

# National Rivers and Streams Assessment Survey Design: 2018-2019

## Objectives:

The data quality objectives, or design requirements, for the National Rivers and Streams Assessment are

- to estimate the proportion of rivers and streams with a margin of error of  $\pm 5\%$  in the conterminous U.S. that fall below the designated threshold for good conditions for selected indicators with 95% confidence
- to estimate the proportion of rivers and streams with a margin of error of  $\pm 15\%$  in each of nine ecological reporting regions that fall below the designated threshold for good conditions for selected indicators with 95% confidence.
- to estimate the change in proportion of river and streams in the conterminous U.S. between 2008-9, 2013-14 and 2018-19 that fall below the designated threshold for good (or poor) condition for selected indicators. Change estimates should have a margin of error of  $\pm 15\%$  at 95% confidence.
- to estimate the change in proportion of river and streams in the conterminous U.S. between 2008-9, 2013-14 and 2018-19 in each of nine ecological reporting regions that fall below the designated threshold for good (or poor) condition for selected indicators. Change estimates should have a margin of error of  $\pm 15\%$  at 95% confidence.
- accomplish the above while ensuring that the minimum sample size for a state will be 20 and maximum will be 75.
- Revisit 10% of the sites in 2013-14 for variance component estimation and quality assurance.

The total number of site visits available to satisfy these objectives is 2000 with 1808 unique sites.

## Target population:

The target populations consists of all streams and rivers within the 48 contiguous states that have flowing water during the study index period excluding portions of tidal rivers up to head of salt. The study index period extends from April/May through September and is generally characterized by low flow conditions. The target population includes the Great Rivers. Run-of-the-river ponds and pools are included while reservoirs are excluded. A complete definition of the target population is given in the field operations manual.

## Sample Frame

The sample frame was derived from the medium National Hydrography Dataset (NHD), in particular NHDPlus.V2. Attributes from NHD-Plus and additional attributes added to the sample frame that are used in the survey design are:

- MajorRiver: rivers identified as major rivers or additional rivers in the book: Rivers of North America
- Strahler order

- Strahler category where categories are RiversMajor (5<sup>th</sup> and higher), RiversOther (5<sup>th</sup> and higher), LargeStreams (3<sup>rd</sup>, 4<sup>th</sup> order), and SmallStreams (1<sup>st</sup>, 2<sup>nd</sup> order)
- BorderRiver: rivers and streams that occur on state and country boundaries. Each reach is identified by two-state postal codes such as MO:IL for the portion of the Mississippi river that forms the boundary between Missouri and Illinois. A border river/stream is assigned to one of the two states for the survey design.
- Ecological Reporting Region: Nine aggregated Omernik ecoregions that are used for reporting
- Omernik and North American ecoregions Levels I, II, III and IV.
- Postal code (state)
- Urban and non-urban rivers and streams
- Landownership as non-federal, Forest Service, BLM, Tribal Land, US Fish and Wildlife Service, US National Park Service, and Department of Defense.

The Urban attribute was created by intersecting a modified version of the Census Bureau national urban boundary GIS coverage with NHD-Plus. The Census Bureau's boundaries were buffered 100 meters to include a majority of stream features intersecting and coincident with urban areas. Where this buffer did not completely gather all the river features within the urban areas (rivers intersecting cities are excluded from the Census Bureau's urban areas), the NHD-Plus river area (polygon) features were clipped at a three kilometer buffer around the urban areas and combined with the buffered urban area to create the modified urban database. If a stream or river segment was within this boundary, it is designated as "Urban"; otherwise as "NonUrban".

