BMP Implementation Survey study plan

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INTRODUCTION

Background

Two previous statewide surveys have been completed that assessed the rate of implementation of forestry BMPs to protect water quality in NC. Final reports were issued in 2005 and 2011. These previous surveys were based on the BMP manual that was current at the time (dated 1998) and assessed only active sites. Field surveys were completed by a combination of Central Office, County, and District NC Forest Service staff. The NC forestry BMP manual underwent significant revisions and a new version issued in 2006. Furthermore, in 2007 the Southern Group of State Foresters Water Resources Committee (SGSF WRC) issued recommendations for conducting BMP surveys in the southeastern region of the U.S. that would enhance data comparability between states, and therefore support analysis of BMP implementation on a regional scale. In 2012, efforts began to repeat the third round of the survey in NC, this time using the revised 2006 BMP manual and primarily Central Office (NPS Branch) staff as surveyors in order to provide more consistency in making the assessments. A major effort was made to streamline data management, and there was a strategic shift to infield data entry using ruggedized tablets rather than paper forms. For this current study, the assessments themselves are much more extensive as compared to previous surveys as they include each of the 392 BMP recommendations included in the 2006 BMP manual. Each of these recommendations is assessed as often as applicable for each survey site; for example, all BMPs associated with skid trails are assessed for each individual skid trail.

Table 1 Summary of previous BMP implementation surveys

Report date	Data collections	# sites
2005	2000-2003	565
2011	2006-2008	212

This document is intended to provide an overall rationale for the study from this point forward in order to: assist with identification of additional field survey sites; identify necessary resources (staff time, travel) and timeline for completing the current field surveys; and provide documentation on the field assessment method and use of the MS Access-based field data entry tool. This will promote the collection of consistent data that will be suitable in terms of quality and quantity to address the questions behind this initiative.

Survey objectives and questions

The primary objectives are to develop estimates, based on a sampling of active or recently completed logging operations, of:

- The frequency of implementation of forestry BMPs for water quality;
- The frequency of risks to water quality when BMPs are not implemented or are implemented incorrectly; and
- Whether the rate of BMP implementation and relative risks to water quality have changed as compared to past surveys.

These estimates will be summarized at several scales: statewide, ecoregional, and by organizational boundaries (NCFS Regions and Districts). Additional analyses will be performed to determine if lower levels of implementation or higher risks to water quality are associated with additional factors, such as site topography (slope, landscape position), land ownership type, the extent of pre-harvest planning and assistance from forestry management professionals, and ProLogger training status. Comparisons to previous surveys may be somewhat

problematic due to the major changes to the number of assessment questions and methodology, but the current survey will provide similar types of data for analysis (percent implementation, percent with a risk to WQ). It is anticipated that the statistical methods to be used (confidence intervals, Chi square-type analyses, etc.) will still allow meaningful comparisons, though with some caveats.

Depending on the findings, outcomes of this project may include:

- Identification of additional training or educational needs for landowners, timber buyers, foresters, and loggers;
- Help with determination of NCFS water quality forester staffing needs;
- Modifications to the current BMP recommendations in order to enhance successful implementation of forestry BMPs, and therefore to increase compliance with state and/or federal water quality protection rules, especially the NC Forest Practices Guidelines Related to Water Quality (FPGs) and the NC General Statutes (GSs) related to stream or ditch obstructions; and
- Support regional characterization of BMP implementation in the southeastern U.S. by the SGSF WRC.

Previous surveys were reviewed to identify the anticipated rate of BMP implementation and to determine which forestry activities were associated with the lowest rate of implementation and highest rate of existing risk to water quality. The 2000-2003 survey had an overall implementation rate of 82% and the 2006-2008 survey an overall implementation rate of 85%. Determination of a significant statistical difference between these two surveys based on previously reported confidence intervals (CI) is not currently possible, as the methods used to determine CIs on these proportions were drastically different between the two surveys, and the method used for the 2000-2003 survey was not statistically valid. So, in order to determine if there was a significant change in BMP implementation between the two surveys, a basic Chi-square test using the total sample sizes provided in the original reports was performed. The basic 2x2 contingency table is shown below. The number of assessments and % implemented were taken directly from the reports from each of the two previous surveys, and represent the total number of individual BMPs that were assessed in each study.

Table 2 Contingency table (2x2) for BMP implementation rates during previous surveys (2000-2003; 2006-2008).

	BMP implemented?			
Survey	Yes	No	Total	% implemented
2000-2003	35,260	7,740	43,000	82%
2006-2008	6,512	1,149	7,661	85%
Total	41,772	8,889	50,661	--

The Chi-square was 40.504, DF = 1, and $p<0.0001$, and therefore the proportions seen in the two surveys were significantly different at the 95% confidence level; in other words, there was a small but statistically significant increase in overall BMP implementation statewide between the 2000-2003 and the 2006-2008 surveys.

Both earlier surveys noted that BMP implementation was lowest in the “mountain” region and highest in the “coastal plain” region (using the regions as defined by the NCFS District Office boundaries). Of concern is that the overall rate of BMP implementation in the “mountain” region declined between the 2000-2003 and 2006-2008 surveys (69% and 66%, respectively), suggesting that this area of the state may warrant additional scrutiny.

In the 2006-2008 survey, the BMPs with the lowest rate of implementation statewide were stream crossings and site rehabilitation. However, potential risks to water quality when BMPs were not implemented were most commonly associated not only with stream crossings and site rehabilitation but also with SMZs, debris in streams, and skid trails. These findings suggest that data analysis for this survey should stress identification of correlated or causative factors for these particular categories of logging activities and suggestions for mitigation of these types of issues.

Differences from previous surveys

The most significant change to this survey as compared to past surveys is that it is occurring after the 2006 revision to the NC Forestry BMP Manual has been in place for a number of years. During the previous surveys, the most current BMP manual was published in 1989, which pre-dated the 1990 enactment of the statewide water quality regulations affecting forestry activities, known as the Forest Practices Guidelines Related to Water Quality (FPGs). Though there may be significant differences in the BMP guidance documents, it is believed that comparability between the different surveys can be maintained by focusing data analysis on specific logging activities/features and identifying the accompanying risk to water quality.

Another significant difference for this project is the method for identification of potential survey sites. In past surveys, site identification was extremely time- and resource-intensive, requiring NCFS staff to drive transects through randomly selected quadrants of each county until they found an active logging site. NCFS GIS Branch staff have developed a forest cover change tool based on remote-sensing data that allows identification of potential logging sites in near-real time using a desktop GIS application and Landsat imagery. While NC is the first state in the southeast to use these types of image analysis for site identification for forestry BMP surveys, the GIS tools are being shared with other state forestry programs in the southeast and an online application is also under development. It is anticipated that these tools (collectively referred to as Landsat Forest Area Change Tools, or LandsatFACT) will be widely used by other states for their BMP survey site selections.

