

# Stream Corridor Guidance

## Part 1: Functional Value Assessment Methodology

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### Abstract

The Functional Value Assessment Methodology is intended to be used by technical planning and science professionals to collect and analyze stream corridor data. It is part one of a two-part series of technical Stream Corridor Guidance documents provided by the Highlands Council for use by municipalities. Part II, Protection and Restoration Planning, is a separate document which provides a framework for identifying, prioritizing and implementing protection and restoration projects for either general planning purposes or mitigation planning related to a specific proposed project.

Although this document is intended primarily for use by municipalities within the Highlands Region (and grant funding is available to support associated work for municipalities that are conforming to the Highlands Regional Master Plan) the principles, strategies and methods outlined herein are applicable to any municipality and may be of interest to other stakeholders.



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## Statutory Platform, Purpose and Funding

Through the passage of the New Jersey Highlands Water Protection and Planning Act in 2004, the NJ Highlands Water Protection and Planning Council (the Highlands Council) was created and charged with developing a Regional Master Plan (RMP). Adopted in 2008, the RMP serves as the guiding document for the long-term protection and restoration of the critical resources of the Highlands Region. In accordance with Objectives 1D4h and 1D4i of the RMP, the Highlands Council has developed Stream Corridor Guidance documents.\* They are presented in two parts:

Part I: Functional Value Assessment Methodology (FVAM)

Part II: Protection and Restoration Planning

These technical documents are intended to be used by planning and science professionals within a municipality to first assess the integrity of Highlands Region streams, rivers and riparian areas within the jurisdiction and then develop targeted protection and restoration plans based on the findings of the assessment.

Part I, the FVAM, is a tool for collecting and analyzing stream corridor data. Part II, provides a framework for identifying, prioritizing and implementing protection and restoration projects for either general planning purposes or mitigation planning related to a specific proposed project.

Funding to support this work within a municipality is provided by the Highlands Council through the Highlands Plan Conformance process. Municipalities with approved Plan Conformance Petitions are eligible for grant funding to cover the reasonable expenses of planning activities associated with the Conformance process and should contact their Highlands Council Municipal Liaison for additional information.

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*\* Copies of the Highlands Regional Master Plan are available in most municipal offices and can be obtained by contacting the Highlands Council office.*

## List of Preparers

This document was prepared by the following firm(s)/individual(s) with project management from Highlands Council technical staff.

Princeton Hydro, LLC  
1108 Old York Road, Suite 1  
P.O. Box 720  
Ringoes, New Jersey 08551  
908.237.5660  
[www.princetonhydro.com](http://www.princetonhydro.com)

Primary Author: Paul Woodworth  
Contributors/Editors: Lauren Kovacs, Christiana Pollack

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## Introduction

The Highlands, a geographic region that spans Pennsylvania, New Jersey, New York and Connecticut, is renowned for scenic vistas of expansive forests, rolling hills, steep ridges, and pastoral valleys. In addition to its natural beauty, the Region boasts a diversity of critical wildlife habitats interspersed among historic rural towns, former mill towns and suburban and urban centers. The Highlands in New Jersey occupies less than one quarter of the state but provides drinking water for 65% of New Jersey residents.

Among numerous other resource protection and enhancement initiatives, the Highlands RMP calls for evaluation, restoration, and measurable improvement of Highlands streams and stream corridors. The Functional Value Assessment Methodology (FVAM) presented herein addresses Objective 1D4h of the RMP, which seeks to protect streams and the significant environmental values/services they provide, such as: aquatic habitat, stormwater and flood water retention and filtration, water quality protection, temperature moderation, aquatic ecosystem integrity, and channel integrity. The FVAM is a tool for assessing the integrity of Highlands streams, rivers and riparian areas. It provides a measurable and scientific approach to evaluating the multiple functional values that streams, stream buffers and riparian areas provide. Only with a clear understanding of the status of these qualities, is it possible to develop strategies for improvement and/or to ensure no net loss in functional value.

## To Assess, Protect and Restore

The FVAM is geared toward Highlands Open Waters – streams and rivers – and Highlands Open Water Buffers and riparian areas. The Highlands Open Water Buffer spans 300 feet from the edge of the discernible bank of Highlands Open Waters or from the centerline where no discernible bank exists. Conventionally, buffers have been viewed as an insignificant strip of land separating human disturbance from natural features. However, the buffer itself holds intrinsic values (i.e. habitat and social) and helps to protect streams and rivers (i.e. water quality, temperature moderation, channel integrity) from adjacent impacts. This assessment is the initial step in a larger effort that culminates in a Stream Corridor Protection and Restoration Plan. The process has been laid out to methodically identify existing conditions and diagnose sources of impairment to reaches of streams and rivers. Ultimately, the assessment leads to targeted protection and restoration plans that can ensure no net loss in functional values and yield measureable improvements. The assessment will be summarized in a report that includes a compilation of data, quantitative and qualitative analyses for each functional value, and a determination of the primary factors affecting the water resource, all of which lay the foundation for developing a Stream Corridor Protection and Restoration Plan.

## Functional Value Assessment Methodology (FVAM) Process Overview

The FVAM is designed to be a detailed and standardized process that if repeated by others would yield a similar result. For Highlands municipalities, the assessment, with supporting materials and

adequate detail, must be submitted to the Highlands Council for approval. While the FVAM process includes steps to ensure data quality, the Highlands Council review provides a final level of quality control and standardization of completed assessments across the Region. In addition, the Highlands Council will serve as the long-term custodian of assessment reports and supporting data, which will be publicly available for future reference and re-use by others in planning and restoration.

The FVAM is intended to be used in two potential scenarios as described in the Highlands Regional Master Plan. First, new development projects must meet a standard for “no net loss of functional values.” The FVAM will be used to establish existing functional values and estimate the effect of the proposed development project on those functional values. Any measurable degradation of functional values must be mitigated. In the second scenario, a community led effort may use the FVAM to assess current conditions, prioritize high value stream reaches for protection, identify impaired reaches and define the extent and type of restoration for streams and riparian areas.

The FVAM may be accomplished by individuals or groups with relevant education and diverse specialties; however, some judgments and technical aspects of the FVAM require the skills of natural resource professionals with training and expertise in watershed management, geographic information systems, botany, ecology, fisheries and fluvial geomorphology. The amount of time and level of effort for the FVAM will vary depending on the length of the target stream or river and the size of the contributing watershed. Prior to starting the FVAM, project leaders should contact the Highlands Council to learn of other related assessments or other information that could aid in the assessment.

## **Functional Values of Streams and Riparian Areas**

This methodology focuses on the five core functional values of streams and riparian areas identified in the RMP: (i) channel integrity, (ii) habitat, (iii) water quality, (iv) temperature moderation, and (v) public use.

***Channel integrity***, as defined in fluvial geomorphology, is the long-term dynamic stability of the dimension, pattern and profile of the stream channel. Channel integrity is best maintained when a stream or river has attained a dynamic equilibrium state, at which point erosion and deposition of sediment are in relative balance. Dynamic stability of stream dimension, pattern and profile are not the same as a fixed, unmoving channel but rather refers to a stream that is changing within a reasonable range around an equilibrium state. Dynamic equilibrium is most likely to occur when a stream retains connection to its riparian corridor and floodplain. Floodplains dissipate the energy associated with high flows, thereby maintaining channel integrity while simultaneously providing important habitat and ecological processes. Past and present human disturbance (to streams and their watersheds) has initiated stream incision and widening, disconnecting channels from floodplains, exacerbating in-stream erosion and impairing channel integrity. Loss of channel integrity often negatively affects other functional values.

Streams and riparian areas provide **Habitat** for a broad range of living organisms including aquatic insects, crustaceans and other invertebrates, fish, amphibians, reptiles, aquatic plants, terrestrial wildlife, and numerous terrestrial plant species. Optimal stream habitat for aquatic fauna is created under equilibrium conditions when sediment, woody material and water flow (depths and velocities) interact to create heterogeneous habitat units for cover, foraging and reproduction. In addition, periodic flooding provides access to the adjacent riparian system that maximizes biotic diversity. Geomorphic changes, like periodic bed and bank erosion, sediment deposition and organic debris accumulation in the channel and floodplain support more complex and diverse aquatic habitat and aquatic communities. Human impacts that alter the quantity, size and distribution of sediment and woody debris or the flow of water can degrade habitat conditions.

**Water Quality** is maintained by stream channels in equilibrium and vegetated riparian buffers that intercept and slow runoff, and remove and process pollutants. Under equilibrium conditions, streams attain their least erosive form when source of the suspended sediment load in a watershed (Simon et al., 2003 and 2006). Stream incision often results in the downcutting of tributaries and major gully formation at stormwater outfalls – exacerbating in-stream sedimentation. Vegetated riparian buffers intercept and infiltrate runoff, take up nutrients, bind metals, and breakdown other pollutants. .

Elevated water temperatures lead to decreased dissolved oxygen and physiological stress on aquatic organisms. **Temperature Moderation** is best provided by riparian vegetation that forms along banks and in cross-channel canopy cover that reduces incident solar radiation. Lower bank heights associated with equilibrium conditions (i.e. little or no channel incision) maintain the connection between root systems, groundwater and surface water thereby maintaining the integrity of riparian vegetation. Groundwater exchange through the stream bed/stream corridor (i.e. “hyporheic” zone), a primary influence in temperature moderation, can be inhibited by excessive sedimentation over coarse-grained, porous substrate. Structures that are incompatible with equilibrium, such as undersized culverts, dams or other barriers, can create backwater conditions that diminish the stream’s capacity to moderate temperatures.

As humans are an inseparable component to the Highlands Region, the **public use** of streams, rivers and riparian buffers will also be considered in the FVAM. People seek out streams, rivers and riparian areas for solace and a wide range of recreational activities such as walking, biking, boating, swimming, fishing and birding. Encroaching development and other human disturbances can inhibit these activities. Trails and access points, while not always compatible with other functional values, shall be considered as part of the social benefits functional value.

The five functional values identified above are inter-related in a variety of ways. For example, improving channel integrity facilitates the increased establishment of diverse and productive aquatic

communities and serves to improve the existing riparian habitat. Alternatively, healthy riparian vegetation can promote channel integrity. Healthy riparian plant communities provide additional water quality protection and temperature moderation. Conversely, impaired habitat and water quality inhibits the public use of streams, rivers and stream-side areas. These are only a few examples of the inter-dependence among the five functional values.

## Assessment Approach

The FVAM approach combines methods from existing protocols that utilize current understanding of stream geomorphic processes, which are driving factors affecting aquatic and riparian habitat, temperature moderation, water quality and channel integrity. For these reasons, the FVAM is partially a geomorphic-based approach. Observations and measurements of the watershed, valley, channel and floodplain aim to discern underlying geomorphic processes that affect four of the primary functional values.

Unique to existing protocols, this approach also draws on an emerging botanical-based methodology in assessing the integrity of terrestrial habitats. The Plant Stewardship Index (PSI) methodology was created in the 1970s in the Chicago region by Floyd Swink and Dr. Gerould Wilhelm and has been developed in many other states as the Floristic Quality Assessment Index. This standardized tool replaces subjective assessments, and although approximate, provides a useful number for comparing various natural areas. PSI is not a stand-alone value, but is used together with other ecological methods to evaluate the quality of a site.

The basis of the PSI calculation is the coefficient of conservatism (C), a value given to each species on a state-wide basis. Each species is assigned a value from 0 to 10, which represents the probability that this plant species is likely to occur in landscapes relatively unaltered from those of pre-settlement times. Plant species with high C values are relatively specialized in their requirements, and thus are found in more habitat quality and ecosystem health. C values are enumerated in the table below:

C Value	Descriptor
0 to 3	Plants with a high range of ecological tolerances/found in a variety of plant communities
4 to 6	Plants with an intermediate range of ecological tolerances/associated with a specific plant community
7 to 8	Plants with a poor range of ecological tolerances/associated with advanced successional state
9 to 10	Plants with a high degree of fidelity to a narrow range of habitats

The C values for New Jersey and the piedmont region of Pennsylvania are provided by Bowman's Hill Wildflower Preserve, after consultation with the leading botanists of NJ and PA. For all of New Jersey and the Piedmont region of Pennsylvania, over 2,000 plants have been catalogued and assigned a number from zero to ten by local experts and botanists. Zero represents the most generalist species; tolerant of disturbance and includes invasive or introduced non-native species such as multiflora rose. Ten represents the most conservative species and includes many rare and endangered state-listed native plants that require special habitats and/or do not regrow after disturbance.

This database of plants and associated numerical values are available to users through the PSI Calculator located on the Bowman's Hill Wildflower Preserve's website. Once a user inputs a list of plants found on a particular site, the PSI Calculator automatically computes: 1. the Mean C, which is the average of all the assigned numbers of plants found on a site and; 2. the Index number, which is the Mean C multiplied by the square root of the total number of plant species.

Individual plant ranks are added together and used to calculate the total mean conservatism and native mean conservatism of a site. High conservatism scores represent more pristine sites which are less likely to recover from disturbance. The Plant Stewardship Index program can be used to establish score ranges to determine the floristic value (high, medium, low) of a site. In addition, the PSI yields a metric that can be used to monitor restoration success over time and to advocate for management and funding prioritization.. Significantly, the PSI program does not rely on the presence of individual rare species to determine an area as valuable; instead, the total composition of species present is evaluated to produce a holistic understanding of the plant community's composition and conservative value.

The FVAM is partitioned into two phases. **Phase 1** is largely a desktop exercise using existing geographic data. **Phase 2** is a field exercise that requires visual observations and data collection in the project reaches and the adjacent riparian buffer. While many existing assessment protocols were reviewed, this methodology is modeled closely after the *Vermont Agency of Natural Resources Stream Geomorphic Assessment Protocols*, specifically the Phase 1 Watershed Assessment (VTANR, 2007), Phase 2 Rapid Stream Assessment and the Reach Habitat Assessment (VTANR, 2007), and the Reach Habitat Assessment (Milone & MacBroom, 2008). Material is used with permission. Despite the similar structure and specific elements, all components have been adapted to the New Jersey Highlands setting and enhanced with existing data specific to the region.

## Phase 1: Watershed Assessment

Phase 1 of the FVAM occurs at a broad-scale and uses publicly available data and mapping to identify larger natural conditions and human impacts that occur off-site and cannot be easily observed in the field. This desktop assessment is an essential step in preparation for the field assessment (Phase 2) and, in fact, no fieldwork should be undertaken without first completing Phase 1. The ability to read topographic maps and interpret aerial photos is required. Some metrics, analyses and map creation are best performed in a Geographic Information System (GIS), which entails specialized software (such as ArcGIS) and requires training to operate effectively. Existing data sources will need to be accessed from the following data portals:

- NJ Highlands Council GIS Data Downloads  
[\[http://www.highlands.state.nj.us/njhighlands/actmaps/maps/gis\\_data.html\]](http://www.highlands.state.nj.us/njhighlands/actmaps/maps/gis_data.html)
- NJDEP GIS Data Downloads  
[\[http://www.state.nj.us/dep/gis/\]](http://www.state.nj.us/dep/gis/)  
[\[http://www.state.nj.us/dep/njgs/geodata/\]](http://www.state.nj.us/dep/njgs/geodata/)
- NJ Geographic Information Network  
[\[https://njgin.state.nj.us/NJ\\_NJGINEExplorer/index.jsp\]](https://njgin.state.nj.us/NJ_NJGINEExplorer/index.jsp)
- USDA Natural Resources Conservation Service  
[\[http://datagateway.nrcs.usda.gov/GDGOrder.aspx\]](http://datagateway.nrcs.usda.gov/GDGOrder.aspx)

Refer to Appendix A for a list of available data layers and sources.

Phase 1 will include the watershed that drains to the study reach as well as the characteristics of the valley, floodplain and corridor, and channel that can be readily assessed from existing aerial orthophotography and geographic data. Based on the characteristics identified during the Phase 1 process, the project reach may be extended upstream or downstream to encompass off-site factors that influence the project site. Data sheets have been included in Appendix B to record Phase 1 observations and measurements.

### Products of Phase 1:

1. Definition of the reference stream type(s)
2. Initial characterization of the subject stream channel, corridor and watershed
3. Impact ratings for five watershed and corridor degrading factors
4. Scores for three supporting factors
5. Supporting information for the Phase 1 Watershed Assessment
6. Annotated maps of watershed, corridor and reach for use in Phase 2
7. Baseline information necessary for developing Stream Corridor Protection and Restoration Plans

The products of Phase 1, such as general watershed maps, detailed field maps, points of access as well as initial interpretations of reference conditions and expected types of impairment, are required for the Phase 2 effort.

### **Major Steps of Phase 1:**

1. Identify the study reach(es) that will be the primary focus of the assessment
2. Gather existing data
3. Characterize
  - a. Reach
  - b. Corridor/watershed
4. Assign Impact Ratings and Scores
5. Compile information and maps
6. Review for quality assurance/quality control

Instructions are provided in the sections that follow.

## **1.0 Reach Conditions/Modifications**

### ***1.1. Define reach(es) to be assessed***

Define the full extent of the assessment project by locating upstream and downstream limits of the area of interest, tributaries, and the contributing watershed. Use a USGS 7.5 Minute Topographic Quadrangle map to differentiate stream reaches by geomorphic conditions: (i) the width of the valley/floodplain, (ii) the character of the channel, and (iii) the confluences of major tributaries (e.g. wide floodplain and meandering channel versus narrow valley and straight channel). Following these geomorphically-defined reaches as closely as possible, subdivide into stream reaches that can be walked in reasonable time (e.g. approximately ½ - 1 mile). Record the following information for the reach being assessed:

**1.1.1. Stream Name:** Full name of stream/river and name of larger watershed.

**1.1.2. Reach ID:** Clearly mark the reaches to be assessed on a topographic map and enumerate from downstream to upstream using the river/stream name followed by a two digit number (e.g. Sawmill-01).

**1.1.3. Endpoint Descriptions:** Describe upstream and downstream endpoints. Note obvious points of access (e.g. road crossings, parks, etc.) and recognizable locations such as “Mill Street Bridge” or “boat launch at Veterans’ Park” where possible.

**1.1.4. Endpoint Coordinates:** Record the latitude and longitude in decimal degrees of the upstream and downstream endpoints of each reach. If not using geographic coordinates, specify projection (i.e. New Jersey State Plane NAD 83 (feet)). Record horizontal and vertical datums.

**1.1.5. National Hydrography Dataset (NHD) Reach Code:** Record the corresponding Reach Code from the NHD Streams 2002 data layer. The study reach may not coincide exactly with NHD delineated reaches; list all that apply.

**1.1.6. HUC 14:** Note the unique ID number from the 14-digit USGS Hydrologic Unit Code (HUC).

**1.1.7. Municipality/County:** Note the municipalities, counties and USGS 7.5 Minute Topographic Quadrangle that cover the reaches and riparian areas to be assessed.

**1.1.8. Excluded Areas:** Isolate reaches that may be difficult or impossible to investigate due to water depth, velocity or obstructions in the channel or riparian area.

***1.2. Land Ownership:*** Review parcel boundary data layer in combination with the online parcel database to identify private properties. In Phase 2, do not cross private property without explicit permission from the landowner. For reaches that cross property owned by individuals or entities not involved in the project, contact landowners. Provide background information on the nature and purpose of the assessment and seek written permission to access.

***1.3. Define Reference Stream Type:*** The metrics in this step are necessary to define the type of stream that should exist under natural, undisturbed conditions – referred to as the “Reference Stream Type” based on the stream reach being assessed. The Reference Stream Types are preliminarily determined to describe stream channel forms and processes that would exist in the absence of human-related changes to the channel, floodplain, or watershed. Understanding the reference stream type allows assessors to compare/contrast among reaches, determines the type of anticipated channel and habitat conditions, and sets an initial guideline for restoration and protection plans. The assessment will then shift focus to human impacts that induce departure from the reference stream type and cause losses to functional values. The following metrics are the basic essential descriptors of channel form necessary for stream classification. Using an aerial photograph and topography data, collect the following information for the stream being assessed.

**1.3.1. Length:** Measure the length (in feet) of the center line of the reach between both endpoints.

**1.3.2. Reach Endpoint Elevations:** Find the elevations (in feet) on the stream polyline at the downstream and upstream endpoints of the reach. Highlands Council’s Light Detection and

Ranging (LiDAR) data are available and suitable for this task. Record the vertical datum and be consistent throughout the exercise.

**1.3.3. Reach Slope:** Compute reach percent slope by subtracting the downstream endpoint elevation from the upstream endpoint elevation, dividing by reach length, then multiplying by 100. Note any waterfalls or bedrock ledges that create punctuated changes in channel bed slope and may serve as natural stream grade controls.

**1.3.4. Valley Length:** Measure the valley length (in feet) as a straight-line distance parallel to the valley walls between the reach endpoints. Do not follow meanders of the stream or cross the toe of either valley wall.

**1.3.5. Valley Slope:** Compute the valley percent slope by subtracting the downstream endpoint elevation from the upstream endpoint elevation, dividing by valley length, then multiplying by 100.

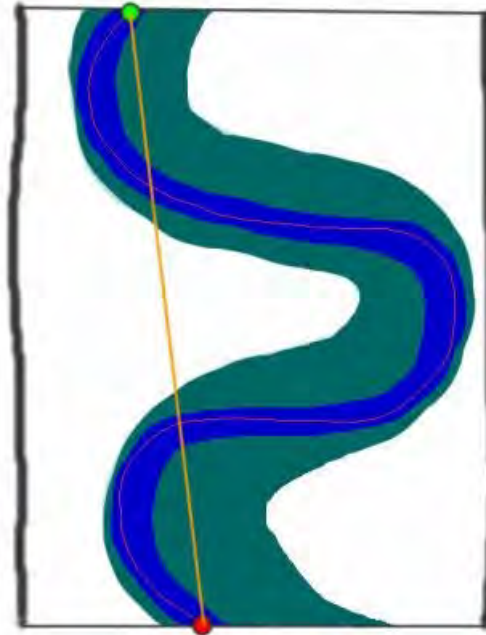
**1.3.6. Sinuosity:** Sinuosity, or the degree of channel meandering, describes the planform pattern of a river and is expressed as the ratio of channel length to valley length. Straight channels equate to low sinuosity. Sinuosity coupled with channel gradient is highly indicative of channel morphology (when bedrock influence is minimal), which can yield information about the sediment transport regime. (1) High gradient streams with low sinuosity form step-pool morphology. (2) Moderate gradient streams with low to moderate sinuosity form plane-bed morphology while moderate gradient streams with high sinuosity form pool-riffle morphology. (3) Low gradient streams often have higher sinuosity and form dune-ripple morphology.

**Metric:** Compute sinuosity by dividing reach length/valley length. See “Sinuosity” table for interpretation.

Sinuosity	
< 1.2	Low
1.2 – 1.5	Moderate
> 1.5	High
> 1.5 w/ oxbows	Very High

## Sinuosity of Natural Channels

### Plan Patterns



$$\text{Sinuosity} = \frac{\text{Channel Length}}{\text{Valley Length}}$$

[http://www.fgmorph.com/fg\\_2\\_22.php](http://www.fgmorph.com/fg_2_22.php)

**1.3.7. Channel Width:** Using a high resolution orthophoto aerials and/or LiDAR topographic data, measure the width (in feet) of the channel from top of banks at a representative cross-section. If channel width varies, measure width in several representative places, and average. This will serve as a preliminary estimate that requires verification in Phase 2.

**1.3.8. Valley Width:** Utilizing the same data sources as above, measure the distance between valley walls (in feet) in a straight line perpendicular to the down valley gradient. If valley width varies, measure width in several representative places, and average.

**1.3.9. Valley Confinement Ratio:** Compute confinement ratio by dividing valley width by channel width. The width of the valley is the land area in which the river is free to move laterally over time by meandering. Confining valleys prevent the channel from meandering laterally and induce a straighter channel alignment. Confinement ratio represents the degree to which channel pattern is restricted by the valley walls. The confinement ratio determines which Geomorphic Assessment sheet is used in Phase 2. See “Confinement Ratio” table for interpretation.

Confinement Ratio (Valley Width/Channel Width)	
1 < 2	Very Confined
2 < 4	Moderately Confined
4 < 6	Minimally Confined
6 < 10	Broad
≥ 10	Very Broad

**1.3.10. Reference Stream Type:** This step involves classifying the stream type that most likely exists under reference conditions (i.e. undisturbed) based on the information collected above (slope, confinement, and sinuosity). As the channel integrity and habitat condition varies by stream type, separate assessment scoring sheets used in Phase 2 are provided for several different stream types. Several stream classification systems (Schumm 1977, Rosgen, D.L. 1994, Montgomery and Buffington, 1997) are combined here to summarize the physical parameters important in defining the typical stream type under reference conditions. First, the reference stream type will be determined by the Rosgen classification system. Second, the reference stream type will be further defined by the channel bed morphology.

**1.3.10.1. Rosgen Stream Type:** Moving from left to right in the Table below, use the measured Valley Slope and Confinement to determine the Rosgen Stream Type. This will serve as a preliminary estimate that requires verification / reassessment in Phase 2 by measuring channel width in the field and visually confirming dominant channel substrate and channel bed morphology. A key to the Rosgen stream classification is adapted and included below. For further description of Rosgen stream types refer to Rosgen, D.L. 1994, “A classification of natural rivers,” Catena 22: 169-199 (see Figure 5 on page 180 – “Key to Classification of Natural Rivers”).

Stream Type by Rosgen (1994)			
Valley Slope		Confinement	Reference Stream Type
< 2.0 %	Moderate – Low	Minimally Confined/Broad/ Very Broad	C / E Single Channel
< 4.0 %	High – Low	Minimally Confined/Broad/ Very Broad	D Braided Channel
2.0 < 3.0 %	Moderate – High	Minimally Confined/ Moderately Confined/ Very Confined	B Single Channel
3.0 < 4.0 %	High	Moderately Confined/ Very Confined	B Single Channel
4.0 < 6.5 %	Very High	Very Confined	A Single Channel
≥ 6.5 %	Very High	Very Confined	A Single Channel

**1.3.10.2. Channel Bed Morphology.** In addition to classifying the Rosgen stream type, the typical channel bed morphology of the reach under reference conditions can also be further defined (Montgomery and Buffington 1997). The dominant channel bed morphology under reference conditions may be assumed based on valley and reach characteristics.

Metric: Moving from left to right in the table below, use the measured channel slope, valley confinement and sinuosity to determine the reference channel bed morphology. The subsequent tables define the specific bed morphology features that comprise each type. For more background information, refer to Montgomery, D.R. and Buffington, J.M. 1997, “Channel-reach morphology in mountain drainage basins,” GSA Bulletin (109) 5:596-611.

<b>Stream Type by Channel Bed Morphology (Montgomery and Buffington 1997)</b>			
Channel Slope (%)	Valley Confinement	Sinuosity	Typical Bed Morphology
3 – 20	< 2 Very Confined	< 1.2 Low	Cascade
2 – 9	2 < 4 Moderately Confined/ Very Confined	< 1.2 Low	Step-Pool
<2 – 5	2 < 6 Moderately Confined/ Minimally Confined	< 1.2 Low	Plane Bed
<0.1 – 3	> 4 Minimally Confined/ Broad/Very Broad	1.2 – 1.5 Moderate	Pool-Riffle
<0.1	> 4 Minimally Confined/ Broad/Very Broad	1.2 > 1.5 Moderate – High	Dune-Ripple
High but variable	Very Confined	Variable Low	Bedrock
High	> 4 Minimally Confined/ Broad/Very Broad	< 1.2 Low	Braided

<b>Definitions of Stream Bed Forms (Montgomery and Buffington 1997, Rosgen, D.L. 1994)</b>	
Cascade	Plunging flow created by a short, steep drop composed of bedrock outcrop or scattered boulders or cobbles.
Step	Plunging flow created by a clearly defined, near-vertical drop composed of boulders, cobbles or large woody debris stacked evenly across the channel.
Riffle	Fast-flowing, shallow water with turbulence created by gravels, cobbles, or boulders.
Run	Fast-flowing, deep water with little turbulence.
Glide	Slow-flowing, shallow water with no turbulence.
Pool	Slow-flowing, deep water with no turbulence.

<b>Definitions of Channel Bed Morphologies (Adapted from Montgomery and Buffington 1997, Rosgen, D.L. 1994)</b>	
Cascade	Longitudinally and laterally disorganized bed materials, typically bedrock, boulders, and cobbles. Short, tightly spaced pools (<1 channel width apart) that do not fully span the channel are common. Typically very steep slopes, with highly confined valleys.
Step-Pool	Longitudinal steps formed by boulders or cobbles organized into discrete steps that span the channel and are alternated with pools, which contain smaller size sediment, spaced 1 - 4 channel widths. Typically steep slopes, low width/depth ratios, with confined valleys.
Plane Bed	Lacking discrete bed forms and may have long stretches of featureless bed. Transitional morphology from step-pool to pool-riffle reaches. Lack tumbling flow and roughness of step-pool and cascade reaches; lack converging flow patterns that produce pool-riffle-point bar morphology. Composed of sand to small boulder, but dominated by gravel and cobble in equilibrium condition. Typically moderate to high slopes, low sinuosity, low to high width/depth ratios, with confined or unconfined valleys.
Pool-Riffle	Undulating bed that defines a sequence of riffles, runs, pools, and bars. Pools spaced every 5 – 7 channel widths when self-formed. Typically low to moderate slopes, moderate sinuosity, unconfined valleys and well-established floodplain.
Dune-Ripple	Sand-dominated, undulating bed that does not form distinct pools or riffles but may form point bars induced by channel pattern. Typically low slopes and high sinuosity.
Bedrock	Bedrock-dominated bed with little sediment. Some sediment may be temporarily deposited in scour holes, or behind obstructions. Typically confined by valley.
Braided	Multiple, interconnected channels in single complex. Bed features form by dynamic erosion and deposition process. Unvegetated islands may shift position frequently during high flow events. Found on steep depositional fans and deltas. Typically steep slope (channel slope matches valley slope), high width-depth ratios, and low sinuosity.

To render the Reference Stream Type, combine the Rosgen Stream Type (Letter Code based on channel dimensions), and the Channel Bed Morphology. The Dominant Channel Bed

Morphology determines which scoring sheets are to be used in the Phase 2 Assessment. Separate Channel Integrity and Habitat Assessment sheets are provided for Step-Pool, Pool-Riffle, and Plane Bed Stream Types.

It is important to realize that stream classification systems attempt to place distinct categories on characteristics that vary across a natural continuum. Thus it is possible that the actual stream type may differ from the predicted Reference Stream Type. Final steps in the assessment will address whether such a discrepancy is due to human disturbance to the study reach or simply natural variation.

**1.4. Channel Canopy Cover:** Temperature moderation during warmer months is provided by shading from overhanging bank vegetation that limits direct insolation (i.e. sunlight) to the water surface. Small streams, headwaters or low order streams (e.g. Strahler stream order 1-4), with narrower channels are normally shaded by extensive woody and herbaceous riparian plant communities. Indeed, with lower discharges, small streams require a minimum 60 percent shading in a 100 foot buffer to avoid extreme temperature increases due to direct sunlight (University of New Hampshire 2013) <http://extension.unh.edu/Headwater-Streams>) Rivers (e.g. Strahler stream order > 4) have wider channels where bank vegetation cannot shade substantial portions of the channel. Rivers, in addition, convey greater water volumes that withstand rapid and drastic temperature fluctuations. (Note: U of New Hampshire “In larger streams, riparian buffers of 300 feet or more provide more effective wildlife travel corridors and habitat.”)

**Metric:** Determine the Strahler stream order of the study reach by enumerating all tributaries on the USGS 7.5 Minute Topographic Quadrangle. Headwaters streams with no tributaries are first order (i.e. 1). When two first order streams join, the next reach is second order (i.e. 2). The process continues, whereby stream order increases only when two reaches of the same order converge. Note that if a first order tributary joins a second order reach, the stream order does not increase. Follow all tributaries to the project reach. If the project reach is order 1 through 4, complete the following metric. Using a recent orthophoto taken during the growing season (i.e. with foliage), estimate the percent cover of the channel from overhanging bank vegetation (Google Earth or USDA NAIP imagery are typically appropriate references of growing season conditions). Ignore dams and impoundments, which will be considered in the next step.



Strahler stream order designation (Federal Interagency Stream Restoration Working Group, 1998, 1-26).

Channel Canopy Cover Impact Rating	
High	> 60% of channel is lacking canopy and exposed to direct insolation.
Low	>10 < 60% of channel is lacking canopy and exposed to direct insolation.
Insignificant	< 10% of channel is lacking canopy and exposed to direct insolation.
No Data	Data sources were not available.
Not Evaluated	Data sources have not been evaluated.

**1.5. Dams/Weirs:** Structures that span the channel and are designed to raise the water surface elevation to create water supply reservoirs, flood control impoundments, recreational ponds, industrial power supply or other uses, slow flow and induce sediment deposition, which can affect channel integrity, aquatic habitat, water quality, and water temperature. Dams typically convert riverine (lotic) habitat into pond (lentic) habitat, bury stream substrate and induce extensive changes in the biological community. Sediment retention in the impoundment can compromise channel integrity downstream, inducing degradation or widening. In addition, historic milldams (from early European colonization) have also drastically altered the landscape in some areas through long-term deposition in impoundments that created elevated floodplains which have since vegetated and may now support mature forests. Historically, when the dams breached by slow deterioration or intentional removal, streams typically responded to the drop in base level by incising into the former impounded sediments. Channels in this process may be entrenched and unstable, with degraded aquatic habitat and water quality. These channels appear to be single-threaded, meandering channels today; however, some published research has shown that prior to long-term dam influence, these channels were originally braided, wetland-dominated channels.

**Metric:** Review topographic maps and current aerials to find existing dams/weirs. In addition, access historic maps from NJDEP online ([www.state.nj.us/dep/njgs/enviroed/vermeulemaps.htm](http://www.state.nj.us/dep/njgs/enviroed/vermeulemaps.htm)) and historical aerials to identify any impoundments of former milldams.

Dam/Weir Impact Rating	
High	Dam that is obvious barrier, creates broad impoundment, has ability to control flow, or allows for water withdrawals. Or, evidence of historic dam and former impoundment through which current channel is flowing.
Moderate	Dam/weir that creates barrier to fish and other aquatic organisms. Impoundments are long (multiple channel widths) and linear with little change in channel width.
Low	Dam/weir that does not completely span the channel nor create a long impoundment but does create channel constriction and may induce localized erosion or channel instability.
None	No dam/weir.
No Data	Data sources were not available.
Not Evaluated	Data sources have not been evaluated.

**1.5.1. Impoundment Canopy Cover:** Dams reduce temperature moderation if they create impoundments broader and shallower than the original channel, regardless of stream order. During warmer months, the reduction in flow velocity and increased water surface area exposed to direct insolation combine to elevate temperatures in the impoundment that persists through downstream reaches. The elevated temperatures reduce the availability of dissolved oxygen, which leads to an impaired aquatic community.

**Metric:** Using an orthophoto taken during the growing season, estimate the percent canopy cover of the impoundment.

Impoundment Canopy Cover Impact Rating	
High	More than 20% of impoundment is exposed to direct insolation.
Low	Less than 20% but more than 10% of impoundment is exposed to direct insolation.
Insignificant	Less than 10% of impoundment is exposed to direct insolation.
No Data	Data sources were not available.
Not Evaluated	Data sources have not been evaluated.

**1.6. Bridges/Culverts:** Structures that convey streams/rivers under crossing roads, railroads, etc. Bridges and culverts (pipes, box culverts, etc.) are often inappropriately sized for the hydrology of the site. Undersized culverts back-up flows on the upstream side, causing deposition and flooding while creating intense velocities and shear stresses on the downstream side that result in scour, and bank erosion/failure. Extensive deposition on the upstream side can redirect flow and create hazardous conditions during floods. Bridges and culverts create fixed points where a channel cannot naturally adjust its dimension, pattern or profile. Many culvert crossings block large woody debris, which can then exacerbate local flooding and deplete downstream reaches of habitat structure and

organic matter. In addition, culverts often impede or prevent the movement and seasonal migration of fish and other aquatic and terrestrial organisms – effectively separating populations and blocking migration pathways. In other situations, over-widened channels created under bridges typically induce the formation of depositional bars that may degrade aquatic habitat or elevate temperatures.

**Metric:** Record the number of bridge or culvert crossings that occur in the project reach and calculate the number per mile.

Bridges / Culverts Impact Rating	
High	More than undersized 4 bridges / culverts per mile.
Low	Less than 4 undersized bridges / culverts per mile.
None	No undersized bridges / culverts.
No Data	Data sources were not available.
Not Evaluated	Data sources have not been evaluated.

**1.7. Channel Straightening:** Stream banks and channel reaches that are straightened or realigned, to accommodate adjacent agriculture, development, roads or railroads. The act of straightening a channel increases the slope, and thereby the flow velocity and the potential for bed and bank erosion. In addition, channel straightening typically disturbs or eliminates the native riparian buffer and stream substrate and may limit access to the floodplain. Bank armoring is often applied to “fix” straightened stream channels in place by attempting to compensate for the added erosional forces and disequilibrium form that has been imposed. Once straightened, channels often undergo a re-adjustment process that begins with bed incision followed by bank failure and channel widening and, if left un-maintained, eventual re-meandering. Sediment mobilized during the straightening process or the subsequent channel re-adjustment may be re-deposited in downstream reaches. Substantial aggradation in downstream reaches can disturb aquatic habitat and may lead to bank erosion and channel widening.

**Metric:** Using orthophotos and topographic maps, delineate areas that have been straightened or realigned. Note riprap banks, concrete walls or other armoring that may be visible in orthophotos.

Channel Straightening Impact Rating	
High	20% or more of reach may be straightened / realigned. Impacts are obvious: gross changes in channel characteristics such as pattern, width, substrate, and bank erosion.
Moderate	Impacts such as pattern, width, substrate type, bank erosion, pool features, and large wood distribution are local and readily apparent. Less than 20% but more than 5% of reach may be straightened/realigned.
Low	-Impacts likely affect only a small area (<1% )of channel . -Channel impacts are not readily apparent. -Channel characteristics such as pattern, width, substrate type, bank erosion, pool features, and large wood distribution are largely unchanged. Less than 5% of reach may be straightened/realigned.
No Data	Data sources were not available.
Not Evaluated	Data sources have not been evaluated.

**1.8. Channel Migration/Avulsion:** A channel moves laterally across a floodplain by eroding outer banks and depositing on the inner banks – meander bends migrate sideways and downstream over time. As a channel becomes more sinuous, meanders may migrate towards each other and cause a “neck cut-off.” Abrupt channel relocations are called “avulsions” and can result in the abandonment of the original channel and formation of an entirely new channel. Channels that bifurcate, or split, into multiple active channels are “braided.” Secondary channels that convey high flood flows are sometimes called “flood chutes.” Bank erosion and channel migration is a natural process that can be rapidly and dramatically accelerated by human disturbances to the watershed, corridor or channel. Channels that are prone to rapid migration or dramatic avulsions suggest human influence to watershed hydrology or sediment supply. In addition, flooding, debris jams, culvert constrictions, or past channel straightening can result in dramatic avulsions. Finally, loss of riparian vegetation can accelerate channel migration and create a propensity for avulsions.

**Metric:** Compare current aerials with historical aerials to identify where channels have migrated, bifurcated, or avulsed over a period of at least two decades. Track the changes in a GIS by tracing the channel alignment for each georeferenced aerial to create a time-series.

Channel Migration/Avulsion Impact Rating	
High	More than 20% of reach exhibits channel migration, braiding, avulsions.
Low	Less than 20% of reach exhibits channel migration, braiding, avulsions.
None	No occurrences of channel migration, braiding, avulsions.
No Data	Data sources were not available.
Not Evaluated	Data sources have not been evaluated.

**1.9. NJ Surface Water Quality Standards:** Obtain the NJ Surface Water Quality Standards data layer, and record the indicated water quality condition for the study reach. Water quality classifications have two components: general water quality condition: 1) Category 1 (C1) and Category 2 (C2) and 2) the known ability to support trout populations (Trout Production, Trout Maintenance, or Non-Trout).

NJ Stream Water Quality Standards Impact Rating	
High	Freshwater 2 – Non-Trout (FW2-NT) Freshwater 2 – Trout Production / Trout Maintenance (FW1-TP/TM)
Low	Freshwater 1 – Non-Trout (FW1-NT) Freshwater 1 – Trout Production / Trout Maintenance (FW1-TP/TM)
No Data	Data sources were not available.
Not Evaluated	Data sources have not been evaluated.

### **Fish Index of Biotic Integrity (FIBI)**

The Bureau of Freshwater and Biological Monitoring began implementing a Fish Index of Biotic Integrity (IBI) sampling program in 2000. The objective is to assess stream quality using the IBI.

The IBI uses the following ten biometrics: 1) total number of fish species, 2) number and identity of benthic insectivorous species, 3) number and identity of trout (nonstocked) and/or sunfish species, 4) number and identity of intolerant species, 5) proportion of individuals as white suckers, 6) proportion of individuals as generalists, 7) proportion of individuals as insectivorous cyprinids, 8) proportion of individuals as non-stocked trout or proportion of individuals as piscivores (excluding American eel), 9) number of individuals in the sample and , 10) proportion of individuals with disease or anomalies.

**Metric:** Fish IBI results from annual sampling seasons may be obtained by visiting the Bureau's webpage ([www.state.nj.us/dep/wmm/bfbm/publications.html](http://www.state.nj.us/dep/wmm/bfbm/publications.html)) or by calling the Bureau at (609) 292-0427.

Fish IBI Ratings	
45-50 Excellent	Comparable to the best situations with minimal human disturbance: all regionally expected species for the habitat and stream size, most intolerant forms are present and there is a balanced trophic structure.
37-44 Good	Species richness somewhat below expectation, especially due to the loss of some intolerant species; some species present with less than optimal abundances or size distributions; trophic structure shows some signs of stress (increasing frequency of generalists and tolerant species)
29-36 Fair	Signs of additional deterioration include fewer species, loss of most intolerant species, highly skewed trophic structure (high frequency of generalists and tolerant species); older age classes of trout and/or top carnivores may be rare.
10-28 Poor	Low species richness, dominated by generalists and tolerant species, few (if any) trout or top carnivores, individuals may show signs of disease/parasites and site may have overall low abundance of fish.

**1.10. NJPDES Surface Water Discharges:** Obtain the NJPDES Surface Water Discharges data layer. This layer contains the surface water discharge points for the active as well as in-active pipes. Identify the mapped discharge points in or near the study reach and list the facility names for each one. Multiple discharge points suggest the reach may have impaired water quality.

NJPDES Surface Water Discharges	
High	Discharges present in study reach or adjacent upstream reach.
Low	No discharges present in study reach or adjacent upstream reach.
No Data	Data sources were not available.
Not Evaluated	Data sources have not been evaluated.

**1.11. AMNET Reference Monitoring Sites:** Obtain the Ambient Biomonitoring Network (AMNET) Reference Monitoring Sites data layer. This layer contains the long-term water quality monitoring sites in minimally impacted areas that serve as good points of comparison for other sites (e.g. reference conditions). The presence of an AMNET site indicates optimal/good water quality and reach conditions. The absence of AMNET sites is not equated to an impairment; thus, this parameter is given a score rather than an impact rating.

NJ AMNET Reference Sites Score	
High	AMNET site present in study reach or adjacent reach.
None	No AMNET sites present.
No Data	Data sources were not available.
Not Evaluated	Data sources have not been evaluated.

**1.12. Section 303(d) List of Water Quality Limited Waters (NJ Integrated Water Quality Monitoring and Assessment Report):** Obtain the most recent 303(d) List or NJ Integrated List of Waters GIS data layer. For stream segments, the 303(d) list identifies: designated uses (e.g. water supply, recreation, aquatic life); attainment of those uses (i.e. fully supporting, not supporting, insufficient information); parameter / pollutant responsible for non-support (e.g. phosphorus, temperature); source of pollutant (e.g. nonpoint source, combined sewer overflows); and, whether a TMDL (Total Maximum Daily Load) has been initiated to address the impairment. This existing information is directly relevant to assessing water quality and temperature condition and, since it is typically based on long-term, measured data, should be weighted heavily in the final scoring process. In addition, with identification of the pollutants and sources of pollutants, advanced consideration can be given toward restoration efforts. If a TMDL exists, obtain a copy via an internet search. A TMDL will provide additional information about existing impairments and corrective measures.

<b>303(d) List of Water Quality Limited Waters</b>	
High	Study reach is listed as “not supporting” in the 303(d) list.
Low	Study reach is listed as “fully supporting” or “insufficient information”.
No Data	Data sources were not available.
Not Evaluated	Data sources have not been evaluated.

## 2.0 Corridor and Watershed Conditions/Modifications

**2.1. Delineate Corridor:** The previous section focused on characterizing the stream/river channel and signs of impacts. This section shifts focus beyond the channel to the encompassing stream corridor and floodplain, which can have an immediate effect on the functional values of the channel and riparian area. For this analysis, the reach corridor corresponds to the Riparian Area as defined in the Ecosystem Management Technical Report. This definition includes (i) floodprone areas as determined by NJDEP and the FEMA 100-year floodplain; (ii) hydric or alluvial soils as determined by USDA NRCS; (iii) highlands streams, rivers, lakes and wetlands that are hydrologically connected with a stream or river identified in the Highland Open Water Inventory, and; (iv) a wildlife corridor that extends 300 feet from a stream or river measured from the top of banks or, in the absence of a defined bank, measured from the stream centerline. By this definition, the corridor is a minimum of 300 feet from a stream or river and regularly extends further to envelop adjacent riparian floodprone areas, wetlands and hydric or alluvial soils.

**Metric:** Clip the Riparian Area data layer to the limits of the study reach(es) to create a Reach Corridor data layer.

