Extent and Condition of Idaho’s Major Rivers, 2010

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# Table of Contents

Table of Contents ........................................................................................................................................ i
List of Tables ............................................................................................................................................... iii
List of Figures .............................................................................................................................................. iv
Abstract ..................................................................................................................................................... v

1 Introduction .............................................................................................................................................. 1

2 Methods .................................................................................................................................................. 3
    2.1 Idaho Major Rivers Survey Design ................................................................................................. 3
    2.2 Field Sampling ................................................................................................................................. 5
        2.2.1 Streams .................................................................................................................................... 5
        2.2.2 Rivers ....................................................................................................................................... 6
        2.2.3 Water Chemistry and Physical Habitat ....................................................................................... 7
    2.3 Data Analysis and Integration ........................................................................................................... 8
        2.3.1 Extent Estimate .......................................................................................................................... 8
        2.3.2 Water Chemistry and Physical Habitat ....................................................................................... 8
        2.3.3 Benthic Macroinvertebrates ....................................................................................................... 9
        2.3.4 Fish .......................................................................................................................................... 10
        2.3.5 Biological Condition .................................................................................................................. 11

3 Results ..................................................................................................................................................... 12
    3.1 Extent Estimates ............................................................................................................................... 12
    3.2 Water Chemistry and Physical Habitat ............................................................................................ 12
    3.3 Benthic Macroinvertebrates ............................................................................................................ 14
    3.4 Fish ............................................................................................................................................... 14
    3.5 Biological Condition ....................................................................................................................... 15

4 Discussion ............................................................................................................................................... 17
4.1 Extent Estimate................................................................. 17
4.2 Water Chemistry and Physical Habitat........................................... 18
4.3 Biological Condition........................................................................... 22
4.4 Recommendations ............................................................................... 23
References.................................................................................................. 24
Appendix A. Idaho Major Rivers Survey Design File................................. 27
Appendix B. Idaho Major River Survey results.......................................... 34
List of Tables

Table 2.1. Impact scores for human influence and human activities and disturbance at river monitoring sites ........................................................................................................... 8

Table 2.2. Scoring criteria for determining condition scores for the Stream Macroinvertebrate Index, Stream Fish Index, 3-metric Macroinvertebrate Index, and River Fish Index by comparison to reference condition .................................................. 10

Table 3.1. Summary statistics for water chemistry results (N = number of records for each analyte) .................................................................................................................. 13

Table 3.2. Summary statistics for Stream Habitat Index (SHI), calculated for wadeable streams, and the Index of Human Impact (IHI), calculated for non-wadeable rivers (N = number of sites) ........................................................................................................... 13

Table 4.1. Extent of specific conductance and pH in Idaho’s major rivers compared to distribution (Reference Condition Category) of least-impacted river sites from Remington and Kosterman (2008) ........................................................................................................... 19

Table 4.2. Idaho Major Rivers Survey chemistry results compared to the EPA’s recommended nutrient reference condition for the Western Mountains and Xeric West nutrient ecoregions .................................................................................................................. 20

Table 4.3. Idaho Major Rivers Survey total phosphorus compared to the wadeable stream assessment reference condition (Herlihy and Sifneos 2008) for sites in the Western Mountains and Xeric West nutrient ecoregions ........................................................................................................... 21
List of Figures

Figure 1.1. Conceptual representation of elements of a probabilistic sampling survey (modified from Olsen and Peck 2008) ................................................................. 2

Figure 2.1. Map of Idaho, with major rivers, sample locations, and sample status displayed. Numbers correspond to Index number for each site (Appendix B) ................. 4

Figure 2.2. Schematic of stream monitoring reach, showing locations of sample collection ................................................................................................................. 6

Figure 2.3. Schematic of river monitoring reach, showing locations of sample collection 7

Figure 3.1. Diagram summarizing extent estimates for Idaho’s major rivers .......... 12

Figure 3.2. Locations of Idaho Major Rivers Survey sites and macroinvertebrate condition ratings, including estimated length (km), standard error (SE), and percent of the sampled population in each condition ................................................................. 14

Figure 3.3. Locations of Idaho Major Rivers Survey sites and fish condition ratings for each site, including estimated length (km), standard error (SE), and percent of the sampled population in each condition ................................................................. 15

Figure 3.4. Locations of Idaho Major Rivers Survey sites and biological condition ratings for each site, including estimated length (km), standard error (SE), and percent of the sampled population in each condition ................................................................. 16
Abstract

To fulfill Clean Water Act reporting requirements, the Idaho Department of Environmental Quality (DEQ) initiated the Idaho Major Rivers Survey (IMRS) in 2006. The IMRS is a probability-based survey designed to provide statistically valid estimates of the condition of the entire population of major rivers in Idaho. For the IMRS, DEQ monitored 49 sites out of a potential 100 sites. All 100 sites were evaluated and either sampled or not sampled due to physical barriers, landowner denial, or classification as nontarget.

Extent estimates were calculated based on an equal-weight approach: all sites within the site file represented an equal length of the entire sample frame. Since all sites were evaluated, it was unnecessary to recalculate site weights. Each site represented approximately 73.85 kilometers (km) of Idaho’s major rivers.

DEQ collected grab-samples at each site for nitrate-nitrite nitrogen (NO$_3$/NO$_2$) and total phosphorus (TP). Temperature, pH, and specific conductance were measured in situ at the GIS coordinate site, or the x-site, with a Hydrolab DS5X sonde.

DEQ collected benthic macroinvertebrates and fish to calculate multimetric indices of ecological integrity.

The total resource length in the IMRS sample frame was 7,384.9 km; an estimated 5,464.9 km (74%) of the sample frame was target (the target population), and 1,920.0 km (26%) was nontarget. The target population represented 5,464.9 km. The sampled population, or the proportion of the target population about which inferences may be made, represented 3,618.6 km, or 66% of the target population. The extent of the target population not sampled due to physical barriers represented 1,107.7 km (20% of the target population), while 738.5 km (13% of the target population) were not sampled due to landowner denial.