The ability to identify survey sites remotely and in near-real-time greatly enhances the efficiency of site identification while reducing site selection bias (e.g., previous survey sites had to be noticeable from the particular roads that were driven). Because of the increased efficiencies in site identification, the survey can feasibly be implemented by just a few Central Office staff rather than relying on numerous County and District Office staff. This reduces additional work loads of frontline NCFS staff, and the limited number of staff performing surveys will greatly enhance consistency of assessments across all sites, statewide.

Efficiency for this round of surveys was also enhanced by the development of a digital application for field data entry and data management, rather than the paper-based survey forms previously used. This minimizes the need for additional data entry, and reduces the risk of transcription errors.

Finally, previous surveys used organizational boundaries—Regional Office boundaries—to determine “mountain”, “piedmont”, and “coastal plain” regions. However, these Regional Office boundaries do not always correspond well with differences in physical conditions (topography, geology, etc.) that would affect the extent and types of streams present in a given region (e.g., stream density, presence of artificial ditches, and relative abundance of intermittent streams) and local conditions that may make protection of water quality during forestry operations more challenging (e.g., topographic slope). For example, the Southeastern Plains ecoregion

was divided in previous surveys such that the northern portion was considered to be part of the Piedmont region and the southern portion (including the Sandhills) was included with the Coastal Plain. However, all of the Southeastern Plains lies to the east of the geologic fall line, and therefore the underlying geology, stream types, soils, and extent of wetlands tend to be inherently different from the Piedmont. Additionally, topographic slopes and other characteristics of the Southeastern Plains tend to differ from those seen in the Mid-Atlantic Coastal Plain ecoregion, and combining these may be inappropriate. It is felt that using ecoregions to control for these factors will provide more meaningful information in this current study, though data analysis based on the NCFS organizational boundaries will still be possible since geolocational information will be collected for each study site.

The remainder of this document provides an overview of the study methods and project schedule. More detailed information on the use of the software applications (LandsatFACT for identifying study sites; MS Access-based data entry application) developed to support this project is provided in separate standard operating procedures (SOPs).

METHODS

Total sample size and stratification

The goal of this study is to characterize BMP implementation across the entire state of NC. The selection of sample size for any survey is generally determined by the size of the population or activity that is being characterized. However, there is no comprehensive tally of all forest harvests in NC, so the total number (N) of such events annually is unknown. However, the SGSF WRC has provided recommendations for determining the appropriate sample size, using the following equation:

$$n = \frac{4p\,(100 - p)}{m^2}$$

where *n* = sample size; *p* = estimated percent implementation of BMPs statewide (85%, based on the last survey); and *m* = margin of error (SGSF WRC guidance suggests using 5%, which corresponds to a 95% confidence level). This method results in a total statewide sample size of 204.

The prevalence of timber operations is highly variable by region within NC. Previous BMP implementation surveys also identified differences in site topography and soils as some of the more important factors affecting the implementation rate of BMPs and resulting risks to water quality, and these factors also vary regionally. Because of these factors, the total sample size of 204 was stratified to ensure that each ecoregion is proportionately represented, based on its relative prevalence of forestry activities. Past surveys commonly stratified samples using political and organizational boundaries (e.g., counties; NCFS District and Regional Offices). However, given the importance of topography and other physical factors on successful BMP implementation, the state would be more appropriately subdivided based on these geophysical characteristics, for example, by using the ecoregions defined by Omernik *et al*, which were defined using factors such as geology, soils, and topography. A map showing the organizational and ecoregional boundaries is shown in Figure 1.

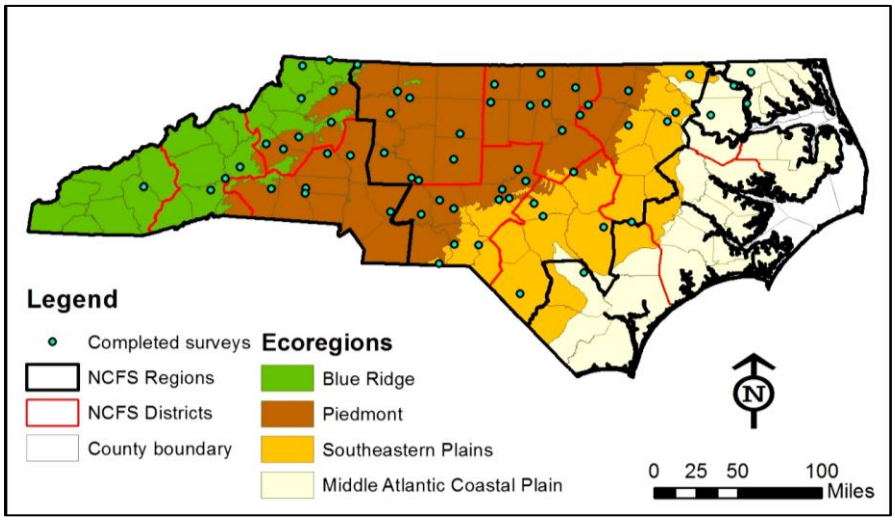

Figure 1 Map of NC physiographic regions (ecoregions), county boundaries, and NC Forest Service Regions and Districts. Also shown are locations of surveys completed through August 2014.

There are four “Level 3” ecoregions in NC: Blue Ridge (mountains), Piedmont (central and foothills), Southeastern Plains (inner coastal plain, including Sandhills), and Mid-Atlantic Coastal Plain (outer coastal plain). The Southeastern Plains (SE Plains) and Mid-Atlantic Coastal Plain (MACP) ecoregions are often combined and referred to using the more general term “coastal plain”, but there are significant differences in terms of topography between the SE Plains and MACP, including slope, drainage areas required for headwater stream formation, prevalence of ditching, and prevalence of jurisdictional wetlands, so these two ecoregions were kept separate for the purposes of site identification. More information on ecoregions in NC can be found at http://www.epa.gov/wed/pages/ecoregions/ncsc_eco.htm#Ecoregions%20denote.

Two options were examined for stratifying the total number of samples (204) across the four ecoregions: based on each ecoregion’s recent timber production as a percentage of total statewide timber production, and based on each ecoregion’s land area as a percentage of total area of the state.