**2.2. Delineate Watershed:** While the stream corridor can have immediate impacts on the channel and riparian area, the contributing watershed, or drainage area, is typically the primary determinant of hydrologic and sediment regimes and channel condition. Assessment of the watershed is intended to capture offsite impacts that are nearly impossible to discern in the field. Consideration of both the surrounding corridor and the larger watershed help to discern the scale of stressors acting on the study reach and, in later data analysis steps, help to focus restoration or protection efforts.

**Metric:** Working from the HUC 14 Watershed data layer, high resolution topography, USGS 7.5 Minute Topographic Quadrangle, and hydrology data (see Appendix A), delineate the watershed to the downstream extent of the study reach to create a new data layer and calculate area (acres).

**2.3. Geology: Bedrock/Surficial Geology:** Stream reaches that have beds and banks composed of surficial geologic materials such as gravel, sand, silt, or clay are far more erodible and sensitive to disturbance than bedrock-controlled reaches that are comparatively static. In the Highlands Region, stream valleys follow along fractured zones and faults or more erodible bedrock. Streams following fractured zones or fault lines may be more stable and resistant to human disturbance; streams in unconsolidated glacial till tend to be less resistant. Ridges are typically composed of metamorphic crystalline rock (e.g. gneiss) while valley bottoms are underlain by erodible sandstone, dolomite and shale.

*Northern Highlands/Southern Highlands:* The last glaciation deposited a terminal moraine that trends east to west across the Highlands Region. North of the moraine, glacial till outwash has heavily influenced the drainage patterns; sand and gravel deposits are common along river corridors. Beyond the extent of glaciation, the southern portion of the Highlands Region is characterized by wider valleys and richer, well-developed soils.

*Carbonate Bedrock:* Streams in areas dominated by carbonate bedrock (i.e. dolomite) may experience more groundwater exchange and hence temperature moderation and better water quality. Generally, carbonate bedrock fosters streams with high buffering capacity that can maintain fairly stable pH within ranges that are more conducive for aquatic biota. Enhanced groundwater exchange helps to absorb high flows during wet conditions and release water slowly during dry conditions which sustains stream flow during droughts, promotes more productive, abundant and diverse aquatic communities and protects channel integrity. However, extensive underlying carbonate bedrock can also draw stream flow creating “losing streams.”

**Metric:** Obtain the Bedrock Geology and Surficial Geology data layers and clip to the boundaries of the Reach Corridor and Watershed. Then compute areas (acres, percentages) of the major classes and report in tabular form. Identify areas that are dominated by carbonate bedrock or glacial till, and that are co-located with fractured zones and faults.

Geologic Conditions Interpretation	
Valley follows fault lines; shallow bedrock	Channel may be bedrock controlled and resistant to human impacts.
Valley dominated by glacial till	Channel may not be resistant to human impacts.
Valley dominated by carbonate bedrock	Channel may be relatively stable with high water quality and healthy aquatic community; however, unless “sinking stream” phenomena.
No Data	Data sources were not available.
Not Evaluated	Data sources have not been evaluated.

**2.4. Valley Slopes:** Steep slopes along a stream corridor combined with erodible surficial materials and soils can contribute high sediment loading to a stream reach. Also, steep slopes adjacent to a river channel may contribute coarse-grained and cobble-s or boulder-sized colluvium (sediment transported by gravity, i.e. downhill) to the channel; larger sediments often becomes bedload colluvium material serves to stabilize channels that as it cannot be transported by except by large flood flows serves to stabilize channels.

**Metric:** Obtain slope data layer (greater than 10% within the riparian area) and clip to reach corridor and watershed. Compute the area (acres, percentages) of slopes greater than 10% within the reach corridor and watershed.

Steep Slopes Impact Rating	
High	More than 20% of corridor/watershed has slopes steeper than 10%.
Low	Less than 20% of corridor/watershed has slopes steeper than 10%.
Insignificant	Less than 2% of corridor/watershed has slopes steeper than 10%.
No Data	Data sources were not available.
Not Evaluated	Data sources have not been evaluated.

**2.5. Soils:** Soil characteristics affect hydrologic and sediment regimes by determining rates of infiltration and runoff as well as sediment load and grain size contributed to the channel. The two characteristics pertinent to this assessment include hydrologic group and erodibility.

**Hydrologic Soil Groups** (HSG) represent runoff characteristics. High runoff potential may contribute to reduced temperature moderation and degraded water quality and aquatic habitat. Some soils are assigned two hydrologic groups. Dual grouping is used for one of two reasons. (1) Some soils have a seasonal high water table but can be drained. In this case, the first letter applies to the drained condition of the soil and second letter to the undrained condition. (2) In some soils that are less than 20 inches deep to bedrock, the first letter applies to the areas where the bedrock is cracked

and pervious and the second letter to areas where the bedrock is impervious or where the exposed bedrock makes up more than 25 percent of the surface of the soil.

**Highly Erodible Land (HEL)** is a soil erodibility factor which represents both susceptibility of soil to erosion and the rate of runoff. Extensive areas of highly erodible soil may contribute to degraded water quality, aquatic habitat, and channel integrity. The USDA NRCS used a number of equations to determine a relative index of susceptibility of bare, cultivated soil to particle detachment and transport by rainfall. This factor therefore, considers erosion caused by overland flow on unvegetated land, and is used here to make general inferences about bank erodibility.

**Metrics:** Obtain Soils data layer and clip to Reach Corridor and Watershed. Using the USDA NRCS Soil Data Viewer, identify the HSG and HEL based on the dominant condition aggregation method. Compute areas of soil type, HSG and HEL (acres, percentages) and tabulate.

Hydrologic Soil Group Definition		
A	High infiltration rate – low runoff potential.	
B	Medium / High infiltration rate.	
C	Medium / Slow infiltration rate.	
D	Slow infiltration rate – high runoff potential.	
A/D	Seasonally variable	(i) High infiltration rate with low runoff potential (ii) undrained, slow infiltration rate with high runoff potential
B/D	Seasonally variable	(i) Medium/High infiltration rate with low runoff potential (ii) undrained, slow infiltration rate with high runoff potential
C /D	Seasonally variable	(i) Medium/Slow infiltration rate with low runoff potential (ii) undrained, slow infiltration rate with high runoff potential
Not Rated	Not rated or no hydrologic group assigned.	
No Data	Data sources were not available.	
Not Evaluated	Data sources have not been evaluated.	

Soil Runoff Impact Rating	
	Hydrologic Soil Group
Very High	D, C/D
High	C, B/D
Moderate	B, A/D
Low	A
No Data	Data sources were not available.
Not Evaluated	Data sources have not been evaluated.

Soil Erodibility Impact Rating	
	Percentage of area with Highly Erodible or Potentially Highly Erodible soils.
Very High	76 – 100%
High	51 – 75%
Moderate	26 – 50%
Low	0 – 25%
No Data	Data sources were not available.
Not Evaluated	Data sources have not been evaluated.

**2.6. Land Use/Land Cover:** Land Use/Land Cover within the stream corridor is a key factor influencing functional values of the channel and riparian area. For example, agriculture may contribute excess sediment and nutrients; developed areas contribute polluted runoff and high peak flows that degrade water quality, temperature moderation, channel integrity and aquatic habitat.

**Metric:** Obtain Land Use/Land Cover data layer and clip to the Reach Corridor and Watershed. Be sure to recalculate the acreage after clipping the data layer. Compute areas of the major classes (acres, percentages) within both the Reach Corridor and Watershed. Compute impervious cover (surface) using the Impervious Surface (IS) field, which represents the percentage of imperviousness for each polygon. Thus, multiply the area of each polygon by the % imperviousness and sum the results to obtain the overall Percent Impervious Cover. (In ArcGIS, this is simply accomplished by the following functions: Add Field, Field Calculator and Field Statistics.)

Land Use/Land Cover Impact Rating	
High	> 25% of corridor / watershed is crop and / or developed.
Moderate	10 – 25% of corridor / watershed is crop and / or developed.
Low	2 – 10% of corridor / watershed is crop and / or developed.
Insignificant	< 2% of corridor / watershed is crop and / or developed.
No Data	Data sources were not available.
Not Evaluated	Data sources have not been evaluated.

Impervious Cover Impact Rating	
High	> 25% of reach corridor is impervious cover.
Moderate	10 – 25% of reach corridor is impervious cover.
Low	2 – 10% of reach corridor is impervious cover.
Insignificant	< 2% of reach corridor is impervious cover.
No Data	Data sources were not available.
Not Evaluated	Data sources have not been evaluated.

**2.7. Land Use/Land Cover Pollutant Loading:** Research (see Highlands Water Resources Technical Report, Ecosystem Management 2008,

[http://www.highlands.state.nj.us/njhighlands/master/tr\\_ecosystem\\_management.pdf](http://www.highlands.state.nj.us/njhighlands/master/tr_ecosystem_management.pdf), pg 18) has shown that land use is strongly correlated to concentrations of a variety of water quality parameters and non-point source contaminants. Pollutant loading coefficients have been developed for each major category that approximate the rate at which each category contributes to non-point source pollution. These coefficients are multiplied by the land area to model the impacts that an area has on water quality of a local receiving body. A pollutant loading analysis can provide a baseline against which proposed conditions from future development proposals can be compared. In addition, multiple tributary watersheds can be analyzed to compare the relative impacts to the study reach. Watersheds with minimal pollutant loading may be targeted for protection efforts; watersheds with relatively higher pollutant loading may be more suitable for restoration efforts. This analysis should be applied as necessary to the efforts to monitor, protect and restore the study reach(es).

**Metric:** Following the method presented in the existing NJ Special Water Resource Protection Area (NJSWRPA) document (NJDEP, July 2010 at: [http://www.njstormwater.org/pdf/Tech%20Manual%20App%20A\\_SWRPA%20FVA%20For%20Comment\\_8\\_3\\_10.pdf](http://www.njstormwater.org/pdf/Tech%20Manual%20App%20A_SWRPA%20FVA%20For%20Comment_8_3_10.pdf)), apply pollutant loading coefficients to the land cover/land use results yielded in Step 2.6 for the Reach Corridor and Watershed. Tabulate results to identify the categories that dominate pollutant loading.

**2.8. Width of Vegetated Buffer:** The width of vegetated riparian area (the “buffer”) largely determines the quality of riparian habitat and the ability to protect and maintain aquatic habitat, water quality, temperature moderation and channel integrity. A developed or disturbed riparian buffer exists only if there are structures or other impervious cover (development) or a lack of woody vegetation (disturbance), unless herbaceous-only vegetation is the natural condition as in an old field or an emergent wetland.

**Metric:** Using recent orthophotos, measure the most representative width of vegetated area along the stream bank. Measure the length of the study reach that has a undisturbed vegetated buffer less than 100 feet wide (on either side of the channel).

Width of Vegetated Buffer Impact Rating	
High	> 20% of right or left bank has an undisturbed buffer width less than 100feet.
Moderate	2 – 20% of right or left bank has an undisturbed buffer width less than 100feet.
Low	< 2% of right or left bank has an undisturbed buffer width less than 100feet.
No Data	Data sources were not available.
Not Evaluated	Data sources have not been evaluated.

**2.9. Floodplain Constrictions:** In general, roads, railroads, impervious utility structures, impervious developed areas and the hardened embankments used to protect them, limit the lateral adjustments of the stream within the corridor and confine flood flows to the channel. Such

constrictions can induce channel instability and limit important seasonal access to the floodplain for aquatic biota. In addition, floodplain constrictions affect water quality by preventing deposition of nutrients, sediment and pollutants on the floodplain.

**Metric:** Measure the linear distance of the study reach that is paralleled by infrastructure or developed areas within the stream corridor that likely occupy the floodplain.

Floodplain Constrictions Impact Rating	
High	> 20% of right or left floodplain is occupied by infrastructure.
Low	5 – 20% of right or left floodplain is occupied by infrastructure.
Insignificant	< 5% of right or left floodplain is occupied by infrastructure.
No Data	Data sources were not available.
Not Evaluated	Data sources have not been evaluated

**2.10. Riparian Wildlife Habitat – Landscape Project 3.0** The presence of habitat for threatened and endangered species within the riparian area is a primary component of the Habitat Functional Value. The Landscape Project 3.0 is a data layer, produced by the Endangered and Nongame Species Program (ENSP) of the Division of Fish and Wildlife (NJDEP), delineates potential rare species habitat within the Highlands Region (see the Landscape 3.0 rankings in the table below for the categories that encompass the term “rare”.) The data layer was developed from 2007 aerial photo-based Land Use/Land Cover (LU/LC) and represents potential rare species habitat based on known species occurrences and custom sets of LU/LC classifications for individual species. The data layer ranks patches on a scale of 0 to 5 (see table).

**Metric:** Clip the Landscape 3.0 data layer to the Riparian Corridor. Quantify (area and percent) of Riparian Corridor that contains patches of each rank. As this evaluates a positive aspect of the riparian area, this metric is not assigned an impact rating (as for all previous metrics) but rather a Wildlife Habitat Score.

Landscape 3.0 Patch Ranking	
5	1 or more occurrences of a Federally listed endangered or threatened species.
4	1 or more occurrences of a State endangered species.
3	1 or more occurrences of a State threatened species.
2	1 or more occurrences of a State special concern species.
1	Meets habitat-specific suitability requirements such as minimum size criteria for endangered, threatened or priority wildlife species but do not intersect w/ any confirmed occurrences of such species.
0	No occurrences of listed species and does not meet any habitat-specific suitability requirements for such species.

Riparian Wildlife Habitat Score	
High	Reach corridor contains Patches Rank 3 or higher.
Moderate	Reach corridor contains Patches Rank 1 or 2.
Low	Reach corridor only contains Patches Rank 1 or 0.
No Data	Data sources were not available.
Not Evaluated	Data sources have not been evaluated.

**2.11. Riparian Plant Community –Index:** The quality of riparian habitat is closely connected to the floristic quality and presence of native plant species; communities with the most abundant rare native plant species represent the most productive and diverse habitats. Floristic quality increases with the duration of time that an area has been free from clearing or other human disturbance

**Metric:** (1) If the most recent orthophoto shows the corridor contains at least 1 contiguous acre of woodlands, evaluate historical orthophotography or Google Earth) to determine whether those same areas were wooded. (2) If the recent orthophoto shows the site contains at least 1 contiguous acre of old fields , thickets or pasture, compare with historical orthophotography or Google Earth) to determine whether those same areas were old fields or pasture. (3) Review **NJ Natural Heritage Priority Sites** for presence of rare plants or ecological communities (4) Review the NJDEP List of Threatened and Endangered Species That Are Critically Dependent On Regulated Waters For Survival (2008) (see reference in Appendix A). Ratings of High and Moderate require follow-up investigation in Phase 2. As this evaluates a positive aspect of the riparian area, this metric is not assigned an impact rating (as for previous metrics) but rather a Riparian Plant Community Score.

Riparian Plant Community Score	
High	Documented habitat for threatened or endangered plant species
High	Rare plants or ecological communities identified in or directly adjacent to the stream corridor
Moderate	1 acre or more were historically wooded and are currently wooded
Moderate	1 acre or more were historically old fields or pasture and are currently old fields or pasture
Low	None of the above conditions. No further assessment is necessary.
No Data	Data sources were not available.
Not Evaluated	Data sources have not been evaluated.

**2.12. Public Uses:** The New Jersey Highlands Council seeks to maintain and expand public use of Highlands Region water resources that are compatible with natural resource conservation and maintenance of stream and riparian functional values. Using USGS topographic maps and aerial photos (i.e., Google Earth) to assess the current and potential public use of the stream and riparian area, identify any public uses or publicly accessible parks or open spaces. Second, note which uses are appropriate in the study reach and riparian area. Such uses include recreation such as

walking/hiking, swimming/wading, fishing, hunting, paddling and motor-boating. As best as possible from the information at hand, estimate which uses are *currently supported* or not supported and which additional uses have the *potential to be supported in the future* (by creation of trails, picnic areas or boat launch, for example). This information will be verified and expanded in Phase 2.

**Metric:** (1) Identify existing publicly accessible areas or open space. (2) Estimate which public uses are appropriate for the study reach and riparian area. (3) Estimate which of those public uses are currently supported or not. (4) Estimate which appropriate uses that are not currently supported could have the potential to be supported in the future.

Public Uses			
Landownership	Compatible with Public Use: (Y/N)		
	Appropriate for Reach (Y/N)	Currently Supported (Y/N)	Potential to be supported in the future (Y/N)
Walking / Hiking			
Picnicking			
Wading / Swimming			
Fishing			
Hunting			
Paddling			
Motor-boating			
Other			

Public Use Score	
High	2 or more uses are currently supported.
Moderate	1 use is currently supported.
Low	No uses currently supported. Some future opportunities exist.
None	No uses currently supported. No future opportunities exist.
No Data	Data sources were not available.
Not Evaluated	Data sources have not been evaluated.

### 3.0 Data Compilation

**3.1. Mapping:** Maps either annotated or produced throughout Phase 1 should be compiled and maintained as a record of the assessment and a mode of reviewing and presenting the information. While Impact Ratings help to call out certain impacts, mapped information may help to better discern the spatial extent and intensity of certain impacts, as well as interpret observations made in the field. Annotated Reach Maps should be developed, using USGS Topo Quads and aerial orthophotographs as basemaps, with reach limits, private properties to be avoided, reference stream type and supporting metrics, dams / weirs, bridges / culverts, straightened channel sections, and channel migration occurrences. These annotations will provide guidance in the field and support

field verification of Phase 1 Impact Ratings. Certain steps, such as 2.3 Geology, do not result in obvious findings that can be quickly evaluated with a simple Impact Rating; these factors are more open-ended and require more extensive review of broad patterns and consideration of longer time scales. Multiple Corridor/Watershed Maps should be generated to depict bedrock and surficial geology, steep slopes, soil types, land use/land cover, floodplain constrictions, riparian wildlife habitat, riparian plant community, and existing and potential public use locations. These maps will also serve as useful reference in the field and as materials for inclusion in the summary report. To maximize their utility, all maps should be formatted with a (1) descriptive but concise title, (2) north arrow, (3) scale (both graphical and rational), (4) legend identifying features and data layers, (5) date of creation, (6) author(s), and (7) detailed citations for original data sources. Both original software files and final formatted image files should be maintained for updating and revising, future reference, submitting to the NJ Highlands Council and distributing to other interested parties.

**3.2. Impact Ratings:** The compilation of the gathered information is necessary to analyze and view all data to gain a complete picture of the nature, intensity, and distribution of impairments through the reach(es) and watersheds. In addition, this information provides insight into the causes and symptoms of anticipated impairments to the study reaches. Individual Impact Ratings serve as a preliminary screening of potential stressors, helping to discriminate between trivial and significant impacts, providing context to the assessor. They also serve to identify “red flags,” helping to prepare and inform the assessors for the Phase 2 field assessment. Impact Ratings for the watershed- and corridor-scale factors that are not modified during the field assessment are used directly in the final assessment scoring sheets (Appendix C). The score from the Watershed Assessment sheet is then carried over to the related functional value assessment sheets. In-channel or buffer related parameters (bridges/culverts, dams, etc.) are followed-up in the field assessment; new information is gathered that supplants the initial Phase 1 Impact Rating. In addition to Impact Ratings, the scores associated with Riparian Wildlife Habitat, Riparian Plant Community, and Public Use should also be tabulated. These scores bring attention to potential positive attributes of the study reach. Riparian Plant Community and Public Use involve further field assessment in Phase 2.

**3.3. Quality Assurance/Quality Control:** Quality Assurance and Quality Control must be implemented to ensure integrity of raw data, generated data, preliminary assessment and final conclusions. For each step, intermediate measurements and output should be checked for logical consistency and accuracy by at least one other individual with relevant experience and familiarity with the protocols. A QA/QC log is included that identifies the original worker, date completed, confidence in raw data, the second reviewer, and the general confidence in output or conclusions. If serious flaws exist, the analysis may need to be repeated. If revision of information is necessary, the reason for the revision and the date should be added to the QA/QC log. This information should be appended to any final summary reports.

## Phase 2: Reach Assessment

Phase 2 of the FVAM utilizes information learned as well as maps from the Phase 1 to assist in the field. Observations in the field may corroborate or correct assessments made in Phase 1 from maps and other geographic data. For example, the extent of the project reach may need to be adjusted due to restricted access or evidence of flow alterations or other impacts that were not apparent in Phase 1.

Throughout the field assessment, private property must be respected when accessing or walking the project reach and riparian buffer. If private property must be crossed, permission from the landowner must be obtained. Large property owners may make valuable project partners that should be included in the assessment. Much of the following protocol is adapted or reprinted from the Vermont Stream Geomorphic Assessment Phase 2 Handbook Rapid Stream Assessment Field Protocols (VTANR, 2007) and the Vermont Agency of Natural Resources Reach Habitat Assessment Protocol (Milone & MacBroom, 2008). Permission was granted from the DEC River Management Program, the lead authoring agency. Aspects and features of other existing protocols were integrated as well. However, many important changes have been made to (i) adapt to the geology, land use and development history of the New Jersey Highlands, (ii) incorporate existing work completed and data generated by the NJ Highlands Council and other state entities, and (iii) incorporate existing proposals and concepts for the functional values proposed in the Highlands Regional Master Plan and other official documents.

Field assessments are best performed in teams of two. Partners can confer on observations and estimates, share in data recording tasks and provide a degree of safety. Field staff should be cautious of deep or fast-moving water, steep slopes and unstable terrain and avoid unnecessary risks. Field assessments should be timed to coincide with safe weather and flow conditions. In addition to the safety hazard, high flow conditions should absolutely be avoided as many characteristics become impossible to observe or measure. Data sheets to record field observations and final scoring sheets are included in Appendix B and C, respectively. For reference, an example completed scoring sheet is also included in Appendix C.

**Equipment:** clip board/notebook, data sheets, scoring sheets, digital camera, 100-meter tape, gravel template, graduated wading rod, writing utensils, and compass.

### Major Steps and Products of Phase 2:

1. Walk the entire project reach
  - a. Tally observations
  - b. Photo document
  - c. Mark field map
  - d. Sketch reach

2. Conduct cross-section survey in representative section
3. Conduct Habitat Assessment
  - a. Complete Plant Stewardship Index (PSI) Procedure in Riparian Buffer
  - b. Assess In-Stream Habitat
4. Score Functional Values
  - a. Channel Integrity
  - b. Habitat
  - c. Water Quality
  - d. Temperature Moderation
  - e. Public Use
5. Synthesize Data and Summarize Findings

## Instructions

**Prepare Field Data Sheet and Reach Map(s):** Basic information (from Phase 1, Step 1.1) about the study reach should be recorded on the field sheet, including: Stream Name, Reach ID, Endpoint Locations, Endpoint Coordinates, NHD Reach Code, HUC 14, and Town / County. Several reach metrics should also be included: reach length and slope (Phase 1, Step 1.3), and watershed area (Phase 1, Step 2.2). If adjustments of the reach limits have to be made to accommodate for on-the-ground conditions, this information should be updated and recorded here. Also, identify the names of the field assessors and note current weather conditions (temperature and precipitation), current flow conditions (low, base, average – check USGS gages), recent precipitation (within 7 days), and recent flood events (check USGS gages, note recurrence interval if known). Annotated Reach Maps (from Phase 1, Step 3.1) should also be utilized in this Phase for verifying Phase 1 findings and labeling the range of features and conditions described below.

**Walk, Measure, Record and Photo-document:** Walk the reach entirely making observations of the channel, banks and riparian area. For each distinct point feature or characteristic, tally the number of occurrences on the field map and make brief measurements and observations. For linear characteristics, like channel width or buffer width, note the dominant or most representative condition and note when a persistent change occurs. Representative conditions and significant point features should be annotated on the reach map and photo-documented. Pronounced, persistent changes in channel condition may warrant dividing the study reach into separate sub-reaches. Measurements can be made with a meter tape and graduated rod; when necessary, measurements can be visually estimated. Most measurements and estimates can be made to the nearest foot or half foot. For each photograph, quickly note the photo number (in sequence to allow for easier recollection and labeling later), the general subject, the direction (upstream/downstream and right bank/left bank, etc.) in the photo log and note the photo number on the Reach Map. Use the following sections (4-11) to complete the field assessment sheets. Blank field assessment sheets are located in Appendix A.

## 4.0 Channel Modifiers

**4.1. Dams/Weirs:** Verify the man-made dams and weirs that were identified in Phase 1, Step 1.6 and identify any additional man-made dams/weirs. Dams/weirs are man-made structures that span the channel and raise the upstream water surface, creating a pond which in turn, affects the elevation of the streambed. Generally, dams are higher structures that create falling water over the spillway. Weirs are lower structures that are mostly submerged. Utility crossings like sewer pipelines that are installed below streambeds sometimes become exposed and also create barriers like weirs or small dams. Dams/weirs that create vertically plunging water higher than 1 foot across the channel are likely barriers to the movement and migration of aquatic organisms. As described in Phase 1, historical dams that no longer exist on-site may have left significant impacts on the channel and floodplain. When the dam is breached by slow deterioration or intentional removal, streams typically incised into the former impounded sediments and may still be entrenched and unstable. Structural remnants of historical dams may be foundations in the channel bed, abutments on the banks, or earthen berms across floodplains.

**Metric:** Record the location of dams/weirs and other man-made barriers (e.g. utility pipes) on the reach map. Carefully measure or estimate the change in water surface elevation (i.e. height of water at the top of the structure to the water on the downstream side), length and width of the impoundment, and the representative width of the channel downstream of the dam. Note if sediments are filled close to the top of the dam and if the sediments are fine (i.e. sand, silt, clay) or coarse (i.e. gravel, cobble). Indicate if the dam is serving as an active water withdrawal. Note if remnants of historic dams are evident.

**4.2. Beaver Dams:** As keystone species, beavers can dramatically transform low gradient streams and small rivers into ponds and freshwater wetlands. Beaver dams are composed of an orderly pile of branches and mud that spans the channel, thereby raising the water surface elevation. Typically, beaver-chewed branches have been chewed off at an angle and show tooth marks. These slackwater habitats interspersed along the river continuum amplify the biological diversity and abundance sustained by the stream system.

Beaver dams do not typically block movement or migration of aquatic organisms over the long-term because organisms are capable of finding paths through and around the woody debris structures, and occasional breaches



Beaver dam, field identified by an abundance of branches cleanly cut at an angle with tooth markings (Princeton Hydro, LLC).

during high flows creating periodic opportunities for passage. After being extirpated from the region, the ecological value of beavers was justification for programs to regulate hunting/trapping and to reintroduce beavers to their former range. With the success of these programs, beaver populations have rebounded in the Eastern U.S., leading to conflicts in densely developed areas. Ecological value notwithstanding, the cycle of sediment trapping and release following dam blowouts creates a dynamic system that increase the natural instability and sensitivity of a reach. When beaver dams breach, the stream will incise into the earthen dam and the impounded sediments, creating a dynamic channel degradation process. It is important to note the presence of beaver dams because they do have the potential to cause channel instabilities, water quality impairment and elevated temperatures; however, such impacts should be weighed against the habitat value and should consider their natural place in the stream system. Channel instability caused primarily by beaver dams will not be scored negatively in the geomorphic assessment.

**Metric:** Record the number of beaver dams in the reach, including intact and partially intact, which may be abandoned. Estimate the length of the study reach impounded or affected by the dam. Note if the beaver impoundment is causing deposition in the channel and diverting flow out of the main channel. If the beaver dam is partially intact (i.e. breached), note if the channel is cutting through the dam and into impounded sediments.

**4.3. Bridges/Culverts:** Bridges and culverts, as described in Phase 1, are structures built to allow roads, railroads, paths or other linear features to cross over rivers and streams. Generally speaking, bridges have foundations on either side of the channel and do not have bottoms; culverts are enclosed pipes or concrete boxes. Bridges and culverts are a potential cause of instability if they constrict the floodplain such that the bridge/culvert crossing and approach is higher than the surrounding floodplain and prevent movement of floodwaters. However, bridges and culverts are a likely cause of instability if they constrict the floodplain and channel (i.e. the bridge/culvert crossing is less than Bankfull Width). Undersized bridges and culverts back up flows on the upstream side, causing deposition and flooding while creating intense velocities and shear stresses on the downstream side that result in scour, and bank erosion/failure.

Extensive deposition and large woody debris jams on the upstream side can redirect flow and exacerbate flooding. In addition, bridges and culverts often impede or prevent the movement and seasonal migration of fish and other aquatic and terrestrial organisms by reducing water depths and increasing velocities and vertical drops. For example, a bridge or culvert that constricts the channel may create high velocities that organisms cannot swim against. Bridges and culverts that create shallow flow (e.g. less than 0.5 FT) can also impede some fish. Culverts that are perched (i.e. elevated so as to create a vertical water drop at the downstream end) are a more severe barrier to the movement of terrestrial and aquatic organisms. Bridges are typically built with foundations buried below the channel bottom and culverts are typically installed flush to the channel bottom. Exposed bridge foundations and culverts perched above the channel are signs of localized scour and, if extensive, may indicate reach-wide channel degradation.

**Metric:** Confirm the number and location of bridges and culverts identified in Phase 1 and record the number and location of any additional bridges and culverts. For each bridge /culvert: (1) On the upstream side, note signs of flow constriction like sediment deposition and debris accumulation or signs of scour on the banks or around the structure. (2) On the downstream side, note signs of scour of the bed and banks or, further downstream, mid-channel sediment deposition. (3) Note if bridge foundations are exposed or culverts are perched; alternatively, note if bridge/culvert openings are buried in or partially blocked by sediment. (4) To assess channel constriction, compare the width of the crossing through the bridge/culvert with the representative Bankfull Width (described below) of the channel upstream or downstream. (5) To assess floodplain encroachment of the bridge/culvert crossing, measure the Bankfull Maximum Depth and Floodplain Encroachment Height and compute the Floodplain Encroachment Ratio (described in 5.10).

**4.4. Stormwater Inputs:** Increased stormwater runoff is a significant stressor of Highlands streams. As a watershed is developed, more stormwater is prevented from infiltrating into the ground and is intercepted by impervious surfaces (e.g. roads, rooftops), and conveyed to the nearest stream. Stormwater enters the channel primarily through stormwater pipes, agricultural ditches, road ditches, and roof leaders. High rates and volumes of stormwater runoff can cause severe erosion to the bed and banks, initiating channel degradation or widening (described in sections below) and impairing in-stream habitat and aquatic communities. Stormwater outfalls are typically installed even with the banks and flush to the stream bottom. Multiple stormwater outfalls extending into the channel suggest that banks have eroded back. Likewise, multiple outfalls perched above the channel suggest that the streambed has eroded and the channel has become incised.

**Metric:** Record the number and type of stormwater outfalls and mark the location on the field map. Perennial or ephemeral tributaries should not be counted here. For stormwater culverts, also indicate the pipe diameter (6", 12", 18", 24", 36" etc.). Also indicate if the outfall is extending out from the banks or is perched above the channel bed.

## 5.0 Channel Dimensions

Streams in different physical settings have predictable flow and sediment discharge patterns determined by the climatic, geographic, and geologic characteristics of the valley in which they occur. Different physical settings result in various fluvial processes and stream types, which are identified by their channel form and sediment transport characteristics. This step involves measuring the dimensions of the channel and its sediments in order to identify the stream type and to determine whether the existing stream type of the present channel is consistent with its setting. For example, a relatively straight channel with little or no access to a floodplain during annual high water is not typically found in an unconfined valley where gravel is the dominant sediment size in the stream bed and banks. This landscape setting would commonly support a meandering, low gradient

channel with floodplain access. Finding such an inconsistency at the observed site may explain observed channel adjustments and reach condition.

***Where to Measure Channel Dimensions:*** Measurements of the following channel dimensions are conducted (i) where channel conditions reflect the dominant condition of the study reach (i.e. representative sections) and (ii) where the thalweg (the deepest part of the channel where velocities are greatest and majority of flow is concentrated) is in the center of the channel or “crossing-over” from the right to the left side of the channel. Avoid meander bends. Riffles are usually located at cross-over locations – in some cases the thalweg may be undefined when the riffle is at an even elevation across the channel. In steep gradient streams that run relatively straight, the main flow of the channel does not usually move from side to side across the channel, but rather cascades over cobble and boulder steps (i.e. Step-Pool stream type) or runs straight over a uniform channel bottom (i.e. Plane-Bed stream type). In these stream types, channel dimensions should be measured at these cascades, steps, or uniform runs. In a very low gradient stream where distinct riffles may not form, cross-over locations may resemble shallow runs. Channel measurements should not be taken at pools where the channel width and maximum depth are exaggerated. Indicate on the Reach Map where the channel dimensions are taken.

***Bankfull:*** During a period of relatively stable climate and watershed land cover, streams and rivers have the opportunity to reach equilibrium between the flow of water and sediment resulting in stable channel dimensions. This flow is assumed to (i) have sufficient sediment transport capacity and (ii) occur at a sufficient frequency to perform the greatest work in maintaining channel dimensions; for this reason it is called the channel-forming flow and is approximated in the field by bankfull indicators. At equilibrium, bankfull, as the name implies, is the water level (or “stage”) at which a stream or river is at the top of its banks and any further rise would lead to water moving out onto the active floodplain. The bankfull flow occurs approximately every 1.5 – 2 years. However, due to human changes in watershed land use and the consequent changes in watershed hydrology, the channel-forming flow has changed and caused changes in channel dimensions often by channel incision. In this common situation, the former bankfull flow maybe at a stage below the tops of banks and, therefore can be more difficult to determine. As incision continues, a new active floodplain typically begins to form at a lower elevation than the original floodplain, which may now become an abandoned floodplain terrace. Bankfull indicators include defined levels of erosion on banks, defined changes in bank slopes, exposed roots of woody vegetation on stable banks, and the elevation at the tops of point bars. Collectively these indicators should occur at a consistent elevation above the water surface. Stream stage, or water surface elevation, is not an indicator of bankfull because it fluctuates greatly. Avoid assessing bankfull indicators near flow obstructions like debris jams or bridge abutments, which may back up flow and locally misrepresent bankfull elevation. Also avoid assessing bankfull indicators at actively eroding and undercut banks or where the channel has bifurcated around permanent islands (e.g. with woody vegetation). To perform the following five measurements, extend a meter tape taut across the channel at a representative cross-

section, perpendicular to bankfull flow. Set the meter tape in place with pins or stakes and use a graduated rod as described below.

**5.1. Bankfull Width:** The bankfull width is a measure of the width of the stream when it is carrying the channel-forming flows. These are the flows that occur on a regular (annual or semi-annual) basis and maintain the channel shape. Bankfull width is function of flood frequency, sediment regime, and the bed and bank materials of the channel (Rosgen, D.L. 1994). Changes in any of these factors may result in a change in width, which in turn changes the hydraulics of the channel and may lead directly to vertical channel adjustments (aggradation or degradation).

**Metric:** Measure across the channel, perpendicular to the direction of bankfull flow, from the point of bankfull elevation on one bank to the point of bankfull elevation on the opposing bank. Be sure the meter tape is level across the channel. Record the width to the nearest foot. If a floodplain terrace is apparent, measure or estimate the distance and elevation from both banks. Compare this width to the channel width measured in Phase 1, Step 1.3.7.

**5.2. Bankfull Maximum Depth:** Bankfull maximum depth is a measure of the deepest part of the channel, or thalweg. In riffle/pool streams the thalweg typically shifts from the outside of the meander bend to the outside of the next meander, crossing over the channel at a riffle. During low flow periods, such as the late summer and mid-winter periods, many aquatic organisms move to the deepest part of the channel, as this area continues to hold water as flows decrease. In channels that have a well-defined, deep thalweg, aquatic organisms have a better chance of surviving the low-flow periods in comparison with widened channels with flat bottoms that become very shallow.

**Metric:** At the same cross-section, measure the depth from the elevation of the bankfull flow to the deepest point in the channel. Record the measurement to the nearest tenth of a foot; do not measure water depth.

**5.3. Bankfull Mean Depth:** The mean bankfull depth varies between bed features like pools and riffles. For this reason, the mean depth of riffles, or steps, (which are depositional features in bankfull flows) are measured to analyze the hydraulics of “transport limited” areas within the stream profile. Standardizing the measurement to one type of bed feature enables comparison among streams. The forces necessary to transport sediment is largely a function of mean bankfull depth, channel slope, and channel roughness. Changes in the mean bankfull depth may lead directly to an increase in deposition or scour of sediment and the adjustments associated with channel evolution.

**Metric:** From the meter tape still stretched across the channel, measure bankfull depth at evenly spaced intervals. Average the measurements to determine mean depth. Also record the depths at both edges of water.

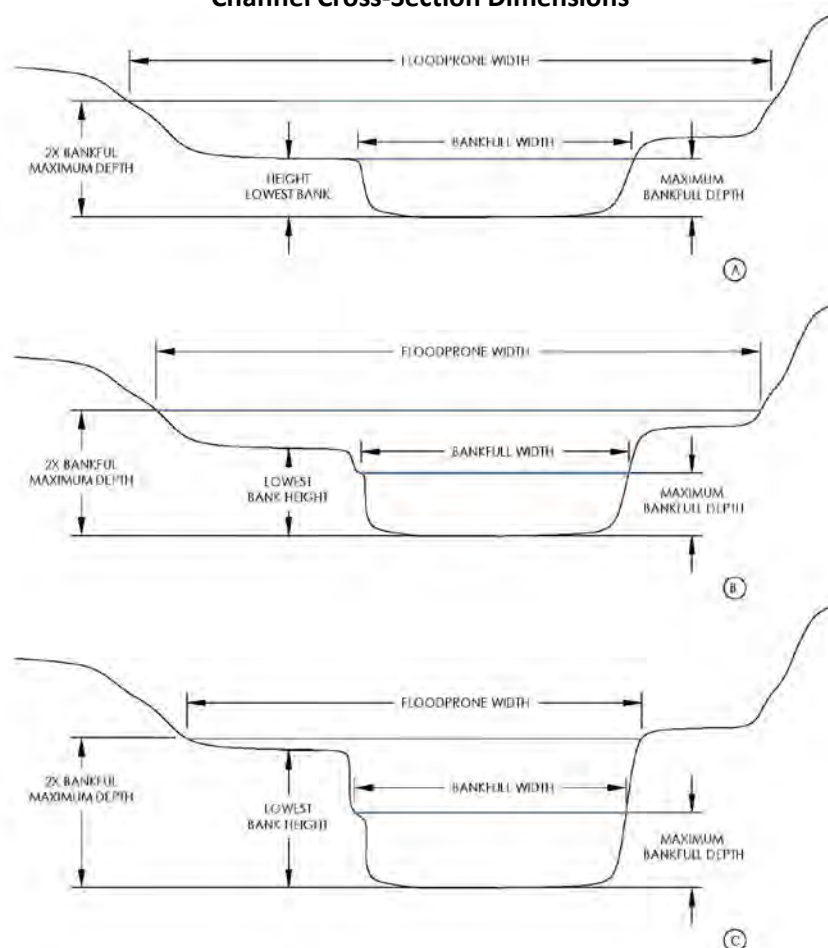
**5.4. Lowest Bank Height:** In channels that have incised into their beds, the Lowest Bank Height will be greater than the Bankfull Maximum Depth. The magnitude of this difference is a measure of the degree of vertical incision that has resulted in the lateral containment of higher flows that had previously accessed the floodplain. A large difference between Lowest Bank Height and Bankfull Maximum Depth suggests that the tops of banks have become abandoned floodplains. Where the stream has not incised, there will be no difference in elevation between the tops of banks and the bankfull indicators. Lowest Bank Height is used to calculate this effect in the Bank Height Ratio below.

**Metric:** As above at the same cross-section, measure the depth from the elevation of the top of the lowest bank to the deepest point in the channel (i.e. thalweg). Record the measurement to the nearest tenth of a foot.

**5.5. Floodprone Width:** The floodplain is the area outside of the channel that is prone to inundation when flows exceed the elevation of the tops of banks. The floodprone area is the portion of the floodplain that is measured at an elevation that is 2x Bankfull Maximum Depth and corresponds to the width of the stream or river at flood flows. The floodprone width is used to calculate an entrenchment ratio (Phase 1, Step 2.8), which helps to describe the vertical containment of the channel.

**Metric:** With the graduated rod at the deepest part of the channel on the same cross-section, measure the width of the floodplain at 2x Bankfull Maximum Depth. If the floodplain is too wide or too densely vegetated to measure with a meter tape, estimate by eye or measure on the Reach Map.

### Channel Cross-Section Dimensions



(A) Channel with no incision and low entrenchment. (B) Channel with some incision but little entrenchment. (C) Channel that is incised and entrenched. Princeton Hydro, LLC.

**5.6. Floodplain Encroachment Height:** Floodplain encroachments like railroads, roads, canals, paths, utilities, and other developments can further reduce the area that a stream can inundate during flood events and become a significant cause of channel impairments. For this reason, human Floodplain Encroachment Height is measured and used to calculate a value (below) for all human-induced encroachments that are within the natural valley walls and are blocking access to the floodplain by lying parallel to the stream. Floodplain encroachments at short sections of the study reach may cause only localized channel instability; however, floodplain encroachment that runs parallel to the reach may induce reach-wide channel instability.

**Metric:** With the graduated rod at the location of Bankfull Maximum Depth, measure the height of the floodplain encroachment (height of roadway, railroad, etc.). If the heights vary widely from right to left sides, measure the lower surface. Use the meter tape if feasible to increase accuracy. If there are multiple separate floodplain encroachments along the study reach (i.e. Bridges/Culverts), repeat this measurement and estimate the length of the reach that the floodplain encroachment extends.

**5.7. Width-Depth Ratio:** The width-depth ratio describes a channel relationship that allows for comparison among channels of any size. The width-depth ratio is a key factor to understanding the distribution of available energy within the channel, and the ability of various discharges occurring within the channel to move sediment (Rosgen, D.L. 1994). For aggrading and widening streams, this ratio is used to describe the magnitude of adjustment. For example, a pool-riffle stream in reference condition may have a width-depth ratio of 18, but a disturbed over-widened stream may have a width-depth ratio of 80. This ratio helps to indicate “departure” from the reference stream type.

**Metric:** Divide the bankfull width by the bankfull mean depth.

Width-Depth Ratio	
< 10	Low – E Channels
< 12	Low – A/B Channels
< 20	Low – C/B Channels
>10 < 12	Low/Moderate – E Channels
>12 < 20	Low/Moderate – A/B Channels
>20 < 30	Low/Moderate – C/B Channels
>12 < 20	Moderate/High – E Channels
>20 < 30	Moderate/High – A/B Channels
>30 < 40	Moderate/High – C/B Channels
> 20	High – E Channels
> 30	High – A/B Channels
> 40	High – C/B Channels

**5.8. Entrenchment Ratio:** Entrenchment is a measure of channel incision and how connected (or disconnected) a stream is to its floodplain. The floodplain provides a pressure release valve for a stream, helping to dissipate erosive forces. During floods, water over-tops the channel banks and spreads out across the floodplain where the flow becomes shallower and slower, and as a result, the potential for scour and erosion-related damage in and adjacent to the channel is reduced. Without access to a floodplain, flood flows are constrained within the channel, which can cause extensive bed and bank erosion depending on the channel substrate and bank materials. Streams are categorized into types based partially on their degree of entrenchment. Highly entrenched streams do not spill out onto the floodplain during high flows, such that high flows are contained entirely within the stream channel. Moderately entrenched streams access the floodplain only during larger flood events. Minimally entrenched streams access their floodplains as soon as flow exceeds the bankfull stage.

**Metric:** Divide the floodprone width by bankfull width. See table for interpretation.

Entrenchment Ratio	
1.0 < 1.2	Highly Entrenched
>1.2 < 1.4	
>1.4 < 2.0	Moderately Entrenched
>2.0 < 2.2	
> 2.2	Minimally Entrenched

**5.9. Bank Height Ratio:** The Bank Height Ratio is a measure of channel incision using vertical dimensions, and, like entrenchment, is another index of how connected a stream is to its floodplain. Bank Height Ratios are a more sensitive measurement of channel degradation than the Entrenchment Ratio, enabling the identification of degradation in its early stages. Streams with wide floodplains have to incise significantly and contain flood flows approaching the 50-year flood before the Entrenchment Ratio value changes substantially. The magnitude of the Bank Height Ratio indicates the degree of vertical channel incision that has resulted in the lateral containment of higher flows that had previously accessed the floodplain. A high Bank Height Ratio suggests that the tops of banks have become abandoned floodplains.

**Metric:** Divide the lowest bank height by the bankfull maximum depth.

Bank Height Ratio	
1.0 < 1.1	No Incision, Stable
>1.1 < 1.3	Minor Incision, Potentially Unstable
>1.3 < 1.5	Moderate Incision, Moderately Unstable
> 1.5	High Incision, Highly Unstable

**5.10. Floodplain Encroachment Ratio:** In addition to the Entrenchment Ratio and Bank Height Ratio, Floodplain Encroachment Ratio is an index used to quantify the magnitude of encroachment on the floodplain caused by direct human activity such as development or filling. The magnitude of the Floodplain Encroachment Ratio indicates the degree of human fill or development on the floodplain that has resulted in the lateral containment of higher flows within the channel that previously had accessed the floodplain. While the Bank Height Ratio measures disconnection from the floodplain caused by channel incision, the Floodplain Encroachment Ratio measures the disconnection caused by human activities on the floodplain itself. A high Floodplain Encroachment Ratio indicates that the channel no longer has access to a floodplain and may be the cause of channel instability or habitat impairment.