Temperatures ranged from 5.6 to 24.5 degrees Celsius (°C), with 6 of 49 sites (12.2%, representing 443 km) having temperatures that exceeded the instantaneous temperature criterion of 22.0 °C (Idaho Administrative Code, IDAPA 58.01.02.250.01.b). Measurements of pH ranged from 7.35 to 9.20; the average pH from 34 sites was 8.37 (standard deviation [SD] = 0.52). Specific conductance ranged from 22.2 microsiemens per centimeter (µS/cm) to 774.0 µS/cm; the average specific conductance among all sites was 218.7 µS/cm (SD = 180.7). NO$_3$/NO$_2$ concentration ranged from below the method detection limit (MDL) of 0.01 milligrams per liter (mg/L) to 1.70 mg/L; the average concentration of NO$_3$/NO$_2$ was 0.27 mg/L (SD = 0.47). NO$_3$/NO$_2$ concentrations were below the MDL at 16 sites representing 1,181.6 km. TP concentration ranged from below the MDL of 0.005 mg/L to 0.295 mg/L; the average TP concentration was 0.038 mg/L (SD = 0.048). Only 1 site, representing 46 km, had TP below the MDL.
Benthic macroinvertebrates were collected at all 49 sites. Macroinvertebrate condition was good at 25 sites (51.0% of the sampled population), fair at 19 sites (38.8%), and poor at 5 sites (10.2%).

Fish indices were calculated at 31 of the 49 sites. Fish condition was good at 19 sites (38.8%), fair at 1 site (2.0%), poor at 11 sites (22.4%), and unassessed at 18 sites (36.7%).

Biological condition was determined by combining macroinvertebrate and fish condition into a single measure. At sites where fish were not sampled or insufficient for assessment, the biological condition was based on the macroinvertebrate condition alone. Following this method, biological condition was good at 20 sites (40.8%), fair at 20 sites (40.8%), and poor at 9 sites (18.4%).

Recommendations for future river monitoring include improving the sample frame and including more indicators, specifically diatoms and physical habitat and chemistry.
1 Introduction

The Idaho Department of Environmental Quality (DEQ) is the state agency responsible for administering the Clean Water Act in Idaho. Administration of the Clean Water Act includes monitoring and assessment of the state’s surface waters to determine compliance with water quality standards. In Idaho, ambient water quality is monitored through the Beneficial Use Reconnaissance Program (BURP), which integrates biological, chemical, and physical habitat monitoring.

The federal Clean Water Act establishes a process for states to report on the quality of their surface waters. Section 305(b) of the statute requires biennial reporting on the state’s water quality. In an effort to fulfill this requirement, BURP initiated the Idaho Major Rivers Survey (IMRS) in 2006; monitoring occurred in 2006 and 2008. This report details the results of those monitoring efforts.

The IMRS was a probability-based survey designed to provide statistically valid estimates of the condition of the entire population of major rivers in Idaho. Probability-based monitoring allows statistically valid estimates of condition for the population being studied while sampling only a fraction of the population. For example, in this study DEQ was able to estimate condition for the length of major rivers in Idaho based on sampling a relatively small proportion of that entire length.

A probabilistic sampling survey is made up of several elements: the target population, sample frame, sampled population, and evaluated sites. Figure 1.1 outlines the conceptual relationship among these elements.
Figure 1.1. Conceptual representation of elements of a probabilistic sampling survey (modified from Olsen and Peck 2008).

The sample frame is a geographical representation of the target population from which sites are selected (Figure 1.1). It is common for the sample frame to include some elements that are not part of the target population or to exclude some elements of the target population. Elements of the sample frame that are not part of the target population are classified as nontarget. In this survey, reservoirs, lakes, or dry channels were classified as nontarget. Elements of the sample frame that are part of the target population make up the sampled population. The sampled population is the population of the resource about which researchers can make statistically valid estimates of condition based on survey results (Olsen and Peck 2008).
2 Methods

2.1 Idaho Major Rivers Survey Design

DEQ used a probability-based survey design in order to make statistically valid estimates of condition for the entire population of rivers being sampled.

The first step in survey design was to clearly identify the target population, or the resource that is to be assessed (Olsen and Peck 2008). For the IMRS, the target population was major rivers in Idaho—as identified by the DEQ major rivers geographic information system (GIS) coverage—with an active stream channel and flowing water present. This coverage includes the main stem, major forks, and major tributaries of the most well-known rivers within Idaho (e.g., Snake, Boise, Salmon, Clearwater, St. Joe, Coeur d’Alene) from their mouths (or Idaho border) to their headwaters (or Idaho border) (Figure 2.1).

For the IMRS, the sample frame was the DEQ major rivers GIS coverage (Figure 2.1). Total resource length in the sample frame was 7,384.9 kilometers (km).

Sites provided in the survey design file (Appendix A) were evaluated for inclusion in the target population. To be considered part of the target population, sites had to have an active stream channel with flowing water present.

The IMRS had an expected sample size of 50 sites, split evenly between two phases, with 25 sites to be monitored in 2006 and 25 sites to be monitored in 2008. In addition, the sample design included oversample sites (i.e., additional sites to be used in the event that the sample frame included nontarget or inaccessible sites). Including these oversample sites, the sample design included 100 total sites.

All 100 sites on the list were evaluated and either sampled or not sampled (due to physical barriers, landowner denial, or classification as nontarget). For the IMRS, DEQ monitored 49 sites. Each site was identified by geographic coordinates and monitoring occurred upstream and downstream from those coordinates. The point represented by the coordinates is known as the x-site.
Figure 2.1. Map of Idaho, with major rivers, sample locations, and sample status displayed. Numbers correspond to Index number for each site (Appendix B).
2.2 Field Sampling

Probabilistic sites are identified by an x-site: a single set of global positioning system (GPS) coordinates falling on a point within the stream or river. The monitored reach must contain the x-site. Crews laid out monitoring reaches so that the x-site would be at or near the center of the reach.

Monitoring of sites followed protocols outlined in either the *Beneficial Use Reconnaissance Program Field Manual for Rivers* (DEQ 2006) or the *Beneficial Use Reconnaissance Program Field Manual for Streams* (DEQ 2007).

Selection of field protocol was based on water body classification as a stream or river following DEQ’s water body size criteria. DEQ classifies flowing waters as streams if they meet two of the following three criteria: 1) stream order is 4th or lower, 2) average wetted width at the reach is less than 15 meters (m), and 3) average depth for the reach is less than 0.4 m. Conversely, if the water body exceeds any two of these three criteria it is classified as a river (Grafe 2002a). Streams were included in this survey due to their occurrence at the headwaters of the major rivers.

