9/99

ARIZONA NAVIGABLE STREAMS ADJUDICATION COMMISSION

FINAL REPORT

SMALL AND MINOR WATERCOURSES PILOT STUDY

CONTRACT No. A7-0109-001

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1.0 Introduction

1.1 GENERAL

The State of Arizona is currently adjudicating in regard to its ownership interest in streambeds throughout Arizona. Claims of streambed ownership turn on whether or not the streams were navigable or susceptible to navigation at the time of statehood in 1912. The reader is referred to the Project Background section of the previously submitted report *Criteria for Assessing Characteristics of Navigability for Small Watercourses in Arizona* (Stantec, 1998) for a complete discussion of the history of the navigability issue in Arizona.

The Arizona Navigable Stream Adjudication Commission (ANSAC) is legislatively mandated to establish administrative procedures, hold public hearings, and make recommendations to the Arizona Legislature as to which watercourses were navigable or non-navigable at statehood. The watercourses that have been adjudicated according to this procedure include a total of 14 major river systems throughout the state.

ANSAC is required to complete the legislatively mandated tasks described above by July 1, 2002. There are over 13,000 documented watercourses in Arizona, the vast majority of which are minor or small watercourses. In consideration of these two factors, ANSAC determined that the small watercourses should be considered separately from the major rivers in order to expedite the evaluation process to meet the target date for completion in the year 2002. ANSAC contracted with Stantec in 1997 to establish minimum technical and historical criteria for small watercourses in accordance with the legislative definition of navigability, susceptibility and non-navigability; develop an evaluation system to assess watercourses utilizing the criteria; catalog in a database all documented watercourses in the state. That work was completed in 1998 and the results are summarized in *Criteria for Assessing Characteristics of Navigability for Small Watercourses in Arizona* (Stantec, 1998).

Subsequently in May 1999, ANSAC authorized the Stantec project team to proceed with a Pilot Study to further test the evaluation system and apply the small watercourse criteria to a limited sample of small watercourses in selected locations. This report presents the scope of work, project approach, analysis, and findings for the Pilot Study. The project team is currently under contract the Arizona State Land Department to continue this work by applying the evaluation system to all remaining watercourses throughout the state that

were not addressed in the Pilot Study. That work is scheduled for completion in August 2001.

The Small and Minor Watercourses Pilot Study fully utilized the ANSAC watercourse database, the minimum technical and historical criteria, and the multi-level watercourse evaluation system as described in *Criteria for Assessing Characteristics of Navigability for Small Watercourses in Arizona* (Stantec, 1998).

1.2 SCOPE OF WORK

The work plan for the Small and Minor Watercourses Pilot Study (hereinafter referred to as the Pilot Study) was comprised of the following main work tasks and activities.

Task 1 – *Fully populate and verify the master watercourse database*

All fields containing data considered diagnostic in the evaluation of watercourse navigability or susceptibility to navigation were fully populated and quality checked. Additionally, other data fields were incorporated into the watercourse satellite databases for information only; including a stream naming convention and township/ range/ section (TRS) information, among others. Further information regarding the master and satellite databases, source data, and data issues is presented in Section 2 of this report.

The analytical utility of the ANSAC master watercourse database previously developed using Microsoft Access software was enhanced by the use of ArcView GIS (Version 3.1), a Geographic Information System (GIS) mapping software product. ArcView provides mapping capabilities and facilitates geographic analysis to evaluate and interpret spatial data. ArcView allows the user to assign unique attributes to each record providing a useful sorting mechanism for analysis and evaluation. In addition, the project team was successful in obtaining valuable GIS hydrologic assessment data developed by various state and federal agencies. These additional data were incorporated into the watercourse database for completeness.

Task 2 – *Perform Level 1 analysis of the entire watercourse dataset statewide*

Level 1 analysis was conducted on all small and minor watercourses statewide. This first level in the watercourse evaluation process consisted of application of six criteria to each watercourse as described in Criteria for Assessing Characteristics of Navigability for Small Watercourses in Arizona (Stantec, 1998). These criteria include: perennial flow regime, dam impacts, historical and/or modern boating accounts, presence of fish, and special

status designation(s). The data fields relating to these diagnostic criteria were fully populated in Task 1.

A database query – a digital expression of the Level 1 screening procedure – was applied to the GIS watercourse database to sort and divide the watercourses into two resultant datasets. Watercourses testing negatively to all of the six criterion were determined most likely to be non-susceptible to navigation. These watercourses were rejected for further evaluation and analysis under the multi-level watercourse evaluation system and comprise the Rejected Level 1 (RL1) dataset. Watercourses that tested affirmatively to at least one of the criterion proceed to qualitative analysis at Level 2 and comprise the Not-Rejected Level 1 (NRL1) dataset. Section 3.1 of this report presents more detailed information regarding the methodology utilized in Level 1 evaluation.

Task 3 – *Perform Level 2 analysis for the Yuma, La Paz, and Mohave Counties*

All watercourses in the NRL1 dataset located in Yuma, La Paz, and Mohave Counties were further analyzed and investigated in the second level of the evaluation system by employing a qualitative approach as described in Section 3.2. The initial Level 2 qualitative analysis resulted in categorization of the watercourses in the three counties into three groups as follows:

- Category A – Potentially Susceptible to Navigation;
- Category B – Not Likely Susceptible to Navigation; and
- Category C – Not Susceptible to Navigation.

A second, more refined, evaluation of the Category B watercourses was performed to determine which watercourses were to potentially susceptible to navigation and, thus, were included in Category A. Watercourses determined to be not susceptible to navigation were included in the Category C dataset. Only those watercourses included in Category A comprised the Not Rejected Level 2 (NRL2) dataset that will advance to more intensive Level 3 evaluation. Category C watercourses comprise the Rejected Level 2 dataset (RL2) and are not further evaluated.

Level 2 analysis will be applied to all NRL1 watercourses in the remaining 12 counties as part of a follow-on contract with the Arizona State Land Department commencing in October 1999.

Task 4 – *Perform Level 3 analysis for three selected watercourses*

The project team selected three NRL2 watercourses from the statewide database for Level 3 analysis. These watercourses were selected based upon geographic representation of the diverse physiographic provinces in Arizona, and to ensure the Level 3 analytical approach developed for the classification analysis is tested under a broad spectrum of stream characteristics. Results of Level 3 analysis will identify watercourses Not Rejected Level 3 (NRL3) which are forwarded to Detailed Study (Level 4) to verify susceptibility to navigation and/or evaluate any evidence of actual or historical navigation. Watercourses which are classified as Rejected Level 3 (RL3) lack sufficient justification for further study. Section 3.3 presents more information regarding Level 3 methodologies.

Results from the Level 2 analysis performed as part of the Pilot Study indicate no watercourses in Yuma and La Paz Counties require Level 3 analysis, while three watercourse in Mohave County will be evaluated at Level 3. One of those watercourses, Kanab Creek, was included as one of the selected watercourses analyzed at Level 3 for the Pilot Study. The other two watercourses analyzed at Level 3 are Aravaipa Creek and Pinal Creek. More detailed information relative to the Level 3 analysis performed for the Pilot Study is presented in Section 4.3.

The remaining NRL2 watercourses for Mohave County and the those located in all other 12 counties in Arizona will be investigated in a separate project under contract to the Arizona State Land Department, excluding the three sample watercourses analyzed as part of the Pilot Study.

Task 5 – *Prepare a final report and work product presentation*

The work products of the Pilot Study include the watercourse database and the final report summarizing the project approach, analysis results, and conclusions of the Pilot Study. Both are delivered in hardcopy and digital formats.

Task 6 – *Meetings and Coordination*

The project team coordinated all project activities with the staff and the Commission. Project briefings were presented to the Commission at the monthly public hearings. In addition, two coordination meetings were held with the Technical Review Committee for the project comprised of technical personnel from five State of Arizona agencies, including: Department of Water Resources, State Land Department, Game and Fish Department, State Parks Department, and Department of Environmental Quality. These meetings were

attended by Commission staff and counsel and a representative from the Arizona Attorney General's Office.

The Scope Of Work for this Pilot Study consists of the limited application of the multi-level evaluation system described in detail in Criteria for Assessing Characteristics of Navigability for Small Watercourses in Arizona (Stantec, 1998) to small and minor watercourses in Arizona for the purpose of testing and refining that system. The results of the Pilot Study are presented in Section 4 of this report, as well as various figures illustrating both the three-level evaluation process and the findings of the analysis. Tabular data summarizing project results are included in the appendices. The CD submitted to the ANSAC contains the entire watercourse database developed for this project in digital form.

2.0 Data Requirements

2.1 BASELINE DATA

The watercourse database operates in a Geographic Information System (GIS) environment. This allows the user to analyze the spatial characteristics of the studied watercourses in a graphical or tabular format. The project team selected Arc View, a GIS analysis and thematic map software, for its ease of use and its operational capabilities. In addition, ArcView supports many of the hydrologic assessment activities that have been conducted by state, federal and local agencies. The viability of this data must meet the following criteria to be considered applicable to this project:

- Data is in, or can be readily converted to, a GIS format
- Data is readily accessible and is technically and historically sound
- Data is sorted, or can be easily sorted, by category criteria.

The primary data source in the development of the master database was obtained from the Arizona Land Resource Information System (ALRIS). The surface water data sets were originally derived from baseline Digital Line Graph (DLG) maps compiled by the US Geological Survey (USGS), which were further enhanced by the US Environmental Protection Agency (EPA) in several versions called the River Reach Files. The latest version, commonly called RF3, is a federal standard for identifying and cataloging water bodies. The RF3 file was converted to a GIS ARC format by ALRIS and has been distributed and used by various public and private agencies working on water management issues.

The base GIS layer used in the master watercourse database is an ALRIS-converted RF3 data set called STREAMS. It is a line coverage of hydrography (streams) within Arizona and contains 87,735 separate watercourse segments. The STREAMS file includes several fields that were relevant in the development of the master watercourse database. They include the Hydrologic Unit Code (HUC), segment number, mileage, watercourse type, and watercourse name. A binary (yes/no) field for each criterion and a county field were added to aid in the Level 1 sorting process. All manmade water features (canals, aqueducts, flumes, etc.) were removed from the master watercourse database. The major rivers previously assessed by the ASLD for characteristics of navigability or susceptibility to navigation

and subsequently adjudicated by the ANSAC were also removed. The resulting master watercourse database contains 76,166 records.

Additional ALRIS datasets were used in conjunction with the STREAMS layer to allow for detailed resolution of the physical location of each watercourse. They include:

Name of Dataset	Data Type / Format	Description
AZSPRINGS	Vector; Point ArcInfo	This coverage consists of spring locations in Arizona. Incorporates information extracted from both the USGS Geonames database and the USGS Digital Line Graphs (DLG).
AZTRS	Vector; Polygon Format: ArcInfo	This statewide coverage consists of the Township, Range and Section grid lines.
County	Vector; Polygon Format: ArcInfo	This polygonal dataset consists of individual county and an appended statewide coverage.
Lakes	Vector; Polygon Format: ArcInfo	This polygon cover consists of all the lakes in Arizona.
HUCS	Vector; Polygon Format: ArcInfo	This data set consists of Hydrologic Unit Code areas (drainage basins) in Arizona.

2.2 DATA CONVERSIONS

The processing of data during query and search operations was slow due to the large file size of the data sets being used. To allow for ease of data storage and manipulation, a method of reducing the file size was undertaken with the goal of minimizing the impact to the outcome of the investigation and analysis.

The largest challenge was identifying a method to combine multiple stream segments into a single watercourse. Approximately 73% (55,387 segments) of the records in the original STREAMS dataset are without names. In addition, there are a large number of watercourses with repeated names; e.g., Sycamore Wash. To resolve this, the project team assigned a unique nomenclature to all unnamed and same-named watercourses. For unnamed watercourses, nomenclature was assigned by combining the HUC ID with the Segment number. For example, H34-2300. Same-named watercourses were assigned new nomenclature by combining the name with the county within which the majority of the watercourse was located. If there were more than

one same-named watercourse within a county, an additional numerical ID was added to the name; e.g., Sycamore Creek, Yavapai 1. This naming convention enabled reliable query and display, and reduced the watercourse records to 39,039.

The project team assigned township/ range/ section (TRS) geographic location attributes to the mouth of each watercourse. The project team was not successful in linking the watercourse database to latitude/ longitude GIS coverages, but this is not essential as the database is linked to the TRS system for location referencing.

2.3 DEVELOPMENT OF SATELLITE DATABASES

Six satellite databases were developed for each of the criterion comprising the Level 1 evaluation screening process. These satellite databases were populated with both diagnostic data fields used for the binary queries in the ANSAC master watercourse database, and also informational fields to provide additional information relative to the Level 1 criteria where readily available. The watercourses that tested affirmatively were converted to new satellite databases (themes) based on the criterion queried and are linked to the master database by a unique watercourse name. Each satellite database can be layered graphically in any selected combination to facilitate watercourse evaluation and to create meaningful reports. Listed below are the six satellite databases (themes) that were created along with the source documentation associated with each database.

Perennial - Only watercourses that have been classified by both the Arizona State Parks (1995) and ALRIS (1988) as perennial are so identified in the database. The approach used in identifying these watercourses in case of classification conflict was presented and described in detail in an earlier ANSAC report by Stantec (1998). Since the original stream database (comprised of 76,166 stream segments) was recently converted into a watercourse database (comprised of 39,039 records), assignment of perennial stream type to watercourses was made for those washes and streams with at least one perennial segment.

Conflicts in the classification of watercourses beyond the two sources named above are addressed in the Level 2 analysis which employs a qualitative approach in the evaluation procedure. The project team acquired a GIS coverage developed by the Arizona Game and Fish Department entitled Perennial Waters of Arizona (AG&F, 1995,1997). The perennial streams originally compiled and mapped by Brown et al (1977, 1978, and 1981) are the foundation of the GIS coverage of perennial streams developed by

Arizona Game and Fish Department (1995, 1997). Those data are used extensively by recognized organizations and agencies – both federal and state – and were used by the project team to supplement the original perennial streams classified by Arizona State Parks (1995) and ALRIS (1988). Brown's perennial streams data were not integrated into the Level 1 analysis, but were used for the qualitative assessment in Level 2 for NRL1 watercourses located in Yuma, La Paz, and Mohave Counties.

Dams - The Arizona Department of Water Resources (ADWR) developed the GIS coverage in point features indicating the location of all the jurisdictional dams in Arizona. The coverage contains data fields describing essential attributes of those dams important to the agency in matters of dam safety, management, and ownership. However, essential data important to the pilot study are not completely populated such as township, range, and section, county, date constructed, dam types, and wash location. The missing information plus the resolution of the dam coverage make the task of identifying dam-impacted streams very difficult. The resolution problem associated with the dam GIS coverage is largely due to inconsistent development standards of different state agencies. Most of the GIS coverages used in the project were developed by ALRIS, while the dam coverage was developed by ADWR.

Aside from ADWR, there are other sources of data for dam structures built in the state of Arizona. The US Geological Survey (USGS) and the Federal Emergency Management Agency (FEMA) maintain a listing of dams for the entire United States. Inconsistency in the use of names for the dams and data attributes between these various sources resulted in the sole utilization of ADWR dam database for the Pilot Study. Originally, the dam coverage from ADWR was comprised of 397 records. After the deletion of dams that are used for tailings and those that are located off-stream (a total of 26 records), the final record count was reduced to 371 dams.

Fish - A report published by the USDA Forest Service titled *Run Wild* (Silvey et al, 1984) was used to identify the occurrence of fish species and their habitat in Arizona. Several documented sources validate the findings as listed in the *Run Wild* document. A total of 292 watercourses were documented to have fish. Efforts to acquire existing fish GIS database information from Arizona State University were not successful. Instead, fish information gathered from a number of reliable federal and state agency sources was used for the Pilot Study. These sources are listed in the references.

Historical And Modern Boating – Published accounts of modern boating were obtained from the Greenlee County Historical Society, Coconino Historical Society, Mormon Archives, Apache County Historical Society, Arizona State Parks, Central Arizona Paddlers Club, Arizona Game and Fish Department, and professional river rafting companies. One watercourse has a documented account of historical boating while 10 others have modern boating accounts.

Special Status – The Special Status category includes water-related characteristics that make a watercourse of particular interest or concern to various organizations and/or governmental agencies. Watercourses identified as having the following designations were included in the Special Status database: In-stream Flow Application and/or Permit, Unique Waters, Wild and Scenic, Riparian or Preserve area. Agencies issuing the Special Status designation were contacted to identify watercourses meeting the criterion.