**Metric:** Divide the floodplain encroachment height by the bankfull maximum depth.

Floodplain Encroachment Ratio	
1.0 < 1.2	No Floodplain Encroachment, Not Incised
>1.2 < 1.4	Minor Encroachment, Potentially Unstable
>1.4 < 2.0	Moderate Encroachment, Moderately Unstable
> 2.0	High Encroachment, Highly Unstable

**5.11. Sinuosity:** Sinuosity, or the degree of channel meandering, was computed in Phase 1 from aerial photos or maps and is not easy to measure in the field without extended survey of the channel. Therefore, confirm that the general channel pattern reflects the pattern that was measured in Phase 1. Otherwise, note any significant changes.

**5.12. Existing Stream Type:** With the above measurements and visual observations of the study reach, the existing stream type is determined. The Existing Stream determined in this step will be compared with the Reference Stream Type determined in Phase 1. A departure from the Reference Stream Type determined in Phase 1 and the Existing Stream Type indicates impaired conditions and will be addressed in Channel Integrity Assessment.

**5.12.1. Rosgen Stream Type:** The Existing Rosgen Stream Type is determined from four metrics, two of which were gathered in preceding Phase 2 steps. In order of priority they are Entrenchment Ratio, Width-Depth Ratio, Sinuosity (Phase 1) and Slope (Phase 1). Refer to the table below; move from left to right to determine letter code. Note: Slope, as obtained in Phase 1, is secondary determinant of Stream Type and as such, may not always occur within the range for the Stream Type denoted by the other parameters. In this case, an asterisk may be added to the letter code. For further description of Rosgen stream types refer to Rosgen, D.L. 1994.

Entrenchment Ratio (+/- 0.2)	Width-Depth Ratio (+/- 2)	Sinuosity (+/- 0.2)	Slope (%)	Rosgen Stream Type Letter Code
< 1.4 Highly Entrenched	< 12 Low	< 1.2 Low	4 – 10	A Single Channel
<1.4 Highly Entrenched	< 12 Low	> 1.2 Low/Moderate	2 – 4	G Single Channel
< 1.4 Highly Entrenched	> 12 Moderate/High	> 1.2 Low/Moderate	< 2	F Single Channel
1.4 – 2.2 Moderately Entrenched	> 12 Moderate	> 1.2 Low/Moderate	2 – 4	B Single Channel
> 2.2 Minimally Entrenched	< 12 Very Low	> 1.5 Very High	< 2	E Single Channel
> 2.2 Minimally Entrenched	> 12 Moderate/High	> 1.2 Moderate	< 2	C Single Channel
> 2.2 Not Entrenched	> 40 Very High	< 1.2 Low	< 4	D Braided Channels

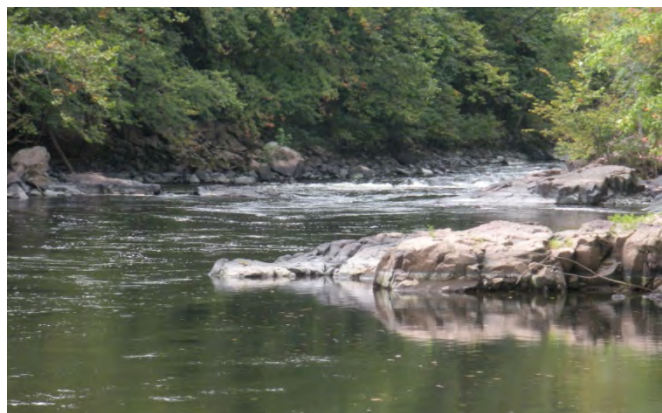
**5.12.2. Dominant Particle Size Class:** The Dominant Particle Size Class is the most common size class of particles present in the reach. The general size classification (see table), can be determined by visual observation. Note that visual observation tends to be biased toward larger particle size. Refer to the table to determine the stream type number code as per the Rosgen classification system. Attach this number to the Phase 1 Reference Stream Type to complete the classification.

General Size Class	Relative Size	Rosgen Stream Type Number Code
Bedrock	Bigger than a compact car	1
Boulder	Basketball to compact car	2
Cobble	Tennis ball to basketball	3
Gravel	Pepper corn to Tennis ball	4
Sand	Smaller than a pepper corn	5
Silt/Clay	Non-gritty, Smeared	6

If however, there is a serious question as to which size class is dominant (i.e. coarse sand vs. small gravel, or coarse gravel vs. small cobble) then a reach-averaged pebble count as per Bunte and Abt (2001) is necessary.

**5.12.3. Channel Bed Morphology:** Under normal flows (i.e. baseflow, or average flows below bankfull), bed forms have typical flow characteristics that are readily identified in the field (see Table) and are used to differentiate stream types and to assess stream condition. This determination should not be attempted in high flows because higher flows create different flow conditions that disguise some forms.

**Metric:** Referring to the Tables in Phase 1, identify the Dominant Channel Bed Morphology (as per Montgomery and Buffington 1997) observed in the study reach. If the channel exhibits more than one bed form, indicate the sub-dominant bed form also. Combine the Rosgen Stream Type (Letter Code based on channel dimensions, Number Code based on Dominant Particle Size Class) and the Dominant Channel Bed Morphology Category to render the complete Existing Stream Type. For example, common stream types are (i) a steep channel with bedrock waterfalls is a A1 cascade channel, (ii) a steep channel with boulders and cobbles is a B2 Step-Pool, and (iii) a lower gradient, gravel-bedded, meandering stream is typically a C4 Pool-Riffle. If the Existing Stream Type identified in this step does not



Bedrock outcrop that constricts flow and controls streambed grade. Princeton Hydro, LLC.

match the Reference Stream Type determined in Phase 1, this indicates a departure from reference conditions that may be due to natural variability or human disturbance.

## 6.0 Channel Features/Condition

**6.1. *Bedrock Grade Controls:*** Bedrock outcrops that span the channel bottom serve as nearly permanent grade controls on the vertical position of the channel and the slope of the reach (i.e. the grade). Waterfalls are dramatic examples, whereas some reaches of river may be underlain by bedrock throughout.

**Metric:** Record the number of individual bedrock outcrops that span the channel and/or create pronounced drops in stream bed elevation. For pronounced drops, measure the height of the grade control. If bedrock underlays a reach of channel, record the length of bedrock observed. Mark the location of these features on the field map.

**6.2. *Head-cuts:*** A head-cut is a short, steep-sloped face in erodible channel substrate that is indicative of streambed erosion and channel incision. The steep-sloped face, also called a nickpoint, is inherently unstable; water flowing over the head-cut has greater velocity and erosive force, eroding the stream substrate at that steep face. With continued erosion, the head-cut moves upstream until it encounters a resistant substrate (e.g. compact cobble, boulder, or bedrock grade control) or the head-cut flattens out as the channel attains a lower equilibrium slope whereby the erosion



Headcut in channel that is actively incising. Note leaning trees. Princeton Hydro, LLC.

is balanced by the incoming flow of water and sediment. The upstream movement of a head-cut can lead to extensive bank erosion and failure, undermining of bridges/culverts, exposure of formerly buried infrastructure, and degradation of in-stream habitat features such as pools and riffles and long-term impairment of stream habitat. Head-cuts can also move up tributaries of the reach and may be observed near confluences.

**Metric:** Record the number and location of head-cuts observed in the channel and in adjacent tributaries. Note any additional exposed structures that may be signs of channel incision.

**6.3. *Riffle or Step Condition:*** The condition of riffles and steps may indicate changes in erosion and depositional processes within the channel. For example, riffles that are complete, clearly formed and perpendicular or only slightly angled across the channel indicate that the channel is

neither aggrading nor degrading. However, meandering streams in unconfined floodplains with riffles that are either partial or non-existent, possibly forming extended runs, may be in the process of degradation. Conversely, streams with continuous riffles sharply angled to the banks may be in the process of aggradation.

**Metric:** Note if riffles or steps are (1) distinctly formed and delineated by pools (well/moderately/poorly formed or absent); (2) completely or partially spanning the channel (complete/incomplete); and, (3) compact or loosely arranged and erodible (stable or unstable). Refer to the following table.

Riffle/Step Condition	
Complete	Riffles/steps completely span the channel and are perpendicular or slightly angled to the channel banks.
Incomplete (Degradation)	Riffles/steps do not completely span the channel and appear to be washed out, creating extended runs.
Extended (Aggradation)	Riffles/steps are steep and span the channel at sharp angles to the banks and may be extended or continuous.

**6.4. Pool Condition:** Pools are the deepest locations in a stream and they provide important habitat for aquatic organisms particularly during times of stress like winter and summer. At normal flows (i.e. below bankfull) pools have flat water slopes and are often located on the outside of meander bends, downstream of constrictions or features that cause plunging flow.

**Metric:** (1) Record the number of pools along the entire reach and indicate whether they are less than or greater than 2 foot deep and less than or greater than half the bankfull width. At low flows, pool depth can be measured as the depth of water. At higher flows however, measure the depth of water in the pool and subtract the depth of water over the downstream riffle to obtain the pool depth. (2) Note if pools are filled with sediment finer than the dominant particle size. (3) Note also the presence or absence of cover over the pool in the form of overhanging banks, overhanging bank vegetation, vegetative material (CPOM, LWD, debris jams), submerged aquatic vegetation, etc.



Point bar composed of gravel and sand. Princeton Hydro, LLC.

**6.5. Sediment Bars:** As sediment moves through a channel, it deposits

temporarily in defined locations, which is known as sediment storage. The sorting and distribution of sediment in bars provides crucial habitat for numerous benthic aquatic invertebrates as well as fish spawning beds. When upstream sediment supply has been increased beyond the natural range of variability, sediment accumulation may become excessive, raising the elevation of the stream bed and inducing channel instability.

Sediment bars take multiple forms. Point bars are connected to the bank at the inside of meanders. Point bars are either devoid of vegetation or have only sparse herbaceous vegetation covering less than 25% of the bar surface. Equally-sized, alternating point bars in a pool-riffle stream suggest the channel is in equilibrium. Unequal alternating point bars and bars with steep faces may indicate channel adjustment. Lateral bars extend longitudinally along the banks and are usually located in straight reaches or stream types with low sinuosity.

Lateral bars are either devoid of vegetation or have only sparse herbaceous vegetation covering less than 25% of the bar surface. Diagonal bars are aligned diagonally to the channel and usually form upstream of meanders that have been armored. Diagonal bars tend to direct flow toward the banks causing erosion. Deltas form where a tributary enters a mainstem river and deposits sediment. The sediment size and volume in a delta is indicative of the sediment load of the tributary. Steep slope tributaries are important sources of coarse sediment in larger streams and rivers. Mid-channel bars are not connected to the banks and usually occur in straight reaches; they often form downstream of obstructions that diverge flow such as boulders, bedrock outcrops or large woody debris. A lack of vegetation suggests a bar has recently formed and/or is actively adjusting. If the bar is stable, not rapidly eroding or depositing, and is above normal high water, it may support perennial vegetation and become an island. Islands are surrounded by flow during most flow conditions, and are not the same as land with flood chutes or high flow channels that only receive flow during high flow events. Multiple sediment bars that have different composition than the surrounding channel substrate may be signs of a sediment pulse moving through the reach, or the sign of a change in sediment regime and channel aggradation. For example, extensive deposits of silt in a gravel-bed stream, or sand in a cobble-boulder stream may indicate such a change. Sediment bars with steep faces on the downstream ends may be signs of streambed erosion and channel incision.



Mid-channel gravel bar bifurcating flow. Princeton Hydro, LLC.

**Metric:** Record the number of each kind of sediment bar observed in the project reach. Note if sediment bars differ markedly in composition from the surrounding channel (i.e. sand bars in a cobble dominated reach), are greater than bankfull height and are longer than a bankfull channel width, which may indicate channel aggradation. Also note if sediment bars have steep, downstream faces, indicating channel incision.

Sediment Bars	
Point	Inside meanders, unvegetated
Lateral	Channel margins, straight reaches, unvegetated
Diagonal	Sharply angled to banks
Mid-Channel	In middle of channel, splitting flow
Islands	Stable, mid-channel formation, vegetated
Deltas	At confluences, sometimes fan-shaped

**6.6. Bed Substrate Composition:** Bed substrate composition represents the particle size distribution of bed sediments and the presence of fine sediments (silt or clay). These factors are a significant influence on channel integrity and aquatic habitat, in addition to the non-living organic matter that occurs on the bed including large woody debris, debris jams and coarse particulate organic matter (i.e. leaves, branches, etc.). Measurements of the bed material are conducted to help characterize the stream's ability to carry the different size sediments. The size of sediment found in the bed and bars of the stream reflects the depth and slope of the bankfull flow and is influenced by the position in the watershed. In the upper reaches of a watershed the bed materials tend to be coarser cobbles and boulders, because steep and narrow streams can easily transport the smaller materials. Further downstream in the watershed the bed material generally becomes finer (gravel, sand and silt) where low slopes and wide channels allow sediments to settle out. Substrate size and abundance are important features of aquatic habitat. Different organisms thrive on different size substrates, and will often use bed sediments for cover (fish, aquatic insects, salamanders) and colonization (algae, aquatic insects).

**6.6.1. Riffle Particle Size:** The median particle size of a riffle is used to calculate the Riffle Stability Index in conjunction with the Average Largest Particle (next step). The median particle diameter (D50) is the 50th percentile of particle diameter size, or 50% of the particles in the riffle are smaller.

**Metric:** Complete a Pebble Count (Wolman 1954, Bunte and Abt 2001) of a typical riffle in the study reach. Visualize 10 evenly spaced transects that cross the riffle perpendicular to flow. At 10 evenly spaced intervals along each transect, blindly touch a particle with an extended finger and measure the intermediate axis (i.e. not the short or long axes) of the particle with a gravel template with Wentworth particle sizes. Replace or discard the particle to prevent re-sampling. Measure at least 100 particles for a statistically valid sample. Record the values by tallying the size

class of each particle on a field sheet. Plot the grain size distribution in a spreadsheet to graphically estimate the median particle size and other quartiles.

**6.6.2. Embeddedness:** Embeddedness is the degree to which coarse bed particles (i.e. gravel, cobble, boulder, large woody debris) are surrounded and covered by finer particles (i.e. sand, silt, clay). Embeddedness is an important factor when considering habitat integrity; when the spaces between rocks are filled with fine sediments, little space is available for fish, amphibians and macroinvertebrates to use for cover, resting, spawning, and feeding. A streambed that is not embedded has many voids for organisms to occupy. Embeddedness is commonly measured as the percentage of the full height of the coarse material that is covered by surrounding finer sediments. An embedded streambed may be compacted with sand and silt such that cobbles are difficult or impossible to remove.

**Metric:** In pool-riffle, plane bed and braided streams, evaluate Embeddedness in the upstream and central portions of riffles or runs that contain cobbles. In step-pool streams, evaluate Embeddedness in the downstream portion of small pools preferably in relatively high velocity areas. Also evaluate Embeddedness outside of the main flow on the channel margins. Measure the height of a cobble above the surrounding finer bed material with a gravel template, graduated wading rod or ruler. Next, remove the cobble and measure the total height of the cobble. Embeddedness of that cobble is the  $(\text{total height} - \text{the exposed height} / \text{total height}) \times 100$ . Repeat that measurement on 3 - 5 cobbles. Also note the stains and algae on cobbles to discern the exposed and embedded portions of each cobble.

**6.6.3. Average Largest Particle:** In equilibrium conditions, the largest particles measured on the bed at the head of riffles may indicate the sediment size the stream typically is not capable of transporting at bankfull flow, while in contrast, the largest particles measured on point bars or side bars may indicate the sediment size the stream typically is capable of transporting at bankfull flow.

**Metric:** At the head of a typical riffle and on a typical unvegetated point bar, identify 3 - 5 particles that represent the largest particle size. Use a ruler or gravel template to measure the intermediate axes. On the point or side bar, focus observations on the downstream 1/3 of the bar, mid-way between the thalweg and the top of the bar.

**6.6.4. Riffle Stability Index:** Riffles are created and maintained by periodic scour and deposition processes that occur with fluctuation in flow. This periodic disturbance at a moderate frequency allows for re-colonization and inhabitation of riffles by benthic organisms such as macroinvertebrates. Highly altered watershed hydrology (i.e. increased peak flows) however, can lead to increased frequency of disturbance to riffles that prohibit the re-colonization and inhabitation and thereby impairing diversity and productivity of the aquatic community. The Riffle Stability Index (RSI) approximates the frequency of disturbance by comparing the riffle

particle size distribution with the largest particles of the adjacent sediment bars. A high RSI indicates the riffle instability may not allow colonization and persistence of benthic organisms.

**Metric:** Using results of the pebble count above, calculate the percent of riffle particles that are fine than the largest mobile particle measured on a nearby exposed sediment bar. Use linear interpolation to solve for the cumulative % finer of the largest particle. Identify the size class that encompasses the bar particle (i.e. the size class that is larger than the bar particle and the size class that is smaller than the bar particle). To solve for the cumulative % finer, the equation is assembled by two ratios as follows: (the larger size class – the smaller size class) / (cumulative % finer of the larger size class – cumulative % finer of the smaller size class) = (the larger size class – the bar particle size) / (cumulative % finer of the larger size class – the unknown cumulative % finer of bar particle).

Riffle Stability Index Values (%)	
< 70	High Stability, Optimal
70 < 80	Moderate Stability, Good
80 < 90	Low Stability, Fair
> 90	Very Low Stability, Poor

**6.7. Vegetative Material:** Tree trunks, branches, leaves and other plant materials that fall or get washed into the channel are sources of nutrients and structure essential to the ecological productivity and diversity of all Highlands rivers. Large Woody Debris (LWD) is wood material (e.g. logs) that is located at least partially within the bankfull channel and meets minimum size criteria (see table).

LWD Dimensions
Minimum length of 6 feet
Minimum diameter at the large end of 0.5 feet
Minimum diameter of 0.5 feet at a distance of 6 feet from the larger end

Coarse Particulate Organic Matter (CPOM) is smaller than LWD and includes leaves, needles, twigs, cones, and other plant parts that provide nutrients for the base of the stream ecosystem. Debris Jams are collections of multiple pieces of LWD and CPOM that nearly or entirely span the channel and may redirect flow at a given cross-section. LWD and Debris Jams are valuable because they provide cover, diverse flow patterns, local scour and depositional features, and organic carbon – all utilized by aquatic organisms. On the other hand, numerous Debris Jams suggests excessive bank erosion and channel instability.

**Metric:** Record the number of LWD pieces and Debris Jams, noting whether they are greater or less than half the bankfull channel width. Also, note CPOM as present, absent or abundant in the channel center and margins.

## 7.0 Stream Banks

Stream banks are features that define the channel sides and contain stream flow within the channel, typically extending from the top of the bank slope to the bankfull elevation or top of banks. Bank characteristics govern the rate of bank erosion. While bank erosion is a natural ongoing process, human impacts can induce geomorphic changes that greatly increase the frequency of occurrence and volume of sediment eroded. The banks are distinct from the streambed, which is normally wetted and provides substrate that supports aquatic organisms. The top of the bank is the point where an abrupt change in slope is usually evident, and where the stream is generally able to overflow the banks and enter the adjacent floodplain. For this parameter, the stream bank includes the near bank area within 5' from the top of bank. The following metrics include the primary factors that affect bank erosion rates. The first three metrics should be assessed at the representative cross-section; the remaining metrics should be assessed throughout the reach.

**7.1. Typical Bank Slope:** Slope of the banks is a key factor in bank stability and erosion. Low bank slopes indicate stable banks while extensive steep banks indicate unstable conditions related to channel bed erosion or widening. Undercut banks adjacent to water do provide habitat value like cover for fish; therefore, it is important to distinguish overhanging banks that are stabilized with boulders, bedrock or vegetation from those that are composed of erodible material and appear to be unstable. In meandering channels with thalwegs that shift from side to side, consider the higher of the two banks, which typically is on the outside of the meander and adjacent to a pool. If the stream has low sinuosity and the thalweg does not shift from side to side, consider both banks.

**Metric:** Record the typical slope of the bank from the toe to the bankfull elevation. See table for reference and interpretation.

Bank Slope Classes	
< 30%, < 3:1	Low
30 – 50%, 3:1 – 2:1	Moderate
> 50%, > 2:1	Steep
90%	Vertical
Overhanging and eroding	Undercut / Unstable
Overhanging but not eroding	Undercut / Stable

**7.2. Bank Materials:** The lower third of the bank is subjected to the greatest shear stresses during bankfull and flood flows. The condition of the lower bank helps to indicate if the bank is susceptible to undercutting and mass failure. Material in the upper third of the bank also indicates the likely mode of bank failure (e.g. slope failure) and influences the type and density of bank vegetation that can take root. Cohesion determines the tendency for erosion. Non-cohesive materials are soft and loose, while cohesive materials are hard and dense. Exposure of layers of subsoil in the bank may indicate channel adjustments. In particular, a distinct layer of imbricated gravels or cobbles (i.e. overlapping in the direction of flow) in the bank may reflect the elevation of the former streambed and suggests that the current channel has undergone degradation.

**Metric:** Identify the general sediment size class (as identified for the Dominant Particle Size Class / Stream Type, Section 5.12.2) for the lower and upper thirds of the bank. See table for interpretation. Indicate whether materials are generally cohesive or non-cohesive, as determined by touch or the physical condition (i.e. crumbling, slumping). Note the presence of exposed layers of subsoil or former streambed materials.

Bank Particle Size Erosion Interpretation	
Bedrock	Very Low erodibility
Boulder	Low erodibility
Cobble	Low erodibility
Gravel	Moderate to high erodibility
Sand	High erodibility
Silt	High erodibility when non-cohesive
Clay	Low erodibility when cohesive
Mix	Varies with composition and cohesiveness

**7.3. Bank Vegetation Coverage:** Vegetation along the banks and immediately set back from the bank bind the soil and provide resistance to bank erosion supporting channel integrity. Bank vegetation also provides shade to moderate temperatures, cover for aquatic organisms, and organic matter to the stream.

**Metric:** For both banks at the representative cross-section, visually estimate the percent of the area covered by tree canopy, understory (shrub/sapling), vines and ground cover (herbaceous plants) from the bankfull elevation to the top of bank and 5 feet set back from the banks. Each layer is assessed individually; coverage among layers will overlap.

Bank Vegetation Layers	
Trees(Canopy)	Woody DBH* > 5 inches and over 20 FT
Saplings	Woody with DBH <0.4 to 5 inches and height 20 FT or taller
Shrub / (Understory)	Usually 3 to 20 ft tall including multi-stemmed ,bushy shrubs and small trees and saplings.
WoodyVines	Variable growth habits
Groundcover	All non-woody plants and woody plants < 3 FT
*DBH is "diameter at breast height" – approximately 4.6 ft. above the ground.	

Next, visually determine the general plant groups in each of the groundcover, understory, and canopy layers. Each layer should be assessed individually and the relative t dominance species should be recorded on field forms.

Relative dominance of a species is determined by the value of the basal cover. Relative dominance is the coverage value of a species with respect to the sum of coverage of the rest of the species in the area.

$$\text{Relative dominance} = \frac{\text{Total basal area of the species}}{\text{Total basal area of all the species}} \times 100$$

Plant Groups		
Trees, Shrubs, Saplings, Herbs	Non-native Invasives	Trees – Black locust, Norway maple, Tree of heaven, Norway spruce Shrubs – Honeysuckle, Japanese barberry Herbs – Japanese knotweed, Phragmites, purple loosestrife, garlic mustard Vines – oriental bittersweet
Trees	Coniferous	With needles and cones – pine, cedar, hemlock
Trees	Deciduous	Broad leaves – maple, elm, ash, sycamore, tulip
Shrubs	Shrubs	Willows, alders, dogwoods – common stream bank shrubs
Saplings	Saplings	Various
Herbs	Grasses	Native grasses, rushes, sedges
Herbs	Forbs	Native non-woody flowering plants other than grasses

**7.4. Cross Channel Shading:** In addition to the Bank Vegetation coverage assessed above, the level of shading provided by the bank vegetation across the channel shading is considered for 1st, 2nd, and 3rd order streams. This metric is less important for larger rivers as they are less likely to have closed canopy shading due to greater channel width.

**Metric:** Standing in the middle of the channel at a representative cross-section, determine if bank trees provide an open or closed canopy. Compare to result of Phase 1, Step 1.4. Trees and shrubs that meet over the channel create a closed canopy. Streamside trees on opposite banks that do not meet over the channel are considered to create an open canopy. Record the condition that best represents the majority of the reach.

**7.5. Bank Erosion:** An eroded bank is an area of exposed soil where vegetation does not have the ability to hold soil and the soil has crumbled, slumped or fallen into the channel. This metric should only include active and accelerated erosion, not natural, gradual erosion. Naturally eroded areas may have exposed woody roots that are holding the banks. In meandering streams, natural bank erosion is typically limited to the outside banks of meanders. Extensive bank slumping with chunks of sediment on the channel margins indicates active and excessive bank erosion. Failing banks may also exhibit fracture lines at the top of the bank that extend parallel to the channel. Extensive leaning trees indicate excessive bank erosion and tree roots that appear to be recently exposed (e.g. fine, hairy or flexible, not brittle or easily broken) are signs of recent bank erosion.

Knowledge of recent major flood events will help to distinguish episodic bank erosion from a chronic channel condition.



Excessive bank erosion on outside meander bends. Princeton Hydro, LLC.

**Metric:** Estimate the proportion of both right and left banks that are eroding throughout the reach. Note whether erosion occurs on opposing banks, particularly at riffles and runs, where the thalweg is in the center of the channel or is limited to the outside of meander bends. Note whether erosion is limited to the base of banks, creating unstable overhangs. Indicate if there are fracture lines at the top of banks, extensive leaning trees, and recently exposed tree roots.

**7.6. *Bank Armoring/Channel Straightening:*** Bank armoring or channel straightening is often attempted with hard structures such as gabions or riprap or bioengineering techniques with rock and woody debris.

**Metric:** Record the length of channel bank (left and right) that has been reinforced or armored with riprap, concrete or other measures. Note the types of stabilization techniques and which banks have been modified. Verify result of Phase 1.



Bank stabilization with riprap. Princeton Hydro, LLC.

## 8.0 Riparian Area/Floodplain

**8.1. Buffer Width:** The width of the area along a stream, river or wetland that is naturally vegetated is a strong indicator of riparian and stream ecological integrity. In general, reater width corresponds to more vegetation types and communities as well as more input of LWD, CPOM, and Debris Jams, greater likelihood of channel shading.

**Metric:** Document onsite plant species and carefully estimate the width of the buffer. For both the right and left sides of the channel, indicate the typical buffer width categories in the table below. The dominant width does not equate to the average width, but rather the width that is most commonly found. Compare to result of Phase 1, Step 2.8.

Buffer Width Classes	
> 300 FT	Very Wide
300-150 FT	Wide
150—75 FT	Intermediate
< 75 FT	Narrow
No vegetated buffer.	None

## 8.2. Riparian Community – Plant Community Assessment

A riparian plant community is best described by its composition and dynamics. It is most important to know for each plant species its abundance, the area covered by it, its rate of reproduction, and its longevity. It is also important to know how soon adult plants are replaced by their young individuals or other species and the frequency with which one species occurs relative to others in the community. All these characteristics are used to describe the normal composition and dynamics of the community (sometimes called the baseline condition) and are influenced by the qualities of the environment, including humidity, temperature, sunlight, soil composition, and the presence or absence of exotic species.

**Metric:** The riparian area on both sides of the channel should be visually assessed to determine the percent of groundcover disturbed by human activities including: pavement, clearing, cultivated fields, lawn/landscaped areas, camp sites, ATV trails, hiking trails or barren land.

Riparian Plant Community Level 1 Score	
10% or less of riparian area is impacted by human disturbance.	High
11-25% of riparian area is impacted by human disturbance.	Moderate
More than 26% of riparian area is impacted by human disturbance.	Low

Plant Community assessment requires a detailed plant survey conducted by a trained person capable of identifying both woody and herbaceous species, including graminoids (e.g., grasses, sedges, and rushes) and pteridophytes (e.g., ferns). The plant survey consists of two parts: a walkthrough to

determine representative plant communities within the site and a detailed sampling of quadrats along a transect within the representative plant community area(s). Surveys must be completed during the growing season, between the dates of May 1 and November 1. Additional equipment required includes: meter tape, stakes, 1-meter quadrats, field guides, compass, and hand lens.

*Walkthrough:* The walkthrough should be completed for as much of a site as practical. At a minimum, a line parallel to the stream should be walked for every 30 feet of buffer width. During the walkthrough, a sketch map of reasonable accuracy should be completed over an aerial photograph marking the location and reference identification of individual plant communities. A representative photograph of each reference community must be taken and later correlated to the sketch map and transect locations. Notes are to be made with the date, type, condition, location of the plant communities encountered. A minimum of one transect is to be completed for each distinct plant community found.

*Transect Sampling:* Choose areas that contain a representative group of plants for each community type. A representative group is defined as a group whose species represent the majority of the various species within a study community.

Note the exact area, date and time, person(s) completing the sampling and sampling length of time. Lay a one hundred meter measuring tape across the area to be surveyed and note the starting location of the transect on the site map and the compass direction in which the transect runs. Take a representative photograph of the transect area. Starting at the beginning of the transect, survey all plants within a minimum distance of one foot of the transect line (on both sides). It is important to identify as many plant species as possible during the field survey; if a species is unknown and unable to be readily identified using a field manual, collect a specimen for identification only if possible to do so without imperiling the survival of the species onsite. It is significant to note that the program does not rely on the quantity of any species present; studies have shown that the absence or presence of species is sufficient to calculate a reliable site assessment.

*Plant Survey Basics:* It is important for site investigators to be consistent in evaluating the floristic composition of an area. Comparison of sites depends on a standardized sampling method, the knowledge and competence of the observer, and good data collection.

Regard should be paid to seasonal fluctuations in plant communities. Multiple survey times might be necessary within one year in order to best capture communities such as vernal wildflowers, sedges, meadow flowers, etc., if a holistic plant list is desired.

Follow-up surveys should be completed relatively close to the date previously surveyed, with a comparable time spent sampling and, if possible, the same surveyors.

Identification of 100% of the plants in a sample area is not necessary. Determining and comparing floristic quality does not require that every single plant be identified. Basic questions regarding the relative quality of a site can be answered by surveyors with an amateur proficiency in field botany. More complex questions, such as measuring the outcome of management, benefit from a higher level of botanical precision.

### ***8.3 Plant Stewardship Index (PSI)***

Once all field surveys have been completed and all plant species identified, compile all species into a single list to be used in calculating the site's PSI.

*Evaluation:* Local plants have been catalogued and assigned a number, called Coefficients of Conservatism (CC), from zero to ten by local experts and botanists for the Index. A list of CCs is available online through the Bowman's Hill Wildflower Preserve's website at [http://www.bhwp.org/psi/pdf/BHWP\\_Full\\_List.pdf](http://www.bhwp.org/psi/pdf/BHWP_Full_List.pdf). Using the single list of species on site generated by site sampling, assign the New Jersey CC to each plant documented. The following must be reported for each surveyed site:

1. Total Number of Species on Site
2. Number of Native Species on Site  
The native or introduced status of species is available on the list of CCs referenced above
3. Total Mean Coefficient (Total Mean C)  
Total all the CC's and divide by Item #1 (the Total Number of Species on Site)
4. Native Mean Coefficient (Native Mean C)  
Total all the CC's and divide by Item #2 (the Number of Native Species on Site)
5. Plant Stewardship Index (PSI)  
Multiply the Total Mean C by the square root of the Total Number of Native Species

The resulting values will identify high quality plant communities worthy of protection and will help set important benchmarks against which proposed developments and mitigation efforts that can be measured. Specifically, the Native Mean C provides a baseline assessment of the riparian habitat value and can be used to determine the level of mitigation to offset impacts to the area by any proposed development. Native Mean C is also valuable for relatively small sites (i.e. less than 100 species), as it is less skewed by small numbers of species than the other metrics. The table below provides conditions for the range of Native Mean C values. The PSI also serves well to monitor the success or failure of any mitigation efforts.

Native Mean C Interpretation	
0 – 2.4	Severely Degraded Area
2.5 – 3.4	Degraded Natural Area
3.5 - 4.4	Quality Natural Area
4.5-	High Quality Natural Area
= 5.5+	Exceptional Quality Natural Area

**8.3. Adjacent Wetlands:** Wetlands generally provide water storage during flood events and contribute to stream flow during dry periods. Adjacent wetlands that are hydrologically connected to a stream also provide refuge, feeding, and spawning habitat during seasonal high water and floods. They are also important in the processing of nutrients and pollutants from runoff draining to the stream as well as stream flow during flood events.

**Metric:** Estimate the extent of wetlands adjacent to the reach. Wetlands are officially classified by hydrologic, vegetation and soil characteristics; for the purposes of this assessment, wetlands can be identified by the presence of shallow water and vegetation that usually requires hydric soils, such as cattails, sedges, rushes, willows and alders.

Adjacent Wetlands	
Extensive	Wetlands present over 75% of reach
Moderate	Wetlands present over 50% of reach
Minimal	Wetlands present less than 25% of reach
Absent	No wetlands present along reach
Altered	Wetlands present but have been physically disturbed.

**8.4. Tributaries/Seeps/Springs:** The prevalence of springs, seeps, vernal pools and small tributaries may indicate the water storage characteristics of the watershed. Streams with greater surface and sub-surface water storage tend to be less flashy. The extended duration of runoff events in high storage watersheds may result in streams with relatively smaller dimensions, which are less sensitive to the adjustment process brought on by storm events. Moreover, groundwater influence in streams and rivers is especially important during periods of drought or low flow. Water that enters a stream from springs, seeps, or small tributaries is often cooler in the summer than surface water temperatures; fish seek out these cooler areas during summer. Similarly, in the winter these areas contain relatively warmer water, due to the groundwater origin, compared to the near freezing temperatures of surface water exposed to the cold winter air, which can exert stress on fish and other aquatic biota.

**Metric:** Note the relative abundance of springs, seeps or small tributaries draining to the channel.

<b>Springs, Seeps, Small Tributaries</b>	
Numerous	Numerous small tributaries, springs, seeps, entering the reach.
Occasional	Occasional small tributaries, springs, seeps, entering the reach.
Infrequent	Infrequent small tributaries, springs, seeps, entering the reach.
Absent	No small tributaries, springs, seeps, entering the reach.
Altered	Small tributaries, springs, seeps, entering the reach but have been physically disturbed.

**8.5. Floodplain Connectivity:** The ability of higher flows to spill out of the channel onto the adjacent floodplain is a primary factor in maintaining channel stability (See Floodplain Encroachment Height, Section 5.6). While the channel relies on the “pressure release” of a floodplain, the native floodplain community relies on the periodic inundation from the channel. Periodic floods provide valuable pulses of water, sediment and nutrients to floodplain vegetation. In addition, flooded floodplains provide important habitat for aquatic organisms for resting, cover, feeding, and spawning. Finally, floodplain and riparian plants serve to trap and process nutrients and pollutants from the floodwaters, helping to improve water quality in streams.

**Metric:** Note signs of flooding on the floodplain including deposition of sediment, LWD, CPOM, as well as water-swept vegetation, high-water lines, and ice scour marks.

<b>Floodplain Connectivity</b>	
Extensive	Signs of flooding or floodplain connectivity are numerous.
Present	Signs of flooding or floodplain connectivity are present.
Minimal	Signs of flooding or floodplain connectivity are minimal. Floodplain connectivity is partially limited by human encroachment.
Absent	Signs of flooding or floodplain connectivity are absent and/or Floodplain encroachment severely restricts connectivity.

**8.6. Flood Chutes, Meander Cutoffs, Braiding and Channel Avulsions:** These features indicate sediment deposition and lateral channel movement. These features are most common in response reaches – lower slope reaches that are typically located in downstream areas of basins and associated with higher stream order. Flood chutes are shallow flow paths on a floodplain that typically form a shorter, more direct path across meander tongues. Meander cutoffs occur when eroding outer banks of two meanders come together creating a steeper, short, straight, channel connection that becomes the preferential flow path and the primary channel, which results in the abandonment of the former meanders. Braiding is described in the table “Stream Type by Channel Bed Morphology,” in the Channel Bed Morphology section (1.3.10.2) as a reach that is composed of multiple interconnected channels which may occur in wetland-dominated settings or depositional fans or deltas. A Channel Avulsion is an abandonment of a channel and the creation of a new channel. Flood chutes, meander cutoffs and braiding may result in the formation of a new channel and the abandonment of the former channel. Major floods may cause abrupt channel avulsions

without the above precursors. Following an avulsion, the former channel is indicated by a dry river bed, linear wetlands, or oxbows. An abundance of these features indicates lateral channel instability, which will be assessed below.

## 9.0 Public Use Opportunities

Verify findings made in Phase 1 and add new information gathered from the field assessment. First, indicate whether land ownership is currently compatible with public use (e.g. is owned publicly, privately or by a land trust provides public access). Second, note which uses are appropriate in the study reach and riparian area. (Not all streams or rivers can support all public uses. For example, paddling or motor-boating is not feasible on a small, steep stream.) Then indicate which uses are currently supported or not supported. Finally, indicate which additional uses have the potential to be supported in the future (by creation of trails, picnic areas or boat launch, for example).

**Metric:** To quantify how well the reach currently supports public use, divide the number of uses appropriate for the stream by the number of uses currently supported. To assess the potential for expanding public use, divide the number of uses that are not currently supported, but are appropriate for the reach, by the number of uses that have the potential to be supported in the future.

Public Uses			
Landownership	Compatible with Public Use: (Y/N)		
	Appropriate for Reach (Y/N)	Currently Supported (Y/N)	Potential to be supported in the future (Y/N)
Walking / Hiking			
Picnicking			
Wading / Swimming			
Fishing			
Hunting			
Paddling			
Motor-boating			
Other			
Sum:			
% Currently Supported:			
% Potentially Supporting:			

## 10.0 Additional Considerations

**10.1. Upstream/Downstream Impacts:** Finally, note any major factors that may affect the study reach that are observed just upstream or downstream of the study reach limits.

**10.2. Reach/Sub-Reach Division:** After the reach walk through it may become apparent that the study reach should be divided into multiple sub reaches due to complete and consistent changes in existing stream type (e.g. significant and persistent changes in channel dimensions or bedforms), bank or riparian conditions (e.g. buffer width) or channel modifiers such as dams. In this case, data and observations should be recorded on separate data sheets.

## 11.0 Functional Value Scoring/Rating

### 11.1. Channel Integrity

**11.1.1. Channel Adjustment Process:** Human activities, which alter the watershed, floodplain or channel, can alter flow conditions that initiate geomorphic changes in the channel. Natural geologic processes such as tectonic uplift, and glacial outwash followed by glacial retreat also can initiate long-term, geomorphic channel adjustment; these pre-historic natural causes are not the focus of the stream corridor assessment but are important to differentiate from more recent human disturbances that may be targeted for management or restoration.

Geomorphic adjustment induced by human disturbances typically causes sweeping fundamental changes in physical habitat and as a result, impairment of the aquatic community including decline of diversity and abundance, if not local extirpation, of many aquatic organisms. The following is a description of the key field indicators that help to determine whether the project reach is in the process of geomorphic adjustment. The four major forms of geomorphic change in channels are degradation, aggradation, widening and re-alignment.

While more than one of these processes can occur simultaneously; a simplified scoring method below helps to determine among various field indicators which adjustments are occurring and whether one process is dominant. These processes tend to occur in a predictable sequence; the Channel Evolution Model described below explains the order and the downstream-to-upstream pattern that may be observed in the field. To determine the geomorphic adjustment process, separate forms are provided for three different anticipated stream types and valley confinement determined in Phase 1. If the Existing Stream Type (Phase 2) differs from the Reference Stream Type (Phase 1), a determination must be made as whether this difference is due to natural variability or human disturbance. If the former, then the Existing Stream Type should be used to select the appropriate assessment form for the Channel Integrity Assessment (and Habitat Assessment). However, if the difference is due to human disturbance, the Phase 1 Reference Stream Type should be used to select the appropriate assessment forms.

**11.1.1.1. General Instability:** Several parameters serve as general indicators of instability and can cause or contribute to any of the four adjustment processes. Some of them are referred to in more detail below for each specific channel adjustment process.

**Scoring and Rating:** On the scoring sheet, check the boxes for each parameter that correspond best to the conditions observed. At the bottom of the section, carefully select a numerical value from the 20-point scale that corresponds to all the observations selected above. When most observations occur around the same condition, the numerical score will be apparent. If however, there is a wide range of conditions across the parameters, use careful judgment to weigh the observations and select a numerical score that best reflects the conditions observed.

**11.1.1.2. Degradation:** Channel bed erosion on a reach scale that lowers the elevation of the channel bed relative to the tops of banks and floodplain is known as channel degradation and is also referred to as incision, down-cutting or entrenchment. Channels degradation occurs after a sustained (1) increase in flow (e.g. higher/more frequent peak flows due to high watershed impervious cover), (2) decrease in sediment supply (e.g. from a built-out watershed or dam with high sediment trapping efficiency), (3) increase in slope (e.g. channel straightening that steepens the reach and increases sediment transport capacity), and (4) substantial human encroachment of the floodplain that confines flood flows to the channel and induces reach-wide scour in the channel. Severe degradation can confine floods to the channel and prevent flood flows from overtopping the banks and spreading out across the floodplain. Confinement of higher flows within the channel exacerbates channel instability, accelerates the degradation process, and washes out in-stream habitat features. The degree of degradation is expressed with two metrics; the Entrenchment Ratio compares horizontal measurements (floodplain width to channel width) while Bank Height Ratio compares vertical measurements – height of lowest bank to maximum depth of bankfull flow. Channel degradation is not the same as localized scour that may be induced by an isolated structure or debris jam – it is important to distinguish between localized and reach-wide effects. Severe degradation can lead to departure from the anticipated stream type (i.e. a C type stream with floodplain access to an entrenched F type stream). Other streams in confined valleys are naturally entrenched and may appear degraded.

**Scoring and Rating:** As described above in the General Instability section, indicate on the scoring sheet the conditions observed for each parameter, and then select a numerical score from 20-point scale at the bottom that represents the observed conditions for all parameters. If there is a wide range of conditions across the parameters, use careful judgment to weigh the observations and select the most representative numerical score. However, specifically for this process of degradation, Poor ratings based on the presence of Headcuts and extreme deviations in the Bank Height Ratio warrant a Poor rating for Degradation, indicate a severe departure from natural conditions, and may warrant a Poor rating in the overall Channel Integrity condition (described below).

**11.1.1.3. Aggradation:** Sediment deposition on the channel bed on a reach scale that raises the elevation of the channel bed relative to the banks and floodplain is known as channel aggradation. Channels aggrade with a significant decrease in flow (e.g., water withdrawal), increase in sediment supply (e.g. from poorly managed land development), or decrease in slope (e.g., due to irregular meander patterns). Sediment deposition that is localized (e.g. associated with a single structure or debris jam) and does not occur throughout the reach, does not represent channel aggradation.

**Scoring and Rating:** As described above in the General Instability section, indicate on the scoring sheet the conditions observed for each parameter, and then select a numerical score from 20-point scale at the bottom that represents the observed conditions for all parameters. If there is a wide range of conditions across the parameters, use careful judgment to weigh the observations and select the most representative numerical score. Specifically for the process of Aggradation, Poor ratings for Step-Pool / Pool-Riffle Condition and Sediment Bars warrant a Poor rating for Aggradation, indicate a severe departure from natural conditions and may warrant a Poor rating in the overall Channel Integrity condition (described below).

**11.1.1.4. Widening:** As the name implies, widening occurs when extensive erosion of both banks increases the width of the channel. Channel widening usually follows the channel degradation process whereby the containment of higher flows within an incised channel produces greater velocity and shear stress on the banks, which accelerates bank erosion. However, channel widening can also occur with channel aggradation. Extensive deposition on the channel bed that expands point bars or forms mid-channel bars that concentrate flows against the bank can also accelerate bank erosion and induce channel widening. This important interaction is described in the Channel Evolution Model below. In equilibrium conditions, bank erosion occurs on the outsides of meanders and is balanced with deposition on the inside of meanders (i.e. point bars which result in “bank building”). Channel widening, in contrast, occurs when erosion is not balanced by deposition or when both banks erode simultaneously in meanders as well as riffles and straight runs. When a reach becomes “over-widened,” sediment transport capacity is reduced and sediment deposits cause aggradation. Channel widening is resisted by the bank stability factors assessed in Phase 2, including bank angle, height, cohesion, erodibility, stratification, and vegetation.

**Scoring and Rating:** As described above in the General Instability section, indicate on the scoring sheet the conditions observed for each parameter, and then select a numerical score from 20-point scale at the bottom that represents the observed conditions for all parameters. If there is a wide range of conditions across the parameters, use careful judgment to weigh the observations and select the most representative numerical score. *Specifically for the Widening process, Poor ratings for Width-Depth Ratio and Bank Erosion warrant a Poor rating for Widening, indicate a severe departure from natural conditions and may warrant a Poor rating in the overall Channel Integrity condition (described below).*

**11.1.1.5 Re-alignment:** The channel alignment is the meander pattern, or planform, as observed on a map or aerial photo. The degree of meandering is expressed by the sinuosity metric. In unconfined valleys, channels move laterally across the floodplain, by eroding on the outside of meanders and depositing on the inside of meanders. In steep, confined valleys, channels do not have the freedom to move laterally and are relatively straight. Often, channels initiate re-alignment if they have been straightened or channelized. Straightening creates a higher gradient, which increases velocity and shear stress that, in turn, induces bank erosion and gradual re-meandering of the channel. Re-alignment may also occur as a response to aggradation or widening. Channels may reduce their sinuosity by at least two typical ways. Flood flows impeded by debris jams or channel constrictions sometimes cut new channels in drastic and sudden events that result in the abandonment of the original channel -- events called channel avulsions. Tight, serpentine meanders (“oxbows”) may eventually erode into themselves causing a short, straight-line connection, or meander cutoff, that results in the abandonment of the former meanders. These processes can occur in equilibrium conditions but may be accelerated by human disturbances that decrease bank stability or increase peak flows.

