in zone 1, is significantly affected by propeller entrainment. Note that SI does not recover for propeller entrainment.

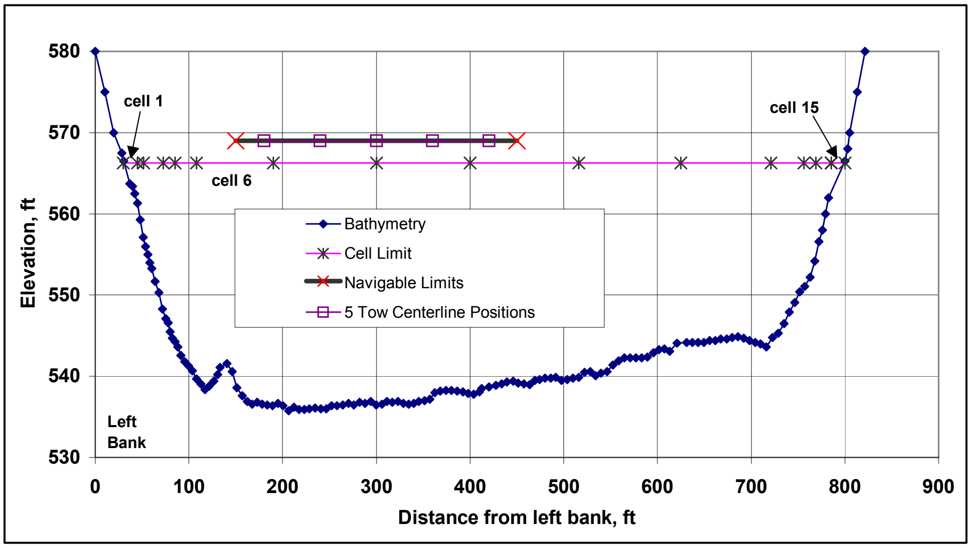


Figure 19. Cross section, cell limits, navigable limits, and five tow positions used in example application of NAVPAT

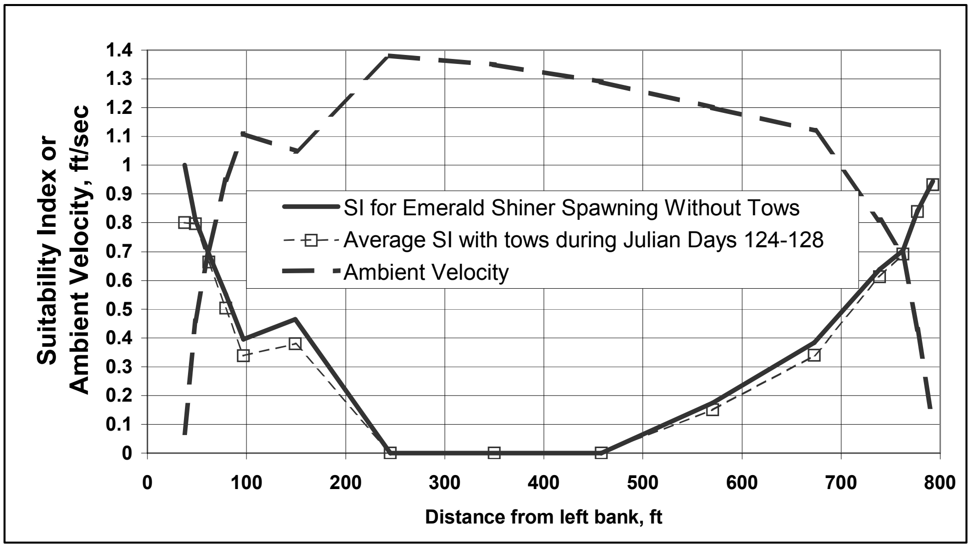


Figure 20. Variation of ambient velocity, without tow SI, and with tow average SI across cross section

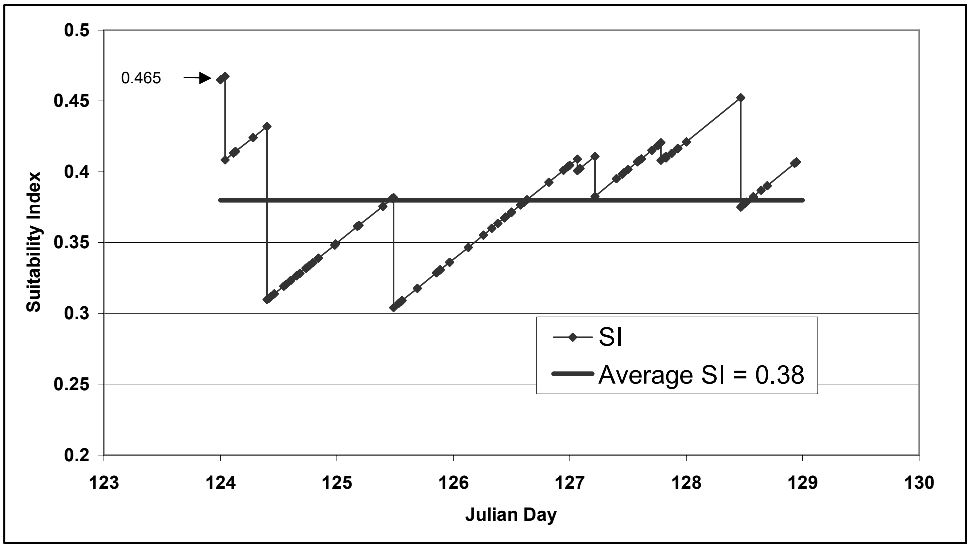


Figure 21. Variation of SI due to tow impacts at cell 6 during flow window and average SI due to tow traffic

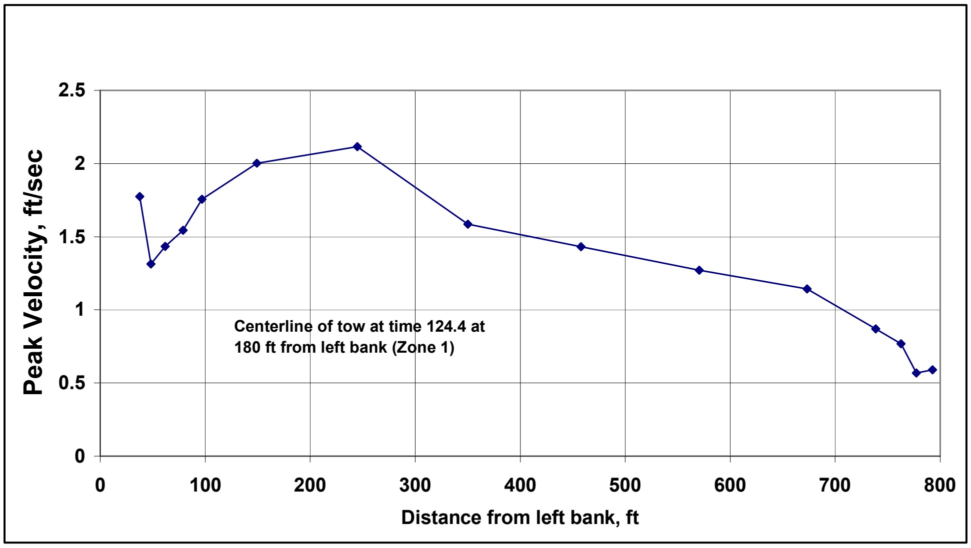


Figure 22. Variation of peak velocity disturbance across section for tow on Julian day 124.4

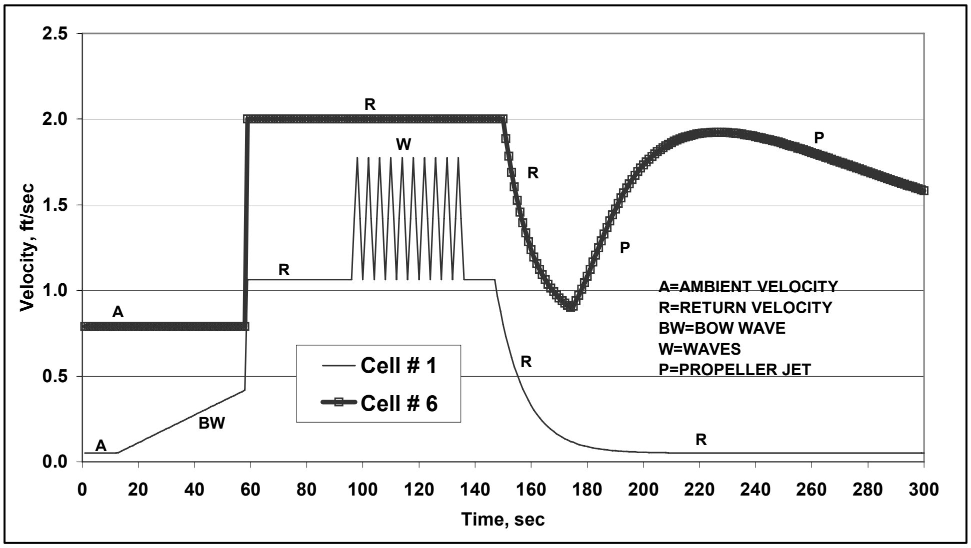


Figure 23. 300-sec time-history of velocity computed in NAVPAT for cells 1 and 6 for tow on Julian day 124.4

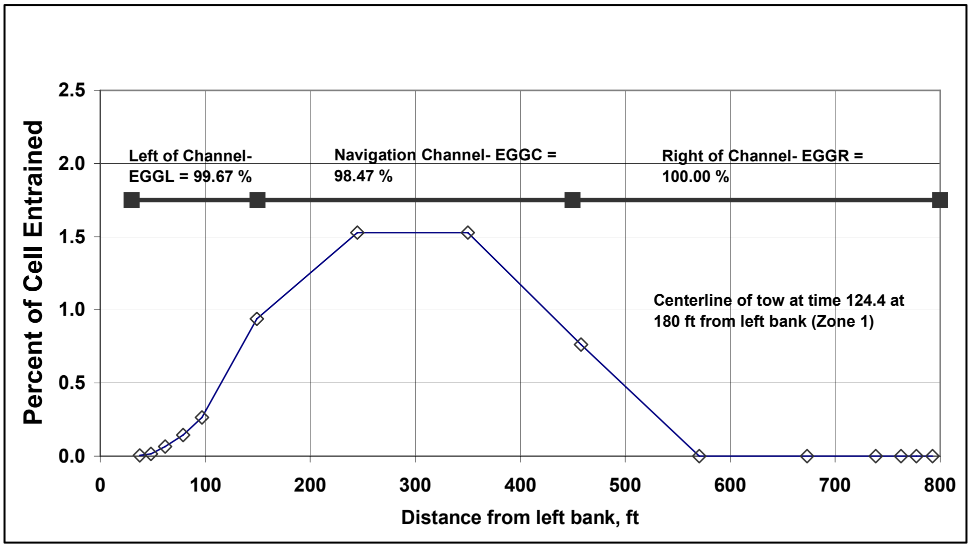


Figure 24. Propeller entrainment parameters for tow passage on Julian day 124.4

8 NAVPAT Results

The data files compiled for the Winfield Pool were run with the NAVPAT model in January 2005. The “run” included each of the 15 fish species at eight different traffic scenarios (5, 10, 15, 20, 25, 30, 35, and 40 MT) under two different conditions (Without Project Condition and With Project Condition). The Without Project Condition, designated “1996,” represented the fleet configuration on the Kanawha River when the original lock at Winfield, measuring 56 ft by 360 ft, was in service. The With Project Condition, or “2000” condition, characterized the fleet after the improvements, which enlarged the lock to 110 ft by 800 ft, were completed. As a result of these modifications, the average tow size increased from 6.0 barges per tow in 1990 to 8.7 barges per tow in 1998.

Initially, all 15 species were run at three traffic levels, 5 MT, 20 MT, and 40 MT. If a species showed no change in available habitat between the lowest traffic level and the highest traffic level, then it was not run with the remaining traffic scenarios. Therefore, species 5, 9, 10, 11, 12, 13, and 15 were only run at three traffic levels. All other groups, including species 1, 2, 3, 4, 6, 7, 8, and 14 were run with all eight traffic levels.

Four values (habitat area with and without traffic and habitat volume with and without traffic) were obtained from each output file. An average of all flow windows for each individual species was then calculated for the four values. Tow traffic effects on fish habitat were revealed by a comparison of the habitat area available during the Without Project Condition in 1996 to the With Project Condition of 2000 at each traffic level.

Table 11 provides results for the 15 species using the Table 1 flow windows for: without traffic, 1996 traffic, and 2000 traffic. Table 12 shows percent reduction in with traffic habitat using [(area habitat in 2000)-(area habitat in 1996)]/[area habitat in 1996] as well as the actual reduction in area habitat. It is important to note that these comparisons are based on equal traffic tonnages for 1996 and 2000 conditions. Actual traffic levels in 1996 and 2000 were close to the same magnitude at about 20 MT. The changes in Table 12 are the result of changes in fleet characteristics, not increases in tonnage.

Figures 26-40 provide comparison of habitat units expressed as a product of the plan view channel area times the SI for the 15 species. For comparison purposes, the entire pool at the stages used in this analysis has a plan view channel area of about 3,310 acres.

Table 11
Summary of NAVPAT Results[1] (Continued)

Species	Year	Tonnage	Season	Begin Day	End Day	# Days	HUAREA-WO	HUVOL-WO	# Tows	HUAREA-WI	HUVOL-WI	HUAREACHG	HUVOLCHG
1	1996	5	sp1	124	128	5	726.2	12603.7	13	704.2	12277.8		
			sp2	134	138	5	897.7	16736.0	12	853.9	16033.8		
			sp3	144	148	5	1143.5	22281.0	11	1121.0	21889.6		
						Avg	922.5	17206.9		893.0	16733.7	29.4	473.2
		10	sp1	124	128	5	726.2	12603.7	26	690.8	12052.2		
			sp2	134	138	5	897.7	16736.0	22	843.0	15867.5		
			sp3	144	148	5	1143.5	22281.0	32	1068.9	21077.1		
						Avg	922.5	17206.9		867.6	16332.3	54.9	874.6
		15	sp1	124	128	5	726.2	12603.7	52	675.1	11747.2		
			sp2	134	138	5	897.7	16736.0	33	828.4	15490.4		
			sp3	144	148	5	1143.5	22281.0	44	1063.4	20708.7		
						Avg	922.5	17206.9		855.6	15982.1	66.8	1224.8
		20	sp1	124	128	5	726.2	12603.7	62	674.2	11742.7		
			sp2	134	138	5	897.7	16736.0	48	800.8	14961.9		
			sp3	144	148	5	1143.5	22281.0	58	1023.2	20034.0		
						Avg	922.5	17206.9		832.7	15579.5	89.7	1627.4
		25	sp1	124	128	5	726.2	12603.7	75	661.8	11474.5		
			sp2	134	138	5	897.7	16736.0	84	786.2	14592.3		
			sp3	144	148	5	1143.5	22281.0	74	1014.0	19756.5		
						Avg	922.5	17206.9		820.7	15274.4	101.8	1932.5
		30	sp1	124	128	5	726.2	12603.7	90	650.6	11260.6		
			sp2	134	138	5	897.7	16736.0	114	781.7	14555.6		
			sp3	144	148	5	1143.5	22281.0	73	964.9	18865.5		
						Avg	922.5	17206.9		799.1	14893.9	123.4	2313.0
		35	sp1	124	128	5	726.2	12603.7	106	642.4	11089.7		
			sp2	134	138	5	897.7	16736.0	102	773.2	14371.5		
			sp3	144	148	5	1143.5	22281.0	119	971.5	18921.6		
						Avg	922.5	17206.9		795.7	14794.3	126.8	2412.6
		40	sp1	124	128	5	726.2	12603.7	127	648.5	11250.3		
			sp2	134	138	5	897.7	16736.0	123	788.7	14756.8		
			sp3	144	148	5	1143.5	22281.0	112	1004.3	19633.1		
						Avg	922.5	17206.9		813.8	15213.4	108.6	1993.5

(Sheet 1 of 19)

[1] Sp = spring
Su = summer
Au = autumn
Wi = winter
Begin day and end day define flow window
WO = without traffic
WI = with traffic
Tonnage in millions of tons
HUAREA = habitat units for entire pool based on plan view area, SI × acres
HUVOL = habitat units for entire pool based on volume, SI × acre-ft
HUAREACHG = change in area-based habitat units from without traffic to with traffic (based on average of all flow windows)
HUVOLCHG = change in volume-based habitat units from without traffic to with traffic (based on average of all flow windows)

Table 11 (Continued)

Species	Year	Tonnage	Season	Begin Day	End Day	# Days	HUAREA-WO	HUVOL-WO	# Tows	HUAREA-WI	HUVOL-WI	HUAREACHG	HUVOLCHG
1	2000	5	sp1	124	128	5	726.2	12603.7	10	642.5	11303.0		
			sp2	134	138	5	897.7	16736.0	6	823.5	15592.6		
			sp3	144	148	5	1143.5	22281.0	4	1068.0	21107.8		
						Avg	922.5	17206.9		844.7	16001.1	77.8	1205.8
		10	sp1	124	128	5	726.2	12603.7	21	618.3	10895.5		
			sp2	134	138	5	897.7	16736.0	21	828.1	15536.8		
			sp3	144	148	5	1143.5	22281.0	19	922.3	18382.1		
						Avg	922.5	17206.9		789.6	14938.1	132.9	2268.8
		15	sp1	124	128	5	726.2	12603.7	29	579.6	10228.9		
			sp2	134	138	5	897.7	16736.0	35	741.2	14166.9		
			sp3	144	148	5	1143.5	22281.0	25	953.0	19082.4		
						Avg	922.5	17206.9		757.9	14492.7	164.5	2714.2
		20	sp1	124	128	5	726.2	12603.7	43	565.7	9920.3		
			sp2	134	138	5	897.7	16736.0	42	734.9	14023.3		
			sp3	144	148	5	1143.5	22281.0	38	891.9	17739.7		
						Avg	922.5	17206.9		730.8	13894.4	191.6	3312.5
		25	sp1	124	128	5	726.2	12603.7	55	571.4	10021.1		
			sp2	134	138	5	897.7	16736.0	57	679.4	12872.9		
			sp3	144	148	5	1143.5	22281.0	51	870.5	17193.4		
						Avg	922.5	17206.9		707.1	13362.5	215.4	3844.4
		30	sp1	124	128	5	726.2	12603.7	74	547.5	9658.1		
			sp2	134	138	5	897.7	16736.0	50	687.6	12965.2		
			sp3	144	148	5	1143.5	22281.0	75	783.2	15213.9		
						Avg	922.5	17206.9		672.8	12612.4	249.7	4594.5
		35	sp1	124	128	5	726.2	12603.7	69	567.4	10038.7		
			sp2	134	138	5	897.7	16736.0	82	659.0	12379.7		
			sp3	144	148	5	1143.5	22281.0	86	810.0	16033.5		
						Avg	922.5	17206.9		678.8	12817.3	243.7	4389.6
		40	sp1	124	128	5	726.2	12603.7	78	567.4	10008.9		
			sp2	134	138	5	897.7	16736.0	87	637.1	12035.4		
			sp3	144	148	5	1143.5	22281.0	92	794.0	15608.4		
						Avg	922.5	17206.9		666.2	12550.9	256.3	4656.0

(Sheet 2 of 19)

Table 11 (Continued)

Species	Year	Tonnage	Season	Begin Day	End Day	# Days	HUAREA-WO	HUVOL-WO	# Tows	HUAREA-WI	HUVOL-WI	HUAREACHG	HUVOLCHG
2	1996	5	sp1	154	158	5	683.4	11342.4	15	671.8	11035.5		
			sp2	164	168	5	881.6	15599.1	11	865.6	15192.3		
			sp3	174	178	5	1117.5	20564.3	13	1107.0	20306.8		
						Avg	894.2	15835.3		881.5	15511.5	12.7	323.7
			spall	154	178	25	881.6	15599.1	77	799.1	13507.4	82.5	2091.7
		10	sp1	154	158	5	683.4	11342.4	32	661.6	10764.1		
			sp2	164	168	5	881.6	15599.1	25	850.3	14801.5		
			sp3	174	178	5	1117.5	20564.3	29	1073.2	19476.6		
						Avg	894.2	15835.3		861.7	15014.1	32.5	821.2
			spall	154	178	25	881.6	15599.1	155	738.7	11991.8	142.9	3607.3
		15	sp1	154	158	5	683.4	11342.4	58	645.1	10334.0		
			sp2	164	168	5	881.6	15599.1	43	834.6	14404.1		
			sp3	174	178	5	1117.5	20564.3	43	1052.0	18954.0		
						Avg	894.2	15835.3		843.9	14564.0	50.3	1271.2
			spall	154	178	25	881.6	15599.1	246	689.6	10764.5	192.0	4834.6
		20	sp1	154	158	5	683.4	11342.4	68	639.5	10188.3		
			sp2	164	168	5	881.6	15599.1	58	820.7	14056.0		
			sp3	174	178	5	1117.5	20564.3	55	1039.1	18640.2		
						Avg	894.2	15835.3		833.1	14294.8	61.1	1540.4
			spall	154	178	25	881.6	15599.1	308	672.0	10325.7	209.6	5273.4
		25	sp1	154	158	5	683.4	11342.4	78	632.1	9993.1		
			sp2	164	168	5	881.6	15599.1	68	798.5	13488.9		
			sp3	174	178	5	1117.5	20564.3	67	1017.4	18106.1		
						Avg	894.2	15835.3		816.0	13862.7	78.2	1972.6
			spall	154	178	25	881.6	15599.1	357	649.4	9762.0	232.2	5837.1
		30	sp1	154	158	5	683.4	11342.4	112	622.5	9746.9		
			sp2	164	168	5	881.6	15599.1	88	805.8	13681.7		
			sp3	174	178	5	1117.5	20564.3	95	981.5	17228.1		
						Avg	894.2	15835.3		803.3	13552.2	90.9	2283.0
			spall	154	178	25	881.6	15599.1	477	633.6	9355.2	248.0	6243.9
		35	sp1	154	158	5	683.4	11342.4	114	616.9	9598.9		
			sp2	164	168	5	881.6	15599.1	95	793.3	13358.3		
			sp3	174	178	5	1117.5	20564.3	110	975.8	17089.8		
						Avg	894.2	15835.3		795.3	13349.0	98.8	2486.3
			spall	154	178	25	881.6	15599.1	517	622.2	9069.2	259.4	6529.9
		40	sp1	154	158	5	683.4	11342.4	124	609.8	9421.2		
			sp2	164	168	5	881.6	15599.1	121	773.8	12874.3		
			sp3	174	178	5	1117.5	20564.3	138	947.1	16372.2		
						Avg	894.2	15835.3		776.9	12889.2	117.3	2946.0
			spall	154	178	25	881.6	15599.1	606	607.2	8690.8	274.4	6908.3

(Sheet 3 of 19)

Table 11 (Continued)