3.0 Methodology

A three-level evaluation system shown in Figure 1 was developed for by the project team under the previous phase of this project (Stantec, 1998) and adopted for use in this Pilot Study. The approach involves a multi-level screening process of increasing refinement designed to identify watercourses least likely to meet the statutory and legal definitions of navigability as early in the process as possible. The evaluation process consists of three levels as follows:

3.1 LEVEL 1 ANALYSIS

The goal of Level 1 of the watercourse evaluation procedure is to perform a first-cut screening of the catalog of small and minor watercourses. The purpose is to eliminate the watercourses most likely to be non-susceptible to navigation and which exhibit no evidence of actual navigation in fact.

The Level 1 analysis is a binary, quantitative sorting process utilizing the data queries programmed into the database catalog. Those queries are the digital expression of the technical and historical criteria considered diagnostic for evaluating watercourses for susceptibility to navigation and for navigation in fact, respectively. Those minimum criteria include stream type, dam information, historical and modern boating accounts, the existence of fish, and any special watercourse status designation as shown in Figure 2.

The Level 1 screening process is applied to all small watercourses in the database catalog using available information from existing databases compiled by various agencies. Only those watercourses that test negatively to all six criteria are rejected at Level 1 as most likely non-susceptible to navigation. All watercourses, which test affirmatively to one or more of the criteria comprising the data queries, require further evaluation at Level 2.

Figure 1
THREE-LEVEL WATERCOURSE
EVALUATION PROCEDURE

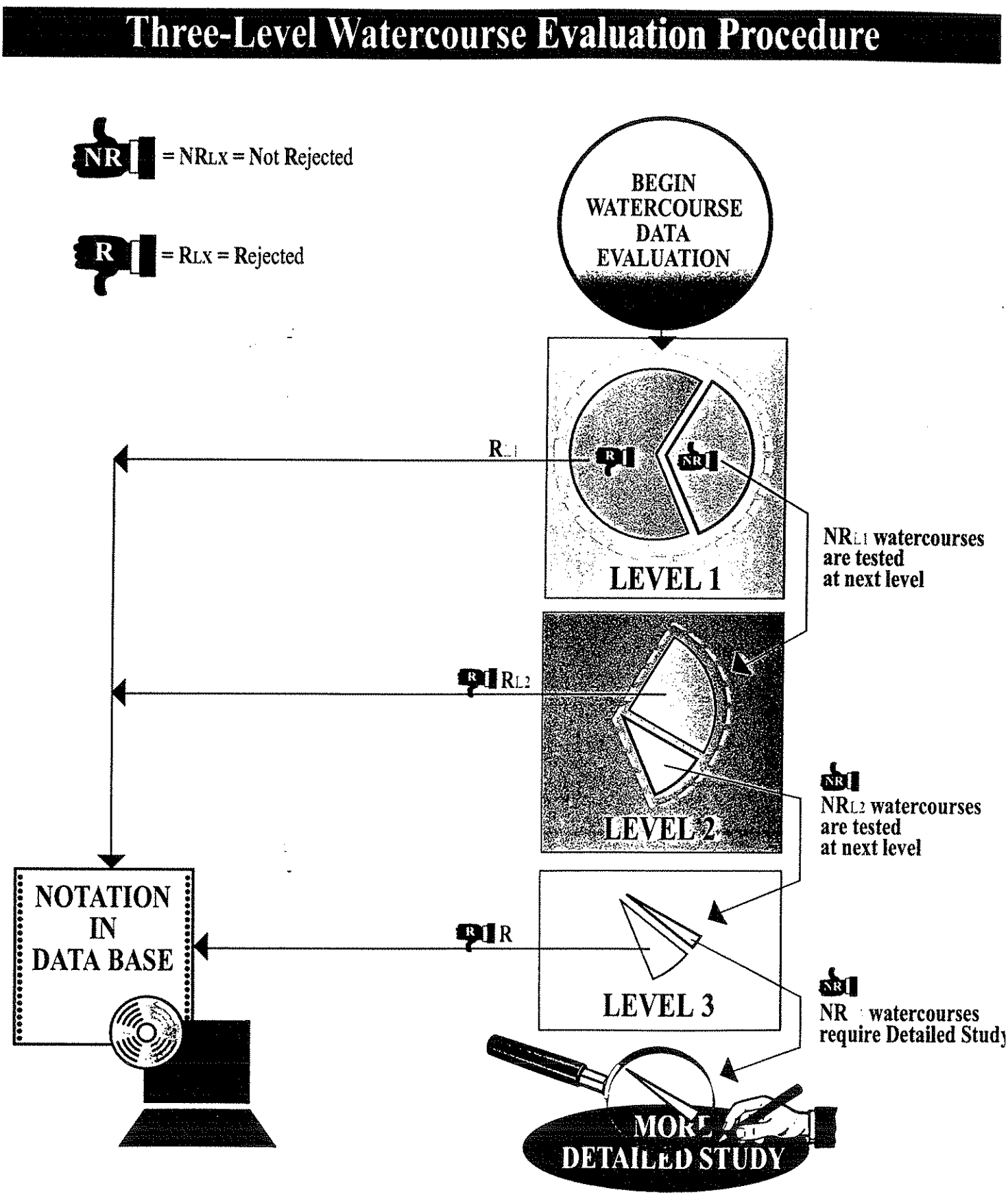
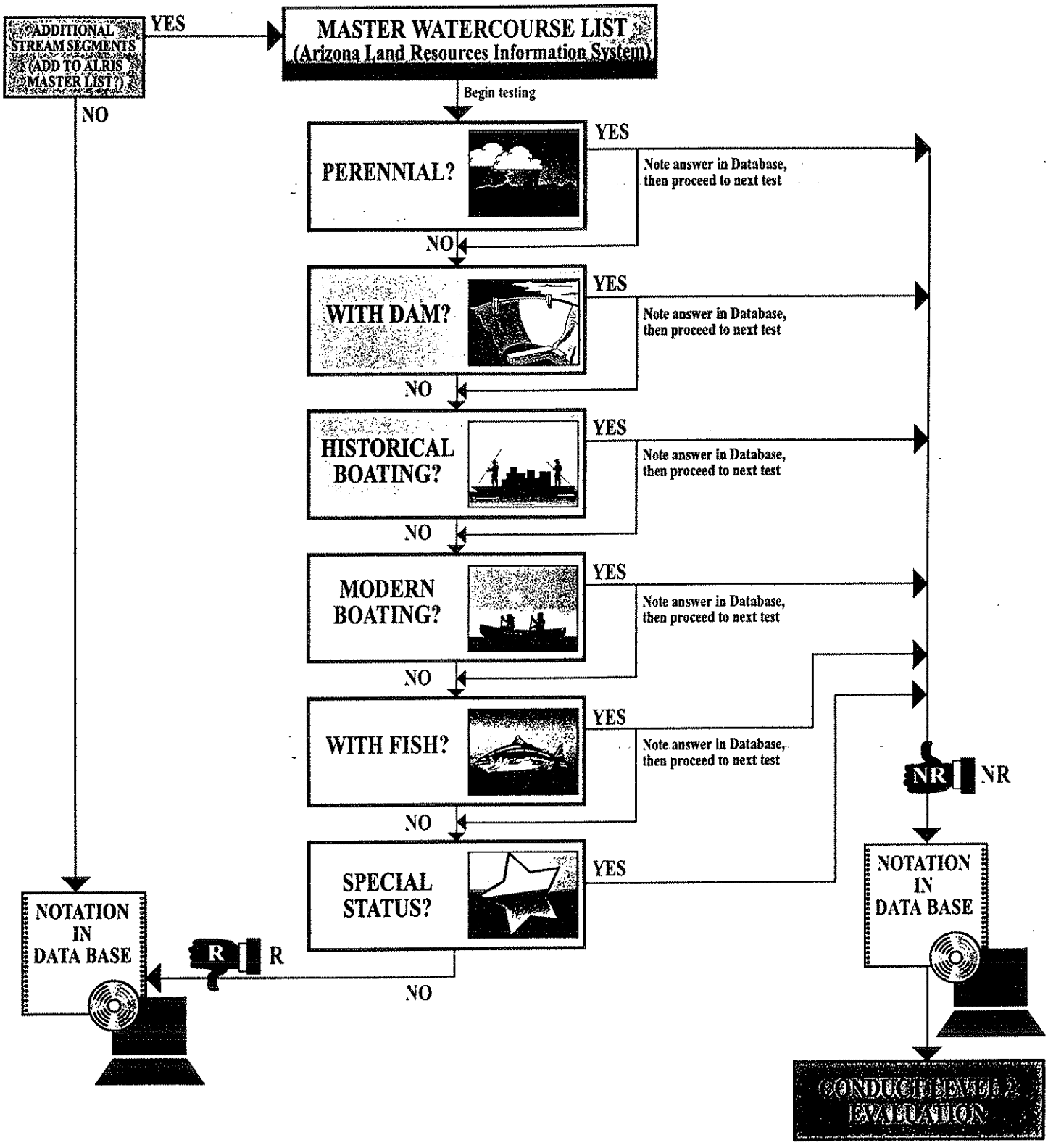


Figure 2
LEVEL 1 SCREENING PROCEDURE

Level 1 Screening Procedure



3.2 LEVEL 2 ANALYSIS

The goal of the Level 2 watercourse evaluation procedure is to perform a refined screening to eliminate the watercourses unlikely to be susceptible to navigation. Contiguous watercourse segments were combined to form study reaches to be evaluated in Level 2.

The Level 2 method of approach is more qualitative than the binary data queries employed at Level 1. Level 2 assessment involves the qualitative review of watercourse location, typical watershed characteristics, typical watercourse characteristics, among other features, for verification and interpretation of the reason(s), which caused them to advance from Level 1. In concept, the recommended Level 2 methodology involves the further assessment of those watercourse characteristics that tested positively at Level 1 in two parts as shown in Figure 3 and briefly described below:

1. The first-cut filter individually analyzes each criterion that caused a particular watercourse to advance to Level 2 – referred to herein as positive "hits" – for information salient to the navigability question as shown in Figure 4. Those watercourses are categorized into three groups as follows:

   Category A – Potentially Susceptible to Navigation;

   Category B – Not Likely Susceptible to Navigation; and

   Category C – Not Susceptible to Navigation.

2. The second-cut filter analyzes Category B watercourses with multiple positive hits on multiple segments for diagnostic hit combinations that are evidence of navigation in fact or are indicative of susceptibility to navigation, as shown in Figure 5. Watercourses will be categorized into two groups based on their likelihood of being susceptible to navigation. All watercourses with documented boating accounts, historical and/or modern, will automatically advance to Category A comprised of watercourses potentially susceptible to navigation. Watercourses with multiple hits indicative of susceptibility on contiguous segments will also advance to Category A. Watercourses which are determined upon visual and/or manual inspection to exhibit physical characteristics incompatible with successful navigation, such as high elevations, steep slopes, etc., will advance to Category C and are rejected from further consideration at Level 2.

The Level 2 qualitative review is applied only to those watercourses that advance from the Level 1 binary sorting process (NRL1 dataset). The Category C watercourses that are unlikely to be susceptible to navigation are identified and rejected at Level 2. Category A watercourses with multiple hits on contiguous segments merit quantitative engineering analysis are potentially susceptible to navigation and advance to Level 3.