**Scoring and Rating:** As described above in the General Instability section, indicate on the scoring sheet the conditions observed for each parameter, and then select a numerical score from 20-point scale at the bottom that represents the observed conditions for all parameters. If there is a wide range of conditions across the parameters, use careful judgment to weigh the observations and select the most representative numerical score. For the Re-alignment process, Poor ratings for Bank Erosion and channel avulsions warrant a Poor rating for Re-alignment, indicate a severe departure from natural conditions and may warrant a Poor rating in the overall Channel Integrity Condition.

**11.1.2. Channel Integrity Condition/Departure:** The overall condition of the reach is based on a summation of the above channel adjustment scores. Streams that are showing signs of degradation or widening may score fair to poor. Streams that are severely degraded or widened and exhibiting a different stream type than anticipated score poorly. These streams are expected to continue to adjust to a new channel form consistent with the new boundary conditions and watershed inputs of flow and sediment. Meanwhile, streams that are undisturbed or have recovered from past disturbances will likely score better. The assessment also refers to Watershed factors assessed during Phase 1. Metrics and observations are checked under the appropriate category (Optimal, Good, Fair, Poor) and corresponding scores ranging from 0 – 20 are selected. Reach Condition is calculated by adding the individual scores for each of the four adjustment processes and dividing by the maximum possible score (100). The channel adjustment process that scores the lowest represents the dominant channel adjustment process. Total scores are assigned ratings of Optimal, Good, Fair, and Poor as per the accompanying table. These ratings also reflect the degree to which the reach has deviated from natural, undisturbed conditions – termed “reference conditions.” Optimal equates to Reference Conditions; Good equates to Minor departure from reference conditions; Fair equates to Major departure; Poor equates to

Severe departure. If, however, the rating that corresponds to the numerical score strongly conflicts with your field observations, you may elect to assign a different rating. For example, a reach score earns a rating of Fair but, based on your assessment and experience, the reach is actually in Poor condition. Detailed explanation must be provided in the scoring sheet and subsequent reports if an alternative rating is assigned. Such a situation may arise with one of the Poor ratings described in each Channel Adjustment Process description above.

**Scoring and Rating:** At the bottom of the Channel Integrity Assessment sheet, list the individual scores for General Instability, Degradation, Aggradation, Widening and Re-alignment. The channel adjustment process that scores the lowest represents the dominant channel adjustment process. Then average the individual scores for each of the major categories and divide by 20 to compute the Channel Integrity Score. Use the adjacent table to convert the score into a Condition (Optimal, Good, Fair, Poor). If any individual process scored Poor (but the Channel Integrity score was higher because it was offset by higher scores for the other processes) consider downgrading the Channel Integrity Condition. Use your knowledge and best judgment to adjust the rating and provide sufficient explanation for your final assessment of Channel Integrity Condition.

**11.1.3. Channel Evolution Stage:** The Channel Evolution Model is useful in determining the dominant channel adjustment process. The previous four geomorphic adjustment processes often proceed in a well-documented predictable sequence following disturbances in the reach, floodplain or watershed. A Channel Evolution Model has been described by multiple researchers (Schumm et al. 1981, Simon and Hupp 1986, Simon 1989) to explain the multi-stage process that occurs in response to channel disturbance. In the NJ Highlands, these disturbances typically include straightening and channelization or urbanization that generates increased runoff volumes and rates. The conceptual model enables inference of past, present and future conditions and is described generally as follows.

- Initially, prior to disturbance, **Stage I – Stable**, channel aggradation and degradation are nearly in balance, erosion of outside bends is offset by deposition on inside bends, bank heights and slopes are stable, bank vegetation root systems can reach baseflow flow elevation, and 1 - 2 year floods access the floodplain.
- Upon disturbance (e.g. channelization/straightening or urbanized watershed), **Stage II – Degradation** is defined by the incision of the channel bed relative to the banks and floodplain. Flood flows become contained in the channel; the increased slope and reduced floodplain connection increase sediment transport and exacerbate the channel degradation process. Bank vegetation root systems lose connection with the normal flow elevation.

- After extensive channel degradation, **Stage III – Widening** occurs, whereby banks become steeper and higher, which induces bank failure (e.g. sloughing) and results in channel widening. Bank vegetation begins falling into the channel at an accelerated rate.
- Eventually, in **Stage IV – Aggradation and Re-alignment**, a threshold is reached where degradation gives way to aggradation, and the channel begins carving a new alignment within a narrower floodplain corridor that is lower in elevation than the former channel.
- If allowed to progress fully without new disturbance or human intervention, **Stage V – Re-stabilization** begins as a new floodplain aggrades at a lower elevation, banks are formed at lower slopes, a meandering thalweg develops alternating depositional bars, new vegetation re-establishes, and erosion on the outside bends balances out with deposition on inside bends. At this final stage a new equilibrium has formed but the newly formed floodplain is set at a lower elevation than the pre-existing floodplain, which has become an abandoned floodplain terrace.

While channel evolution occurs in a temporal sequence, the stages may be observed in the field in a spatial sequence, where the initial stages progress from downstream to upstream. Thus, Degradation (Stage II), indicated by head-cuts, is upstream of and followed by widening (Stage III), Aggradation and Re-alignment (Stage IV) may be observed further downstream. The timing associated with each stage can vary widely depending on the magnitude and scale of the disturbance, the geology, bed and bank materials and riparian vegetation. Re-initiation of the process can occur at any time with a new disturbance.

**Metric:** The channel adjustment processes that score poorly are the dominant channel forming process and indicate what stage of channel evolution that the reach is undergoing.

**11.1.4. Channel Sensitivity:** Channel Sensitivity refers to the likelihood that a stream will undergo geomorphic adjustment in response to a human disturbance based on the Channel Integrity rating. Sensitivity is driven by the geology, valley conditions, dominant bed materials, or position within the watershed. Highly sensitive streams are most likely to undergo geomorphic adjustment following a disturbance, while low sensitive streams are very resistant to human disturbance.

**Metric:** Using the Existing Rosgen Stream Type (determined first in Phase 1 and then verified in Phase 2) and Channel Integrity Rating determined above, determine the Channel Sensitivity from the table below.

<b>Channel Sensitivity Based on Stream Type and Channel Integrity Rating</b>			
Existing Stream Type	Good	Fair	Poor
A1, A2, B1, B2	Very Low	Very Low	Low
C1, C2	Very Low	Low	Moderate
G1, G2	Low	Moderate	High
F1, F2	Low	Moderate	High
B3, B4, B5	Moderate	High	High
B3c, C3, E3	Moderate	High	High
C4, C5, B4*, B5*, E4, E5	High	Very High	Very High
A3, A4, A5, G3, F3	High	Very High	Extreme
G4, G5, F4, F5	Very High	Very High	Extreme
D3, D4, D5	Extreme	Extreme	Extreme

**11.2. Habitat Value:** Habitat assessment is completed in one of three sheets for the primary stream types determined in Phase 1 and confirmed or reassessed in Phase 2. If the Existing Stream Type (Phase 2) differs from the Reference Stream Type (Phase 1), a determination must be made as to whether this difference is due to natural variability or human disturbance. If the stream reach has an undeveloped watershed and has not been directly impacted, then the difference between the reference stream type and the existing stream type may be due to natural variability; the Existing Stream Type should be used to select the appropriate assessment form for the Habitat Assessment. However, if the difference is due to human disturbance, the Phase 1 Reference Stream Type should be used to select the appropriate assessment forms. Initially, as in the Channel Integrity Assessment sheets, metrics and observations are checked under the appropriate condition (Optimal, Good, Fair, Poor) and corresponding scores ranging from 0 – 20 are selected. The assessment includes watershed factors assessed during Phase 1 as well as the result of the Channel Integrity Assessment. The Habitat Condition is calculated by averaging the individual scores for each of the major categories and dividing by 20. Total scores are assigned ratings of Optimal, Good, Fair, and Poor as per the accompanying table. If the rating that corresponds to the numerical score strongly conflicts with your field observations (e.g. a poorly scoring parameter), you may elect to assign a different rating. Detailed explanation must be provided in the scoring sheet and subsequent reports, if an alternative rating is assigned.

**11.3. Water Quality:** Water quality parameters are assessed in a single Water Quality assessment sheet that incorporates parameters also related to temperature moderation, watershed factors assessed during Phase 1 as well as the result of the Channel Integrity Assessment. As in the other assessments, observations for each parameter are checked under the appropriate condition (Optimal, Good, Fair, Poor) and corresponding scores ranging from 0 – 20 are selected. The Water Quality condition is calculated by averaging the individual scores for each of the major categories and dividing by 20. Total scores are assigned ratings of Optimal, Good, Fair, and Poor as per the accompanying table. If the rating that corresponds to the numerical score strongly conflicts with

your field observations (e.g. a poorly scoring parameter), you may elect to assign a different rating. Detailed explanation must be provided in the scoring sheet and subsequent reports, if an alternative rating is assigned.

**11.4. *Temperature Moderation:*** Temperature Moderation parameters are assessed in a single assessment sheet. Some of these parameters are also applied to the Water Quality assessment. As in the other assessments, observations for each parameter are checked under the appropriate condition (Optimal, Good, Fair, Poor) and corresponding scores ranging from 0 – 20 are selected. The Temperature Moderation condition is calculated by averaging the individual scores for each of the major categories and dividing by 20. Total scores are assigned ratings of Optimal, Good, Fair, and Poor as per the accompanying table. If the rating that corresponds to the numerical score strongly conflicts with your field observations (e.g. a poorly scoring parameter), you may elect to assign a different rating. Detailed explanation must be provided in the scoring sheet, and subsequent reports, if an alternative rating is assigned.

**11.5. *Public Use:*** Public use is the final functional value scored in this assessment. The primary variables include existing and potential public uses, and the assessment incorporates the results of the preceding Channel Integrity, Habitat, Water Quality and Temperature Moderation assessments. The purpose for their inclusion is that channel integrity, habitat, water quality and temperature moderation all directly influence the ability of the stream to accommodate the range of public uses. As in the other scoring sheets, the public use value is calculated by averaging the individual scores for each of the major categories and dividing by 20. Total scores are assigned ratings of Optimal, Good, Fair, and Poor as per the accompanying table. If however, the rating that corresponds to the numerical score strongly conflicts with your field observations, you may elect to assign a different rating. Detailed explanation must be provided in the scoring sheet, and subsequent reports, if an alternative rating is assigned.

## **12.0 Data Summary**

### **12.1. *Data Review and Interpretation***

After completing all the scoring sheets, compare and review the scores and condition ratings. Multiple observations, measurements, and estimates have been boiled down to these six scores, (the Watershed Assessment, plus the five functional value scores) which provide a broad picture of the condition of the Highlands Open Water, Highlands Open Water Buffer, and the greater riparian area. At this point, it is important to take time to examine all the information at hand, confirm its accuracy, and gain a full understanding of the conditions throughout the surveyed reaches and contributing watersheds. If any values strongly conflict with the prevailing understanding of the reach condition, revisit the individual parameters to confirm or revise. These scores and ratings serve as a solid baseline assessment of existing conditions against which future change, either improvements or impairments, can be measured.

For each assessed reach, examine the conditions of each functional value. Refer to the field maps to observe the distribution of structures, features and signs of impairments. Refer to photographs to re-affirm the field observations. If multiple reaches have been assessed throughout a watershed, map and depict reaches by functional value scores to determine any spatial patterns that may suggest interactions among the functional values, upstream to downstream trends, small stream to large stream differences, differences among sub-watersheds, and landscape scale influences. If the conditions of the functional values vary, consider the lowest functional value and the individual parameters that contributed to the overall poor condition. Are the poor conditions attributed to the watershed, corridor, buffers, banks, or in-channel modifiers? For these parameters, consider the causes of the impairments, or the specific stressors, that result in the observed impacts. Are the impaired functional values related or do they represent separate sources? Are the sources of disturbance ongoing processes, actions that occurred in the past or fixed features and structures? Consider also the timing, duration, rate of the stressors and impairments. Have the stressors existed for years to decades, but the impairments have evolved slowly over time? Alternatively, are the stressors and impairments relatively recent occurrences, or have they both existed for years to decades?

**Watershed/Corridor** – The watershed assessment incorporates factors that are beyond the scale of the study reach (and therefore very likely to occur in other reaches) and include natural and man-made factors. Native soil conditions, steep slopes and land use / land cover conditions may be powerful factors driving down the conditions of the functional values.

**Channel Integrity** – Poor channel conditions indicate severe channel instability and potentially rapid adjustment, which is likely impacting habitat and water quality. Compare the results among adjacent reaches, and look for any upstream to downstream patterns. Recall that channel degradation proceeds in the upstream direction, until grade controls are encountered; widening tends to follow degradation, though the two processes may also coincide, particularly where banks are unvegetated. Aggradation and planform adjustment eventually result or are manifested downstream, where sediment is depositing. Consider the sequence of these channel adjustments – is incision migrating upstream through the reach and stream system? Project into the future; how are channel adjustments likely to continue if left unabated? Review the individual parameters to identify the underlying causes of instability. Is disconnection from the floodplain the primary factor? Are structures and lack of bank vegetation playing a role? Are structures and properties at risk?

**Habitat** – Poor habitat conditions may present stream reaches and riparian areas that should be prioritized for restoration while good/optimal habitat conditions should be targeted for protection or active stewardship. Review the individual parameters to confirm where the poor conditions are manifested – channel, banks and/or riparian area. Confirm each poorly rated parameter. Poor habitat conditions are often driven by poor channel conditions or poor riparian land use. Note that the Riparian Plant Community parameter provides quantitative metrics – total number of species, number of natives, total mean coefficient, native mean coefficient, and plant stewardship index,

which should be applied to track changes, and monitor the success of restoration or mitigation projects. Stream side planting projects provide obvious benefits, however their restorative effects take years to develop.

**Water Quality** – Poor water quality conditions are often driven by watershed scale factors (i.e. land use/land cover). Review the individual parameters to identify where the poor conditions are manifested – watershed, channel integrity, existing data, flow modifiers, banks, or riparian areas. If the stream is listed on the Clean Water Act List of Impaired Waters (Section 303(d),) examine the pollutant and source of pollutant – these data should factor heavily in this assessment. Examine also the Pollutant Loading analysis – which pollutants are the greatest concerns and which areas produce the greatest pollutant loads? Compare and contrast the field conditions (like stormwater inputs), water quality standards, the Section 303(d) List, and the pollutant loading analysis – are they generally consistent? Do watershed/corridor conditions appear to exert greater impairment than in-channel and buffer conditions? To gain a long view of the changes in water quality based on land use/land cover, consider repeating the pollutant loading analysis based on past land use conditions or projected build-out conditions.

**Temperature Moderation** – Review the individual parameters to identify where the poor conditions are manifested – watershed, channel integrity, existing data, flow modifiers, banks, or riparian areas. Are poor Temperature Moderation conditions closely tied to channel integrity (i.e. an overwidened channel)? Are bank vegetation and buffer widths as important as discharges and stormwater inputs?

**Public Use** – With few individual parameters, the Public Use score can be heavily influenced by the related parameters. Ensure that the final rating is reasonable and that a reach that has met all appropriate existing public uses is not scored negatively for a lack of potential public use. Additional attention should be given to the related parameter that is also impairing public use.

Carefully examining and contemplating the conditions revealed by this assessment will ultimately lead to the next question: what to do about them? For functional values rated in good or optimal condition, efforts should be focused on sustaining the condition through management and protection. Conversely, functional values rated fair or poor should be targeted for restoration and rehabilitation. Good functional values should be maintained; poor functional values should be restored. A stream or buffer currently in good condition should not be assumed to remain so if left alone; careful attention should be given to actions in the channel, buffer and throughout the watershed (such as development patterns, zoning ordinances, stream channel alterations, etc.), which can slowly impair these functional values if implemented with little planning or without appropriate conservation measures.

Efforts to address the impairments and identified sources are most likely to succeed when coordinated under a stream corridor protection and restoration plan or watershed management plan.

(Interested parties are strongly encouraged to consult the NJ Highlands Commission for further guidance.) A stream protection and restoration plan would build from this assessment, establish over-arching goals and supporting tasks, identify specific restoration projects and practices, identify responsible parties, identify sources of financial and technical assistance, and set a schedule for implementation. While the planning process may seem like a lengthy next step after the completion of this assessment, an effective response to restore Highlands streams and buffers will require a long-term, multi-faceted effort.

Initial steps in stream and buffer protection and restoration begin with realizing that something can, and should, be done. As implied by the questions posed above, careful distinction must be made between observed impairments and underlying causes or stressors. Fixing an impairment without acknowledgement of the underlying cause is not an enduring solution. Restoration measures should consider the duration, extent, intensity and scale of the impairment and the stressor. For example, spot treatments of bank stabilization and pool-riffle creation will have little effect on improving channel integrity, habitat, and water quality downstream of urbanized watersheds – stormwater management in the uplands gets closer to the source of the impairments. Channel restoration plans should look to remove constrictions and improve floodplain connection. Unvegetated banks and riparian areas call for re-planting native communities, which can have real benefits to all five functional values.

## ***12.2. Data Compilation and Reporting***

Results of both phases of the assessment shall be compiled and summarized in a single report that includes all supporting documentation. The document template provided by Highlands Council staff (see Appendix E) may be used during report preparation. The report should provide background on the project and the reason for conducting the assessment. It shall identify (and include contact information for) primary project proponents and their partners, technical advisory individuals or agencies, the project manager and workers who conducted the assessment. The report shall include a written description of the results of the Phase 1 assessment referencing GIS maps (of the watershed, corridor and reach), impact ratings and scores. Mapping and digital data standards provided by the Highlands Council must be used during report preparation (see Appendix D). The report shall also include a written description of the study reach with findings from the Phase 2 assessment that references field observations and measurements, labeled maps of the study reach, labeled photos and a discussion of the resulting assessment scores for each functional value. (Authors of the report should plan to retain and preserve all original digital and physical files future use and reference; the Highlands Council will be cataloguing all project reports.) Any alternative ratings assigned must include detailed justification.

## ***12.3. Quality Assurance/Quality Control***

The report shall address quality assurance and quality control issues that may compromise the validity of the final conclusions. A QA/QC log must be included that documents (i) sources of data, (ii) presumed accuracy of supporting information and secondary analyses, (iii) identify information

gaps or unmet data needs, and (iv) any steps or portions of the protocol that may have been modified or abridged. The discussion of the assessment scores and ratings should identify high scoring reaches that warrant protection as well as low scoring reaches in need of restoration or management. For reaches with impaired functional values, the written narrative should differentiate between cause and effect by identifying the primary stressors impairing the functional values, and recommend actions to remove stressors and/or recommend restoration projects or management measures to mitigate for permanent stressors (e.g. urbanization). Recommendations should consider both active and passive restoration approaches. This information provides a valuable basis for a stream protection and restoration effort. Project proponents are strongly encouraged to refer to the Stream Corridor Protection and Restoration Plan Guidance Document developed by the NJ Highlands Council to take the subsequent steps to protect and restore their Highlands stream.

### ***12.4. Application of Results***

These results can be applied in various ways depending on the initial reasons for conducting the assessment. If this assessment was initiated to document the high quality of a valued natural resource, these results should be applied to adjust or revise current management efforts (“adaptive management”), and to justify and guide future efforts to manage and protect the resource. In addition, the assessment results should be reviewed closely to identify early signs of impairments and direct pro-active attention toward underlying causes. In this case, the assessment should be applied to arrest and regain any net losses in functional values.

If the assessment was initiated in response to a specific proposed activity that may affect the resources, then the results serve as a baseline against which no net loss in functional value can be determined. For example, the individual parameters of this assessment can be used as guidelines for any proposed activities to prevent any reduction in functional value scores and consequently, any net loss in functional values. Following implementation of the proposed activity, the assessment (or individual components) can be repeated to monitor functional values and trigger remedial actions if necessary.

## Glossary

**Aggradation:** The process of sediment deposition on the channel bed on a reach scale that raises the elevation of the channel bed relative to the banks and floodplain.

**Bedrock channel:** A stream reach with bed and banks composed primarily of bedrock and normally confined by the valley.

**Braided channel:** A stream reach composed of a complex of multiple, interconnected channels with bed features that form by dynamic erosion and deposition processes.

**Cascade channel:** A steep stream reach with longitudinally and laterally disorganized bed materials, typically composed of bedrock, boulders, cobbles or large woody material.

**Channel avulsion:** The process, often occurring suddenly during flood events, in which a new channel is created and the original channel is abandoned.

**Channel canopy cover:** Shading from overhanging bank vegetation that limits direct insolation to the water surface and thereby serves to moderate water temperatures.

**Channel evolution model:** An empirical framework that explains the geomorphic processes a stream channel undergoes in response to a disturbance in the channel or floodplain.

**Channel integrity:** The quality of a stream channel defined by long-term dynamic stability of dimension, pattern and profile, and at which point, erosion and deposition of sediment are in relative balance.

**Channel migration:** The process in which a channel shifts downstream or laterally and can result in greater reach sinuosity.

**Channel sensitivity:** The likelihood that a stream will undergo geomorphic adjustment in response to a disturbance.

**Channel straightening:** The realignment of a channel creating a straighter and thus steeper reach that is more prone to instability, often done intentionally to accommodate adjacent agriculture, development, roads or railroads.

**Coefficients of Conservatism (CC):** A numerical value (0-10) that represents a plant's rarity and tolerance to disturbance, which is assigned to plants by local experts and botanists. A list of CCs is available online through the Bowman's Hill Wildflower Preserve's website at [http://www.bhwp.org/psi/pdf/BHWP\\_Full\\_List.pdf](http://www.bhwp.org/psi/pdf/BHWP_Full_List.pdf).

**Dams/Weirs:** Structures that span the channel and are designed to raise the water surface elevation to create impoundments for water supply, flood control, recreational, industrial power supply or other uses.

**Degradation:** The process of erosion of the channel bed that lowers the elevation of the channel bed relative to the tops of banks and floodplain; also referred to as incision, down-cutting or entrenchment.

**Dune-Ripple channel:** A stream reach with a sand-dominated, undulating bed that does not form distinct pools or riffles but may form point bars induced by channel pattern.

**Flood chutes:** Shallow flow paths on a floodplain that typically form a shorter, more direct path across meander tongues.

**Geomorphic Change:** Changes in channel slope, cross-section or alignment that occur through any of four processes: degradation, aggradation, widening and re-alignment.

**Habitat:** The space, and its associated biological and physical conditions, in which an organism or population inhabits. Optimal stream habitat is created under equilibrium conditions when sediment, woody material and water flow (depths and velocities) interact to create heterogeneous habitat units for cover, foraging and reproduction.

**Highly Erodible Land (HEL):** A soil erodibility factor, which represents both susceptibility of soil to erosion and the rate of runoff.

**Mainstem:** The major reach of a river or stream formed by the smaller tributaries which flow into it.

**Plane Bed channel:** A stream reach lacking discrete bed forms that occurs as a transitional morphology from step-pool to pool-riffle reaches.

**Pool-Riffle channel:** A stream reach with undulating bed that defines a sequence of riffles, runs, pools, and bars.

**Reference Conditions:** The highest quality, or optimal condition, of a natural system that is expected to occur in the absence of human disturbance.

**Representative Group:** A group whose species represent the majority of the various species within a study community.

**Response reaches:** Stream reaches with lower slopes, typically located in downstream areas of basins that have the tendency to adjust geomorphically due to changes in flow of water or sediment from upstream reaches.

**Sinuosity:** The planform pattern of a river that describes the degree of meandering and is expressed as the ratio of channel length to valley length – straight channels equate to low sinuosity.

**Hydrologic Soil Hydrologic Groups (HSG):** Classes of soils that represent runoff characteristics. High runoff potential may contribute to reduced temperature moderation and degraded water quality and aquatic habitat.

**Step-Pool channel:** a stream reach with steps formed by boulders or cobbles organized into discrete steps that span the channel and are alternated with pools.

**Thalweg:** The deepest part of the channel where velocities are greatest and majority of flow is concentrated.

**Widening:** The process of erosion of both banks that increases the width of the channel.

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**Appendix A:**  
**Phase 1 Required Data Sources**

Appendix A Phase I Required Data Layers and Source		
Data Layer	Source	Source URL
1930's aerial	New Jersey Geographic Information Network website	<a href="https://njgin.state.nj.us/NJ_NJGINExplorer/index.jsp">https://njgin.state.nj.us/NJ_NJGINExplorer/index.jsp</a>
Aerial orthoimagery	New Jersey Geographic Information Network website	<a href="https://njgin.state.nj.us/NJ_NJGINExplorer/index.jsp">https://njgin.state.nj.us/NJ_NJGINExplorer/index.jsp</a>
AMNET Reference Monitoring Sites	New Jersey Department of Environmental Protection GIS website	<a href="http://www.state.nj.us/dep/gis/">http://www.state.nj.us/dep/gis/</a>
Bedrock Geology and Faults	New Jersey Department of Environmental Protection Geological Survey website	<a href="http://www.state.nj.us/dep/njgs/geodata">http://www.state.nj.us/dep/njgs/geodata</a>
County Boundary	New Jersey Geographic Information Network website	<a href="https://njgin.state.nj.us/NJ_NJGINExplorer/index.jsp">https://njgin.state.nj.us/NJ_NJGINExplorer/index.jsp</a>
Highlands LiDAR contours and DEM	US Geological Survey (USGS) 1/9 Arc Second NED Product	<a href="http://nationalmap.gov/viewer.html">http://nationalmap.gov/viewer.html</a>
Highlands Riparian Area	Highlands Council website	<a href="http://www.highlands.state.nj.us/njhighlands/actmaps/maps/gis_data.html">http://www.highlands.state.nj.us/njhighlands/actmaps/maps/gis_data.html</a>
HUC14	New Jersey Department of Environmental Protection GIS website	<a href="http://www.state.nj.us/dep/gis/">http://www.state.nj.us/dep/gis/</a>
Integrated List of Waters	New Jersey Department of Environmental Protection GIS website	<a href="http://www.state.nj.us/dep/gis/">http://www.state.nj.us/dep/gis/</a>
Landscape Project	New Jersey Department of Environmental Protection GIS website	<a href="http://www.state.nj.us/dep/gis/">http://www.state.nj.us/dep/gis/</a>
List of Threatened and Endangered Species That Are Critically Dependent On Regulated Waters For Survival	New Jersey Department of Environmental Protection	<a href="http://www.nj.gov/dep/landuse/download/fh_009.pdf">http://www.nj.gov/dep/landuse/download/fh_009.pdf</a>
Municipality Boundary	New Jersey Geographic Information Network website	<a href="https://njgin.state.nj.us/NJ_NJGINExplorer/index.jsp">https://njgin.state.nj.us/NJ_NJGINExplorer/index.jsp</a>
Natural Heritage	New Jersey Department of Environmental Protection GIS website	<a href="http://www.state.nj.us/dep/gis/">http://www.state.nj.us/dep/gis/</a>
NJDEP Land Use/Land Cover	New Jersey Department of Environmental Protection GIS website	<a href="http://www.state.nj.us/dep/gis/">http://www.state.nj.us/dep/gis/</a>
NJDOT Roads	New Jersey Department of Transporation GIS website	<a href="http://www.state.nj.us/transportation/gis/data.shtm">http://www.state.nj.us/transportation/gis/data.shtm</a>
NJPDES Syrface Water Discharges	New Jersey Department of Environmental Protection GIS website	<a href="http://www.state.nj.us/dep/gis/">http://www.state.nj.us/dep/gis/</a>
Open Space/State Owned Land	New Jersey Department of Environmental Protection GIS website	<a href="http://www.state.nj.us/dep/gis/">http://www.state.nj.us/dep/gis/</a>
Parcels	New Jersey Geographic Information Network website	<a href="https://njgin.state.nj.us/NJ_NJGINExplorer/index.jsp">https://njgin.state.nj.us/NJ_NJGINExplorer/index.jsp</a>
SSURGO Soils and data tables	USDA NRCS Soil Survey Geographic (SSURGO) Database website	<a href="http://soils.usda.gov/survey/geography/ssurgo/">http://soils.usda.gov/survey/geography/ssurgo/</a>
Streams 2002 NHD	New Jersey Department of Environmental Protection GIS website	<a href="http://www.state.nj.us/dep/gis/">http://www.state.nj.us/dep/gis/</a>
Surface Water Quality Standards	New Jersey Department of Environmental Protection GIS website	<a href="http://www.state.nj.us/dep/gis/">http://www.state.nj.us/dep/gis/</a>
Surficial Geology	New Jersey Department of Environmental Protection Geological Survey website	<a href="http://www.state.nj.us/dep/njgs/geodata">http://www.state.nj.us/dep/njgs/geodata</a>
USDA NAIP data	USDA GeoSpatial Data Gateway website	<a href="http://datagateway.nrcs.usda.gov/GDGOrder.aspx">http://datagateway.nrcs.usda.gov/GDGOrder.aspx</a>
USGS 7.5' Quadrangle DRG	USDA GeoSpatial Data Gateway website	<a href="http://datagateway.nrcs.usda.gov/GDGOrder.aspx">http://datagateway.nrcs.usda.gov/GDGOrder.aspx</a>
USGS 7.5' Quadrangle Index	New Jersey Department of Environmental Protection GIS website	<a href="http://www.state.nj.us/dep/gis/">http://www.state.nj.us/dep/gis/</a>
Watershed Management Areas	New Jersey Department of Environmental Protection GIS website	<a href="http://www.state.nj.us/dep/gis/">http://www.state.nj.us/dep/gis/</a>

## **Appendix B:**

### **Data Sheets**

# Highlands Functional Value Assessment Methodology

## Phase 1 Watershed Assessment - Data Sheet

Impact Ratings	
V	Very High
H	High
M	Moderate
L	Low
I/N	Insignificant / None

US = Upstream  
DS = Downstream  
# = Numerical Value  
IR = Impact Rating  
T = Text Value  
S = Score

Step

### 1.1 Define Study Reach

1.1.1	Stream Name		
1.1.2	Reach ID		
1.1.3	Endpoint Descriptions	US:	DS:
1.1.4	Endpoint Coordinates	US:	DS:
1.1.5	NHD Reach Code(s)		
1.1.6	HUC 14		
	Town(s)		
1.1.7	County		
	USGS Quadrangle		
1.1.8	Excluded Areas		

### 1.2 Landownership

Private Properties


### 1.3 Define Reference Stream Type

1.3.1	Reach Length (ft)	#:	
1.3.2	Endpoint Elevations (ft)	US:	DS:
1.3.3	Reach Slope	#:	
1.3.4	Valley Length (ft)	#:	
1.3.5	Valley Slope	#:	
1.3.6	Sinuosity	#:	
1.3.7	Channel Width (ft)	#:	
1.3.8	Valley Width (ft)	#:	
1.3.9	Confinement Ratio	#:	T:
1.3.10.1	Rosgen Stream Type	T:	
1.3.10.2	Channel Bed Morphology	T:	

# Highlands Functional Value Assessment Methodology

## Phase 1 Watershed Assessment - Data Sheet

Impact Ratings:

1.4 Channel Canopy Cover

#:	IR:		H/L/I
----	-----	--	-------

1.5 Dams / Weirs

#:	IR:		H/M/L/N
----	-----	--	---------

1.5.1 Impoundment Canopy Cover

#:	IR:		H/L/I
----	-----	--	-------

1.6 Bridges / Culverts

#:	IR:		H/L/N
----	-----	--	-------

1.7 Channel Straightening

#:	IR:		H/L/I
----	-----	--	-------

1.8 Channel Migration / Avulsion

#:	IR:		H/L/N
----	-----	--	-------

1.9 Water Quality Standard

#:	IR:		H/L/N
----	-----	--	-------

1.10 Surface Water Discharges

#:	IR:		H/L/N
----	-----	--	-------

1.11 AMNET Reference Sites

#:	S:		H/N
----	----	--	-----

1.12 303(d) List

#:	S:		H/L
----	----	--	-----

2.1 Delineate Corridor Area (acres)

#:	
----	--

2.2 Delineate Watershed Area (acres)

#:	
----	--

2.3 Geology

Bedrock

Surficial

#:	IR:		H/L/I

2.4 Valley Slopes

2.5 Soils

Hydrologic Group

	Area (acres) Corridor/Watershed	Percent Corridor/Watershed	
A			
B			
C			
D			
A/D			
B/D			
C/D			
Corridor		IR:	V/H/M/L
Watershed		IR:	V/H/M/L
Highly Erodible			
Potentially Highly Erodible			
Not Highly Erodible			
Corridor		IR:	V/H/M/L
Watershed		IR:	V/H/M/L

HEL

## Highlands Functional Value Assessment Methodology

### Phase 1 Watershed Assessment - Data Sheet

#### 2.6 Land Use / Land Cover

	Area (acres) Corridor/Watershed	Percent Corridor/Watershed	
Urban			
Agriculture			
Wetlands			
Forest			
Corridor		IR:	H/M/L/I
Watershed		IR:	H/M/L/I

#### Impervious Cover

	Area (acres) Corridor/Watershed	Percent Corridor/Watershed	
%IC			
Corridor		IR:	H/M/L/I
Watershed		IR:	H/M/L/I

#### 2.7 Pollutant Loading

	Corridor	Watershed	
TP			
TN			
TSS			
	#:	IR:	H/L/I
	#:	IR:	H/L/I

#### 2.8 Width of Vegetated Buffer (ft)

#### 2.9 Floodplain Constrictions

#### 2.10 Wildlife Habitat - Landscape 3.0

Vernal Pools

Stream Rank

Species Patch Rank

#:		
#:		
5	Area (acres):	Percent:
4	Area (acres):	Percent:
3	Area (acres):	Percent:
2	Area (acres):	Percent:
1	Area (acres):	Percent:
0	Area (acres):	Percent:
	S:	Moderate H/M/L
	S:	H/M/L
	S:	H/M/L/N

#### 2.11 Riparian Plant Community - PSI

#### 2.12 Public Uses

**Highlands Functional Value Assessment Methodology**  
**Phase 2 Reach Assessment - Data Sheet**

Step

4.0 Channel Modifiers

4.1 Dams / Weirs

Tally:	
Height:	
WSEL Change:	
Length of Impoundment:	
Width of Impoundment:	
Width of DS Channel:	
Active Withdrawal:	

4.2 Beaver Dams

Tally:	
Length of Reach Affected:	
Notes:	

4.3 Bridges / Culverts

Tally:	
Signs of Constriction US:	
Scour DS:	
Width of Crossing:	
Width of DS Channel:	

4.4 Stormwater Inputs

Type:	
Pipe Diameter:	

## Highlands Functional Value Assessment Methodology

### Phase 2 Reach Assessment - Data Sheet

5	Channel Dimensions	
5.1	Bankfull Width	
5.2	Bankfull Max Depth	
5.3	Bankfull Mean Depth	
5.4	Lowest Bank Height	
5.5	Floodprone Width	
5.6	Floodplain Encroachment Height	
5.7	Width-Depth Ratio	
5.8	Entrenchment Ratio	
5.9	Bank Height Ratio	
5.10	Floodplain Encroachment Ratio	
5.11	Sinuosity	
5.12	Existing Stream Type	
	Rosgen Stream Type	
	Dominant Particle Size	
	Channel Bed Morphology	

## Highlands Functional Value Assessment Methodology

### Phase 2 Reach Assessment - Data Sheet

#### 6 Channel Features / Condition

##### 6.1 Bedrock Grade Controls

Tally:	
Height:	
Length:	

##### 6.2 Head-cuts

Tally:	
Notes:	

##### 6.3 Riffle / Step Condition

Tally:	
Form:	
Complete:	
Stability:	

##### 6.4 Pool Condition

< 1 FT:	
> 1 FT:	
< Wbf:	
= Wbf:	
Notes:	

##### 6.5 Sediment Bars

Point:	
Lateral:	
Diagonal:	
Mid-Channel:	
Islands:	
Deltas:	

##### 6.6 Bed Substrate Composition

Riffle Particle Size	
Embeddedness	
Average Largest Particle	
Riffle Stability Index	

##### 6.7 Vegetative Material

CPOM:	
LWD < Wbf:	
LWD > Wbf:	
Debris Jams < Wbf:	
Debris Jams > Wbf:	

Highlands Functional Value Assessment Methodology

Phase 2 Reach Assessment - Data Sheet

7 Stream Banks	Right Bank
7.1 Typical Bank Slope	
7.2 Bank Materials	
Interpretation	
7.3 Bank Vegetation Coverage	Right Bank
Canopy:	
Understory:	
Groundcover:	
Canopy	
Non-native invasives:	
Coniferous Trees:	
Deciduous Trees:	
Understory	
Non-native invasives:	
Shrubs:	
Saplings:	
Groundcover	
Non-native invasives:	
Grasses:	
Forbs:	
7.4 Cross Channel Shading	
7.5 Bank Erosion	Right Bank
Length:	
Height:	
7.6 Bank Armoring / Channelization	
Length:	
Type:	

## Highlands Functional Value Assessment Methodology

### Phase 2 Reach Assessment - Data Sheet

8 Riparian Area / Floodplain

Right Bank

8.1 Buffer Width

Class:

8.2 Riparian Community - PSI

Level 1 Score:

Plant Survey

Total Species #:

Native Species #:

Total Mean Coefficient:

PSI:

8.3 Adjacent Wetlands

8.4 Tributaries / Seeps / Springs

8.5 Floodplain Connectivity

Flood Chutes, Meander Cutoffs,

8.6 Braiding and Channel Avulsions

9 Public Use Opportunities

Public Uses			
Landownership	Compatible with Public Use: (Y/N)		
	Appropriate for Reach (Y/N)	Currently Supported (Y/N)	Potential to be supported in the future (Y/N)
Walking / Hiking			
Picnicking			
Wading / Swimming			
Fishing			
Hunting			
Paddling			
Motor-boating			
Other			
Sum:			
% Currently Supported:			
% Potentially Supporting:			

10 Additional Considerations

Upstream / Downstream

Reach / Sub-Reach Division

## Highlands Functional Value Assessment Methodology

### Phase 2 Reach Assessment - Reference Tables

5.7

Width-Depth Ratio	
$\leq 10$	Low – E Channels
$\leq 12$	Low – A/B Channels
$\leq 20$	Low – C/B Channels
$>10 \leq 12$	Low/Moderate – E Channels
$>12 \leq 20$	Low/Moderate – A/B Channels
$>20 \leq 30$	Low/Moderate – C/B Channels
$>12 \leq 20$	Moderate/High – E Channels
$>20 \leq 30$	Moderate/High – A/B Channels
$>30 \leq 40$	Moderate/High – C/B Channels
$> 20$	High – E Channels
$> 30$	High – A/B Channels
$> 40$	High – C/B Channels

5.8

Entrenchment Ratio	
$1.0 \leq 1.2$	Highly Entrenched
$>1.2 \leq 1.4$	
$>1.4 \leq 2.0$	Moderately Entrenched
$>2.0 \leq 2.2$	
$> 2.2$	Minimally Entrenched

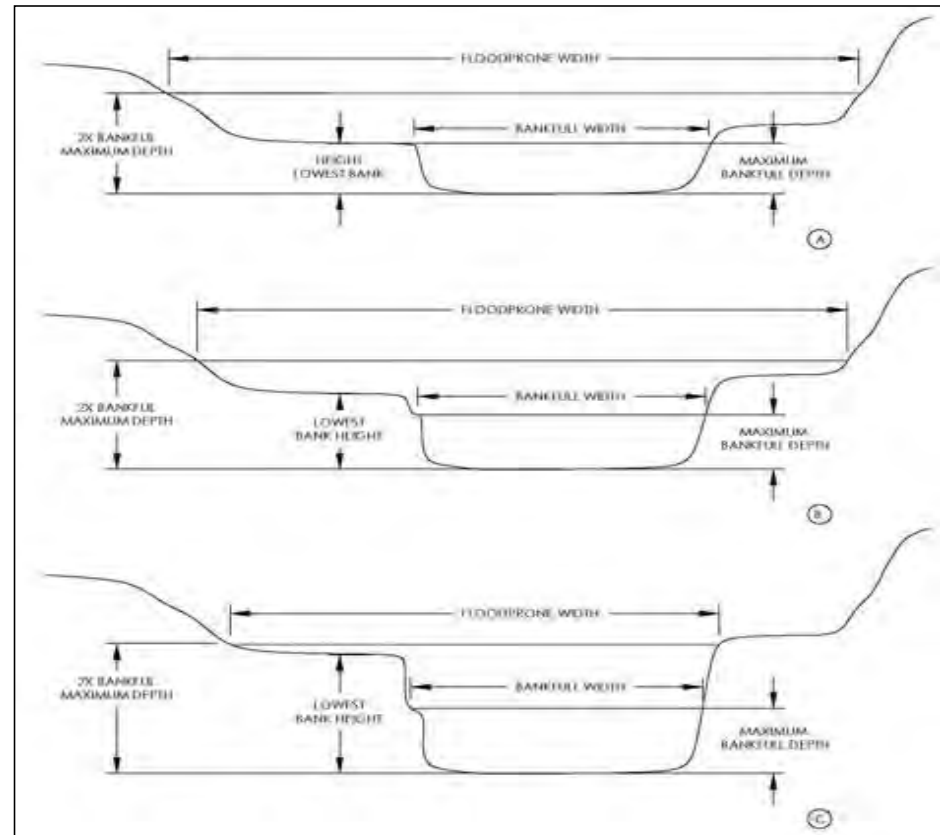
5.9

Bank Height Ratio	
$1.0 \leq 1.1$	No Incision, Stable
$>1.1 \leq 1.3$	Minor Incision, Potentially Unstable
$>1.3 < 1.5$	Moderate Incision, Moderately Unstable
$\geq 1.5$	High Incision, Highly Unstable

5.10

Floodplain Encroachment Ratio	
$1.0 \leq 1.2$	No Floodplain Encroachment, Not Incised
$>1.2 \leq 1.4$	Minor Encroachment, Potentially Unstable
$>1.4 \leq 2.0$	Moderate Encroachment, Moderately Unstable
$> 2.0$	High Encroachment, Highly Unstable

Channel Cross-Section Dimensions



## Highlands Functional Value Assessment Methodology

### Phase 2 Reach Assessment - Reference Tables

#### 5.12.1

Entrenchment Ratio (+/- 0.2)	Width-Depth Ratio (+/- 2)	Sinuosity (+/- 0.2)	Slope (%)	Rosgen Stream Type Letter Code
< 1.4 Highly Entrenched	< 12 Low	< 1.2 Low	4 – 10	A Single Channel
< 1.4 Highly Entrenched	< 12 Low	> 1.2 Low/Moderate	2 – 4	G Single Channel
< 1.4 Highly Entrenched	> 12 Moderate/High	> 1.2 Low/Moderate	< 2	F Single Channel
1.4 – 2.2 Moderately Entrenched	> 12 Moderate	> 1.2 Low/Moderate	2 – 4	B Single Channel
> 2.2 Minimally Entrenched	< 12 Very Low	> 1.5 Very High	< 2	E Single Channel
> 2.2 Minimally Entrenched	> 12 Moderate/High	> 1.2 Moderate	< 2	C Single Channel
>>2.2 Not Entrenched	> 40 Very High	< 1.2 Low	< 4	D Braided Channels

#### 5.12.2

General Size Class	Relative Size	Rosgen Stream Type Number Code
Bedrock	Bigger than a compact car	1
Boulder	Basketball to compact car	2
Cobble	Tennis ball to basketball	3
Gravel	Pepper corn to Tennis ball	4
Sand	Smaller than a pepper corn	5
Silt/Clay	Non-gritty, Smeared	6

#### 6.3

Riffle / Step Condition	
Complete	Riffles/steps completely span the channel and are perpendicular or slightly angled to the channel banks.
Incomplete (Degradation)	Riffles/steps do not completely span the channel and appear to be washed out, creating extended runs.
Extended (Aggradation)	Riffles/steps are steep and span the channel at sharp angles to the banks and may be extended or continuous.

#### 6.5

Sediment Bars	
Point	Inside meanders, unvegetated
Lateral	Channel margins, straight reaches, unvegetated
Diagonal	Sharply angled to banks
Mid-channel	In middle of channel, splitting flow
Islands	Stable, mid-channel formation, vegetated
Deltas	At confluences, sometimes fan-shaped

## Highlands Functional Value Assessment Methodology

### Phase 2 Reach Assessment - Reference Tables

6.6.4

Riffle Stability Index Values (%)	
< 70	High Stability, Optimal
70 ≤ 80	Moderate Stability, Good
80 ≤ 90	Low Stability, Fair
> 90	Very Low Stability, Poor

6.7

LWD Dimensions
Minimum length of 6 feet
Minimum diameter at the large end of 0.5 feet
Minimum diameter of 0.5 feet at a distance of 6 feet from the larger end

7.1

Bank Slope Classes	
< 30%, < 3:1	Low
30 – 50%, 3:1 – 2:1	Moderate
> 50%, > 2:1	Steep
90%	Vertical
Overhanging and eroding	Undercut / Unstable
Overhanging but not eroding	Undercut / Stable

7.2

Bank Particle Size Erosion Interpretation	
Bedrock	Very Low erodibility
Boulder	Low erodibility
Cobble	Low erodibility
Gravel	Moderate to high erodibility
Sand	High erodibility
Silt	High erodibility when non-cohesive
Clay	Low erodibility when cohesive
Mix	Varies with composition and cohesiveness

## Highlands Functional Value Assessment Methodology

### Phase 2 Reach Assessment - Reference Tables

7.3

Bank Vegetation Layers	
Trees (Canopy)	Woody with DBH* $\geq$ 3 inches and any height
Shrub / Sapling (Understory)	Woody with DBH < 3 inches and height $\geq$ 3 FT
Herbs (Groundcover)	All non-woody plants and woody plants < 3 FT
*DBH is "diameter at breast height" – approximately 4.6 ft. above the ground.	