2.2.1 Streams

Streams, as determined by the above classification scheme, were monitored following the BURP protocol for streams (DEQ 2007).

For streams, the reach length sampled was 30 times the average bankfull width at the x-site. The bankfull width is the channel width where the flow of water just fills the channel to the top of its banks and where the water begins to overflow onto the floodplain.

Reaches were sampled at six transects. DEQ collected macroinvertebrates at three transects from three separate riffle habitats using a Hess sampler. At each macroinvertebrate collection transect DEQ also performed a modified pebble count and measured canopy closure using a modified concave densiometer. At transects 10 m upstream from where the macroinvertebrates were sampled, DEQ measured bankfull width and height, wetted width and depth, distance of undercut banks, and canopy closure. DEQ assessed reachwide habitat and other physical characteristics of the stream (Figure 2.2). The entire reach was electrofished, and DEQ identified fish to species or the lowest possible taxonomic level.
2.2.2 Rivers

Rivers were monitored following the 2006 draft BURP protocol for rivers, which was finalized in 2009 (DEQ 2009).

For rivers, the reach length sampled was 40 times the wetted width at base flow, generally determined by GIS and aerial photography. Reaches were sampled at six transects. Macroinvertebrates were collected from alternating banks at each of the six transects. DEQ recorded shoreline and bottom substrate, riparian condition and human disturbances; measured canopy closure with a modified convex densiometer, and...
measured depth and erosion at each transect. Any reachwide human activities and disturbances were documented (Figure 2.3). DEQ electrofished the entire reach and identified fish to species or the lowest possible taxonomic level.

Figure 2.3. Schematic of river monitoring reach, showing locations of sample collection

2.2.3 Water Chemistry and Physical Habitat
DEQ collected grab-samples for chemical analysis from all 49 sites. Samples were collected prior to monitoring at or near the x-site for streams and at the final (i.e., downstream) transect for rivers. Water samples were analyzed for nitrate-nitrite nitrogen (NO$_3$/NO$_2$) following U.S. Environmental Protection Agency (EPA) method number 353.2 (EPA 1993a) and for total phosphorus (TP) following EPA method number 365.1 (EPA 1993b). All water analyses were provided by the Idaho Bureau of Laboratories in Boise, Idaho. Temperature, pH, and specific conductance were measured in situ at the x-site with a Hydrolab DS5X sonde.
Physical habitat data were collected at each transect and over the entire reach (Figure 2.2; Figure 2.3).

At each river transect, crews looked for the presence of 11 unique signs of human influence at each bank. Crews determined whether signs of these activities were absent, present within the 10 × 20 m riparian plot, or present outside the plot but observable from the plot (Figure 2.3).

In addition, field crews estimated the level of human activities and disturbances for the site’s entire watershed. Crews evaluated whether the level of human activity and disturbance was absent, low, moderate, or high for indicators of residential, agricultural, industrial, recreational, and active management activities (DEQ 2007).

### 2.3 Data Analysis and Integration

#### 2.3.1 Extent Estimate

Extent estimates were calculated based on an equal-weight approach: all sites within the site file represented an equal length of the entire sample frame. Since all sites were evaluated, it was unnecessary to recalculate site weights. Each evaluated site represented approximately 74 km of Idaho’s major rivers.

#### 2.3.2 Water Chemistry and Physical Habitat

For statistic calculations, water chemistry measurements that were below the method detection limit (MDL) were assigned the MDL. Summary statistics of water chemistry data included minimum; maximum; 5th, 25th, 75th, and 95th percentiles; median; average; and standard deviation (SD).

For streams, the habitat data were used to calculate the Stream Habitat Index (SHI), a multimetric index used to compare sample sites to a least-impacted reference condition. The SHI is composed of 10 component metrics, and the index is scaled from 0 to 100, with 100 being the best possible score (see Grafe 2002a).

For river sites, a simplified Index of Human Impact (IHI) was calculated based on observations of human influence at each of the six transects and estimates of watershed-level human activities and disturbances (DEQ 2006). A weighted sum of both human influence and human activities and disturbances was calculated by summing their impact scores (Table 2.1).

| Table 2.1. Impact scores for human influence and human activities and disturbance at river monitoring sites |
|--------------------------------------------------|--------------------------------------------------|-----------------|
| Human Influence (transects) | Human Activities and Disturbance (watershed) | Score |
| Absent | Absent | 0 |
| Present, outside plot | Low | 1 |
| Present, inside plot | Moderate | 2 |
| NA | High | 3 |
The IHI was then calculated according to the following equation:

\[
IHI = 100 - \left( \frac{IS_{HumInf}}{Max IS_{HumInf}} \times 100 + \frac{IS_{HumAD}}{Max IS_{HumAD}} \times 100 \right)
\]

Where:

- \(IS_{HumInf}\) is the impact score of human influence (see Table 2.1);
- \(Max IS_{HumInf}\) is the maximum \(IS_{HumInf}\) possible;
- \(IS_{HumAD}\) is the impact score of human activities and disturbance; and
- \(Max IS_{HumAD}\) is the maximum \(IS_{HumAD}\) possible.

IHI was scaled from 0 to 100, with 100 indicating the lowest possible level of human impact.

**2.3.3 Benthic Macroinvertebrates**

Benthic macroinvertebrate samples were composited by site. All macroinvertebrate identification and enumeration was performed by EcoAnalysts, Inc. of Moscow, Idaho. Composite samples were randomly subsampled to the first 500 organisms for identification. Issues of ambiguous taxa were resolved by substitution: distributing the ambiguous parent taxa among its children in proportion to the relative abundance of each child in the individual sample (Cuffney et al. 2007).

DEQ has developed multimetric indices for assessing stream and river macroinvertebrate communities. Both approaches compare sample sites to a least-impacted reference condition. For streams, DEQ uses the Stream Macroinvertebrate Index (SMI) to assess benthic macroinvertebrate communities. The SMI is based on nine metrics. Calculation of each metric returns a number from 1 to 100. The SMI is the average of these component metric scores; this index is then assigned a condition rating, or SMI condition score, of 1, 2, or 3 based on comparison to a bioregional reference condition (Table 2.2). For more discussion of the SMI and its development refer to the *Idaho Small Stream Ecological Assessment Framework* (Grafe 2002a).