Figure 3

LEVEL 2 SCREENING – CONCEPT

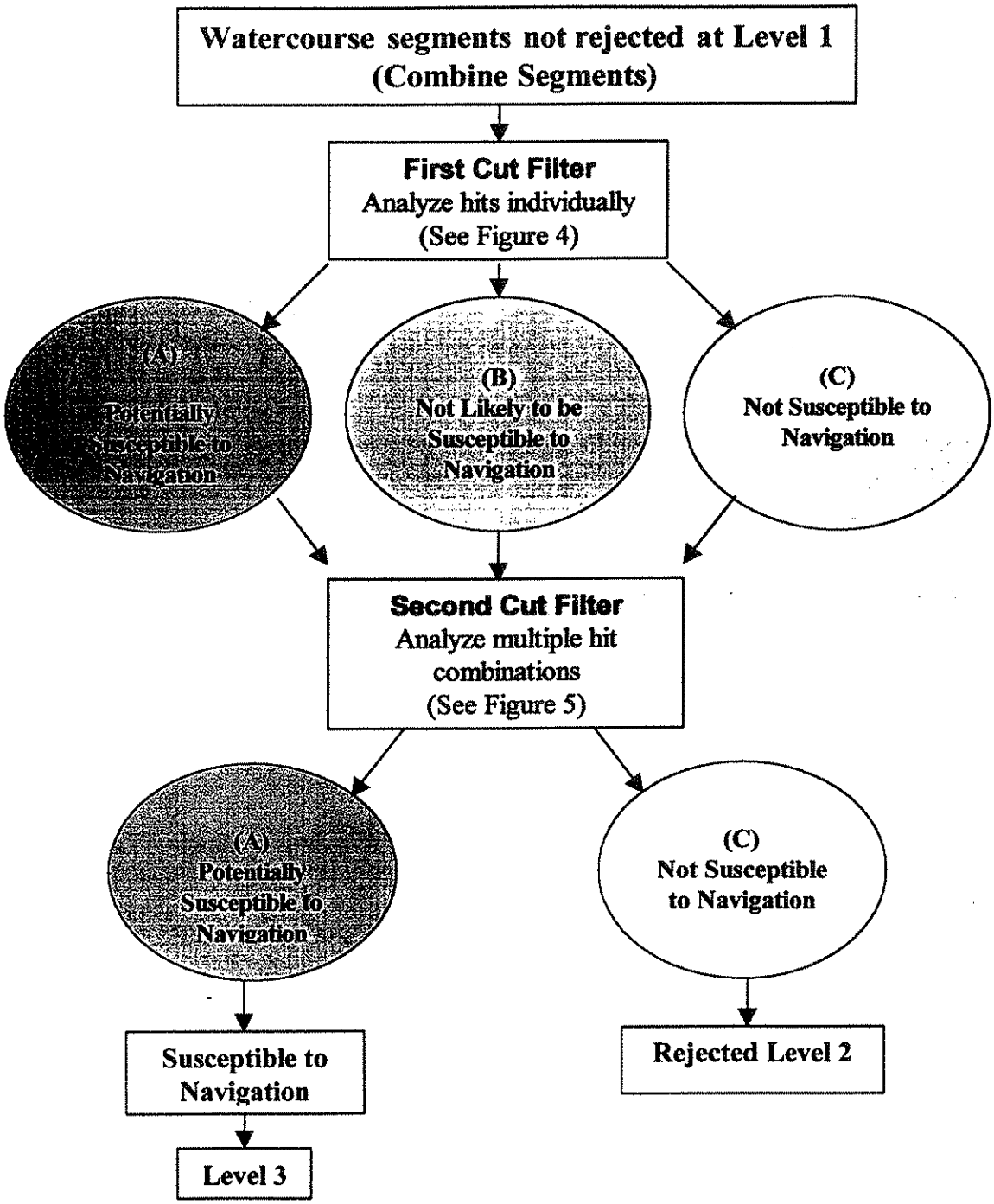


Figure 4

LEVEL 2 WATERCOURSE SCREENING
FIRST CUT FILTER

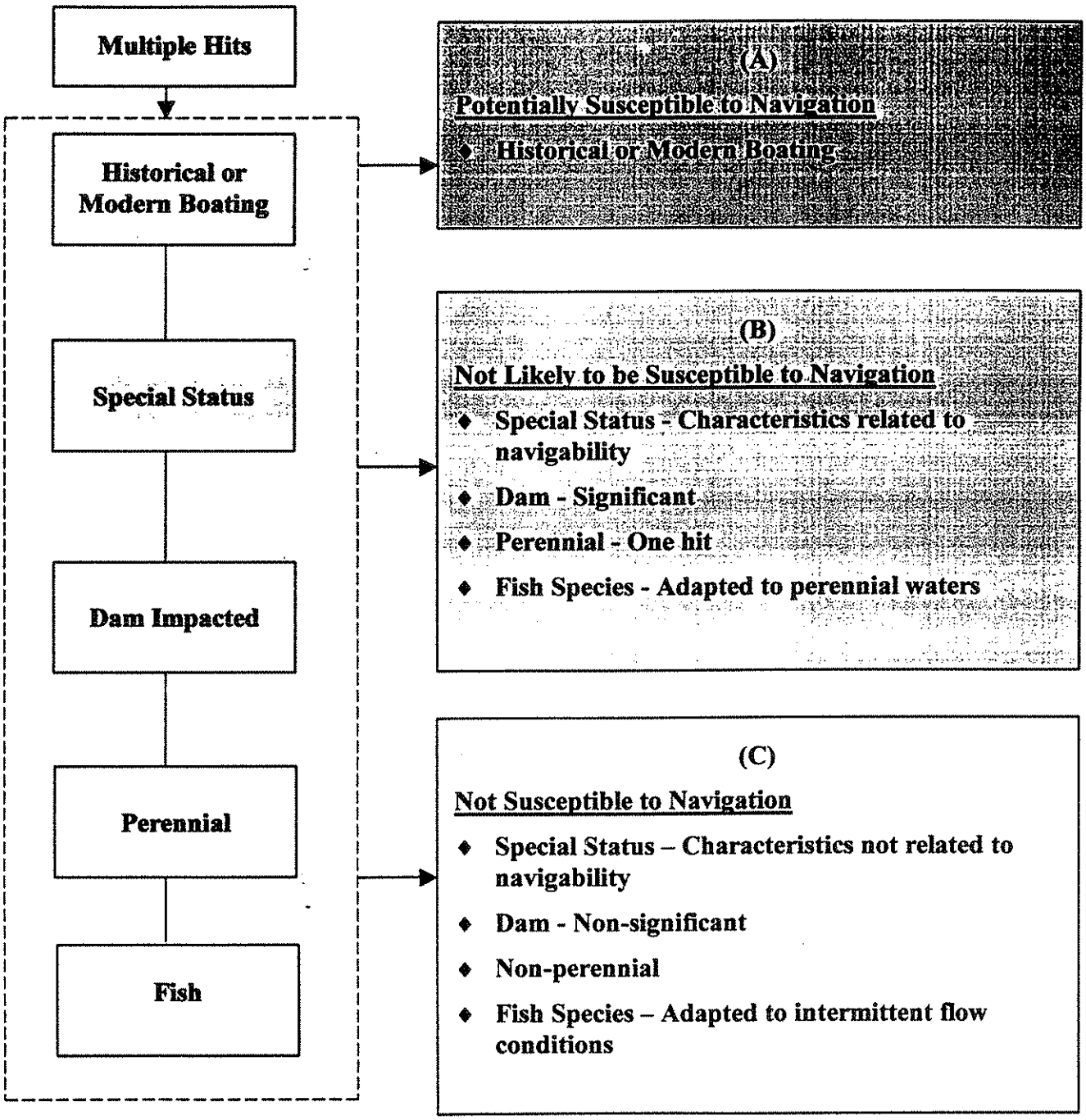
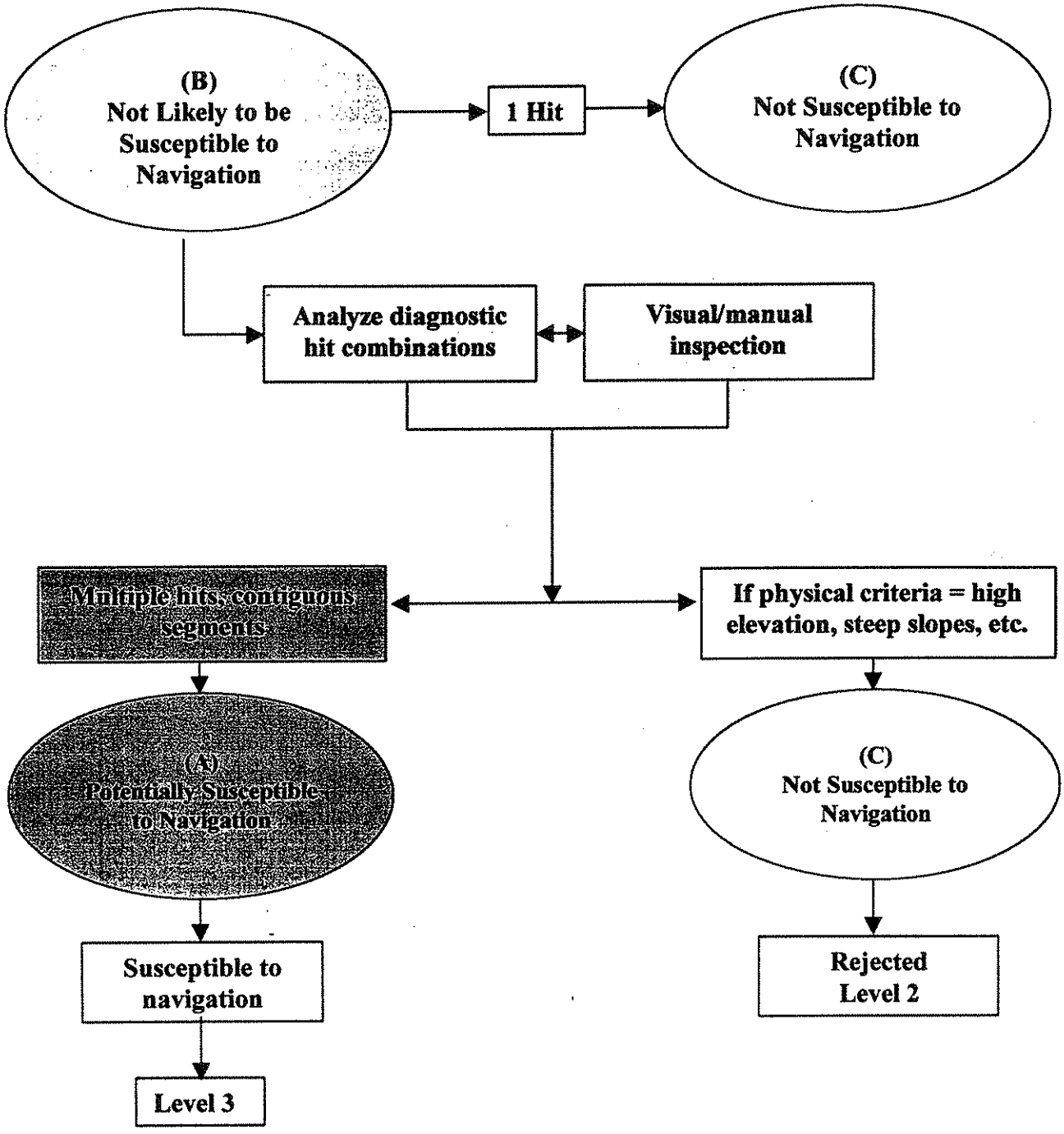


Figure 5

LEVEL 2 WATERCOURSE SCREENING SECOND CUT FILTER



3.3 LEVEL 3 ANALYSIS

The goal of the Level 3 fine sorting process is to eliminate watercourses that are non-susceptible to navigation utilizing quantitative engineering methodologies. The primary objective of the Level 3 engineering methodologies is to provide technically sound data from which typical channel characteristics and flow rates for each watercourse can be estimated and used to determine susceptibility to navigation. Additionally, any physical obstacles to successful navigation along a watercourse will be identified and assessed at Level 3.

The recommended methodologies for the Level 3 screening process involve application of quantitative hydrologic and hydraulic analysis procedures that require a significant level of effort to meet the requirements of the adjudication process. The availability of streamgage data significantly impacts the level of effort required to quantify discharge rate and hydraulic geometry for evaluation of watercourse susceptibility to navigation. The recommended methodologies include:

1. Quantitative analysis of US Geological Survey (USGS) streamflow records, or USGS regression-type methodologies based on streamflow records, or extrapolation of gage data to adjacent watersheds to estimate discharge in the subject watercourse; and

2. Use of USGS rating curves or Manning's ratings to estimate flow characteristics such as depth, width, and velocity in the subject watercourse.

The Level 3 screening process is applied only to those watercourses not rejected at Level 2 (NRL2 dataset). The watercourses with no evidence of actual navigation in fact and determined to be not susceptible to navigation are rejected at Level 3. All remaining watercourses merit Detailed Study (Level 4) comparable to that performed for the major river studies and advance to the final level of the watercourse evaluation system.

4.0 Results

4.1 LEVEL 1 ANALYSIS

The application of the Level 1 sorting procedure to all small and minor watercourses in Arizona resulted into two datasets. The RL1 dataset is comprised of all watercourses that test negatively for each criterion used in the Level 1 database query. This indicates that no characteristics of stream susceptibility to navigation are exhibited based upon know records and information. Level 1 analysis results indicate a significant percentage of the watercourses (99.4% or 38,785 records out of 39,039 total) test negatively to all Level 1 criteria and, therefore, do not justify further evaluation at Level 2.

Conversely, the NLR1 dataset is comprised of those watercourses that exhibit some characteristics of susceptibility to navigation based upon at least one affirmative response (hit) to the six criteria used in the Level 1 evaluation. Results of the analysis indicate that there are 1025 watercourses (approximately 0.6%) in Arizona which justify analysis at Level 2. The Pilot Study addressed Level 2 analysis of only those NRL 1 watercourses in La Paz, Mohave, and Yuma Counties (i.e., about 79 watercourses). NRL1 watercourses in the remaining 12 counties will be assessed at Level 2 under a separate contract.

A summary of listing of the NRL1 dataset for all counties is presented in Table A-1 in the Appendix. By inspection, the majority of the NRL1 watercourses (i.e., 762 records or 74%) are one-hitters and approximately 26% tested affirmatively to more that one of the Level 1 criteria used in the database query.

The shape files associated with the RL1 and NRL1 data sets evaluated from Level 1 sort are shown in Figures 6 and 7, respectively.

FIGURE 6

RL1 Data Set from Statewide Level 1 Analysis

30 0 30 60 90 120 150 Miles

SCALE

LEGEND:

County

RL1 Watercourses

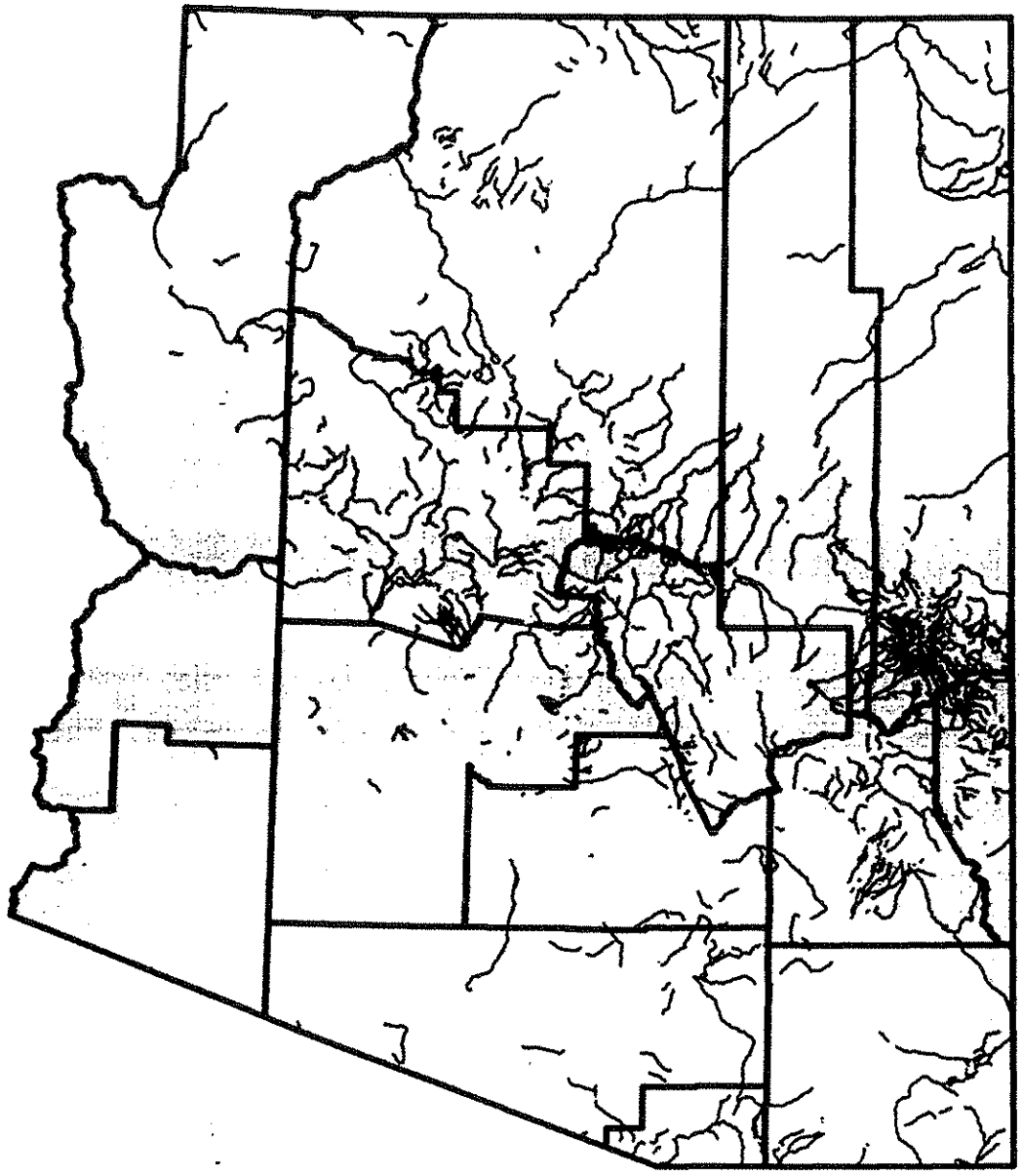
N

W E

S

FIGURE 7

NRL1 Data Set from Statewide Level 1 Analysis

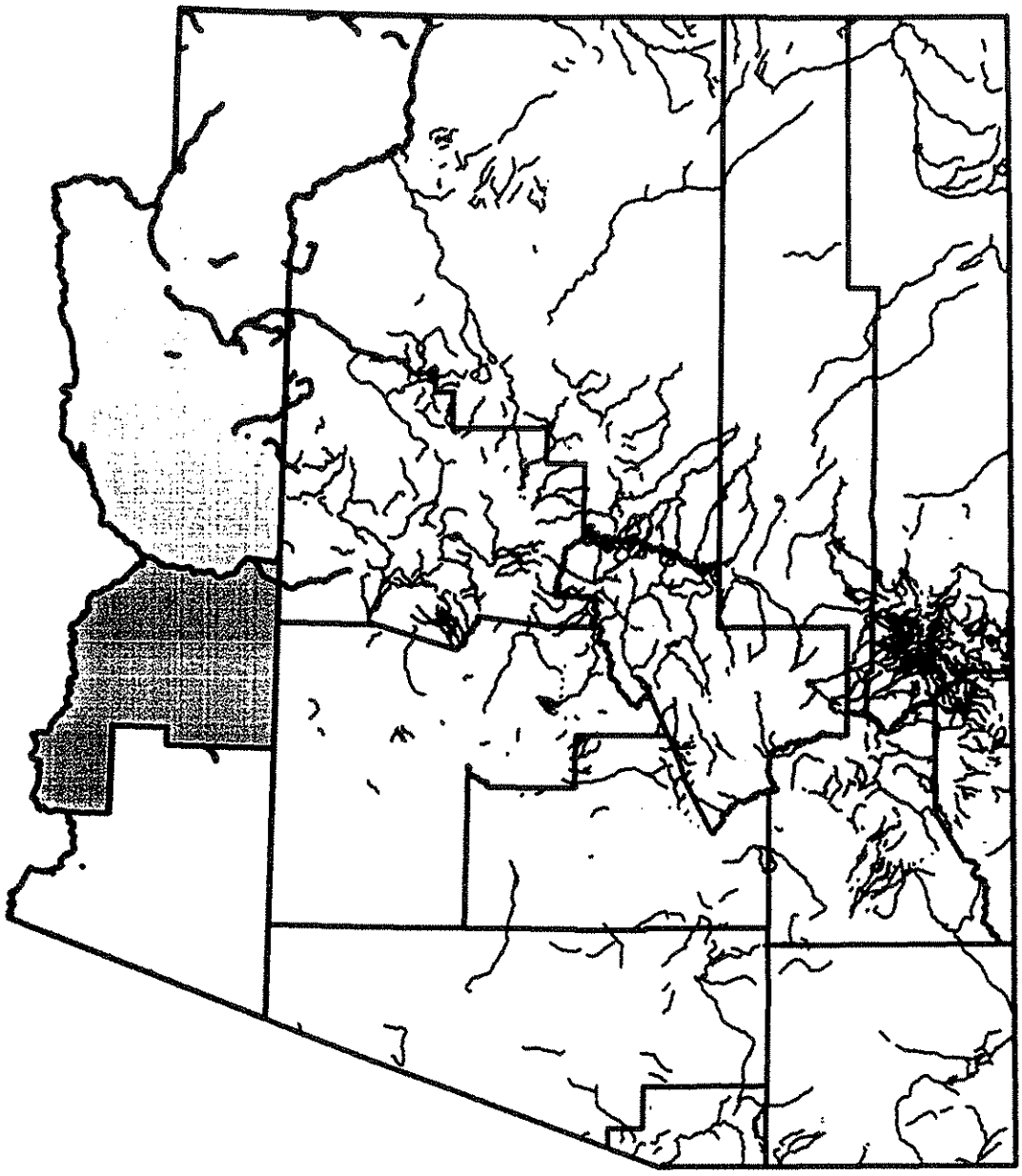


4.2 LEVEL 2 ANALYSIS FOR YUMA, LA PAZ, AND MOHAVE COUNTIES

The NRL1 dataset resulting from statewide Level 1 analysis contains 79 watercourses that are located in Yuma, La Paz, and Mohave Counties. Of those, 26 watercourses are located in La Paz County, 36 in Mohave County, and 17 in Yuma County. Results from the application of the Level 2 approach to the 79 watercourses are presented and discussed in the sections that follow. Figure 8 illustrates the NRL1 dataset for the three counties.