Plant Groups		
Trees, Shrubs, Saplings, Herbs	Non-native Invasives	Trees – Black locust, Norway maple, Tree of heaven Shrubs – Honeysuckle, Japanese barberry Herbs – Japanese knotweed, Phragmites, purple loosestrife, garlic mustard Vines – oriental bittersweet
Trees	Coniferous	With needles and cones – pine, cedar, hemlock, spruce
Trees	Deciduous	Broad leaves – maple, elm, ash, sycamore, tulip
Shrubs	Shrubs	Willows, alders, dogwoods – common stream bank shrubs
Saplings	Saplings	Various
Herbs	Grasses	Native grasses, rushes, sedges
Herbs	Forbs	Native non-woody flowering plants other than grasses

8.1

Buffer Width Classes	
> 300 FT	Very Wide
300 < 50 FT	Wide
< 50 FT	Narrow
No vegetated buffer.	None

8.2

Riparian Plant Community Level 1 Score	
10% or less of riparian area is impacted by human disturbance.	High
11-25% of riparian area is impacted by human disturbance.	Moderate
More than 26% of riparian area is impacted by human disturbance.	Low

Native Mean C Interpretation	
0 – 2.4	Poor
2.5 – 3.4	Fair
3.5 – 4.5	Good
> 4.5	Optimal

## Highlands Functional Value Assessment Methodology

### Phase 2 Reach Assessment - Reference Tables

8.3

Adjacent Wetlands	
Extensive	Wetlands present over 75% of reach
Present	Wetlands present approximately 50% of reach
Minimal	Wetlands present less than 25% of reach
Absent	No wetlands present along reach
Altered	Wetlands present but have been physically disturbed.

8.4

Springs, Seeps, Small Tributaries	
Numerous	Numerous small tributaries, springs, seeps, entering the reach.
Occasional	Occasional small tributaries, springs, seeps, entering the reach.
Infrequent	Infrequent small tributaries, springs, seeps, entering the reach.
Absent	No small tributaries, springs, seeps, entering the reach.
Altered	Small tributaries, springs, seeps, entering the reach but have been physically disturbed.

8.5

Floodplain Connectivity	
Extensive	Signs of flooding or floodplain connectivity are numerous.
Present	Signs of flooding or floodplain connectivity are present.
Minimal	Signs of flooding or floodplain connectivity are minimal. Floodplain connectivity is partially limited by human encroachment.
Absent	Signs of flooding or floodplain connectivity are absent and/or Floodplain encroachment severely restricts connectivity.

## **Appendix C:**

### **Scoring Sheets**

Functional Value Assessment Methodology: Reach ID Form

FORM 1-ID

Stream Name:

Reach ID:

Location:

Date:

Town:

Observers:

Elevation:

Upstream Endpoint

Downstream Endpoint

Organization/Agency:

Latitude (N/S):

USGS Map Name:

Longitude (E/W):

Weather:

Drainage Area:

Rain Storm w/in 7 days:

Y / N

Segment Length:

# Phase 1 Watershed Assessment Scoring Sheet

FORM 2-WA

Stream Name:

Reach ID:

Watershed / Corridor Parameter	Condition Category			
	Optimal	Good	Fair	Poor
Geology	<input type="checkbox"/> Bedrock has significant stabilizing influence. <input type="checkbox"/> Unconsolidated glacial till is minimal or absent.	<input type="checkbox"/> Bedrock has some stabilizing influence. <input type="checkbox"/> Unconsolidated glacial till is present.	<input type="checkbox"/> Bedrock has minimal influence. <input type="checkbox"/> Unconsolidated glacial till is common.	<input type="checkbox"/> Bedrock has little or no stabilizing influence. <input type="checkbox"/> Unconsolidated glacial till predominates.
<b>Score:</b>	20   19   18   17   16	15   14   13   12   11	10   9   8   7   6	5   4   3   2   1
Valley Slopes	<input type="checkbox"/> Insignificant Steep Slope Impact Rating.	<input type="checkbox"/> Low Steep Slope Impact Rating.	<input type="checkbox"/> High Steep Slope Impact Rating.	<input type="checkbox"/> High Steep Slope Impact Rating.
<b>Score:</b>	20   19   18   17   16	15   14   13   12   11	10   9   8   7   6	5   4   3   2   1
Soil Runoff	<input type="checkbox"/> Low Soil Runoff Impact Rating.	<input type="checkbox"/> Moderate Soil Runoff Impact Rating.	<input type="checkbox"/> High Soil Runoff Impact Rating.	<input type="checkbox"/> Very High Soil Runoff Impact Rating.
<b>Score:</b>	20   19   18   17   16	15   14   13   12   11	10   9   8   7   6	5   4   3   2   1
Soil Erodibility	<input type="checkbox"/> Low Soil Erodibility Impact Rating.	<input type="checkbox"/> Moderate Soil Erodibility Impact Rating.	<input type="checkbox"/> High Soil Erodibility Impact Rating.	<input type="checkbox"/> Very High Soil Erodibility Impact Rating.
<b>Score:</b>	20   19   18   17   16	15   14   13   12   11	10   9   8   7   6	5   4   3   2   1
Land Use / Land Cover	<input type="checkbox"/> Insignificant Land Use / Land Cover Impact Rating. <input type="checkbox"/> Insignificant Impervious Cover Impact Rating.	<input type="checkbox"/> Low Land Use / Land Cover Impact Rating. <input type="checkbox"/> Low Impervious Cover Impact Rating.	<input type="checkbox"/> High Land Use / Land Cover Impact Rating. <input type="checkbox"/> High Impervious Cover Impact Rating.	<input type="checkbox"/> High Land Use / Land Cover Impact Rating. <input type="checkbox"/> High Impervious Cover Impact Rating.
<b>Score:</b>	20   19   18   17   16	15   14   13   12   11	10   9   8   7   6	5   4   3   2   1

Watershed

Score:

(Average the scores above; divide by 20)

Condition:

Score	Condition
0.85 - 1.0	Optimal
0.65 - 0.84	Good
0.35 - 0.64	Fair
0.00 - 0.34	Poor

# Channel Integrity Assessment for Step-Pool Reaches

FORM 3-CH1

Stream Name:

Reach ID:

For Reaches in Moderately to Highly Confined Valleys (Valley Confinement Ratio < 4)

Primarily step-pool streams; also cascade or bedrock channels; A/B channels.

Related Parameter	Condition Category			
	Optimal	Good	Fair	Poor
Phase 1 Watershed (From FORM 2-WA)	<input type="checkbox"/> Optimal Score.	<input type="checkbox"/> Good Score.	<input type="checkbox"/> Fair Score.	<input type="checkbox"/> Poor Score.
Score:	20   19   18   17   16	15   14   13   12   11	10   9   8   7   6	5   4   3   2   1
<b>General Instability</b>				
Dams / Weirs	<input type="checkbox"/> Dams / weirs are absent. <input type="checkbox"/> No evidence of historic dams.	<input type="checkbox"/> A weir present that creates limited impounded water that is not wider or deeper than the normal channel. <input type="checkbox"/> Little evidence of a historic dam.	<input type="checkbox"/> Dam / weirs present. <input type="checkbox"/> Impoundment is wider than the typical channel and contains some sediment. <input type="checkbox"/> Evidence of historic dam that may have created an elevated floodplain.	<input type="checkbox"/> Dam(s) create deep and wide impoundment that traps sediment. <input type="checkbox"/> Impoundment is >2x normal channel width and depth and contains fine sediment. <input type="checkbox"/> Clear evidence of historic dam that has left an elevated floodplain.
Beaver Dams	<input type="checkbox"/> Signs of instability are directly related to Beaver Dams.	<input type="checkbox"/> Signs of instability are related to Beaver Dams.	<input type="checkbox"/> Signs of instability are NOT related to Beaver Dams.	<input type="checkbox"/> Signs of instability are NOT related to Beaver Dams.
Bridges / Culverts	<input type="checkbox"/> Few or no bridges / culvert crossings [< 2 / mile]. <input type="checkbox"/> Typical crossing width > channel width.	<input type="checkbox"/> Some bridges / culvert crossings [2 - 3 / mile]. <input type="checkbox"/> Typical crossing width > channel width.	<input type="checkbox"/> Bridges / culvert crossings are common [ave. 4 - 6 / mile]. <input type="checkbox"/> Typical crossing width ≤ channel width.	<input type="checkbox"/> Many bridges / culvert crossings [> 6 / mile]. <input type="checkbox"/> Typical crossing width < channel width.
Stormwater Inputs	<input type="checkbox"/> No stormwater inputs observed.	<input type="checkbox"/> Few stormwater inputs. [< 10 / mile]	<input type="checkbox"/> Some stormwater inputs [10 - 25 / mile].	<input type="checkbox"/> Many stormwater inputs [> 25 / mile].
Floodplain Encroachment Ratio	<input type="checkbox"/> No Floodplain Encroachment concentrating downstream flows. <input type="checkbox"/> 1.0 < Floodplain Encroachment Ratio < 1.2	<input type="checkbox"/> Minor Floodplain Encroachment concentrating downstream flows. <input type="checkbox"/> 1.2 ≤ Floodplain Encroachment Ratio < 1.4	<input type="checkbox"/> Moderate Floodplain Encroachment concentrating downstream flows. <input type="checkbox"/> 1.4 ≤ Floodplain Encroachment Ratio < 2.0	<input type="checkbox"/> Major Floodplain Encroachment concentrating downstream flows. <input type="checkbox"/> Floodplain Encroachment Ratio > 2.0
Bank Erosion	<input type="checkbox"/> Eroded banks extend < 10% of reach.	<input type="checkbox"/> Eroded banks extend 10% < 25% of reach.	<input type="checkbox"/> Eroded banks extend 25% < 50% of reach.	<input type="checkbox"/> Eroded banks extend ≥ 50% of reach.
Bank Armoring / Channel Straightening	<input type="checkbox"/> No evidence of bank armoring / channel straightening.	<input type="checkbox"/> Bank armoring extends 10% < 25% of reach. <input type="checkbox"/> Channel straightening < 10% of reach.	<input type="checkbox"/> Bank armoring extends 25% < 50% of reach. <input type="checkbox"/> Channel straightening < 25% of reach.	<input type="checkbox"/> Bank armoring extends ≥ 50% of reach. <input type="checkbox"/> Channel straightening ≥ 25% of reach.
General Score:	20   19   18   17   16	15   14   13   12   11	10   9   8   7   6	5   4   3   2   1

# Channel Integrity Assessment for Step-Pool Reaches

FORM 3-CH1

Stream Name:

Reach ID:

Degradation	Optimal	Good	Fair	Poor
Bridges / Culverts	<input type="checkbox"/> No bed and bank erosion associated with bridges/culverts. <input type="checkbox"/> Bridge foundations are not exposed; culverts are not perched.	<input type="checkbox"/> Adjacent bed and bank erosion are minor and confined to immediately upstream or downstream of crossings. <input type="checkbox"/> Bridge foundations are not exposed; culverts are not perched.	<input type="checkbox"/> Adjacent bed and bank erosion is moderate and typical. <input type="checkbox"/> Some bridge foundations are exposed; some culverts are perched.	<input type="checkbox"/> Adjacent bed and bank erosion is severe and extensive. <input type="checkbox"/> Most bridge foundations are exposed or undermined; most culverts are perched.
Stormwater Inputs		<input type="checkbox"/> Stormwater outfalls do not appear to be perched above the streambed.	<input type="checkbox"/> Stormwater outfalls are perched above the streambed. <input type="checkbox"/> Some stormwater ditches have headcuts.	<input type="checkbox"/> Stormwater outfalls are perched above the streambed. <input type="checkbox"/> Headwalls have been undermined and are collapsing into the channel. <input type="checkbox"/> Stormwater ditches have headcuts.
Bank Height Ratio	<input type="checkbox"/> $1.0 \leq \text{Bank Height Ratio} < 1.1$ <b>and</b> <input type="checkbox"/> Where Channel Slope $< 4\%$ , Entrenchment Ratio $> 1.4$ ; <input type="checkbox"/> Where Channel Slope $\geq 4\%$ , Entrenchment Ratio $> 1.2$ .	<input type="checkbox"/> $1.1 \leq \text{Bank Height Ratio} < 1.3$ <b>and</b> <input type="checkbox"/> Where Channel Slope $< 4\%$ , Entrenchment Ratio $> 1.4$ ; <input type="checkbox"/> Where Channel Slope $\geq 4\%$ , Entrenchment Ratio $> 1.2$ .	<input type="checkbox"/> $1.3 \leq \text{Bank Height Ratio} < 1.5$ <b>and</b> <input type="checkbox"/> Where Channel Slope $< 4\%$ , Entrenchment Ratio $> 1.4$ ; <input type="checkbox"/> Where Channel Slope $\geq 4\%$ , Entrenchment Ratio $> 1.2$ .	<input type="checkbox"/> Bank Height Ratio $\geq 1.5$ <b>and</b> <input type="checkbox"/> Where Channel Slope $< 4\%$ , Entrenchment Ratio $\leq 1.4$ ; <input type="checkbox"/> Where Channel Slope $\geq 4\%$ , Entrenchment Ratio $\leq 1.2$ .

# Channel Integrity Assessment for Step-Pool Reaches

FORM 3-CH1

Stream Name:

Reach ID:

Dominant Particle Size Class	<input type="checkbox"/> Stream substrate is compact and resistant to erosion. <input type="checkbox"/> Dominant particle size class is cobble, boulder or bedrock.	<input type="checkbox"/> Stream substrate is compact and resistant to erosion. <input type="checkbox"/> Dominant particle size class is cobble, boulder or bedrock.	<input type="checkbox"/> Stream substrate is not compact and prone to erosion. <input type="checkbox"/> Dominant particle size class is fine gravel or sand.	<input type="checkbox"/> Stream substrate is not compact and prone to erosion. <input type="checkbox"/> Dominant particle size class is fine gravel or sand.
Bedrock Grade Controls	<input type="checkbox"/> Bedrock grade controls are present, preventing further channel degradation.	<input type="checkbox"/> Bedrock grade controls are present, preventing further channel degradation.	<input type="checkbox"/> Bedrock grade controls are absent, allowing channel degradation.	<input type="checkbox"/> Bedrock grade controls are absent, allowing channel degradation.
Headcuts	<input type="checkbox"/> No headcuts. <input type="checkbox"/> Substrates are compact and stable. <input type="checkbox"/> No signs of historic incision.	<input type="checkbox"/> No headcuts. <input type="checkbox"/> Signs of historic incision: sharp changes of slope / steep riffles.	<input type="checkbox"/> Headcut seen in the main channel and some tributaries. <input type="checkbox"/> Signs of recent incision: sharp changes in slope / steep riffles.	<input type="checkbox"/> Multiple headcuts in the main channel and tributaries. <input type="checkbox"/> Signs of active incision: substrates are loose and actively eroding at headcuts.
Bank Slope	<input type="checkbox"/> Bank slopes are typically low.	<input type="checkbox"/> Bank slopes are typically moderate.	<input type="checkbox"/> Banks are typically steep or vertical.	<input type="checkbox"/> Banks are typically vertical.
Bank Materials	<input type="checkbox"/> No subsoil layers exposed in the banks.	<input type="checkbox"/> Few banks with exposed subsoil layers.	<input type="checkbox"/> Subsoil layers clearly exposed in banks.	<input type="checkbox"/> Former streambed materials clearly exposed in banks.
Meander Cutoffs, Channel Avulsions	<input type="checkbox"/> No evidence of historic or recent meander cutoffs or channel avulsions.	<input type="checkbox"/> Some evidence of historic, not recent, meander cutoffs or channel avulsions.	<input type="checkbox"/> Evidence of recent meander cutoffs or channel avulsions.	<input type="checkbox"/> Evidence of recent and/or impending meander cutoffs or channel avulsions.
<b>Degradation Score:</b>	20   19   18   17   16	15   14   13   12   11	10   9   8   7   6	5   4   3   2   1

# Channel Integrity Assessment for Step-Pool Reaches

FORM 3-CH1

Stream Name:

Reach ID:

Aggradation	Optimal	Good	Fair	Poor
Bridges / Culverts	<input type="checkbox"/> No sediment deposition upstream of crossings. <input type="checkbox"/> No sediment deposition downstream of crossings. <input type="checkbox"/> Bridge / Culvert openings are not blocked by sediment.	<input type="checkbox"/> Some sediment deposition upstream of crossings. <input type="checkbox"/> Some sediment deposition downstream of crossings. <input type="checkbox"/> Bridge / Culvert openings are not blocked by sediment.	<input type="checkbox"/> Moderate sediment deposition upstream of crossings. <input type="checkbox"/> Moderate sediment deposition downstream of crossings. <input type="checkbox"/> Bridge / Culvert openings are partially blocked by sediment.	<input type="checkbox"/> Significant sediment deposition upstream of crossings. <input type="checkbox"/> Significant sediment deposition downstream of crossings. <input type="checkbox"/> Bridge / Culvert openings are blocked by sediment.
Stormwater Inputs	<input type="checkbox"/> No stormwater inputs observed.	<input type="checkbox"/> Minor sediment deposition at stormwater outfalls.	<input type="checkbox"/> Moderate sediment deposition at stormwater outfalls. <input type="checkbox"/> Multiple stormwater outfalls are partially buried in sediment. <input type="checkbox"/> Multiple stormwater ditches are partially filled with sediment finer than bed.	<input type="checkbox"/> Extensive sediment deposition at stormwater outfalls. <input type="checkbox"/> Stormwater outfalls are partially buried in sediment. <input type="checkbox"/> Stormwater ditches are partially filled with sediment finer than bed.
Channel Dimensions	Low Width-Depth Ratio <input type="checkbox"/> $\leq 20$ , where Channel Slope < 4% <input type="checkbox"/> $\leq 12$ , where Channel Slope $\geq 4\%$	Low to Moderate Width-Depth Ratio <input type="checkbox"/> $>20 \leq 30$ , where Channel Slope < 4% <input type="checkbox"/> $>12 \leq 20$ , where Channel Slope $\geq 4\%$	Moderate to High Width-Depth Ratio <input type="checkbox"/> $>30 \leq 40$ , where Channel Slope < 4% <input type="checkbox"/> $>20 \leq 30$ , where Channel Slope $\geq 4\%$	High Width-Depth Ratio <input type="checkbox"/> $> 40$ , where Channel Slope < 4% <input type="checkbox"/> $> 30$ , where Channel Slope $\geq 4\%$

# Channel Integrity Assessment for Step-Pool Reaches

FORM 3-CH1

Stream Name:

Reach ID:

Step-Pool Condition	<input type="checkbox"/> All steps are well formed, complete and stable. <input type="checkbox"/> < 10% pools are < 2 FT deep. <input type="checkbox"/> No pools are filled with sediment.	<input type="checkbox"/> Steps are moderately well formed, complete and stable. 10% < 25% pools are: <input type="checkbox"/> < 2 FT deep. <input type="checkbox"/> filled with sediment finer than dominant particle size.	<input type="checkbox"/> Steps are not clearly formed creating plane bed features. 25% < 50% pools are: <input type="checkbox"/> < 2 FT deep. <input type="checkbox"/> filled with sediment finer than dominant particle size.	<input type="checkbox"/> Steps are not clearly formed creating plane bed features. > 50% pools are: <input type="checkbox"/> < 2 FT deep <input type="checkbox"/> filled with sediment finer than dominant particle size.
Sediment Bars	<input type="checkbox"/> Few or no lateral, diagonal, mid-channel bars. <input type="checkbox"/> Lateral bars and deltas in typical positions. <input type="checkbox"/> Sediment bars less than bankfull height.	<input type="checkbox"/> Some lateral, diagonal, mid-channel bars. <input type="checkbox"/> Lateral bars and deltas in typical positions. <input type="checkbox"/> Sediment bars composed of sediment similar to dominant substrate. <input type="checkbox"/> Sediment bars less than bankfull height.	<input type="checkbox"/> Multiple lateral, diagonal, mid-channel bars, or deltas. <input type="checkbox"/> Sediment bars composed of sediment different than dominant substrate. <input type="checkbox"/> Sediment bars are greater than bankfull height and/or longer than a channel width.	<input type="checkbox"/> Many lateral, diagonal, mid-channel bars, or deltas. <input type="checkbox"/> Sediment bars composed of sediment finer than dominant substrate. <input type="checkbox"/> Sediment bars above bankfull elevation and/or multiple channel widths in length. <input type="checkbox"/> Sediment bars split flow in multiple paths.
Embeddedness	<input type="checkbox"/> Coarse gravels, cobbles, boulders are not embedded in finer sediments. <input type="checkbox"/> Embeddedness < 25%.	<input type="checkbox"/> Coarse gravels, cobbles, boulders are not embedded in finer sediments. <input type="checkbox"/> 25% < Embeddedness < 50%.	<input type="checkbox"/> Coarse gravels, cobbles, boulders are embedded in finer sediments. <input type="checkbox"/> 50% ≤ Embeddedness < 75%.	<input type="checkbox"/> Coarse gravels, cobbles, boulders are heavily embedded in finer sediments. <input type="checkbox"/> Embeddedness ≥ 75%.
Braiding	<input type="checkbox"/> No channel braiding.	<input type="checkbox"/> No channel braiding.	<input type="checkbox"/> Channel braiding present.	<input type="checkbox"/> Channel braiding extensive throughout reach.
<b>Aggradation Score:</b>	20   19   18   17   16	15   14   13   12   11	10   9   8   7   6	5   4   3   2   1

# Channel Integrity Assessment for Step-Pool Reaches

FORM 3-CH1

Stream Name:

Reach ID:

Widening	Optimal	Good	Fair	Poor
Stormwater Inputs	<input type="checkbox"/> No stormwater inputs observed.	<input type="checkbox"/> Stormwater outfalls do not appear to extending out from the banks.	<input type="checkbox"/> Stormwater outfalls are extending out from the banks.	<input type="checkbox"/> Stormwater outfalls are extending out from the banks. <input type="checkbox"/> Headwalls have been undermined and are collapsing into the channel.
Width-Depth Ratio	Low Width-Depth Ratio <input type="checkbox"/> < 20, where Channel Slope < 4% <input type="checkbox"/> < 10, where Channel Slope > 4%	Low to Moderate Width-Depth Ratio <input type="checkbox"/> >20 ≤ 30, where Channel Slope < 4% <input type="checkbox"/> >10 ≤ 12, where Channel Slope > 4%	Moderate to High Width-Depth Ratio <input type="checkbox"/> >30 ≤ 40, where Channel Slope < 4% <input type="checkbox"/> >12 ≤ 20, where Channel Slope > 4%	Moderate to High Width-Depth Ratio <input type="checkbox"/> > 40, where Channel Slope < 4% <input type="checkbox"/> > 20, where Channel Slope > 4%
Sediment Bars	<input type="checkbox"/> Few or no lateral, diagonal, mid-channel bars. <input type="checkbox"/> Lateral bars and deltas in typical positions. <input type="checkbox"/> Sediment bars at or below bankfull height.	<input type="checkbox"/> Some lateral, diagonal, mid-channel bars. <input type="checkbox"/> Lateral bars and deltas in typical positions. <input type="checkbox"/> Sediment bars composed of sediment similar to dominant substrate. <input type="checkbox"/> Sediment bars at or below bankfull height.	<input type="checkbox"/> Multiple lateral, diagonal, mid-channel bars, or deltas. <input type="checkbox"/> Sediment bars composed of sediment different than dominant substrate. <input type="checkbox"/> Sediment bars are greater than bankfull height and/or longer than a channel width.	<input type="checkbox"/> Many lateral, diagonal, mid-channel bars, or deltas. <input type="checkbox"/> Sediment bars composed of sediment finer than dominant substrate. <input type="checkbox"/> Sediment bars above bankfull elevation and/or multiple channel widths in length. <input type="checkbox"/> Sediment bars split flow in multiple paths.
Bank Materials	<input type="checkbox"/> Bank materials have low or very low erodibility. <input type="checkbox"/> Bank materials are cohesive.	<input type="checkbox"/> Bank materials have low or moderate erodibility. <input type="checkbox"/> Bank materials are cohesive.	<input type="checkbox"/> Bank materials have moderate or high erodibility. <input type="checkbox"/> Bank materials are non-cohesive.	<input type="checkbox"/> Bank materials have high erodibility. <input type="checkbox"/> Bank materials are non-cohesive.
Bank Erosion	<input type="checkbox"/> No erosion on opposing banks; overhanging banks are stable. <input type="checkbox"/> Occasional leaning trees and no recently exposed roots.	<input type="checkbox"/> Minimal erosion at the base of opposing banks; overhanging banks are stable. <input type="checkbox"/> Some leaning trees and few recently exposed roots.	<input type="checkbox"/> Extensive erosion at the base of both banks creating unstable overhangs. <input type="checkbox"/> Many leaning trees, recently exposed roots and/or fracture lines.	<input type="checkbox"/> Continuous, extensive erosion at the base of both banks creating unstable overhangs. <input type="checkbox"/> Continuous leaning trees, recently exposed roots and/or fracture lines.
<b>Widening Score:</b>	20   19   18   17   16	15   14   13   12   11	10   9   8   7   6	5   4   3   2   1

# Channel Integrity Assessment for Step-Pool Reaches

FORM 3-CH1

Stream Name: \_\_\_\_\_

Reach ID: \_\_\_\_\_

Re-alignment	Optimal	Good	Fair	Poor
Bridges / Culverts	<input type="checkbox"/> Channel is aligned with bridge / culvert openings.	<input type="checkbox"/> Channel is aligned with bridge / culvert openings.	<input type="checkbox"/> Channel is askew to bridge / culvert openings.	<input type="checkbox"/> Channel makes tight meander at bridge / culvert openings.
Sinuosity	<input type="checkbox"/> No change in sinuosity.	<input type="checkbox"/> May accompany minor change in sinuosity.	<input type="checkbox"/> May accompany moderate change in sinuosity.	<input type="checkbox"/> May accompany major change in sinuosity.
Bank Erosion	<input type="checkbox"/> Typical bank erosion on outside meander bends. <input type="checkbox"/> Overhangs are stable. No slumping. <input type="checkbox"/> Few leaning trees, no recently exposed roots. No fracture lines.	<input type="checkbox"/> Typical bank erosion on outside meander bends. <input type="checkbox"/> Overhangs are stable. Little slumping. <input type="checkbox"/> Few leaning trees, recently exposed roots. No fracture lines.	<input type="checkbox"/> Moderate to high bank erosion on many outside meander bends creating unstable overhangs. <input type="checkbox"/> Multiple leaning trees, recently exposed roots and/or fracture lines.	<input type="checkbox"/> Extensive, severe bank erosion on outside meander bends creating unstable overhangs and/or slumping. <input type="checkbox"/> Numerous leaning trees, recently exposed roots and/or fracture lines.
Flood chutes, Meander Cutoffs, Braiding, Channel Avulsions	<input type="checkbox"/> Limited potential for channel avulsions. <input type="checkbox"/> No evidence of historic or recent channel avulsions.	<input type="checkbox"/> Limited potential for channel avulsions. <input type="checkbox"/> 10% < 25% of reach exhibits historic or recent channel avulsions.	<input type="checkbox"/> Flood chutes, meander cutoffs, and braiding potentially leading to channel avulsions. <input type="checkbox"/> 25% < 50% of reach exhibits historic or recent channel avulsions.	<input type="checkbox"/> Flood chutes, meander cutoffs, braiding causing channel avulsions. <input type="checkbox"/> ≥ 50% of reach exhibits historic or recent channel avulsions.
<b>Re-alignment Score:</b>	20   19   18   17   16	15   14   13   12   11	10   9   8   7   6	5   4   3   2   1

**Watershed Score:** \_\_\_\_\_

**General Instability**

**Score:** \_\_\_\_\_

**Degradation Score:** \_\_\_\_\_

**Aggradation Score:** \_\_\_\_\_

**Widening Score:** \_\_\_\_\_

**Re-alignment Score:** \_\_\_\_\_

**Channel Integrity**

**Score:**

(Average the scores above; divide by 20)

**Channel Integrity**

**Condition:**

**Channel Sensitivity:** \_\_\_\_\_

(Refer to Item 11.1.4 from Phase 2)

Score	Condition
0.85 - 1.0	Optimal
0.65 - 0.84	Good
0.35 - 0.64	Fair
0.00 - 0.34	Poor

# Channel Integrity Assessment for Pool-Riffle Reaches

FORM 3-CH2

Stream Name:

Reach ID:

For Reaches in Minimally Confined to Broad Valleys (Valley Confinement Ratio  $\geq 4$ )

Primarily pool-riffle streams; C/E channels; some B channels.

Related Parameter	Condition Category																			
	Optimal					Good					Fair					Poor				
Phase 1 Watershed (From FORM 2-WA)	<input type="checkbox"/> Optimal Score.					<input type="checkbox"/> Good Score.					<input type="checkbox"/> Fair Score.					<input type="checkbox"/> Poor Score.				
Score:	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
<b>General Instability</b>																				
Dams / Weirs	<input type="checkbox"/> Dams / weirs are absent. <input type="checkbox"/> No evidence of historic dams.					<input type="checkbox"/> A weir present that creates limited impounded water that is not wider or deeper than the normal channel. <input type="checkbox"/> Little evidence of a historic dam.					<input type="checkbox"/> Dam / weirs present. <input type="checkbox"/> Impoundment is wider than the typical channel and contains some sediment. <input type="checkbox"/> Evidence of historic dam that may have created an elevated floodplain.					<input type="checkbox"/> Dam(s) create deep and wide impoundment that traps sediment. <input type="checkbox"/> Impoundment is >2x normal channel width and depth and contains fine sediment. <input type="checkbox"/> Clear evidence of historic dam that has left an elevated floodplain.				
Beaver Dams	<input type="checkbox"/> Signs of instability are directly related to Beaver Dams.					<input type="checkbox"/> Signs of instability are related to Beaver Dams.					<input type="checkbox"/> Signs of instability are NOT related to Beaver Dams.					<input type="checkbox"/> Signs of instability are NOT related to Beaver Dams.				
Bridges / Culverts	<input type="checkbox"/> Few or no bridges / culvert crossings [ $< 2$ / mile]. <input type="checkbox"/> Typical crossing width $>$ channel width.					<input type="checkbox"/> Some bridges / culvert crossings [2 - 3 / mile]. <input type="checkbox"/> Typical crossing width $>$ channel width.					<input type="checkbox"/> Bridges / culvert crossings are common [ave. 4 - 6 / mile]. <input type="checkbox"/> Typical crossing width $\leq$ channel width.					<input type="checkbox"/> Many bridges / culvert crossings [ $> 6$ / mile]. <input type="checkbox"/> Typical crossing width $<$ channel width.				
Stormwater Inputs	<input type="checkbox"/> No stormwater inputs observed.					<input type="checkbox"/> Few stormwater inputs. [ $< 10$ / mile]					<input type="checkbox"/> Some stormwater inputs [10 - 25 / mile].					<input type="checkbox"/> Many stormwater inputs [ $> 25$ / mile].				
Floodplain Encroachment Ratio	<input type="checkbox"/> No Floodplain Encroachment concentrating downstream flows. <input type="checkbox"/> $1.0 <$ Floodplain Encroachment Ratio $< 1.2$					<input type="checkbox"/> Minor Floodplain Encroachment concentrating downstream flows. <input type="checkbox"/> $1.2 \leq$ Floodplain Encroachment Ratio $< 1.4$					<input type="checkbox"/> Moderate Floodplain Encroachment concentrating downstream flows. <input type="checkbox"/> $1.4 \leq$ Floodplain Encroachment Ratio $< 2.0$					<input type="checkbox"/> Major Floodplain Encroachment concentrating downstream flows. <input type="checkbox"/> Floodplain Encroachment Ratio $> 2.0$				
Bank Erosion	<input type="checkbox"/> Eroded banks extend $< 10\%$ of reach.					<input type="checkbox"/> Eroded banks extend $10\% < 25\%$ of reach.					<input type="checkbox"/> Eroded banks extend $25\% < 50\%$ of reach.					<input type="checkbox"/> Eroded banks extend $\geq 50\%$ of reach.				
Bank Armoring / Channel Straightening	<input type="checkbox"/> No evidence of bank armoring / channel straightening.					<input type="checkbox"/> Bank armoring extends $10\% < 25\%$ of reach. <input type="checkbox"/> Channel straightening $< 10\%$ of reach.					<input type="checkbox"/> Bank armoring extends $25\% < 50\%$ of reach. <input type="checkbox"/> Channel straightening $< 25\%$ of reach.					<input type="checkbox"/> Bank armoring extends $\geq 50\%$ of reach. <input type="checkbox"/> Channel straightening $\geq 25\%$ of reach.				
General Score:	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1

# Channel Integrity Assessment for Pool-Riffle Reaches

FORM 3-CH2

Stream Name:

Reach ID:

Degradation	Optimal	Good	Fair	Poor
Bridges / Culverts	<input type="checkbox"/> No bed and bank erosion associated with bridges/culverts. <input type="checkbox"/> Bridge foundations are not exposed; culverts are not perched.	<input type="checkbox"/> Adjacent bed and bank erosion are minor and confined to immediately upstream or downstream of crossings. <input type="checkbox"/> Bridge foundations are not exposed; culverts are not perched.	<input type="checkbox"/> Adjacent bed and bank erosion is moderate and typical. <input type="checkbox"/> Some bridge foundations are exposed; some culverts are perched.	<input type="checkbox"/> Adjacent bed and bank erosion is severe and extensive. <input type="checkbox"/> Most bridge foundations are exposed or undermined; most culverts are perched.
Stormwater Inputs		<input type="checkbox"/> Stormwater outfalls do not appear to be perched above the streambed.	<input type="checkbox"/> Stormwater outfalls are perched above the streambed. <input type="checkbox"/> Some stormwater ditches have headcuts.	<input type="checkbox"/> Stormwater outfalls are perched above the streambed. <input type="checkbox"/> Headwalls have been undermined and are collapsing into the channel. <input type="checkbox"/> Stormwater ditches have headcuts.
Bank Height Ratio	<input type="checkbox"/> $1.0 \leq \text{Bank Height Ratio} < 1.1$ <b>and</b> <input type="checkbox"/> Entrenchment Ratio $> 2.0$	<input type="checkbox"/> $1.1 \leq \text{Bank Height Ratio} < 1.3$ <b>and</b> <input type="checkbox"/> Entrenchment Ratio $> 2.0$	<input type="checkbox"/> $1.3 \leq \text{Bank Height Ratio} < 1.5$ <b>and</b> <input type="checkbox"/> Entrenchment Ratio $> 2.0$	<input type="checkbox"/> Bank Height Ratio $\geq 1.5$ <b>or</b> <input type="checkbox"/> Entrenchment Ratio $\leq 2.0$
Dominant Particle Size Class	<input type="checkbox"/> Stream substrate is compact and resistant to erosion. <input type="checkbox"/> Dominant particle size class is cobble, boulder or bedrock.	<input type="checkbox"/> Stream substrate is compact and resistant to erosion. <input type="checkbox"/> Dominant particle size class is cobble, boulder or bedrock.	<input type="checkbox"/> Stream substrate is not compact and prone to erosion. <input type="checkbox"/> Dominant particle size class is fine gravel or sand.	<input type="checkbox"/> Stream substrate is not compact and prone to erosion. <input type="checkbox"/> Dominant particle size class is fine gravel or sand.
Bedrock Grade Controls	<input type="checkbox"/> Bedrock grade controls are present, preventing further channel degradation.	<input type="checkbox"/> Bedrock grade controls are present, preventing further channel degradation.	<input type="checkbox"/> Bedrock grade controls are absent, allowing channel degradation.	<input type="checkbox"/> Bedrock grade controls are absent, allowing channel degradation.
Headcuts	<input type="checkbox"/> No headcuts. <input type="checkbox"/> Substrates are compact and stable. <input type="checkbox"/> No signs of historic incision.	<input type="checkbox"/> No headcuts. <input type="checkbox"/> Signs of historic incision: sharp changes of slope / steep riffles.	<input type="checkbox"/> Headcut seen in the main channel and some tributaries. <input type="checkbox"/> Signs of recent incision: sharp changes in slope / steep riffles.	<input type="checkbox"/> Multiple headcuts in the main channel and tributaries. <input type="checkbox"/> Signs of active incision: substrates are loose and actively eroding at headcuts.
Bank Slope	<input type="checkbox"/> Bank slopes are typically low.	<input type="checkbox"/> Bank slopes are typically moderate.	<input type="checkbox"/> Banks are typically steep or vertical.	<input type="checkbox"/> Banks are typically vertical.
Bank Materials	<input type="checkbox"/> No subsoil layers exposed in the banks.	<input type="checkbox"/> Few banks with exposed subsoil layers.	<input type="checkbox"/> Subsoil layers clearly exposed in banks.	<input type="checkbox"/> Former streambed materials clearly exposed in banks.
Meander Cutoffs, Channel Avulsions	<input type="checkbox"/> No evidence of historic or recent meander cutoffs or channel avulsions.	<input type="checkbox"/> Some evidence of historic, not recent, meander cutoffs or channel avulsions.	<input type="checkbox"/> Evidence of recent meander cutoffs or channel avulsions.	<input type="checkbox"/> Evidence of recent and/or impending meander cutoffs or channel avulsions.
<b>Degradation Score:</b>	20   19   18   17   16	15   14   13   12   11	10   9   8   7   6	5   4   3   2   1

# Channel Integrity Assessment for Pool-Riffle Reaches

FORM 3-CH2

Stream Name:

Reach ID:

Aggradation		Optimal	Good	Fair	Poor
Bridges / Culverts		<input type="checkbox"/> No sediment deposition upstream of crossings. <input type="checkbox"/> No sediment deposition downstream of crossings. <input type="checkbox"/> Bridge / Culvert openings are not blocked by sediment.	<input type="checkbox"/> Some sediment deposition upstream of crossings. <input type="checkbox"/> Some sediment deposition downstream of crossings. <input type="checkbox"/> Bridge / Culvert openings are not blocked by sediment.	<input type="checkbox"/> Moderate sediment deposition upstream of crossings. <input type="checkbox"/> Moderate sediment deposition downstream of crossings. <input type="checkbox"/> Bridge / Culvert openings are partially blocked by sediment.	<input type="checkbox"/> Significant sediment deposition upstream of crossings. <input type="checkbox"/> Significant sediment deposition downstream of crossings. <input type="checkbox"/> Bridge / Culvert openings are buried in sediment.
Stormwater Inputs		<input type="checkbox"/> No stormwater inputs observed.	<input type="checkbox"/> Minor sediment deposition at stormwater outfalls.	<input type="checkbox"/> Moderate sediment deposition at stormwater outfalls. <input type="checkbox"/> Multiple stormwater outfalls are partially buried in sediment. <input type="checkbox"/> Multiple stormwater ditches are partially filled with sediment finer than bed.	<input type="checkbox"/> Extensive sediment deposition at stormwater outfalls. <input type="checkbox"/> Stormwater outfalls are partially buried in sediment. <input type="checkbox"/> Stormwater ditches are partially filled with sediment finer than bed.
Channel Dimensions		Low Width-Depth Ratio <input type="checkbox"/> $\leq 20$ for C or B channels <input type="checkbox"/> $\leq 10$ for E channels	Low to Moderate Width-Depth Ratio <input type="checkbox"/> $>20 \leq 30$ for C or B channels <input type="checkbox"/> $>10 \leq 12$ for E channels	Moderate to High Width-Depth Ratio <input type="checkbox"/> $>30 \leq 40$ for C or B channels <input type="checkbox"/> $>12 \leq 20$ for E channels	High Width-Depth Ratio <input type="checkbox"/> $> 40$ for C or B channels <input type="checkbox"/> $> 20$ for E channels
Pool-Riffle Condition		<input type="checkbox"/> All Pool-Riffles are well formed, complete and stable. <input type="checkbox"/> $< 10\%$ pools are $< 2$ FT deep. <input type="checkbox"/> No pools are filled with sediment.	<input type="checkbox"/> Pool-Riffles are moderately well formed, complete and stable. <input type="checkbox"/> $10\% < 25\%$ pools are: <input type="checkbox"/> $< 2$ FT deep. <input type="checkbox"/> filled with sediment finer than dominant particle size.	<input type="checkbox"/> Pool-Riffles are not clearly formed creating plane bed features. <input type="checkbox"/> $25\% < 50\%$ pools are: <input type="checkbox"/> $< 2$ FT deep. <input type="checkbox"/> filled with sediment finer than dominant particle size.	<input type="checkbox"/> Pool-Riffles are not clearly formed creating plane bed features. <input type="checkbox"/> $> 50\%$ pools are: <input type="checkbox"/> $< 2$ FT deep. <input type="checkbox"/> filled with sediment finer than dominant particle size.

# Channel Integrity Assessment for Pool-Riffle Reaches

FORM 3-CH2

Stream Name:

Reach ID:

Sediment Bars	<input type="checkbox"/> Few or no lateral, diagonal, mid-channel bars. <input type="checkbox"/> Lateral bars and deltas in typical positions. <input type="checkbox"/> Sediment bars less than bankfull height.	<input type="checkbox"/> Some lateral, diagonal, mid-channel bars. <input type="checkbox"/> Lateral bars and deltas in typical positions. <input type="checkbox"/> Sediment bars composed of sediment similar to dominant substrate. <input type="checkbox"/> Sediment bars at or below bankfull height.	<input type="checkbox"/> Multiple lateral, diagonal, mid-channel bars, or deltas. <input type="checkbox"/> Sediment bars composed of sediment different than dominant substrate. <input type="checkbox"/> Sediment bars are greater than bankfull height and/or longer than a channel width.	<input type="checkbox"/> Many lateral, diagonal, mid-channel bars, or deltas. <input type="checkbox"/> Sediment bars composed of sediment finer than dominant substrate. <input type="checkbox"/> Sediment bars above bankfull elevation and/or multiple channel widths in length. <input type="checkbox"/> Sediment bars split flow in multiple paths.
Embeddedness	<input type="checkbox"/> Coarse gravels, cobbles, boulders are not embedded in finer sediments. <input type="checkbox"/> Embeddedness < 25%.	<input type="checkbox"/> Coarse gravels, cobbles, boulders are not embedded in finer sediments. <input type="checkbox"/> 25% < Embeddedness < 50%.	<input type="checkbox"/> Coarse gravels, cobbles, boulders are embedded in finer sediments. <input type="checkbox"/> 50% ≤ Embeddedness < 75%.	<input type="checkbox"/> Coarse gravels, cobbles, boulders are heavily embedded in finer sediments. <input type="checkbox"/> Embeddedness ≥ 75%.
Braiding	<input type="checkbox"/> No channel braiding.	<input type="checkbox"/> No channel braiding.	<input type="checkbox"/> Channel braiding present.	<input type="checkbox"/> Channel braiding extensive throughout reach.
<b>Aggradation Score:</b>	20   19   18   17   16	15   14   13   12   11	10   9   8   7   6	5   4   3   2   1

# Channel Integrity Assessment for Pool-Riffle Reaches

FORM 3-CH2

Stream Name:

Reach ID:

Widening	Optimal	Good	Fair	Poor
Stormwater Inputs	<input type="checkbox"/> No stormwater inputs observed.	<input type="checkbox"/> Stormwater outfalls do not appear to extending out from the banks.	<input type="checkbox"/> Stormwater outfalls are extending out from the banks.	<input type="checkbox"/> Stormwater outfalls are extending out from the banks. <input type="checkbox"/> Headwalls have been undermined and are collapsing into the channel.
Width-Depth Ratio	Low Width-Depth Ratio <input type="checkbox"/> < 20 for C or B channels <input type="checkbox"/> < 10 for E channels	Low to Moderate Width-Depth Ratio <input type="checkbox"/> >20 ≤ 30 for C or B channels <input type="checkbox"/> >10 ≤ 12 for E channels	Moderate to High Width-Depth Ratio <input type="checkbox"/> >30 ≤ 40 for C or B channels <input type="checkbox"/> >12 ≤ 20 for E channels	Moderate to High Width-Depth Ratio <input type="checkbox"/> > 40 for C or B channels <input type="checkbox"/> > 20 for E channels
Sediment Bars	<input type="checkbox"/> Few or no lateral, diagonal, mid-channel bars. <input type="checkbox"/> Lateral bars and deltas in typical positions. <input type="checkbox"/> Sediment bars below bankfull height.	<input type="checkbox"/> Some lateral, diagonal, mid-channel bars. <input type="checkbox"/> Lateral bars and deltas in typical positions. <input type="checkbox"/> Sediment bars composed of sediment similar to dominant substrate. <input type="checkbox"/> Sediment bars at or below bankfull height.	<input type="checkbox"/> Multiple lateral, diagonal, mid-channel bars, or deltas. <input type="checkbox"/> Sediment bars composed of sediment different than dominant substrate. <input type="checkbox"/> Sediment bars are greater than bankfull height and/or longer than a channel width.	<input type="checkbox"/> Many lateral, diagonal, mid-channel bars, or deltas. <input type="checkbox"/> Sediment bars composed of sediment finer than dominant substrate. <input type="checkbox"/> Sediment bars above bankfull elevation and/or multiple channel widths in length. <input type="checkbox"/> Sediment bars split flow in multiple paths.
Bank Materials	<input type="checkbox"/> Bank materials have low or very low erodibility. <input type="checkbox"/> Bank materials are cohesive.	<input type="checkbox"/> Bank materials have low or moderate erodibility. <input type="checkbox"/> Bank materials are cohesive.	<input type="checkbox"/> Bank materials have moderate or high erodibility. <input type="checkbox"/> Bank materials are non-cohesive.	<input type="checkbox"/> Bank materials have high erodibility. <input type="checkbox"/> Bank materials are non-cohesive.
Bank Erosion	<input type="checkbox"/> No erosion on opposing banks; overhanging banks are stable. <input type="checkbox"/> Occasional leaning trees and no recently exposed roots.	<input type="checkbox"/> Minimal erosion at the base of opposing banks; overhanging banks are stable. <input type="checkbox"/> Some leaning trees and few recently exposed roots.	<input type="checkbox"/> Moderate erosion at the base of both banks creating unstable overhangs. <input type="checkbox"/> Many leaning trees, recently exposed roots and/or fracture lines.	<input type="checkbox"/> Continuous, extensive erosion at the base of both banks creating unstable overhangs. <input type="checkbox"/> Continuous leaning trees, recently exposed roots and/or fracture lines.
<b>Widening Score:</b>	20   19   18   17   16	15   14   13   12   11	10   9   8   7   6	5   4   3   2   1

# Channel Integrity Assessment for Pool-Riffle Reaches

FORM 3-CH2

Stream Name: \_\_\_\_\_

Reach ID: \_\_\_\_\_

Re-alignment	Optimal	Good	Fair	Poor
Bridges / Culverts	<input type="checkbox"/> Channel is aligned with bridge / culvert openings.	<input type="checkbox"/> Channel is aligned with bridge / culvert openings.	<input type="checkbox"/> Channel is askew to bridge / culvert openings.	<input type="checkbox"/> Channel makes tight meander at bridge / culvert openings.
Sinuosity	<input type="checkbox"/> No change in sinuosity.	<input type="checkbox"/> May accompany minor change in sinuosity.	<input type="checkbox"/> May accompany moderate change in sinuosity.	<input type="checkbox"/> May accompany major change in sinuosity.
Bank Erosion	<input type="checkbox"/> Typical bank erosion on outside meander bends. <input type="checkbox"/> Overhangs are stable. No slumping. <input type="checkbox"/> Few leaning trees, no recently exposed roots. No fracture lines.	<input type="checkbox"/> Typical bank erosion on outside meander bends. <input type="checkbox"/> Overhangs are stable. Little slumping. <input type="checkbox"/> Few leaning trees, recently exposed roots. No fracture lines.	<input type="checkbox"/> Moderate to high bank erosion on many outside meander bends creating unstable overhangs. <input type="checkbox"/> Multiple leaning trees, recently exposed roots and/or fracture lines.	<input type="checkbox"/> Extensive, severe bank erosion on outside meander bends creating unstable overhangs and/or slumping. <input type="checkbox"/> Numerous leaning trees, recently exposed roots and/or fracture
Flood chutes, Meander Cutoffs, Braiding, Channel Avulsions	<input type="checkbox"/> Limited potential for channel avulsions. <input type="checkbox"/> No evidence of historic or recent channel avulsions.	<input type="checkbox"/> Limited potential for channel avulsions. <input type="checkbox"/> 10% < 25% of reach exhibits historic or recent channel avulsions.	<input type="checkbox"/> Flood chutes, meander cutoffs, and braiding potentially leading to channel avulsions. <input type="checkbox"/> 25% < 50% of reach exhibits historic or recent channel	<input type="checkbox"/> Flood chutes, meander cutoffs, braiding causing channel avulsions. <input type="checkbox"/> ≥ 50% of reach exhibits historic or recent channel avulsions.
<b>Re-alignment Score:</b>	20   19   18   17   16	15   14   13   12   11	10   9   8   7   6	5   4   3   2   1

**Watershed Score:** \_\_\_\_\_

**General Instability** \_\_\_\_\_

**Score:** \_\_\_\_\_

**Degradation Score:** \_\_\_\_\_

**Aggradation Score:** \_\_\_\_\_

**Widening Score:** \_\_\_\_\_

**Re-alignment Score:** \_\_\_\_\_

**Channel Integrity** \_\_\_\_\_

**Score:** \_\_\_\_\_

(Average the scores above; divide by 20)

**Channel Integrity** \_\_\_\_\_

**Condition:** \_\_\_\_\_

Score	Condition
0.85 - 1.0	Optimal
0.65 - 0.84	Good
0.35 - 0.64	Fair
0.00 - 0.34	Poor

**Channel Sensitivity:** \_\_\_\_\_

(Refer to Item 11.1.4 from Phase 2)

# Channel Integrity Assessment for Plane-Bed Channels

FORM 3-CH3

Stream Name:

Reach ID:

For Reaches in Moderately to Minimally Confined Valleys (Valley Confinement Ratio 3 - 5).