To determine timber yields, timber harvest data for NC (cubic feet by county and species) for the five-year period of 2009-2013 were obtained using the US Forest Service’s Forest Inventory Data Online website (http://apps.fs.fed.us/fia/fido/index.html). Data were summarized to get total timber harvested (all species) for each NC county for the five-year time period (Figure 2). The county-level data were then aggregated to get the total timber yields for each ecoregion. In cases where a county lay in more than one ecoregion, the yield for the county was proportionately divided amongst the ecoregions based on the county area within each ecoregion. For example, Johnston County had 20% of its area in the Piedmont and 80% of its area in the Southeastern Plains, and had a total 5-year timber yield of 92 million cubic feet (MM ft^3). In this case, ~18 MM ft^3 (~20% of total county timber yield) was used as Johnston’s contribution to the total yield for the Piedmont ecoregion and ~74 MM ft^3 (~80% of the county timber yield) was used as the county’s contribution to the total yield for the Southeastern Plains ecoregion.

Finally, the percent contribution to the total statewide timber yields for each ecoregion was calculated. The percent contribution by ecoregion was multiplied by the target sample size (204) to determine the target number of samples for each. The percent land area of the state covered by each ecoregion was also determined in ArcGIS, and these percentages were used to determine a second set of sample sizes. Results from both stratification methods, as well as sample sizes from the last survey, are shown in Table 3.

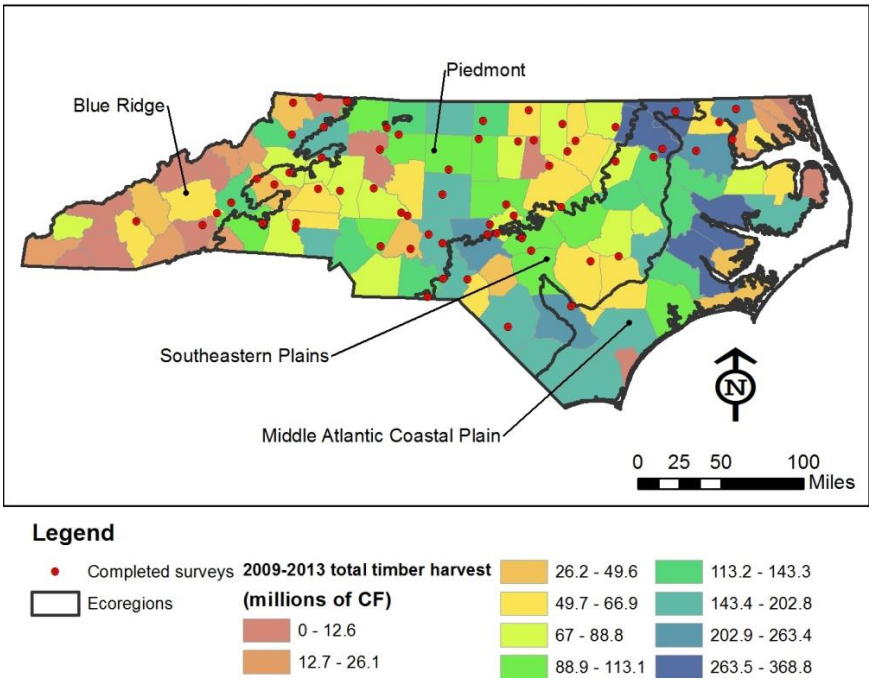

Figure 2 2009-2013 timber yields (millions of cu. ft. of growing-stock tree removals) by NC county. Also shown are physiographic regions (ecoregions) and locations of completed surveys as of August 2014.

Table 3 Sample size results based on each ecoregion's contribution to total area of the state and to total timber harvests (2009-2013).

	Stratification by ecoregion area		Stratification by 2009-2013 timber yields			2006-2008 survey	
Ecoregion	% of total NC area	Target # of survey sites	Total harvest of growing-stock trees (MM CF)	% of statewide harvest	Target # of survey sites	% of total	# sites
Blue Ridge	17%	35	831	9%	18	14%	30
Piedmont	37%	75	3,510	37%	75	38%	81
SE Plains	20%	41	2,274	24%	49	17%	37
Mid-Atlantic Coastal Plain	26%	53	2,981	31%	63	30%	64
TOTAL	**100%**	**204**	**9,596**	**101%**	**205**	**99%**	**212**

The target number of samples for the Piedmont ecoregion was similar for both methods but there were large differences for the other ecoregions. The Blue Ridge represented a very small portion of the total timber harvest statewide (9%), resulting in a fairly small target sample size (18). However, results from past implementation surveys showed a lower incidence of BMP implementation and more widespread risks to water quality in this part of the state as compared to central and eastern NC, though it should be noted that the "mountain" region defined in earlier surveys was based on organizational boundaries and was much more extensive than the Blue Ridge ecoregion used here. Because of the past issues with BMP implementation documented in the western part of the state, it was felt that a slight oversampling of the Blue Ridge would be appropriate, and so the results from the ecoregional area stratification were used to determine sample sizes. However, by allocating samples by this method, it introduces the risk that other areas of the state (the MACP and SE Plains ecoregions) will be undersampled, though past surveys have shown that successful BMP implementation is higher overall in these areas.

In past surveys, there has been a goal of having at least one field assessment in each NC county; however, at the level of sampling effort identified (204 samples statewide), there will be insufficient data for inter-county comparisons and so this requirement is, statistically, not appropriate for the chosen study design. The total sample size would need to be greatly increased (e.g., 3-4/county, or 300-400 samples statewide) to attain marginally acceptable sample sizes for inter-county comparisons. Therefore, stratification of sample sites by county will not be performed, though additional sites (above the target sample size of 204 randomly selected sites) can be identified to ensure at least one survey is performed in each county, if desired.

Site identification

Survey site identification methods have drastically changed from previous surveys, which relied on driving transects through randomly selected quadrants within each county or from NCFS aerial surveys. These earlier methods were the most reasonable method for survey site identification at the time, but they still introduced significant bias into the site identification process, in addition to being time- and resource-intensive. For this latest survey, a remote sensing methodology for ESRI ArcGIS—the Landsat Forest Area Change Tool (LandSatFACT)—was developed by NCFS GIS Branch staff to identify near-real time forest cover change using LandSat7 and LandSat8 satellite imagery. This tool can be applied to large areas of the state and all potential harvest events can be identified; a random subset can then be taken to meet the sample size required for each ecoregion, which will further reduce site selection bias. Since the final sites are randomly selected, they will be statistically valid representation of other factors affecting BMP implementation and water quality risks (e.g., landowner type, landscape position, soils, topography).

The general work process of site identification is described below. More detailed information on the background and use of the LandsatFACT tools is found in a separate Standard Operating Procedure (SOP) document.

Landsat imagery is collected on a 16-day cycle, with an 8-day overlap between the Landsat 7 and Landsat 8 cycles, and is generally made freely and publicly available via the internet on the day of collection. The imagery is organized and provided for download by pre-staged "scenes" (or tiles), which are identified by a Path and Row number. NC is covered by 12 scenes (Paths 14-19 Rows 35-36) (Figure 3). All rows within a single path are collected on a single day.