FCODE is directly from NHD-Plus and is used to identify which segments in NHD were included in the sample frame. The attribute NRS18\_SF identifies each segment as either "Include" or "Exclude". NRS18\_SF was created so that segments included in the sample frame could be easily identified. FCODE values included in the GIS shapefile:

Included in sample frame:

- 33600 Canal/Ditch
- 42801 Pipeline: Pipeline Type = Aqueduct; Relationship to Surface = At or Near Surface
- 46000 Stream/River
- 46006 Stream/River (Perennial)
- 58000 Artificial Path (removed from dataset if coded through Lake/Pond and Reservoirs)

Excluded in FW08 sample frame

- 33400 Connector
- 46003 Stream/River (Intermittent)
- 42800 Pipeline
- 42802 Pipeline: Pipeline Type = Aqueduct; Relationship to Surface = Elevated
- 42803 Pipeline: Pipeline Type = Aqueduct; Relationship to Surface = Underground
- 42804 Pipeline: Pipeline Type = Aqueduct; Relationship to Surface = Underwater
- 42806 Pipeline: Pipeline Type = General Case; Relationship to Surface = Elevated
- 4280 Pipeline: Pipeline Type = General Case; Relationship to Surface = Underground
- 42809 Pipeline: Pipeline Type = Penstock; Relationship to Surface = At or Near
- 42811 Pipeline: Pipeline Type = Penstock; Relationship to Surface = Underground
- 42813 Pipeline: Pipeline Type = Siphon
- 56600 Coastline
- 58000 Artificial Path if coded through Lake/Pond and Reservoirs

## Survey Design

The survey design consists of two separate designs to address the dual objectives of (1) estimating current status and (2) estimating change in status for all flowing waters:

- Resample design applied to NRSA 2008-9 and NRSA 2013-14 sites
- New site design for NRSA 2018-19.

Five basic panels are used for NRSA 2018-19:

- NRS18\_08TS3R2: sites from NRSA 2008-9 that were sampled twice in 2008-9 and then sampled twice again in 2013-14 (a few exceptions). TS3 designates that the site will have been sampled in all three NRSA surveys. R2 designates a site that will be sampled twice in 2018-19.
- NRS18\_08TS3: sites from NRSA 2008-9 that were sampled once in 2008-9 and sampled again in 2013-14. TS3 designates that the site will have been sampled in all three NRSA surveys.
- NRS18\_13TS2R2: sites from NRSA 2013-14 that were sampled twice in 2013-14. TS2 designates that the site will have been sampled in two NRSA surveys. R2 designates a site that will be sampled twice in 2018-19.
- NRS18\_13TS2: sites from NRSA 2013-14 that were sampled once in 2013-14 and will be sampled again in 2018-19. TS2 designates that the site will have been sampled in two NRSA surveys.
- NRS18\_18: new sites selected for NRSA 2018-19 that will be sampled once in 2018-19.

The first four panels are part of the Resample Design and the last is the New Site Design. Each of the five panels have “Base” sites and “Over Sample” sites.

The survey design is explicitly stratified by state for both designs. The unequal probability categories are specific to survey design used for NRSA 2008-9, NRSA 2013-14 and NRSA 2018-19. In all cases the categories are specific combinations of Strahler order categories and NARS nine aggregated ecoregions. In addition, a minimum of 20 sites (Resample and New) was guaranteed in each state and a maximum of 75 sites was limit for a state.

**Resample Design:** The Resample survey design is a subsample of the NRSA 2008-9 sites and NRSA 2013-14 sites that were target and sampled in NRSA 2008-9 and NRSA 2013-14. The major objective for this design is change estimation, although all sites sampled in 2013-14 will be used when change is estimated. The resample design has four panels:

- NRS18\_08TS3R2 – 96 sites (two per state) from NRSA 2008-9 sites that were sampled twice in 2008-9 and that were also sampled twice in 2013-14 and will be sampled twice in 2018-19. In each state one site is a stream (Strahler order 1-4) and one site is a river (Strahler order 5-10). Note that Arizona sites visited twice are both rivers since no streams were available that were visited twice in prior surveys.
- NRS18\_08TS3 – 377 sites that were sampled once in 2008-9, once in 2013-14 and will be sampled once in 2018-19. Approximately 50% of sites in each state will be

streams and 50% will be rivers. Sample size for each state is based on sample size used in 2013-14 proportional to achieve 408 sites.