DEQ developed the River Macroinvertebrate Index (RMI) to assess river benthic macroinvertebrate communities. The RMI is comprised of five metrics (Grafe 2002b). However, subsequent work with rivers as part of the Idaho Rivers Environmental Monitoring and Assessment Program (EMAP) project determined that the RMI lacked sensitivity in identifying moderately impacted sites. Further analysis identified a revised 3-Metric Macroinvertebrate Index (3MI) as providing the best performance in
distinguishing impacted sites from least-impacted reference sites (Remington and Kosterman 2008). The 3MI used a 1-3-5 scoring convention (Table 2.2).

Table 2.2. Scoring criteria for determining condition scores for the Stream Macroinvertebrate Index, Stream Fish Index, 3-metric Macroinvertebrate Index, and River Fish Index by comparison to reference condition.

<table>
<thead>
<tr>
<th>Stream Macroinvertebrate Index (SMI)</th>
<th>Condition Category</th>
<th>Condition Score</th>
<th>Condition Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;25th percentile of bioregional reference condition</td>
<td>3</td>
<td>Good</td>
<td></td>
</tr>
<tr>
<td>10th-25th percentile of bioregional reference condition</td>
<td>2</td>
<td>Fair</td>
<td></td>
</tr>
<tr>
<td>reference minimum to &lt;10th percentile of reference condition</td>
<td>1</td>
<td>Poor</td>
<td></td>
</tr>
<tr>
<td>&lt; reference minimum</td>
<td>0</td>
<td>Minimum Threshold</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3-Metric Macroinvertebrate Index (3MI)</th>
<th>Condition Category</th>
<th>Condition Score</th>
<th>Condition Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 25th percentile of reference condition</td>
<td>5</td>
<td>Good</td>
<td></td>
</tr>
<tr>
<td>reference minimum-25th percentile of reference condition</td>
<td>3</td>
<td>Fair</td>
<td></td>
</tr>
<tr>
<td>&lt; reference minimum</td>
<td>1</td>
<td>Poor</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Stream Fish Index (SFI)</th>
<th>Condition Category</th>
<th>Condition Score</th>
<th>Condition Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; median of reference condition</td>
<td>3</td>
<td>Good</td>
<td></td>
</tr>
<tr>
<td>25th percentile-median of reference condition</td>
<td>2</td>
<td>Fair</td>
<td></td>
</tr>
<tr>
<td>5th-25th percentile of reference condition</td>
<td>1</td>
<td>Poor</td>
<td></td>
</tr>
<tr>
<td>&lt; 5th percentile of reference condition</td>
<td>0</td>
<td>Minimum Threshold</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>River Fish Index (RFI)</th>
<th>Condition Category</th>
<th>Condition Score</th>
<th>Condition Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; median of reference condition</td>
<td>3</td>
<td>Good</td>
<td></td>
</tr>
<tr>
<td>25th percentile-median of reference condition</td>
<td>2</td>
<td>Fair</td>
<td></td>
</tr>
<tr>
<td>5th-25th percentile of reference condition</td>
<td>1</td>
<td>Poor</td>
<td></td>
</tr>
<tr>
<td>&lt; 5th percentile of reference condition</td>
<td>0</td>
<td>Minimum Threshold</td>
<td></td>
</tr>
</tbody>
</table>

aThe SMI, SFI, and RFI were not developed to determine condition; these condition ratings are for the purposes of this report alone.
bThe minimum threshold is used for determining beneficial use support status. For the purposes of this report, all SMI, SFI, and RFI scores of 0 were assigned a poor condition rating.

2.3.4 Fish

DEQ developed multimetric indices for assessing fish communities as well. DEQ uses the Stream Fish Index (SFI) for streams. The SFI is based on six component metrics. Sites are classified into fish bioregions, which are based on a combination of Omernik ecoregion and elevation (Grafe 2002a). Sites are assigned a condition rating, or SFI condition score, of 1, 2, or 3, based on comparison to a bioregional reference condition (Table 2.2). For more discussion of the SFI and its development refer to the Idaho Small Stream Ecological Assessment Framework (Grafe 2002a).

DEQ developed the River Fish Index (RFI) to assess river fish communities. The RFI is composed of 10 component metrics. An RFI is calculated for any site with a minimum of
20 fish. The RFI is compared to the reference condition and assigned a condition rating, or RFI condition score of 1, 2, or 3 (Table 2.2). For more discussion of the RFI and its development refer to the *Idaho River Ecological Assessment Framework* (Grafe 2002b).

### 2.3.5 Biological Condition

To calculate biological condition, DEQ averaged the macroinvertebrate and fish indices. The SMI, SFI, and RFI all use a 1-2-3 scoring convention, with 1 corresponding to poor condition, or the greatest deviation from reference condition; 2 representing fair; and 3 representing good. The 3MI uses a 1-3-5 scoring convention, with 1 representing poor, or the greatest deviation from reference; 3 representing fair; and 5 representing good.

To integrate these indices into a single index of biological condition, DEQ standardized the scoring convention for the SMI, 3MI, SFI, and RFI to a 1-3-5 scoring convention.

For each site, the biological condition score is the average of the scores from the two indices (SMI and SFI for streams, 3MI and RFI for rivers). For sites where fish data were unavailable or insufficient for calculating an index score, DEQ based the biological condition score on only the macroinvertebrate index score. Biological condition scores greater than 4.25 were considered good, scores from 2.75 to 4.25 were fair, and scores less than 2.75 were considered poor.
3 Results

For a summary of all monitoring results—including water body classification, bioregion, ecoregion, water chemistry, and all index scores and conditions—see Appendix B.

3.1 Extent Estimates

The total resource length (extent) in the Idaho major rivers sample frame was 7,384.9 km; an estimated 5,464.9 km (74%) of the sample frame was target (the target population), and 1,920.0 km (26%) was nontarget. The absence of water or an active channel, inundation by a reservoir or impoundment, or inundation by a natural lake resulted in classification as nontarget.