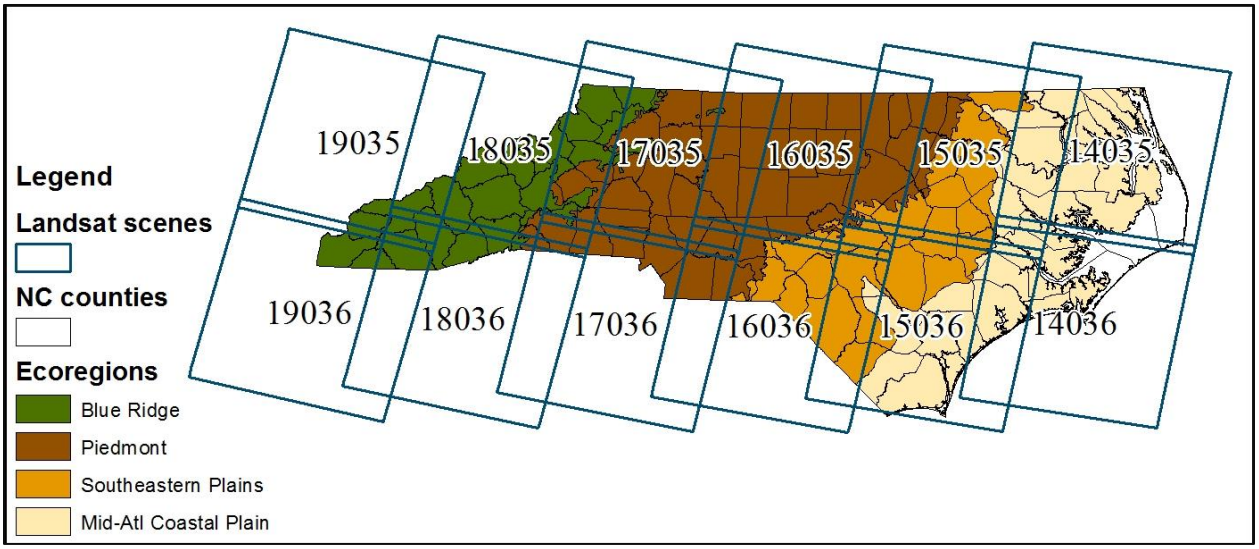

Figure 3 Landsat scene coverage of NC. Counties and ecoregions are shown for reference.

The LandsatFACT tools are currently provided as an ESRI ArcMap add-in for local implementation on a PC, though development of an online application is ongoing and anticipated to be completed in 2015. The tools allow calculation of three different established methods used for remote identification of vegetation presence and/or condition: the Normalized Difference Vegetation Index (NDVI), Normalized Difference Moisture Index (NDMI), and Band 7 (near infrared) Differencing. The tools require ArcGIS and two Landsat images collected at different times (ideally 8 days apart). The resulting rasters, which depict the associated index values for each method for each pixel, are subtracted from each other. Differences near 0 imply that no change in vegetation presence or condition has occurred between the two times. Larger differences suggest that there has been a change in vegetation for that pixel, such as a timber harvest, though other factors (clouds; shadows; seasonal changes to leaf color, leaf drop, or leafing out; soil moisture) can also result in large differences which may produce false positives. Thresholds for differences that indicate likely vegetation removal for each index have been empirically determined by NCFS staff and are provided in the more detailed SOP (currently under development).

Site identification and preparation for field surveys can be somewhat time-intensive, so it is most efficient if it is done to identify many (rather than one or a few) sites at once. The LandsatFACT tools will therefore be applied to an entire ecoregion. The survey is intended to include currently active and recently closed harvest sites, so the site ID work can be done several weeks in advance of field work. However, results from the site ID process should be considered to have a limited “shelf life”, i.e., if many unsampleable sites (e.g., closed sites with significant regrowth that makes assessment of key features difficult or impossible) are being encountered using the current site list, the site ID process should be repeated with more recent Landsat imagery. This will ensure that both active and recently closed harvest sites are represented in the final data set.

The general work flow involved in site identification follows:

- Identify appropriate Landsat 7 and/or Landsat 8 imagery using the USGS Global Visualization (GloVis) website at http://glovis.usgs.gov/. Of primary importance is to find imagery for the scene(s) of interest that were collected as close in time as possible but with minimal cloud cover over the area of interest.
- Download Landsat imagery products from GloVis. These are provided as zip files with the .gz extension.
- Run LandsatFACT tools (ESRI ArcMap add-in).
- Open results from LandsatFACT in ArcGIS for manual screening. Symbolize the rasters using the appropriate threshold(s) (see SOP) to emphasize the location of pixels exhibiting large differences in the vegetation indices. Add any masks used (non-forest cover, cloud mask, Landsat 7 gap mask, ecoregion) to the ArcGIS map document to block out areas where forestry activities are unlikely (e.g., agriculture, urban areas), data quality is suspect (e.g., cloud presence), or is outside of the area of interest (ecoregion).
- In ArcGIS, manually review each group of pixels showing a significant difference in vegetation indices and their associated parcels against recent aerial photography, ownership data, etc. to exclude sites that may have been previously converted, are likely being converted to non-forestry use, or other factors. Parcels that are ***not*** excluded in this process are added to a separate shapefile of potential sites.
- Once screening is complete, the shapefile of potential sites (i.e., parcels with likely forest cover change) is exported to a text file.
- Open the file in appropriate software (e.g., Excel, JMP) and use the appropriate functions to select a random sample of the potential sites. The number selected should correspond to the number of sites needed in that ecoregion and where field assessments can be completed within a reasonable time frame (likely within the upcoming 1-2 months).
- From the remaining potential sites, randomly select a second set of sites to use as backup sites. The number needed will require some best professional judgment, since it will depend on the rate of false positives, conversions to non-forestry uses, and other factors found during field visits that would preclude assessment of a site for the BMP implementation survey. Time of year (growing/non-growing season, leaf change, leaf out), differences in precipitation and soil moisture, terrain (which can cause shadows), and cloud cover in the Landsat imagery can increase the rate of false positives, which will increase the need for backup sites.
- Attribute the parcel shapefile in ArcGIS to indicate the randomly selected sites and backups. This shapefile will be used for making field maps and notifying appropriate county and/or district NCFS staff of potential survey locations.