FIGURE 8

Three West Counties with NRL1 Watercourses



20 0 20 40 60 80 100 Miles

SCALE

LEGEND:

Yuma County

La Paz County

Mohave County

Other Counties

NRL1 Watercourses (Pilot Study)

NRL1 Watercourses

N

W E

S

La Paz County

There are 26 watercourses in La Paz County forwarded for Level 2 analysis. Table A-2 in the Appendix lists the NRL1 watercourses evaluated for La Paz with the six criteria that serve as key attributes in Level 1 evaluation. By inspection, all the watercourses are one-hitters (see column (13)) except for Date Creek which has two-hits. Furthermore, all the watercourses are classified as perennial (see column (6)) by ALRIS (1988) and Arizona State Parks (1995), but the same watercourses, except for Date Creek, are identified as non-perennial according to Brown's perennial streams map developed by Arizona Game and Fish Department (1995, 1997). Considering the reliability of the Brown's perennial map in comparison to the other data sources, all the watercourses except for Date Creek do not exhibit any characteristics supporting evidence of potential susceptibility to navigation. Thus, these 25 watercourses are classified under stream Category C and are considered not susceptible to navigation.

Date Creek has two affirmative hits including perennial stream classification and fish. The watercourse is 49.3 miles long and is comprised of 54 segments. It runs from Yavapai to La Paz Counties. Date Creek in La Paz County is contains 15 segments along its 16 mile length; while Date Creek in Yavapai County is composed of 39 segments and is about 33.3 miles long. Using the Brown's perennial map and the original stream database by ALRIS (1988), all the 15 segments of Date Creek in La Paz County are non-perennial which reduces this particular watercourse from a two-hitter to a one-hitter. For the fish criterion, Silvey et al (1984) document only one fish species for Date Creek. By virtue of weak evidence, Date Creek is classified under stream Category C.

In summary, all the NRL1 watercourses in La Paz County are classified under stream category C indicating these streams to exhibit no evidence or, at the least, very weak characteristics indicative of susceptibility to navigation.

Mohave County

Based upon the Level 1 evaluation, there are 36 watercourses in Mohave County forwarded for Level 2 analysis. Table A-3 in the Appendix lists the NRL1 watercourses evaluated for Mohave County with the six criteria that serve as key attributes in the Level 1 evaluation. From Table A-3, there are 29 watercourses that are one-hitters (see column (13)), 4 are two-hitters, 1 is a three-hitter, and one is a four-hitter. The list also includes one watercourse identified as Spencer Canyon that was originally included in the RL1 dataset, but later moved to the NRL1 dataset. Spencer Canyon tested negatively to all

six of the Level 1 diagnostic criteria; however, Brown's perennial streams map classified Spencer Canyon as a perennial stream. This data inconsistency justified included Spencer Canyon in the NRL1 dataset for further evaluation in Level 2.

Applying Brown's perennial streams information further relative to the initial classification (see column (13)), about 20 watercourses from the list becomes candidates for elimination from further analysis. This is because these watercourses are not perennial streams according to Brown's perennial streams map, which reduces confidence about their initial classification as perennial streams according to the ASP and AG&E data sources. Applying Brown's perennial streams standard to the other watercourses, the initial classification is modified with the following results: 20 watercourses become no hitters, 12 become one-hitters, 2 become two-hitters, with one each for three- and four-hitters. The no-hitters and the one-hitters (i.e., 32 watercourses), based on the evaluation procedure outlined for Level 2, are classified under stream category C, i.e., not susceptible to navigation.

The multiple hitters, on the other hand, including: Beaver Dam Wash, Francis Creek, Kanab Creek, and Trout Creek, are classified under stream category B, i.e., not likely susceptible to navigation. Further evaluation is performed for these four watercourses to refine their classification by examining the various hits involved. Ultimately, these four watercourses, after thorough investigation and qualitative analysis at Level 3, could end up in either Categories A or C. Streams classified under stream Category A are strong candidates for Level 3 analysis, while streams classified under stream Category C are eliminated from further evaluation and analysis.

Beaver Dam Wash

Beaver Dam Wash, which has three affirmative hits that include its perennial stream classification, fish, and special status, is about 9.6 miles long with only one segment. According to Brown's perennial streams map (Arizona Game and Fish Department, 1997), only about 1.5 miles of the watercourse's lower reach is perennial.

Regarding fish, about eight fish species are widely documented by Silvey et al (1984).

Regarding special status, Beaver Dam Wash has both riparian classification and instream flow permit designations. Since instream flow permits are significantly related to characteristics of navigability, the watercourse indicates of susceptibility to navigation. The watercourse could be classified under

stream category A indicating potential susceptibility to navigation and justification for forwarding to Level 3.

Francis Creek

Francis Creek, which has two affirmative hits that include having fish and special status, flow from Mohave County into Yavapai County. The stream is about 23.8 miles long comprising of 20 identified segments.

About five fish species are widely documented by Silvey et al (1984). From to the listing provided by Arizona Game and Fish Department (1999), the fish species are both native and non-native fish.

Regarding special status, Francis Creek has a riparian classification according to Nationwide Rivers Inventory by National Park Service (1997). Since the riparian status of the watercourse is not water-related and the classification carries no bearing on navigability question, Francis Creek is classified under stream category C and the watercourse is excluded from any further investigation.

Kanab Creek

Kanab Creek, which has three affirmative hits that include perennial, fish and special status, is about 72.5 miles long with 47 segments. This watercourse flows from Utah to the Colorado River along the Mohave-Coconino County border. The watercourse is classified perennial according to Arizona State Parks (1995), but Brown's perennial streams map indicates the watercourse is interrupted – not fully perennial with intervening non-perennial stream segments. From Brown's perennial stream map, two intervening non-perennial reaches (a total of 51.5 miles) separate three stretches of perennial stream segments (a total length of 21.0 miles). Further, ALRIS (1988) listed Kanab Creek as entirely non-perennial weakening the case for perennial classification for this Pilot Study.

About eight fish species are widely documented by Silvey et al (1984). The fish species identified in Kanab Creek include both native and non-native species based on the information provided by Arizona Game and Fish Department (1999).

For the special status designations, Kanab Creek has a riparian classification and a Wild And Scenic status according to Nationwide Rivers Inventory by National Park Service (1997). From further examination of the facts, these special status classifications are not water-related and are not diagnostic relative to the navigability question. Kanab Creek, by virtue of its twenty-one-

mile long perennial segments and by its various fish species, is classified under stream Category A and forwarded for Level 3 evaluation.

Trout Creek

Trout Creek, which has two affirmative hits including having perennial stream classification and fish, is about 54.2 miles long with 43 segments. The watercourse is located in Mohave and Yavapai Counties. All the perennial segments of the watercourse, according to ALRIS (1988) and to the Brown's perennial stream map (1997), are located entirely in Mohave County with a total length of about 24.8 miles.

About seven fish species are widely documented in the literature that includes Silvey et al (1984). The fish species identified in Trout Creek include both native and non-native species based on the information provided by Arizona Game and Fish Department (1999).

Based on the two hits from Level 1 and from thorough investigation of these hits in Level 2, Trout Creek could be classified under stream category A like Beaver Dam Wash and Kanab Creek and ought to be further investigated in Level 3 analysis.

In summary, only Francis Creek is not recommended for Level 3 analysis. The other three watercourses, Kanab Creek, Beaver Dam Wash, and Trout Creek, by virtue of their classification under stream category A, are recommended for further investigation and analysis in Level 3.

Yuma County

There are 17 watercourses in Yuma County forwarded for Level 2 analysis. Table A-4 in the Appendix lists the NRL1 watercourses evaluated for Yuma County with the six criteria that serve as key attributes in Level 1 evaluation. From the list, all the watercourses are one-hitters (see column (13)). Furthermore, all the watercourses are classified as perennial (see column (6)) by ALRIS (1988) and Arizona State Parks (1995) but the same watercourses are declared non-perennial except for Date Creek according to Brown's perennial streams map developed by Arizona Game and Fish Department (1995, 1997). Considering the reliability of the Brown's perennial map, all the watercourses do not exhibit characteristics supporting evidence of susceptibility to navigation. In summary, all the NRL1 watercourses in Yuma County are classified in stream Category C.

4.2 LEVEL 3 ANALYSIS FOR THREE SELECTED WATERCOURSES

Three watercourses, representative of various physiographic provinces in the state of Arizona, were selected for pilot evaluation at Level 3 as described in *Criteria for Assessing Characteristics of Navigability for Small Watercourses in Arizona* (Stantec, 1998). The objective was to test the recommended methodologies on a full spectrum of stream conditions. The selected watercourses are described below and illustrated in Figure 9. Details of the analysis plus a presentation of the Level 3 analysis results for each of the three watercourses follows.

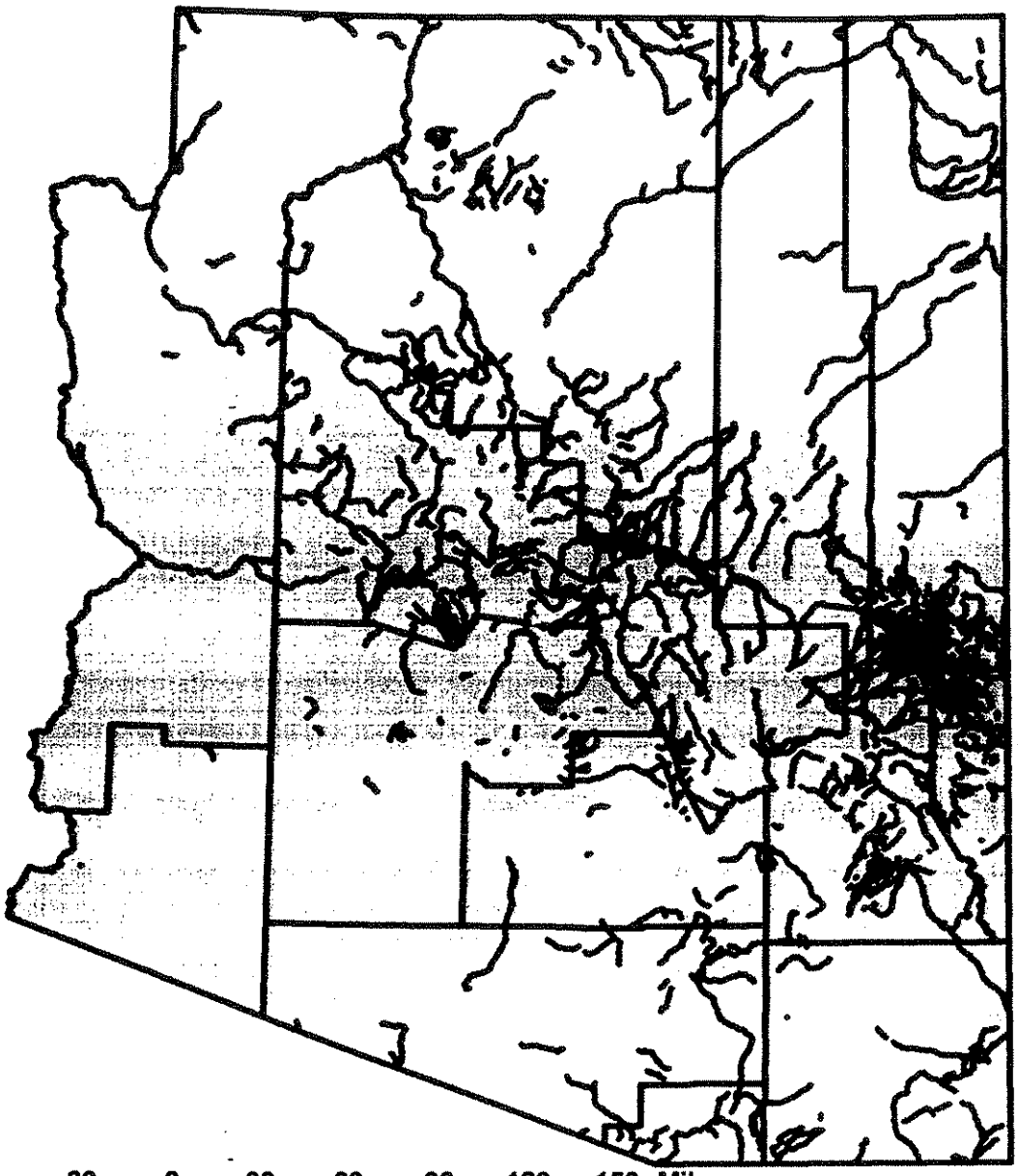
1. **Kanab Creek** in northern Arizona forms the boundary between Mohave and Coconino Counties starting from the Utah border to the north flowing into the Colorado River to the south;

2. **Aravaipa Creek** in southeastern Arizona, which is a tributary to the San Pedro River, is located in Pinal and Graham Counties.

3. **Pinal Creek** located in central Arizona in Gila County, is a tributary to the Upper Salt River.

FIGURE 9

Selected Watercourses for Level 3 Analysis



4.3 KANAB CREEK

Introduction

The following summarizes our preliminary information for the Level 3 analysis of Kanab Creek. The purpose of the Level 3 analysis is to provide basic technical data regarding stream characteristics from which the ANSAC can make a recommendation of navigability or non-navigability.

Stream Geomorphology

Kanab Creek, a tributary to the Colorado River, forms the boundary between Mohave and Coconino Counties from the North Rim of the Grand Canyon to the Utah border. The 2,322 square mile watershed drains the Grand Staircase and Kaibab Plateau regions of the Arizona Strip and Southern Utah. Approximately 625 square miles of the Kanab Creek watershed lies in Utah, with the remainder in Arizona. Elevations in the watershed range from about 9,350 feet near the headwaters of Johnson Wash to about 2,590 feet at the Colorado River confluence.

The Arizona portion of Kanab Creek can be divided into the following two stream reaches:

- Upper Alluvial Reach – Utah border to Confluence of Johnson Wash
- Lower Canyon Reach – Johnson Wash to Colorado River Confluence

The upper reach flows through the alluvial valley located between Kanab, Utah and Fredonia, Arizona. Most of the natural runoff in the upper reach is diverted for municipal and agricultural use. The upper reach is perennial where it enters Arizona until it reaches the town of Fredonia, where it becomes ephemeral. The channel in the upper reach underwent extensive erosion and entrenchment near the turn of the 20th century (Webb, et al, 1991). Since the time of Arizona statehood, the channel in the upper reach has been characterized by a wide braided stream bed inset between steep banks of erodible alluvium. The average channel slope is less than one percent.

The lower reach extends from downstream of Johnson Wash where the Kanab Creek Canyon begins to the Colorado River confluence. Most of the lower reach is non-perennial, according to the Arizona Department of Water Resources, although numerous springs provide a level of base flow to short reaches of the stream or its tributaries. The lower reach consists of flat-

bottomed, boulder-strewn channels between vertical bedrock canyon walls. The lower reach has a slope of less than one percent.