Species	Year	Tonnage	Season	Begin Day	End Day	# Days	HUAREA-WO	HUVOL-WO	# Tows	HUAREA-WI	HUVOL-WI	HUAREACHG	HUVOLCHG
2	2000	5	sp1	154	158	5	683.4	11342.4	13	670.7	11006.5		
			sp2	164	168	5	881.6	15599.1	12	866.1	15207.3		
			sp3	174	178	5	1117.5	20564.3	10	1092.7	19955.2		
						Avg	894.2	15835.3		876.5	15389.7	17.7	445.6
			spall	154	178	25	881.6	15599.1	52	798.8	13512.5	82.8	2086.6
		10	sp1	154	158	5	683.4	11342.4	22	658.7	10691.2		
			sp2	164	168	5	881.6	15599.1	17	859.4	15037.8		
			sp3	174	178	5	1117.5	20564.3	18	1067.8	19348.0		
						Avg	894.2	15835.3		862.0	15025.7	32.2	809.6
			spall	154	178	25	881.6	15599.1	85	758.4	12514.8	123.2	3084.3
		15	sp1	154	158	5	683.4	11342.4	32	646.8	10381.2		
			sp2	164	168	5	881.6	15599.1	30	838.0	14494.9		
			sp3	174	178	5	1117.5	20564.3	27	1055.2	19036.2		
						Avg	894.2	15835.3		846.7	14637.4	47.5	1197.8
			spall	154	178	25	881.6	15599.1	146	704.8	11173.5	176.8	4425.6
		20	sp1	154	158	5	683.4	11342.4	39	641.0	10231.7		
			sp2	164	168	5	881.6	15599.1	35	835.0	14422.2		
			sp3	174	178	5	1117.5	20564.3	40	1017.2	18112.0		
						Avg	894.2	15835.3		831.1	14255.3	63.1	1580.0
			spall	154	178	25	881.6	15599.1	189	682.8	10625.3	198.8	4973.8
		25	sp1	154	158	5	683.4	11342.4	56	631.5	9982.2		
			sp2	164	168	5	881.6	15599.1	46	818.0	13997.1		
			sp3	174	178	5	1117.5	20564.3	51	996.0	17582.4		
						Avg	894.2	15835.3		815.2	13853.9	79.0	1981.4
			spall	154	178	25	881.6	15599.1	271	648.0	9739.4	233.6	5859.7
		30	sp1	154	158	5	683.4	11342.4	66	625.8	9843.2		
			sp2	164	168	5	881.6	15599.1	66	795.1	13422.0		
			sp3	174	178	5	1117.5	20564.3	71	983.9	17296.8		
						Avg	894.2	15835.3		801.6	13520.7	92.6	2314.6
			spall	154	178	25	881.6	15599.1	300	645.4	9673.4	236.2	5925.7
		35	sp1	154	158	5	683.4	11342.4	90	604.6	9302.2		
			sp2	164	168	5	881.6	15599.1	72	786.7	13206.3		
			sp3	174	178	5	1117.5	20564.3	67	984.7	17314.9		
						Avg	894.2	15835.3		792.0	13274.5	102.2	2560.8
			spall	154	178	25	881.6	15599.1	375	607.4	8710.6	274.2	6888.5
		40	sp1	154	158	5	683.4	11342.4	81	606.6	9347.7		
			sp2	164	168	5	881.6	15599.1	57	808.0	13739.9		
			sp3	174	178	5	1117.5	20564.3	90	952.5	16541.5		
						Avg	894.2	15835.3		789.0	13209.7	105.1	2625.6
			spall	154	178	25	881.6	15599.1	407	610.2	8776.0	271.4	6823.1

(Sheet 4 of 19)

Table 11 (Continued)

Species	Year	Tonnage	Season	Begin Day	End Day	# Days	HUAREA-WO	HUVOL-WO	# Tows	HUAREA-WI	HUVOL-WI	HUAREACHG	HUVOLCHG
3	1996	5	sp1	110	114	5	2485.8	50768.2	11	2312.6	47825.9		
			sp2	120	124	5	2461.7	50105.8	16	2299.5	47405.5		
			sp3	130	134	5	2427.9	49239.0	17	2323.7	47579.1		
						Avg	2458.5	50037.7		2311.9	47603.5	146.5	2434.2
		10	sp1	110	114	5	2485.8	50768.2	32	2225.2	46272.6		
			sp2	120	124	5	2461.7	50105.8	31	2179.7	45341.4		
			sp3	130	134	5	2427.9	49239.0	24	2144.6	44475.6		
						Avg	2458.5	50037.7		2183.2	45363.2	275.3	4674.5
		15	sp1	110	114	5	2485.8	50768.2	50	2188.7	45677.9		
			sp2	120	124	5	2461.7	50105.8	49	2111.2	44230.9		
			sp3	130	134	5	2427.9	49239.0	39	2096.4	43640.4		
						Avg	2458.5	50037.7		2132.1	44516.4	326.4	5521.3
		20	sp1	110	114	5	2485.8	50768.2	67	2151.3	44993.1		
			sp2	120	124	5	2461.7	50105.8	59	2054.3	43165.8		
			sp3	130	134	5	2427.9	49239.0	58	2084.9	43444.0		
						Avg	2458.5	50037.7		2096.8	43867.6	361.6	6170.0
		25	sp1	110	114	5	2485.8	50768.2	66	2152.9	45044.9		
			sp2	120	124	5	2461.7	50105.8	78	2120.7	44413.9		
			sp3	130	134	5	2427.9	49239.0	79	2017.0	42288.2		
						Avg	2458.5	50037.7		2096.9	43915.7	361.6	6122.0
		30	sp1	110	114	5	2485.8	50768.2	87	2146.8	44989.1		
			sp2	120	124	5	2461.7	50105.8	93	1991.8	41881.6		
			sp3	130	134	5	2427.9	49239.0	89	2007.8	42060.6		
						Avg	2458.5	50037.7		2048.8	42977.1	409.7	7060.6
		35	sp1	110	114	5	2485.8	50768.2	108	2041.9	43060.9		
			sp2	120	124	5	2461.7	50105.8	103	2039.7	42821.1		
			sp3	130	134	5	2427.9	49239.0	118	1975.6	41514.9		
						Avg	2458.5	50037.7		2019.1	42465.6	439.4	7572.0
		40	sp1	110	114	5	2485.8	50768.2	108	2010.1	42434.3		
			sp2	120	124	5	2461.7	50105.8	123	2013.6	42334.1		
			sp3	130	134	5	2427.9	49239.0	107	1969.3	41428.9		
						Avg	2458.5	50037.7		1997.7	42065.8	460.8	7971.9
Species	Year	Tonnage	Season	Begin Day	End Day	# Days	HUAREA-WO	HUVOL-WO	# Tows	HUAREA-WI	HUVOL-WI	HUAREACHG	HUVOLCHG
3	2000	5	sp1	110	114	5	2485.8	50768.2	11	2168.7	45309.8		
			sp2	120	124	5	2461.7	50105.8	14	1910.7	40505.2		
			sp3	130	134	5	2427.9	49239.0	9	2125.6	44243.4		
						Avg	2458.5	50037.7		2068.3	43352.8	390.1	6684.9
		10	sp1	110	114	5	2485.8	50768.2	17	2078.8	43744.6		
			sp2	120	124	5	2461.7	50105.8	25	2019.4	42534.7		
			sp3	130	134	5	2427.9	49239.0	19	2006.8	42143.0		
						Avg	2458.5	50037.7		2035.0	42807.4	423.5	7230.2
		15	sp1	110	114	5	2485.8	50768.2	28	1958.3	41602.6		
			sp2	120	124	5	2461.7	50105.8	33	1847.0	39414.8		
			sp3	130	134	5	2427.9	49239.0	25	1879.2	39853.1		
						Avg	2458.5	50037.7		1894.8	40290.2	563.6	9747.5
		20	sp1	110	114	5	2485.8	50768.2	39	1933.1	41104.6		
			sp2	120	124	5	2461.7	50105.8	45	1788.0	38290.5		
			sp3	130	134	5	2427.9	49239.0	35	1855.8	39490.9		
						Avg	2458.5	50037.7		1859.0	39628.7	599.5	10409.0

(Sheet 5 of 19)

Table 11 (Continued)

		25	sp1	110	114	5	2485.8	50768.2	62	1818.1	38937.4		
			sp2	120	124	5	2461.7	50105.8	58	1910.4	40528.2		
			sp3	130	134	5	2427.9	49239.0	49	1838.1	39078.1		
						Avg	2458.5	50037.7		1855.5	39514.6	602.9	10523.1
		30	sp1	110	114	5	2485.8	50768.2	68	1862.4	39825.6		
			sp2	120	124	5	2461.7	50105.8	71	1697.5	36424.7		
			sp3	130	134	5	2427.9	49239.0	65	1735.4	37325.5		
						Avg	2458.5	50037.7		1765.1	37858.6	693.4	12179.1
		35	sp1	110	114	5	2485.8	50768.2	80	1787.0	38322.4		
			sp2	120	124	5	2461.7	50105.8	70	1771.7	37913.1		
			sp3	130	134	5	2427.9	49239.0	72	1759.2	37635.7		
						Avg	2458.5	50037.7		1772.6	37957.1	685.8	12080.6
		40	sp1	110	114	5	2485.8	50768.2	84	1762.7	37944.5		
			sp2	120	124	5	2461.7	50105.8	86	1692.2	36549.4		
			sp3	130	134	5	2427.9	49239.0	81	1659.5	35728.1		
						Avg	2458.5	50037.7		1704.8	36740.7	753.7	13297.0

Species	Year	Tonnage	Season	Begin Day	End Day	# Days	HUAREA-WO	HUVOL-WO	# Tows	HUAREA-WI	HUVOL-WI	HUAREACHG	HUVOLCHG
4	1996	5	sp1	124	128	5	3309.6	63895.8	13	3203.9	61728.6		
			sp2	134	138	5	3305.6	63538.0	12	3185.7	61101.4		
			sp3	144	148	5	3302.0	63239.3	11	3187.7	60923.4		
						Avg	3305.7	63557.7		3192.4	61251.1	113.3	2306.6
		10	sp1	124	128	5	3309.6	63895.8	26	3111.9	59831.8		
			sp2	134	138	5	3305.6	63538.0	22	3100.1	59353.4		
			sp3	144	148	5	3302.0	63239.3	32	3055.1	58229.2		
						Avg	3305.7	63557.7		3089.0	59138.1	216.7	4419.6
		15	sp1	124	128	5	3309.6	63895.8	52	2911.5	55629.2		
			sp2	134	138	5	3305.6	63538.0	33	3008.9	57459.9		
			sp3	144	148	5	3302.0	63239.3	44	2954.0	56123.4		
						Avg	3305.7	63557.7		2958.1	56404.2	347.6	7153.5
		20	sp1	124	128	5	3309.6	63895.8	62	2852.7	54409.7		
			sp2	134	138	5	3305.6	63538.0	48	2904.4	55275.9		
			sp3	144	148	5	3302.0	63239.3	58	2843.5	53848.5		
						Avg	3305.7	63557.7		2866.9	54511.4	438.9	9046.3
		25	sp1	124	128	5	3309.6	63895.8	75	2769.7	52665.4		
			sp2	134	138	5	3305.6	63538.0	84	2738.8	51818.5		
			sp3	144	148	5	3302.0	63239.3	74	2785.0	52686.5		
						Avg	3305.7	63557.7		2764.5	52390.1	541.2	11167.6
		30	sp1	124	128	5	3309.6	63895.8	90	2678.3	50782.5		
			sp2	134	138	5	3305.6	63538.0	114	2539.9	47563.0		
			sp3	144	148	5	3302.0	63239.3	73	2784.0	52619.9		
						Avg	3305.7	63557.7		2667.4	50321.8	638.3	13235.9
		35	sp1	124	128	5	3309.6	63895.8	106	2689.7	50911.6		
			sp2	134	138	5	3305.6	63538.0	102	2627.2	49431.0		
			sp3	144	148	5	3302.0	63239.3	119	2557.1	47803.3		
						Avg	3305.7	63557.7		2624.7	49382.0	681.1	14175.7
		40	sp1	124	128	5	3309.6	63895.8	127	2494.8	46790.4		
			sp2	134	138	5	3305.6	63538.0	123	2553.4	47881.5		
			sp3	144	148	5	3302.0	63239.3	112	2645.4	49692.0		
						Avg	3305.7	63557.7		2564.5	48121.3	741.2	15436.4

(Sheet 6 of 19)

Table 11 (Continued)

Species	Year	Tonnage	Season	Begin Day	End Day	# Days	HUAREA-WO	HUVOL-WO	# Tows	HUAREA-WI	HUVOL-WI	HUAREACHG	HUVOLCHG
4	2000	5	sp1	124	128	5	3309.6	63895.8	10	3183.9	61313.4		
			sp2	134	138	5	3305.6	63538.0	6	3242.4	62258.9		
			sp3	144	148	5	3302.0	63239.3	4	3270.0	62601.8		
						Avg	3305.7	63557.7		3232.1	62058.0	73.6	1499.7
		10	sp1	124	128	5	3309.6	63895.8	21	3078.6	59127.9		
			sp2	134	138	5	3305.6	63538.0	21	3051.4	58349.3		
			sp3	144	148	5	3302.0	63239.3	19	3034.2	57827.4		
						Avg	3305.7	63557.7		3054.7	58434.9	251.0	5122.8
		15	sp1	124	128	5	3309.6	63895.8	29	2959.0	56627.6		
			sp2	134	138	5	3305.6	63538.0	35	2907.6	55388.3		
			sp3	144	148	5	3302.0	63239.3	25	3024.4	57638.7		
						Avg	3305.7	63557.7		2963.7	56551.5	342.1	7006.2
		20	sp1	124	128	5	3309.6	63895.8	43	2842.0	54181.8		
			sp2	134	138	5	3305.6	63538.0	42	2854.3	54286.6		
			sp3	144	148	5	3302.0	63239.3	38	2885.4	54794.5		
						Avg	3305.7	63557.7		2860.6	54421.0	445.2	9136.7
		25	sp1	124	128	5	3309.6	63895.8	55	2749.0	52261.4		
			sp2	134	138	5	3305.6	63538.0	57	2777.9	52645.7		
			sp3	144	148	5	3302.0	63239.3	51	2835.0	53703.9		
						Avg	3305.7	63557.7		2787.3	52870.3	518.4	10687.4
		30	sp1	124	128	5	3309.6	63895.8	74	2578.4	48651.5		
			sp2	134	138	5	3305.6	63538.0	50	2738.9	51851.1		
			sp3	144	148	5	3302.0	63239.3	75	2601.0	48816.7		
						Avg	3305.7	63557.7		2639.4	49773.1	666.3	13784.6
		35	sp1	124	128	5	3309.6	63895.8	69	2700.0	51216.1		
			sp2	134	138	5	3305.6	63538.0	82	2567.8	48281.5		
			sp3	144	148	5	3302.0	63239.3	86	2589.7	48583.7		
						Avg	3305.7	63557.7		2619.2	49360.4	686.6	14197.3
		40	sp1	124	128	5	3309.6	63895.8	78	2596.7	49065.1		
			sp2	134	138	5	3305.6	63538.0	87	2485.2	46466.8		
			sp3	144	148	5	3302.0	63239.3	92	2471.2	46097.3		
						Avg	3305.7	63557.7		2517.7	47209.7	788.0	16348.0

(Sheet 7 of 19)

Table 11 (Continued)

Species	Year	Tonnage	Season	Begin Day	End Day	# Days	HUAREA-WO	HUVOL-WO	# Tows	HUAREA-WI	HUVOL-WI	HUAREACHG	HUVOLCHG
5	1996	5	wi1	14	18	5	2476.1	47597.2	8	2472.6	47535.5		
			wi2	44	48	5	2391.6	46731.3	12	2390.6	46707.9		
			wi3	73	77	5	2266.4	45027.3	17	2264.8	44989.4		
			sp1	124	128	5	2476.2	47415.6	13	2474.0	47375.5		
			sp2	134	138	5	2496.4	47469.4	12	2492.9	47410.7		
			sp3	144	148	5	2507.5	47420.8	11	2506.1	47393.3		
			su1	196	200	5	2509.7	46794.9	16	2505.6	46734.5		
			su2	226	230	5	2508.4	46670.4	19	2502.8	46593.6		
			su3	257	261	5	2507.4	46565.2	13	2501.4	46485.0		
			au1	288	292	5	2507.8	46606.5	21	2503.0	46541.2		
			au2	318	322	5	2509.4	46762.9	19	2500.4	46633.8		
			au3	349	353	5	2514.4	47376.7	15	2509.1	47294.4		
						Avg	2472.6	46869.9		2468.6	46807.9	4.0	62.0
		20	wi1	14	18	5	2476.1	47597.2	39	2471.0	47511.4		
			wi2	44	48	5	2391.6	46731.3	61	2389.6	46691.2		
			wi3	73	77	5	2266.4	45027.3	64	2263.8	44973.5		
			sp1	124	128	5	2476.2	47415.6	62	2470.5	47322.8		
			sp2	134	138	5	2496.4	47469.4	48	2489.0	47351.2		
			sp3	144	148	5	2507.5	47420.8	58	2499.8	47299.8		
			su1	196	200	5	2509.7	46794.9	72	2489.8	46506.6		
			su2	226	230	5	2508.4	46670.4	62	2493.2	46453.6		
			su3	257	261	5	2507.4	46565.2	70	2490.7	46332.4		
			au1	288	292	5	2507.8	46606.5	66	2496.2	46447.9		
			au2	318	322	5	2509.4	46762.9	74	2493.3	46532.1		
			au3	349	353	5	2514.4	47376.7	68	2501.0	47176.7		
						Avg	2472.6	46869.9		2462.3	46716.6	10.3	153.3
		40	wi1	14	18	5	2476.1	47597.2	129	2468.5	47473.7		
			wi2	44	48	5	2391.6	46731.3	113	2389.0	46680.8		
			wi3	73	77	5	2266.4	45027.3	117	2263.7	44971.2		
			sp1	124	128	5	2476.2	47415.6	127	2469.3	47304.1		
			sp2	134	138	5	2496.4	47469.4	123	2484.0	47275.6		
			sp3	144	148	5	2507.5	47420.8	112	2496.7	47254.7		
			su1	196	200	5	2509.7	46794.9	145	2485.3	46444.5		
			su2	226	230	5	2508.4	46670.4	109	2487.5	46373.3		
			su3	257	261	5	2507.4	46565.2	134	2482.7	46216.8		
			au1	288	292	5	2507.8	46606.5	118	2483.6	46266.3		
			au2	318	322	5	2509.4	46762.9	117	2488.2	46460.3		
			au3	349	353	5	2514.4	47376.7	146	2497.4	47122.1		
						Avg	2472.6	46869.9		2458.0	46653.6	14.6	216.2
Species	Year	Tonnage	Season	Begin Day	End Day	# Days	HUAREA-WO	HUVOL-WO	# Tows	HUAREA-WI	HUVOL-WI	HUAREACHG	HUVOLCHG
5	2000	5	wi1	14	18	5	2476.1	47597.2	12	2467.9	47466.3		
			wi2	44	48	5	2391.6	46731.3	9	2390.0	46697.9		
			wi3	73	77	5	2266.4	45027.3	13	2263.2	44962.4		
			sp1	124	128	5	2476.2	47415.6	10	2465.3	47237.9		
			sp2	134	138	5	2496.4	47469.4	6	2491.2	47381.5		
			sp3	144	148	5	2507.5	47420.8	4	2501.0	47319.6		
			su1	196	200	5	2509.7	46794.9	10	2501.4	46674.8		
			su2	226	230	5	2508.4	46670.4	11	2502.0	46575.5		
			su3	257	261	5	2507.4	46565.2	15	2473.4	46070.3		
			au1	288	292	5	2507.8	46606.5	13	2485.9	46295.2		
			au2	318	322	5	2509.4	46762.9	11	2493.0	46523.2		
			au3	349	353	5	2514.4	47376.7	9	2505.2	47234.2		
						Avg	2472.6	46869.9		2461.6	46703.2	11.0	166.6
		20	wi1	14	18	5	2476.1	47597.2	45	2452.4	47211.4		
			wi2	44	48	5	2391.6	46731.3	34	2381.5	46553.2		
			wi3	73	77	5	2266.4	45027.3	40	2260.5	44914.5		
			sp1	124	128	5	2476.2	47415.6	43	2452.7	47031.6		
			sp2	134	138	5	2496.4	47469.4	42	2473.7	47112.5		
			sp3	144	148	5	2507.5	47420.8	38	2473.6	46897.1		
			su1	196	200	5	2509.7	46794.9	45	2470.3	46218.5		
			su2	226	230	5	2508.4	46670.4	52	2466.1	46043.2		
			su3	257	261	5	2507.4	46565.2	43	2458.9	45849.6		
			au1	288	292	5	2507.8	46606.5	43	2459.4	45896.9		
			au2	318	322	5	2509.4	46762.9	37	2473.7	46233.7		
			au3	349	353	5	2514.4	47376.7	43	2473.9	46757.6		
						Avg	2472.6	46869.9		2441.4	46393.3	31.2	476.5

(Sheet 8 of 19)

Table 11 (Continued)

		40	wi1	14	18	5	2476.1	47597.2	71	2446.4	47109.4		
			wi2	44	48	5	2391.6	46731.3	94	2372.4	46394.7		
			wi3	73	77	5	2266.4	45027.3	85	2259.5	44896.5		
			sp1	124	128	5	2476.2	47415.6	78	2444.2	46899.9		
			sp2	134	138	5	2496.4	47469.4	87	2452.5	46763.8		
			sp3	144	148	5	2507.5	47420.8	92	2457.2	46633.1		
			su1	196	200	5	2509.7	46794.9	98	2449.9	45896.6		
			su2	226	230	5	2508.4	46670.4	80	2449.0	45780.2		
			su3	257	261	5	2507.4	46565.2	91	2451.7	45744.4		
			au1	288	292	5	2507.8	46606.5	81	2454.8	45825.7		
			au2	318	322	5	2509.4	46762.9	78	2448.9	45850.0		
			au3	349	353	5	2514.4	47376.7	111	2454.7	46447.9		
						Avg	2472.6	46869.9		2428.4	46186.9	44.2	683.0
Species	Year	Tonnage	Season	Begin Day	End Day	# Days	HUAREA-WO	HUVOL-WO	# Tows	HUAREA-WI	HUVOL-WI	HUAREACHG	HUVOLCHG
6	1996	5	sp1	140	144	5	3303.3	63341.1	9	3246.9	62206.4		
			sp2	150	154	5	3300.2	63091.7	14	3200.0	61073.1		
			sp3	160	164	5	3297.6	62871.1	16	3164.4	60208.9		
						Avg	3300.4	63101.3		3203.8	61162.8	96.6	1938.5
		10	sp1	140	144	5	3303.3	63341.1	23	3137.4	59975.7		
			sp2	150	154	5	3300.2	63091.7	28	3096.2	58949.8		
			sp3	160	164	5	3297.6	62871.1	30	3000.7	56929.0		
						Avg	3300.4	63101.3		3078.1	58618.2	222.3	4483.1
		15	sp1	140	144	5	3303.3	63341.1	34	3047.6	58137.0		
			sp2	150	154	5	3300.2	63091.7	49	2943.9	55834.0		
			sp3	160	164	5	3297.6	62871.1	43	2902.6	54916.9		
						Avg	3300.4	63101.3		2964.7	56296.0	335.7	6805.3
		20	sp1	140	144	5	3303.3	63341.1	44	3001.5	57179.8		
			sp2	150	154	5	3300.2	63091.7	67	2830.2	53487.9		
			sp3	160	164	5	3297.6	62871.1	52	2874.0	54328.3		
						Avg	3300.4	63101.3		2901.9	54998.7	398.5	8102.6
		25	sp1	140	144	5	3303.3	63341.1	94	2572.5	48229.6		
			sp2	150	154	5	3300.2	63091.7	85	2701.6	50792.2		
			sp3	160	164	5	3297.6	62871.1	76	2758.6	51904.5		
						Avg	3300.4	63101.3		2677.6	50308.8	622.8	12792.5
		30	sp1	140	144	5	3303.3	63341.1	85	2699.8	50931.8		
			sp2	150	154	5	3300.2	63091.7	104	2596.9	48575.6		
			sp3	160	164	5	3297.6	62871.1	73	2809.3	52933.6		
						Avg	3300.4	63101.3		2702.0	50813.7	598.4	12287.6
		35	sp1	140	144	5	3303.3	63341.1	107	2696.2	50793.2		
			sp2	150	154	5	3300.2	63091.7	106	2589.0	48471.8		
			sp3	160	164	5	3297.6	62871.1	90	2656.1	49766.3		
						Avg	3300.4	63101.3		2647.1	49677.1	653.3	13424.2
		40	sp1	140	144	5	3303.3	63341.1	126	2476.7	46132.2		
			sp2	150	154	5	3300.2	63091.7	119	2518.4	46965.2		
			sp3	160	164	5	3297.6	62871.1	89	2675.2	50152.1		
						Avg	3300.4	63101.3		2556.8	47749.8	743.6	15351.5