For example, the Mid-Atlantic Coastal Plain needs an additional 53 sites assessed to meet its target sample size. Assuming that an average of 2-3 sites/day can be completed, it would take 18-27 work days (approximately 4-6 weeks) to complete this ecoregion. In this case, LandsatFACT would be run for scenes in paths 14-15, the results clipped to the Mid-Atlantic Coastal Plain ecoregion, the clipped data manually reviewed, and then a random subset of 48 identified. A second set of random sites (likely around 10 sites) would be selected to use as backups in cases where sites in the original random selection are false positives, are not forestry activities (e.g., are being converted to other land uses), or are found to be inaccessible or unsafe. If, after several weeks of field work, only severely grown-over closed out sites are being found using this list of random sites, the remaining sites

would be discarded and LandsatFACT re-run for the ecoregion. If all sites are visited and the target sample size of 53 is not met, the site identification, random selection, and field assessments will be repeated until the target sample size is met.

While identification of the core 204 random sites will be the primary focus of this study, these can be supplemented with additional, non-random sites. Examples would include opportunistic sites or sites suggested or requested by other NCFS staff. These types of sites just need to be flagged as non-random when entered into the data entry application so they can be easily identified at the time of data analysis.

Pre-field work

Prior to field work commencing on a random site list, the following should be completed:

- Prepare hard copy field maps for each site that show parcel data, random sampling sites and backups, terrain (e.g., USGS topo), surface water (USGS hydrography), wetlands (National Wetland Inventory or similar), aerial imagery, roads, and any other features to assist with locating and assessing the site.
- Identify appropriate metadata associated with each site, including: county, river basin, parcel acreage, ecoregion.
- Notify appropriate county and district NCFS staff that BMP surveys will be occurring in their work areas. Provide them with site location information, such as physical addresses/locations or by exporting the site shapefile to a .kmz file and uploading to Google maps.
- If using GPS or Google Maps to navigate to the study sites, export the site shapefile to the appropriate format and import to the GPS device or Google Maps.

Field assessments

- **Safety should be first priority.** Logging sites, particularly active harvest operations, contain very significant hazards. **All NCFS safety policies and procedures should be followed when entering or working on survey sites**, including:
    - Drive slow, lights-on, window-down, listen for oncoming log trucks when nearing site.
    - Park vehicle off the haul road, out of way from equipment, away from tree felling/skidding. Back-in parking usually is best.
    - Required personal protective equipment (PPE) includes: hardhat, high-visibility vest, sturdy boots, bottled water, sun-block, and bug repellent. In some cases, eye protection and ear plugs may also be appropriate in some situations.
    - Check-in with the crew foreman, usually the loader operator. Present him with handout explaining what we're doing.
    - Keep Situational Awareness: look up, down, and all around; listen for equipment; stay well clear of logs, limbs, and whips when skidder passes by. Stay away from feller-buncher sawhead & log loader. Keep a minimum distance of 200 feet from active equipment.
    - Walk deliberately and carefully. Watch for holes, vines, and stumps. Avoid stepping on top of logs.
    - Make eye contact & hand-signal operator if you need to walk past or around a machine; or when walking alongside a log truck being loaded or strapped-down (watch for flying straps/chains).

    - Watch for hazardous animals and plants, such as venomous snakes, fire ant mounds, stinging insects, poison ivy.
- Determine if site meets the criteria for inclusion in the survey:
    - Is it an active timber harvest site? If not, does it appear to be recently completed? For example, leaves on slash/tops will still be green if the site was very recently closed. Closed sites with significant re-growth of vegetation should not be surveyed since this makes observation of impacts from the logging operation difficult.
    - Is it a forestry management operation? Sites being converted to other uses will not be assessed in this study. Conversion sites can be identified by an absence of woody material/slash/tops being left behind; removal of tree stumps and root balls; or presence of survey stakes denoting future roads/lots. Talking with the logger and/or landowner is another option that may be used to determine if a land use conversion is underway.
    - Is it at least five acres in area?
    - If the site does not meet these criteria, note the reason and do not assess the site. This information will be helpful for future refinements to the accuracy of the LandsatFACT results (i.e., false positives).
- If a GPS is available, record lat/long of site (usually taken at/near the main logging deck). Recording a GPS track is also helpful (though optional) to capture locations of key linear features (e.g., skid trails) and/or timber harvest boundaries. Waypoints can be taken to record locations of key point features (stream crossings, etc.).
- Talk to the logger, forester, etc. (if available) to notify them you will be walking the tract to do a BMP implementation survey and to get basic site information, such as:
    - Name of logger, buyer, and landowner
    - Purpose of harvest (forestry or conversion)
    - Acres being harvested and relative level of completion
    - Any pre-harvest planning assistance that was received
    - Any known problem areas/issues on the site
    - Any safety concerns (where is active felling taking place, active skid trails, etc.)
- Determine dominant soil texture by feel, using the NRCS method (see http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/edu/?cid=nrcs142p2_054311). A bucket or Dutch auger can be used to get a representative sample from the top 12 inches of soil. This step is optional, due to the difficulty in obtaining an accurate texture in the field because of the soil disturbance inherent in logging operations. Adjacent, undisturbed soils could be used to determine texture, or alternatively, it can be obtained from NRCS soil maps/geospatial data.
- Determine if the tract can be considered a single *survey site* or if it should be subdivided into two or more *survey units*. Based on existing surveys, subdividing sites is not common and is primarily limited to tracts with distinctly different operations occurring, such as:
    - More than one logger or timber buyer harvesting on the tract; or
    - Substantially different operations on different portions of the tract (e.g., clearcutting in one area, selective harvest on another area).

However, the surveyor should use best professional judgment and subdivide the tract whenever they feel it is appropriate in order to capture significantly different conditions. Alternatively, the tract could be divided into individual *survey sites*. If the *survey site* is divided into one or more *survey units*, then the surveyor must keep track of which assessed features occurred on which *survey unit*. If no subdivision is needed for a tract, then the *survey site* is composed of a single *survey unit*.