Photographs of the two reaches of Kanab Creek are provided in the Appendix.

Hydrology

Hydrologic data are available from the USGS stream gage "Kanab Creek near Fredonia, AZ" (Station #09403780), and "Kanab Creek near Kanab, UT (Station #09403600), both of which are located in the upper Reach of Kanab Creek, as described above. For this analysis, the USGS flow data were used as representative of the upper reach only. Because the lower reach is non-perennial, it is not considered in detail for the level 3 evaluation.

Flow data for Kanab Creek reported by the USGS (Pope et. al, 1999) and the Utah Department of Water Resources (1993) are summarized in Table 1 and Figures 1 and 2. Flow duration data are not available for the Kanab near Kanab, UT station.

Table 1. Flow Data
Kanab Creek @ USGS Stations

	Discharge (cfs)	
Period	Fredonia 09403780	Kanab 09403600
Mean Annual Flow	6.8	6.8
90% Flow Duration	0	-
50% Flow Duration	0	-
10% Flow Duration	11	-
2-Year Flood Peak	875	541

Figure 1. Kanab Creek Flow Duration Data
Kanab Creek Near Fredonia

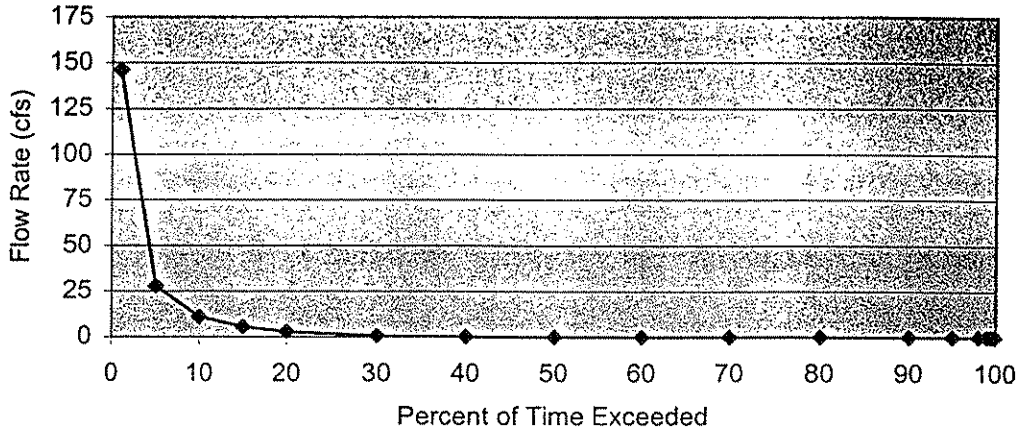
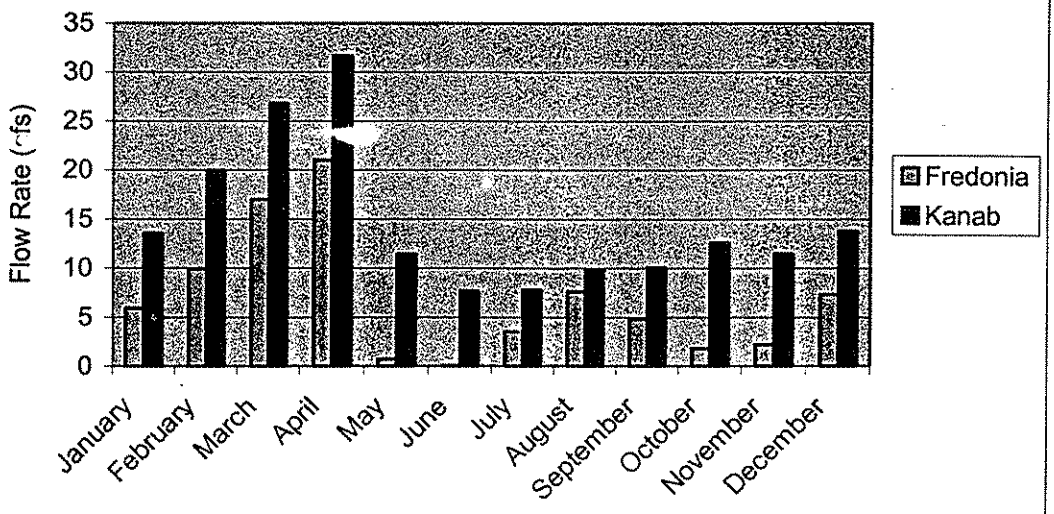


Figure 2. Kanab Creek Monthly Average Flow Rate



The flow data summarized above indicate that the lower reach of Kanab Creek is not perennial at the USGS gage near Fredonia, with zero flow about 50 percent of the time. Upstream near Kanab, monthly average flow rates confirm published descriptions of perennial flow, although no flow duration data were readily available. Diversion and groundwater pumping probably deplete surface runoff supplies from Kanab Creek near Fredonia. Higher periods of flow occur in late winter and early spring during snowmelt, with

average flow rates approaching 20 to 30 cfs. Seasonal low flow occurs during the summer months. The average annual flow rate is 6.8 cfs at both USGS gaging stations, and the median flow rate (50% duration) is 0 cfs at the Fredonia gaging station. The flow data reported above generally applies to the portion of the upper reach nearest the town of Fredonia. Near Kanab, marginally higher flow rates and perennial flow is expected, although not documented by the USGS. These data do not apply to the lower canyon reach, which is not perennial and typically has a dry streambed over most of its length.

Hydraulics

USGS rating curves were not available for either of the Kanab Creek gaging stations. Therefore, channel geometry and roughness coefficients were estimated from historic and recent photographs of the stream. Channel slope was estimated from USGS topographic maps. Hydraulic data reported in Tables 2 and 3 were obtained from rating curves developed using Manning's equation.

Table 2. ANSAC Pilot Study Level 3 Analysis
Kanab Creek in Upper Alluvial Reach (See Photograph #1 in Appendix)

	Discharge (cfs)	Depth (ft)	Width (ft)	Velocity (ft)
Mean Annual Flow	6.8	0.3	16	1.4
90% Flow Duration	0	0.0	0.0	0.0
50% Flow Duration	0	0.0	0.0	0.0
10% Flow Duration	11	0.4	16	1.7
2-Year Flood Peak	875	4.1	151	4.0

Table 3. ANSAC Pilot Study Level 3 Analysis
Kanab Creek in Lower Canyon Reach (See Photograph #2 in Appendix)

	Discharge (cfs)	Depth (ft)	Width (ft)	Velocity (ft)
Mean Annual Flow	6.8	0.1	49	1.1
90% Flow Duration	No Info.	-	-	-
50% Flow Duration	No Info.	-	-	-
10% Flow Duration	No Info.	-	-	-
2-Year Flood Peak	875	2.4	49	7.4

Boating Criteria

The boating criteria cited below were reported in previous detailed navigability studies prepared for the Arizona State Land Department, and are based on the following references:

1. Cooperative Instream Flow Service Group, 1978. Methods of Assessing Instream Flows for Recreation. Instream Flow Information Paper: No. 6. FWS/OBS-78/34. June. Report prepared by U.S. Fish and Wildlife Service, U.S. Environmental Protection Agency, Heritage Conservation and Recreation Service, and Bureau of Reclamation.

2. Jason M. Cortell and Associates, Inc., 1977, Recreation and Instream Flow, Vol. 1: Flow Requirements, Analysis of Benefits, Legal & Institutional Constraints. Report submitted to U.S. Department of the Interior, Bureau of Outdoor Recreation #BOR D6429. July.

3. Walter B. Langbein, 1962. Hydraulics of River Channels as Related to Navigability. U.S. Geological Survey Water-Supply Paper 1539-W.

4. Jim Slingluff, 1987. Deposition of Jim Slingluff for No. C 569870, Maricopa County, et al and Arizona Center for Law in the Public Interest, et al., and Calmat Co. of Arizona, et al, v. State of Arizona, Arizona State Land Department, M. Jean Hassel, and Milo J. Hassel, et al. November 23, 1987.

The following tables summarize navigability criteria information from references 1 to 4. Note that these data reference recreational boating, not necessarily commercial boating.

Table 4. Minimum Required Stream Width and Depth for Recreation Craft[1]

Type of Craft	Depth (ft.)	Width (ft.)
Canoe, Kayak	0.5	4
Raft, Drift Boat, Row Boat	1.0	6
Tube	1.0	4
Power Boat	3.0	6

[1] After reference #1

Table 5. Minimum and Maximum Conditions for Recreational Water Boating[1]						
Type of Boat	Minimum Condition			Maximum Condition		
	Width	Depth	Velocity	Width	Depth	Velocity
Canoe, Kayak	25 ft.	3-6 in.	5 fps	-	-	15 fps
Raft, Drift Boat	50 ft.	1 ft.	5 fps	-	-	15 fps
Low Power Boating	25 ft.	1 ft.	-	-	-	10 fps
Tube	25 ft.	1 ft.	1 fps	-	-	10 fps
[1] After reference 2.						

Table 6. Flow Requirements for Pre-1940 Canoe Boating[1]	
Boat Type	Depth
Flat Bottomed (Wood or Canvas)	4 in.
Round Bottomed (Wood or Canvas)	6 in.
[1] After reference 4.	

Summary

Comparison of the boating criteria and hydraulic data for Kanab Creek shown above indicate that the lower reach generally could not be boated even by low draft canoes or kayaks more than 90 percent of the time, and that boating by larger commercial craft would be even more unlikely. During floods, even low draft recreational boating would be difficult due to overhanging vegetation, fences and other obstructions. No modern or historical accounts of any type of boating in Kanab Creek were obtained during the course of the Small Watercourse Study. A Level 4 study is not recommended for Kanab Creek.

Limitations

This evaluation is based on readily available information that reflects the level of detail and funding authorized for the ANSAC Small Watercourses Navigability Study. The following limitations apply to the results presented above:

- The hydraulic rating sections may or may not apply to the entire study reach. However, the rating section results probably represent better than order-of-magnitude accuracy for estimates of width, depth, and velocity at any given point within the study reach.

- Hydrologic data for any stream varies with location within a reach, and with time in response to climatic conditions. The hydrologic information provided is best readily available data for the stream.

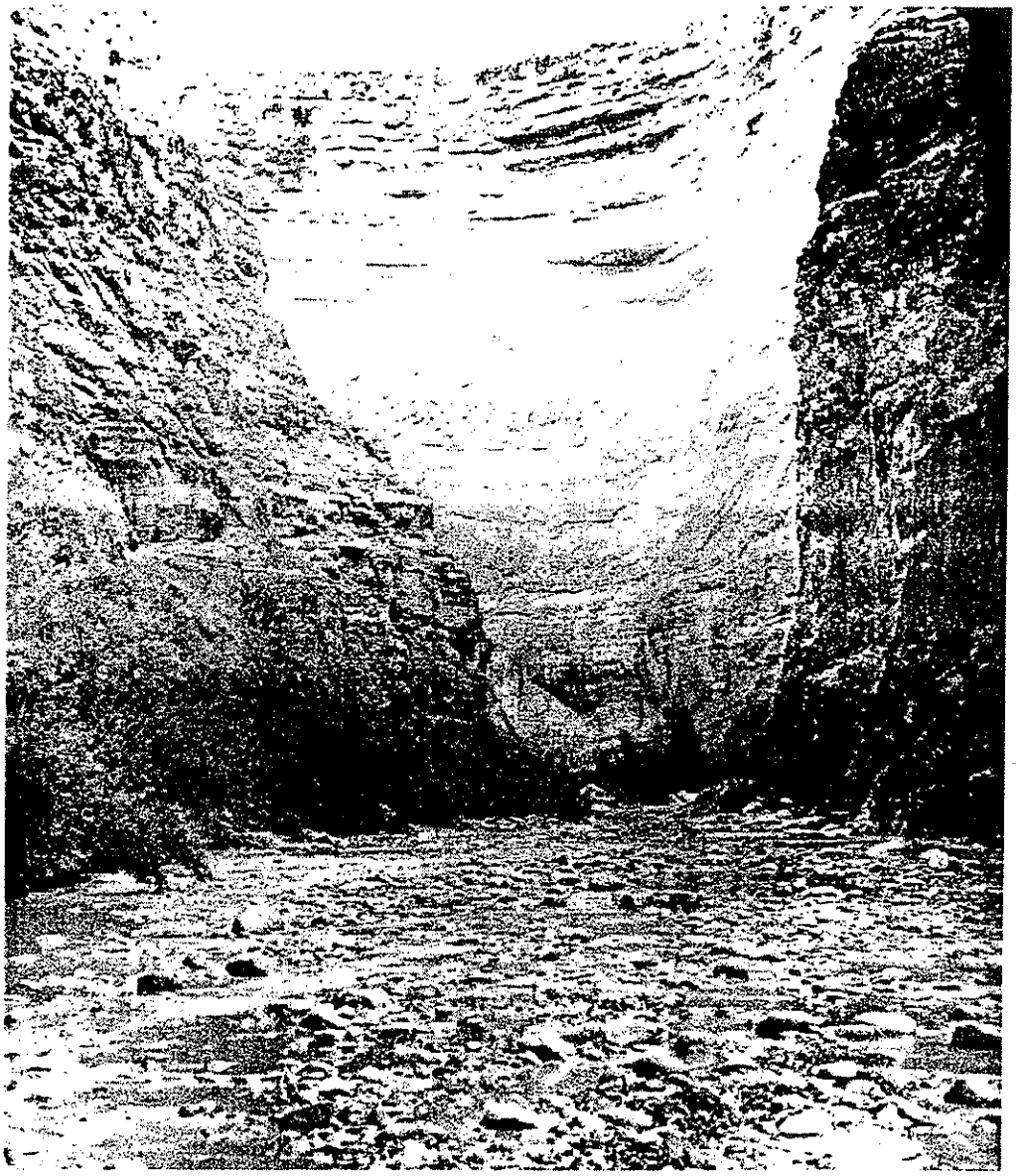
- Stream conditions were assumed to represent conditions as of the time of Arizona statehood. Unless stated otherwise, no data were identified during the Level 3 analysis that indicated substantive changes in stream morphology with respect to navigability criteria.

Photographs of Kanab Creek

Photograph #1

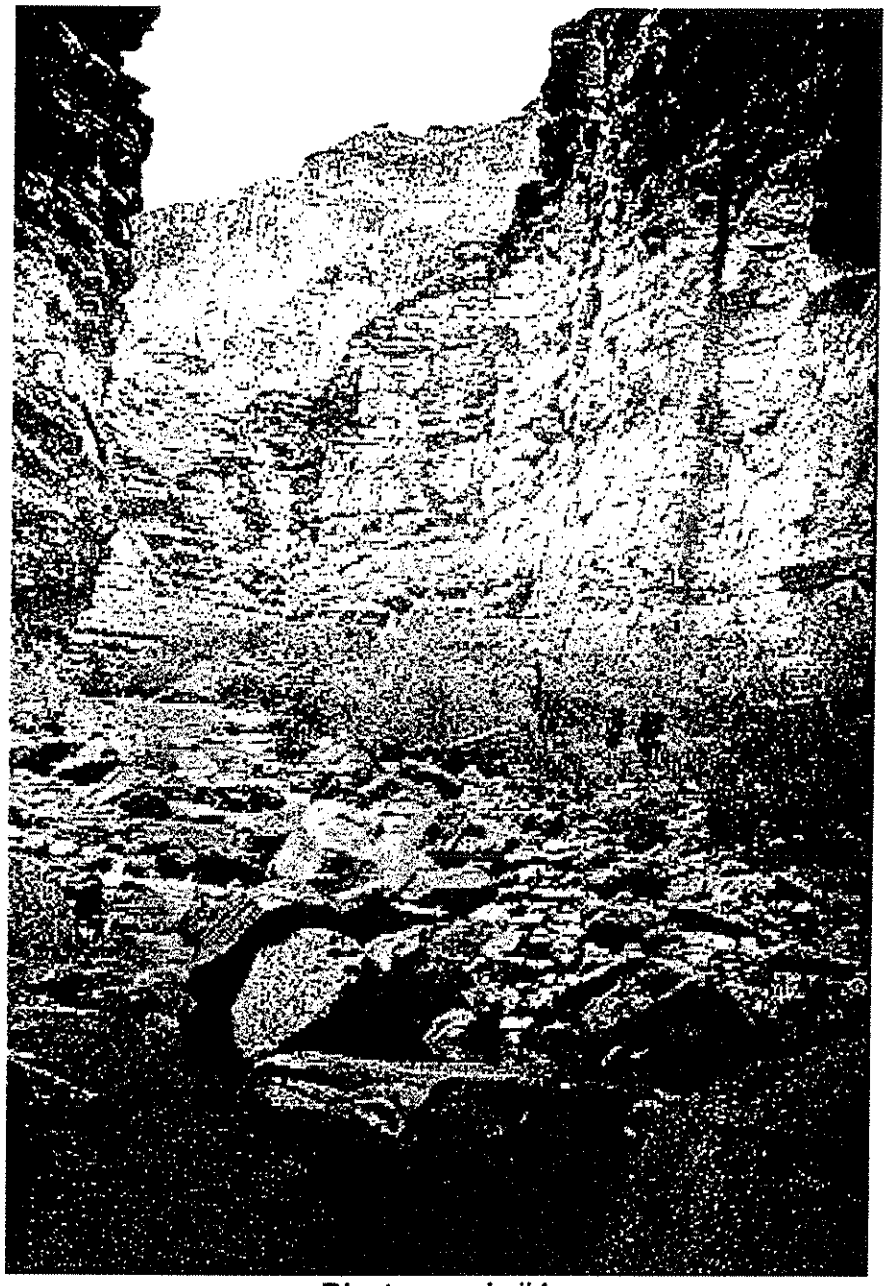
View of Kanab Creek near the Vermillion Cliffs. This photo was used to estimate channel geometry for the hydraulic rating curve summarized in Table 2 (Source: Figure 3-4B of Webb, R.H., Smith, S.S., McCord, V.A.S., 1991)

Photograph #2
View of Upper Kanab Creek near Kanab.