(Sheet 9 of 19)

Table 11 (Continued)

Species	Year	Tonnage	Season	Begin Day	End Day	# Days	HUAREA-WO	HUVOL-WO	# Tows	HUAREA-WI	HUVOL-WI	HUAREACHG	HUVOLCHG
6	2000	5	sp1	140	144	5	3303.3	63341.1	7	3209.5	61448.4		
			sp2	150	154	5	3300.2	63091.7	10	3197.5	61021.3		
			sp3	160	164	5	3297.6	62871.1	9	3177.3	60458.6		
						Avg	3300.4	63101.3		3194.8	60976.1	105.6	2125.2
		10	sp1	140	144	5	3303.3	63341.1	17	3118.1	59600.4		
			sp2	150	154	5	3300.2	63091.7	24	3043.7	57907.7		
			sp3	160	164	5	3297.6	62871.1	16	3111.8	59136.0		
						Avg	3300.4	63101.3		3091.2	58881.4	209.2	4219.9
		15	sp1	140	144	5	3303.3	63341.1	23	3011.9	57426.9		
			sp2	150	154	5	3300.2	63091.7	33	2946.1	55908.0		
			sp3	160	164	5	3297.6	62871.1	31	2983.1	56528.5		
						Avg	3300.4	63101.3		2980.4	56621.1	320.0	6480.2
		20	sp1	140	144	5	3303.3	63341.1	35	2930.7	55759.0		
			sp2	150	154	5	3300.2	63091.7	36	2934.3	55664.0		
			sp3	160	164	5	3297.6	62871.1	39	2893.8	54704.5		
						Avg	3300.4	63101.3		2919.6	55375.8	380.8	7725.5
		25	sp1	140	144	5	3303.3	63341.1	46	2833.6	53715.5		
			sp2	150	154	5	3300.2	63091.7	52	2747.5	51798.8		
			sp3	160	164	5	3297.6	62871.1	53	2752.7	51853.4		
						Avg	3300.4	63101.3		2777.9	52455.9	522.4	10645.4
		30	sp1	140	144	5	3303.3	63341.1	49	2828.5	53591.4		
			sp2	150	154	5	3300.2	63091.7	54	2826.1	53412.8		
			sp3	160	164	5	3297.6	62871.1	40	2826.4	53306.2		
						Avg	3300.4	63101.3		2827.0	53436.8	473.4	9664.5
		35	sp1	140	144	5	3303.3	63341.1	69	2661.8	50147.3		
			sp2	150	154	5	3300.2	63091.7	72	2652.2	49840.8		
			sp3	160	164	5	3297.6	62871.1	66	2720.3	51127.4		
						Avg	3300.4	63101.3		2678.1	50371.8	622.3	12729.5
		40	sp1	140	144	5	3303.3	63341.1	72	2672.6	50334.3		
			sp2	150	154	5	3300.2	63091.7	88	2548.4	47693.6		
			sp3	160	164	5	3297.6	62871.1	83	2605.1	48707.4		
						Avg	3300.4	63101.3		2608.7	48911.8	691.7	14189.5

Species	Year	Tonnage	Season	Begin Day	End Day	# Days	HUAREA-WO	HUVOL-WO	# Tows	HUAREA-WI	HUVOL-WI	HUAREACHG	HUVOLCHG
7	1996	5	sp1	84	88	5	2544.7	52458.2	14	2043.7	43615.2		
			sp2	94	98	5	2563.1	52596.8	13	2202.3	46431.1		
			sp3	104	108	5	2569.9	52532.9	25	2108.5	44760.9		
						Avg	2559.2	52529.3		2118.2	44935.7	441.1	7593.6
		10	sp1	84	88	5	2544.7	52458.2	24	2154.9	45666.4		
			sp2	94	98	5	2563.1	52596.8	33	2031.2	43107.0		
			sp3	104	108	5	2569.9	52532.9	36	2048.2	43691.8		
						Avg	2559.2	52529.3		2078.1	44155.1	481.1	8374.2
		15	sp1	84	88	5	2544.7	52458.2	40	1890.6	40704.5		
			sp2	94	98	5	2563.1	52596.8	54	1927.2	41341.3		
			sp3	104	108	5	2569.9	52532.9	52	1849.4	39973.6		
						Avg	2559.2	52529.3		1889.1	40673.1	670.2	11856.2
		20	sp1	84	88	5	2544.7	52458.2	57	1827.5	39512.7		
			sp2	94	98	5	2563.1	52596.8	67	1840.3	39721.1		
			sp3	104	108	5	2569.9	52532.9	60	1833.3	39729.1		
						Avg	2559.2	52529.3		1833.7	39654.3	725.5	12875.0

(Sheet 10 of 19)

Table 11 (Continued)

		25	sp1	84	88	5	2544.7	52458.2	93	1785.0	38550.9		
			sp2	94	98	5	2563.1	52596.8	82	1734.3	37830.7		
			sp3	104	108	5	2569.9	52532.9	65	1855.6	39999.4		
						Avg	2559.2	52529.3		1791.6	38793.7	767.6	13735.6
		30	sp1	84	88	5	2544.7	52458.2	97	1692.7	37007.3		
			sp2	94	98	5	2563.1	52596.8	92	1831.4	39610.6		
			sp3	104	108	5	2569.9	52532.9	85	1799.1	38917.3		
						Avg	2559.2	52529.3		1774.4	38511.7	784.8	14017.6
		35	sp1	84	88	5	2544.7	52458.2	115	1792.6	38900.2		
			sp2	94	98	5	2563.1	52596.8	92	1732.1	37716.0		
			sp3	104	108	5	2569.9	52532.9	119	1863.6	40392.7		
						Avg	2559.2	52529.3		1796.1	39003.0	763.1	13526.3
		40	sp1	84	88	5	2544.7	52458.2	123	1692.4	37024.6		
			sp2	94	98	5	2563.1	52596.8	126	1809.6	39284.8		
			sp3	104	108	5	2569.9	52532.9	121	1734.7	37859.9		
						Avg	2559.2	52529.3		1745.6	38056.4	813.7	14472.9
Species	Year	Tonnage	Season	Begin Day	End Day	# Days	HUAREA-WO	HUVOL-WO	# Tows	HUAREA-WI	HUVOL-WI	HUAREACHG	HUVOLCHG
7	2000	5	sp1	84	88	5	2544.7	52458.2	8	1912.1	41293.0		
			sp2	94	98	5	2563.1	52596.8	6	2074.5	44286.2		
			sp3	104	108	5	2569.9	52532.9	8	2017.6	43117.6		
						Avg	2559.2	52529.3		2001.4	42898.9	557.8	9630.4
		10	sp1	84	88	5	2544.7	52458.2	17	1792.8	39193.8		
			sp2	94	98	5	2563.1	52596.8	21	1603.5	35535.1		
			sp3	104	108	5	2569.9	52532.9	19	1672.1	37138.8		
						Avg	2559.2	52529.3		1689.5	37289.2	869.8	15240.1
		15	sp1	84	88	5	2544.7	52458.2	25	1711.7	37659.6		
			sp2	94	98	5	2563.1	52596.8	29	1486.0	33509.7		
			sp3	104	108	5	2569.9	52532.9	28	1461.1	32736.1		
						Avg	2559.2	52529.3		1552.9	34635.1	1006.3	17894.2
		20	sp1	84	88	5	2544.7	52458.2	34	1574.6	34951.9		
			sp2	94	98	5	2563.1	52596.8	40	1435.9	32276.9		
			sp3	104	108	5	2569.9	52532.9	41	1395.1	31335.8		
						Avg	2559.2	52529.3		1468.5	32854.9	1090.7	19674.4
		25	sp1	84	88	5	2544.7	52458.2	47	1523.0	34050.1		
			sp2	94	98	5	2563.1	52596.8	42	1448.4	32558.5		
			sp3	104	108	5	2569.9	52532.9	46	1443.5	32272.3		
						Avg	2559.2	52529.3		1471.6	32960.3	1087.6	19569.0
		30	sp1	84	88	5	2544.7	52458.2	67	1399.6	31711.0		
			sp2	94	98	5	2563.1	52596.8	62	1337.2	30137.8		
			sp3	104	108	5	2569.9	52532.9	50	1457.8	32735.5		
						Avg	2559.2	52529.3		1398.2	31528.1	1161.0	21001.2
		35	sp1	84	88	5	2544.7	52458.2	70	1423.7	31740.4		
			sp2	94	98	5	2563.1	52596.8	70	1318.9	29767.9		
			sp3	104	108	5	2569.9	52532.9	74	1443.2	32757.8		
						Avg	2559.2	52529.3		1395.3	31422.0	1164.0	21107.3
		40	sp1	84	88	5	2544.7	52458.2	76	1410.3	31625.7		
			sp2	94	98	5	2563.1	52596.8	72	1393.2	31666.1		
			sp3	104	108	5	2569.9	52532.9	69	1238.7	28367.7		
						Avg	2559.2	52529.3		1347.4	30553.2	1211.8	21976.1

(Sheet 11 of 19)

Table 11 (Continued)

Species	Year	Tonnage	Season	Begin Day	End Day	# Days	HUAREA-WO	HUVOL-WO	# Tows	HUAREA-WI	HUVOL-WI	HUAREACHG	HUVOLCHG
8	1996	5	sp1	110	114	5	3315.2	64435.5	11	3223.8	62547.9		
			sp2	120	124	5	3311.3	64047.9	16	3222.3	62207.2		
			sp3	130	134	5	3307.2	63678.4	17	3189.0	61269.3		
						Avg	3311.2	64053.9		3211.7	62008.1	99.5	2045.8
		10	sp1	110	114	5	3315.2	64435.5	32	3035.4	58621.8		
			sp2	120	124	5	3311.3	64047.9	31	3072.9	59115.9		
			sp3	130	134	5	3307.2	63678.4	24	3076.6	58959.5		
						Avg	3311.2	64053.9		3061.6	58899.1	249.6	5154.9
		15	sp1	110	114	5	3315.2	64435.5	50	2966.2	57140.2		
			sp2	120	124	5	3311.3	64047.9	49	2918.2	55885.4		
			sp3	130	134	5	3307.2	63678.4	39	2956	56444.2		
						Avg	3311.2	64053.9		2946.8	56489.9	364.4	7564.0
		20	sp1	110	114	5	3315.2	64435.5	67	2834.7	54370.5		
			sp2	120	124	5	3311.3	64047.9	59	2866.5	54790.9		
			sp3	130	134	5	3307.2	63678.4	58	2861.9	54469.7		
						Avg	3311.2	64053.9		2854.4	54543.7	456.9	9510.2
		25	sp1	110	114	5	3315.2	64435.5	66	2769.6	52938.7		
			sp2	120	124	5	3311.3	64047.9	78	2782.3	53010.9		
			sp3	130	134	5	3307.2	63678.4	79	2742	51968		
						Avg	3311.2	64053.9		2764.6	52639.2	546.6	11414.7
		30	sp1	110	114	5	3315.2	64435.5	87	2762.3	52798.9		
			sp2	120	124	5	3311.3	64047.9	93	2726.3	51808		
			sp3	130	134	5	3307.2	63678.4	89	2704.5	51131.9		
						Avg	3311.2	64053.9		2731.0	51912.9	580.2	12141.0
		35	sp1	110	114	5	3315.2	64435.5	108	2612.5	49604.2		
			sp2	120	124	5	3311.3	64047.9	103	2691	51062		
			sp3	130	134	5	3307.2	63678.4	118	2527.1	47363.6		
						Avg	3311.2	64053.9		2610.2	49343.3	701.0	14710.7
		40	sp1	110	114	5	3315.2	64435.5	108	2595.6	49259.7		
			sp2	120	124	5	3311.3	64047.9	123	2610.1	49276.4		
			sp3	130	134	5	3307.2	63678.4	107	2618.1	49335.5		
						Avg	3311.2	64053.9		2607.9	49290.5	703.3	14763.4
Species	Year	Tonnage	Season	Begin Day	End Day	# Days	HUAREA-WO	HUVOL-WO	# Tows	HUAREA-WI	HUVOL-WI	HUAREACHG	HUVOLCHG
8	2000	5	sp1	110	114	5	3315.2	64435.5	11	3186.0	61758.0		
			sp2	120	124	5	3311.3	64047.9	14	3092.8	59528.7		
			sp3	130	134	5	3307.2	63678.4	9	3193.9	61374.1		
						Avg	3311.2	64053.9		3157.6	60886.9	153.7	3167.0
		10	sp1	110	114	5	3315.2	64435.5	17	3115.9	60283		
			sp2	120	124	5	3311.3	64047.9	25	3028.4	58160.4		
			sp3	130	134	5	3307.2	63678.4	19	3093.3	59300		
						Avg	3311.2	64053.9		3079.2	59247.8	232.0	4806.1
		15	sp1	110	114	5	3315.2	64435.5	28	3032.5	58534.9		
			sp2	120	124	5	3311.3	64047.9	33	2907.4	55665.6		
			sp3	130	134	5	3307.2	63678.4	25	3050.7	58442.8		
						Avg	3311.2	64053.9		2996.9	57547.8	314.4	6506.2
		20	sp1	110	114	5	3315.2	64435.5	39	2928.7	56337.3		
			sp2	120	124	5	3311.3	64047.9	45	2805.4	53507.0		
			sp3	130	134	5	3307.2	63678.4	35	2954.7	56450.5		
						Avg	3311.2	64053.9		2896.3	55431.6	415.0	8622.3

(Sheet 12 of 19)

Table 11 (Continued)

		25	sp1	110	114	5	3315.2	64435.5	62	2792.9	53434.7		
			sp2	120	124	5	3311.3	64047.9	58	2781.3	53018.5		
			sp3	130	134	5	3307.2	63678.4	49	2799.3	53160.4		
						Avg	3311.2	64053.9		2791.2	53204.5	520.1	10849.4
		30	sp1	110	114	5	3315.2	64435.5	68	2712	51733.3		
			sp2	120	124	5	3311.3	64047.9	71	2683.9	50928.1		
			sp3	130	134	5	3307.2	63678.4	65	2712.8	51388.2		
						Avg	3311.2	64053.9		2702.9	51349.9	608.3	12704.1
		35	sp1	110	114	5	3315.2	64435.5	80	2603.5	49457.2		
			sp2	120	124	5	3311.3	64047.9	70	2626.2	49711.4		
			sp3	130	134	5	3307.2	63678.4	72	2590.1	48800.1		
						Avg	3311.2	64053.9		2606.6	49322.9	704.6	14731.0
		40	sp1	110	114	5	3315.2	64435.5	84	2604.7	49470.3		
			sp2	120	124	5	3311.3	64047.9	86	2533.2	47774.9		
			sp3	130	134	5	3307.2	63678.4	81	2626.6	49537.3		
						Avg	3311.2	64053.9		2588.2	48927.5	723.1	15126.4

Species	Year	Tonnage	Season	Begin Day	End Day	# Days	HUAREA-WO	HUVOL-WO	# Tows	HUAREA-WI	HUVOL-WI	HUAREACHG	HUVOLCHG
9	1996	5	sp1	154	158	5	211.5	935.5	15	211.5	935.5		
			sp2	164	168	5	213.7	951.2	11	213.7	951.2		
			sp3	174	178	5	216.1	967.2	13	216.1	967.2		
						Avg	213.8	951.3		213.8	951.3	0.0	0.0
		20	sp1	154	158	5	211.5	935.5	68	211.5	935.5		
			sp2	164	168	5	213.7	951.2	58	213.7	951.2		
			sp3	174	178	5	216.1	967.2	55	216.1	967.2		
						Avg	213.8	951.3		213.8	951.3	0.0	0.0
		40	sp1	154	158	5	211.5	935.5	124	211.5	935.5		
			sp2	164	168	5	213.7	951.2	121	213.7	951.2		
			sp3	174	178	5	216.1	967.2	138	216.1	967.2		
						Avg	213.8	951.3		213.8	951.3	0.0	0.0

Species	Year	Tonnage	Season	Begin Day	End Day	# Days	HUAREA-WO	HUVOL-WO	# Tows	HUAREA-WI	HUVOL-WI	HUAREACHG	HUVOLCHG
9	2000	5	sp1	154	158	5	211.5	935.5	13	211.5	935.5		
			sp2	164	168	5	213.7	951.2	12	213.7	951.2		
			sp3	174	178	5	216.1	967.2	10	216.1	967.2		
						Avg	213.8	951.3		213.8	951.3	0.0	0.0
		20	sp1	154	158	5	211.5	935.5	39	211.5	935.5		
			sp2	164	168	5	213.7	951.2	35	213.7	951.2		
			sp3	174	178	5	216.1	967.2	40	216.1	967.2		
						Avg	213.8	951.3		213.8	951.3	0.0	0.0
		40	sp1	154	158	5	211.5	935.5	81	211.4	935.5		
			sp2	164	168	5	213.7	951.2	57	213.7	951.2		
			sp3	174	178	5	216.1	967.2	90	216.0	967.2		
						Avg	213.8	951.3		213.7	951.3	0.1	0.0

(Sheet 13 of 19)

Table 11 (Continued)

Species	Year	Tonnage	Season	Begin Day	End Day	# Days	HUAREA-WO	HUVOL-WO	# Tows	HUAREA-WI	HUVOL-WI	HUAREACHG	HUVOLCHG
10	1996	5	sp1	124	128	5	114.9	388.8	13	114.9	388.8		
			sp2	134	138	5	123.2	469.0	12	123.2	469.0		
			sp3	144	148	5	139.6	655.0	11	139.6	655.0		
						Avg	125.9	504.3		125.9	504.3	0.0	0.0
		20	sp1	124	128	5	114.9	388.8	62	114.9	388.8		
			sp2	134	138	5	123.2	469.0	48	123.1	469.0		
			sp3	144	148	5	139.6	655.0	58	139.6	655.0		
						Avg	125.9	504.3		125.9	504.3	0.0	0.0
		40	sp1	124	128	5	114.9	388.8	127	114.9	388.8		
			sp2	134	138	5	123.2	469.0	123	123.2	469.0		
			sp3	144	148	5	139.6	655.0	112	139.6	655.0		
						Avg	125.9	504.3		125.9	504.3	0.0	0.0
Species	Year	Tonnage	Season	Begin Day	End Day	# Days	HUAREA-WO	HUVOL-WO	# Tows	HUAREA-WI	HUVOL-WI	HUAREACHG	HUVOLCHG
10	2000	5	sp1	124	128	5	114.9	388.8	10	114.9	388.8		
			sp2	134	138	5	123.2	469.0	6	123.1	468.8		
			sp3	144	148	5	139.6	655.0	4	139.5	655.0		
						Avg	125.9	504.3		125.8	504.2	0.1	0.1
		20	sp1	124	128	5	114.9	388.8	43	114.7	388.6		
			sp2	134	138	5	123.2	469.0	42	123.1	468.8		
			sp3	144	148	5	139.6	655.0	38	139.3	653.2		
						Avg	125.9	504.3		125.7	503.5	0.2	0.7
		40	sp1	124	128	5	114.9	388.8	78	114.8	388.6		
			sp2	134	138	5	123.2	469.0	87	122.9	468.6		
			sp3	144	148	5	139.6	655.0	92	138.4	637.4		
						Avg	125.9	504.3		125.4	498.2	0.5	6.1
Species	Year	Tonnage	Season	Begin Day	End Day	# Days	HUAREA-WO	HUVOL-WO	# Tows	HUAREA-WI	HUVOL-WI	HUAREACHG	HUVOLCHG
11	1996	5	sp1	140	144	5	165.0	1198.9	9	165.0	1198.9		
			sp2	150	154	5	211.6	2190.7	14	211.6	2190.7		
			sp3	160	164	5	302.0	4445.5	16	302.0	4445.5		
						Avg	226.2	2611.7		226.2	2611.7	0.0	0.0
		20	sp1	140	144	5	165.0	1198.9	44	165.0	1198.8		
			sp2	150	154	5	211.6	2190.7	67	211.6	2190.7		
			sp3	160	164	5	302.0	4445.5	52	302.0	4445.5		
						Avg	226.2	2611.7		226.2	2611.7	0.0	0.0
		40	sp1	140	144	5	165.0	1198.9	126	165.0	1198.8		
			sp2	150	154	5	211.6	2190.7	119	211.6	2190.7		
			sp3	160	164	5	302.0	4445.5	89	302.0	4445.4		
						Avg	226.2	2611.7		226.2	2611.6	0.0	0.1
Species	Year	Tonnage	Season	Begin Day	End Day	# Days	HUAREA-WO	HUVOL-WO	# Tows	HUAREA-WI	HUVOL-WI	HUAREACHG	HUVOLCHG
11	2000	5	sp1	140	144	5	165.0	1198.9	7	165.0	1198.8		
			sp2	150	154	5	211.6	2190.7	10	211.6	2190.6		
			sp3	160	164	5	302.0	4445.5	9	302.0	4445.4		
						Avg	226.2	2611.7		226.2	2611.6	0.0	0.1
		20	sp1	140	144	5	165.0	1198.9	35	165.0	1198.8		
			sp2	150	154	5	211.6	2190.7	36	211.6	2190.5		
			sp3	160	164	5	302.0	4445.5	39	302.0	4445.4		
						Avg	226.2	2611.7		226.2	2611.6	0.0	0.1
		40	sp1	140	144	5	165.0	1198.9	72	165.0	1198.6		
			sp2	150	154	5	211.6	2190.7	88	211.6	2190.5		
			sp3	160	164	5	302.0	4445.5	83	302.0	4445.2		
						Avg	226.2	2611.7		226.2	2611.4	0.0	0.3

(Sheet 14 of 19)

Table 11 (Continued)