- The features or activities to be assessed on each survey unit include:
    - Decks and landings
    - Logging systems
    - Access roads (these are distinct from skid trails, in that they are intended for tractor-trailer use)
    - Primary skid trails (these are distinct from access roads, in that they are not intended for use by log trucks or hauling units). ***Spurs from the main skid trail should be assessed as separate skid trails.***
    - Stream crossings
    - Streamside management zones (SMZs). ***Note that the SMZ on <u>each side</u> of a stream is considered to be a separate SMZ.*** SMZs can be subdivided if there is a significant break (e.g., stream crossing), confluence with a tributary, a change in stream flow regime (e.g., transition from intermittent to perennial), or other situations where there is a significant change in conditions in the SMZ. The average width of each SMZ can be estimated visually, by pacing, or measured with a field tape. If under 10 feet in width, round to the nearest foot. If width is >10 feet, estimate to the nearest 5 feet.
    - Runoff control structures, including broad-based dips, cross drains, inside ditchlines, road sloping/crowning, turnouts, and waterbars. ***Note that every individual runoff control structure must be assessed.***
    - Sediment capture structures, including brush barriers, check dams, filter areas, straw bales, silt fences, and sediment traps/pits. ***Note that every individual sediment capture structure must be assessed.***
    - Site rehabilitation
    - Forestry activities in wetlands
    - Equipment fluid and solid waste handling and management
    - Chemical application and handling
    - Mechanical site preparation
    - Firelines, prescribed fire planning, and wildfire suppression activities
- To determine exact items to be assessed on a given site, refer to the full list of approximately 400 assessment questions (metrics) in Appendix 1. Metrics have been organized into metric categories, but note that a single feature on-the-ground (e.g., SMZ) may require assessments from multiple metric categories. For example, to fully assess a single SMZ on a braided stream, the metrics associated with codes SMZW ("Streamside Management Zone – Width"), SMZO ("Streamside Management Zone – Operations"), and SMZBRD ("Streamside Management Zone – Braided") will all have to be asked-and-answered. Having a hard copy of the metric list in the field and during data entry will be helpful to ensure that salient features are fully assessed.

- The scale at which each metric should be assessed is also provided in Appendix 1.
    - For metrics designated with an "X" in the **"Overall"** column, the metric applies to the entire *survey unit*, and **should only be answered once per survey unit**. Duplicate answers will increase the time and effort needed to clean up the data set before analysis, and if conflicting answers are provided, both will be discarded and not included in the final analysis.
    - For metrics designated with "X" in the **"AU"** (assessment unit) column, the metric **should be assessed as many times as applicable for each survey unit**. For example, if there are three skid trails on a survey unit, then the metrics in category SKTR ("Skid Trails") should be assessed once for each skid trail. Note that there are also categories associated with individual runoff control BMPs (broad-based dips, water bars, cross drains). These metrics need to be assessed for every individual BMP on the site.
- To answer each assessment metric on each survey unit, determine if:
    - The metric is applicable; if so, indicate whether the BMP has been correctly implemented. Unsuccessful attempts at BMP implementation should be considered "not implemented".
    - The metric is applicable; if so, indicate whether or not a risk to water quality exists (see box on next page for guidance on determining water quality risk).
    - N/A: The metric is not applicable to the survey unit. This is the default for all metrics in the data entry application. Any metrics that cannot be assessed should be left as "N/A". This will be common on closed out sites.
- The specific procedures for survey unit examinations may vary, depending on location, terrain, type of operation, etc., but the entire site that has been harvested should be examined, with particular attention paid to skid trails, roads, and potential stream features (ephemeral, intermittent, or perennial). Areas that are yet to be harvested can also be examined to determine if SMZs have been flagged, etc. Waypoints can be recorded using a GPS for key features, such as stream crossings, decks, broad-based dips, or waterbars.
- It is important to avoid "double dipping" on BMP assessments, i.e., if straw bales are used to control runoff and sediment from a road at a stream crossing, they should be assessed and entered into the data entry application as sediment capture structures OR as part of the stream crossing OR as part of the road construction, but not all three.
- Photograph any key features as needed, including any potential FPG compliance issues, novel/effective BMPs, examples of good or bad BMP usage, etc.
- To assist with data entry, it may be helpful to keep a tally in a field book for each category of BMPs to record each instance where a BMP was needed, whether or not the BMP was implemented, and whether or not there was an associated risk to water quality. This is especially helpful for BMPs that can be very numerous, such as water bars.

What is a "risk to water quality"?

In general, a risk to water quality exists if:

- Visible sediment is reaching (or could potentially reach) an intermittent or perennial stream or perennial waterbody due to accelerated erosion (water or wind);
- Water flow and/or water quality is being inhibited or degraded by debris in an intermittent or perennial stream or perennial waterbody;
- Inadequate stream shading causes large fluctuations in stream water temperatures and/or increases water temperature to above water quality standards;
- Vehicle fluids, pesticides, herbicides, fertilizers, or other chemicals/wastes are reaching (or could potentially reach) an intermittent stream, perennial stream, perennial waterbody, or groundwater;
- Site activities (e.g., ditching, deep-ripping) are extensive enough that they threaten de-watering of wetlands and create potential for converting them to non-wetlands.

Specific examples of a water quality risk exists include:

- Sediment is actually being delivered to a stream or waterbody. Example: Trees/logs are being skidded directly through a stream; soil/sediment has washed off from a road, skid trail, fireline, or deck and into the stream.
- Sediment is likely to be delivered to a stream or waterbody during a normal rainfall event (≤ 1" within a 24-hour period). Examples: Water diversion devices are absent, or are present but have failed, allowing sediment to deposit nearby to the stream or waterbody; Sediment plume "breakthroughs" are observed within a SMZ in close proximity to the stream channel.
- Substantive amounts of sediment are likely to be delivered to a stream or waterbody via wind gusts or sustained winds eroding bare mineral soils.
- Logging or site-prep debris and/or by-products are left in a stream or waterbody to the extent and magnitude that water flow or water movement is adversely impeded or completely obstructed. Examples: Debris or soil in the channel results in water damming on the upstream side; Debris will adversely affect the dissolved oxygen (DO) levels via decomposition of organic matter.
- Evidence of heavy equipment operation in stream channel.
- Waterbody banks compromised by equipment or skidding activities.
- Road or skid trail too steep or so poorly located that stabilization is improbable.
- Adverse stream temperature fluctuations can reasonably be expected to result from excessive canopy removal/harvest within a previously well-forested stream channel, thus substantially reducing or eliminating shading over the stream channel.
- Chemical or petroleum products associated with the forestry operation have a moderate to high potential of reaching the stream or waterbody.

- Enter findings into the data entry application. The application is housed on a ruggedized tablet but it is generally easier and more efficient to take notes in a field book while on site and perform the data entry after the site assessment is complete. A separate SOP is being developed that details use of the data entry tool, but the general process is:
    - Create a survey site and enter general survey information (surveyor name, lat/long) and site information (short description/name, county, nearest town and road, river basin, site ID method).
    - Create a survey unit and enter general information (acreage, ownership type, relative stage of completion of forestry operations). For harvest sites, enter additional information on: logger, timber buyer, technical assistance type, operational information (harvest method, species, utilization, felling/skidding equipment), forest management type, landform, soil texture, and wetland and stream presence.
    - Answer all applicable metric questions for all instances of BMPs on the survey unit.
    - If needed, create an additional survey unit, enter general information and harvesting information, and answer all applicable metric questions for the second survey unit. Repeat if necessary for any additional survey units on the survey site.
    - Once data entry is complete, open the "Survey Site FPG Compliance" form to review the number of instances of non-compliance with FPGs. These are automatically calculated by the database, but they can be modified if needed.
    - If reviewing the compliance score (as %) for the survey site or survey unit is desired, open the "Manage Survey System" form, click the "Clean N/A" button, return to the main data entry form, open the "Get Statistics" form, and click the appropriate button (statistics for survey unit, survey site, etc.). In the form that opens, click on the drop down box and select the appropriate survey site or survey unit ID and the score will be displayed on the form.
- **Note that once a new survey site or survey unit is created, you cannot go back and add any additional information to a previous site or unit through the front end of the data entry application. Also, once information is entered, it cannot be edited or deleted through the data entry application front end. Edits and revisions can only be made by working directly with the source tables within the database.**