Photograph #3

View of Kanab Creek downstream of Showerbath Spring in Lower Canyon Reach. This photo was used to estimate channel geometry for the hydraulic rating curve summarized in Table 3 (Source: Figure 3-12B of Webb, R.H., Smith, S.S., McCord, V.A.S., 1991)



Photograph #4
Modern Photo of Lower Canyon Reach near Colorado River Confluence.

4.4 ARAVAIPA CREEK

Introduction

The following summarizes our preliminary information for the Level 3 analysis of Aravaipa Creek. The purpose of the Level 3 analysis is to provide basic technical data regarding stream characteristics from which the ANSAC can make a recommendation of navigability or non-navigability.

Stream Geomorphology

Aravaipa Creek, a tributary to the San Pedro River, is located in Pinal and Graham Counties in southeastern Arizona. The 541 square mile watershed drains the Galiuro, Pinaleno, and Santa Teresa Mountains, as well as the intervening alluvial fill valleys. Elevations in the watershed range from about 8,400 feet in the Pinaleno Moutains to 2,160 feet at the San Pedro River confluence, although the maximum elevation along Aravaipa Creek itself is only about 4200 feet.

Aravaipa Creek can be divided into the following three stream reaches:

- Upper Reach – Aravaipa Valley above BLM Wilderness Area
- Middle Reach – BLM Wilderness Area & Canyon
- Lower Reach – Downstream of BLM Wilderness Area to San Pedro River

The upper reach flows through the Aravaipa Valley, an agricultural region located mostly upstream of the town of Klondyke. The upper reach is ephemeral or intermittent, and consists of wide, braided channels which are normally dry. The upper reach is about 55 miles long and has a slope of about 0.9 percent. The middle reach extends through the Aravaipa Canyon Wilderness Area managed by the Bureau of Land Management, with portions owned by The Nature Conservancy. The middle reach is perennial, and consists of sand- and gravel-bedded stream segments flowing in the bottom of deep, vertical-walled bedrock canyons. The middle reach is about 11.5 miles long and is slightly steeper than the adjacent reaches with a slope of about 2.5 percent. The lower reach extends from the downstream end of the Aravaipa Canyon Wilderness Area to the San Pedro River confluence. Most of the lower reach is perennial, with the flow becoming less reliable in the downstream direction. The lower reach is approximately 6 miles long, consists of wide, shallow, slightly braided channels, and has an average slope of about 0.9 percent.

Photographs of Aravaipa Creek are provided in the Appendix.

Hydrology

Hydrologic data are available from the USGS stream gage "Aravaipa Creek Near Mammoth, AZ" (Station #09473000), which is located in the Lower Reach of Aravaipa Creek, as described above. Other gaging information is also available from the US Fish & Wildlife Service, the Bureau of Land Management, the Nature Conservancy, and some private parties living along the wash. For this analysis, only the USGS data were considered due to the high quality of USGS sampling and reporting procedures, the length of record at the USGS station (1919-1921, 1931-1941, 1965-1999), and the availability of the USGS data. The USGS gage data are most applicable to the middle and lower reaches of the study area.

Flow data for Aravaipa Creek reported by the USGS (Pope et. al, 1999) are summarized in Table 1 and Figures 1 and 2.

Table 1. Flow Data
Aravaipa Creek @ USGS Station 09473000

Period	Discharge (cfs)
Mean Annual Flow	36
90% Flow Duration	6.2
50% Flow Duration	17
10% Flow Duration	48
2-Year Flood Peak	3,980

Figure 1. Aravaipa Creek Flow Duration Data

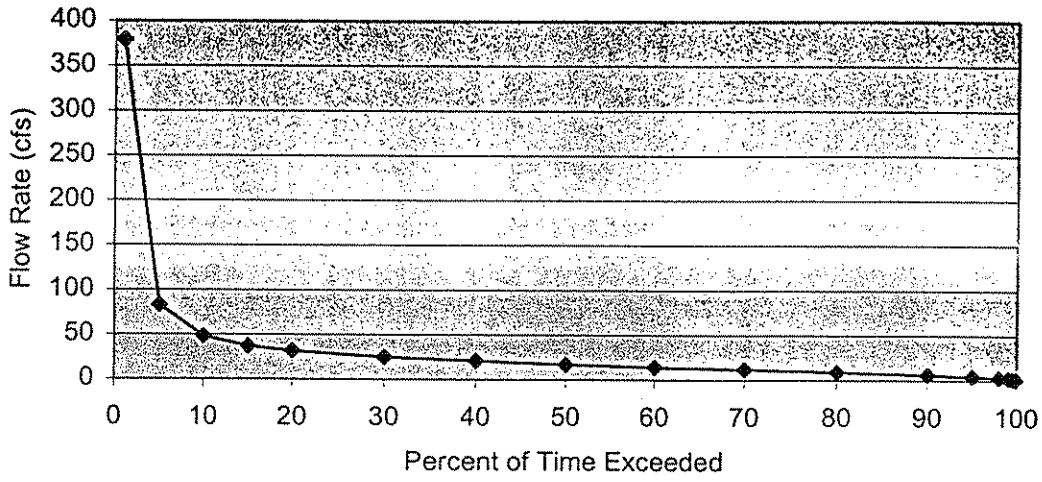
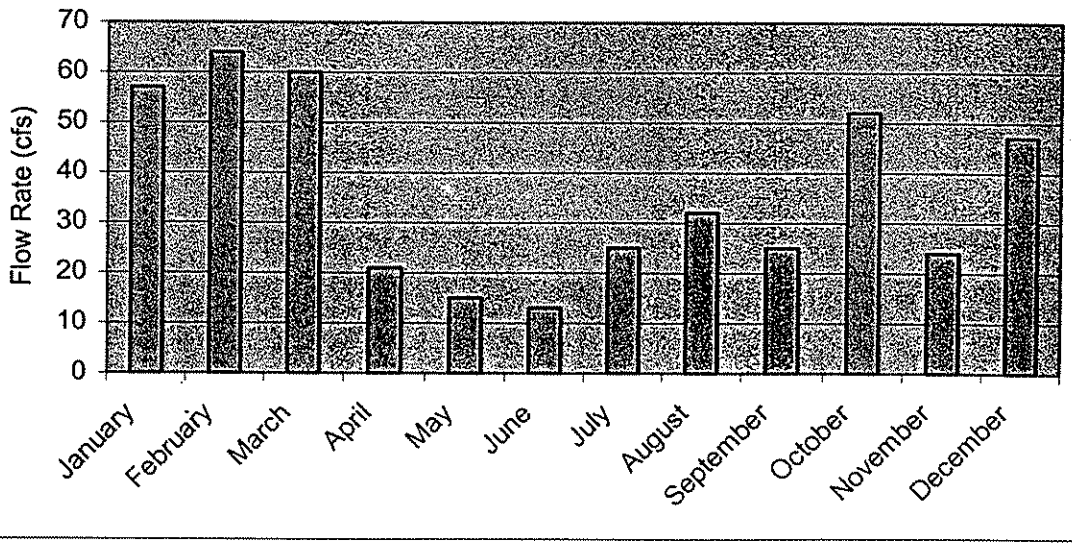


Figure 2. Aravaipa Creek Monthly Flow Data



The flow data summarized above confirm that Aravaipa Creek is perennial, and that flow rates average 50-60 cfs between January and March each year. The average annual flow rate is 36 cfs, although the median flow rate (50% duration) is only 17 cfs. The flow data reported above generally applies to the lower and middle reaches of Aravaipa Creek. These data do not apply to the upper reach, which is not perennial and typically has a dry streambed.

Hydraulics

Rating curves were obtained from USGS records and from field-surveyed cross sections. Field sections were hand gaged at discharges ranging from 12 cfs to 17 cfs. Hydraulic data reported for the field sections at the 50 percent flow duration are actual measurements of depth, width and velocity at 17 cfs. Hydraulic data reported for other frequencies were obtained from rating curves developed using Manning's equation. The hydraulic data from the USGS gage are from actual field measurements by USGS staff.

Table 2. ANSAC Pilot Study Level 3 Analysis Aravaipa Creek @ USGS Gage

	Discharge (cfs)	Depth (ft)	Width (ft)	Velocity (ft)
Mean Annual Flow	36	1.6	32	2.2
90% Flow Duration	6.2	1.2	18	0.5
50% Flow Duration	17	1.4	30	1.3
10% Flow Duration	48	1.7	32	2.3
2-Year Flood Peak	3,980	6.1	No info.	No info.

Table 3. ANSAC Pilot Study Level 3 Analysis
Aravaipa Creek in BLM Wilderness (Canyon Reach, Field Surveyed Sections)

	Discharge (cfs)	Depth (ft)		Width (ft)		Velocity (ft)	
		Xn #1	Xn #2	Xn #1	Xn #2	Xn #1	Xn #2
Mean Annual Flow	36	1.6	0.7	12	23	4.0	3.1
90% Flow Duration	6.2	0.8	0.3	5	19	2.9	1.8
50% Flow Duration	17	1.2	0.5	7	21	3.6	2.5
10% Flow Duration	48	1.8	0.8	15	24	4.3	3.2
2-Year Flood Peak	3,980	14.9	8.6	31	40	12.8	13.5

Notes:
1. Section #1 (Xn#1) is located immediately downstream of the Painted Cave Creek confluence.
2. Section #2 (Xn#2) is located immediately upstream of the Turkey Creek confluence.

Boating Criteria

The boating criteria cited below were reported in previous detailed navigability studies prepared for the Arizona State Land Department, and are based on the following references:

1. Cooperative Instream Flow Service Group, 1978. Methods of Assessing Instream Flows for Recreation. Instream Flow Information Paper: No. 6. FWS/OBS-78/34. June. Report prepared by U.S. Fish and Wildlife Service, U.S. Environmental Protection Agency, Heritage Conservation and Recreation Service, and Bureau of Reclamation.

2. Jason M. Cortell and Associates, Inc., 1977, Recreation and Instream Flow, Vol. 1: Flow Requirements, Analysis of Benefits, Legal & Institutional Constraints. Report submitted to U.S. Department of the Interior, Bureau of Outdoor Recreation #BOR D6429. July.

3. Walter B. Langbein, 1962. Hydraulics of River Channels as Related to Navigability. U.S. Geological Survey Water-Supply Paper 1539-W.

4. Jim Slingluff, 1987. Deposition of Jim Slingluff for No. C 569870, Maricopa County, et al and Arizona Center for Law in the Public Interest, et al., and Calmat Co. of Arizona, et al, v. State of Arizona, Arizona State Land Department, M. Jean Hassel, and Milo J. Hassel, et al. November 23, 1987.

The following tables summarize navigability criteria information from references 1 to 4. Note that these data reference recreational boating, not necessarily commercial boating.

Table 4. Minimum Required Stream Width and Depth for Recreation Craft[1]

Type of Craft	Depth (ft.)	Width (ft.)
Canoe, Kayak	0.5	4
Raft, Drift Boat, Row Boat	1.0	6
Tube	1.0	4
Power Boat	3.0	6

[1] After reference #1

Table 5. Minimum and Maximum Conditions for Recreational Water Boating[1]

Type of Boat	Minimum Condition			Maximum Condition		
	Width	Depth	Velocity	Width	Depth	Velocity
Canoe, Kayak	25 ft.	3-6 in.	5 fps	-	-	15 fps
Raft, Drift Boat	50 ft.	1 ft.	5 fps	-	-	15 fps
Low Power Boating	25 ft.	1 ft.	-	-	-	10 fps
Tube	25 ft.	1 ft.	1 fps	-	-	10 fps

[1] After reference 2.

Table 6. Flow Requirements for Pre-1940 Canoe Boating[1]

Boat Type	Depth
Flat Bottomed (Wood or Canvas)	4 in.
Round Bottomed (Wood or Canvas)	6 in.

[1] After reference 4.

Stantec

Summary

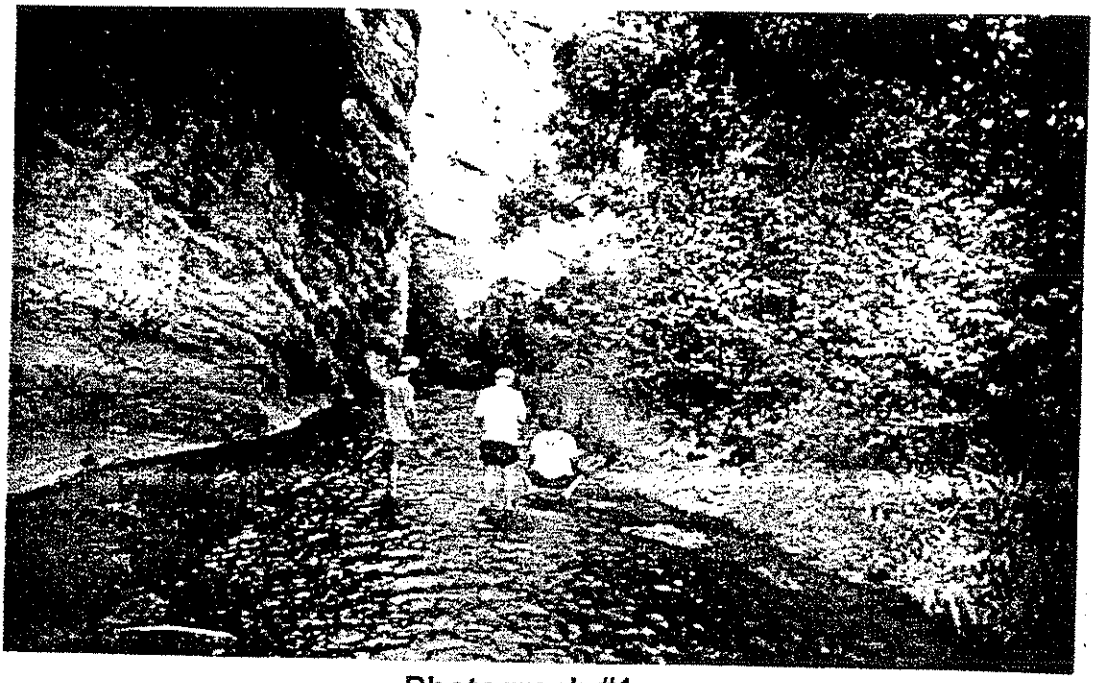
Comparison of the boating criteria and hydraulic data for Aravaipa Creek shown above indicate that the lower and middle reaches could be boated by low draft canoes or kayaks slightly more than half the time, but that boating by larger commercial craft would be unlikely. Expected velocities during the 2-year flood approach the maximum rates for recreational boating, and would seriously hinder upstream travel. Field data collected by the author indicates that such recreational boating would be moderately difficult due to numerous shallow riffles and overhanging vegetation. No modern or historical accounts of any type of boating in Aravaipa Creek were obtained during the course of the Small Watercourse Study. A Level 4 study is not recommended for Aravaipa Creek.