Species	Year	Tonnage	Season	Begin Day	End Day	# Days	HUAREA-WO	HUVOL-WO	# Tows	HUAREA-WI	HUVOL-WI	HUAREACHG	HUVOLCHG
12	1996	5	wi1	14	18	5	365.8	4497.2	8	365.8	4497.1		
			wi2	44	48	5	243.1	1800.1	12	243.1	1800.1		
			wi3	73	77	5	193.0	1025.3	17	193.0	1025.3		
			sp1	124	128	5	351.2	4125.6	13	351.2	4125.6		
			sp2	134	138	5	432.1	6132.6	12	432.1	6132.6		
			sp3	144	148	5	590.9	10149.0	11	590.9	10149.0		
			su1	196	200	5	1814.4	35913.9	16	1814.2	35910.9		
			su2	226	230	5	2019.6	39092.8	19	2019.3	39089.6		
			su3	257	261	5	2208.4	41845.6	18	2207.7	41837.1		
			au1	288	292	5	2099.2	40265.3	21	2099.0	40262.2		
			au2	318	322	5	1647.6	32530.0	19	1647.4	32526.4		
			au3	349	353	5	748.2	13697.2	15	748.2	13697.1		
						Avg	1059.5	19256.2		1059.3	19254.4	0.1	1.8
		20	wi1	14	18	5	365.8	4497.2	39	365.8	4497.1		
			wi2	44	48	5	243.1	1800.1	61	243.1	1800.1		
			wi3	73	77	5	193.0	1025.3	64	193.0	1025.3		
			sp1	124	128	5	351.2	4125.6	62	351.2	4125.6		
			sp2	134	138	5	432.1	6132.6	48	432.1	6132.6		
			sp3	144	148	5	590.9	10149.0	58	590.9	10149.0		
			su1	196	200	5	1814.4	35913.9	72	1813.6	35901.3		
			su2	226	230	5	2019.6	39092.8	62	2018.6	39076.6		
			su3	257	261	5	2208.4	41845.6	70	2206.5	41818.1		
			au1	288	292	5	2099.2	40265.3	66	2098.4	40254.0		
			au2	318	322	5	1647.6	32530.0	74	1647.2	32522.4		
			au3	349	353	5	748.2	13697.2	68	748.2	13697.1		
						Avg	1059.5	19256.2		1059.1	19249.9	0.4	6.3
		40	wi1	14	18	5	365.8	4497.2	129	365.8	4497.2		
			wi2	44	48	5	243.1	1800.1	113	243.1	1800.1		
			wi3	73	77	5	193.0	1025.3	117	193.0	1025.3		
			sp1	124	128	5	351.2	4125.6	127	351.2	4125.6		
			sp2	134	138	5	432.1	6132.6	123	432.1	6132.6		
			sp3	144	148	5	590.9	10149.0	112	590.9	10149.0		
			su1	196	200	5	1814.4	35913.9	145	1813.5	35898.2		
			su2	226	230	5	2019.6	39092.8	109	2018.1	39069.0		
			su3	257	261	5	2208.4	41845.6	134	2205.2	41797.9		
			au1	288	292	5	2099.2	40265.3	118	2097.0	40232.0		
			au2	318	322	5	1647.6	32530.0	117	1647.1	32520.6		
			au3	349	353	5	748.2	13697.2	146	748.2	13697.1		
						Avg	1059.5	19256.2		1058.8	19245.4	0.7	10.8

Species	Year	Tonnage	Season	Begin Day	End Day	# Days	HUAREA-WO	HUVOL-WO	# Tows	HUAREA-WI	HUVOL-WI	HUAREACHG	HUVOLCHG
12	2000	5	wi1	14	18	5	365.8	4497.2	12	365.8	4497.2		
			wi2	44	48	5	243.1	1800.1	9	243.1	1800.1		
			wi3	73	77	5	193.0	1025.3	13	193.0	1025.2		
			sp1	124	128	5	351.2	4125.6	10	351.2	4125.5		
			sp2	134	138	5	432.1	6132.6	6	432.1	6132.6		
			sp3	144	148	5	590.9	10149.0	4	590.9	10149.0		
			su1	196	200	5	1814.4	35913.9	10	1814.1	35908.9		
			su2	226	230	5	2019.6	39092.8	11	2019.1	39085.2		
			su3	257	261	5	2208.4	41845.6	15	2204.2	41782.0		
			au1	288	292	5	2099.2	40265.3	13	2097.6	40242.6		
			au2	318	322	5	1647.6	32530.0	11	1647.2	32523.6		
			au3	349	353	5	748.2	13697.2	9	748.2	13697.1		
						Avg	1059.5	19256.2		1058.9	19247.4	0.6	8.8
		20	wi1	14	18	5	365.8	4497.2	45	365.8	4497.0		
			wi2	44	48	5	243.1	1800.1	34	243.1	1799.8		
			wi3	73	77	5	193.0	1025.3	40	193.0	1025.2		
			sp1	124	128	5	351.2	4125.6	43	351.2	4125.1		
			sp2	134	138	5	432.1	6132.6	42	432.1	6132.5		
			sp3	144	148	5	590.9	10149.0	38	590.8	10148.8		
			su1	196	200	5	1814.4	35913.9	45	1812.7	35886.9		
			su2	226	230	5	2019.6	39092.8	52	2016.1	39036.6		
			su3	257	261	5	2208.4	41845.6	43	2201.2	41735.9		
			au1	288	292	5	2099.2	40265.3	43	2094.2	40187.3		
			au2	318	322	5	1647.6	32530.0	37	1646.3	32508.0		
			au3	349	353	5	748.2	13697.2	43	748.1	13696.8		
						Avg	1059.5	19256.2		1057.9	19231.7	1.6	24.6

(Sheet 15 of 19)

Table 11 (Continued)

		40	wi1	14	18	5	365.8	4497.2	71	365.8	4496.9		
			wi2	44	48	5	243.1	1800.1	94	243.1	1799.7		
			wi3	73	77	5	193.0	1025.3	85	193.0	1025.1		
			sp1	124	128	5	351.2	4125.6	78	351.2	4125.0		
			sp2	134	138	5	432.1	6132.6	87	432.0	6131.7		
			sp3	144	148	5	590.9	10149.0	92	590.8	10148.0		
			su1	196	200	5	1814.4	35913.9	98	1810.8	35853.7		
			su2	226	230	5	2019.6	39092.8	80	2013.4	38993.0		
			su3	257	261	5	2208.4	41845.6	91	2199.8	41714.2		
			au1	288	292	5	2099.2	40265.3	81	2092.5	40161.8		
			au2	318	322	5	1647.6	32530.0	78	1644.9	32484.7		
			au3	349	353	5	748.2	13697.2	111	748.1	13695.8		
						Avg	1059.5	19256.2		1057.1	19219.1	2.3	37.1
Species	Year	Tonnage	Season	Begin Day	End Day	# Days	HUAREA-WO	HUVOL-WO	# Tows	HUAREA-WI	HUVOL-WI	HUAREACHG	HUVOLCHG
13	1996	5	wi1	14	18	5	1244.6	24173.9	8	1244.5	24171.6		
			wi2	44	48	5	1012.3	19975.3	12	1012.2	19974.7		
			wi3	73	77	5	754.5	14665.2	17	754.4	14664.1		
			sp1	124	128	5	1244.5	24087.8	13	1244.4	24085.5		
			sp2	134	138	5	1334.9	25542.8	12	1334.8	25540.4		
			sp3	144	148	5	1406.9	26672.4	11	1406.8	26670.4		
			su1	196	200	5	1626.5	30196.6	16	1626.4	30193.7		
			su2	226	230	5	1649.8	30582.1	19	1649.6	30579.0		
			su3	257	261	5	1676.6	31045.1	18	1676.3	31041.2		
			au1	288	292	5	1660.4	30757.4	21	1660.2	30754.7		
			au2	318	322	5	1605.7	29710.2	19	1605.3	29704.1		
			au3	349	353	5	1494.0	27962.3	15	1493.8	27959.1		
						Avg	1392.6	26280.9		1392.4	26278.2	0.2	2.7
		20	wi1	14	18	5	1244.6	24173.9	39	1244.3	24169.3		
			wi2	44	48	5	1012.3	19975.3	61	1012.2	19974.1		
			wi3	73	77	5	754.5	14665.2	64	754.4	14662.9		
			sp1	124	128	5	1244.5	24087.8	62	1244.3	24083.5		
			sp2	134	138	5	1334.9	25542.8	48	1334.7	25538.1		
			sp3	144	148	5	1406.9	26672.4	58	1406.6	26666.7		
			su1	196	200	5	1626.5	30196.6	72	1625.5	30181.4		
			su2	226	230	5	1649.8	30582.1	62	1648.9	30569.7		
			su3	257	261	5	1676.6	31045.1	70	1675.6	31030.4		
			au1	288	292	5	1660.4	30757.4	66	1659.7	30748.3		
			au2	318	322	5	1605.7	29710.2	74	1604.8	29696.3		
			au3	349	353	5	1494.0	27962.3	68	1493.5	27953.0		
						Avg	1392.6	26280.9		1392.0	26272.8	0.5	8.1
		40	wi1	14	18	5	1244.6	24173.9	129	1244.3	24168.2		
			wi2	44	48	5	1012.3	19975.3	113	1012.2	19973.9		
			wi3	73	77	5	754.5	14665.2	117	754.3	14662.4		
			sp1	124	128	5	1244.5	24087.8	127	1244.2	24082.4		
			sp2	134	138	5	1334.9	25542.8	123	1334.5	25535.3		
			sp3	144	148	5	1406.9	26672.4	112	1406.4	26664.2		
			su1	196	200	5	1626.5	30196.6	145	1624.9	30173.5		
			su2	226	230	5	1649.8	30582.1	109	1648.4	30561.7		
			su3	257	261	5	1676.6	31045.1	134	1674.8	31019.9		
			au1	288	292	5	1660.4	30757.4	118	1658.6	30733.4		
			au2	318	322	5	1605.7	29710.2	117	1604.4	29691.2		
			au3	349	353	5	1494.0	27962.3	146	1493.2	27949.1		
						Avg	1392.6	26280.9		1391.7	26267.9	0.9	13.0

(Sheet 16 of 19)

Table 11 (Continued)

Species	Year	Tonnage	Season	Begin Day	End Day	# Days	HUAREA-WO	HUVOL-WO	# Tows	HUAREA-WI	HUVOL-WI	HUAREACHG	HUVOLCHG
13	2000	5	wi1	14	18	5	1244.6	24173.9	12	1244.4	24170.4		
			wi2	44	48	5	1012.3	19975.3	9	1012.2	19974.7		
			wi3	73	77	5	754.5	14665.2	13	754.4	14664.0		
			sp1	124	128	5	1244.5	24087.8	10	1244.2	24082.8		
			sp2	134	138	5	1334.9	25542.8	6	1334.8	25540.3		
			sp3	144	148	5	1406.9	26672.4	4	1406.7	26669.6		
			su1	196	200	5	1626.5	30196.6	10	1626.1	30190.5		
			su2	226	230	5	1649.8	30582.1	11	1649.5	30577.5		
			su3	257	261	5	1676.6	31045.1	15	1674.9	31020.7		
			au1	288	292	5	1660.4	30757.4	13	1659.5	30744.7		
			au2	318	322	5	1605.7	29710.2	11	1605.0	29699.1		
			au3	349	353	5	1494.0	27962.3	9	1493.8	27958.4		
						Avg	1392.6	26280.9		1392.1	26274.4	0.4	6.5
		20	wi1	14	18	5	1244.6	24173.9	45	1244.0	24164.0		
			wi2	44	48	5	1012.3	19975.3	34	1012.1	19972.5		
			wi3	73	77	5	754.5	14665.2	40	754.3	14662.4		
			sp1	124	128	5	1244.5	24087.8	43	1243.9	24076.7		
			sp2	134	138	5	1334.9	25542.8	42	1334.3	25531.9		
			sp3	144	148	5	1406.9	26672.4	38	1405.8	26654.6		
			su1	196	200	5	1626.5	30196.6	45	1624.3	30164.3		
			su2	226	230	5	1649.8	30582.1	52	1647.5	30548.0		
			su3	257	261	5	1676.6	31045.1	43	1673.6	31001.2		
			au1	288	292	5	1660.4	30757.4	43	1657.3	30713.7		
			au2	318	322	5	1605.7	29710.2	37	1603.7	29679.4		
			au3	349	353	5	1494.0	27962.3	43	1492.5	27937.8		
						Avg	1392.6	26280.9		1391.1	26258.9	1.4	22.0
		40	wi1	14	18	5	1244.6	24173.9	71	1243.7	24158.1		
			wi2	44	48	5	1012.3	19975.3	94	1011.8	19966.6		
			wi3	73	77	5	754.5	14665.2	85	754.3	14662.1		
			sp1	124	128	5	1244.5	24087.8	78	1243.6	24072.9		
			sp2	134	138	5	1334.9	25542.8	87	1333.3	25515.6		
			sp3	144	148	5	1406.9	26672.4	92	1404.9	26640.8		
			su1	196	200	5	1626.5	30196.6	98	1622.1	30130.6		
			su2	226	230	5	1649.8	30582.1	80	1645.4	30516.4		
			su3	257	261	5	1676.6	31045.1	91	1672.8	30989.1		
			au1	288	292	5	1660.4	30757.4	81	1656.2	30697.7		
			au2	318	322	5	1605.7	29710.2	78	1601.4	29645.6		
			au3	349	353	5	1494.0	27962.3	111	1490.7	27909.7		
						Avg	1392.6	26280.9		1390.0	26242.1	2.5	38.8
Species	Year	Tonnage	Season	Begin Day	End Day	# Days	HUAREA-WO	HUVOL-WO	# Tows	HUAREA-WI	HUVOL-WI	HUAREACHG	HUVOLCHG
14	1996	5	sp1	124	128	5	226.0	1874.7	13	101.3	963.4		
			sp2	134	138	5	266.1	2723.1	12	123.7	1479.2		
			sp3	144	148	5	343.5	4550.5	11	189.5	2683.9		
						Avg	278.5	3049.4		138.2	1708.8	140.4	1340.6
		10	sp1	124	128	5	226.0	1874.7	26	70.2	685.8		
			sp2	134	138	5	266.1	2723.1	22	104.1	1244.1		
			sp3	144	148	5	343.5	4550.5	32	121.9	1788.7		
						Avg	278.5	3049.4		98.7	1239.5	179.8	1809.9
		15	sp1	124	128	5	226.0	1874.7	52	62	575.8		
			sp2	134	138	5	266.1	2723.1	33	92.7	1118.1		
			sp3	144	148	5	343.5	4550.5	44	123.3	1705.9		
						Avg	278.5	3049.4		92.7	1133.3	185.9	1916.2
		20	sp1	124	128	5	226.0	1874.7	62	55.8	519.8		
			sp2	134	138	5	266.1	2723.1	48	66.4	818.3		
			sp3	144	148	5	343.5	4550.5	58	96.4	1370.1		
						Avg	278.5	3049.4		72.9	902.7	205.7	2146.7

(Sheet 17 of 19)

Table 11 (Continued)

		25	sp1	124	128	5	226.0	1874.7	75	53.7	512.9		
			sp2	134	138	5	266.1	2723.1	84	60.2	682		
			sp3	144	148	5	343.5	4550.5	74	95.4	1333.7		
						Avg	278.5	3049.4		69.8	842.9	208.8	2206.6
		30	sp1	124	128	5	226.0	1874.7	90	46.1	450.4		
			sp2	134	138	5	266.1	2723.1	114	54.3	622.3		
			sp3	144	148	5	343.5	4550.5	73	80.2	1179.5		
						Avg	278.5	3049.4		60.2	750.7	218.3	2298.7
		35	sp1	124	128	5	226.0	1874.7	106	46.9	452.1		
			sp2	134	138	5	266.1	2723.1	102	55.7	651.5		
			sp3	144	148	5	343.5	4550.5	119	73.7	1039.4		
						Avg	278.5	3049.4		58.8	714.3	219.8	2335.1
		40	sp1	124	128	5	226.0	1874.7	127	45.1	426.9		
			sp2	134	138	5	266.1	2723.1	123	53.2	607.2		
			sp3	144	148	5	343.5	4550.5	112	76.5	1053.4		
						Avg	278.5	3049.4		58.3	695.8	220.3	2353.6
Species	Year	Tonnage	Season	Begin Day	End Day	# Days	HUAREA-WO	HUVOL-WO	# Tows	HUAREA-WI	HUVOL-WI	HUAREACHG	HUVOLCHG
14	2000	5	sp1	124	128	5	226.0	1874.7	10	80.9	795.1		
			sp2	134	138	5	266.1	2723.1	6	147.8	1734.9		
			sp3	144	148	5	343.5	4550.5	4	229.6	3338.1		
						Avg	278.5	3049.4		152.8	1956.0	125.8	1093.4
		10	sp1	124	128	5	226.0	1874.7	21	56.8	594.8		
			sp2	134	138	5	266.1	2723.1	21	91.5	1041.2		
			sp3	144	148	5	343.5	4550.5	19	91.9	1522.9		
						Avg	278.5	3049.4		80.1	1053.0	198.5	1996.5
		15	sp1	124	128	5	226.0	1874.7	29	43.3	459.2		
			sp2	134	138	5	266.1	2723.1	35	52.3	672.8		
			sp3	144	148	5	343.5	4550.5	25	80.1	1273.9		
						Avg	278.5	3049.4		58.6	802.0	220.0	2247.5
		20	sp1	124	128	5	226.0	1874.7	43	36.8	382.6		
			sp2	134	138	5	266.1	2723.1	42	48.5	621.6		
			sp3	144	148	5	343.5	4550.5	38	59.7	925.3		
						Avg	278.5	3049.4		48.3	643.2	230.2	2406.3
		25	sp1	124	128	5	226.0	1874.7	55	36.6	376.4		
			sp2	134	138	5	266.1	2723.1	57	41.3	539		
			sp3	144	148	5	343.5	4550.5	51	66.5	993.9		
						Avg	278.5	3049.4		48.1	636.4	230.4	2413.0
		30	sp1	124	128	5	226.0	1874.7	74	24.5	260.1		
			sp2	134	138	5	266.1	2723.1	50	43.3	538.2		
			sp3	144	148	5	343.5	4550.5	75	44.6	656.6		
						Avg	278.5	3049.4		37.5	485.0	241.1	2564.5
		35	sp1	124	128	5	226.0	1874.7	69	31.8	332.8		
			sp2	134	138	5	266.1	2723.1	82	29.9	366.4		
			sp3	144	148	5	343.5	4550.5	86	40.1	587.8		
						Avg	278.5	3049.4		33.9	429.0	244.6	2620.4
		40	sp1	124	128	5	226.0	1874.7	78	30.4	314.3		
			sp2	134	138	5	266.1	2723.1	87	28.2	350.6		
			sp3	144	148	5	343.5	4550.5	92	36.7	549.9		
						Avg	278.5	3049.4		31.8	404.9	246.8	2644.5

(Sheet 18 of 19)

Table 11 (Concluded)

Species	Year	Tonnage	Season	Begin Day	End Day	# Days	HUAREA-WO	HUVOL-WO	# Tows	HUAREA-WI	HUVOL-WI	HUAREACHG	HUVOLCHG
15	1996	5	sp1	124	128	5	384.6	3266.5	13	384.6	3266.3		
			sp2	134	138	5	430.8	3886.7	12	430.8	3886.4		
			sp3	144	148	5	476.8	4494.6	11	476.8	4494.4		
			su1	196	200	5	642.9	6598.8	16	642.8	6597.3		
			su2	226	230	5	662.2	6818.5	19	662.1	6816.3		
			su3	257	261	5	680.7	7032.1	18	680.5	7029.3		
			au1	288	292	5	670.4	6910.4	21	670.3	6908.7		
			au2	318	322	5	640.0	6557.0	19	639.7	6553.5		
			au3	349	353	5	545.8	5417.2	15	545.8	5416.2		
						Avg	570.5	5664.6		570.4	5663.2	0.1	1.5
		20	sp1	124	128	5	384.6	3266.5	62	384.6	3266.1		
			sp2	134	138	5	430.8	3886.7	48	430.7	3886.1		
			sp3	144	148	5	476.8	4494.6	58	476.7	4493.4		
			su1	196	200	5	642.9	6598.8	72	642.3	6590.0		
			su2	226	230	5	662.2	6818.5	62	661.7	6811.0		
			su3	257	261	5	680.7	7032.1	70	679.9	7022.2		
			au1	288	292	5	670.4	6910.4	66	670.0	6904.2		
			au2	318	322	5	640.0	6557.0	74	639.4	6549.0		
			au3	349	353	5	545.8	5417.2	68	545.6	5413.8		
						Avg	570.5	5664.6		570.1	5659.5	0.4	5.1
		40	sp1	124	128	5	384.6	3266.5	127	384.5	3265.5		
			sp2	134	138	5	430.8	3886.7	123	430.7	3885.0		
			sp3	144	148	5	476.8	4494.6	112	476.6	4492.3		
			su1	196	200	5	642.9	6598.8	145	641.9	6584.8		
			su2	226	230	5	662.2	6818.5	109	661.3	6806.0		
			su3	257	261	5	680.7	7032.1	134	679.4	7015.0		
			au1	288	292	5	670.4	6910.4	118	669.3	6894.6		
			au2	318	322	5	640.0	6557.0	117	639.2	6545.9		
			au3	349	353	5	545.8	5417.2	146	545.5	5412.0		
						Avg	570.5	5664.6		569.8	5655.7	0.6	9.0
Species	Year	Tonnage	Season	Begin Day	End Day	# Days	HUAREA-WO	HUVOL-WO	# Tows	HUAREA-WI	HUVOL-WI	HUAREACHG	HUVOLCHG
15	2000	5	sp1	124	128	5	384.6	3266.5	10	384.6	3265.8		
			sp2	134	138	5	430.8	3886.7	6	430.8	3886.4		
			sp3	144	148	5	476.8	4494.6	4	476.7	4493.8		
			su1	196	200	5	642.9	6598.8	10	642.6	6595.2		
			su2	226	230	5	662.2	6818.5	11	662.1	6816.2		
			su3	257	261	5	680.7	7032.1	15	679.7	7018.2		
			au1	288	292	5	670.4	6910.4	13	669.9	6902.6		
			au2	318	322	5	640.0	6557.0	11	639.6	6551.1		
			au3	349	353	5	545.8	5417.2	9	545.8	5416.0		
						Avg	570.5	5664.6		570.2	5660.6	0.3	4.1
		20	sp1	124	128	5	384.6	3266.5	43	384.5	3264.8		
			sp2	134	138	5	430.8	3886.7	42	430.6	3884.3		
			sp3	144	148	5	476.8	4494.6	38	476.4	4489.1		
			su1	196	200	5	642.9	6598.8	45	641.6	6580.8		
			su2	226	230	5	662.2	6818.5	52	660.9	6800.0		
			su3	257	261	5	680.7	7032.1	43	678.9	7007.1		
			au1	288	292	5	670.4	6910.4	43	668.5	6884.8		
			au2	318	322	5	640.0	6557.0	37	638.9	6541.4		
			au3	349	353	5	545.8	5417.2	43	545.2	5408.2		
						Avg	570.5	5664.6		569.5	5651.2	1.0	13.5
		40	sp1	124	128	5	384.6	3266.5	78	384.4	3263.7		
			sp2	134	138	5	430.8	3886.7	87	430.3	3880.2		
			sp3	144	148	5	476.8	4494.6	92	476.1	4484.8		
			su1	196	200	5	642.9	6598.8	98	640.4	6564.3		
			su2	226	230	5	662.2	6818.5	80	659.6	6782.6		
			su3	257	261	5	680.7	7032.1	91	678.3	6999.9		
			au1	288	292	5	670.4	6910.4	81	667.8	6875.1		
			au2	318	322	5	640.0	6557.0	78	637.6	6523.6		
			au3	349	353	5	545.8	5417.2	111	544.4	5396.7		
						Avg	570.5	5664.6		568.8	5641.2	1.7	23.4

(Sheet 19 of 19)