The target population represented 5,464.9 km. The sampled population, or the proportion of the target population about which inferences may be made, represented 3,618.6 km, or 66% of the target population.

Elements of the target population not sampled due to physical barriers represented 1,107.7 km (20% of the target population), while elements of the target population not sampled due to landowner denial represented 738.5 km (14% of the target population).

A summary of extent estimates for the IMRS is provided in Figure 3.1.

![Figure 3.1. Diagram summarizing extent estimates for Idaho’s major rivers](image)

3.2 Water Chemistry and Physical Habitat

DEQ monitored a total of 42 river sites and 7 stream sites and analyzed water chemistry for each site. Temperature, pH, and specific conductance were recorded at 49, 34, and 49 sites, respectively. NO₃/NO₂ and TP were reported for 37 and 48 sites, respectively (Table 3.1).
Instantaneous temperature measurements ranged from 5.6 degrees Celsius (°C) to 24.5 °C; average temperature among all sites was 16.2 °C (SD = 5.07).

The range of pH measurements was 7.35 to 9.20; the average pH from 34 sites was 8.37 (SD = 0.52). Specific conductance ranged from 22.2 microsiemens per centimeter (µS/cm) to 774.0 µS/cm; average specific conductance among all sites was 218.7 µS/cm (SD = 180.7) (Table 3.1).

Table 3.1. Summary statistics for water chemistry results (N = number of records for each analyte)

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Specific Conductance</th>
<th>Nitrite-Nitrate N</th>
<th>Total Phosphorus</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>°C</td>
<td>pH</td>
<td>µS/cm</td>
</tr>
<tr>
<td>Minimum</td>
<td>5.6</td>
<td>7.35</td>
<td>22.2</td>
</tr>
<tr>
<td>5th</td>
<td>8.6</td>
<td>7.42</td>
<td>40.9</td>
</tr>
<tr>
<td>25th</td>
<td>12.1</td>
<td>8.04</td>
<td>75.0</td>
</tr>
<tr>
<td>75th</td>
<td>20.3</td>
<td>8.70</td>
<td>310.0</td>
</tr>
<tr>
<td>95th</td>
<td>23.2</td>
<td>8.84</td>
<td>564.8</td>
</tr>
<tr>
<td>Maximum</td>
<td>24.5</td>
<td>9.20</td>
<td>774.0</td>
</tr>
<tr>
<td>Median</td>
<td>17.5</td>
<td>8.60</td>
<td>158.2</td>
</tr>
<tr>
<td>Average</td>
<td>16.2</td>
<td>8.37</td>
<td>218.7</td>
</tr>
<tr>
<td>Stand Dev</td>
<td>5.1</td>
<td>0.52</td>
<td>180.7</td>
</tr>
<tr>
<td>N</td>
<td>49</td>
<td>34</td>
<td>49</td>
</tr>
</tbody>
</table>

Data presented in **bold** represent the method detection limit (MDL) for the analyte.

NO₃/NO₂ concentration ranged from below the MDL of 0.01 milligrams per liter (mg/L) to 1.70 mg/L; average concentration of NO₃/NO₂ was 0.27 mg/L (SD = 0.47) (Table 3.1). NO₃/NO₂ concentrations were below the MDL at 16 sites representing 1,181.6 km.

TP concentration ranged from below the MDL of 0.005 mg/L to 0.295 mg/L; average concentration of TP was 0.038 mg/L (SD = 0.048) (Table 3.1). Only 1 site, representing 46 km, had TP below the MDL.

The SHI was calculated for the 7 stream sites, while the IHI was calculated for the 42 river sites. SHI scores ranged from 49 to 76. IHI scores ranged from 74 to 99 (Table 3.2).

Table 3.2. Summary statistics for Stream Habitat Index (SHI), calculated for wadeable streams, and the Index of Human Impact (IHI), calculated for non-wadeable rivers (N = number of sites)

<table>
<thead>
<tr>
<th></th>
<th>SHI</th>
<th>IHI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>49</td>
<td>74</td>
</tr>
<tr>
<td>Median</td>
<td>61</td>
<td>90</td>
</tr>
<tr>
<td>Average</td>
<td>61</td>
<td>90</td>
</tr>
<tr>
<td>Maximum</td>
<td>76</td>
<td>99</td>
</tr>
<tr>
<td>N</td>
<td>7</td>
<td>42</td>
</tr>
</tbody>
</table>
3.3  Benthic Macroinvertebrates

Benthic macroinvertebrates were collected at all 49 sites. Macroinvertebrate condition was good at 25 sites (51%), fair at 19 sites (38.8%), and poor at 5 sites (10.2%) (Figure 3.2).

![Map of Idaho Major Rivers Survey sites and macroinvertebrate condition ratings](image)

<table>
<thead>
<tr>
<th>Macroinvertebrate</th>
<th>km</th>
<th>SE</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>1846.2</td>
<td>182.2</td>
<td>31.0</td>
</tr>
<tr>
<td>Fair</td>
<td>1403.1</td>
<td>170.6</td>
<td>38.8</td>
</tr>
<tr>
<td>Poor</td>
<td>369.2</td>
<td>116.0</td>
<td>10.2</td>
</tr>
<tr>
<td>Unassessed</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Figure 3.2. Locations of Idaho Major Rivers Survey sites and macroinvertebrate condition ratings, including estimated length (km), standard error (SE), and percent of the sampled population in each condition.

3.4  Fish

Fish index scores were calculated for 31 of the 49 sites. Fish condition was good at 19 sites (38.8% of the sampled population), fair at 1 site (2.0%), and poor at 11 sites (22.4%). Fish were unassessed at 18 sites (36.7% of the sampled population) (Figure 3.3).
Figure 3.3. Locations of Idaho Major Rivers Survey sites and fish condition ratings for each site, including estimated length (km), standard error (SE), and percent of the sampled population in each condition.