Post-field work

- Notify appropriate county and/or district staff of sites that you visited, whether or not they were surveyed, and any potential FPG compliance issues that were seen. Note that the BMP Implementation Survey is not intended to be a FPG compliance inspection; FPG compliance inspections should be handled by the NCFS County, District, or Region staff.
- Download GPS track(s) and waypoint(s) (if applicable) and export as a GPX file. Convert to a shapefile for inclusion in main geospatial data set.
- Download photos and save to a folder created for that site.
- Dropbox is being used to share and backup the data entry database and other project data. To sync the updated data entry database with Dropbox, the ruggedized tablet only needs to be

connected to the internet and it will automatically update the cloud version of the database. Dropbox also archives older versions of files.

- Geodatabase(s) to warehouse the spatial data created during this project are in development. Once finalized, a guidance document for data structure and maintenance will be provided.

Data analysis and reporting

Data analysis will focus on determining percentage of sites where BMPs were implemented and percentage of instances where there was a threat to water quality. Analyses will be performed using all data (statewide), by ecoregion, and by NCFS organizational boundaries. If time allows and sufficient geospatial information has been collected from field sites, additional analyses may be performed to determine if BMP implementation and/or water quality risks are correlated with landscape factors (such as local slope), soils, or other variables. Data analysis will be completed using SAS JMP software.

Results will be detailed in a non-technical report intended for a general audience, similar to those produced in past surveys. It is anticipated that the report will be publicly disseminated via the NCFS website and distribution of printed copies. Oral presentations to internal NCFS staff and external parties will also occur. The results will also be shared within the Southern Group of State Foresters.

Project schedule

A summary of existing samples (as of August 2014), target sample sizes, and number of remaining assessments by ecoregion is shown in **Error! Reference source not found.**. An estimate of field time required to complete the surveys is also shown, using an estimate of 2-3 sites surveyed/day. Additional time will be required to allow for pre- and post-field office work (site ID/field work prep, data management, contacting county/district staff, etc.); this was estimated as one week/ecoregion.

Assuming 20 work days/month, the field component of this survey is estimated to require approximately 3-5 months of staff time to complete, though this does not allow for delays due to technical issues (e.g., poor quality Landsat imagery), weather, or other project responsibilities of NCFS staff. Additional time will also be required for field data compilation and analysis; draft report preparation; internal report reviews and revisions; and issuance of the final report. A tentative schedule is shown in **Error! Reference source not found.**, with an anticipated completion date of January 2016. Note that this field work schedule is rather conservative (allocating 6 months, rather than the estimated 3-5 months) to allow for project delays due to technical issues, weather conditions, or other NCFS staff duties.

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APPENDIX 1: BMP Implementation Survey Metrics

This appendix provides a full list of all 392 assessment questions (metrics) included in the data entry application. They are organized by metric category, and more than one metric category can be applicable to a single physical feature on the ground (SMZ, skid trail, etc.). Some metrics are only assessed once per survey unit; these are designated with an "X" in the "Overall" column. All other metrics, designated by an "X" in the "AU" column, are to be assessed as many times as applicable for a survey unit.

Metric code: BURNPFFC **Prescribed Fire - Fireline Construction**

Metric Question	Overall	AU
Construct firelines along the contour and avoid straight uphill/downhill placement where possible.		X
Construct firelines only as deep as necessary.	X	
Construct firelines only as wide as necessary.	X	
Construct firelines that minimize erosion and runoff.		X
Fireline slope 25 percent or less.		X
Keep firelines out of SMZs, streams, wetlands, etc. where possible. If unavoidable, avoid heavy equipment use.		X
Minimize using soil disturbing tractor-plow firelines.	X	

Metric code: BURNPFFM **Prescribed Fire - Fireline Maintenance**

Metric Question	Overall	AU
Clear streams and ditches of debris.		X
Maintain erosion control structures to control runoff on firelines.		X
Minimize accelerated erosion into waterbodies.		X
Revegetate and/or stabilize firelines that pose a risk of accelerated erosion to waterbodies.		X

Metric code: BURNPFP **Prescribed Fire - Planning**

Metric Question	Overall	AU
Consider site and weather conditions in order to protect water quality.	X	
Keep high intensity burns out of the SMZ unless suitable WQ measures taken.		X
Note type, width, and location of firebreaks/lines on burn plan and/or map.	X	
Retain duff layer on the soil while meeting prescribed burn goals.	X	
Use natural or in-place barriers to minimize fireline construction.		X

Metric code: BURNWF **Wildfire - Wildfire Suppression and Control Firelines**

Metric Question	Overall	AU
Clean and maintain firefighting equipment away from SMZs, riparian buffers or waterbodies.	X	
Establish groundcover, re-vegetate or stabilize areas that have a high risk for accelerated erosion.		X
Expose no more ground surface than is necessary to control the fire.	X	

Keep fire-retardant chemicals out of SMZs, riparian buffers or waterbodies.		X
Minimize soil disturbance along streambanks and within SMZs or riparian buffers. Avoid crossing streams with heavy equipment unless necessary.		X
Protect surface waters from polluted runoff.		X
Return water retention areas to pre-existing hydrologic conditions to the extent possible.		X
Stabilize and/or retire firelines and access trails or roads using suitable water diversion / control structures.		X

Metric code: CHEMAPPL **Chemicals - Applying**

Metric Question	Overall	AU
Apply at least 50 feet away from intermittent and perennial streams or waterbodies, unless these areas are the intended target.		X
Apply in a controlled manner and only to those areas that need it.	X	
Avoid broadcast application in SMZs and over water, unless applied for aquatic use.		X
Fertilizer - Apply sparingly within ephemeral areas.	X	
Maintain accurate and calibrated application equipment.	X	
Pesticide - Low pressure and large droplet nozzle equipment should be used.	X	
Pesticide - Use aerial and ground application methods designed to assure optimum control of the spray path, minimizing drift.	X	
Use product label and/or MSDS for specific recommendations.	X	
Use the minimal amount of chemical to accomplish desired result(s).	X	