Table 12
Effects of Project

Species	% Habitat Unit Change (Change in Habitat Units = SI × Acres)		
	5 MT	**20 MT**	**40 MT**
1. Emerald Shiner (spawning)***	-5.4(-48.3)	-12.2(-102)	-18.1(-148)
2. Emerald Shiner (fry)**	-0.6(-5.0)	-0.2(-2.1)	1.6(12)
3. Paddlefish (spawning)***	-10.5(-244)	-11.3(-238)	-14.7(-293)
4. Paddlefish (larval)**	1.2(40)	-0.2(-6.3)	-1.8(-47)
5. Freshwater Drum (adult food)*	-0.3(-7.0)	-0.9(-21)	-1.2(-30)
6. Freshwater Drum (larval)**	-0.3(-9.0)	0.6(18)	2(52)
7. Sauger (spawning)***	-5.5(-117)	-19.9(-365)	-22.8(-398)
8. Sauger (larval)**	-1.7(-54)	1.5(42)	-0.8(-20)
9. Channel Catfish*	0(0)	0(0)	0(-0.1)
10. Black Crappie (spawning)*	-0.1(-0.1)	-0.1(-0.2)	-0.4(-0.5)
11. Black Crappie (fry)*	0(0)	0(0)	0(0)
12. Black Crappie (juv. Food)*	0(-0.5)	-0.1(-1.2)	-0.2(-1.6)
13. Black Crappie (adult food)*	0(-0.3)	-0.1(-0.9)	-0.1(-1.7)
14. Spotted Bass (spawning)***	10.6(15)	-33.7(-25)	-45.5(-27)
15. Spotted Bass (juv. food)*	0(-0.2)	-0.1(-0.6)	-0.2(-1.1)

Note: Percent habitat unit change based on [(area habitat units in 2000)-(area habitat units in 1996)]/[area habitat units in 1996] and area habitat unit change equal to 2000 area habitat units – 1996 area habitat units. Note that changes are the result of fleet characteristic changes due to project conditions, not increases in traffic.
*Slackwater group
**Swiftwater larval/fry
***Swiftwater spawning

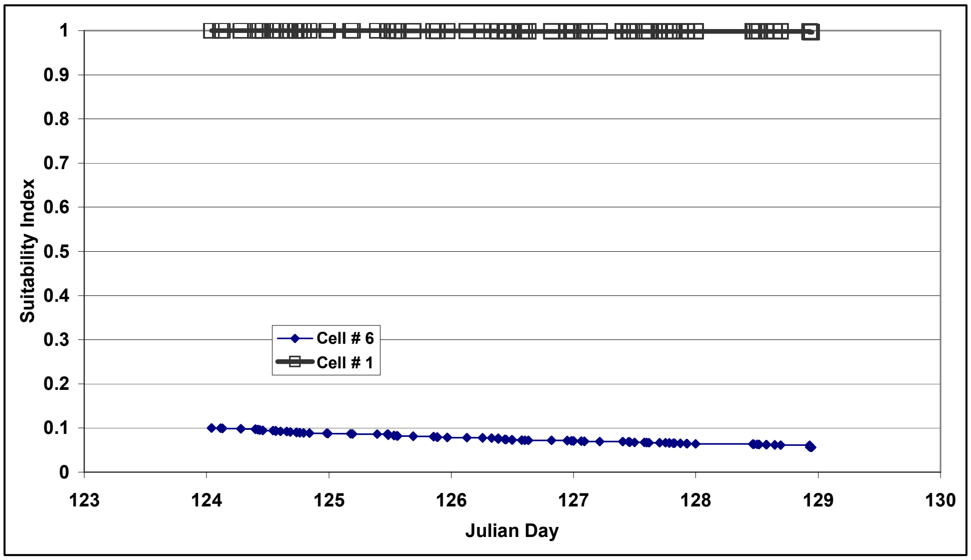


Figure 25. Variation of SI over flow window for emerald shiner fry index resulting from propeller entrainment

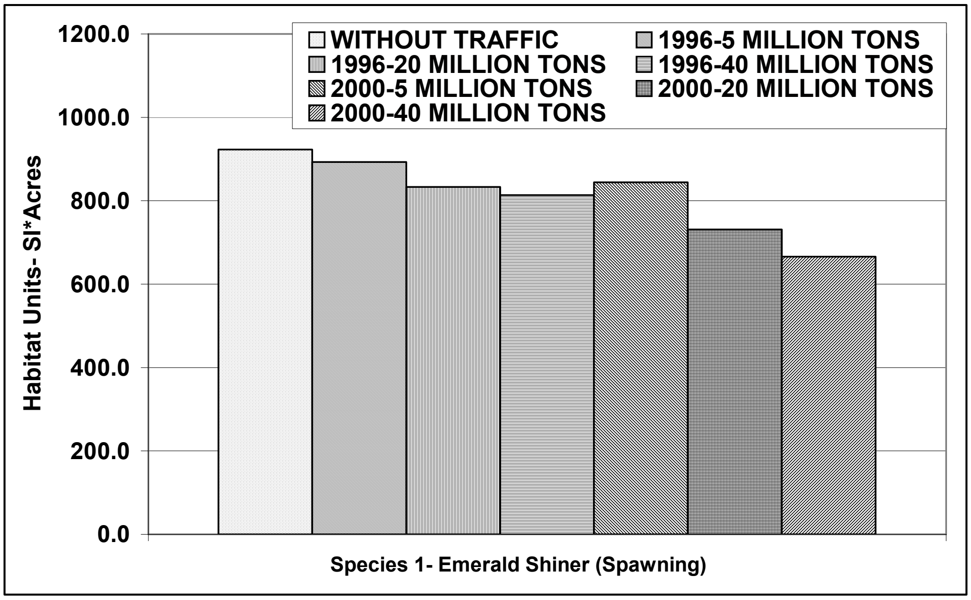


Figure 26. Habitat units for species 1 – emerald shiner (spawning)

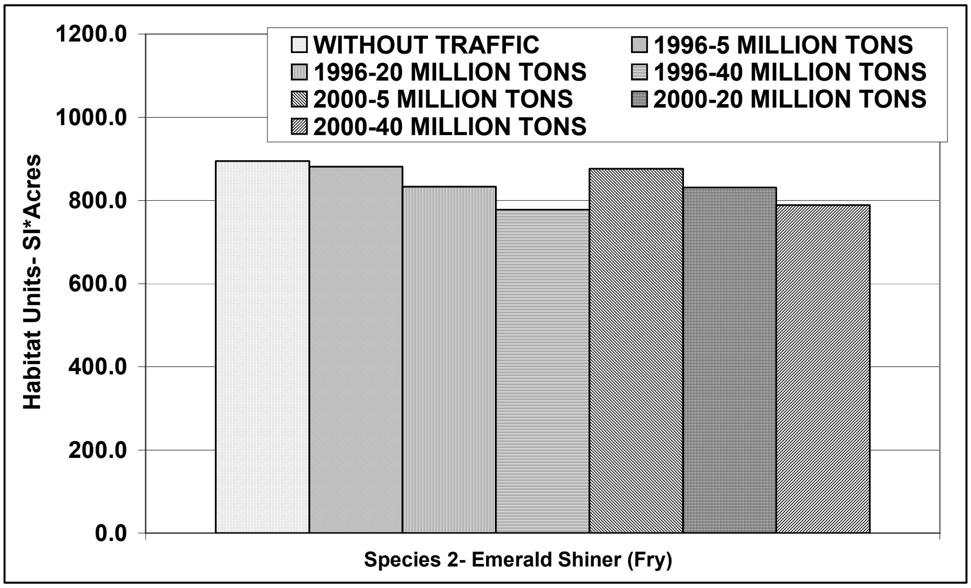


Figure 27. Habitat units for species 2 – emerald shiner (fry index)

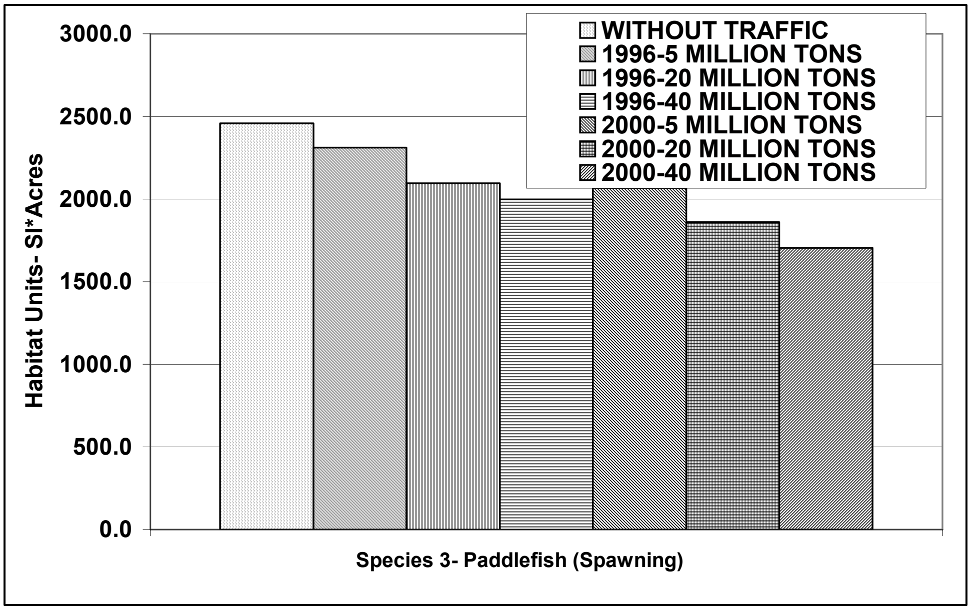


Figure 28. Habitat units for species 3 – paddlefish (spawning)

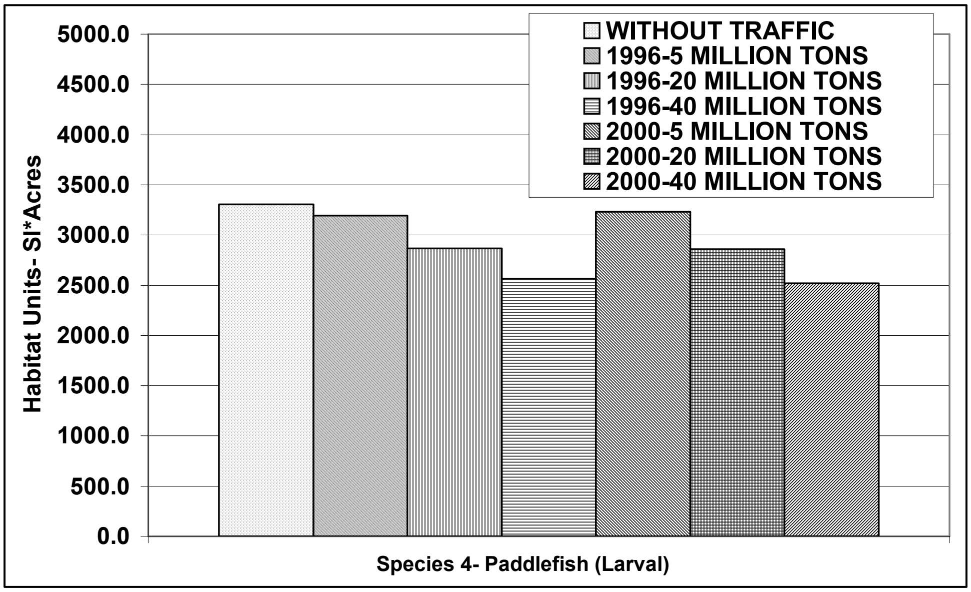


Figure 29. Habitat units for species 4 – paddlefish (larval)

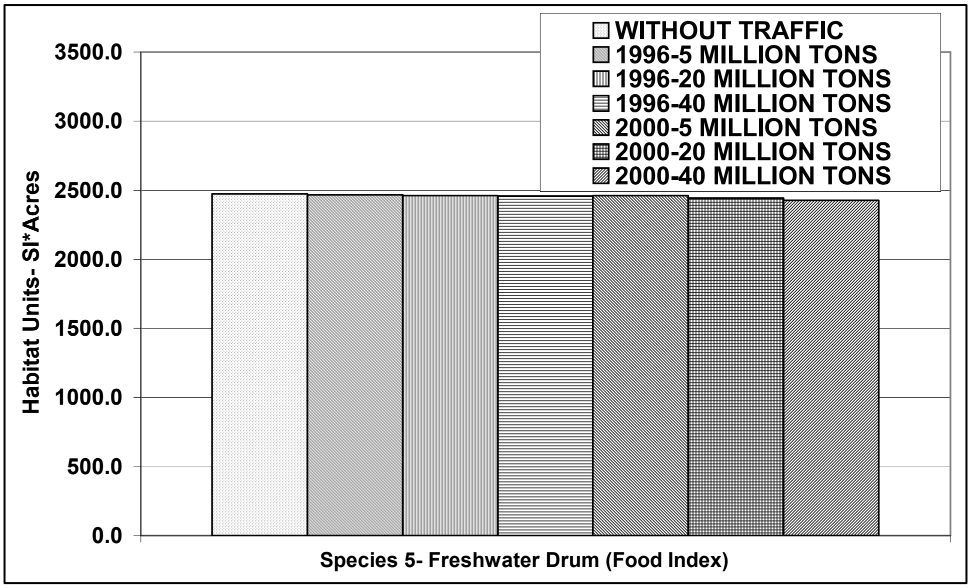


Figure 30. Habitat units for species 5 – freshwater drum (food index)

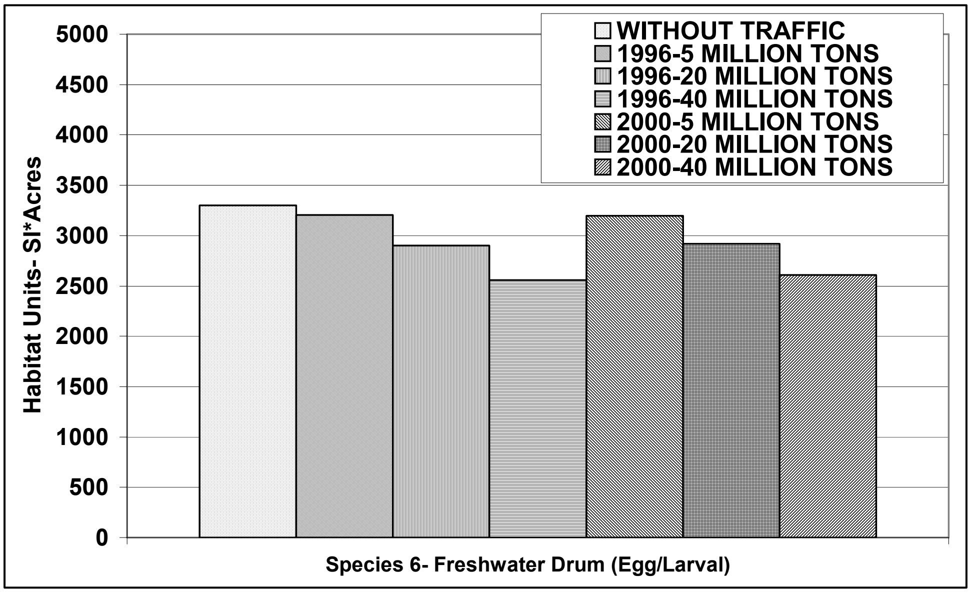


Figure 31. Habitat units for species 6 – freshwater drum (egg/larval)

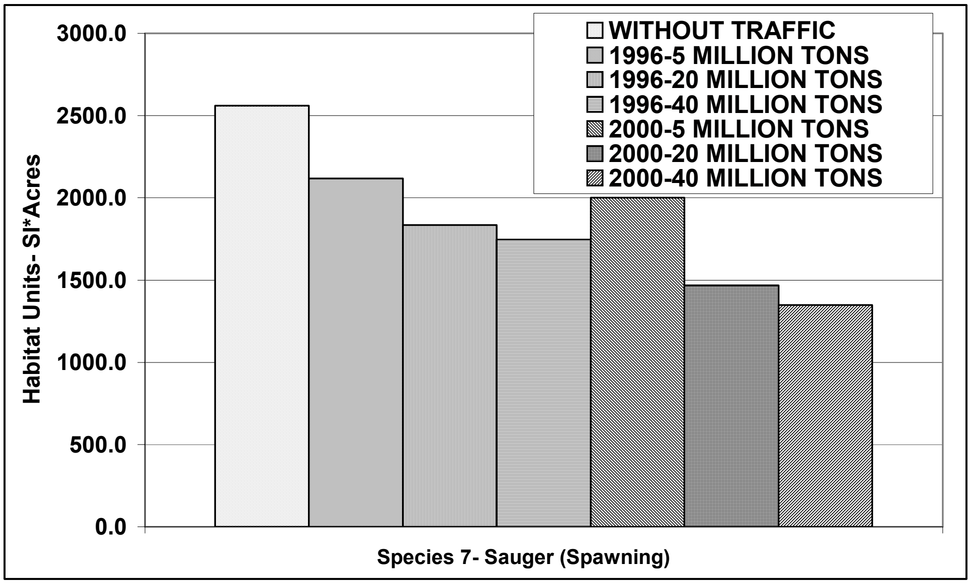


Figure 32. Habitat units for species 7 – sauger (spawning)

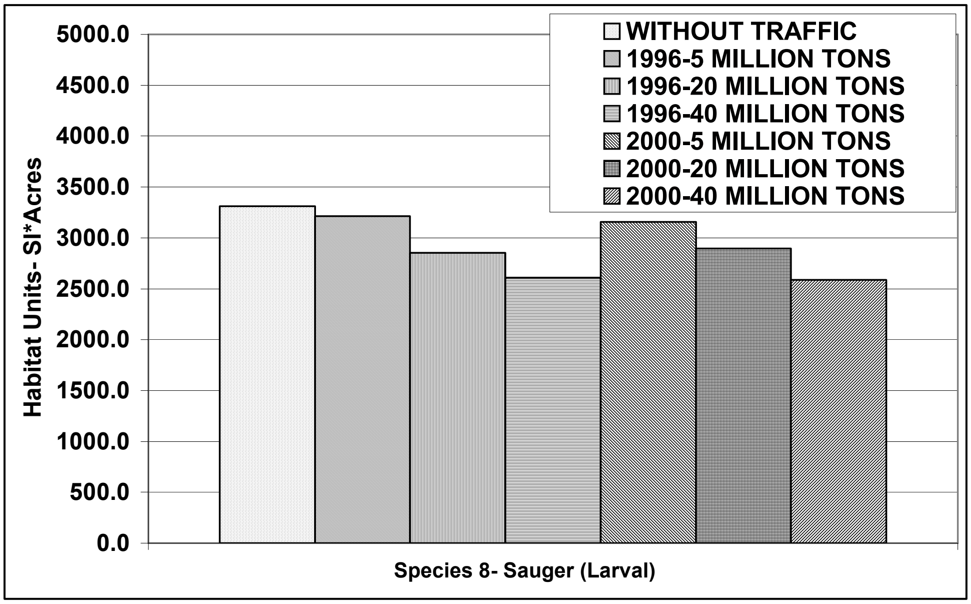


Figure 33. Habitat units for species 8 – sauger (larval)

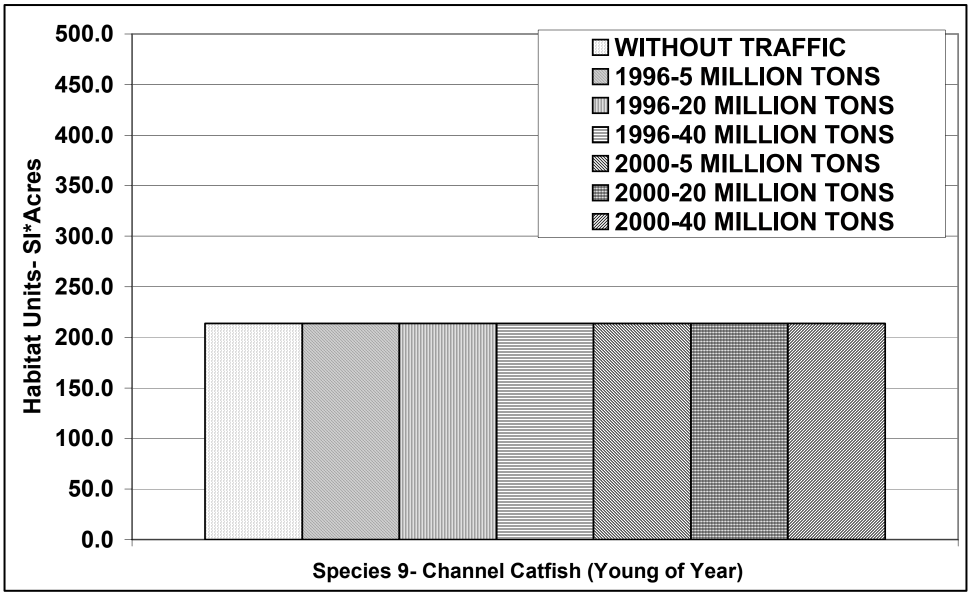


Figure 34. Habitat units for species 9 – channel catfish (young of year)

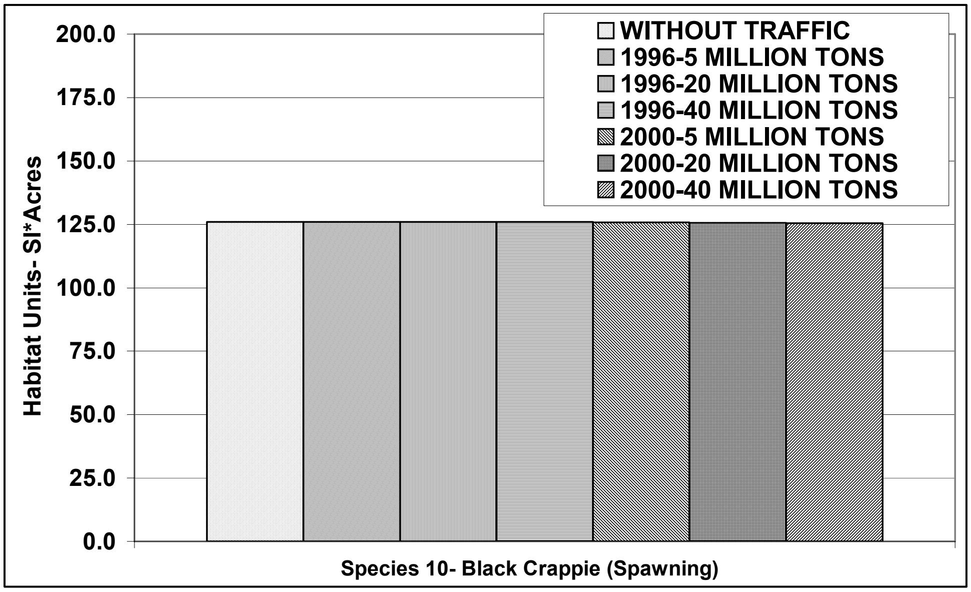


Figure 35. Habitat units for species 10 – black crappie (spawning)