3.5 Biological Condition

DEQ determined biological condition by combining macroinvertebrate and fish conditions into a single measure. For sites where there was insufficient data to calculate RFI, DEQ based biological condition on the macroinvertebrate condition alone. Following this method, biological condition was good at 20 sites (40.8% of the sampled population), fair at 20 sites (40.8%), and poor at 9 sites (18.4%) (Figure 3.4).
Figure 3.4. Locations of Idaho Major Rivers Survey sites and biological condition ratings for each site, including estimated length (km), standard error (SE), and percent of the sampled population in each condition.
4 Discussion

4.1 Extent Estimate

The original sample frame included 7,384.9 km of river and stream length; of this sample frame, 26% was nontarget. Nontarget designations were due to either dry, impounded, or inundated stream channels (Figure 3.1). Dry stream channels represented 12% of the sample frame (886.2 km) (Figure 3.1). Dry stream channels in the IMRS were due to upstream irrigation withdrawal, with the majority (9 out of 12 evaluated sites) in the arid Snake River Plain Level 3 Ecoregion and the remainder in the Dry Intermontane Sagebrush Valleys Level 4 Ecoregion (McGrath et al. 2001). These data indicate that irrigation withdrawal has a significant effect on the extent of flowing water resources in Idaho.

Similarly, inundation by either manmade reservoirs or natural lakes was responsible for 14% of the sample frame (1,033.8 km). This subset is an indication of inaccuracies in the sample frame’s representation of the target population (Figure 3.1).

Physical barriers accounted for 15% of the sample frame (1,107.7 km) (Figure 3.1). Physical barriers included inaccessible canyons and dangerous rapids that would make sampling unsafe and sites that were too remote to be sampled practically. Since these sites would likely be in areas that had limited human disturbance, as opposed to occurring at random, it is not appropriate to include their lengths in our estimates of condition. If we did, we would be extrapolating good, fair, and poor conditions to this 15% of the sample frame in the same proportion that they occur in the sampled population. In reality, these inaccessible sites are likely to have a greater proportion in good condition due to their remoteness.

Similarly, landowner denial accounted for 10% of the sample frame (738.5 km) (Figure 3.1). The landowner denial category included sites on Indian reservations, sites where landowners did not respond to requests for access, and sites where landowners denied access. As with sites that were inaccessible due to physical barriers, it is not appropriate to include the length of streams or rivers where access was denied in our estimates of condition, as they do not occur at random.

Overall, the condition estimates were applicable to 3,618.6 km of Idaho’s major rivers—only 49% of the original 7,384.9 km sample frame. Increasing the proportion of the sampled population to the sample frame requires a sample frame that better represents actual conditions on the ground.

Although the comparison is not ideal due to differences in survey design, these results are similar to extent estimates found in other probabilistic surveys of flowing water conducted in Idaho. For example, a survey of wadeable streams in Idaho found that 32% of the sample frame was nontarget (Kosterman 2008). Likewise, a survey of nonwadeable rivers in Idaho found that 30% of the sample frame was nontarget. These results, in conjunction with the estimate of 26% nontarget in the IMRS, indicate the need for more
accurate sample frames (i.e., the need for geographical data that more accurately represents geographical reality).

Furthermore, properly identifying a target population would benefit future probabilistic surveys of Idaho’s water resources. For this survey, the target population was defined as major rivers in Idaho, as identified by the DEQ major rivers GIS coverage, with an active stream channel and flowing water present. One of the limitations of this target population was that it was defined by an arbitrary GIS layer. For example, this definition of the target population did not include all large rivers in Idaho, as defined by stream order or catchment area, nor was it limited to only water bodies classified by DEQ as rivers, as it included wadeable streams in the headwaters of some river systems.

4.2 Water Chemistry and Physical Habitat

Water chemistry results for the IMRS were highly variable (Table 3.1).

Temperatures ranged from 5.6 to 24.5 °C, with 6 of 49 sites (12.2%, representing 443 km) having temperatures that exceeded the instantaneous temperature criterion of 22.0 °C (Idaho Administrative Code, IDAPA 58.01.02.250.01.b). These temperature measurements do not necessarily coincide with the maximum temperature for any given site; measurements were often taken early in the day, before one would expect maximum daily temperature to occur. In addition, not all sample dates coincided with expected maximum annual temperature. Therefore, the likelihood of exceeding the 22.0 °C temperature criterion is likely much higher than what is reported here.

All temperature data were collected as single, instantaneous measurements. Although comparing such a measurement to the criterion is insufficient for determining water quality impairment (Grafe et al. 2002), it does indicate that excess temperature is a common problem in Idaho’s major rivers. This observation is complemented by the proportion of Idaho’s streams and rivers that are impaired by temperature. In 2008, there were 15,293 stream and river miles listed as impaired by temperature (about 16% of total stream and river miles within Idaho) (DEQ 2009).

Remington and Kosterman (2008) reported on the ecological condition of large, nonwadeable rivers in Idaho. They identified reference conditions for Idaho rivers and included water chemistry. Comparing IMRS chemistry results to the reference site distribution puts the IMRS results into context. Measurements common to both the IMRS sample sites and those in the Remington and Kosterman (2008) report include specific conductance and pH. Comparison of reference conditions and IMRS results for specific conductance and pH are presented in Table 4.1.
When compared to reference condition, a high proportion of Idaho’s major rivers have high specific conductance. For example, the 75th percentile of specific conductance for the IMRS was 310.0 (Table 3.1), compared to 114.8 for the reference condition (Table 4.1). On the other hand, the range and distribution of pH in Idaho’s major rivers is similar to the reference condition for large nonwadeable rivers. For example, the 75th percentile of pH for the IMRS was 8.70 (Table 3.1), compared to 8.55 for reference (Table 4.1).

EPA has recommended nutrient reference values for rivers based on aggregated ecoregions. There are two nutrient ecoregions in Idaho, the Western Mountains and the Xeric West. For the IMRS, 32 sites fall within the Western Mountains ecoregion while the remaining 17 fall within the Xeric West ecoregion.

Compared to EPA’s recommended reference values for the Western Mountains nutrient ecoregion (EPA 2000a), NO$_3$/NO$_2$ concentrations were relatively good, with only 15.6% of sites in the Western Mountains exceeding the recommended reference concentration of 0.014 mg/L. However, results from the IMRS exceeded the recommended reference TP concentration of 0.010 mg/L at 68.8% of sites in the Western Mountains (Table 4.2).
In the Xeric West nutrient ecoregion, IMRS NO₃/NO₂ concentration was above the recommendation of 0.025 mg/L at 88.2% of sites and above the TP recommendation of 0.022 mg/L at 94.1% of sites (EPA 2000b) (Table 4.2).