Related Parameter	Condition Category																			
	Optimal					Good					Fair					Poor				
Phase 1 Watershed (From FORM 2-WA)	<input type="checkbox"/> Optimal Score.					<input type="checkbox"/> Good Score.					<input type="checkbox"/> Fair Score.					<input type="checkbox"/> Poor Score.				
Score:	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
<b>General Instability</b>																				
Dams / Weirs	<input type="checkbox"/> Dams / weirs are absent. <input type="checkbox"/> No evidence of historic dams.					<input type="checkbox"/> A weir present that creates limited impounded water that is not wider or deeper than the normal channel. <input type="checkbox"/> Little evidence of a historic dam.					<input type="checkbox"/> Dam / weirs present. <input type="checkbox"/> Impoundment is wider than the typical channel and contains some sediment. <input type="checkbox"/> Evidence of historic dam that may have created an elevated floodplain.					<input type="checkbox"/> Dam(s) create deep and wide impoundment that traps sediment. <input type="checkbox"/> Impoundment is >2x normal channel width and depth and contains fine sediment. <input type="checkbox"/> Clear evidence of historic dam that has left an elevated floodplain.				
Beaver Dams	<input type="checkbox"/> Signs of instability are directly related to Beaver Dams.					<input type="checkbox"/> Signs of instability are related to Beaver Dams.					<input type="checkbox"/> Signs of instability are NOT related to Beaver Dams.					<input type="checkbox"/> Signs of instability are NOT related to Beaver Dams.				
Bridges / Culverts	<input type="checkbox"/> Few or no bridges / culvert crossings [ $< 2$ / mile]. <input type="checkbox"/> Typical crossing width $>$ channel width.					<input type="checkbox"/> Some bridges / culvert crossings [2 - 3 / mile]. <input type="checkbox"/> Typical crossing width $>$ channel width.					<input type="checkbox"/> Bridges / culvert crossings are common [ave. 4 - 6 / mile]. <input type="checkbox"/> Typical crossing width $\leq$ channel width.					<input type="checkbox"/> Many bridges / culvert crossings [ $> 6$ / mile]. <input type="checkbox"/> Typical crossing width $<$ channel width.				
Stormwater Inputs	<input type="checkbox"/> No stormwater inputs observed.					<input type="checkbox"/> Few stormwater inputs. [ $< 10$ / mile]					<input type="checkbox"/> Some stormwater inputs [10 - 25 / mile].					<input type="checkbox"/> Many stormwater inputs [ $> 25$ / mile].				
Floodplain Encroachment Ratio	<input type="checkbox"/> No Floodplain Encroachment concentrating downstream flows. <input type="checkbox"/> $1.0 <$ Floodplain Encroachment Ratio $< 1.2$					<input type="checkbox"/> Minor Floodplain Encroachment concentrating downstream flows. <input type="checkbox"/> $1.2 \leq$ Floodplain Encroachment Ratio $< 1.4$					<input type="checkbox"/> Moderate Floodplain Encroachment concentrating downstream flows. <input type="checkbox"/> $1.4 \leq$ Floodplain Encroachment Ratio $< 2.0$					<input type="checkbox"/> Major Floodplain Encroachment concentrating downstream flows. <input type="checkbox"/> Floodplain Encroachment Ratio $> 2.0$				
Bank Erosion	<input type="checkbox"/> Eroded banks extend $< 10\%$ of reach.					<input type="checkbox"/> Eroded banks extend $10\% < 25\%$ of reach.					<input type="checkbox"/> Eroded banks extend $25\% < 50\%$ of reach.					<input type="checkbox"/> Eroded banks extend $\geq 50\%$ of reach.				
Bank Armoring / Channel Straightening	<input type="checkbox"/> No evidence of bank armoring / channel straightening.					<input type="checkbox"/> Bank armoring extends $10\% < 25\%$ of reach. <input type="checkbox"/> Channel straightening $< 10\%$ of reach.					<input type="checkbox"/> Bank armoring extends $25\% < 50\%$ of reach. <input type="checkbox"/> Channel straightening $< 25\%$ of reach.					<input type="checkbox"/> Bank armoring extends $\geq 50\%$ of reach. <input type="checkbox"/> Channel straightening $\geq 25\%$ of reach.				
General Score:	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1

# Channel Integrity Assessment for Plane-Bed Channels

FORM 3-CH3

Stream Name:

Reach ID:

Degradation	Optimal	Good	Fair	Poor
Bridges / Culverts	<input type="checkbox"/> No bed and bank erosion associated with bridges/culverts. <input type="checkbox"/> Bridge foundations are not exposed; culverts are not perched.	<input type="checkbox"/> Adjacent bed and bank erosion are minor and confined to immediately upstream or downstream of crossings. <input type="checkbox"/> Bridge foundations are not exposed; culverts are not perched.	<input type="checkbox"/> Adjacent bed and bank erosion is moderate and typical. <input type="checkbox"/> Some bridge foundations are exposed; some culverts are perched.	<input type="checkbox"/> Adjacent bed and bank erosion is severe and extensive. <input type="checkbox"/> Most bridge foundations are exposed or undermined; most culverts are perched.
Stormwater Inputs	<input type="checkbox"/> Stormwater outfalls are not perched above the streambed.	<input type="checkbox"/> Stormwater outfalls do not appear to be perched above the streambed.	<input type="checkbox"/> Stormwater outfalls are perched above the streambed. <input type="checkbox"/> Some stormwater ditches have headcuts.	<input type="checkbox"/> Stormwater outfalls are perched above the streambed. <input type="checkbox"/> Headwalls have been undermined and are collapsing into the channel. <input type="checkbox"/> Stormwater ditches have headcuts.
Bank Height Ratio	<input type="checkbox"/> $1.0 \leq \text{Bank Height Ratio} < 1.1$ and <input type="checkbox"/> Where Channel Slope > 2%, Entrenchment Ratio > 1.4; <input type="checkbox"/> Where Channel Slope $\leq$ 2%, Entrenchment Ratio > 2.0.	<input type="checkbox"/> $1.1 \leq \text{Bank Height Ratio} < 1.3$ and <input type="checkbox"/> Where Channel Slope > 2%, Entrenchment Ratio > 1.4; <input type="checkbox"/> Where Channel Slope $\leq$ 2%, Entrenchment Ratio > 2.0.	<input type="checkbox"/> $1.3 \leq \text{Bank Height Ratio} < 1.5$ and <input type="checkbox"/> Where Channel Slope > 2%, Entrenchment Ratio > 1.4; <input type="checkbox"/> Where Channel Slope $\leq$ 2%, Entrenchment Ratio > 2.0.	<input type="checkbox"/> Bank Height Ratio $\geq 1.5$ and <input type="checkbox"/> Where Channel Slope > 2%, Entrenchment Ratio > 1.4; <input type="checkbox"/> Where Channel Slope $\leq$ 2%, Entrenchment Ratio > 2.0.
Dominant Particle Size Class	<input type="checkbox"/> Stream substrate is compact and resistant to erosion. <input type="checkbox"/> Dominant particle size class is cobble, boulder or bedrock.	<input type="checkbox"/> Stream substrate is compact and resistant to erosion. <input type="checkbox"/> Dominant particle size class is cobble, boulder or bedrock.	<input type="checkbox"/> Stream substrate is not compact and prone to erosion. <input type="checkbox"/> Dominant particle size class is fine gravel or sand.	<input type="checkbox"/> Stream substrate is not compact and prone to erosion. <input type="checkbox"/> Dominant particle size class is fine gravel or sand.
Bedrock Grade Controls	<input type="checkbox"/> Bedrock grade controls are present, preventing further channel degradation.	<input type="checkbox"/> Bedrock grade controls are present, preventing further channel degradation.	<input type="checkbox"/> Bedrock grade controls are absent, allowing channel degradation.	<input type="checkbox"/> Bedrock grade controls are absent, allowing channel degradation.
Headcuts	<input type="checkbox"/> No headcuts. <input type="checkbox"/> Substrates are compact and stable. <input type="checkbox"/> No signs of historic incision.	<input type="checkbox"/> No headcuts. <input type="checkbox"/> Signs of historic incision: sharp changes of slope / steep riffles.	<input type="checkbox"/> Headcut seen in the main channel and some tributaries. <input type="checkbox"/> Signs of recent incision: sharp changes in slope / steep riffles.	<input type="checkbox"/> Multiple headcuts in the main channel and tributaries. <input type="checkbox"/> Signs of active incision: substrates are loose and actively eroding at headcuts.
Bank Slope	<input type="checkbox"/> Bank slopes are typically low.	<input type="checkbox"/> Bank slopes are typically moderate.	<input type="checkbox"/> Banks are typically steep or vertical.	<input type="checkbox"/> Banks are typically vertical.
Bank Materials	<input type="checkbox"/> No subsoil layers exposed in the banks.	<input type="checkbox"/> Few banks with exposed subsoil layers.	<input type="checkbox"/> Subsoil layers clearly exposed in banks.	<input type="checkbox"/> Former streambed materials clearly exposed in banks.
Meander Cutoffs, Channel Avulsions	<input type="checkbox"/> No evidence of historic or recent meander cutoffs or channel avulsions.	<input type="checkbox"/> Some evidence of historic, not recent, meander cutoffs or channel avulsions.	<input type="checkbox"/> Evidence of recent meander cutoffs or channel avulsions.	<input type="checkbox"/> Evidence of recent and/or impending meander cutoffs or channel avulsions.
Degradation Score:	20   19   18   17   16	15   14   13   12   11	10   9   8   7   6	5   4   3   2   1

# Channel Integrity Assessment for Plane-Bed Channels

FORM 3-CH3

Stream Name:

Reach ID:

Aggradation	Optimal	Good	Fair	Poor
Bridges / Culverts	<input type="checkbox"/> No sediment deposition upstream of crossings. <input type="checkbox"/> No sediment deposition downstream of crossings. <input type="checkbox"/> Bridge / Culvert openings are not blocked by sediment.	<input type="checkbox"/> Some sediment deposition upstream of crossings. <input type="checkbox"/> Some sediment deposition downstream of crossings. <input type="checkbox"/> Bridge / Culvert openings are not blocked by sediment.	<input type="checkbox"/> Moderate sediment deposition upstream of crossings. <input type="checkbox"/> Moderate sediment deposition downstream of crossings. <input type="checkbox"/> Bridge / Culvert openings are partially blocked by sediment.	<input type="checkbox"/> Significant sediment deposition upstream of crossings. <input type="checkbox"/> Significant sediment deposition downstream of crossings. <input type="checkbox"/> Bridge / Culvert openings are buried in sediment.
Stormwater Inputs	<input type="checkbox"/> No stormwater inputs observed.	<input type="checkbox"/> Minor sediment deposition at stormwater outfalls.	<input type="checkbox"/> Moderate sediment deposition at stormwater outfalls. <input type="checkbox"/> Multiple stormwater outfalls are partially buried in sediment. <input type="checkbox"/> Multiple stormwater ditches are partially filled with sediment finer than bed.	<input type="checkbox"/> Extensive sediment deposition at stormwater outfalls. <input type="checkbox"/> Stormwater outfalls are partially buried in sediment. <input type="checkbox"/> Stormwater ditches are partially filled with sediment finer than bed.
Sediment Bars	<input type="checkbox"/> Few or no lateral, diagonal, mid-channel bars. <input type="checkbox"/> Lateral bars and deltas in typical positions. <input type="checkbox"/> Sediment bars less than bankfull height.	<input type="checkbox"/> Some lateral, diagonal, mid-channel bars. <input type="checkbox"/> Lateral bars and deltas in typical positions. <input type="checkbox"/> Sediment bars composed of sediment similar to dominant substrate. <input type="checkbox"/> Sediment bars at or below bankfull height.	<input type="checkbox"/> Multiple lateral, diagonal, mid-channel bars, or deltas. <input type="checkbox"/> Sediment bars composed of sediment different than dominant substrate. <input type="checkbox"/> Sediment bars are greater than bankfull height and/or longer than a channel width.	<input type="checkbox"/> Many lateral, diagonal, mid-channel bars, or deltas. <input type="checkbox"/> Sediment bars composed of sediment finer than dominant substrate. <input type="checkbox"/> Sediment bars above bankfull elevation and/or multiple channel widths in length. <input type="checkbox"/> Sediment bars split flow in multiple paths.
Embeddedness	<input type="checkbox"/> Coarse gravels, cobbles, boulders are not embedded in finer sediments. <input type="checkbox"/> Embeddedness < 25%.	<input type="checkbox"/> Coarse gravels, cobbles, boulders are not embedded in finer sediments. <input type="checkbox"/> 25% < Embeddedness < 50%	<input type="checkbox"/> Coarse gravels, cobbles, boulders are embedded in finer sediments. <input type="checkbox"/> 50% ≤ Embeddedness < 75%	<input type="checkbox"/> Coarse gravels, cobbles, boulders are heavily embedded in finer sediments. <input type="checkbox"/> Embeddedness ≥ 75%.
Braiding	<input type="checkbox"/> No channel braiding.	<input type="checkbox"/> No channel braiding.	<input type="checkbox"/> Channel braiding present.	<input type="checkbox"/> Channel braiding extensive throughout reach.
<b>Aggradation Score:</b>	20   19   18   17   16	15   14   13   12   11	10   9   8   7   6	5   4   3   2   1

# Channel Integrity Assessment for Plane-Bed Channels

FORM 3-CH3

Stream Name:

Reach ID:

Widening	Optimal	Good	Fair	Poor
Stormwater Inputs	<input type="checkbox"/> No stormwater inputs observed.	<input type="checkbox"/> Stormwater outfalls do not appear to extending out from the banks.	<input type="checkbox"/> Stormwater outfalls are extending out from the banks.	<input type="checkbox"/> Stormwater outfalls are extending out from the banks. <input type="checkbox"/> Headwalls have been undermined and are collapsing into the channel.
Width-Depth Ratio	Low Width-Depth Ratio <input type="checkbox"/> $< 20$	Low to Moderate Width-Depth Ratio <input type="checkbox"/> $>20 \leq 30$	Moderate to High Width-Depth Ratio <input type="checkbox"/> $>30 \leq 40$	Moderate to High Width-Depth Ratio <input type="checkbox"/> $> 40$
Sediment Bars	<input type="checkbox"/> Few or no lateral, diagonal, mid-channel bars. <input type="checkbox"/> Lateral bars and deltas in typical positions. <input type="checkbox"/> Sediment bars at or below bankfull height.	<input type="checkbox"/> Few lateral, diagonal, mid-channel bars. <input type="checkbox"/> Lateral bars and deltas in typical positions. <input type="checkbox"/> Sediment bars composed of sediment similar to dominant substrate. <input type="checkbox"/> Sediment bars at or below bankfull height.	<input type="checkbox"/> Multiple lateral, diagonal, mid-channel bars, or deltas. <input type="checkbox"/> Sediment bars composed of sediment different than dominant substrate. <input type="checkbox"/> Sediment bars are greater than bankfull height and/or longer than a channel width.	<input type="checkbox"/> Many lateral, diagonal, mid-channel bars, or deltas. <input type="checkbox"/> Sediment bars composed of sediment finer than dominant substrate. <input type="checkbox"/> Sediment bars above bankfull elevation and/or multiple channel widths in length. <input type="checkbox"/> Sediment bars split flow in multiple paths.
Bank Materials	<input type="checkbox"/> Bank materials have low or very low erodibility. <input type="checkbox"/> Bank materials are cohesive.	<input type="checkbox"/> Bank materials have low or moderate erodibility. <input type="checkbox"/> Bank materials are cohesive.	<input type="checkbox"/> Bank materials have moderate or high erodibility. <input type="checkbox"/> Bank materials are non-cohesive.	<input type="checkbox"/> Bank materials have high erodibility. <input type="checkbox"/> Bank materials are non-cohesive.
Bank Erosion	<input type="checkbox"/> No erosion on opposing banks; overhanging banks are stable. <input type="checkbox"/> Occasional leaning trees and no recently exposed roots.	<input type="checkbox"/> Minimal erosion at the base of opposing banks; overhanging banks are stable. <input type="checkbox"/> Some leaning trees and few recently exposed roots.	<input type="checkbox"/> Moderate erosion at the base of both banks creating unstable overhangs. <input type="checkbox"/> Many leaning trees, recently exposed roots and/or fracture lines.	<input type="checkbox"/> Continuous, extensive erosion at the base of both banks creating unstable overhangs. <input type="checkbox"/> Continuous leaning trees, recently exposed roots and/or fracture lines.
<b>Widening Score:</b>	20   19   18   17   16	15   14   13   12   11	10   9   8   7   6	5   4   3   2   1

# Channel Integrity Assessment for Plane-Bed Channels

FORM 3-CH3

Stream Name: \_\_\_\_\_

Reach ID: \_\_\_\_\_

Re-alignment	Optimal	Good	Fair	Poor
Bridges / Culverts	<input type="checkbox"/> Channel is aligned with bridge / culvert openings.	<input type="checkbox"/> Channel is aligned with bridge / culvert openings.	<input type="checkbox"/> Channel is askew to bridge / culvert openings.	<input type="checkbox"/> Channel makes tight meander at bridge / culvert openings.
Sinuosity	<input type="checkbox"/> No change in sinuosity.	<input type="checkbox"/> May accompany minor change in sinuosity.	<input type="checkbox"/> May accompany moderate change in sinuosity.	<input type="checkbox"/> May accompany major change in sinuosity.
Bank Erosion	<input type="checkbox"/> Typical bank erosion on outside meander bends. <input type="checkbox"/> Overhangs are stable. No slumping. <input type="checkbox"/> Few leaning trees, no recently exposed roots. No fracture lines.	<input type="checkbox"/> Typical bank erosion on outside meander bends. <input type="checkbox"/> Overhangs are stable. Little slumping. <input type="checkbox"/> Few leaning trees, recently exposed roots. No fracture lines.	<input type="checkbox"/> Moderate to high bank erosion on many outside meander bends creating unstable overhangs. <input type="checkbox"/> Multiple leaning trees, recently exposed roots and/or fracture lines.	<input type="checkbox"/> Extensive, severe bank erosion on outside meander bends creating unstable overhangs and/or slumping. <input type="checkbox"/> Numerous leaning trees, recently exposed roots and/or fracture lines.
Flood chutes, Meander Cutoffs, Braiding, Channel Avulsions	<input type="checkbox"/> Limited potential for channel avulsions. <input type="checkbox"/> No evidence of historic or recent channel avulsions.	<input type="checkbox"/> Limited potential for channel avulsions. <input type="checkbox"/> 10% < 25% of reach exhibits historic or recent channel avulsions.	<input type="checkbox"/> Flood chutes, meander cutoffs, and braiding potentially leading to channel avulsions. <input type="checkbox"/> 25% < 50% of reach exhibits historic or recent channel	<input type="checkbox"/> Flood chutes, meander cutoffs, braiding causing channel avulsions. <input type="checkbox"/> ≥ 50% of reach exhibits historic or recent channel avulsions.
<b>Re-alignment Score:</b>	20   19   18   17   16	15   14   13   12   11	10   9   8   7   6	5   4   3   2   1

Watershed Score: \_\_\_\_\_

General Instability \_\_\_\_\_

Score: \_\_\_\_\_

Degradation Score: \_\_\_\_\_

Aggradation Score: \_\_\_\_\_

Widening Score: \_\_\_\_\_

Re-alignment Score: \_\_\_\_\_

Channel Integrity \_\_\_\_\_

Score: \_\_\_\_\_

(Average the scores above; divide by 20)

Channel Integrity \_\_\_\_\_

Condition: \_\_\_\_\_

Channel Sensitivity: \_\_\_\_\_

(Refer to Item 11.1.4 from Phase 2)

Score	Condition
0.85 - 1.0	Optimal
0.65 - 0.84	Good
0.35 - 0.64	Fair
0.00 - 0.34	Poor

# Habitat Assessment for Step-Pool Reaches

FORM 4-HA1

Stream Name:

Reach ID:

For Reaches in Moderately to Highly Confined Valleys (Valley Confinement Ratio < 4)

Primarily step-pool streams; also cascade or bedrock channels; A/B channels.

Related Parameter	Condition Category			
	Optimal	Good	Fair	Poor
Channel Integrity (From FORM 3-CHx)	<input type="checkbox"/> Optimal Channel Integrity <input type="checkbox"/> Low Channel Sensitivity	<input type="checkbox"/> Good Channel Integrity <input type="checkbox"/> Moderate Channel Sensitivity	<input type="checkbox"/> Fair Channel Integrity <input type="checkbox"/> High Channel Sensitivity	<input type="checkbox"/> Poor Channel Integrity <input type="checkbox"/> Very High Channel Sensitivity
<b>Score:</b>	20   19   18   17   16	15   14   13   12   11	10   9   8   7   6	5   4   3   2   1
<b>Available Data</b>				
NJ Stream Water Quality Standards	<input type="checkbox"/> Freshwater 1 - Trout Production / Trout Maintenance (FW1-TP/TM)	<input type="checkbox"/> Freshwater 1 - Non-Trout (FW1-NT)	<input type="checkbox"/> Freshwater 2 - Trout Production / Trout Maintenance (FW2-TP/TM)	<input type="checkbox"/> Freshwater 2 - Non-Trout (FW2-NT)
<b>Score:</b>	20   19   18   17   16	15   14   13   12   11	10   9   8   7   6	5   4   3   2   1
<b>Channel Modifiers</b>				
Dams / Weirs	<input type="checkbox"/> Dams / weirs are absent. <input type="checkbox"/> No evidence of historic dams.	<input type="checkbox"/> A weir present that creates limited impounded water that is not wider or deeper than the normal channel. <input type="checkbox"/> Little evidence of a historic dam.	<input type="checkbox"/> Dam / weirs present that create impoundment that is wider than the normal channel and retains some sediment. <input type="checkbox"/> Evidence of historic dam.	<input type="checkbox"/> Dam(s) create deep and wide impoundment that traps sediment. <input type="checkbox"/> Clear evidence of historic dam.
Beaver Dams	<input type="checkbox"/> Beaver dam(s) are present.	<input type="checkbox"/> Beaver dam(s) are present.		
Bridges / Culverts	<input type="checkbox"/> Few or no bridges / culvert crossings [< 2 / mile]. <input type="checkbox"/> No bridges / culverts appear to block aquatic organism passage by channel constriction/increased velocity, shallow flow, or perch.	<input type="checkbox"/> Some bridges / culvert crossings [2 - 4 / mile]. <input type="checkbox"/> No bridges / culverts appear to block aquatic organism passage by channel constriction/increased velocity, shallow flow, or perch.	<input type="checkbox"/> Many bridges / culvert crossings [4 - 6 / mile]. <input type="checkbox"/> Multiple bridges / culverts appear to block aquatic organism passage by channel constriction/increased velocity, shallow flow, or perch.	<input type="checkbox"/> Many bridges / culvert crossings [> 6 / mile]. <input type="checkbox"/> Multiple bridges / culverts appear to block aquatic organism passage by channel constriction/increased velocity, shallow flow, or perch.
<b>Score:</b>	20   19   18   17   16	15   14   13   12   11	10   9   8   7   6	5   4   3   2   1

# Habitat Assessment for Step-Pool Reaches

FORM 4-HA1

Stream Name:

Reach ID:

In-Stream Features				
Pool Condition	<input type="checkbox"/> > 70 pools / mile. <input type="checkbox"/> > 50% pools are > 2 FT deep. <input type="checkbox"/> > 50% pools span channel width.	<input type="checkbox"/> 70 ≥ pools / mile ≤ 50 . <input type="checkbox"/> 50 > 25% pools are > 2 FT deep. <input type="checkbox"/> 50 > 25% pools span channel width.	<input type="checkbox"/> 50 > pools / mile < 30 . <input type="checkbox"/> 25 > 10% pools are > 2 FT deep. <input type="checkbox"/> 25 > 10% pools span channel width.	<input type="checkbox"/> ≤ 30 pools / mile. <input type="checkbox"/> ≤ 10% pools are > 2 FT deep. <input type="checkbox"/> ≤ 10% pools span channel width.
Bed Substrate	<input type="checkbox"/> pool embeddedness < 25%. <input type="checkbox"/> margin embeddedness < 40%.	<input type="checkbox"/> 25 ≤ pool embeddedness < 50%. <input type="checkbox"/> 40 ≤ margin embeddedness < 60%.	<input type="checkbox"/> 50 ≤ pool embeddedness < 75%. <input type="checkbox"/> 60 ≤ margin embeddedness < 80%.	<input type="checkbox"/> pool embeddedness ≥ 75%. <input type="checkbox"/> margin embeddedness ≥ 80%.
<b>Score:</b>	20   19   18   17   16	15   14   13   12   11	10   9   8   7   6	5   4   3   2   1
Vegetative Material	<input type="checkbox"/> > 200 LWD / mile. <input type="checkbox"/> > 25 Debris Jams / mile. <input type="checkbox"/> CPOM abundant in margin and center.	<input type="checkbox"/> 200 ≥ LWD / mile > 100. <input type="checkbox"/> 25 ≥ Debris Jams / mile > 15. <input type="checkbox"/> CPOM abundant in margins, present in center.	<input type="checkbox"/> 100 ≥ LWD / mile > 50. <input type="checkbox"/> 15 ≥ Debris Jams / mile > 5. <input type="checkbox"/> CPOM present in margin, absent in center.	<input type="checkbox"/> ≤ 50 LWD / mile. <input type="checkbox"/> ≤ 5 Debris Jams / mile. <input type="checkbox"/> CPOM absent.
<b>Score:</b>	20   19   18   17   16	15   14   13   12   11	10   9   8   7   6	5   4   3   2   1
Banks				
Bank Slope	<input type="checkbox"/> > 15 stable, undercut banks / mile.	<input type="checkbox"/> 15 ≥ stable, undercut banks / mile > 10.	<input type="checkbox"/> 10 ≥ stable, undercut banks / mile > 5.	<input type="checkbox"/> < 5 stable, undercut banks / mile.
Bank Vegetation	<input type="checkbox"/> > 90% coverage in tree, shrub and herb layers. <input type="checkbox"/> Non-native invasives are absent.	<input type="checkbox"/> 90 ≥ coverage > 75% in tree, shrub and herb layers. <input type="checkbox"/> Non-native invasives are minimal.	<input type="checkbox"/> 75 ≥ coverage > 50% in tree, shrub and herb layers. <input type="checkbox"/> Non-native invasives are abundant.	<input type="checkbox"/> 50% ≤ coverage in tree, shrub and herb layers. <input type="checkbox"/> Non-native invasives are dominant.
Cross Channel Shading	<input type="checkbox"/> Closed cross-channel canopy.	<input type="checkbox"/> Cross-channel canopy is mostly closed.	<input type="checkbox"/> Cross-channel canopy is mostly open.	<input type="checkbox"/> Open cross-channel canopy.
Bank Erosion	<input type="checkbox"/> Eroded banks extend < 10% of reach.	<input type="checkbox"/> Eroded banks extend 10% < 25% of reach.	<input type="checkbox"/> Eroded banks extend 25% < 50% of reach.	<input type="checkbox"/> Eroded banks extend ≥ 50% of reach.
Bank Armoring / Channel Straightening	<input type="checkbox"/> No evidence of bank armoring / channel straightening.	<input type="checkbox"/> Bank armoring extends 10% < 25% of reach.	<input type="checkbox"/> Bank armoring extends 25% < 50% of reach.	<input type="checkbox"/> Bank armoring extends ≥ 50% of reach.
Buffer Width	<input type="checkbox"/> Buffer width > 300 FT.	<input type="checkbox"/> Buffer width is 300 - 50 FT.	<input type="checkbox"/> Buffer width is < 50 FT.	<input type="checkbox"/> No buffer.
<b>RB Score:</b>	10   9	8   7   6	5   4   3	2   1
<b>LB Score:</b>	10   9	8   7   6	5   4   3	2   1

Habitat Assessment for Step-Pool Reaches

FORM 4-HA1

Stream Name:

Reach ID:

Riparian Area																				
Riparian Wildlife Habitat (Phase I)	<input type="checkbox"/> High Score; Reach corridor contains patches rank 3 or higher.					<input type="checkbox"/> Moderate Score; Reach corridor contains patches rank 1 or 2.					<input type="checkbox"/> Low Score; Reach corridor contains patches rank 1.					<input type="checkbox"/> Reach corridor contains patches rank 0.				
Riparian Plant Community	<input type="checkbox"/> Native Mean C $\geq$ 4.5					<input type="checkbox"/> $3.5 \leq$ Native Mean C > 4.5					<input type="checkbox"/> $2.5 \leq$ Native Mean C > 3.4					<input type="checkbox"/> Low Phase 1 Plant Community Score. <input type="checkbox"/> $0 \leq$ Native Mean C > 2.4				
Adjacent Wetlands	<input type="checkbox"/> Wetlands are extensive, extend over 75% of reach.					<input type="checkbox"/> Wetlands are present, approximately 50% of reach.					<input type="checkbox"/> Wetlands are minimal, approximately 25% of reach.					<input type="checkbox"/> Wetlands are altered or absent.				
Floodplain Connectivity	<input type="checkbox"/> Floodplain connectivity is extensive throughout study reach with numerous signs of flooding. <input type="checkbox"/> Little or no encroachment on the floodplain.					<input type="checkbox"/> Floodplain connectivity is present throughout the study reach with some signs of flooding. <input type="checkbox"/> Floodplain encroachment is minimal.					<input type="checkbox"/> Floodplain connectivity is minimal. <input type="checkbox"/> Floodplain connectivity is partially limited by encroachment.					<input type="checkbox"/> No Floodplain connectivity. <input type="checkbox"/> Floodplain connectivity is severely limited by encroachment.				
Score:	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1

Habitat Score:

(Average the scores above; divide by 20)

Habitat Condition:

Score	Condition
0.85 - 1.0	Optimal
0.65 - 0.84	Good
0.35 - 0.64	Fair
0.00 - 0.34	Poor

# Habitat Assessment for Pool-Riffle Reaches

FORM 4-HA2

Stream Name:

Reach ID:

For Reaches in Minimally Confined to Broad Valleys (Valley Confinement Ratio  $\geq 4$ )

Primarily pool-riffle streams; C/E channels; some B channels.

Related Parameter	Condition Category																			
	Optimal					Good					Fair					Poor				
Channel Integrity (From FORM 3-CHx)	<input type="checkbox"/> Optimal Channel Integrity <input type="checkbox"/> Low Channel Sensitivity					<input type="checkbox"/> Good Channel Integrity <input type="checkbox"/> Moderate Channel Sensitivity					<input type="checkbox"/> Fair Channel Integrity <input type="checkbox"/> High Channel Sensitivity					<input type="checkbox"/> Poor Channel Integrity <input type="checkbox"/> Very High Channel Sensitivity				
<b>Score:</b>	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
<b>Available Data</b>																				
NJ Stream Water Quality Standards	<input type="checkbox"/> Freshwater 1 - Trout Production / Trout Maintenance (FW1-TP/TM)					<input type="checkbox"/> Freshwater 1 - Non-Trout (FW1-NT)					<input type="checkbox"/> Freshwater 2 - Trout Production / Trout Maintenance (FW2-TP/TM)					<input type="checkbox"/> Freshwater 2 - Non-Trout (FW2-NT)				
<b>Score:</b>	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
<b>Channel Modifiers</b>																				
Dams / Weirs	<input type="checkbox"/> Dams / weirs are absent. <input type="checkbox"/> No evidence of historic dams.					<input type="checkbox"/> A weir present that creates limited impounded water that is not wider or deeper than the normal channel. <input type="checkbox"/> Little evidence of a historic dam.					<input type="checkbox"/> Dam / weirs present that create impoundment that is wider than the normal channel and retains some sediment. <input type="checkbox"/> Evidence of historic dam.					<input type="checkbox"/> Dam(s) create deep and wide impoundment that traps sediment. <input type="checkbox"/> Clear evidence of historic dam.				
Beaver Dams	<input type="checkbox"/> Beaver dam(s) are present.					<input type="checkbox"/> Beaver dam(s) are present.														
Bridges / Culverts	<input type="checkbox"/> Few or no bridges / culvert crossings [ $< 2$ / mile]. <input type="checkbox"/> No bridges / culverts appear to block aquatic organism passage by channel constriction/increased velocity, shallow flow, or perch.					<input type="checkbox"/> Some bridges / culvert crossings [2 - 4 / mile]. <input type="checkbox"/> No bridges / culverts appear to block aquatic organism passage by channel constriction/increased velocity, shallow flow, or perch.					<input type="checkbox"/> Many bridges / culvert crossings [4 - 6 / mile]. <input type="checkbox"/> Multiple bridges / culverts appear to block aquatic organism passage by channel constriction/increased velocity, shallow flow, or perch.					<input type="checkbox"/> Many bridges / culvert crossings [ $> 6$ / mile]. <input type="checkbox"/> Multiple bridges / culverts appear to block aquatic organism passage by channel constriction/increased velocity, shallow flow, or perch.				
<b>Score:</b>	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1

# Habitat Assessment for Pool-Riffle Reaches

FORM 4-HA2

Stream Name:

Reach ID:

In-Stream Features				
Pool Condition	<input type="checkbox"/> > 40 pools / mile. <input type="checkbox"/> > 50% pools are > 2 FT deep. <input type="checkbox"/> > 50% pools span channel width.	<input type="checkbox"/> $40 \geq$ pools / mile $\leq 20$ . <input type="checkbox"/> 50 > 25% pools are > 2 FT deep. <input type="checkbox"/> 50 > 25% pools span channel width.	<input type="checkbox"/> 20 > pools / mile < 10. <input type="checkbox"/> 25 > 10% pools are > 2 FT deep. <input type="checkbox"/> 25 > 10% pools span channel width.	<input type="checkbox"/> $\leq 30$ pools / mile. <input type="checkbox"/> $\leq 10\%$ pools are > 2 FT deep. <input type="checkbox"/> $\leq 10\%$ pools span channel width.
Bed Substrate Composition	<input type="checkbox"/> riffle embeddedness < 20%. <input type="checkbox"/> margin embeddedness < 40%. <input type="checkbox"/> Riffle Stability Index $\leq 70\%$ .	<input type="checkbox"/> $25 \leq$ riffle embeddedness < 40%. <input type="checkbox"/> $40 \leq$ margin embeddedness < 60%. <input type="checkbox"/> $70\% \leq$ RSI < 80%.	<input type="checkbox"/> $40 \leq$ riffle embeddedness < 75%. <input type="checkbox"/> $60 \leq$ margin embeddedness < 80%. <input type="checkbox"/> $80\% < \text{RSI} < 90\%$ .	<input type="checkbox"/> riffle embeddedness $\geq 75\%$ . <input type="checkbox"/> margin embeddedness $\geq 80\%$ . <input type="checkbox"/> Riffle Stability Index $\geq 90\%$ .
<b>Score:</b>	20   19   18   17   16	15   14   13   12   11	10   9   8   7   6	5   4   3   2   1
Vegetative Material	<input type="checkbox"/> > 100 LWD / mile. <input type="checkbox"/> > 5 Debris Jams / mile. <input type="checkbox"/> CPOM abundant in margin and center.	<input type="checkbox"/> $100 \geq$ LWD / mile > 50. <input type="checkbox"/> $5 \geq$ Debris Jams / mile > 3. <input type="checkbox"/> CPOM abundant in margins, present in center.	<input type="checkbox"/> $50 \geq$ LWD / mile > 25. <input type="checkbox"/> $3 \geq$ Debris Jams / mile > 1. <input type="checkbox"/> CPOM present in margin, absent in center.	<input type="checkbox"/> $\leq 25$ LWD / mile. <input type="checkbox"/> Debris Jams absent. <input type="checkbox"/> CPOM absent.
<b>Score:</b>	20   19   18   17   16	15   14   13   12   11	10   9   8   7   6	5   4   3   2   1
Banks				
Bank Slope	<input type="checkbox"/> > 30 stable, undercut banks / mile.	<input type="checkbox"/> $30 \geq$ stable, undercut banks / mile > 15.	<input type="checkbox"/> $15 \geq$ stable, undercut banks / mile > 5.	<input type="checkbox"/> < 5 stable, undercut banks / mile.
Bank Vegetation	<input type="checkbox"/> > 90% coverage in tree, shrub and herb layers. <input type="checkbox"/> Non-native invasives are absent.	<input type="checkbox"/> $90 \geq$ coverage > 75% in tree, shrub and herb layers. <input type="checkbox"/> Non-native invasives are minimal.	<input type="checkbox"/> $75 \geq$ coverage > 50% in tree, shrub and herb layers. <input type="checkbox"/> Non-native invasives are abundant.	<input type="checkbox"/> $50\% \leq$ coverage in tree, shrub and herb layers. <input type="checkbox"/> Non-native invasives are dominant.
Cross Channel Shading	<input type="checkbox"/> Closed cross-channel canopy.	<input type="checkbox"/> Cross-channel canopy is mostly closed.	<input type="checkbox"/> Cross-channel canopy is mostly open.	<input type="checkbox"/> Open cross-channel canopy.
Bank Erosion	<input type="checkbox"/> Eroded banks extend < 10% of reach.	<input type="checkbox"/> Eroded banks extend $10\% < 25\%$ of reach.	<input type="checkbox"/> Eroded banks extend $25\% < 50\%$ of reach.	<input type="checkbox"/> Eroded banks extend $\geq 50\%$ of reach.
Bank Armoring / Channel Straightening	<input type="checkbox"/> No evidence of bank armoring / channel straightening.	<input type="checkbox"/> Bank armoring extends $10\% < 25\%$ of reach.	<input type="checkbox"/> Bank armoring extends $25\% < 50\%$ of reach.	<input type="checkbox"/> Bank armoring extends $\geq 50\%$ of reach.
Buffer Width	<input type="checkbox"/> Buffer width > 300 FT.	<input type="checkbox"/> Buffer width is 300 - 50 FT.	<input type="checkbox"/> Buffer width is < 50 FT.	<input type="checkbox"/> No buffer.
<b>RB Score:</b>	10   9	8   7   6	5   4   3	2   1
<b>LB Score:</b>	10   9	8   7   6	5   4   3	2   1

# Habitat Assessment for Pool-Riffle Reaches

FORM 4-HA2

Stream Name:

Reach ID:

Riparian Area				
Riparian Wildlife Habitat (Phase I)	<input type="checkbox"/> High Score; Reach corridor contains patches rank 3 or higher	<input type="checkbox"/> Moderate Score; Reach corridor contains patches rank 1 or 2.	<input type="checkbox"/> Low Score; Reach corridor contains patches rank 1.	<input type="checkbox"/> Reach corridor contains patches rank 0.
Riparian Plant Community	<input type="checkbox"/> Native Mean C $\geq$ 4.5	<input type="checkbox"/> $3.5 \leq$ Native Mean C $>$ 4.5	<input type="checkbox"/> $2.5 \leq$ Native Mean C $>$ 3.4	<input type="checkbox"/> Low Phase 1 Plant Community Score. <input type="checkbox"/> $0 \leq$ Native Mean C $>$ 2.4
Adjacent Wetlands	<input type="checkbox"/> Wetlands are extensive, extend over 75% of reach.	<input type="checkbox"/> Wetlands are present, approximately 50% of reach.	<input type="checkbox"/> Wetlands are minimal, approximately 25% of reach.	<input type="checkbox"/> Wetlands are altered or absent.
Floodplain Connectivity	<input type="checkbox"/> Floodplain connectivity is extensive throughout study reach with numerous signs of flooding. <input type="checkbox"/> Little or no encroachment on the	<input type="checkbox"/> Floodplain connectivity is present throughout the study reach with some signs of flooding. <input type="checkbox"/> Floodplain encroachment is minimal.	<input type="checkbox"/> Floodplain connectivity is minimal. <input type="checkbox"/> Floodplain connectivity is partially limited by encroachment.	<input type="checkbox"/> No Floodplain connectivity. <input type="checkbox"/> Floodplain connectivity is severely limited by encroachment.
<b>Score:</b>	20   19   18   17   16	15   14   13   12   11	10   9   8   7   6	5   4   3   2   1

Habitat Score:

(Average the scores above; divide by 20)

Habitat Condition:

Score	Condition
0.85 - 1.0	Optimal
0.65 - 0.84	Good
0.35 - 0.64	Fair
0.00 - 0.34	Poor

# Habitat Assessment for Plane-Bed Reaches

FORM 4-HA3

Stream Name:

Reach ID:

For Reaches in Moderately to Minimally Confined Valleys (Valley Confinement Ratio 3 - 5).