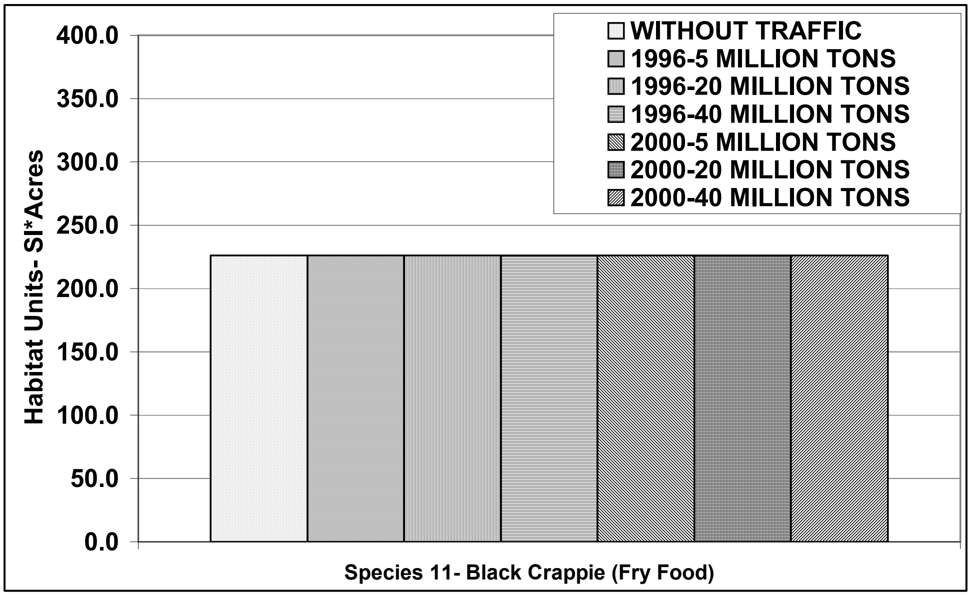


Figure 36. Habitat units for species 11 – black crappie (fry food)

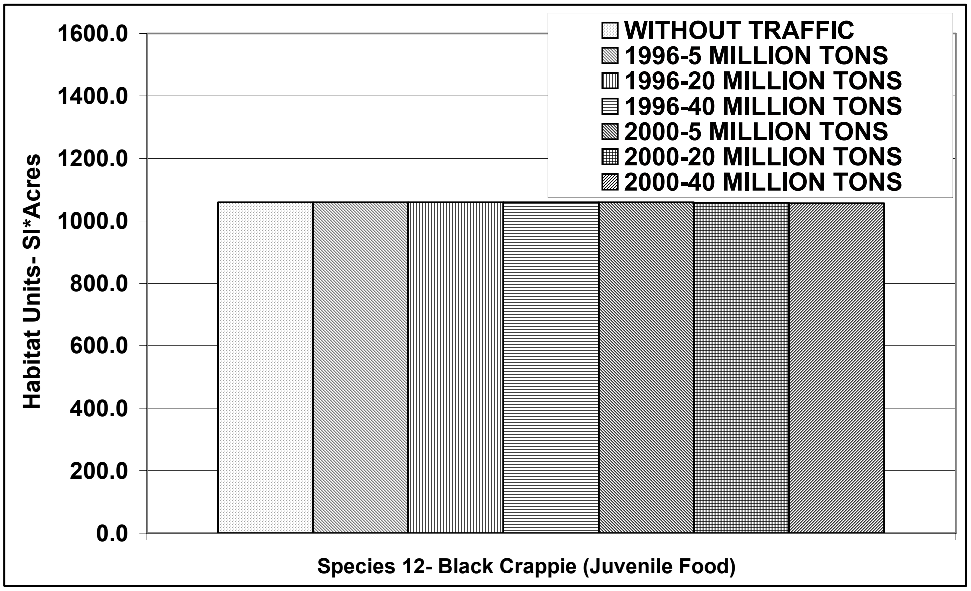


Figure 37. Habitat units for species 12 – black crappie (juvenile food)

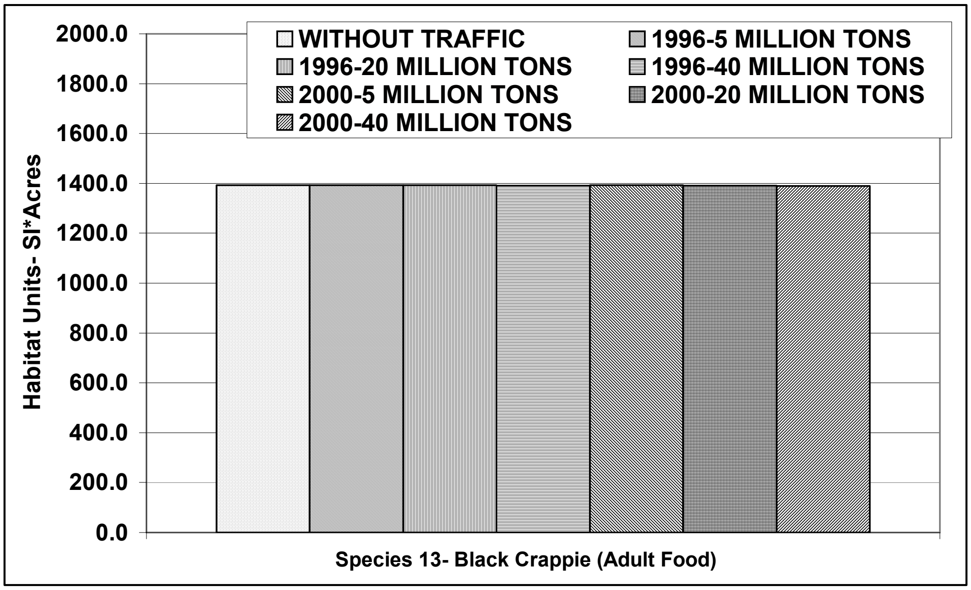


Figure 38. Habitat units for species 13 – black crappie (adult food)

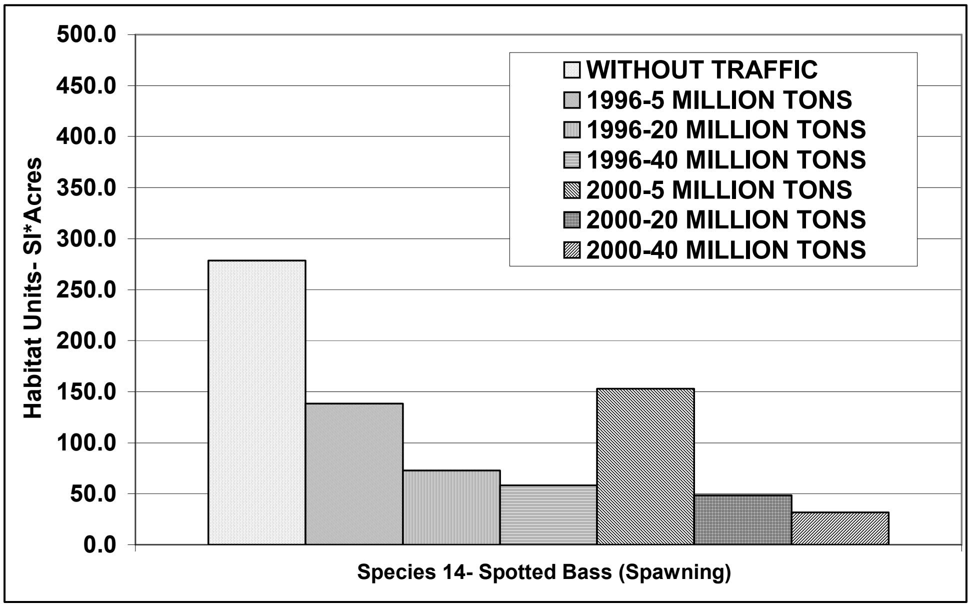


Figure 39. Habitat units for species 14 – spotted bass (spawning)

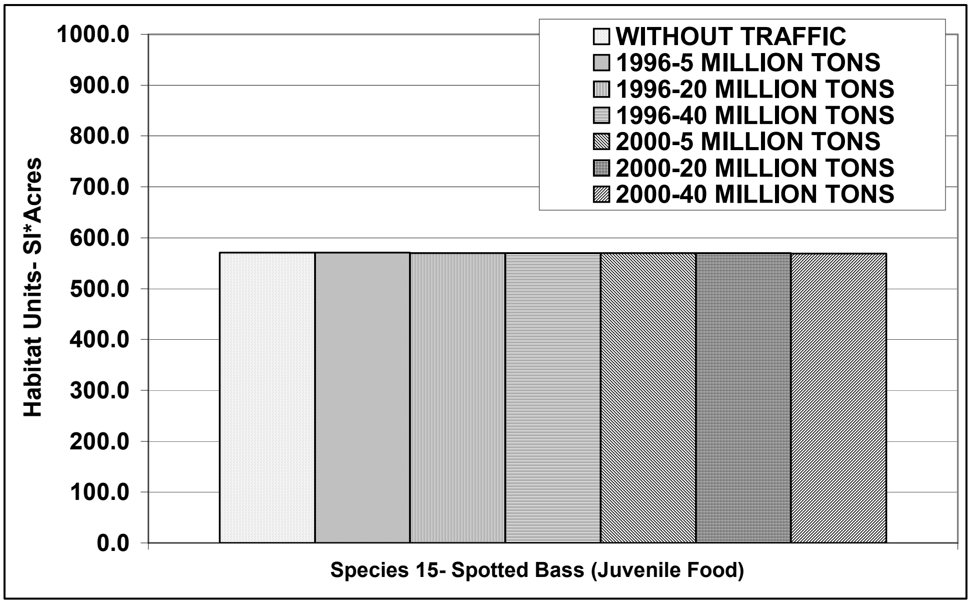


Figure 40. Habitat units for species 15 – spotted bass (juvenile food)

9 Evaluation of NAVPAT Habitat Relationships

NAVPAT output for each alternative was reviewed and summarized as part of the evaluation of the Winfield Pool navigation project. For this analysis, seven fish species were evaluated, some represented by multiple life stages (spawning, fry) and functions (feeding), resulting in a total of 15 iterations for each alternative. The seven species were emerald shiner, paddlefish, freshwater drum, sauger, channel catfish, black crappie, and spotted bass. In addition to summarizing NAVPAT results on the various fish species/life stages, recommendations were provided on model improvements and applicability.

Ecological Guild

The seven fish species were placed into an ecological guild of all fishes known to occur in the lower Mississippi/Ohio River systems (Table 13). This approach provides more of a community-level perspective rather than a single-species approach. Guilds were arranged by preferred spawning substrates (vertical axis), velocity preference of juveniles and adults (horizontal axis), and tolerance ranking (generalists/invasive). Reproductive strategy of fishes was included for species that release floating eggs (i.e., pelagic spawners) and those that deposit demersal and often adhesive eggs over sand, gravel, and vegetation. These modes of reproduction can be influenced by navigation traffic through scour and shoreline dewatering. Another category included species that hide their eggs in crevices. Habitat preference was delineated according to swiftwater, slackwater, and wetland/backwater inhabitants. In addition, those species that tolerate a wide range of habitat conditions with no well-defined preference were placed into the “Generalist” guild. This arrangement resulted in 14 functional guild cells that represented the broad range of reproductive requirements and habitat preferences of the fish assemblage in large navigable rivers.

Table 13
Species Guilds for Fishes of the Lower Mississippi River and Ohio River Basins

	Generalist/Invasive	Slackwater	Swiftwater	Wetland/Backwater
Pelagic	Gizzard shad, *Dorosoma cepedianum* Grass carp, *Ctenopharyngodon idella* Silver carp, *Hypophthalmichthys molitrix* Bighead carp, *Hypophthalmichthys nobilis* Western mosquitofish, *Gambusia affinis*	Threadfin shad, *D. petenense* Miss. Silvery minnow, *Hybognathus nuchalis* Plains minnow, *H. placitus*	Goldeye, *Hiodon alosoides* Mooneye, *Hiodon. Tergisus* American eel, *Anguilla rostrata*[1] Alabama shad, ***Alosa alabamae*** Skipjack herring, *A. chrysochloris* **Emerald shiner, *N. atherinoldes*** River shiner, *N. blennius* Mimic shiner, *N. volucellus* Silverband shiner, *N. shumardi* Channel shiner, *N. wickliffi* **Freshwater drum, *Aplodinotus grunniens***	
Vegetation	Common carp, *Cyprinus carpio* Golden shiner, *Notemigonus crysoleucas*	Shortnose gar, *L. platostomus* Alligator gar, ***L. spatula*** Inland silverside, *Menidia beryllina* Bigmouth buffalo, *I. cyprinellus*	Longnose gar, *L. osseus* Smallmouth buffalo, *Ictiobus bubalus* Black buffalo, *I. niger*	Spotted gar, *Lepisosteus oculatus* Bowfin, *Amia calva* Brook silverside, *Labidesthes sicculus* Grass pickerel, *Esox americanus* Chain pickerel, *E. niger* Taillight shiner, *Notropis maculatus* Weed shiner, *N. texanus* Golden topminnow, *Fundulus chrysotus* Blackspotted topminnow, *F. olivaceus* Starhead topminnow, *F. dispar* Blackstripe topminnow, *F. notatus*
Crevice	**Channel catfish, *Ictalurus punctatus*** Red shiner, *Cyprinella lutrensis* Bullhead minnow, *Pimephales vigilax*		Stonecat, *Noturus flavus* Freckled madtom, *N. nocturnus* Blue catfish, *Ictalurus furcatus* Flathead catfish, *Pylodictis olivaris* Whitetail shiner, *Cyprinella galactura* Blacktail shiner, *C. venusta* Steelcolor shiner, *C. whipplei*	Pugnose minnow, *Opsopoeodus emiliae* Pirate perch, *Aphredoderus sayanus*

Note: Guilds were arranged by preferred spawning substrates (vertical axis), velocity preference of juveniles and adults (horizontal axis), and tolerance ranking (generalists/invasive). Boldfaced species are the evaluation species used in NAVPAT. Species are arranged in phylogenic and alphabetic order within a guild cell.

[1] Does not spawn in the Mississippi or Ohio Rivers.

(Continued)

Table 13 (Concluded)

	Generalist/Invasive	Slackwater	Swiftwater	Wetland/Backwater
Sand and Gravel	Green sunfish, *Lepomis cyanellus* Orangespotted sunfish, *L. humilus* Bluegill, *L. macrochirus*	Spotted sucker, *Minytrema melanops* Ribbon shiner, *Lythrurus fumeus* Redfin shiner, *L. umbratilis* Weed shiner, *N. texanus* Bullhead minnow, *Pimephales notatus* Redear, *L. microlophus* Largemouth bass, *Micropterus salmoides* White crappie, *Pomoxis annularis* **Black crappie, *Pomoxis nigromaculatus***	Chestnut lamprey, *Ichthyomyzon castaneus* **Paddlefish, *Polyodon spathula*** Pallid sturgeon, ***Scaphirhynchus albus*** Shovelnose sturgeon, *S. platorynchus* River carpsucker, *Carpiodes carpio* Quillback, *Carpiodes cyprinus* Highfin carpsucker, *C. velifer* Blue sucker, *Cycleptus elongatus* Northern hog sucker, *Hypentelium nigricans* Golden redhorse, *Maxostoma erythrurum* Shorthead redhorse, *Maxostoma macrolepidotum* Rainbow smelt, *Osmerus mordax* Central stoneroller, *Campostoma anomalum* Gravel chub, *Erimystax x-punctatus* Speckled chub, *Macrhybopsis aestivalis* Sturgeon chub, *M. gelida* Sicklefin chub, *M. meeki* Silver chub, *Macrhybopsis storeriana* Pallid shiner, *Notropis amnis* Ghost shiner, *N. buchanani* Spottail shiner, *N. hudsonius* Sabine shiner, *N. sabinae* Flathead chub, *Platygobio gracilis* White bass, *Morone chrysops* Yellow bass, *M. mississippiensis* Longear, *L. megalotis* **Spotted bass, *Micropterus punctulatus*** Smallmouth bass, *Micropterus dolomieu* Western sand darter, ***Ammocrypta clara*** Scaly sand darter, *A. vivax* Mud darter, *Etheostoma asprigene* Harlequin darter, *E. histrio* Speckled darter, *E. stigmaeum* Logperch, *Percina caprodes* Blackside darter, *P. maculata* Dusky darter, *P. sciera* River darter, *P. shumardi* Saddleback darter, *P. vigil* **Sauger, *Stizostedlon canadense***	Flier, *Centrarchus macropterus* Banded pygmy sunfish, *Elassoma zonatum* Warmouth, *Lepomis gulosus* Redspotted sunfish, *L. miniatus* Bantam sunfish, *L. symmetricus* Bluntnose darter, *Etheostoma chlorosomum* Slough darter, *E. gracile* Cypress darter, *E. proeliare*

Based on this arrangement, the seven species of fish used in NAVPAT represent approximately 30 percent of all fishes that may occur in the navigation channel, channel border, and littoral area including backwaters (approximately 110 species). However, the swiftwater guild is well represented, and this group is particularly susceptible to navigation effects because of their preference to flowing water habitats. The swiftwater guild includes species with pelagic eggs (e.g., emerald shiner and freshwater drum) and pelagic larvae (emerald shiner, drum, paddlefish, sauger) that occur in navigation channels. Channel catfish, black crappie and spotted bass construct nests, so early life history stages of these three species would be sensitive to wave wash and shoreline dewatering.

Species Response to Navigation Traffic

NAVPAT models physical effects of various tow configurations, frequencies, and sailing lines, and calculates impacts of these navigation effects on fish habitats. In the present study, a series of habitat suitability index (HSI) models was used to evaluate baseline conditions of fish habitat and conditions under different traffic scenarios. The results of these models are presented in Figures 26-40. The basic habitat relationships that supported the results in these figures are presented in an earlier report summarizing the application of NAVPAT to Pool 13 of the Upper Mississippi River (USAED, Louisville 1995). In the following paragraphs, the results of application of these models to the Winfield Pool are described, constraints of using HSI models to examine navigation effects are discussed, and modifications that might improve this modeling approach are recommended.

Based on the threshold for insignificant changes in model output presented in Chapter 10, eleven of the fifteen species' responses (Table 12) show no impact of traffic changes. Also revealing is the fact that seven of fifteen models show no differences in habitat between simulations for conditions with versus without traffic (Table 11). Model insensitivity to traffic reflects that many of the species and life stages selected do not utilize main channels as reproductive habitat.

Species 1 – Emerald shiner spawning (Figure 26). Three variables are equally important in the "basic" model (i.e., the no traffic version of the model). These variables are depth (>2 ft is ideal), velocity (<0.2 ft/sec is ideal), and substratum (>0.175 mm is ideal). According to the model, emerald shiner spawning is impaired by extremely shallow conditions, perceptible water current, and silt or clay substratum. Thus, the model defines the emerald shiner as a littoral spawner in the Kanawha River that uses quiet water overall but extremely fine-grained sediments. However, this species is known to spawn in navigation channels and has pelagic eggs and larvae.

Increased water velocity caused by passing tows accounts for any decrease in habitat value; as velocity increases from 1 to 4 ft/sec, SI falls from 1.0 to 0.0. Recovery is allowed. Habitat units (HU, which is the product of SI × cell area) with respect to emerald shiner spawning declined by approximately 20 percent for 2000 projections based on 5 versus 20 MT of traffic.

Increased rates of traffic have a moderate effect on HUs. Pelagic shiner eggs can float into the navigation channels despite being laid elsewhere. Thus, it is reasonable that a moderate negative impact of increased traffic is predicted.

Species 2 – Emerald shiner fry (Figure 27). In the fry stage, depth greater than 0.1 ft and velocity <0.2 ft/sec are optimum. The model estimates fry vulnerability to propeller entrainment solely from the percent of water entrained. No recovery is allowed. Thus, any entrained fry are assumed to be killed. It is not realistic to assume that SI would be reduced simply in proportion to the percent water entrained. The spatial distribution of larvae in mid channel (which contributes most to entrainment) compared to water nearer the shore is unknown. In addition, it is unlikely that all entrained fry are killed. A sizable fraction probably survives entrainment.

Species 3 – Paddlefish spawning (Figure 28). Substratum particle size, velocity, and depth are treated with equal importance in the basic model. The model portrays paddlefish spawning as best over gravel, at intermediate velocity (1 to 3 ft/sec), and in deep water (>6 ft). Traffic lowers habitat value if velocity is increased to more than 4 ft/sec, with habitat value equal to zero at velocity greater than 6 ft/sec. Some recovery after each tow passage is allowed, at a “rate” of SI/7.

Impacts to paddlefish spawning habitat were predicted in the Kanawha application. The no traffic scenario shows nearly 2,500 habitat units (in SI × acres) versus approximately 2,300 to 1,700 for the six different traffic scenarios.

Species 4 – Paddlefish larval (Figure 29). The larval model relies solely on water depth, with an SI of 1.0 corresponding to all water deeper than 0.1 ft. This simple model of baseline habitat requirements for paddlefish larvae should be considered for refinement. Entrainment is the source of “habitat decline” as with the emerald shiner fry model. SI is reduced by the percent of water entrained. Paddlefish larvae habitat units show moderate decline under increasing traffic scenarios. The without traffic scenario shows the entire pool (3,300 SI × acres) versus approximately 3,200 to 2,500 for the six different traffic scenarios.

Species 5 – Freshwater drum food index (Figure 30). The adult model relies on the most limiting of three variables – substratum particle size, water depth, and velocity. The substrate SI values suggest that drum prefer to feed on silty or gravelly bottoms, while sandy bottoms are less preferred. Depth is increasingly limiting if less than 3 ft; optimum depths are those greater than 3 ft. Current velocity rapidly becomes limiting as values increase above 2 ft/sec. The basic model is reasonable.

Traffic effects are attributed to depth of substratum disturbance, with SI declining slightly as 0 to 3 in. of substratum are eroded by tow passage. Thus, the model implies that food for drum depends on an uneroded substratum and is somewhat limited by recent scour. A recovery rate of SI of 1/21 is allowed.

The drum index model is insensitive to water velocity less than 2 ft/sec. Higher velocities are required to accomplish substantial bottom scour. The without traffic scenario shows 2,473 HU versus approximately 2,468 to 2,428 HU for the six different traffic scenarios. Not surprisingly, there are negligible effects of traffic on the adult food aspect of drum habitat.

Species 6 – Freshwater drum egg/larval (Figure 31). As was the case with paddlefish larvae, the model implies that drum eggs and larvae require water deeper than 0.1 ft, simply suggesting they can occur almost anywhere. This is not unreasonable for drum. Traffic has an effect via entrainment. Entrainment is dealt in precisely the same manner as for previously described larvae and fry models. Patterns of traffic effect are similar to those for the other fish larvae and fry, except that the baseline amount of drum egg/larvae habitat and paddlefish larval habitat in the river is estimated to be approximately three times greater than that of emerald shiners. Thus, freshwater drum and paddlefish show about an equal and moderately negative response to increased traffic that is greater than that of emerald shiners The without traffic scenario shows the entire pool (3,300 SI × acres) versus approximately 3,200 to 2,600 for the six different traffic scenarios.

Species 7 – Sauger spawning (Figure 32). The basic model for this life stage relies on substratum size, velocity, and depth. Sauger spawning is best over gravel and cobble, at intermediate velocity (1 to 2 ft/sec), and in water greater than 1 ft deep. Traffic effects are via velocity increases and substratum disturbance. As velocity increased from 2 to 4 ft/sec due to traffic, SI declines rapidly from 1.0 to 0.0. SI values decrease less strikingly from 1.0 to 0.5 as depth of substratum scour increases from 0 to 3 in. A recovery "rate" of SI/6 is allowed.

Navigation traffic effects predicted with respect to sauger spawning are among the greatest in the study, probably due to sauger affinity for coarse substratum near mid channel and nearby barge traffic. Habitat units slightly exceed 2,500 without traffic and range from 2,100 to 1,350 under the six traffic scenarios.