- NRS18\_13TS2R2 - 96 sites (two per state) from NRSA 2013-14 sites that were sampled twice in 2013-14 and will be sampled twice in 2018-19. In each state one site is a stream (Strahler order 1-4) and one site is a river (Strahler order 5-10). Note that Vermont sites visited twice are both streams since no rivers were available that were visited twice in prior surveys.
- NRS18\_13TS2 – 414 sites that were sampled once in 2013-14 and will be sampled once in 2018-19. Approximately 25% of sites in each state will be SmallStreams(1<sup>st</sup>-2<sup>nd</sup>), LargeStreams (3<sup>rd</sup>-4<sup>th</sup>), RiversMajor (5<sup>th</sup>+) and Rivers Other (5<sup>th</sup>+). Sample size for each state is based on sample size used in 2013-14 proportional to achieve 408 sites.

This results in 983 unique sites in the Resample Design. Allocation of sites to NARS aggregated ecoregions is proportional to the number sampled in the prior surveys.

**New Site Design:** The NRSA 2018-19 new site survey design is a new survey design where the expected sample sizes are based on the nine ecological reporting regions and four categories of RiversMajor (5<sup>th</sup> and greater), RiversOther (5<sup>th</sup> and greater), LargeStreams (Strahler order 3<sup>rd</sup>, 4<sup>th</sup>), and SmallStreams (Strahler order 1<sup>st</sup>, 2<sup>nd</sup>). Allocation of number of sites to states is proportional to stream length. The New Site Design is explicitly stratified by state. Unequal probability categories are 36 combinations of NARS nine aggregated ecoregions and four Strahler order categories (SS – small streams (1<sup>st</sup>-2<sup>nd</sup>), LS – large streams (3<sup>rd</sup>-4<sup>th</sup>), RM – major rivers (5<sup>th</sup>+) and RO – other rivers (5<sup>th</sup>+). In addition, a minimum of 20 sites (Resample and New) was guaranteed in each state and a maximum of 75 sites (Resample and New) for a state.

First each state was assigned one site for each unequal probability category of streams and rivers that occur in the state. This allocates 414 sites in the New Site Design. Next the remaining 411 sites were allocated to the states proportional to their stream and river length.

## Sample Size Summary

The number of sites by NARS nine aggregated ecoregions and four Strahler order categories

	LargeStreams	RiversMajor	RiversOther	SmallStreams	NoneKS	Sum
CPL	54	54	41	68	0	217
SAP	60	50	58	71	0	239
WMT	49	39	35	74	0	197
XER	40	66	53	40	0	199
SPL	35	64	46	20	18	183
NAP	53	37	43	89	0	222
TPL	55	43	54	40	15	207
UMW	63	29	43	55	0	190
NPL	36	51	53	14	0	154
Sum	445	433	426	471	33	1808

The number of sites by state and four Strahler order categories

	LargeStreams	RiversMajor	RiversOther	SmallStreams	NoneKS	Sum
AL	5	7	6	9	0	27
AR	6	7	6	8	0	27

AZ	6	10	6	5	0	27
CA	9	14	13	20	0	56
CO	13	15	11	9	0	48
CT	3	4	4	9	0	20
DE	6	0	6	8	0	20
FL	4	3	4	9	0	20
GA	8	9	5	7	0	29
IA	10	7	11	7	0	35
ID	8	12	9	14	0	43
IL	11	8	13	12	0	44
IN	9	8	7	9	0	33
KS	5	5	2	1	33	46
KY	8	9	7	9	0	33
LA	4	8	5	5	0	22
MA	6	4	3	7	0	20
MD	5	6	3	6	0	20
ME	6	4	7	10	0	27
MI	20	4	16	18	0	58
MN	23	12	17	21	0	73
MO	13	12	9	8	0	42
MS	4	8	3	7	0	22
MT	22	18	21	14	0	75
NC	8	4	8	7	0	27
ND	10	13	18	4	0	45
NE	15	18	17	7	0	57
NH	6	6	2	6	0	20
NJ	5	6	3	6	0	20
NM	7	10	8	7	0	32
NV	7	8	6	6	0	27
NY	14	13	12	28	0	67
OH	9	6	10	10	0	35
OK	14	25	17	9	0	65
OR	7	9	11	15	0	42
PA	11	8	11	15	0	45
RI	5	0	4	11	0	20
SC	5	5	5	5	0	20
SD	13	23	17	8	0	61
TN	7	6	6	7	0	26
TX	16	27	15	13	0	71
UT	8	10	7	6	0	31
VA	7	2	3	8	0	20
VT	6	1	2	11	0	20
WA	9	10	10	11	0	40
WI	22	11	12	17	0	62
WV	5	3	4	8	0	20
WY	15	15	24	14	0	68
Sum	445	433	426	471	33	1808