Limitations

This evaluation is based on readily available information that reflects the level of detail and funding authorized for the ANSAC Small Watercourses Navigability Study. The following limitations apply to the results presented above:

- The hydraulic rating sections may or may not apply to the entire study reach. However, the rating section results probably represent better than order-of-magnitude accuracy for estimates of width, depth, and velocity at any given point within the study reach.
- Hydrologic data for any stream varies with location within a reach, and with time in response to climatic conditions. The hydrologic information provided is best readily available data for the stream.
- Stream conditions were assumed to represent conditions as of the time of Arizona statehood. Unless stated otherwise, no data were identified during the Level 3 analysis that indicated substantive changes in stream morphology with respect to navigability criteria.

Photographs of Aravaipa Creek



Photograph #1
Aravaipa Creek above Turkey Creek (Canyon Reach) at approximately 17 cfs on July 2, 1999.

Photograph #2
Aravaipa Creek below Painted Cave Creek (Canyon Reach) at approximately 17 cfs on July 5, 1999.

4.5 PINAL CREEK

Introduction

The following summarizes our preliminary information for the Level 3 analysis of Pinal Creek. The purpose of the Level 3 analysis is to provide basic technical data regarding stream characteristics from which the ANSAC can make a recommendation of navigability or non-navigability.

Stream Geomorphology

Pinal Creek, a tributary to the upper Salt River, is located in Gila County in central Arizona. The 195 square mile watershed drains the Pinal and Salt River Mountains, as well as urbanized and mined areas within the Globe-Miami copper mining district. Elevations in the watershed range from about 7,600 feet at Pinal Peak to about 2,400 feet at the Salt River confluence, although the maximum elevation along Pinal Creek itself is only about 4,400 feet.

Pinal Creek can be divided into the following two stream reaches:

- Upper Reach – Headwaters to Horseshoe Bend Wash
- Lower Reach – Horseshoe Bend Wash to Salt River Confluence

The upper reach flows through the Globe-Miami copper mining district and the small cities of Globe, Miami, and Claypool, as well as portions of unincorporated Gila County downstream of Globe. The upper reach is ephemeral and consists of relatively wide, braided channels which are normally dry except during floods. The average channel slope is about one percent. The lower reach extends from downstream of Horseshoe Bend Wash where perennial flow begins to the Salt River confluence. Most of the lower reach is perennial, with the flow rate highly dependent on the rate of groundwater infiltration, depth to bedrock, and groundwater pumping. The lower reach is approximately 7 miles long, consists of relatively wide, shallow channels with a broad floodplain that transitions to a moderately narrow, deep canyon about 3 miles upstream of the Salt River confluence. The lower reach has a slope of about 0.9 percent.

Photographs of the two reaches of Pinal Creek are provided in the Appendix.

Hydrology

Hydrologic data are available from the USGS stream gage "Pinal Creek at Inspiration Dam, Near Globe, AZ" (Station #09498400), which is located in the

Lower Reach of Pinal Creek, as described above. For this analysis, the USGS flow data were used as representative of the lower reach. Because the upper reach is ephemeral, it is not considered in detail for the level 3 evaluation.

Flow data for Pinal Creek reported by the USGS (Pope et. al, 1999) are summarized in Table 1 and Figures 1 and 2.

Table 1. Flow Data

Pinal Creek @ USGS Station 09498400

Period	Discharge (cfs)
Mean Annual Flow	15
90% Flow Duration	5.2
50% Flow Duration	8.1
10% Flow Duration	13
2-Year Flood Peak	1,320

Figure 1. Pinal Creek @ Inspiration Dam Flow Duration Curve

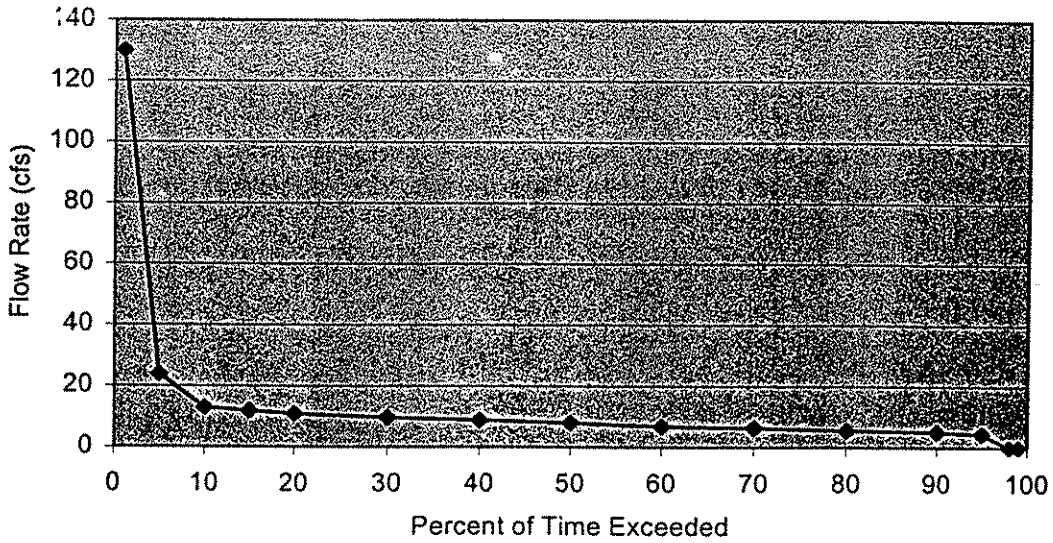
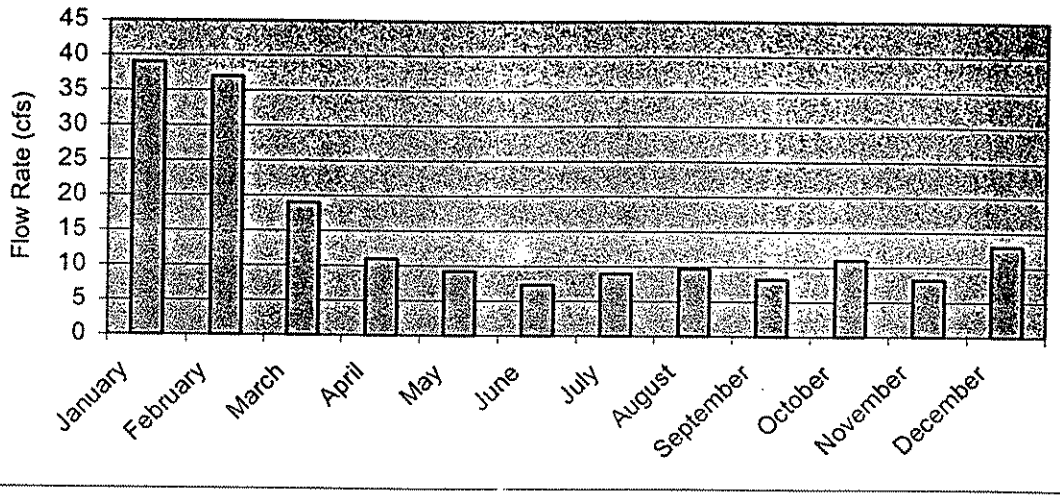


Figure 2. Pinal Creek @ Inspiration Dam Average Monthly Flow Rate (cfs)



The flow data summarized above indicate that the lower reach of Pinal Creek is nearly perennial at the USGS gage, with non-zero flows about 98 percent of the time. The average monthly flow rates are all above zero flow, indicating that periods of zero flow are brief, and may be related to seasonal groundwater pumping or other withdrawals. The USGS gage data also indicate that the minimum average monthly flow rates are also above 0 cfs. The typical flow rate is less than 13 cfs about 90 percent of the time, except during the winter months of January, February, and March, or during summer flash floods. The average annual flow rate is only 15 cfs, although the median flow rate (50% duration) is only 8.1 cfs. The flow data reported above generally applies to the lower reach of Pinal Creek. These data do not apply to the Upper Reach, which is not perennial and typically has a dry streambed.

Hydraulics

Rating curves were obtained from USGS records for the USGS gaging station at Inspiration Dam for the lower reach (Table 2), and from a field-surveyed cross section from the upper reach. Hydraulic data reported in Table 3 were obtained from rating curves developed using Manning's equation.

Table 2. ANSAC Pilot Study Level 3 Analysis Pinal Creek @ USGS Gage at Inspiration Dam (Lower Reach)				
	Discharge (cfs)	Depth (ft)	Width (ft)	Velocity (ft)
Mean Annual Flow	15	0.7	15	2.4
90% Flow Duration	5.2	0.4	12	1.7
50% Flow Duration	8.1	0.5	13	1.9
10% Flow Duration	13	0.6	14	2.2
2-Year Flood Peak	1,320	4.5	57	8.2

Table 3. ANSAC Pilot Study Level 3 Analysis Pinal Creek in Upper Reach near Wilbanks Drive				
	Discharge (cfs)	Depth (ft)	Width (ft)	Velocity (ft)
Mean Annual Flow	n/a	0.6	21	1.4
90% Flow Duration	n/a	0.3	18	1.0
50% Flow Duration	n/a	0.4	19	1.2
10% Flow Duration	n/a	0.5	20	1.4
2-Year Flood Peak	1,320	4.8	138	4.1
Note: Provided for only comparison of potential flow depths. Non-flood flow duration data from the USGS gage do not apply to the non-perennial upper reach of Pinal Creek.				

Boating Criteria

The boating criteria cited below were reported in previous detailed navigability studies prepared for the Arizona State Land Department, and are based on the following references:

1. Cooperative Instream Flow Service Group, 1978. Methods of Assessing Instream Flows for Recreation. Instream Flow Information Paper: No. 6. FWS/OBS-78/34. June. Report prepared by U.S. Fish and Wildlife Service, U.S. Environmental Protection Agency, Heritage Conservation and Recreation Service, and Bureau of Reclamation.

2. Jason M. Cortell and Associates, Inc., 1977, Recreation and Instream Flow, Vol. 1: Flow Requirements, Analysis of Benefits, Legal & Institutional Constraints. Report submitted to U.S. Department of the Interior, Bureau of Outdoor Recreation #BOR D6429. July.

3. Walter B. Langbein, 1962. Hydraulics of River Channels as Related to Navigability. U.S. Geological Survey Water-Supply Paper 1539-W.

4. Jim Slingluff, 1987. Deposition of Jim Slingluff for No. C 569870, Maricopa County, et al and Arizona Center for Law in the Public Interest, et al., and Calmat Co. of Arizona, et al, v. State of Arizona, Arizona State Land Department, M. Jean Hassel, and Milo J. Hassel, et al. November 23, 1987.

The following tables summarize navigability criteria information from references 1 to 4. Note that these data reference recreational boating, not necessarily commercial boating.

Table 4. Minimum Required Stream Width and Depth for Recreation Craft[1]

Type of Craft	Depth (ft.)	Width (ft.)
Canoe, Kayak	0.5	4
Raft, Drift Boat, Row Boat	1.0	6
Tube	1.0	4
Power Boat	3.0	6

[1] After reference #1

Table 5. Minimum and Maximum Conditions for Recreational Water Boating[1]

Type of Boat	Minimum Condition			Maximum Condition		
	Width	Depth	Velocity	Width	Depth	Velocity
Canoe, Kayak	25 ft.	3-6 in.	5 fps	-	-	15 fps
Raft, Drift Boat	50 ft.	1 ft.	5 fps	-	-	15 fps
Low Power Boating	25 ft.	1 ft.	-	-	-	10 fps
Tube	25 ft.	1 ft.	1 fps	-	-	10 fps

[1] After reference 2.

Table 6. Flow Requirements for Pre-1940 Canoe Boating[1]

Boat Type	Depth
Flat Bottomed (Wood or Canvas)	4 in.
Round Bottomed (Wood or Canvas)	6 in.

[1] After reference 4.

Summary

Comparison of the boating criteria and hydraulic data for Pinal Creek shown above indicate that the lower reach could be boated by low draft canoes or kayaks during less than 10 percent of the time, and that boating by larger commercial craft would be unlikely. Field data collected by the author indicates that low-draft recreational boating would be difficult due to overhanging vegetation, fences and other obstructions. No modern or historical accounts of any type of boating in Pinal Creek were obtained during

the course of the Small Watercourse Study. A Level 4 study is not recommended for Pinal Creek.

Limitations

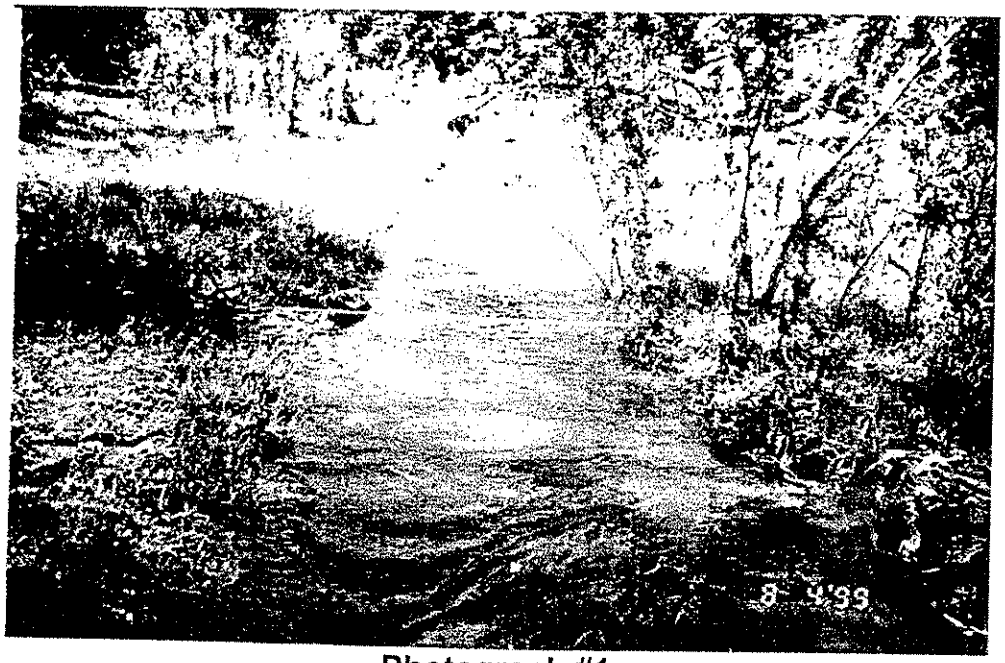
This evaluation is based on readily available information that reflects the level of detail and funding authorized for the ANSAC Small Watercourses Navigability Study. The following limitations apply to the results presented above:

- The hydraulic rating sections may or may not apply to the entire study reach. However, the rating section results probably represent better than order-of-magnitude accuracy for estimates of width, depth, and velocity at any given point within the study reach.

- Hydrologic data for any stream varies with location within a reach, and with time in response to climatic conditions. The hydrologic information provided is best readily available data for the stream.

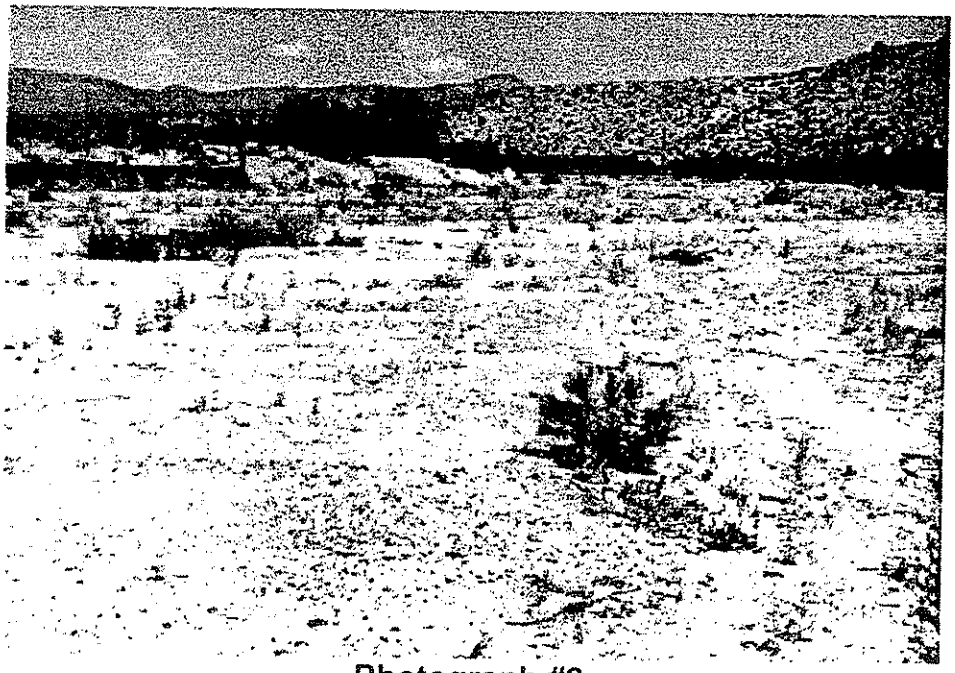
- Stream conditions were assumed to represent conditions as of the time of Arizona statehood. Unless stated otherwise, no data were identified during the Level 3 analysis that indicated substantive changes in stream morphology with respect to navigability criteria.