Species 8 – Sauger larval (Figure 33). This life stage model is identical to those previously described for emerald shiner, paddlefish, and drum early life stages. Depth is ideal if greater than 0.1 ft. Traffic has a negative effect via entrainment. Entrainment is dealt in the same manner as previously described larvae and fry models. Baseline habitat units are similar to those from paddlefish and drum and approximately three times greater than those for shiners. The without traffic scenario shows the entire pool (3,300 SI × acres) versus approximately 3,200 to 2,600 for the six different traffic scenarios.

Species 9 – Channel catfish young of the year (Figure 34). The basic young-of-the-year catfish model relies on velocity, depth, structure (e.g., large woody debris and undercut banks), and substrate size. This early life stage is assumed to prefer slack or slow-flowing water (<1 ft/sec), shallow depth (1.5 to 5.5 ft), abundant structure (>40 percent of cell with cover), and fine gravel (12 to 32 mm). Traffic effects become negative via sediment erosion, with a decline in SI from 1.0 to 0.7 with 0 to 3 in. of sediment scour. This is a reasonable model.

Without traffic HU was equal to 214, which is roughly 6 percent of the entire pool, reflecting the degree to which channel catfish utilize structure. The model predicts no effects. Baseline conditions are no different than traffic scenarios. Traffic scenarios do not differ from one another. Essentially this reflects the preference for relatively slack water, with cover, near the shore. Such areas are simply not subjected to scour or deposition due to barge passage. Like the drum adult food index model, the young-of-the-year catfish model is not sensitive to commercial navigation traffic impacts.

Species 10 – Black crappie spawning (Figure 35). This life stage model relies on four variables: structure (large woody debris, undercut banks, overhanging vegetation), ambient water velocity, depth, and substratum. Ideal habitat corresponds with moderate structure, very slow flow, depth greater than 1.5 ft, and rocky substratum. These rules are valid. Turbulence and substratum erosion by traffic are used as modifier variables to analyze traffic effects. Without traffic habitat value was 126 HU, which is roughly 4 percent of the entire pool. No effects of traffic are predicted by the model. Baseline conditions are no different than traffic scenarios, and scenarios show no differences among each other. A lack of impacts reflects that the habitat used by spawning black crappie is too far removed from the channel to experience turbulence or scour.

Species 11 – Black crappie fry food (Figure 36). Without traffic HU was 226, which is roughly 7 percent of the entire pool. This life stage model was similarly insensitive to traffic. The main variable was the water depth SI model, which indicates steep decline in habitat value if water is less than 1 or more than 3 ft deep. This depth preference is a valid interpretation of black crappie fry habitat use. Bottom areas between 1 and 3 ft deep will not be affected by traffic in the NAVPAT model for this species.

Species 12 – Black crappie juvenile food (Figure 37). Basic habitat requirements were determined by substratum (a complex relationship presumably implying that sand is suboptimal), nearshore structure (25 to 80 percent of cell with structure is ideal), water velocity (<0.5 ft/sec is ideal), and water depth (0.25 ft is ideal). Substratum disturbance was used as a modifier variable, but the maximum reduction in without traffic habitat was 30 percent at a substrate scour of 3 in. The model is reasonable.

Without traffic habitat value was 1,060 HU, which is roughly 32 percent of the entire pool, reflecting increased habitat area use by juveniles versus fry. No effects of traffic or any traffic scenario were predicted by the model. As for the two previous black crappie life stage models, the preferred habitat was not affected by traffic.

Species 13 – Black crappie adult food (Figure 38). The adult food index model was virtually identical to the juvenile food index model and was yet another example of a model for a life stage of a fish that uses habitat that is insensitive to commercial navigation traffic. Without traffic habitat value was 1,393 HU, which is roughly 42 percent of the entire pool.

Species 14 – Spotted bass spawning (Figure 39). The without traffic condition predicted about twofold more habitat units for spotted bass spawning than any of the with traffic scenarios. Habitat value without traffic was 279 HU. Habitat value with traffic ranged from approximately 30 to 150 HU, depending on the particular scenario. Spotted bass spawning SI models are shown in Figures 41-44 because they were not presented in the UMR report (USAED, Louisville

1995). Spotted bass tend to be found in areas with moderate current (i.e., in deeper water and closer to the channel than other sunfishes). Rock and gravel are usually chosen as suitable spawning areas, and males guard nests during egg incubation and for up to 4 weeks after eggs hatch.

Species 15 – Spotted bass juvenile food (Figure 40). Spotted bass juvenile food SI models are shown in Figures 45-49. Without traffic habitat value was 570 HU. Traffic had no effects on juvenile food habitat for spotted bass.

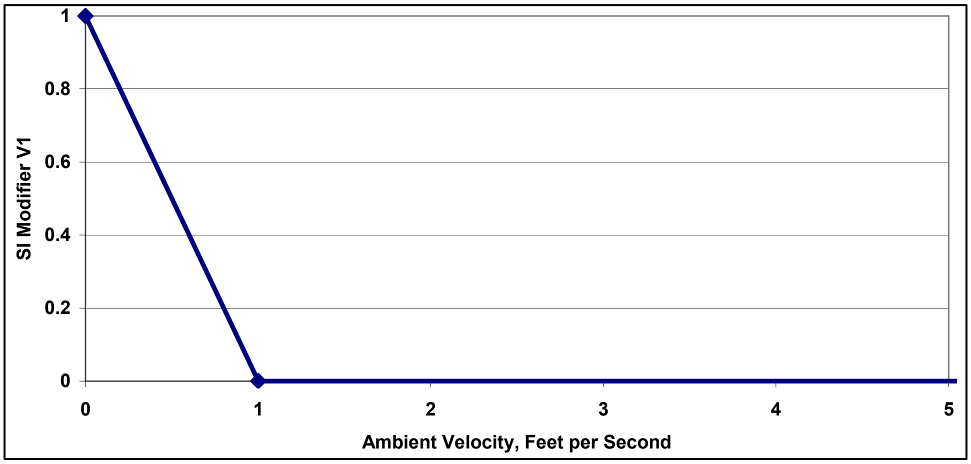


Figure 41. SI modifier V1 versus ambient velocity for species 14, spotted bass spawning

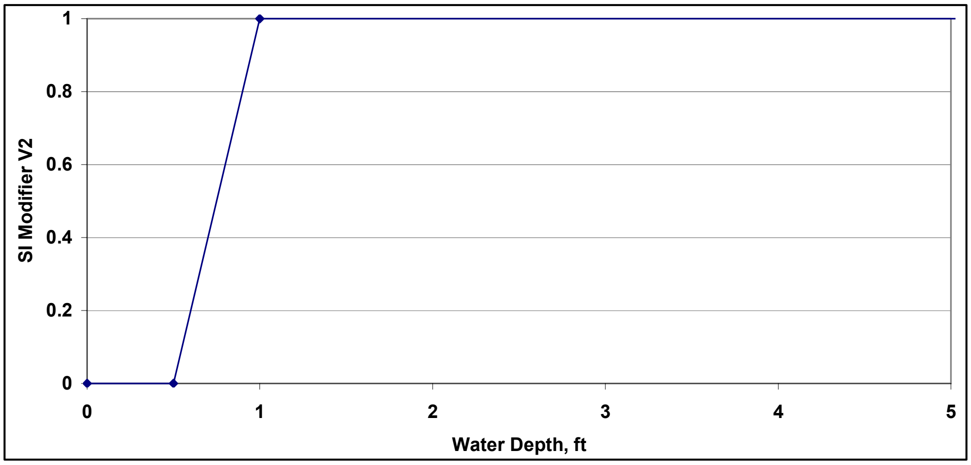


Figure 42. SI modifier V2 versus depth for species 14, spotted bass spawning

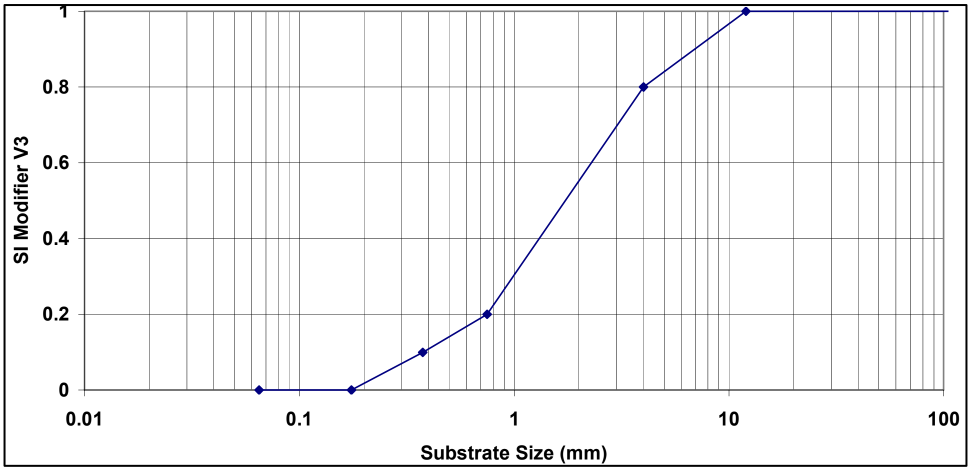


Figure 43. SI modifier V3 versus substrate size for species 14, spotted bass spawning

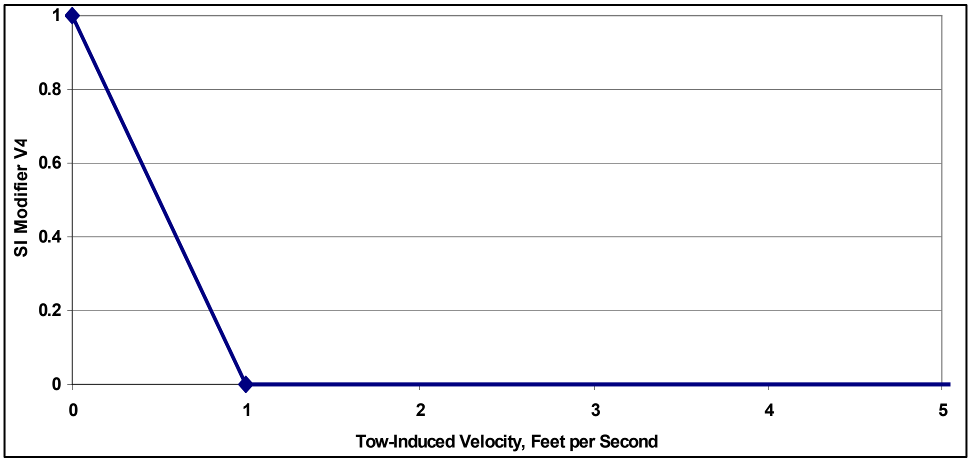


Figure 44. SI modifier V4 versus velocity disturbance modifier for species 14, spotted bass spawning

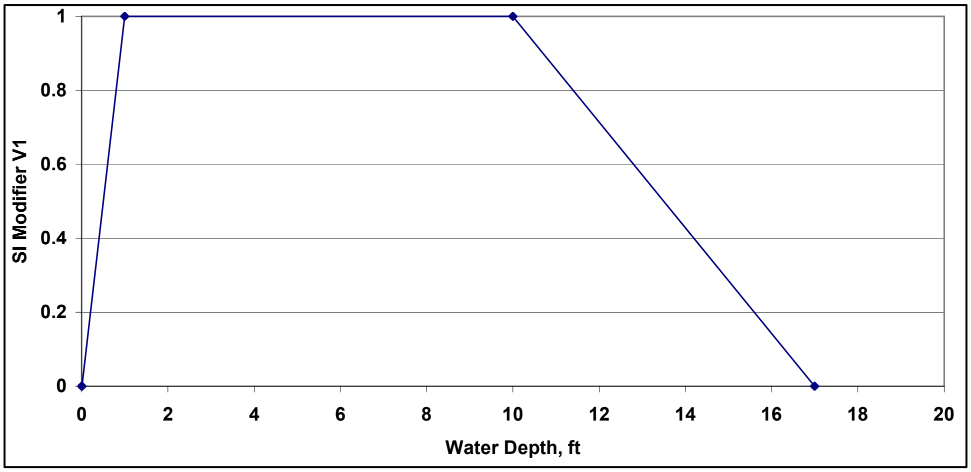


Figure 45. SI modifier VI versus water depth for species 15, spotted bass juvenile food

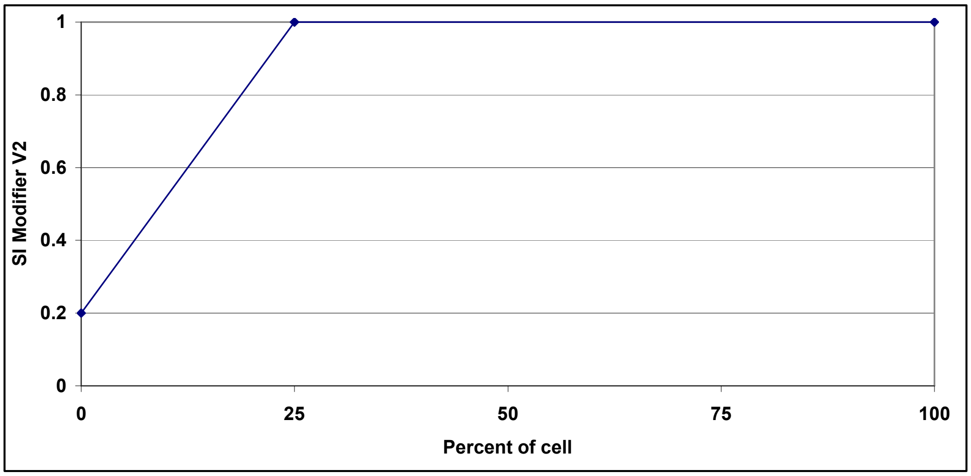


Figure 46. SI modifier V2 versus percent of structure in cell for species 15, spotted bass juvenile food

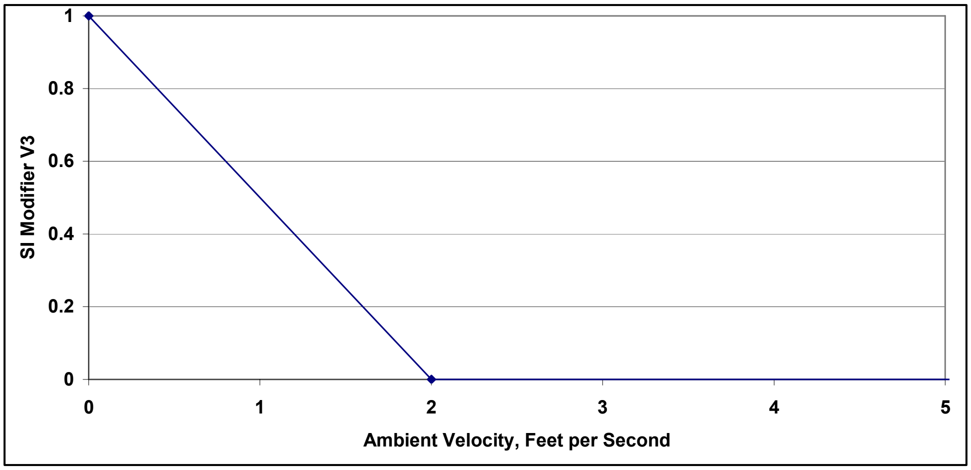


Figure 47. SI modifier V3 versus ambient velocity for species 15, spotted bass juvenile food

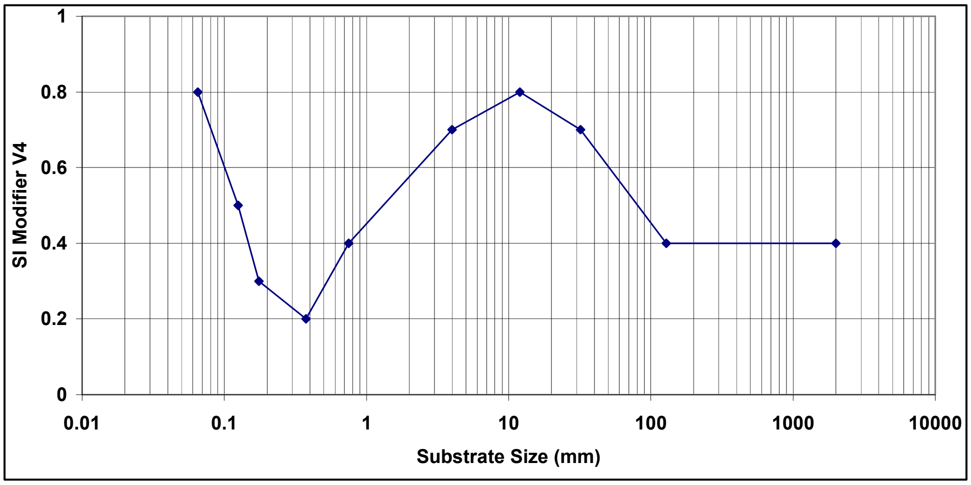


Figure 48. SI modifier V4 versus substrate size for species 15, spotted bass juvenile food

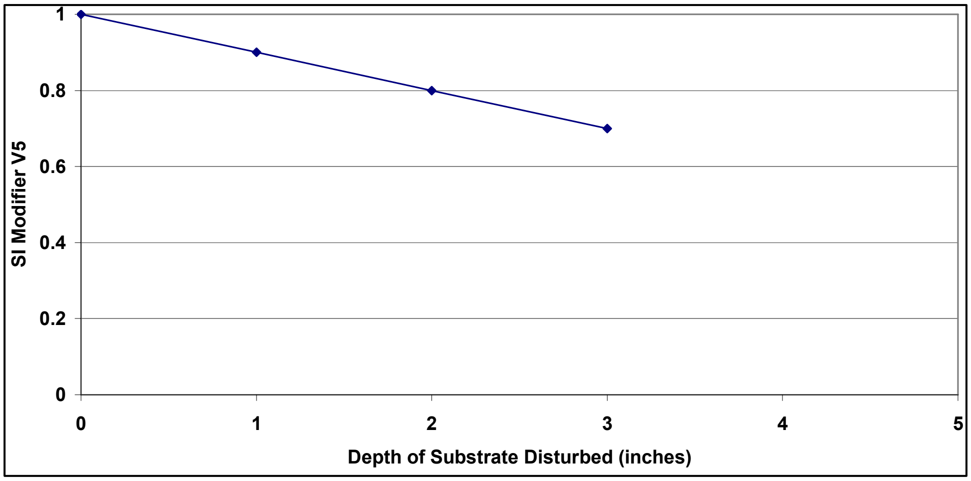


Figure 49. SI modifier V5 versus substrate disturbance for species 15, spotted bass juvenile food

Specially, the greatest impacts of changing from 1996 to 2000 project conditions were on those fish that spawn or rear in channel environments: paddlefish, emerald shiner, and sauger. Those species and life stages that occur near shore showed minimal effects, except for spotted bass. Adults are probably least susceptible to impacts.

NAVPAT's strength derives from the spatially explicit approach taken to evaluating effects. However, it must be recognized that mid-channel habitat in close proximity to passing traffic will be the main region of impacts. In addition, extremely shallow littoral habitats, especially with respect to vulnerable early life stages or nest-spawners, will experience wave wash and drawdown. Spotted bass apparently represented this type of impact. The area between these extremes may be minimally affected by traffic – at least compared to natural ambient variability experienced by fish in a dynamic large river.

Wave wash is not unique to commercial barge traffic. Large, v-hulled recreational craft create much more forceful wave run-up along the river shore. In contrast, drawdown is a phenomenon unique to commercial barge traffic. Shallow littoral models should focus on species susceptible to drawdown impacts, particularly nest-builders. In addition to stranding of eggs, nest-builders have complex behaviors that may be disrupted during turbulent events associated with tow passage. However, mid-channel species or life stage should be emphasized. Entrainment of early life stages of fish and scouring of substrates can have a direct impact to fishes.

Recommendations for Improved Habitat Models

Use of the guild should be expanded to promote a more community-level approach to habitat assessment that is not feasible using the existing models. A first step is to rely more on mid-channel entrainable or drawdown-susceptible species. Seasonal variability in spawning patterns must also be considered. Fish species spawn at different time periods and utilize different habitats within the river during reproductive activities. Spawning/rearing chronologies need to be better identified, and recommendations need to be made on the appropriate months to evaluate navigation-related impacts. At a minimum, early, mid, and late season spawners should be treated separately.

Variables of importance will be depth, velocity, velocity disturbance, substratum, substratum disturbance, and structure. Essentially, these are the same variables that dominate the existing models. However, consideration should be given to probable spatial distribution of evaluation species within the river so the model can delineate specific areas where evaluation species are most and least susceptible to navigation effects.

Modifications on the criteria of entrainment are required. Water volume entrained and the assumption that 100 percent of the fish entrained were killed can be updated using recent information obtained from the UMR/IWW Navigation Project.

The existing physical data in NAVPAT is suitable to evaluate nearshore slope associated with dewatering. Stranding potential and other behavioral responses to wave wash and dewatering can be incorporated in the analysis framework.

10 Analysis of Results

Fish species fell into three distinct groups (swiftwater spawning, swiftwater larval/fry, and slackwater). Members of each group shared a number of common features including guild designations proposed within this report, response to fleet reconfiguration, and similar habitat relationships.

Before further describing the three groups, the basis for classifying a group as having an effect from traffic or an effect from the project must be established. NAVPAT has variability in results that result from flow window size, traffic file variability, and the effect of the seed value for traffic levels and flow windows having a small number of tows. Figure 2 shows how NAVPAT output varies as a result of the seed value. Figure 3 shows that the effect of the seed value becomes small when the flow window contains somewhere between 75 and 162 tows. Chapter 6 under "traffic" discusses how variations in the traffic file can lead to variations in the output. All of this underscores that NAVPAT output should be examined for trends and that comparing small differences should be avoided. Tables 11 and 12 present results that combine all the three sources of variability of the NAVPAT output. Results from Table 11 for four species/life stages were used to plot area-SI versus tonnage level along with a best-fit curve. The relationship between area-SI and tonnage level was nonlinear. The plots clearly showed that at the lower tonnage levels (specifically 5 and 10 MT), the results exhibited greater variability because of the lower number of tows in the flow windows. At the 15- to 25-MT range, which contains the traffic level that actually occurred in 1996 and 2000, the NAVPAT data departed from the best-fit line by an average of ±3 percent. This value is not proposed as a universal value of "noise" in NAVPAT output and only applies to the flow window size and traffic files used in Winfield. A difference in area-SI habitat of less than 3 percent at equal tonnage was used to define the threshold for lack of effect for both with traffic versus without traffic and with project versus without project. The lack of applicability of the 3 percent threshold to a small number of tows in the flow window is shown in Tables 11 and 12 for species 14, spotted bass spawning at 5 MT. In Table 12 for 5 MT, area based habitat increases by 10.6 percent with project, whereas habitat decreases by 33.7 percent and 45.5 percent at traffic levels of 20 and 40 MT, respectively. The anomalous result for 5 MT is based on the low number of tows in the flow window shown in Table 11. Based on Table 11 in year 2000, the three flow windows for species 14 at 5 MT had ten, six, and four tows.