### Over Sample and Site Replacement

Site replacement is based on the 2018-19 panel variable NRS18\_PNL. Five basic panels are used for NRSA 2018-19:

- NRS18\_08TS3R2: sites from NRSA 2008-9 that were sampled twice in 2008-9 and then sampled twice again in 2013-14 (a few exceptions). TS3 designates that the site

will have been sampled in all three NRSA surveys. R2 designates a site that will be sampled twice in 2018-19.

- NRS18\_08TS3: sites from NRSA 2008-9 that were sampled once in 2008-9 and sampled again in 2013-14. TS3 designates that the site will have been sampled in all three NRSA surveys.
- NRS18\_13TS2R2: sites from NRSA 2013-14 that were sampled twice in 2013-14. TS2 designates that the site will have been sampled in two NRSA surveys. R2 designates a site that will be sampled twice in 2018-19.
- NRS18\_13TS2: sites from NRSA 2013-14 that were sampled once in 2013-14 and will be sampled again in 2018-19. TS2 designates that the site will have been sampled in two NRSA surveys.
- NRS18\_18: new sites selected for NRSA 2018-19 that will be sampled once in 2018-19.

NRSA 2018-19 panel	Base sites within 2018-19 panel	Over sample sites within 2018-19 panel that will be used as replacement sites within the panel
NRS18_08TS3R2	NRS18_08TS3R2_BaseStream	NRS18_08TS3R2_OverStream
NRS18_08TS3R2	NRS18_08TS3R2_BaseRiver	NRS18_08TS3R2_OverRiver
NRS18_08TS3	NRS18_08TS3_BaseStream	NRS18_08TS3_OverStream
NRS18_08TS3	NRS18_08TS3_BaseRiver	NRS18_08TS3_OverRiver
NRS18_13TS2R2	NRS18_13TS2R2_BaseStream	NRS18_13TS2R2_OverStream
NRS18_13TS2R2	NRS18_13TS2R2_BaseRiver	NRS18_13TS2R2_OverRiver
NRS18_13TS2	NRS18_13TS2_BaseSS	NRS18_13TS2_OverSS
NRS18_13TS2	NRS18_13TS2_BaseLS	NRS18_13TS2_OverLS
NRS18_13TS2	NRS18_13TS2_BaseRO	NRS18_13TS2_OverRO
NRS18_13TS2	NRS18_13TS2_BaseRM	NRS18_13TS2_OverRM
NRS18_18	NRS18_18_BaseSS_XXX	NRS18_18_BaseSS_XXX
NRS18_18	NRS18_18_BaseLS_XXX	NRS18_18_BaseLS_XXX
NRS18_18	NRS18_18_BaseRO_XXX	NRS18_18_BaseRO_XXX
NRS18_18	NRS18_18_BaseRM_XXX	NRS18_18_BaseRM_XXX

XXX designates one of the nine aggregated ecoregions: CPL, NAP, NPL, SAP, SPL, TPL, UMW, WMT, or XER. Sites within each state and above six categories are provided in siteID order and the replacement must be in siteID order within the panel. Panels with “R2” are sites that will be sampled twice in 2018-19. If no over sample sites are available, or all over sample sites have been used, for an “R2” panel, then the next site in siteID order within the same basic panel is used. For example, if no over sample site are available in panel NRS18\_08TS3R2\_BaseStream, then use first site in panel NRS18\_08TS3\_BaseStream.

## State Designs

Three states have state-specific survey designs: Kansas, New Hampshire and Virginia. These designs are described below.