Evidence from wadeable streams suggests that the EPA’s recommendations may be too stringent in these nutrient ecoregions. Herlihy and Sifneos (2008) found that among least-impacted wadeable streams, the 75th percentile for TP was 0.019 mg/L and 0.040 mg/L for the Western Mountains and Xeric West, respectively. Using these numbers as thresholds, the IMRS results exceed the recommended TP levels at only 34.4% of sites in the Western Mountains and only 76.5% of the sites in the Xeric West (Table 4.3).
Regardless of the disagreement in how to set nutrient reference values, the fact remains that Idaho’s major rivers generally have nutrients above the suggested reference value.

Previous studies in Idaho have found that TP is an important stressor of ecological condition in wadeable streams, affecting both macroinvertebrate community integrity and taxa loss (Kosterman 2008). Excess nitrogen and phosphorus have likewise been associated with significant impairment of macroinvertebrate communities in wadeable streams, both nationally and regionally in the West (Van Sickle and Paulsen 2008). However, Idaho code establishes a narrative nutrient criterion, as opposed to a numeric criteria (IDAPA 58.01.02).

Physical habitat data indicate that human activities and disturbances to Idaho’s major rivers varied throughout the state (Table 3.2).

For the seven stream sites, SHI ranged from 49 to 76. Of the seven sites, only one was below its ecoregional threshold, meaning it was below the lowest SHI among reference sites. In other words, SHI scores at six of the seven stream sites were within the range expected for reference sites in the appropriate bioregion (Grafe 2002a).

While DEQ does use the SHI as a tool for assessing impairment in wadeable streams, a similar physical habitat index for assessing habitat for nonwadeable rivers is not available. The IHI presented here is a useful tool for summarizing human impacts, but it has not been developed for use as a multimetric indicator of ecological integrity. Thus, a reference condition does not exist and DEQ is unable to assign condition ratings to the IHI scores.
4.3 Biological Condition

Benthic macroinvertebrate condition was considered good for 51.0% (1,846.2 km) of Idaho’s major rivers, fair for 38.8% (1,403.1 km), and poor for 10.2% (369.2 km) (Figure 3.2).

These estimates are in line with those found in other estimates of condition for flowing waters in Idaho. For example, Kosterman (2008) found that 10.42% of wadeable perennial stream length in Idaho was in poor condition. In a survey of large, nonwadeable rivers in Idaho, Remington and Kosterman (2008) reported that macroinvertebrate condition was good for 37% of river kilometers, fair for 52%, and poor for 11%.

Nationwide assessments of the biological condition of nonwadeable rivers are currently unavailable. However, for illustrative purposes it may be helpful to compare results from the IMRS to results from the national wadeable stream assessment (EPA 2006). When compared to national and regional estimates of macroinvertebrate condition in wadeable streams, major rivers in Idaho are in relatively good condition. The EPA (2006) found that just 28.2% of wadeable stream miles nationwide were considered to be in good condition based on macroinvertebrates, while nearly 42% were in poor condition. Although conditions in the West were better (45.1% good, 25.8% fair, and 27.4% poor), Idaho’s major rivers were still in better shape.

As might be expected, the highest benthic macroinvertebrate index scores occurred in upstream reaches, with the lowest scores found in the Snake River and the lower reaches of the Big Lost River and Camas Creek (Figure 3.2). This finding is also similar to results reported by Remington and Kosterman (2008): river reaches in the lower elevation Southern Basins Bioregion accounted for the river lengths classified as poor.

There are two possible explanations for why this pattern appears: 1) the lower elevation plains are where the greatest human perturbations to the aquatic and upland environment occur, and 2) the 3MI overestimates ecological potential for lower-elevation sites.

In order to compare sampled sites to reference condition, it is necessary to account for natural variability. In bioassessments, this is usually accomplished through site classification or regionalization based on physical environmental factors. A common classification system includes ecoregions (McGrath et al. 2001). For streams, DEQ uses bioregions (Grafe 2002a). However, for large, nonwadeable rivers, DEQ uses a single statewide index and reference condition for assessments (Grafe 2002b), which may result in comparisons to an inappropriate reference condition.

Fish condition was considered good for 38.8% (1,403.1 km) of Idaho’s major river length, fair for 2.0% (73.8 km), poor for 22.4% (812.3 km), and was unassessed for 36.7% (1329.3 km) (Figure 3.3). Fish were not sampled for the national wadeable streams assessment (EPA 2006) or the Idaho rivers assessment (Remington and Kosterman 2008); therefore, comparing fish condition in Idaho to the West or the nation as a whole is not possible.
DEQ was unable to assess a large proportion of sites for fish condition due to insufficient fish abundance or federal permit restrictions. Calculating RFI requires at least 20 fish at a sample site, so any river site with less than 20 fish was categorized as unassessed. Also, under the terms of DEQ’s Endangered Species Act scientific research permit, DEQ is restricted from electrofishing in waters known to support anadromous fish when water temperatures exceed 18 °C or when adult salmon are observed.

Of the 18 sites unassessed for fish, 16 had insufficient fish abundance and 2 had permit restrictions.

Assigning a poor condition rating to all sites with insufficient fish data adjusts the condition estimates would drastically change the fish condition estimates and the overall biological condition estimates; however, it is not an appropriate substitution. Many factors can lead to insufficient fish data, including crew inefficiency, low stream conductivity, or dangerous conditions that may make electrofishing prime habitat difficult or impossible. In addition, crews were only able to devote a single day to monitoring at each site due to field schedules.

Given these limitations, this survey based the biological condition on macroinvertebrate condition alone when fish condition was unassessed. Although this strategy is less than ideal, it is more appropriate than downgrading all sites with insufficient fish data to a poor fish condition.

### 4.4 Recommendations

It is important for DEQ to continue probabilistic monitoring. Probabilistic surveys provide cost-efficient, statistically valid estimates of geographically large and diverse resources and are very useful tools for assessing streams and rivers in Idaho. However, the target population must be properly defined prior to selecting a sample frame. The IMRS targeted both streams and rivers but not all streams or rivers within the state. The survey was limited to the mainstem and major forks and tributaries of only the most well-known rivers within Idaho (e.g., Snake, Boise, Salmon, Clearwater, St. Joe, and Coeur d’Alene Rivers).