The three groups are further described as follows:

a. **Slackwater group.** This group showed no effects from navigation on without traffic habitat at any traffic level up to 40 MT. (Lack of effect is defined as less than a 3 percent change at equal traffic levels.) Seven species made up the slackwater group. These species/life stages were freshwater drum food index (species 5); channel catfish young of year (species 9); black crappie – all stages (species 10-13); and spotted bass juvenile food (species 15). All of these species occur in shallow, slow-moving water. Without traffic habitat quality for this group is described by rather complicated habitat relationships that involve two or more of substrate, ambient current, water depth, and structure. Because these species/life stage show no effects of traffic at the levels tested, and these are the only species using structure to define without traffic SI, these factors remove concern about the uncertainty of the structure data that was primarily based on shoreline photographs. All black crappie species/life stages are assigned to the slackwater guild as presented in this report. This species of fish is abundant around shelter such as submerged vegetation in very slow-flowing, shallow water. Channel catfish also prefer slack or slow-moving water, shallow depth, and fine gravel. All species include a substrate disturbance modifier when calculating the SI value "with traffic." Note that species 5, 9, 11-13, and 15 are the only six species that use only substrate scour as the tow effect. Species 10 is one of the two species that uses both substrate scour and velocity change as the tow effect. The lack of substrate scour tow effects at Winfield is likely the result of the relatively deep channel that is generally greater than 16 ft in depth at the average stage used in the Winfield simulations.

b. **Swiftwater larval/fry group.** This group showed effects from navigation on without traffic habitat but no effect on habitat from 1996 to 2000 when comparing the same traffic level (equal tonnage). Lack of effect is defined as less than 3 percent change at equal traffic levels. The swiftwater larval/fry group included four species that prefer a swiftwater environment as adults and generally spawn in flowing water. Species/life stages emerald shiner fry (species 2) and freshwater drum egg/larval (species 6) are pelagic spawners. Species/life stages paddlefish larval (species 4) and sauger larval (species 8) prefer sand and gravel substrate for spawning. Note that species 2, 4, 6, and 8 are the only species/life stages that use propeller entrainment as the tow effect. The lack of project effects from 1996 to 2000 on entrainment species suggests that the larger number of smaller tows using the 56-ft-wide lock in 1996 have similar entrainment effects as the smaller number of larger tows using the 110-ft-wide lock that existed in 2000. This statement is true when comparing equal traffic levels for the two locks. This conclusion for the entrainment species needs to be verified for flow window size effects because propeller entrainment is the tow effect that does not have recovery between tow passages. This means that the length of the flow window dictates the magnitude of the tow effects on the habitat. Additional simulations were run with species 2 to determine if the length of the flow window would change the conclusion that the four entrainment species/life stages would have no reduction of habitat from 1996 to 2000. In Table 11, the results for species 2 show the simulations labeled "spall," which used a 25-day flow window rather than the average of three 5-day flow windows. The 25-day flow window had greater tow effects as expected. For the 1996 traffic at 20 MT, the with traffic habitat for species 2 was reduced to 672 SI × acres for the 25-day flow window versus 833 SI × acres for the average of the three 5-day flow windows. However, the 1996 (20 MT) with traffic habitat for species 2 of 672 SI × acres for the 25-day flow window was a less than 3 percent change from the 2000 (20 MT) with traffic habitat for species 2 of 683 SI × acres for the 25-day flow window. The results for the 25-day flow window also support the conclusion of no effect on habitat from 1996 to 2000 when comparing the same traffic level.

c. **Swiftwater spawning group.** This group showed effects from navigation on without traffic habitat and effects on habitat from 1996 to 2000 when comparing the same traffic level (equal tonnage). The species/life stages in this group are emerald shiner spawning (species 1), paddlefish spawning (species 3), sauger spawning (species 7), and spotted bass spawning (species 14). These species were similar in the fact that spawning was the life stage of interest and they preferred swiftwater habitat. Species 3, 7, and 14 spawn in sand and gravel, while species 1 is a pelagic spawner. Note that species 1, 3, and 14 are the only three species that use only tow-induced velocity to define the tow effect. Species 7 is one of two species that uses both tow-induced velocity and substrate scour to define tow effects. Depending on the traffic level, these species lost from 5.4 percent to 45.5 percent of habitat available at the 1996 condition.

11 Display of NAVPAT Input/Output in GIS

Conversion of NAVPAT Cells to GIS Polygons

NAVPAT calculations are based on dividing each cross section into up to 50 cells of various width. Cell width is based on providing constant depth, ambient velocity, substrate size, and structure over the width of the cell. Cell area is obtained by multiplying the cell width by the reach length that the cross section represents.

The first step in developing the GIS approach is to define a unique identification (ID) for the cell/polygon. The cell ID used in the GIS polygon file is a unique combination of the river mile and the cell number. For example, at river mile 31.425 and cell number 4, the unique cell ID is 3142504.

The cell as used in NAVPAT is a six-sided polygon in ARCGIS. The GIS polygon file contains the unique cell ID and the 7 x,y points defining the boundaries of each polygon. The file format used for GIS polygons is as follows:

```
3142501
  1741101.8, 558030.8
  1741095.4, 558038.6
  1740496.3, 557591.3
  1740104.3, 557278.9
  1740111.0, 557270.4
  1740503.0, 557582.8
  1741101.8, 558030.8
end
```

These seven coordinates define the six-sided polygon. Note that the first and last coordinates are the same because definition of polygons in GIS requires the polygon be a closed object. Figure 50 shows how cross section and cell data are transformed into polygons.

Note that in NAVPAT the cells are lateral divisions of the cross section. NAVPAT requires a reach length that each cross section represents. Also note that references to left and right banks or sides of cells are based on looking downstream. In the Winfield application of NAVPAT, the total reach length for a cross section is composed of a reach upstream and a reach downstream. The key to converting NAVPAT cells into GIS polygons is how the cell boundaries are defined at the upstream (points P3 and P4) and downstream (points P1 and P6) limits of the cross section. Points P2 and P5 are straightforward because they are on the NAVPAT cross section and are defined by the NAVPAT cell left and right positions. The first step is to define points PA and PB. Point PA is assumed to lie on a straight line between cross-section points PC and PD. This straight-line assumption can be in error in bendways but the Winfield cross sections are close enough that this is not a significant problem. The location of point PA along line PC-PD is proportional to the ratio (distance from the cross section to the downstream limit) / (distance between cross sections). For the example river miles shown on Figure 50, the proportion is

$$\frac{\text{Dist PA-PC}}{\text{Dist PC-PD}} = \frac{31.711-31.567}{31.711-31.425}$$

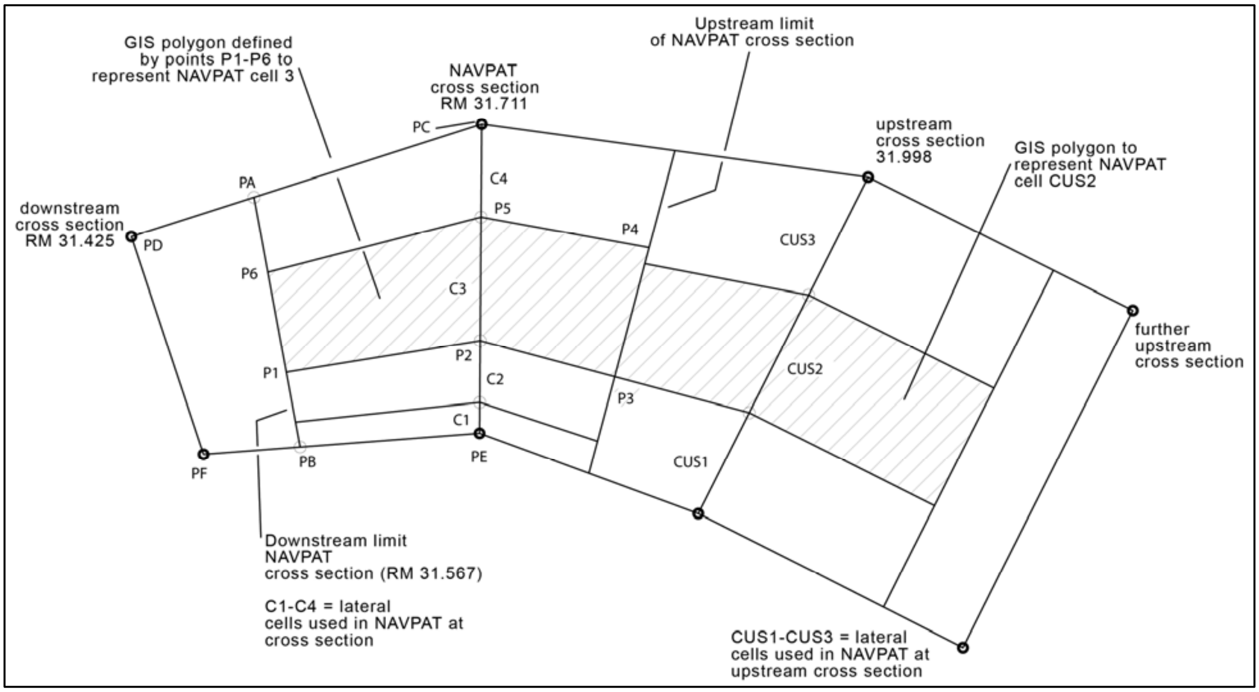


Figure 50. Schematic of NAVPAT cells and GIS polygons

Point PB is located in the same way. The next step is to locate the cell corners along line PA-PB. Proportions must be used to define cell corners because the length of line PA-PB differs from the length of line PC-PE. For example, if point P2 is 30 percent of the length of line PC-PE from point PE, then point P1 will be 30 percent of the length of line PA-PB from point PB.

Note that because the number of cells can differ from one NAVPAT cross section to the next, the polygon corners can differ as shown on Figure 50.

Example Display in GIS

Figures 51-53 show input and output of NAVPAT in a GIS format for the reach including the previously used cross section at river mile 41.555. Figure 51 shows the variation of ambient velocity. Figure 52 shows the SI for conditions without project, which is the 1996 traffic. Figure 53 shows the SI for conditions with project, which is the 2000 traffic.

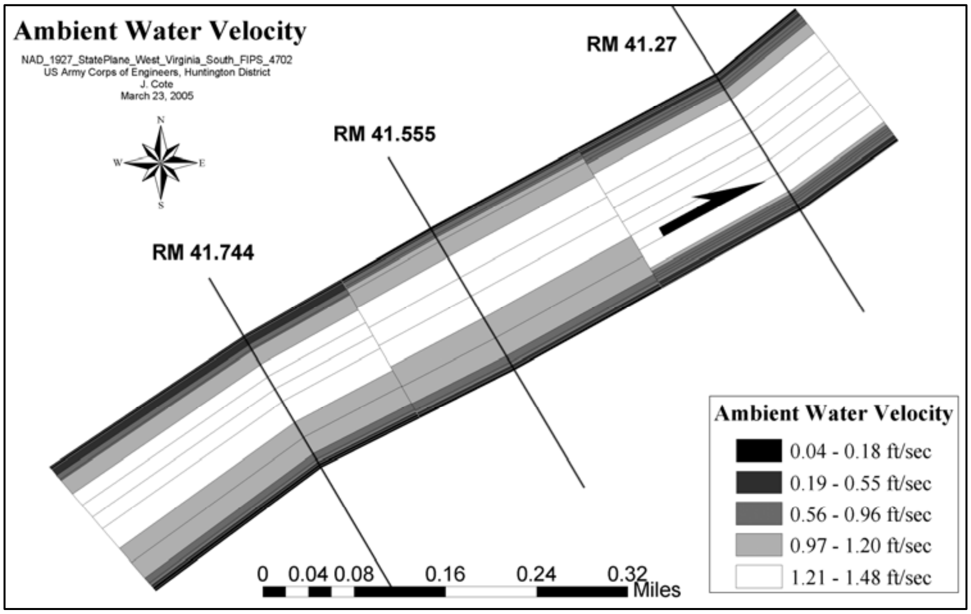


Figure 51. GIS display of ambient velocity at reaches represented by cross sections 41.27, 41.555, and 41.744

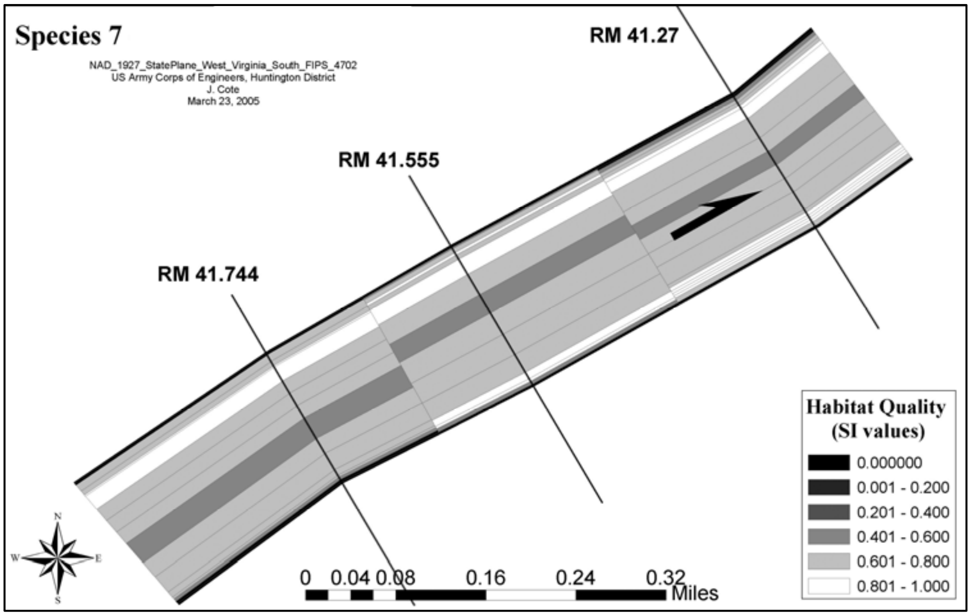


Figure 52. GIS display of SI values for the without project condition, which is the 1996 traffic, for cross sections 41.27, 41.555, and 41.744

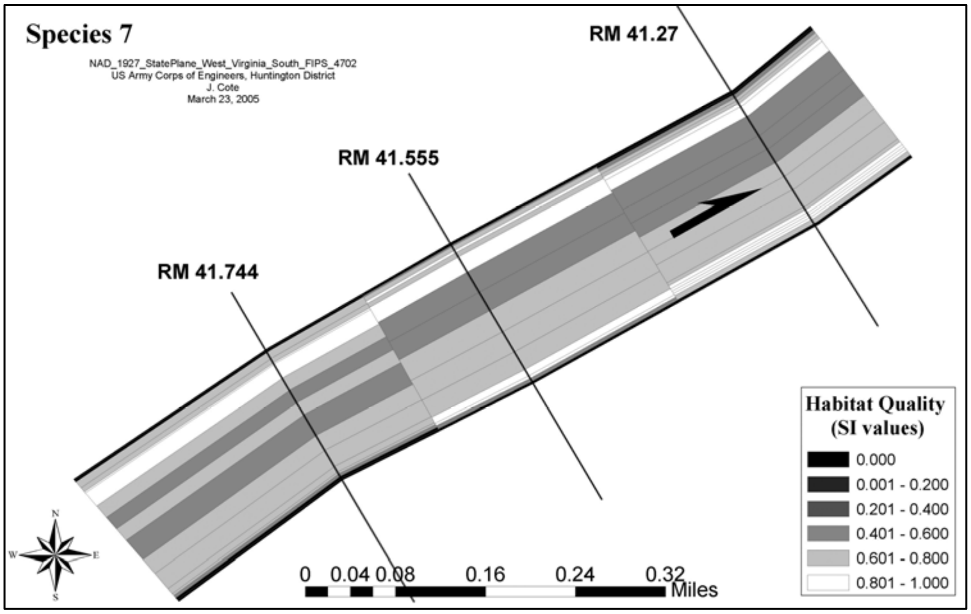


Figure 53. GIS display of SI values for the with project condition, which is the 2000 traffic, for cross sections 41.27, 41.555, and 41.744

12 Summary and Conclusions

Evaluation of NAVPAT results must distinguish between (1) effects of navigation on without traffic habitat, and (2) effects between project alternatives such as the 56-ft-wide lock that existed at Winfield in 1996 and the 110-ft-wide lock that began in 2000. Project effects were due to changes in fleet characteristics as a result of the increased lock dimensions. This analysis indicated three different responses to navigation traffic that are consistent with known life-history patterns of the fish assemblage.

The slackwater group, composed of 7 of the 15 species/life stages, shows no effects of navigation at any of the traffic levels evaluated. Effect is defined herein as more than a 3-percent change in habitat units based on area. This indicates that slackwater fishes are least affected by passing vessels in large navigation channels primarily due to their nearshore preference. The swiftwater larval/fry group, composed of 4 of the 15 species/life stages, shows effects of navigation but no difference in effects between the 1996 and 2000 project conditions. The swiftwater spawning group, composed of 4 of the 15 species/life stages, showed not only effects of navigation but also showed effects between the 1996 and 2000 project conditions. The four swiftwater spawning species/life stages are emerald shiner spawning, paddlefish spawning, sauger spawning, and spotted bass spawning. The without traffic habitat for this group in the Winfield Pool totaled 923, 2,459, 2,559, and 279 SI × acres. At the average stage used in the Winfield simulations, total pool area is about 3,310 acres. With 1996 traffic at 20 MT, habitat for the four swiftwater spawning species was reduced to 833, 2,097, 1,834, and 73 SI × acres. With 2000 traffic at 20 MT, habitat for the four swiftwater spawning species was reduced to 731, 1,859, 1,469, and 48 SI × acres. The corresponding percent reductions in area habitat units based on with traffic 1996 to 2000 conditions, as a percentage of with traffic 1996 habitat, were 12, 11, 20, and 34 percent for the 20 MT traffic level. In conclusion, the group of fishes most susceptible to changes in project conditions is those that spawn in or near the main channel.

Based on the evaluation of existing NAVPAT habitat relationships, use of the guild should be expanded to promote a more community-level approach to habitat assessment. A first step is to rely more on main-channel species. Spawning/rearing chronologies need to be better identified, and recommendations need to be made on the appropriate months to evaluate navigation-related impacts. The variables of importance are depth, velocity, velocity disturbance, substratum, substratum disturbance, and structure. Essentially, these are the same variables that dominate the existing models. Consideration should be given to probable spatial distribution of evaluation species within the river so the model can delineate specific areas where evaluation species are most and least susceptible to navigation effects. Modifications on the criteria of propeller entrainment are required and can be updated using recent information obtained from the UMR/IWW Navigation Project. The existing physical data in NAVPAT is suitable to evaluate nearshore slope associated with dewatering. Stranding potential and other behavioral responses to wave wash and dewatering can be incorporated in the analysis framework.

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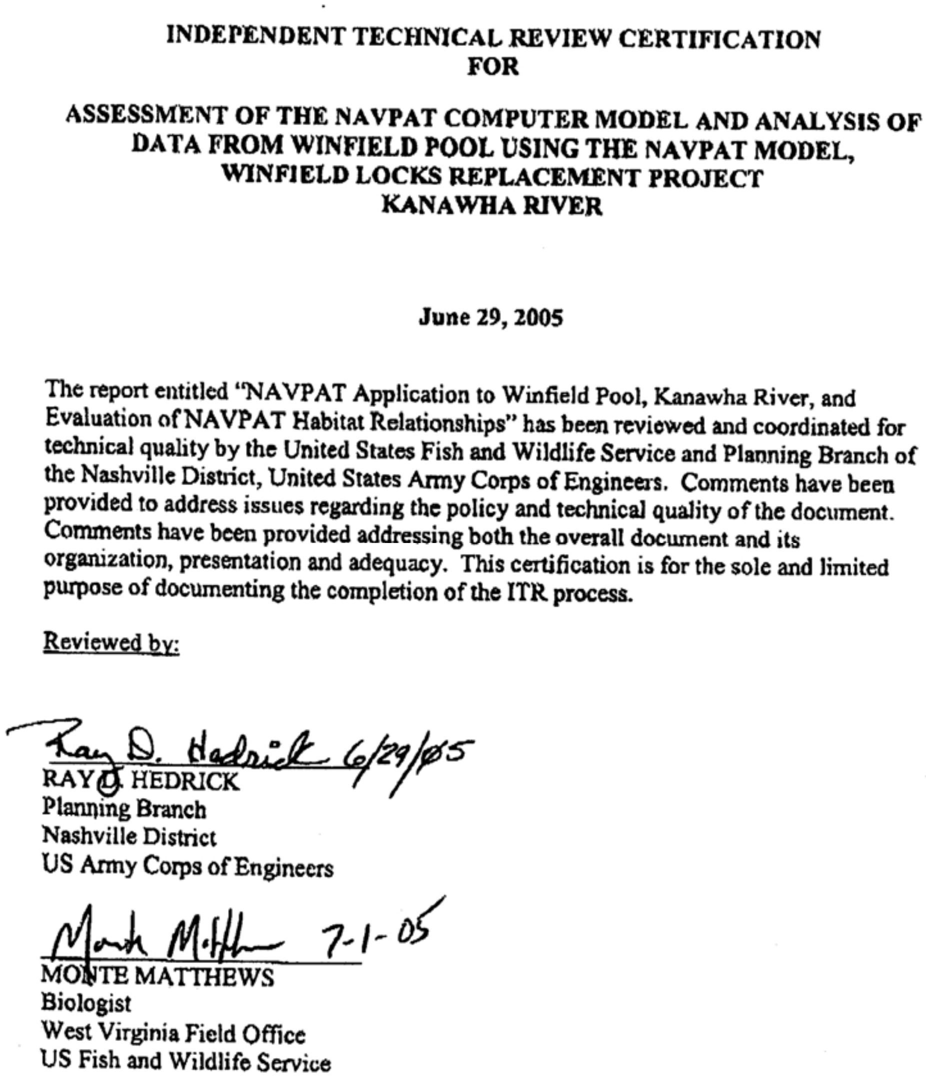
Appendix A
Review Certification



INDEPENDENT TECHNICAL REVIEW CERTIFICATION
FOR
ASSESSMENT OF THE NAVPAT COMPUTER MODEL AND ANALYSIS OF DATA FROM WINFIELD POOL USING THE NAVPAT MODEL, WINFIELD LOCKS REPLACEMENT PROJECT KANAWHA RIVER

June 29, 2005

The report entitled "NAVPAT Application to Winfield Pool, Kanawha River, and Evaluation of NAVPAT Habitat Relationships" has been reviewed and coordinated for technical quality by the United States Fish and Wildlife Service and Planning Branch of the Nashville District, United States Army Corps of Engineers. Comments have been provided to address issues regarding the policy and technical quality of the document. Comments have been provided addressing both the overall document and its organization, presentation and adequacy. This certification is for the sole and limited purpose of documenting the completion of the ITR process.

Reviewed by:

Ray D. Hedrick 6/29/05
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Planning Branch
Nashville District
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14. ABSTRACT

NAVPAT evaluates the effects of commercial navigation traffic on riverine fish habitat. On the Winfield Pool of the Kanawha River, NAVPAT was used to evaluate changes in fish habitat as a result of lock improvements at the Winfield Lock and Dam made during the 1990's. Fifteen species/life stages were evaluated at a range of traffic levels. The Winfield Pool was divided into 127 longitudinal reaches and each reach was divided into lateral cells having similar depth, velocity, and substrate size. Without traffic habitat quality is determined based on ambient depth, velocity, substrate size, and available structure. Without traffic habitat is degraded by tow traffic as a result of velocity change, substrate scour, and propeller entrainment. NAVPAT results on Winfield Pool showed three different responses to navigation traffic. Seven of the fifteen species/life stages showed no effects of navigation traffic on riverine fish habitat at any of the traffic levels tested on Winfield Pool. Four of the fifteen species/life stages showed effects of navigation traffic but no difference as a result of the lock improvements made during the 1990's. The last four of the fifteen species/life stages, swiftwater spawners, showed not only effects of navigation but also differences in habitat quality as a result of the lock improvements. Evaluation of the existing NAVPAT habitat relationships suggests using a guild approach to promote a more community level approach to habitat assessment.

15. SUBJECT TERMS

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