Related Parameter	Condition Category																			
	Optimal					Good					Fair					Poor				
Channel Integrity (From FORM 3-CHx)	<input type="checkbox"/> Optimal Channel Integrity <input type="checkbox"/> Low Channel Sensitivity					<input type="checkbox"/> Good Channel Integrity <input type="checkbox"/> Moderate Channel Sensitivity					<input type="checkbox"/> Fair Channel Integrity <input type="checkbox"/> High Channel Sensitivity					<input type="checkbox"/> Poor Channel Integrity <input type="checkbox"/> Very High Channel Sensitivity				
<b>Score:</b>	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
<b>Available Data</b>																				
NJ Stream Water Quality Standards	<input type="checkbox"/> Freshwater 1 - Trout Production / Trout Maintenance (FW1-TP/TM)					<input type="checkbox"/> Freshwater 1 - Non-Trout (FW1-NT)					<input type="checkbox"/> Freshwater 2 - Trout Production / Trout Maintenance (FW2-TP/TM)					<input type="checkbox"/> Freshwater 2 - Non-Trout (FW2-NT)				
<b>Score:</b>	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
<b>Channel Modifiers</b>																				
Dams / Weirs	<input type="checkbox"/> Dams / weirs are absent. <input type="checkbox"/> No evidence of historic dams.					<input type="checkbox"/> A weir present that creates limited impounded water that is not wider or deeper than the normal channel. <input type="checkbox"/> Little evidence of a historic dam.					<input type="checkbox"/> Dam / weirs present that create impoundment that is wider than the normal channel and retains some sediment. <input type="checkbox"/> Evidence of historic dam.					<input type="checkbox"/> Dam(s) create deep and wide impoundment that traps sediment. <input type="checkbox"/> Clear evidence of historic dam.				
Beaver Dams	<input type="checkbox"/> Beaver dam(s) are present.					<input type="checkbox"/> Beaver dam(s) are present.														
Bridges / Culverts	<input type="checkbox"/> Few or no bridges / culvert crossings [< 2 / mile]. <input type="checkbox"/> No bridges / culverts appear to block aquatic organism passage by channel constriction/increased velocity, shallow flow, or perch.					<input type="checkbox"/> Some bridges / culvert crossings [2 - 4 / mile]. <input type="checkbox"/> No bridges / culverts appear to block aquatic organism passage by channel constriction/increased velocity, shallow flow, or perch.					<input type="checkbox"/> Many bridges / culvert crossings [4 - 6 / mile]. <input type="checkbox"/> Multiple bridges / culverts appear to block aquatic organism passage by channel constriction/increased velocity, shallow flow, or perch.					<input type="checkbox"/> Many bridges / culvert crossings [> 6 / mile]. <input type="checkbox"/> Multiple bridges / culverts appear to block aquatic organism passage by channel constriction/increased velocity, shallow flow, or perch.				
<b>Score:</b>	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1

# Habitat Assessment for Plane-Bed Reaches

FORM 4-HA3

Stream Name:

Reach ID:

In-Stream Features				
Pool Condition	<input type="checkbox"/> > 40 pools / mile. <input type="checkbox"/> > 50% pools are > 2 FT deep. <input type="checkbox"/> > 50% pools span channel width.	<input type="checkbox"/> $40 \geq$ pools / mile $\leq 20$ . <input type="checkbox"/> 50 > 25% pools are > 2 FT deep. <input type="checkbox"/> 50 > 25% pools span channel width.	<input type="checkbox"/> 20 > pools / mile < 10. <input type="checkbox"/> 25 > 10% pools are > 2 FT deep. <input type="checkbox"/> 25 > 10% pools span channel width.	<input type="checkbox"/> $\leq 30$ pools / mile. <input type="checkbox"/> $\leq 10\%$ pools are > 2 FT deep. <input type="checkbox"/> $\leq 10\%$ pools span channel width.
Bed Substrate Composition	<input type="checkbox"/> riffle embeddedness < 20%. <input type="checkbox"/> margin embeddedness < 40%.	<input type="checkbox"/> $25 \leq$ riffle embeddedness < 40%. <input type="checkbox"/> $40 \leq$ margin embeddedness < 60%.	<input type="checkbox"/> $40 \leq$ riffle embeddedness < 75%. <input type="checkbox"/> $60 \leq$ margin embeddedness < 80%.	<input type="checkbox"/> riffle embeddedness $\geq 75\%$ . <input type="checkbox"/> margin embeddedness $\geq 80\%$ .
<b>Score:</b>	20   19   18   17   16	15   14   13   12   11	10   9   8   7   6	5   4   3   2   1
Vegetative Material	<input type="checkbox"/> > 100 LWD / mile. <input type="checkbox"/> > 5 Debris Jams / mile. <input type="checkbox"/> CPOM abundant in margin and center.	<input type="checkbox"/> $100 \geq$ LWD / mile > 50. <input type="checkbox"/> $5 \geq$ Debris Jams / mile > 3. <input type="checkbox"/> CPOM abundant in margins, present in center.	<input type="checkbox"/> $50 \geq$ LWD / mile > 25. <input type="checkbox"/> $3 \geq$ Debris Jams / mile > 1. <input type="checkbox"/> CPOM present in margin, absent in center.	<input type="checkbox"/> $\leq 25$ LWD / mile. <input type="checkbox"/> Debris Jams absent. <input type="checkbox"/> CPOM absent.
<b>Score:</b>	20   19   18   17   16	15   14   13   12   11	10   9   8   7   6	5   4   3   2   1
Banks				
Bank Slope	<input type="checkbox"/> > 30 stable, undercut banks / mile.	<input type="checkbox"/> $30 \geq$ stable, undercut banks / mile > 15.	<input type="checkbox"/> $15 \geq$ stable, undercut banks / mile > 5.	<input type="checkbox"/> < 5 stable, undercut banks / mile.
Bank Vegetation	<input type="checkbox"/> > 90% coverage in tree, shrub and herb layers. <input type="checkbox"/> Non-native invasives are absent.	<input type="checkbox"/> $90 \geq$ coverage > 75% in tree, shrub and herb layers. <input type="checkbox"/> Non-native invasives are minimal.	<input type="checkbox"/> $75 \geq$ coverage > 50% in tree, shrub and herb layers. <input type="checkbox"/> Non-native invasives are abundant.	<input type="checkbox"/> $50\% \leq$ coverage in tree, shrub and herb layers. <input type="checkbox"/> Non-native invasives are dominant.
Cross Channel Shading	<input type="checkbox"/> Closed cross-channel canopy.	<input type="checkbox"/> Cross-channel canopy is mostly closed.	<input type="checkbox"/> Cross-channel canopy is mostly open.	<input type="checkbox"/> Open cross-channel canopy.
Bank Erosion	<input type="checkbox"/> Eroded banks extend < 10% of reach.	<input type="checkbox"/> Eroded banks extend $10\% < 25\%$ of reach.	<input type="checkbox"/> Eroded banks extend $25\% < 50\%$ of reach.	<input type="checkbox"/> Eroded banks extend $\geq 50\%$ of reach.
Bank Armoring / Channel Straightening	<input type="checkbox"/> No evidence of bank armoring / channel straightening.	<input type="checkbox"/> Bank armoring extends $10\% < 25\%$ of reach.	<input type="checkbox"/> Bank armoring extends $25\% < 50\%$ of reach.	<input type="checkbox"/> Bank armoring extends $\geq 50\%$ of reach.
Buffer Width	<input type="checkbox"/> Buffer width > 300 FT.	<input type="checkbox"/> Buffer width is 300 - 50 FT.	<input type="checkbox"/> Buffer width is < 50 FT.	<input type="checkbox"/> No buffer.
<b>RB Score:</b>	10   9	8   7   6	5   4   3	2   1
<b>LB Score:</b>	10   9	8   7   6	5   4   3	2   1

# Habitat Assessment for Plane-Bed Reaches

FORM 4-HA3

Stream Name:

Reach ID:

Riparian Area				
Riparian Wildlife Habitat (Phase I)	<input type="checkbox"/> High Score; Reach corridor contains patches rank 3 or higher.	<input type="checkbox"/> Moderate Score; Reach corridor contains patches rank 1 or 2.	<input type="checkbox"/> Low Score; Reach corridor contains patches rank 1.	<input type="checkbox"/> Reach corridor contains patches rank 0.
Riparian Plant Community	<input type="checkbox"/> Native Mean C $\geq$ 4.5	<input type="checkbox"/> $3.5 \leq$ Native Mean C $>$ 4.5	<input type="checkbox"/> $2.5 \leq$ Native Mean C $>$ 3.4	<input type="checkbox"/> Low Phase 1 Plant Community Score. <input type="checkbox"/> $0 \leq$ Native Mean C $>$ 2.4
Adjacent Wetlands	<input type="checkbox"/> Wetlands are extensive, extend over 75% of reach.	<input type="checkbox"/> Wetlands are present, approximately 50% of reach.	<input type="checkbox"/> Wetlands are minimal, approximately 25% of reach.	<input type="checkbox"/> Wetlands are altered or absent.
Floodplain Connectivity	<input type="checkbox"/> Floodplain connectivity is extensive throughout study reach with numerous signs of flooding. <input type="checkbox"/> Little or no encroachment on the	<input type="checkbox"/> Floodplain connectivity is present throughout the study reach with some signs of flooding. <input type="checkbox"/> Floodplain encroachment is minimal.	<input type="checkbox"/> Floodplain connectivity is minimal. <input type="checkbox"/> Floodplain connectivity is partially limited by encroachment.	<input type="checkbox"/> No Floodplain connectivity. <input type="checkbox"/> Floodplain connectivity is severely limited by encroachment.
<b>Score:</b>	20   19   18   17   16	15   14   13   12   11	10   9   8   7   6	5   4   3   2   1

Habitat Score:

(Average the scores above; divide by 20)

Habitat Condition:

Score	Condition
0.85 - 1.0	Optimal
0.65 - 0.84	Good
0.35 - 0.64	Fair
0.00 - 0.34	Poor

# Water Quality Assessment

FORM 5-WQ

Stream Name:

Reach ID:

For assessing Functional Values: NonPoint Source Pollution and Water Quality

Related Parameters	Condition Category			
	Optimal	Good	Fair	Poor
Phase 1 Watershed (From FORM 2-WA)	<input type="checkbox"/> Optimal Score	<input type="checkbox"/> Good Score	<input type="checkbox"/> Fair Score	<input type="checkbox"/> Poor Score
Channel Integrity (From FORM 3-CHx)	<input type="checkbox"/> Optimal Channel Integrity <input type="checkbox"/> Low Channel Sensitivity	<input type="checkbox"/> Good Channel Integrity <input type="checkbox"/> Moderate Channel Sensitivity	<input type="checkbox"/> Fair Channel Integrity <input type="checkbox"/> High Channel Sensitivity	<input type="checkbox"/> Poor Channel Integrity <input type="checkbox"/> Very High Channel Sensitivity
<b>Score:</b>	20   19   18   17   16	15   14   13   12   11	10   9   8   7   6	5   4   3   2   1
<b>Existing Data</b>				
NJ Surface Water Quality Standards	<input type="checkbox"/> Freshwater 1 - Trout Production / Trout Maintenance (FW1-TP/TM)	<input type="checkbox"/> Freshwater 1 - Non-Trout (FW1-NT)	<input type="checkbox"/> Freshwater 2 - Trout Production / Trout Maintenance (FW2-TP/TM)	<input type="checkbox"/> Freshwater 2 - Non-Trout (FW2-NT)
NJPDES Surface Water Discharges	<input type="checkbox"/> No Discharges	<input type="checkbox"/> No Discharges	<input type="checkbox"/> One Discharge	<input type="checkbox"/> Multiple Discharges
AMNET Reference Sites	<input type="checkbox"/> One sites	<input type="checkbox"/> One site	<input type="checkbox"/> No sites	<input type="checkbox"/> No sites
Section 303(d) List	<input type="checkbox"/> Not listed or Fully Supporting	<input type="checkbox"/> Insufficient information	<input type="checkbox"/> Not Supporting for one use	<input type="checkbox"/> Not supporting for multiple uses
<b>Score:</b>	20   19   18   17   16	15   14   13   12   11	10   9   8   7   6	5   4   3   2   1
<b>Flow Modifiers</b>				
Dams / Weirs	<input type="checkbox"/> Dams / weirs are absent.	<input type="checkbox"/> A dam / weir is present that creates limited impounded water that is not wider than the normal channel and does not extend over 20% of the reach.	<input type="checkbox"/> Dam(s) / weir(s) are present that create some impounded water that is not wider than the normal channel but extends over 20% of the reach.	<input type="checkbox"/> Dam(s) / weir(s) create deep impounded water that dominates the reach, is much wider than the normal channel and is exposed to direct sunlight.
Stormwater Inputs	<input type="checkbox"/> No stormwater inputs observed.	<input type="checkbox"/> Few stormwater inputs. <input type="checkbox"/> Stormwater outfalls contribute little or no urban/crop runoff.	<input type="checkbox"/> Some stormwater inputs. <input type="checkbox"/> Stormwater outfalls contribute urban/crop runoff.	<input type="checkbox"/> Many stormwater inputs. <input type="checkbox"/> Stormwater outfalls contribute high quantities of urban/crop runoff relative to study reach.
<b>Score:</b>	20   19   18   17   16	15   14   13   12   11	10   9   8   7   6	5   4   3   2   1
<b>Banks</b>				
Bank Erosion	<input type="checkbox"/> Banks are not eroded and are stable.	<input type="checkbox"/> Few banks are eroded. <input type="checkbox"/> Most banks are stable and erosion appears natural.	<input type="checkbox"/> Many banks are eroded. <input type="checkbox"/> Some banks are undercut or steep. <input type="checkbox"/> Bank erosion may be contributing in-stream sediment.	<input type="checkbox"/> Most banks are eroded. <input type="checkbox"/> Most banks are undercut or steep. <input type="checkbox"/> Bank erosion appears to be contributing in-stream sediment.
<b>RB Score:</b>	10   9	8   7   6	5   4   3	2   1
<b>LB Score:</b>	10   9	8   7   6	5   4   3	2   1

# Water Quality Assessment

FORM 5-WQ

Stream Name:

Reach ID:

## Riparian Area

Buffer Width	<input type="checkbox"/> Buffer width > 300 FT. <input type="checkbox"/> Buffer is wooded; and appears sufficient to intercept, infiltrate and filter surface runoff.	<input type="checkbox"/> Buffer width is 300 - 50 FT. <input type="checkbox"/> Buffer appears sufficient to intercept, infiltrate and filter surface runoff.	<input type="checkbox"/> Buffer width is < 50 FT. <input type="checkbox"/> Buffer does not intercept runoff in all locations.	<input type="checkbox"/> No buffer. <input type="checkbox"/> Surface runoff reaches channel directly.
<b>RB Score:</b>	10   9	8   7   6	5   4   3	2   1
<b>LB Score:</b>	10   9	8   7   6	5   4   3	2   1
Wetlands, Tributaries / Seeps / Springs	<input type="checkbox"/> Wetlands are extensive, extend over 75% of reach. <input type="checkbox"/> Tributaries / Seeps / Springs are numerous.	<input type="checkbox"/> Wetlands are present approximately 50% of reach. <input type="checkbox"/> Tributaries / Seeps / Springs are occasional.	<input type="checkbox"/> Wetlands are minimal, approximately 25% of reach. <input type="checkbox"/> Tributaries / Seeps / Springs are infrequent.	<input type="checkbox"/> Wetlands are altered or absent. <input type="checkbox"/> Tributaries / Seeps / Springs are altered or absent.
Floodplain Connectivity	<input type="checkbox"/> Floodplain connectivity is extensive throughout study reach with numerous signs of flooding. <input type="checkbox"/> Little or no encroachment on the floodplain.	<input type="checkbox"/> Floodplain connectivity is present throughout the study reach with some signs of flooding. <input type="checkbox"/> Floodplain encroachment is minimal.	<input type="checkbox"/> Floodplain connectivity is minimal throughout study reach with few signs of flooding. <input type="checkbox"/> Floodplain connectivity is partially limited by	<input type="checkbox"/> Signs of floodplain connectivity are absent. <input type="checkbox"/> Floodplain connectivity is severely limited by encroachment.
<b>Score:</b>	20   19   18   17   16	15   14   13   12   11	10   9   8   7   6	5   4   3   2   1

<b>Water Quality Score:</b>		Score	Condition
(Average the scores above; divide by 20)		0.85 - 1.0	Optimal
<b>Water Quality Condition:</b>		0.65 - 0.84	Good
		0.35 - 0.64	Fair
		0.00 - 0.34	Poor

# Temperature Moderation Assessment

FORM 6-TM

Stream Name:

Reach ID:

Related Parameters	Condition Category			
	Optimal	Good	Fair	Poor
Channel Integrity (From FORM 3-CHx)	<input type="checkbox"/> Optimal Channel Integrity <input type="checkbox"/> Low Channel Sensitivity	<input type="checkbox"/> Good Channel Integrity <input type="checkbox"/> Moderate Channel Sensitivity	<input type="checkbox"/> Fair Channel Integrity <input type="checkbox"/> High Channel Sensitivity	<input type="checkbox"/> Poor Channel Integrity <input type="checkbox"/> Very High Channel Sensitivity
<b>Score:</b>	20   19   18   17   16	15   14   13   12   11	10   9   8   7   6	5   4   3   2   1
<b>Existing Data</b>				
NJPDES Surface Water Discharges	<input type="checkbox"/> No Discharges	<input type="checkbox"/> No Discharges	<input type="checkbox"/> One Discharge	<input type="checkbox"/> Multiple Discharges
Section 303(d) List	<input type="checkbox"/> Not listed or Fully Supporting	<input type="checkbox"/> Insufficient information	<input type="checkbox"/> Not Supporting for one use due to Temperature	<input type="checkbox"/> Not Supporting for one use due to Temperature
<b>Score:</b>	20   19   18   17   16	15   14   13   12   11	10   9   8   7   6	5   4   3   2   1
<b>Flow Modifiers</b>				
Dams / Weirs	<input type="checkbox"/> Dams / weirs are absent.	<input type="checkbox"/> A dam / weir is present that creates limited impounded water that is not wider than the normal channel and does not extend over 20% of the	<input type="checkbox"/> Dam(s) / weir(s) are present that create some impounded water that is not wider than the normal channel but extends over 20% of the reach.	<input type="checkbox"/> Dam(s) / weir(s) create deep impounded water that dominates the reach, is much wider than the normal channel and is exposed to direct sunlight.
Stormwater Inputs	<input type="checkbox"/> No stormwater inputs observed.	<input type="checkbox"/> Few stormwater inputs. <input type="checkbox"/> Stormwater outfalls contribute little or no urban/crop runoff.	<input type="checkbox"/> Some stormwater inputs. <input type="checkbox"/> Stormwater outfalls contribute urban/crop runoff.	<input type="checkbox"/> Many stormwater inputs. <input type="checkbox"/> Stormwater outfalls contribute high quantities of urban/crop runoff relative to study reach.
<b>Score:</b>	20   19   18   17   16	15   14   13   12   11	10   9   8   7   6	5   4   3   2   1
<b>Banks</b>				
Bank Vegetation	<input type="checkbox"/> > 90% coverage in tree, shrub and herb layers.	<input type="checkbox"/> 90 ≥ coverage > 75% in tree, shrub and herb layers.	<input type="checkbox"/> 75 ≥ coverage > 50% in tree, shrub and herb layers.	<input type="checkbox"/> 50% ≤ coverage in tree, shrub and herb layers.
Cross Channel Shading	<input type="checkbox"/> Channel is fully shaded. <input type="checkbox"/> For channels wider than 50 FT, banks/channel margins are fully shaded.	<input type="checkbox"/> Channel is mostly shaded. <input type="checkbox"/> For channels wider than 50 FT, banks/channel margins are mostly shaded.	<input type="checkbox"/> Channel is minimally shaded. <input type="checkbox"/> For channels wider than 50 FT, banks / channel margins are partly shaded.	<input type="checkbox"/> Channel is not shaded. <input type="checkbox"/> For channels wider than 50 FT, banks / channel margins are not shaded.
<b>RB Score:</b>	10   9	8   7   6	5   4   3	2   1
<b>LB Score:</b>	10   9	8   7   6	5   4   3	2   1

# Temperature Moderation Assessment

FORM 6-TM

Stream Name:

Reach ID:

## Riparian Area

Buffer Width	<input type="checkbox"/> Buffer width > 300 FT. <input type="checkbox"/> Buffer is wooded; and appears sufficient to intercept and infiltrate surface runoff.	<input type="checkbox"/> Buffer width is 300 - 50 FT. <input type="checkbox"/> Buffer appears sufficient to intercept and infiltrate surface runoff.	<input type="checkbox"/> Buffer width is < 50 FT. <input type="checkbox"/> Buffer does not intercept runoff in all locations.	<input type="checkbox"/> No buffer. <input type="checkbox"/> Surface runoff reaches channel directly.
<b>RB Score:</b>	10   9	8   7   6	5   4   3	2   1
<b>LB Score:</b>	10   9	8   7   6	5   4   3	2   1
Wetlands, Tributaries / Seeps / Springs	<input type="checkbox"/> Wetlands are extensive, extend over 75% of reach. <input type="checkbox"/> Tributaries / Seeps / Springs are numerous.	<input type="checkbox"/> Wetlands are present approximately 50% of reach. <input type="checkbox"/> Tributaries / Seeps / Springs are occasional.	<input type="checkbox"/> Wetlands are minimal, approximately 25% of reach. <input type="checkbox"/> Tributaries / Seeps / Springs are infrequent.	<input type="checkbox"/> Wetlands are altered or absent. <input type="checkbox"/> Tributaries / Seeps / Springs are altered or absent.
<b>Score:</b>	20   19   18   17   16	15   14   13   12   11	10   9   8   7   6	5   4   3   2   1

<b>Temperature Moderation Score:</b>		Score	Condition
(Average the scores above; divide by 20)		0.85 - 1.0	Optimal
<b>Temp Moderation Condition:</b>		0.65 - 0.84	Good
		0.35 - 0.64	Fair
		0.00 - 0.34	Poor

# Public Use Assessment

FORM 7-PU

Stream Name:

Reach ID:

Related Parameters	Condition Category			
	Optimal	Good	Fair	Poor
Channel Integrity (From FORM 3-CHx)	<input type="checkbox"/> Optimal Channel Integrity <input type="checkbox"/> Low Channel Sensitivity	<input type="checkbox"/> Good Channel Integrity <input type="checkbox"/> Moderate Channel Sensitivity	<input type="checkbox"/> Fair Channel Integrity <input type="checkbox"/> High Channel Sensitivity	<input type="checkbox"/> Poor Channel Integrity <input type="checkbox"/> Very High Channel Sensitivity
Habitat (From FORM 4-HAx)	<input type="checkbox"/> Habitat condition is optimal.	<input type="checkbox"/> Habitat condition is good.	<input type="checkbox"/> Habitat condition is fair.	<input type="checkbox"/> Habitat condition is poor.
Water Quality (Form FORM 5-WQ)	<input type="checkbox"/> Water quality condition is optimal.	<input type="checkbox"/> Water quality condition is good.	<input type="checkbox"/> Water quality condition is fair.	<input type="checkbox"/> Water quality condition is poor.
<b>Score:</b>	20   19   18   17   16	15   14   13   12   11	10   9   8   7   6	5   4   3   2   1
<b>Public Use Parameter</b>				
Existing Public Use	<input type="checkbox"/> Land ownership is compatible with public use. <input type="checkbox"/> > 75% of appropriate public uses are currently supported.	<input type="checkbox"/> Land ownership is compatible with public use. <input type="checkbox"/> < 50 - 75% of appropriate public uses are currently supported.	<input type="checkbox"/> Land ownership may be compatible with public use. <input type="checkbox"/> 25 - 50% of appropriate public uses are currently supported.	<input type="checkbox"/> Land ownership is incompatible with public use. <input type="checkbox"/> < 25% of appropriate public uses are currently supported.
<b>Score:</b>	20   19   18   17   16	15   14   13   12   11	10   9   8   7   6	5   4   3   2   1
Potential Public Use	<input type="checkbox"/> > 75% of currently non-supported uses have potential. <input type="checkbox"/> All appropriate public uses are supported.	<input type="checkbox"/> < 50 - 75% of currently non-supported uses have potential.	<input type="checkbox"/> 25 - 50% of currently non-supported uses have potential.	<input type="checkbox"/> < 25% of currently non-supported uses have potential.
<b>Score:</b>	20   19   18   17   16	15   14   13   12   11	10   9   8   7   6	5   4   3   2   1

<b>Public Use Score:</b>	<input type="text"/>	Score	Condition
(Average the scores above; divide by 20)		0.85 - 1.0	Optimal
<b>Public Use Condition:</b>	<input type="text"/>	0.65 - 0.84	Good
		0.35 - 0.64	Fair
		0.00 - 0.34	Poor

# Channel Integrity Assessment for Pool-Riffle Reaches

FORM 3-CH2

Stream Name:

Reach ID:

For Reaches in Minimally Confined to Broad Valleys (Valley Confinement Ratio  $\geq 4$ )  
Primarily pool-riffle streams; C/E channels; some B channels.

EXAMPLE SHEET

Related Parameter	Condition Category			
	Optimal	Good	Fair	Poor
Phase 1 Watershed (From FORM 2-WA)	<input type="checkbox"/> Optimal Score.	<input type="checkbox"/> Good Score.	<input checked="" type="checkbox"/> Fair Score.	<input type="checkbox"/> Poor Score.
Score:	20   19   18   17   16	15   14   13   12   11	10   9   8   7   6	5   4   3   2   1
<b>General Instability</b>				
Dams / Weirs	<input checked="" type="checkbox"/> Dams / weirs are absent. <input type="checkbox"/> No evidence of historic dams.	<input type="checkbox"/> A weir present that creates limited impounded water that is not wider or deeper than the normal channel. <input checked="" type="checkbox"/> Little evidence of a historic dam.	<input type="checkbox"/> Dam / weirs present. <input type="checkbox"/> Impoundment is wider than the typical channel and contains some sediment. <input type="checkbox"/> Evidence of historic dam that may have created an elevated floodplain.	<input type="checkbox"/> Dam(s) create deep and wide impoundment that traps sediment. <input type="checkbox"/> Impoundment is $>2x$ normal channel width and depth and contains fine sediment. <input type="checkbox"/> Clear evidence of historic dam that has left an elevated floodplain.
Beaver Dams	<input type="checkbox"/> Signs of instability are directly related to Beaver Dams.	<input type="checkbox"/> Signs of instability are related to Beaver Dams.	<input checked="" type="checkbox"/> Signs of instability are NOT related to Beaver Dams.	<input type="checkbox"/> Signs of instability are NOT related to Beaver Dams.
Bridges / Culverts	<input type="checkbox"/> Few or no bridges / culvert crossings [ $< 2$ / mile]. <input type="checkbox"/> Typical crossing width $>$ channel width.	<input checked="" type="checkbox"/> Some bridges / culvert crossings [2 - 3 / mile]. <input type="checkbox"/> Typical crossing width $>$ channel width.	<input type="checkbox"/> Bridges / culvert crossings are common [ave. 4 - 6 / mile]. <input checked="" type="checkbox"/> Typical crossing width $\leq$ channel width.	<input type="checkbox"/> Many bridges / culvert crossings [ $> 6$ / mile]. <input type="checkbox"/> Typical crossing width $<$ channel width.
Stormwater Inputs	<input type="checkbox"/> No stormwater inputs observed.	<input type="checkbox"/> Few stormwater inputs. [ $< 10$ / mile]	<input checked="" type="checkbox"/> Some stormwater inputs. [10 - 25 / mile].	<input type="checkbox"/> Many stormwater inputs [ $> 25$ / mile].
Floodplain Encroachment Ratio	<input type="checkbox"/> No Floodplain Encroachment concentrating downstream flows. <input type="checkbox"/> $1.0 <$ Floodplain Encroachment Ratio $< 1.2$	<input checked="" type="checkbox"/> Minor Floodplain Encroachment concentrating downstream flows. <input checked="" type="checkbox"/> $1.2 \leq$ Floodplain Encroachment Ratio $< 1.4$	<input type="checkbox"/> Moderate Floodplain Encroachment concentrating downstream flows. <input type="checkbox"/> $1.4 \leq$ Floodplain Encroachment Ratio $< 2.0$	<input type="checkbox"/> Major Floodplain Encroachment concentrating downstream flows. <input type="checkbox"/> Floodplain Encroachment Ratio $> 2.0$
Bank Erosion	<input type="checkbox"/> Eroded banks extend $< 10\%$ of reach.	<input type="checkbox"/> Eroded banks extend $10\% < 25\%$ of reach.	<input checked="" type="checkbox"/> Eroded banks extend $25\% < 50\%$ of reach.	<input type="checkbox"/> Eroded banks extend $\geq 50\%$ of reach.
Bank Armoring / Channel Straightening	<input type="checkbox"/> No evidence of bank armoring / channel straightening.	<input checked="" type="checkbox"/> Bank armoring extends $10\% < 25\%$ of reach. <input checked="" type="checkbox"/> Channel straightening $< 10\%$ of reach.	<input type="checkbox"/> Bank armoring extends $25\% < 50\%$ of reach. <input type="checkbox"/> Channel straightening $< 25\%$ of reach.	<input type="checkbox"/> Bank armoring extends $\geq 50\%$ of reach. <input type="checkbox"/> Channel straightening $\geq 25\%$ of reach.
General Score:	20   19   18   17   16	15   14   13   12   11	10   9   8   7   6	5   4   3   2   1

# Channel Integrity Assessment for Pool-Riffle Reaches

FORM 3-CH2

Stream Name:

Reach ID:

Degradation	Optimal	Good	Fair	Poor
Bridges / Culverts	<input type="checkbox"/> No bed and bank erosion associated with bridges/culverts. <input type="checkbox"/> Bridge foundations are not exposed; culverts are not perched.	<input type="checkbox"/> Adjacent bed and bank erosion are minor and confined to immediately upstream or downstream of crossings. <input type="checkbox"/> Bridge foundations are not exposed; culverts are not perched.	<input checked="" type="checkbox"/> Adjacent bed and bank erosion is moderate and typical. <input type="checkbox"/> Some bridge foundations are exposed; some culverts are perched.	<input type="checkbox"/> Adjacent bed and bank erosion is severe and extensive. <input type="checkbox"/> Most bridge foundations are exposed or undermined; most culverts are perched.
Stormwater Inputs		<input type="checkbox"/> Stormwater outfalls do not appear to be perched above the streambed.	<input checked="" type="checkbox"/> Stormwater outfalls are perched above the streambed. <input type="checkbox"/> Some stormwater ditches have headcuts.	<input type="checkbox"/> Stormwater outfalls are perched above the streambed. <input type="checkbox"/> Headwalls have been undermined and are collapsing into the channel. <input type="checkbox"/> Stormwater ditches have headcuts.
Bank Height Ratio	<input type="checkbox"/> $1.0 \leq \text{Bank Height Ratio} < 1.1$ and <input type="checkbox"/> Entrenchment Ratio $> 2.0$	<input type="checkbox"/> $1.1 \leq \text{Bank Height Ratio} < 1.3$ and <input type="checkbox"/> Entrenchment Ratio $> 2.0$	<input checked="" type="checkbox"/> $1.3 \leq \text{Bank Height Ratio} < 1.5$ and <input checked="" type="checkbox"/> Entrenchment Ratio $> 2.0$	<input type="checkbox"/> Bank Height Ratio $\geq 1.5$ or <input type="checkbox"/> Entrenchment Ratio $\leq 2.0$
Dominant Particle Size Class	<input type="checkbox"/> Stream substrate is compact and resistant to erosion. <input type="checkbox"/> Dominant particle size class is cobble, boulder or bedrock.	<input checked="" type="checkbox"/> Stream substrate is compact and resistant to erosion. <input type="checkbox"/> Dominant particle size class is cobble, boulder or bedrock.	<input type="checkbox"/> Stream substrate is not compact and prone to erosion. <input type="checkbox"/> Dominant particle size class is fine gravel or sand.	<input type="checkbox"/> Stream substrate is not compact and prone to erosion. <input type="checkbox"/> Dominant particle size class is fine gravel or sand.
Bedrock Grade Controls	<input type="checkbox"/> Bedrock grade controls are present, preventing further channel degradation.	<input type="checkbox"/> Bedrock grade controls are present, preventing further channel degradation.	<input checked="" type="checkbox"/> Bedrock grade controls are absent, allowing channel degradation.	<input type="checkbox"/> Bedrock grade controls are absent, allowing channel degradation.
Headcuts	<input type="checkbox"/> No headcuts. <input type="checkbox"/> Substrates are compact and stable. <input type="checkbox"/> No signs of historic incision.	<input checked="" type="checkbox"/> No headcuts. <input checked="" type="checkbox"/> Signs of historic incision: sharp changes of slope / steep riffles.	<input type="checkbox"/> Headcut seen in the main channel and some tributaries. <input type="checkbox"/> Signs of recent incision: sharp changes in slope / steep riffles.	<input type="checkbox"/> Multiple headcuts in the main channel and tributaries. <input type="checkbox"/> Signs of active incision: substrates are loose and actively eroding at headcuts.
Bank Slope	<input type="checkbox"/> Bank slopes are typically low.	<input type="checkbox"/> Bank slopes are typically moderate.	<input checked="" type="checkbox"/> Banks are typically steep or vertical.	<input type="checkbox"/> Banks are typically vertical.
Bank Materials	<input type="checkbox"/> No subsoil layers exposed in the banks.	<input type="checkbox"/> Few banks with exposed subsoil layers.	<input checked="" type="checkbox"/> Subsoil layers clearly exposed in banks.	<input type="checkbox"/> Former streambed materials clearly exposed in banks.
Meander Cutoffs, Channel Avulsions	<input checked="" type="checkbox"/> No evidence of historic or recent meander cutoffs or channel avulsions.	<input type="checkbox"/> Some evidence of historic, not recent, meander cutoffs or channel avulsions.	<input type="checkbox"/> Evidence of recent meander cutoffs or channel avulsions.	<input type="checkbox"/> Evidence of recent and/or impending meander cutoffs or channel avulsions.
Degradation Score:	20   19   18   17   16	15   14   13   12   11	10   9   8   7   6	5   4   3   2   1

EXAMPLE SHEET

# Channel Integrity Assessment for Pool-Riffle Reaches

FORM 3-CH2

Stream Name:

Reach ID:

Aggradation	Optimal	Good	Fair	Poor
Bridges / Culverts	<input checked="" type="checkbox"/> No sediment deposition upstream of crossings. <input checked="" type="checkbox"/> No sediment deposition downstream of crossings. <input checked="" type="checkbox"/> Bridge / Culvert openings are not blocked by sediment.	<input type="checkbox"/> Some sediment deposition upstream of crossings. <input type="checkbox"/> Some sediment deposition downstream of crossings. <input type="checkbox"/> Bridge / Culvert openings are not blocked by sediment.	<input type="checkbox"/> Moderate sediment deposition upstream of crossings. <input type="checkbox"/> Moderate sediment deposition downstream of crossings. <input type="checkbox"/> Bridge / Culvert openings are partially blocked by sediment.	<input type="checkbox"/> Significant sediment deposition upstream of crossings. <input type="checkbox"/> Significant sediment deposition downstream of crossings. <input type="checkbox"/> Bridge / Culvert openings are buried in sediment.
Stormwater Inputs	<input type="checkbox"/> No stormwater inputs observed.	<input checked="" type="checkbox"/> Minor sediment deposition at stormwater outfalls.	<input type="checkbox"/> Moderate sediment deposition at stormwater outfalls. <input type="checkbox"/> Multiple stormwater outfalls are partially buried in sediment. <input type="checkbox"/> Multiple stormwater ditches are partially filled with sediment finer than bed.	<input type="checkbox"/> Extensive sediment deposition at stormwater outfalls. <input type="checkbox"/> Stormwater outfalls are partially buried in sediment. <input type="checkbox"/> Stormwater ditches are partially filled with sediment finer than bed.
Channel Dimensions	<input checked="" type="checkbox"/> Low Width-Depth Ratio <input type="checkbox"/> $\leq 20$ for C or B channels <input type="checkbox"/> $\leq 10$ for E channels	<input type="checkbox"/> Low to Moderate Width-Depth Ratio <input type="checkbox"/> $>20 \leq 30$ for C or B channels <input type="checkbox"/> $>10 \leq 12$ for E channels	<input type="checkbox"/> Moderate to High Width-Depth Ratio <input type="checkbox"/> $>30 \leq 40$ for C or B channels <input type="checkbox"/> $>12 \leq 20$ for E channels	<input type="checkbox"/> High Width-Depth Ratio <input type="checkbox"/> $> 40$ for C or B channels <input type="checkbox"/> $> 20$ for E channels
Pool-Riffle Condition	<input type="checkbox"/> All Pool-Riffles are well formed, complete and stable. <input type="checkbox"/> $< 10\%$ pools are $< 2$ FT deep. <input checked="" type="checkbox"/> No pools are filled with sediment.	<input checked="" type="checkbox"/> Pool-Riffles are moderately well formed, complete and stable. <input type="checkbox"/> $10\% < 25\%$ pools are: <input checked="" type="checkbox"/> $< 2$ FT deep. <input type="checkbox"/> filled with sediment finer than dominant particle size.	<input type="checkbox"/> Pool-Riffles are not clearly formed creating plane bed features. <input type="checkbox"/> $25\% < 50\%$ pools are: <input type="checkbox"/> $< 2$ FT deep. <input type="checkbox"/> filled with sediment finer than dominant particle size.	<input type="checkbox"/> Pool-Riffles are not clearly formed creating plane bed features. <input type="checkbox"/> $> 50\%$ pools are: <input type="checkbox"/> $< 2$ FT deep. <input type="checkbox"/> filled with sediment finer than dominant particle size.

EXAMPLE SHEET

# Channel Integrity Assessment for Pool-Riffle Reaches

FORM 3-CH2

Stream Name:

Reach ID:

Sediment Bars	<input type="checkbox"/> Few or no lateral, diagonal, mid-channel bars. <input checked="" type="checkbox"/> Lateral bars and deltas in typical positions. <input checked="" type="checkbox"/> Sediment bars less than bankfull height.	<input checked="" type="checkbox"/> Some lateral, diagonal, mid-channel bars. <input checked="" type="checkbox"/> Lateral bars and deltas in typical positions. <input checked="" type="checkbox"/> Sediment bars composed of sediment similar to dominant substrate. <input checked="" type="checkbox"/> Sediment bars at or below bankfull height.	<input type="checkbox"/> Multiple lateral, diagonal, mid-channel bars, or deltas. <input type="checkbox"/> Sediment bars composed of sediment different than dominant substrate. <input type="checkbox"/> Sediment bars are greater than bankfull height and/or longer than a channel width.	<input type="checkbox"/> Many lateral, diagonal, mid-channel bars, or deltas. <input type="checkbox"/> Sediment bars composed of sediment finer than dominant substrate. <input type="checkbox"/> Sediment bars above bankfull elevation and/or multiple channel widths in length. <input type="checkbox"/> Sediment bars split flow in multiple paths.
Embeddedness	<input checked="" type="checkbox"/> Coarse gravels, cobbles, boulders are not embedded in finer sediments. <input checked="" type="checkbox"/> Embeddedness < 25%.	<input type="checkbox"/> Coarse gravels, cobbles, boulders are not embedded in finer sediments. <input type="checkbox"/> 25% < Embeddedness < 50%.	<input type="checkbox"/> Coarse gravels, cobbles, boulders are embedded in finer sediments. <input type="checkbox"/> 50% ≤ Embeddedness < 75%.	<input type="checkbox"/> Coarse gravels, cobbles, boulders are heavily embedded in finer sediments. <input type="checkbox"/> Embeddedness ≥ 75%.
Braiding	<input checked="" type="checkbox"/> No channel braiding.	<input type="checkbox"/> No channel braiding.	<input type="checkbox"/> Channel braiding present.	<input type="checkbox"/> Channel braiding extensive throughout reach.
Aggradation Score:	20   19   18   17   16	15   14   13   12   11	10   9   8   7   6	5   4   3   2   1

EXAMPLE SHEET

# Channel Integrity Assessment for Pool-Riffle Reaches

FORM 3-CH2

Stream Name:

Reach ID:

Widening	Optimal	Good	Fair	Poor
Stormwater Inputs	<input type="checkbox"/> No stormwater inputs observed.	<input checked="" type="checkbox"/> Stormwater outfalls do not appear to extending out from the banks.	<input type="checkbox"/> Stormwater outfalls are extending out from the banks.	<input type="checkbox"/> Stormwater outfalls are extending out from the banks. <input type="checkbox"/> Headwalls have been undermined and are collapsing into the channel.
Width-Depth Ratio	<input checked="" type="checkbox"/> Low Width-Depth Ratio $< 20$ for C or B channels <input type="checkbox"/> $< 10$ for E channels	Low to Moderate Width-Depth Ratio <input type="checkbox"/> $> 20 \leq 30$ for C or B channels <input type="checkbox"/> $> 10 \leq 12$ for E channels	Moderate to High Width-Depth Ratio <input type="checkbox"/> $> 30 \leq 40$ for C or B channels <input type="checkbox"/> $> 12 \leq 20$ for E channels	Moderate to High Width-Depth Ratio <input type="checkbox"/> $> 40$ for C or B channels <input type="checkbox"/> $> 20$ for E channels
Sediment Bars	<input type="checkbox"/> Few or no lateral, diagonal, mid-channel bars. <input type="checkbox"/> Lateral bars and deltas in typical positions. <input type="checkbox"/> Sediment bars below bankfull height.	<input checked="" type="checkbox"/> Some lateral, diagonal, mid-channel bars. <input type="checkbox"/> Lateral bars and deltas in typical positions. <input checked="" type="checkbox"/> Sediment bars composed of sediment similar to dominant substrate. <input checked="" type="checkbox"/> Sediment bars at or below bankfull height.	<input type="checkbox"/> Multiple lateral, diagonal, mid-channel bars, or deltas. <input type="checkbox"/> Sediment bars composed of sediment different than dominant substrate. <input type="checkbox"/> Sediment bars are greater than bankfull height and/or longer than a channel width.	<input type="checkbox"/> Many lateral, diagonal, mid-channel bars, or deltas. <input type="checkbox"/> Sediment bars composed of sediment finer than dominant substrate. <input type="checkbox"/> Sediment bars above bankfull elevation and/or multiple channel widths in length. <input type="checkbox"/> Sediment bars split flow in multiple paths.
Bank Materials	<input type="checkbox"/> Bank materials have low or very low erodibility. <input checked="" type="checkbox"/> Bank materials are cohesive.	<input checked="" type="checkbox"/> Bank materials have low or moderate erodibility. <input checked="" type="checkbox"/> Bank materials are cohesive.	<input type="checkbox"/> Bank materials have moderate or high erodibility. <input type="checkbox"/> Bank materials are non-cohesive.	<input type="checkbox"/> Bank materials have high erodibility. <input type="checkbox"/> Bank materials are non-cohesive.
Bank Erosion	<input type="checkbox"/> No erosion on opposing banks; overhanging banks are stable. <input type="checkbox"/> Occasional leaning trees and no recently exposed roots.	<input type="checkbox"/> Minimal erosion at the base of opposing banks; overhanging banks are stable. <input checked="" type="checkbox"/> Some leaning trees and few recently exposed roots.	<input checked="" type="checkbox"/> Moderate erosion at the base of both banks creating unstable overhangs. <input type="checkbox"/> Many leaning trees, recently exposed roots and/or fracture lines.	<input type="checkbox"/> Continuous, extensive erosion at the base of both banks creating unstable overhangs. <input type="checkbox"/> Continuous leaning trees, recently exposed roots and/or fracture lines.
<b>Widening Score:</b>	20   19   18   17   16	15   14   13   12   11	10   9   8   7   6	5   4   3   2   1

EXAMPLE SHEET

# Channel Integrity Assessment for Pool-Riffle Reaches

FORM 3-CH2

Stream Name:

Reach ID:

Re-alignment	Optimal	Good	Fair	Poor
Bridges / Culverts	<input type="checkbox"/> Channel is aligned with bridge / culvert openings.	<input checked="" type="checkbox"/> Channel is aligned with bridge / culvert openings.	<input type="checkbox"/> Channel is askew to bridge / culvert openings.	<input type="checkbox"/> Channel makes tight meander at bridge / culvert openings.
Sinuosity	<input type="checkbox"/> No change in sinuosity.	<input checked="" type="checkbox"/> May accompany minor change in sinuosity.	<input type="checkbox"/> May accompany moderate change in sinuosity.	<input type="checkbox"/> May accompany major change in sinuosity.
Bank Erosion	<input type="checkbox"/> Typical bank erosion on outside meander bends. <input type="checkbox"/> Overhangs are stable. No slumping. <input type="checkbox"/> Few leaning trees, no recently exposed roots. No fracture lines.	<input type="checkbox"/> Typical bank erosion on outside meander bends. <input checked="" type="checkbox"/> Overhangs are stable. Little slumping. <input checked="" type="checkbox"/> Few leaning trees, recently exposed roots. No fracture lines.	<input checked="" type="checkbox"/> Moderate to high bank erosion on many outside meander bends creating unstable overhangs. <input type="checkbox"/> Multiple leaning trees, recently exposed roots and/or fracture lines.	<input type="checkbox"/> Extensive, severe bank erosion on outside meander bends creating unstable overhangs and/or slumping. <input type="checkbox"/> Numerous leaning trees, recently exposed roots and/or fracture
Flood chutes, Meander Cutoffs, Braiding, Channel Avulsions	<input checked="" type="checkbox"/> Limited potential for channel avulsions. <input checked="" type="checkbox"/> No evidence of historic or recent channel avulsions.	<input type="checkbox"/> Limited potential for channel avulsions. <input type="checkbox"/> 10% < 25% of reach exhibits historic or recent channel avulsions.	<input type="checkbox"/> Flood chutes, meander cutoffs, and braiding potentially leading to channel avulsions. <input type="checkbox"/> 25% < 50% of reach exhibits historic or recent channel	<input type="checkbox"/> Flood chutes, meander cutoffs, braiding causing channel avulsions. <input type="checkbox"/> ≥ 50% of reach exhibits historic or recent channel avulsions.
Re-alignment Score:	20   19   18   17   16	15   14   13   12   11	10   9   8   7   6	5   4   3   2   1

10

Watershed Score:

General Instability

Score:

12

Degradation Score:

9

Aggradation Score:

17

Widening Score:

14

Re-alignment Score:

14

Channel Integrity

Score:

0.66

(Average the scores above; divide by 20)

Channel Integrity

Condition:

Good

Channel Sensitivity:

very high

(Refer to Item 11.1.4 from Phase 2)

Score	Condition
0.85 - 1.0	Optimal
0.65 - 0.84	Good
0.35 - 0.64	Fair
0.00 - 0.34	Poor

EXAMPLE SHEET

**Appendix D:**  
**NJDEP GIS Mapping and Digital Data Standards**



***New Jersey  
Department of Environmental Protection  
Geographic Information System***

**Mapping and Digital Data  
Standards**

**Prepared by:**

**New Jersey Department of Environmental Protection  
Office of Information Resources Management  
Bureau of Geographic Information Systems  
Post Office Box 428  
Trenton, NJ 08625-0428**

**Revised: February 23, 2006**

## **Summary**

- 1.0 Introduction**
- 2.0 Geospatial Positioning Accuracy Standards and Testing**
  - 2.1 Federal Geographic Data Committee – National Standard for Spatial Data Accuracy**
  - 2.2 National Map Accuracy Standards**
  - 2.3 Threshold Accuracy Values**
- 3.0 NJ Department of Environmental Protection Standards**
  - 3.1 Datum and Projection**
    - 3.1.1 Horizontal and Vertical Datum's**
    - 3.1.2 Projection & Coordinate Systems**
  - 3.2 Data Capture Methodology**
    - 3.2.1 Tablet Digitizing**
    - 3.2.2 Heads-up Digitizing**
    - 3.2.3 Scanning & Recompilation**
- 4.0 Global Positioning System (GPS)**
- 5.0 Metadata Standards**
- 6.0 Data Transfer Standards**
  - 6.1 Software**
  - 6.2 Data Distribution**
    - 6.2.1 Digital Transfer Methods**
    - 6.2.2 Offline Data Transfer – Distribution Agreement**

## **APPENDIX**

- A. National Map Accuracy Standards (NMAS)**
- B. Digital Imagery Which Meet NMAS**
- C. New Jersey Basemaps Which Meet NMAS**
  - Hardcopy (Mylar) Basemaps**
- D. Basemap Resources**
  - Aerial Photography Resources**
- E. Metadata**
- F. Internet Resources**

## **RESOURCES**

## SUMMARY

The New Jersey Department of Environmental Protection (NJDEP) maintains a Geographic Information System (GIS) for the storage and analysis of cartographic (mapped) and related environmental scientific and regulatory information for use by the Department. A GIS is a computer mapping system used to display and analyze geographic information and spatial databases.