In addition, a state may implement a state-level survey using the national design for their state. The above survey design describes the national survey design and sets the required number of sites that must be sampled within each state. If a state implements a state-level design, the NRSA 2018-19 design sites must be sampled as part of the state-wide design. A state-level design based on the national design for the state is one where a state may simply sample additional sites from the over sample list of sites within their state to achieve their desired sample size for the state-level design. It is critical that the site replacement process be followed and that the state communicate to the NRSA 2018-19 coordinator whether only the required NRSA 2018-19 sites will collect all the NRSA indicators or if all state-level sites will collect all the NRSA indicators. This information is required by the NRSA staff to know what sites evaluated should be included in the weight adjustment after field implementation.

### **Arizona:**

Arizona plans to conduct a state-level assessment and a special study on warm water streams and rivers. The sample frame and the survey design used for NRSA 2018-19 will be used. That is, no special design is required. Additional over sample sites were selected to ensure that sufficient sites will be available to achieve their required sample sizes. It is anticipated that only the required 27 NRSA 2018-19 sites will become part of the national assessment. The additional sites will not have all national indicators collected. After all sites are evaluated and field work is completed, two weight adjustments will be necessary. One to account for the sites evaluated to sample the 27 national sites and one to account for all sites evaluated to complete the state-level assessment and special study. Sites must be replaced within the panels as described above and in siteID order within the panels. For the special study, additional criteria, such as sites below 5,000 ft (warm water) and not on tribal land may be used in addition. Sites must be replaced in siteID order within these additional categories as well.

### **Kansas:**

The Kansas state-specific design is based on the Kansas Surface Water Register (KSWR) GIS layer of officially recognized streams and rivers within the state. It is based on the 1:24000 NHD. The current version was provided by Kansas during the summer 2016. The NRSA design team restricted the GIS layer to the state of Kansas borders and added variables to match those used for all NRSA states. In prior studies, it was determined that the KSWR includes streams and rivers that meet the definition of the NRSA target population. The survey design consists of the Resample Design for Kansas as describes above and an equal probability survey design for new sites. Since the NRSA 2013-14 survey design for new sites for Kansas was also an equal probability survey design, most sites are selected with equal probability. That is not the case for NRSA 2008-9 sites where an unequal probability design was used. The panels and number of sites are:

- NRS18\_08TS3R2: 2 sites from NRSA 2008-9 to be sampled twice in 2018-19. Required for NRSA 2018-19. If site cannot be sampled, then use over sample sites as describes for all states.

- NRS18\_08TS3: 9 sites from NRSA 2008-9 to be sampled once in 2018-19. Required for NRSA 2018-19. If site cannot be sampled, then use over sample sites as describes for all states.
- NRS18\_13TS2R2: 2 sites from NRSA 2013-14 to be sampled twice in 2018-19. Required for NRSA 2018-19. If site cannot be sampled, then use over sample sites as describes for all states.
- NRS18\_18: 33 new sites selected with equal probability. Required for NRSA 2018-19. If site cannot be sampled, then use over sample sites as describes for all states.
- State-level design: The additional over sample sites for NRS18\_18 (1650 sites) to be used as necessary to satisfy site replacement requirements and for Kansas to use for the state-level design in 2018-19 as well as in future years until the next NRSA design in 2023-24.

### **New Hampshire:**

New Hampshire provided a state-specific sample frame based on NHD 1:24000. They explicitly identified stream reaches that are in the NHDPlus 1:100000 sample frame. These categories are identified in the NH State Specific sample frame under the variable STATE\_SF with the values of Include\_100K if from NHDPlus and Include\_24K for additional streams not in NHDPlus.

### **Virginia:**

Virginia conducts state-level probability surveys. Given that the design is compatible with NRSA 2018-19, the NRSA design will consist of the panels from the Resample Design and the sites from the Virginia state-level survey. No New Site Design is required for Virginia. Virginia samples by year and that process must be followed for NRSA 2018-19

## **Sample Frame Summary**

The sample frame is available as 48 state shapefiles. A summary of the sample frame by state, NARS nine aggregated ecoregions and four Strahler order categories is available in the file: NRSA18 Sample Frame Summary.csv. Note that this file does not include changes in the sample frame associated with the four state-specific designs.