For future surveys, it might be better to separate nonwadeable rivers and streams into two separate surveys, or to have a single, statewide survey of all flowing waters within Idaho.

Refined river assessment tools could provide better, more meaningful results. The results of this study may be biased because DEQ does not have a geographical classification scheme for large, nonwadeable rivers. Furthermore, this survey relied on only two indices for assessing river condition (3MI and RFI). When fish data were unavailable or insufficient, biological condition was based on the 3MI data alone. However, DEQ has developed both a River Diatom Index and a River Physicochemical Index for assessing river condition (DEQ 2006). Due to resource limitations, we were unable to collect the necessary parameters for calculating these two indices; future river monitoring efforts should collect these parameters to ensure multiple indices can be used for assessing condition.
References


IDAPA 58.01.02. Water quality standards and wastewater treatment requirements.


United States Environmental Protection Agency (EPA). 2000a. Ambient water quality criteria recommendations: Information supporting the development of state and tribal nutrient criteria, rivers and streams in nutrient ecoregion II. EPA. Washington, DC.

United States Environmental Protection Agency (EPA). 2000b. Ambient water quality criteria recommendations: Information supporting the development of state and tribal nutrient criteria, rivers and streams in nutrient ecoregion III. EPA. Washington, DC.


Appendix A. Idaho Major Rivers Survey Design File
Idaho Major River
Survey Design 2006-2008

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Description of Sample Design

Target population: Major rivers in Idaho, as identified by Idaho.

Sample Frame: To identify the target population streams, Mary Anne Nelson provided the GIS stream coverage. It is based on NHD with only major rivers included. Note that it appears that run-of-the-river reservoirs were included in the GIS coverage. They were included in the design.

Survey Design: A Generalized Random Tessellation Stratified (GRTS) survey design for a linear resource was used. The GRTS design includes reverse hierarchical ordering of the selected sites.

Multi-density categories: None

Stratification: None.

Panels: Two panels to be visited in two different years: Panel_2006 and Panel_2008.

Expected sample size: Expected sample size 25 sites per panel.

Over sample: 200% (100 sites).

Site Use: Within State, the base design has 50 sites. Sites are listed in SiteID order and must be used in that order. All sites that occur prior to the last site used must have been evaluated for use and then either sampled or reason documented why that site was not
used. As an example, if 50 sites are to be sampled and it required that 80 sites be evaluated in order to locate 50 sampleable stream sites, then the first 80 sites in SiteID order would be used.

If the design is implemented over two years, then use the sites in siteID order within year and then continue with the next siteID in the next year. If want to identify revisit sites, use the first 5 sites in siteID order that were actually sampled in the field each year.

**Sample Frame Summary**

Total stream length (in km) in the sample frame is 7384.939 km.

**Site Selection Summary**

<table>
<thead>
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<th>mdcaty</th>
<th>Equal</th>
<th>Sum</th>
</tr>
</thead>
<tbody>
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<td>100</td>
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<td>25</td>
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<tr>
<td>Panel_2008</td>
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<td>25</td>
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</tbody>
</table>

**Description of Sample Design Output:**

The dbf file for the shapefile (“ID Major Rivers 2006-08 Sites”) has the following variable definitions:

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<th>Variable Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiteID</td>
<td>Unique site identification (character)</td>
</tr>
<tr>
<td>x</td>
<td>x-coordinate from map projection (see below)</td>
</tr>
<tr>
<td>y</td>
<td>y-coordinate from map projection (see below)</td>
</tr>
<tr>
<td>mdcaty</td>
<td>Multi-density categories used for unequal probability selection</td>
</tr>
<tr>
<td>weight</td>
<td>Weight (in km), inverse of inclusion probability, to be used in statistical analyses</td>
</tr>
<tr>
<td>stratum</td>
<td>Strata used in the survey design</td>
</tr>
<tr>
<td>panel</td>
<td>Identifies base sample by panel name and Oversample by OverSamp</td>
</tr>
<tr>
<td>EvalStatus</td>
<td>Site evaluation decision for site: TS: target and sampled, LD: landowner denied access, etc (see below)</td>
</tr>
<tr>
<td>EvalReason</td>
<td>Site evaluation text comment</td>
</tr>
</tbody>
</table>
Evaluation Process

The survey design weights that are given in the design file assume that the survey design is implemented as designed. Typically, users prefer to replace sites that can not be sampled with other sites to achieve the sample size planned. The site replacement process is described above. When sites are replaced, the survey design weights are no longer correct and must be adjusted. The weight adjustment requires knowing what happened to each site in the base design and the over sample sites. EvalStatus is initially set to “NotEval” to indicate that the site has yet to be evaluated for sampling. When a site is evaluated for sampling, then the EvalStatus for the site must be changed. Recommended codes are:

<table>
<thead>
<tr>
<th>EvalStatus Code</th>
<th>Name</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>TS</td>
<td>Target Sampled</td>
<td>site is a member of the target population and was sampled</td>
</tr>
<tr>
<td>LD</td>
<td>Landowner Denial</td>
<td>landowner denied access to the site</td>
</tr>
<tr>
<td>PB</td>
<td>Physical Barrier</td>
<td>physical barrier prevented access to the site</td>
</tr>
<tr>
<td>NT</td>
<td>Non-Target</td>
<td>site is not a member of the target population</td>
</tr>
</tbody>
</table>
Not Needed

NN

site is a member of the over sample and was not evaluated for sampling

Other codes

Many times useful to have other codes. For example, rather than use NT, may use specific codes indicating why the site was non-target.

Statistical Analysis

Any statistical analysis of data must incorporate information about the monitoring survey design. In particular, when estimates of characteristics for the entire target population are computed, the statistical analysis must account for any stratification or unequal probability selection in the design. Procedures for doing this are available from the Aquatic Resource Monitoring web page given in the bibliography. A statistical analysis library of functions is available from the web page to do common population estimates in the statistical software environment R.

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Bibliography:


Web Page: http://www.epa.gov/nheerl/arm
Appendix B. Idaho Major River Survey results
<table>
<thead>
<tr>
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<th>Site ID</th>
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