Many Departmental programs require the submission of mapped data to a GIS standard. The submission of mapped data by all sectors based on this standard will facilitate data input into the Department's GIS and the integration of data with the New Jersey Environmental Management System (NJEMS). Much of these data can be shared back with the regulated community and public as appropriate. Important concepts regarding the creation, capture and delivery of digital mapped information are addressed in this document.

There are three basic concepts that must be followed.

The first concept addresses the need for all mapping to meet accepted accuracy standards. All digital data must meet or reference published standards such as those defined by the Federal Geographic Data Committee or a defined survey standard, regardless of scale. Testing against base maps or photography of known accuracy determines the accuracy of data. This will ensure appropriate positional accuracy of the geographic data and, therefore, compatibility of digital information.

Secondly, digital data provided to or produced for the Department are required to be in North American Datum 1983 (NAD83) horizontal geodetic datum and in the New Jersey State Plane Coordinate system (SPC). SPC is a geographic reference system in the horizontal plane describing the position of points or features with respect to other points in New Jersey. All coordinates of the system are expressed in meters. The Department, however, prefers to receive and maintain data in U.S. survey feet. The official survey base of the State is known as the New Jersey State Plane Coordinate System whose geodetic positions have been adjusted on the NAD83 as per Chapter 218, Laws of New Jersey 1989.

Lastly, GIS data must also be documented using the Federal Geographic Data Committee (FGDC) Metadata Standard or be compliant with the FGDC Metadata Standard. Metadata is information about the digital data being provided. It is important to know not only the positional coordinates of mapped information, but also how the data was produced and the accuracy of the data being made available. The Federal Spatial Data Transfer Standard (SDTS) requires that a quality report accompany the data. This information should include a statement of the positional accuracy of the data and testing procedures used to determine positional accuracy. Geographic data must be delivered according to standard media and digital formats. Accepted formats and media currently used by the Department are presented in the body of this paper.

Programs within the Department may define additional technical mapping requirements to accommodate specific program needs.

**MAPPING AND DIGITAL DATA STANDARDS  
GEOGRAPHIC INFORMATION SYSTEM  
NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION**

## **1.0 INTRODUCTION**

Geographic Information System technology has become a tool for innovative efforts to protect the natural environment and the public health of citizens, nationally and within the State of New Jersey. To adequately address these and other issues, the Department must make decisions based on sound data of known and adequate accuracy. This document provides guidance for the basic standards for creating, describing and distributing spatial data on a GIS. Basic standards will ensure consistent data quality and documentation, provide for compatibility between data sets, facilitate interactive analysis within the Department and ensure the highest quality of results derived from the GIS.

The Department endorses the Federal Geospatial Standards (FGDC, 1998) for positional accuracy as the most comprehensive and current standard. The Department continues to support National Map Accuracy Standards.

## **2.0 GEOSPATIAL POSITIONING ACCURACY STANDARDS AND TESTING**

There are two widely accepted standards for positioning accuracy for mapped data, the Federal Geographic Data Committee (FGDC) “Geospatial Positioning Accuracy Standards Part 3: National Standard for Spatial Data Accuracy” (1998) and National Map Accuracy Standard (1947). The Department supports both these standards and either standard can be used for mapped data. The Department recommends the more current FGDC (1998) standard.

### **2.1 Federal Geographic Data Committee (FGDC)**

The Federal Geographic Data Committee (FGDC) in 1998 released the endorsed version of “Geospatial Positioning Accuracy Standards Part 3: National Standard for Spatial Data Accuracy” (NSSDA) (<http://www.fgdc.gov/standards/>). This standard is designed for digital spatial data. In spite of the title, it prescribes a testing methodology, rather than threshold accuracy values, and is described as a Data Usability Standard.

The NSSDA requires the following test (quoted from Sections 3.2.1, 3.2.2, and Appendix 3-A):

The NSSDA uses root-mean-square error (RMSE) to estimate positional accuracy. RMSE is the square root of the average of the set of squared differences between dataset coordinate values and coordinate values from an independent source of higher accuracy for identical points.

Accuracy is reported in ground distances at the 95% confidence level. Accuracy reported at the 95% confidence level means that 95% of the positions in the dataset will have an error with respect to true ground position that is equal to or smaller than the reported accuracy value. The reported accuracy value reflects all uncertainties, including those introduced by geodetic control coordinates, compilation, and final computation of ground coordinate values in the product.

Horizontal accuracy shall be tested by comparing the planimetric coordinates of well-defined points in the dataset with coordinates of the same points from an independent source of higher

accuracy. Vertical accuracy shall be tested by comparing the elevations in the dataset with elevations of the same points as determined from an independent source of higher accuracy.

Errors in recording or processing data, such as reversing signs or inconsistencies between the dataset and independent source of higher accuracy in coordinate reference system definition, must be corrected before computing the accuracy value.

A minimum of 20 checkpoints shall be tested, distributed to reflect the geographic area of interest and the distribution of error in the dataset. When 20 points are tested, the 95% confidence level allows one point to fail the threshold given in product specifications.

Horizontal Root Mean Square Error is known as RMSE<sub>r</sub>.

If error is normally distributed and independent in each the x- and y-component and error, the factor 2.4477 is used to compute horizontal accuracy at the 95% confidence level (Greenwalt and Schultz, 1968). When the preceding conditions apply, Accuracy<sub>r</sub>, the accuracy value according to NSSDA, shall be computed by the formula:

$$\begin{aligned} \text{Accuracy}_r &= 2.4477 * \text{RMSE}_x = 2.4477 * \text{RMSE}_y \\ &= 2.4477 * \text{RMSE}_r / 1.4142 \\ \text{Accuracy}_r &= 1.7308 * \text{RMSE}_r \end{aligned}$$

Note that because this formula is based on statistical probabilities, the satisfaction of the underlying assumptions is important, and the formula also applies to a specific number of error measurements (20 points). The full FGDC document gives more information on what to do in cases where either of these requirements cannot be satisfied. It also gives direction on additional topics, and a worked example.

The NSSDA test described above has been embodied in the ArcView 3.x extension RMSEr2.avx, written by Gregory Herman of the New Jersey Geological Survey; the extension is available from the ESRI web site (<http://arcscripts.esri.com/details.asp?dbid=10672>). Note that the extension does not provide a test of the validity of the assumptions.

A data set that has been tested for horizontal accuracy per the NSSDA standard should be reported in the metadata as “*Tested \_\_\_\_\_(meters, feet) horizontal accuracy at 95% confidence level.*” Tests and reporting statements for vertical accuracy are analogous, and are shown in the FGDC document.

If alternate means of evaluating accuracy are used, the data set should be reported in the metadata as “*Compiled to meet \_\_\_\_\_(meters, feet) horizontal accuracy at 95% confidence level.*”

In summary, there are seven steps in applying the NSSDA (from Positional Accuracy Handbook, 1999, Minnesota Planning Land Management Information Center):

1. Determine if the test involves horizontal accuracy, vertical accuracy, or both.
2. Select a set of test points from the data set being evaluated.
3. Select an independent data set of higher accuracy that corresponds to the data set being evaluated.
4. Collect measurements from identical points from each of those two sources.
5. Calculate a positional accuracy statistic using either the horizontal or vertical accuracy statistic worksheet.
6. Prepare an accuracy statement in a standardized report form.
7. Include that report in a comprehensive description of the data set called metadata.

The Positional Accuracy Handbook provides a very clear explanation of NSSDA and excellent examples of testing methods and non-testing assessments. It can be found at ([http://www.mnplan.state.mn.us/pdf/1999/lmic/nssda\\_o.pdf](http://www.mnplan.state.mn.us/pdf/1999/lmic/nssda_o.pdf)).

The NSSDA itself does not include threshold values, i.e. values of accuracy that are required for particular purposes. Sources for appropriate threshold values are discussed further below in Section 2.3.

## **2.2 National Map Accuracy Standard (NMAS)**

The National Map Accuracy Standard, designed for paper maps, has been used since their adoption in 1941 to set accuracy requirements and to describe accuracy levels of maps. The 1947 revision is quoted in part below:

1. Horizontal accuracy for maps on publication scales larger than 1:20,000, not more than 10% of the points tested shall be in error by more than 1/30 inch, measured on the publication scale; for maps on publication scales of 1:20,000 or smaller, 1/50th of an inch. These limits of accuracy shall apply in all cases to positions of well-defined points only. Well-defined points are those that are easily visible or recoverable on the ground, such as the following: monuments or markers, such as benchmarks, property boundary monuments; intersections of roads, railroads, etc.; corners of large buildings or structures (or center points of small buildings); etc. In general what is well defined will also be determined by what is plottable on the scale of the map within 1/100 inch. Thus, while the intersection of two road or property lines meeting at right angles would come within a sensible interpretation, identification of the intersection of such lines meeting at an acute angle would obviously not be practicable within 1/100 inch. Similarly, features not identifiable upon the ground within close limits are not to be considered as test points within the limits quoted, even though their positions may be scaled closely upon the map. Examples of data in this class would be timberlines, soil boundaries, etc.

2. Vertical Accuracy, as applied to contour maps on all publication scales, shall be such that not more than 10 percent of the elevations tested shall be in error more than one-half the contour interval. In checking elevations taken from the map, the apparent vertical error may be decreased by assuming a horizontal displacement within the permissible horizontal error for a map of that scale.

NMAS accuracy is described in map units (inches on the map), rather than ground units (feet or meters in the real world). Given a scale, one can translate the map units into ground units. For example, NMAS requires that a map of scale 1:12,000 shall have an accuracy of 1/30 inch; the corresponding ground unit accuracy is 33.3 ft. Although designed for paper maps, NMAS has been widely used to describe the accuracy level of digital data; for example, a digital data set is commonly described as meeting NMAS at a particular nominal scale.

As discussed above, NMAS is based on statistical testing; however the confidence level is set at 90%, in contrast to the 95% confidence level required by NSSDA. This means that the same map or data set will have a different accuracy level description (i.e. different numerical accuracy value in feet or meters) for NMAS vs. NSSDA. One can think of the horizontal accuracy as a circle of that radius around each well-defined position point: the confidence level expresses the likelihood that the actual location of the point falls within that circle. For a given “quality” of data, one needs a larger circle for a 95% confidence level than for a 90% confidence level. Appendix 3-D of the NSSDA document gives a fuller treatment of the relationship between NMAS and NSSDA.

The full text of National Map Accuracy Standards (1947) is shown in Appendix A.

## 2.3 Threshold Accuracy Values

The Department continues to support positioning data to meet the accuracy level of the NMAS, but using the testing methodology and reporting language of NSSDA. One approach to satisfying this requirement is to establish an appropriate nominal scale for the data/mapping in question, and use the NSSDA equivalent of NMAS values to establish threshold values for accuracy. The mathematical relationship is described in the NSSDA document (Appendix 3-D). Table 2.3.1 below shows the results of this calculation for a range of scales.

**Table 2.3.1** Threshold accuracy values in ground units.

Scale	NMAS accuracy (feet)	NSSDA Accuracy <sub>r</sub> (feet)	NMAS accuracy (meters)	NSSDA Accuracy <sub>r</sub> (meters)
Large scale	1/30 inch (map)			
1:1,200	3.3	3.8	1.0	1.2
1:2,400	6.7	7.7	2.0	2.3
1:6,000	16.7	19	5.1	5.8
1:12,000	33.3	38	10.1	12
Small scale	1/50 inch (map)			
1:24,000	40	46	12.2	14
1:63,360	106	120	32.3	37
1:100,000	167	190	50.9	58
1:250,000	417	475	127	145
1:500,000	833	950	254	290

*Derived from National Map Accuracy Standards (1947).*

When the FGDC began work on the NSSDA, the subcommittee used Accuracy Standards for Large-Scale Maps (Interim, 1990) from the American Society for Photogrammetry and Remote Sensing (ASPRS) as the basis for updating NMAS. The ASPRS standards use  $RMSE_x$  and  $RMSE_y$  as their base statistics, and state threshold values for various scales. (Note that  $RMSE_x$  and  $RMSE_y$  are NOT the same as  $RMSE_r$ .) Discussion of these standards can be found in the NSSDA document (section 3.1.5 and Appendix 3-D). Table 2.3.2 below shows the threshold values of the ASPRS Class 1 mapping standards and their translation into Accuracy<sub>r</sub> of NSSDA (note that statistical assumptions are involved in making this calculation). As comparison of Accuracy<sub>r</sub> values between the two tables shows, the ASPRS standards are stricter than NMAS.

Should the map producer not be able to test the quality of the submitted data by either of these two tests, then the producer shall document this fact in the metadata submitted with the digital GIS data. The Department strongly recommends that when a producer of mapped information is not required to submit data to a quality standard by regulation or by contract, that an accuracy statement be submitted with the GIS data and referenced in the metadata.

**Table 2.3.2** Threshold accuracy values in ground units.

Scale	Class 1 Planimetric Accuracy, limiting RMSE (feet)	Equivalent Accuracy <sub>r</sub> , NSSDA (feet)	Class 1 Planimetric Accuracy, limiting RMSE (meters)	Equivalent Accuracy <sub>r</sub> , NSSDA (meters)
1:60	0.05	0.12		
1:1,200	1.0	2.4		
1:2,000			0.50	1.2
1:2,400	2.0	4.9		
1:5,000			1.25	3.1
1:6,000	5.0	12.2		
1:10,000			2.50	6.1
1:12,000	10.0	24.5		
1:20,000	16.7	40.9	5.00	12.2

*Derived from American Society for Photogrammetry and Remote Sensing Class 1 Horizontal Interim Accuracy Standards for Large-Scale maps (1990).*

The New Jersey Society of Professional Land Surveyors (NJSPLS, <http://www.njspls.org/>) has also produced a set of proposed threshold Accuracy<sub>r</sub> values for several specific types of GIS data. Because these standards have not yet been adopted, they are not shown here.

### **3.0 NEW JERSEY DEPARTMENT ENVIRONMENTAL PROTECTION GIS DATA STANDARDS**

The remainder of this document describes standards adopted by the Department to facilitate data sharing and provide the basic standards for creating, describing and distributing spatial data on its GIS. The objective is to facilitate interactive analysis of data of the highest quality within the Department.

#### **3.1 Datum and Projection**

##### **3.1.1 Horizontal and Vertical Datums**

The North American Datum of 1983 (NAD83) is required for mapping in the horizontal plane. The North American Vertical Datum of 1988 (NAVD 88) should be used when possible rather than the older National Geodetic Vertical Datum of 1929 (NGVD29).

##### **3.1.2 Projection and Coordinate System**

Based on the Chapter 218, Laws of New Jersey 1989, New Jersey State Plane is required in meters (the Department prefers feet), NAD83. The State of New Jersey is entirely contained within one state plane zone (2900). Special situations may require

other projection systems for small-scale maps of regional (interstate) or national interest. The Department prefers to use feet as the units of measure and serves all of its data in the following Projected Coordinate System: **NAD\_1983\_StatePlane\_New\_Jersey\_FIPS\_2900\_Feet**

## **3.2 Data Capture Methodology and Procedure**

GIS information comes from a variety of sources, which can produce a wide range of positional accuracy. Consequently, each source must be evaluated to determine whether redrafting is necessary to prepare the data for entry into the GIS. Heads-up digitizing, Tablet digitizing, Scanning, and Global Positioning Systems (See Section 4.0) are all viable methods to input data to a GIS. Much of the data required for a GIS can be derived directly from the photo-interpretation of aerial photos or from rectified photo basemaps. Whichever method is used it is important that the most accurate data source set be used whenever possible. For NJ, the February-April, 2002 digital color infrared (CIR) orthophotography 1:2400 (1"=200') are currently the preferred reference for heads up digitizing. Only differentially corrected GPS coordinates may surpass this source in accuracy.

### **3.2.1 Heads-Up Digitizing**

Heads-Up digitizing is a technique that is useful for capturing or updating data from digital imagery on screen. High-resolution digital imagery now allows GIS users to edit and delineate features directly on the screen using desktop GIS software. The following considerations should be carefully planned out in advance.

1. The user must document procedures when using this technique.
2. Scale used for data capture should be established & documented. Recommended scales for digitizing should be between 1:1200 to 1:4000 over DOQQ. Below 1:1200 the imagery becomes extremely blurred. Above 1:4000 accuracy could be compromised.
3. Digitizing tolerances should be established and documented.
4. Users should maintain clear definitions or classifications of features that are being interpreted and delineated.
5. Ground truth (field verification) remains an important step in establishing the quality of heads-up digitizing, particularly for land cover delineation.
6. Make sure appropriate entries concerning the quality of the data are documented in the metadata files.

Detailed classification systems and resolution of imagery may require that features be captured on the screen and then photo-interpreted from aerial photography to the digital image. Photo-interpreting and heads-up digitizing at the same time can be extremely difficult even for experienced users.

All attribute coding shall be 100% correctly coded. A full description of each code should be provided as part of the metadata. The coding of features should follow an approved classification system as adopted by State and Federal agencies. These codes follow specifications of organizations responsible for deriving and maintaining the data. For example, the Department uses the Cowardin et al. (1979) system for the Classification of Wetland and Subaqueous Lands in the United States as adopted by the National Wetlands Inventory of the U.S. Fish and Wildlife Service. In addition the Department supports a modified version of Anderson et al. (1976), USGS, for classifying

land use/land cover. For prototype classification schemes, clear concise documentation describing the classes is required.

### **3.2.2 Tablet Digitizing**

Tablet digitizing is a common method of getting data into a GIS. The procedure involves tracing lines or locating points with a computer mouse on a digitizer. The manuscript's lines should be clear and complete with no gaps or shortfalls. Operators should not interpret and digitize at the same time. The digitizer should concentrate solely on capturing the exact nature of the features. All maps shall be edge matched prior to digitization to eliminate cartographic errors and reduce digital problems. Digital accuracy shall be evaluated by proof plotting the digital data to the base at the same scale as the manuscript and overlaying the data to the original map. The line work should be digitized in such a way as to create a digital copy that is within +/- one line width of the original. Edits can be flagged and corrected such that the standard is met. Coverage TICS should be identified and RMS errors documented in the metadata.

### **3.2.3 Scanning and Recompilation**

Scanning of features from hardcopy sources or the recompilation of existing digital data, involves the redrafting of features from one source to a more accurate, planimetric source based on identifiable features. This method is commonly used to improve the quality of data that has been delineated on sources of unknown or unspecified quality or paper manuscripts. It is also commonly used to transfer data or non-rectified photography to a rectified orthophoto basemap based on a series of local fits of common photo-identifiable features, such as roads.

Other data sources without photo-images may be recompiled to planimetric sources by using other coincident features. For instance, grids on source data may be generated and plotted to planimetric basemaps and used as a guide for the redrafting of information that would otherwise not be usable in a digital form. This has been used to draft historical surveyor boundaries from old atlas sheets to the photoquads, for instance. Whatever the technique, metadata must be completed describing the recompilation techniques employed.

## **4.0 GLOBAL POSITIONING SYSTEM (GPS)**

The NAVSTAR Global Positioning System (GPS) has become a mainstream technology for data collection for GIS. In New Jersey, state, county and municipal government agencies, academic institutions, public utilities, non-profit organizations, and private firms are using the technology to collect positions of features associated with their activities. A GPS receiver is able to determine its 3D position (latitude, longitude, and elevation) on the surface of the earth, store location information and convert the coordinates into features for use in a GIS. Users can not only capture a feature's location, but also enter descriptive attribute data that significantly adds to the final data layer's value in GIS.

GPS is most effective when the GPS receiver's antenna has an unobstructed view of the sky. Buildings in urban areas and dense tree cover can create reception problems making GPS collection work difficult in these types of environments. The GPS receiver must be able to

receive relatively clear signals from at least four satellites simultaneously to determine a 3D position or fix. Depending on the design of the GPS receiver, and the data collection/data processing techniques used, the horizontal range of accuracy can be 15 meters to sub-centimeter.

Positional data collected with GPS must, at a minimum, meet within a 5 meter, 95% confidence standard. This requires all GPS data to be differentially corrected. If accuracy requirements call for higher accuracy, parameter settings have to be adjusted accordingly in order to meet the higher standard.

The Department has adopted standards for the critical settings for rover (field data) receivers that are consistent regardless of which receiver model is being used. Users should not deviate from these standards. These settings include:

**Table 4.0.1** Critical and Recommended Settings for Data Collection

<b>Standard GPS Collection Parameter Settings</b>	
Position Mode	Manual 3D is the normal setting.
Elevation Mask	15 degrees above horizon.
PDOP Mask	6
Signal to Noise Ratio Mask (SNR)	6
Minimum Positions for Point Features	200 (100 for Trimble Pro XL, 60 for Pro XR)
Logging Intervals	Intervals for point features will be 1 second or faster. Intervals for line and area features depend on the velocity at which the receiver will be traveling and the nature of the feature and the operating environment. Under normal circumstances (i.e., when the user is walking with the receiver) the interval for line and area features will be set to a 5-second interval.
Logging of DOP	Turned On.

For detailed information on recommended GPS receiver settings and collection procedures, see the Department's *Standards for Using Code-Based Global Positioning Systems (GPS) for the Development of Accurate Location Data for Use with Arc/Info and ArcView Geographic Information Systems*. (<http://www.state.nj.us/dep/gis/gpsoutstand.html>)

## **5.0 METADATA standards**

Metadata is required for all digital data layers created by the Department. Metadata is supporting information that describes the digital data layer and is critical for users to understand the key components of the data. Metadata describes how the data were created, who created and maintains the data, when the data were created and/or updated, item (attribute) descriptions, transfer standards, and more. The Federal Geographic Data Committee has defined the Federal metadata standard that all Federal agencies are required to follow for each digital data layer. The Department requires that metadata be provided with each digital data layer and that the metadata be FGDC compliant. Standard FGDC compliant metadata is a critical component of information management systems (clearinghouses) on the World Wide Web (WWW) and for any interactive mapping applications provided across the WWW.

The following is a statement from the FGDC on the metadata standard:

The objectives of the standard are to provide a common set of terminology and definitions for the documentation of digital geospatial data. The standard establishes the names of data elements and compound elements (groups of data elements) to be used for these purposes, the definitions of these compound elements and data elements, and information about the values that are to be provided for the data elements.

This standard is the data documentation standard referenced in the executive order (Executive Order 12906, "Coordinating Geographic Data Acquisition and Access: the National Spatial Data Infrastructure)." The standard was developed from the perspective of defining the information required by a prospective user to determine the availability of a set of geospatial data, to determine the fitness the set of geospatial data for an intended use, to determine the means of accessing the set of geospatial data, and to successfully transfer the set of geospatial data. As such, the standard establishes the names of data elements and compound elements to be used for these purposes, the definitions of these data elements and compound elements, and information about values that are to be provided for the data elements.

For more information on metadata, go to the Department's GIS Metadata page (<http://www.state.nj.us/dep/gis/metastan.htm>). For examples of metadata for GIS data layers go to the New Jersey Geographic Information Network (NJGIN) and "Search" for data ([https://njgin.state.nj.us/NJ\\_NJGINExplorer/index.jsp](https://njgin.state.nj.us/NJ_NJGINExplorer/index.jsp)).

Additional information can be found at (<http://www.fgdc.gov/metadata/>).

## **6.0 DATA TRANSFER STANDARDS**

In order to enhance data exchange, the following standards should be followed. Presented below are recommended exchange standards for ESRI's Arc suite of products.

## 6.1 SOFTWARE

### Digital Exchange Standards for GIS

Table 6.1.1 details the exchange standards recommended for the exchange with the Department's GIS software. For "relate," "join" or "link" databases, dbase IV, Access and Excel are preferred over INFO look up tables.

**Table 6.1.1 NJDEP GIS Compatible Configurations**

<i><b>PLATFORM</b></i>	<i><b>UNIX Workstation</b></i>	<i><b>PC</b></i>
<i><b>OPERATING SYSTEM</b></i>	<b>UNIX</b>	<b>Windows 2000, XP</b>
<i><b>SOFTWARE/ File Format</b></i>	<b>ArcGIS 9.x Workstation Geodatabase Coverage Shape Files</b>  <b>ArcView 3.x Coverage Shape Files</b>  <b>DXF</b>	<b>ArcGIS 9.x Geodatabase Personal Geodatabase Coverage Shape Files</b>  <b>ArcView 3.x shape files</b>  <b>DWG (AutoCad)</b> <b>DGN (Microstation)</b> <b>DXF</b>
<i><b>DATA TRANSFER</b></i>	<b>Arc/Info Interchange File (*.e00)</b> <b>Shapefile</b> <b>XML</b>	<b>Arc/Info Interchange File (*.e00)</b> <b>Shapefile</b> <b>XML</b> <b>Winzip (rename to *.abc) (*=name of file)</b>
<i><b>MEDIA</b></i>	<b>CD-ROM (CD-R)</b> <b>DVD</b> <b>3 1/2" HD 1.44MB</b>	<b>CD-ROM (CD-R)</b> <b>DVD</b> <b>3 1/2" HD 1.44MB</b> <b>Zip Disk (100 or 250MB)</b>

## 6.2 DATA DISTRIBUTION

### 6.2.1 Digital Transfer Methods

Data are available in the following variety of formats from a variety of sources today. The formats, usually available in compressed Zip file format, should be compatible with Table 6.1. The New Jersey Geographic Information Network (NJGIN) ([https://njgin.state.nj.us/NJ\\_NJGINExplorer/index.jsp](https://njgin.state.nj.us/NJ_NJGINExplorer/index.jsp)) is the preferred centralized location and method for data distribution to users outside the Department.

### **6.2.2 Data Supplied by NJDEP**

For data supplied by the Department the following Distribution Agreement (NJDEP) shall accompany all data transfers. The users agree to abide by the terms and conditions of the following:

#### **I. Description of Data to be provided**

The data provided herein are distributed subject to the following conditions and restrictions.

For all data contained herein, (NJDEP) makes no representations of any kind, including, but not limited to, the warranties of merchantability or fitness for a particular use, nor are any such warranties to be implied with respect to the digital data layers furnished hereunder. NJDEP assumes no responsibility to maintain them in any manner or form.

#### **II. Terms of Agreement**

1. Digital data received from the NJDEP are to be used solely for internal purposes in the conduct of daily affairs.
2. The data are provided, as is, without warranty of any kind and the user is responsible for understanding the accuracy limitations of all digital data layers provided herein, as documented in the accompanying Metadata, Data Dictionary and Readme files. Any reproduction or manipulation of the above data must ensure that the coordinate reference system remains intact.
3. Digital data received from the NJDEP may not be reproduced or redistributed for use by anyone without first obtaining written permission from the NJDEP. This clause is not intended to restrict the distribution of printed mapped information produced from the digital data.
4. Any maps, publications, reports, or other documents produced as a result of this project that utilize the Department's digital data will credit the Department's Geographic Information System (GIS) as the source of the data with the following credit/disclaimer: "This (map/publication/report) was developed using New Jersey Department of Environmental Protection Geographic Information System digital data, but this secondary product has not been verified by NJDEP and is not State-authorized."
5. Users shall require any independent contractor, hired to undertake work that will utilize digital data obtained from the Department, to agree not to use, reproduce, or redistribute NJDEP GIS data for any purpose other than the specified contractual work. All copies of the Department's GIS data utilized by an independent contractor will be required to be returned to the original user at the close of such contractual work.

Users hereby agree to abide by the use and reproduction conditions specified above and agree to hold any independent contractor to the same terms. By using data provided herein, the user acknowledges that terms and conditions have been read and that the user is bound by these criteria.

# APPENDIX

## Appendix A. National Map Accuracy Standard (NMAS)

### **NATIONAL MAP ACCURACY STANDARDS United States National Map Accuracy Standards U.S. Bureau of the Budget, Revised June 17, 1947**

With a view to the utmost economy and expedition in producing maps, which fulfill not only the broad needs for standard or principal maps, but also the reasonable particular needs of individual agencies, standards of accuracy for published maps are defined as follows.

1. Horizontal accuracy, for maps on publication scales larger than 1:20,000, not more than 10% of the points tested shall be in error by more than 1/30 inch, measured on the publication scale; for maps on publication scales of 1:20,000 or smaller, 1/50<sup>th</sup> of an inch. These limits of accuracy shall apply in all cases to positions of well-defined points only. Well-defined points are those that are easily visible or recoverable on the ground, such as the following: monuments or markers, such as benchmarks, property boundary monuments; intersections of roads, railroads, etc.; corners of large buildings or structures (or center points of small buildings); etc. In general what is well defined will also be determined by what is plotable on the scale of the map within 1/100 inch. Thus, while the intersection of two road or property lines meeting at right angles would come within a sensible interpretation, identification of the intersection of such lines meeting at an acute angle would obviously not be practicable within 1/100 inch. Similarly, features not identifiable upon the ground within close limits are not to be considered as test points within the limits quoted, even though their positions may be scaled closely upon the map. This class would include timberlines, soil boundaries, etc.
2. Vertical Accuracy, as applied to contour maps on all publication scales, shall be such that not more than 10 percent of the elevations tested shall be in error more than one-half the contour interval. In checking elevations taken from the map, the apparent vertical error may be decreased by assuming a horizontal displacement within the permissible horizontal error for a map of that scale.
3. The accuracy of any map may be tested by comparing the positions of points whose locations or elevations are shown upon it with corresponding positions as determined by surveys of a higher accuracy. Tests shall be made by the producing agency, which shall also determine which of its maps are to be tested, and the extent of such testing.
4. Published maps meeting these accuracy requirements shall note this fact on their legends, as follows: "This map complies with National Map Accuracy Standards."
5. Published maps whose errors exceed that aforesaid shall omit from their legends all mention of standard accuracy.
6. When a published map is a considerable enlargement of a map drawing (manuscript) or of a published map, that fact shall be stated in the legend. For example, "This map is an enlargement of a 1:20000-scale map drawing," or "This map is an enlargement of a 1:24000-scale published map."
7. To facilitate ready interchange and use of basic information for map construction among all Federal mapmaking agencies, feasible and consistent with the uses to which the map is to be put, shall conform to latitude and longitude boundaries, being 15 minutes of latitude and longitude, or 7.5 minutes, or 3-3/4 minutes in size. (From Thompson, 1987).

## **Appendix B. Digital Imagery (Meets NMAS)**

### **2002 Digital color infrared (CIR) orthophotography**

Aerial photography of the entire State of New Jersey was captured during February-April, 2002. Digital color infrared (CIR) orthophotography was produced at a scale of 1:2400 (1"=200') with a 1 foot pixel resolution for New Jersey in State Plane NAD83 Coordinates, U.S. Survey Feet. Digital orthophotography combines the image characteristics of a photograph with the geometric qualities of a map. Digital orthophotography is a process, which converts aerial photography from an original photonegative to a digital product that has been positionally corrected for camera lens distortion, vertical displacement and variations in aircraft altitude and orientation. The ortho-rectification process achieved a +/-4.0 ft. horizontal accuracy at a 95% confidence level, National Standard for Spatial Data Accuracy (NSSDA).

This dataset consists of 5000' x 5000' files in MrSID format with a 15:1 compression ratio. The files, which can be selected and downloaded from the NJGIN site, were produced utilizing MrSID Geospatial Edition 1.4 and are approximately 5 MB in size.

**State Resource:**                      **NJ Geographic Information Network (NJGIN)**  
[https://njgin.state.nj.us/NJ\\_NJGINExplorer/index.jsp](https://njgin.state.nj.us/NJ_NJGINExplorer/index.jsp)

The 2002 orthos are available for purchase in MrSID compressed format (on DVD media only) from the USGS-EROS Data Center.

A complete set of orthos for the State is available on 13 DVDs at a cost of \$785.00. Note: If you are NOT purchasing a complete set of orthos on 13 DVDs, you need to include the DVD series number (i.e., DVD 1 of 13, DVD 2 of 13, etc.) with your order.

The MrSID Index with the series number for each DVD is provided as an ESRI shapefile from the NJGIN site.

Pricing Information: \$60 per DVD + \$5 handling fee per order (subject to change).

Payment, or obligation by way of a purchase order, must be received by the USGS-EROS Data Center before order processing may begin. All instruments of payment are to be made payable to Department of the Interior, USGS. The link for payment options is:  
<http://edc.usgs.gov/about/customer/modes.html>

To order: Send email to [custserv@usgs.gov](mailto:custserv@usgs.gov) or contact Kim Brown at 1-800-252-4547, ext. 2061. USGS-EROS Data Center Business Hours: Monday through Friday, 8:00 a.m. to 4:00 p.m., Central Time.

### **1995-97 Digital color infrared (CIR) orthophotography**

The imagery conforms to the standards of USGS “standard product” for digital orthophoto quarterquads (DOQQs). Many organizations including the Department use these high quality images as digital base maps for mapping applications.

The 1995/97 imagery is color infrared (CIR), has 3 bands, 1 meter resolution, and is NAD83 in UTM (meters). The standard product is available through the USGS EROS Data Center. The Department has made the data available on the GIS server in SPC feet, NAD83. The imagery is available from the following resources:

- Federal Resource:**      <http://earthexplorer.usgs.gov>  
                                 <http://www.usgs.gov/pubprod/index.html>  
                                 USGS (703) 648-5931
- State Resource:**        **NJ Geographic Information Network**  
                                 ([https://njgin.state.nj.us/NJ\\_NJGINExplorer/index.jsp](https://njgin.state.nj.us/NJ_NJGINExplorer/index.jsp))

### **1991-92 Digital imagery**

The 1991-92 digital imagery is available at 5-ft (quarter quad) resolution or 10 ft (quad) grayscale (1 band) digital files, NAD83. These images meet NMAS at the production scale (1:12000) and are the manuscript images from which the 1991-92 Mylar basemaps were made. The files are .gis (ERDAS) files and are 16mb each. These digital images are available only from MARKHURD.

- Contractor Resource:**    **MARKHURD, Minneapolis, MN (1-800-MAP-HURD).**

## **Appendix C.**

## **New Jersey Basemaps Which Meet NMAS**

The Department has created several source basemaps that are available for mapping initiatives that meet or exceed NMAS. Basemaps provide the foundation for many mapping projects and for the display of mapped information. As such, basemaps must meet uniform, rigorous standards for positional accuracy and cartographic integrity. Over the years, several series of quality basemaps that meet or exceed NMAS have been produced. Basemaps can be either hardcopy (Mylar or acetate) or digital (softcopy). A statewide synoptic set of hardcopy basemaps for New Jersey was made from aerial over-flights sponsored by the Department in 1991 and 1986. In both cases, both quadrangle (1:24000) and quarter quadrangle (1:12000) hardcopy Mylar basemaps were produced. Other basemaps cover specific areas only, such as the 1977-78 Tidelands photo basemaps. Two series of digital (softcopy) basemaps have also been produced, from the 1991 and 1995/97 over-flights. The digital images were produced at quarterquad scale (1:12000).

### **\* Hardcopy (Mylar) Basemaps**

Listed below in order of general overall quality is available New Jersey basemap series that were produced on stable base mylar and meet a definable mapping standard (NMAS). The first four series listed are photo basemaps, derived from aerial photography. The 1991/92 and the 1986 wetland series are both orthophoto basemaps compiled from a sophisticated aero-triangulation process. They should be used whenever possible to generate GIS compatible data and/or to use as a recompilation base.

All the hardcopy basemaps described herein with the exception of the 1991/92 products are referenced in NAD27. For this reason, the 1991/92 mylar basemap quads (1:24000) and quarterquads (1:12000) series, referenced in NAD83 are highly recommended by the Department over all other sources listed for mapping at these scales. Stable base site maps of large scale meeting NMAS, produced by surveying, mapping or photogrammetric firms may qualify as GIS compatible if they contain a minimum of four registration tics in the New Jersey State Plane Coordinate System, North American Datum 1983 (NAD83), the official survey base of New Jersey. The USGS topoquad series are not recommended as a delineation source because they are generally available only on paper and are not synoptic data sources. Rather, they represent variable data sources and dates.

### **\* 1991/92 Orthophoto Basemaps (Quadrangles and Quarter quadrangles)**

The most recent statewide set of hardcopy chronoflex quarterquad (1:12000) and photoquad (1:24000) photo basemaps were produced from the 1991/92 aerial overflight of the State. These basemaps meet or exceed NMAS. This series of maps is referenced in SPC feet in NAD83, but also has NAD27 tics in the margin. This series is the most current, highest quality basemaps of their scale available statewide, that are referenced in the new datum, NAD83. This basemap series is highly recommended by the Department for mapping efforts at these scales.

### **\* 1986 Freshwater Wetlands Orthophoto Quarterquad Basemaps (1:12000)**

The passage of the Freshwater Wetlands Act of 1987 required the State to produce a composite map of the freshwater wetlands (FWW) for the State. Subsequently, a set of 635 chronoflex photo quarterquads for the entire State from the March 1986 overflight was produced. The maps represent an excellent source for both photo-interpretation and

recompilation at a county, municipal or site level. However, these maps are dated and are referenced in the old datum (NAD27). The 1991/92 series now supercedes these maps. There is also a set of composite hardcopy FWW maps with the delineation superimposed on the image.

**\* 1986 Photoquad Basemaps (1:24000)**

A statewide overflight in March 1986 produced a complete set of stable base photoquads at 1:24000. The control for the production of these basemaps was the Mylar USGS 7.5-Minute topoquads. The photoquads have been widely used both to create data layers and to recompile other data sources from paper or non-planimetric sources. These basemaps did not follow rigorous orthophoto techniques and are referenced in the old datum. The 1991/92 basemaps supercedes these maps.

**\* 1977/78 Tidelands Basemaps (1:2400)**

The tidelands maps are a series of 1:2400 base maps for the coastal zone that include all tidal areas in the State to delineate the State's claim to all tide-flowed lands. The series consists of 1628 photo basemaps. These maps are rectified products that meet NMAS below the ten-foot contour. The photo-image is late summer of 1977 and 1978. These maps cover the entire coastal zone up to the head-of-tide.

**\* USGS 7.5-Minute Series Topoquad Basemaps (1:24000)**

The USGS has published an entire series of 172 topographic maps for the State at a scale of 1:24000. The base information ranged from the late 1940's to the 1980's with photo-updates into the mid 1990's. Because these maps vary in source date, and because more accurate and current basemaps (1991/92) are available, the USGS topoquads series *is not recommended* by the Department as a mapping base. The topoquads do represent an excellent reference source, particularly for named places and features.

## **Appendix D. Basemap Resources**

Mylar photo basemaps from 1991, 1986 and 1977/78 and the digital imagery from 1991 may be obtained from MARKHURD, Minneapolis, MN (1-800-MAP-HURD). There are several sets of the 1986 and 1991 chronoflex (Mylar) base maps in the Department. The GIS Unit has a set of each for reference.

Paper prints of 1986 and 1991 orthophoto basemap series, as well as paper prints of USGS topoquads, may be obtained from the Department's Maps and Publications; (609) 777-1038. Paper prints from the 1977/78 series are available from the Bureau of Tidelands Management: (609) 292-2573.

Topoquads and other USGS Federal maps (and aerial photos) may be ordered from 1-800-USA-MAPS or (703) 648-5931.

### **\* Aerial Photograph Resources**

Historic aerial photography is available for inspection at the Department's Tidelands Management Program (TMP) by scheduled appointment. The 1986, 1991/92, 1995/97 and 2002 photo color infrared frames are also available for inspection at the TMP. Appointments are required. The 1991/92 and 1995/97 photos may also be purchased from the USGS EROS Data Center.

**Federal Resource:**      <http://www.usgs.gov/pubprod/index.html>  
USGS (703) 648-5931

**Department Resource:**    **Tidelands Management Program (609) 633-7369**

## **Appendix E. Metadata**

For examples of metadata please go to the New Jersey Geographic Information Network and search for GIS data ([https://njgin.state.nj.us/NJ\\_NJGINExplorer/index.jsp](https://njgin.state.nj.us/NJ_NJGINExplorer/index.jsp)). For additional resources go to the Department's GIS web site (<http://www.state.nj.us/dep/gis/metastan.htm>) for a description of metadata and additional examples.

## **Appendix F. Internet Resources**

**NJDEP, GIS:** <http://www.state.nj.us/dep/gis>

**NJ Geographic  
Information  
Network:** [https://njgin.state.nj.us/NJ\\_NJGINExplorer/index.jsp](https://njgin.state.nj.us/NJ_NJGINExplorer/index.jsp)

**GPS Resource:** <http://www.state.nj.us/dep/gis/newgps.htm>

**Appendix E:**  
**Highlands Technical Documentation Template**

# New Jersey Highlands Water Protection and Planning Council

## [Title]

---

Release Date: [DATE]

### **Abstract**

[75-100 word description of document clarifying intended audience and use.]



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## Statutory Platform, Purpose and Funding

250 word max. Clarify:

1. Why this document was prepared (ACT/RMP context: cite goals and objectives that drive need for this document)
2. What this document is/does.
3. Who it is intended to be used by.
4. How it will be funded for Highlands conforming towns.

Example provided by Highlands Council:

Through the passage of the New Jersey Highlands Water Protection and Planning Act in 2004, the NJ Highlands Water Protection and Planning Council (the Highlands Council) was created and charged with developing a Regional Master Plan (RMP). Adopted in 2008, the RMP serves as the guiding document for the long-term protection and restoration of the region's critical resources. This Lake Management Plan Guidance document was developed in accordance with Objective 1L6a of the RMP. \*

This is a technical document, intended to be used by planning and science professionals within a municipality to aid in the development of an Adaptive Lake Management strategy, by providing the tools to analyze lake management needs, set corresponding goals, identify appropriate solutions, implement those solutions, and establish ongoing monitoring and management tactics.

Funding to support this work within a municipality is provided through the Highlands Plan Conformance process. Municipalities with approved Plan Conformance Petitions are eligible for grant funding to cover the reasonable expenses of planning activities associated with the Conformance process and should contact their Highlands Council Municipal Liaison for additional information.

*\* Copies of the Highlands Regional Master Plan are available in most municipal offices and can be obtained by contacting the Highlands Council office.*

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Third level heading – Use style “Heading 3” .....	1
Fourth level heading – Use style “Heading 4” .....	1
Fifth Level Heading – Use style “Heading 5.....	1
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## **Chapter 1 Title – Use style “Heading 1, Chapter Title”**

This Microsoft Word template was created using styles that will allow for the automatic creation of a table of contents ONLY IF the appropriate styles are selected. A copy of the MS Word file is available by contacting the Highlands Council.

Body copy for main chapter text, and all text under heading 1, 2 and 3, should use the “Normal” style. Use a manual return between paragraphs and before the first line of text in a new chapter, but NOT after subheadings.

Please use APA style for all in-text citations and reference list at end of document. If another style is preferable, please just remain consistent throughout document and include complete reference list at end of document.

### **Second-level heading – Use style “Heading 2”**

Text goes here. Text goes here. Text goes here. Text goes here. Text goes here. Text goes here. Text goes here. Text goes here..

### ***Third level heading – Use style “Heading 3”***

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### **Fourth level heading – Use style “Heading 4”**

For body copy under this level heading use style “Body Copy level 4 and 5 (indent).”

Text goes here. Text goes here. Text goes here. Text goes here..

### ***Fifth Level Heading – Use style “Heading 5***

Here again, use “Body Copy level 4 and 5 (indent).”

At the end of a Chapter, insert a “Next Page” Section Break, so that the page footer can be customized with the chapter title.



## **Appendix A: Case Studies/Success Stories**

## Case Study 1

[illegible]

## Case Study 2

[illegible]

## **Glossary of Commonly Used Terms**

**Word** – Definition.

**Word** – Definition.

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**Word** – Definition.

## References

[Please use APA style for all in-text citations and reference list at end of document. If another style is preferable, please just remain consistent throughout document and include complete reference list at end of document.]