Photographs of Pinal Creek



Photograph #1

Pinal Creek at Inspiration Dam near Globe, at approximately 8 cfs on August 4, 1999 (Lower Reach).



Photograph #2

Pinal Creek upstream of Wilbanks Drive Bridge below Miami Wash at 0 cfs on July 15, 1998 (Upper Reach).

5.0 Conclusions and Recommendations

- A Pilot Study was performed for assessing navigability and susceptibility to navigation for small watercourses in Arizona using the criteria described in *Criteria for Assessing Characteristics of Navigability for Small Watercourses in Arizona* (Stantec, 1998). Project approach and results of the multiple levels of analysis are presented in this document.

- An ArcView GIS master watercourse database was developed and fully populated for data fields relating to the diagnostic criteria evaluated at Level 1 of the multi-level watercourse evaluation system for all small and minor watercourses in Arizona. Satellite databases provide additional informational data fields related to each of the six criterions comprising the Level 1 assessment. The primary utility of the databases is for spatial data interpretation and as a data management tool only. A digital version of those databases was delivered to the ANSAC with this report.

- Information supplied is based on the best available data and information obtainable at the time of delivery. It should be noted that conditions may have been different at the time of statehood in 1912, but those data are lacking. Interpretation of the variation of the conditions represented by the data used herein compared to those found at statehood must be conducted in consultation with the appropriate local, state and federal officials supplying that data.

- The databases need to be continually updated to incorporate new data or information and to reflect future analysis and findings. The work to be conducted by the project team under contract to the ASLD in applying the multi-level evaluation system to all remaining watercourses statewide will serve this purpose, in part.

6.0 References

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Arizona Game and Fish Department, Geospatial Data set: Perennial Waters of Arizona, a digital file submitted to Stantec Consulting, Inc. dated July 9, 1999.

Arizona State Land Department, Arizona Land Resources Information System (ALRIS), Geospatial Data set: Streams, a digital file submitted to Stantec Consulting, Inc. dated July 13, 1999.

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Stantec Consulting, Inc., (1999), Small and Minor Watercourses Analysis, a proposal submitted to Arizona State Land Department, Phoenix, Arizona on June 1999.

Stantec Consulting, Inc., (1998), Criteria for assessing characteristics of navigability for small watercourses in Arizona, Final Report, submitted to Arizona Navigable Streams Adjudication Commission (ANSAC), on September 1998.

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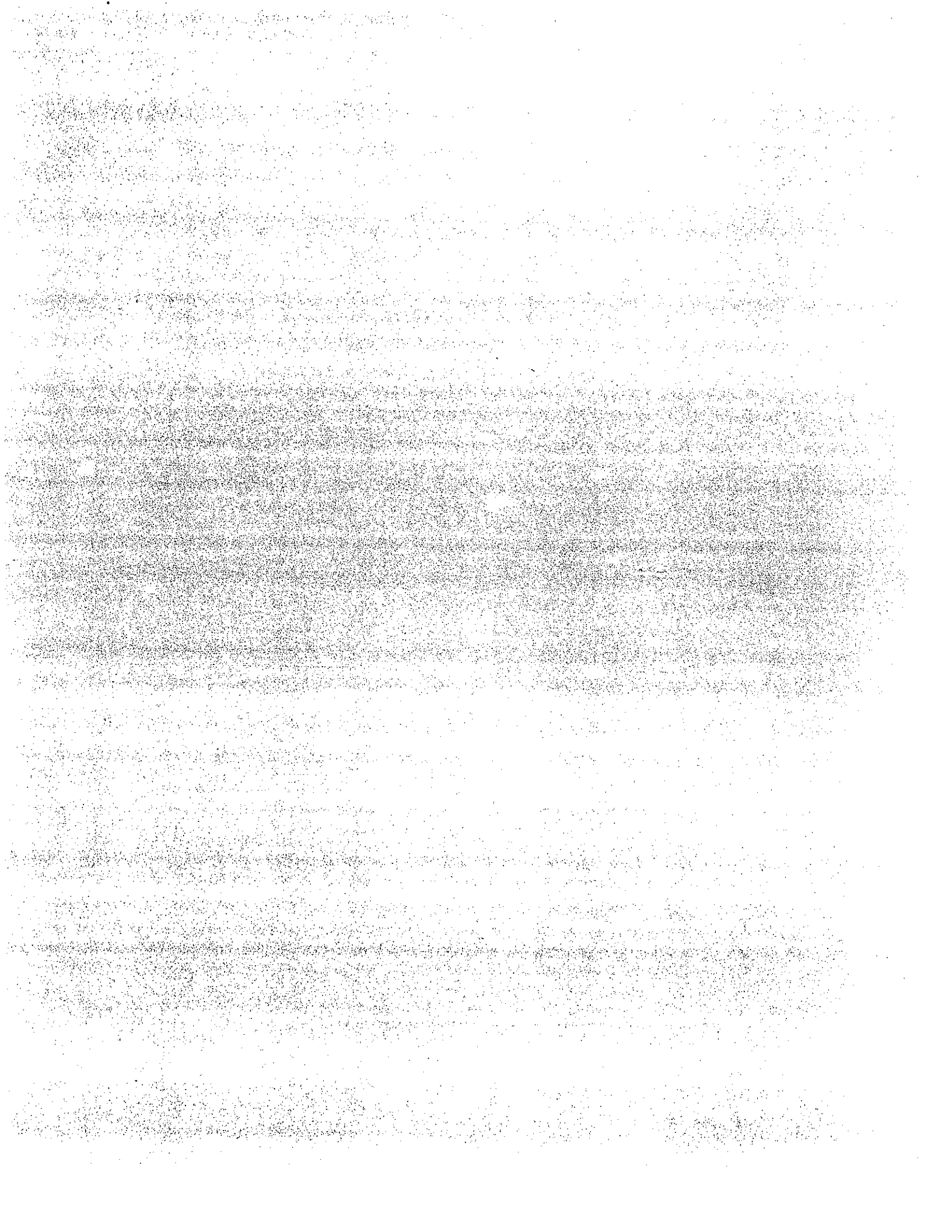
Young, K. L., and Lopez, M., (1995), Fall Fish Count Summary, 1988-1994, Technical Report 81, Nongame and Endangered Wildlife Program, Arizona Game and Fish Department, Phoenix, Arizona, 119 pp., June 1995.



APPENDIX

TABLE A-1

Summary of Number of Hits for Watercourses Evaluated in Level 1 Analysis

No.	Number of Hits	Watercourses		Total
		Without Names	With Names	
(1)	(2)	(3)	(4)	(5)
0	0	0	1	1
1	1	489	273	762
2	2	9	176	185
3	3	0	62	62
4	4	0	13	13
5	5	0	1	1
6	6	0	1	1
7	Total	498	527	1025

NRL1 Watercourses Evaluated for La Paz County
(Table A-2)

No.	Name of Watercourse	Segments	Miles	Counties	Perennial	Modern Boating	Historical Boating	Fish	Special Status	Dam Impacted	Perrenial [Brown]	Hits	Hits [Brown]
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1	Date Creek	54	49.2629	La Paz/Yavapai	Yes	No	No	Yes	No	No	Yes	2	2
2	H70_0317	1	0.1576	La Paz/Mohave	Yes	No	No	No	No	No	No	1	0
3	H70_0520	1	0.0659	La Paz/Mohave	Yes	No	No	No	No	No	No	1	0
4	H34_0297	1	0.0934	La Paz	Yes	No	No	No	No	No	No	1	0
5	H34_0299	1	0.2758	La Paz	Yes	No	No	No	No	No	No	1	0
6	H34_0460	1	0.0291	La Paz	Yes	No	No	No	No	No	No	1	0
7	H34_1395	1	2.8275	La Paz	Yes	No	No	No	No	No	No	1	0
8	H34_2321	5	0.7047	La Paz	Yes	No	No	No	No	No	No	1	0
9	H34_2322	1	0.1978	La Paz	Yes	No	No	No	No	No	No	1	0
10	H34_2323	1	0.0741	La Paz	Yes	No	No	No	No	No	No	1	0
11	H34_2324	1	0.4562	La Paz	Yes	No	No	No	No	No	No	1	0
12	H34_2325	1	0.0517	La Paz	Yes	No	No	No	No	No	No	1	0
13	H34_2372	1	0.0174	La Paz	Yes	No	No	No	No	No	No	1	0
14	H34_2377	2	0.7972	La Paz	Yes	No	No	No	No	No	No	1	0
15	H34_2378	2	0.8832	La Paz	Yes	No	No	No	No	No	No	1	0
16	H34_2380	1	0.5760	La Paz	Yes	No	No	No	No	No	No	1	0
17	H34_3004	1	0.0318	La Paz	Yes	No	No	No	No	No	No	1	0
18	H34_3006	1	0.0501	La Paz	Yes	No	No	No	No	No	No	1	0
19	H34_3007	1	0.1192	La Paz	Yes	No	No	No	No	No	No	1	0
20	H34_3008	1	0.1308	La Paz	Yes	No	No	No	No	No	No	1	0
21	H34_3009	1	0.1283	La Paz	Yes	No	No	No	No	No	No	1	0
22	H34_3010	1	0.0439	La Paz	Yes	No	No	No	No	No	No	1	0
23	H34_3011	1	0.1799	La Paz	Yes	No	No	No	No	No	No	1	0
24	H34_3012	1	0.1130	La Paz	Yes	No	No	No	No	No	No	1	0
25	H34_3044	1	0.0557	La Paz	Yes	No	No	No	No	No	No	1	0
26	H70_0518	1	0.2099	La Paz	Yes	No	No	No	No	No	No	1	0

NRL1 Watercourses Evaluated for Mohave County
(Table A-3)

No.	Name of Watercourse	Segments	Miles	Counties	Perennial	Modern Boating	Historical Boating	Fish	Special Status	Dam Impacted	Perennial [Brown]	Hits	Hits [Brown]
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
0	Kanab Creek	47	72.516	Mohave/Coconino	Yes	No	No	Yes	Yes	No	Yes	3	3
1	Beaver Dam Wash - Mohav	1	9.589	Mohave	Yes	No	No	Yes	Yes	No	Yes	3	3
2	Francis Creek	20	23.796	Yavapai/Mohave	No	No	No	Yes	Yes	No	No	2	2
3	Trout Creek	43	54.226	Yavapai/Mohave	Yes	No	No	Yes	No	No	Yes	2	2
4	Short Creek	35	26.203	Mohave	Yes	No	No	No	No	Yes	No	2	1
5	Truxton Wash	71	77.324	Yavapai/Mohave	Yes	No	No	Yes	No	No	No	2	1
6	Boulder Wash	1	1.628	Mohave	Yes	No	No	No	No	No	Yes	1	1
7	Cottonwood Creek 3 - Moh	5	8.447	Mohave	Yes	No	No	No	No	No	Yes	1	1
8	Diamond Creek 1	22	25.383	Coconino/Mohave	No	No	No	Yes	No	No	Yes	1	1
9	H23_0601	2	4.598	Mohave	No	No	No	No	No	Yes	No	1	1
10	H57_0490	2	1.836	Mohave	No	No	No	No	No	Yes	No	1	1
11	H64_0498	7	6.570	Yavapai/Mohave	No	No	No	No	No	Yes	No	1	1
12	Meriwhitica Canyon	8	11.575	Mohave	No	No	No	Yes	No	No	No	1	1
13	Travertine Canyon	1	1.114	Mohave	No	No	No	Yes	No	No	No	1	1
14	Wrights Canyon	1	2.994	Mohave	No	No	No	Yes	No	No	No	1	1
15	Spencer Canyon	26	27.430	Mohave	No	No	No	No	No	No	Yes	0	1
16	Grand Wash	68	43.375	Mohave	Yes	No	No	No	No	No	No	1	0
17	H07_0740	1	0.286	Mohave	Yes	No	No	No	No	No	No	1	0
18	H07_0741	1	0.171	Mohave	Yes	No	No	No	No	No	No	1	0
19	H07_1662	1	0.524	Mohave	Yes	No	No	No	No	No	No	1	0
20	H07_1664	1	0.336	Mohave	Yes	No	No	No	No	No	No	1	0
21	H21_1365	2	0.797	Mohave	Yes	No	No	No	No	No	No	1	0
22	H21_1366	3	0.766	Mohave	Yes	No	No	No	No	No	No	1	0
23	H21_1367	1	0.025	Mohave	Yes	No	No	No	No	No	No	1	0
24	H21_1368	1	0.137	Mohave	Yes	No	No	No	No	No	No	1	0
25	H21_1369	1	0.432	Mohave	Yes	No	No	No	No	No	No	1	0
26	H21_1370	1	0.074	Mohave	Yes	No	No	No	No	No	No	1	0
27	H64_0073	1	0.136	Mohave	Yes	No	No	No	No	No	No	1	0
28	H70_0211	4	1.448	Mohave	Yes	No	No	No	No	No	No	1	0
29	H70_0317	1	0.158	La Paz/Mohave	Yes	No	No	No	No	No	No	1	0
30	H70_0520	1	0.066	La Paz/Mohave	Yes	No	No	No	No	No	No	1	0
31	Hualapai Wash	47	26.244	Mohave	Yes	No	No	No	No	No	No	1	0
32	Rock Canyon - Mohave	13	23.672	Mohave	Yes	No	No	No	No	No	No	1	0
33	South Moccasin Wash	8	8.127	Mohave	Yes	No	No	No	No	No	No	1	0
34	Topock Marsh	50	32.037	Mohave	Yes	No	No	No	No	No	No	1	0
35	Twomile Wash	2	5.741	Mohave	Yes	No	No	No	No	No	No	1	0

NRL1 Watercourses Evaluated for Yuma County
(Table A-4)

No.	Name of Watercourse	Segments	Miles	Counties	Perennial	Modern Boating	Historical Boating	Fish	Special Status	Dam Impacted	Perennial [Brown]	Hits	Hits [Brown]
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1	Cementosa Wash	7	7.727	Yuma/La Paz	Yes	No	No	No	No	No	No	1	0
2	H34_2568	1	0.469	Yuma	Yes	No	No	No	No	No	No	1	0
3	H34_2569	1	0.714	Yuma	Yes	No	No	No	No	No	No	1	0
4	H34_2570	1	0.537	Yuma	Yes	No	No	No	No	No	No	1	0
5	H34_2571	1	0.027	Yuma	Yes	No	No	No	No	No	No	1	0
6	H40_0652	1	0.170	Yuma	Yes	No	No	No	No	No	No	1	0
7	H44_0128	1	0.574	Yuma	Yes	No	No	No	No	No	No	1	0
8	H44_0130	1	0.218	Yuma	Yes	No	No	No	No	No	No	1	0
9	H44_0138	1	0.703	Yuma	Yes	No	No	No	No	No	No	1	0
10	H44_0444	1	0.829	Yuma	Yes	No	No	No	No	No	No	1	0
11	H44_0445	1	0.190	Yuma	Yes	No	No	No	No	No	No	1	0
12	H44_0446	1	0.107	Yuma	Yes	No	No	No	No	No	No	1	0
13	H44_0450	1	0.701	Yuma	Yes	No	No	No	No	No	No	1	0
14	H44_0451	1	0.390	Yuma	Yes	No	No	No	No	No	No	1	0
15	H44_0452	1	0.171	Yuma	Yes	No	No	No	No	No	No	1	0
16	H44_0453	1	0.085	Yuma	Yes	No	No	No	No	No	No	1	0
17	H47_0126	1	0.011	Yuma	Yes	No	No	No	No	No	No	1	0