Metric code: CHEMHMS **Chemicals - Handling, Mixing, and Storing**

Metric Question	Overall	AU
Dispose of chemical containers properly.	X	
Park application equipment outside of the SMZ or away from water.		X
Plan for the containment and cleanup of spills or leaks.	X	
Store, mix, and load chemicals away from SMZs or in a location where spills or leaks will not enter the water.		X
Use product label and/or MSDS for specific recommendations.	X	

Metric code: DS **Decks and Landings**

Metric Question	Overall	AU
Establish deck at locations where soil disturbance is minimized.		X
Install sufficient erosion control measures to control runoff and capture sediment.		X
Minimize the number of decks.	X	
Minimize the size of decks.		X
Select side-ridge location if steep terrain is unavoidable and use additional BMPs as needed.		X
Situate deck atop flat or gently sloping land.		X
Situate deck atop stable soil.		X
Situate deck outside ephemeral drainages.		X

Situate deck outside SMZ.		X
Use groundcover materials (slash, laps, limbs, tops, etc.) as needed to minimize disturbance to exposed soils.		X

Metric code: EFSWM **Equipment Fluids and Solid Waste - Solid Waste Management**

Metric Question	Overall	AU
Do not burn or bury garbage and trash on-site.	X	
Empty waste containers once they are full.	X	
Secure the waste bin after hours to prevent accidental tipping or vandalism.	X	
Store garbage and waste in a container (or bag), empty/replace as needed, and store to prevent spill or vandalism.	X	

Metric code: EFSWMF **Equipment Fluids and Solid Waste - Managing Fluids**

Metric Question	Overall	AU
Clean equipment with water - not degreasers or detergents.	X	
Designate area for equipment servicing and fueling on level ground away from streams and waterbodies.	X	
Equipment, vehicles, and machinery free of leaking fluids. No stains on the ground that would indicate leak.	X	
Keep fluid spill, containment, and clean-up tools and materials on-site (e.g., hose clamps, extra empty containers, absorbent material/pads, plastic sheeting, etc.)	X	
Keep fluids secure in labeled containers that control or minimize leakage or spillage.	X	
Service and fuel equipment at least X00 feet from streams, waterbodies, ditches, and ephemeral drainages.	X	
Service equipment in a way that minimizes potential for fluids to enter waterbodies or the groundwater.	X	
Use appropriate containers to store oils, fuels, and other fluids - minimizing leakage/spillage.	X	

Metric code: LS **Logging Systems**

Metric Question	Overall	AU
Cease operations when inclement weather and/or wet site conditions persist.	X	
Harvest timber in a manner that minimizes significant changes to soil structure or organic matter.	X	
Single pass of equipment does not produce significant rut.	X	

Metric code: LSB **Logging Systems - Biomass**

Metric Question	Overall	AU
Avoid harvesting dead coarse wood when present.	X	
Avoid harvesting snags when present.	X	
Avoid harvesting tree roots, stumps, or existing duff liter.	X	

Metric code: MECHPREPBED **Mechanical Site Preparation - Bedding**

Metric Question	Overall	AU

Align beds along the land contours.		X
Conduct bedding when soil moisture conditions are appropriate to avoid impacts to soil structure and infiltration.	X	
Keep beds from connecting into a stream or water drainage system.		X
Minimize number of passes made with bedding equipment.	X	
Retain undisturbed groundcover between beds.	X	
Stagger bed openings from one bed row to the next when gap openings are used within rows.		X
Stop beds at the outer edge of the SMZ or riparian buffer.		X

Metric code: MECHPREPDC **Mechanical Site Preparation - Drum Chopping**

Metric Question	Overall	AU
Avoid creating large contiguous areas of exposed bare soil.	X	
Minimize intensive soil disturbance and reduce the risk of erosion and sediment transport.	X	
Minimize number of passes made with chopper and equipment.	X	
Minimize the potential of concentrating surface runoff.	X	
Minimize uprooting of leftover trees and stumps.	X	

Metric code: MECHPREPHERB **Mechanical Site Preparation - Herbicides Applied by Tractor**

Metric Question	Overall	AU
If applied by tractor, avoid impacts to soil structure, infiltration, or runoff.	X	
Keep number of passes with tractor and equipment to a minimum.	X	

Metric code: MECHPREPLOP **Mechanical Site Preparation - Lopping**

Metric Question	Overall	AU
Conduct vegetation management and site prep within the SMZ or riparian buffer via lopping.		X
Keep felled or lopped vegetation out of streams and waterbodies.		X
Retain sufficient shade within the SMZ to prevent adverse temperature fluctuations.		X

Metric code: MECHPREPSRP **Mechanical Site Preparation - Shearing, Raking or Piling**

Metric Question	Overall	AU
Avoid gouging the soil surface in a manner that could funnel runoff and transport sediment into nearby waterbodies.		X
Keep equipment out of the SMZ or riparian buffers.		X
Maintain existing debris and groundcover within ephemeral drains or dry gullies.	X	
Minimize the amount of soil that is disturbed by the equipment blade/rake and avoid uprooting leftover trees and stumps.	X	
Minimize the removal of surface organic matter.	X	
Prevent the movement of significant amounts of soil into debris piles.		X
Set windrows along the landÆs topographic contour.		X
Stagger windrow opening from one row to the next.		X

Metric code: MECHPREPTILL **Mechanical Site Preparation - Tillage**

Metric Question	Overall	AU
Conduct tillage activities when soil moisture is appropriate to avoid negative impacts to soil structure and infiltration.	X	
Minimize the number of passes with the tillage equipment.	X	
Minimize tillage work within ephemeral drainages or dry gullies, maintaining existing debris and groundcover.		X
Retain undisturbed vegetation and groundcover between tillage strips.	X	
Stop tillage work at the outer edge of the SMZ or riparian buffer. Tillage should not funnel runoff into streams or water.		X
Till along the land contours, not up or down the slope.		X

Metric code: MECHPREPTPLT **Mechanical Site Preparation - Tree Planting**

Metric Question	Overall	AU
Conduct machine planting when the site conditions are appropriate to avoid intensive soil disturbance or accelerated runoff.	X	
Dispose of seedling bags, boxes, and culled seedlings appropriately. Do not place in or near streams and waterbodies.	X	
Minimize the number of passes made with the tractor.	X	
Operate equipment along the land contours.		X

Metric code: RDCONST **Roads - Construction (New or Existing)**

Metric Question	Overall	AU
In low lying areas, keep the roadbed as close to the original ground level as possible.		X
In low lying areas, provide adequate cross drainage when fill material is used.		X
Install cut bank no steeper than 0.5:X with tight soils when conditions allow.		X
Install cut bank no steeper than 2:X with loose soils when conditions allow.		X
Install diversion or other structures to control and capture runoff (e.g., broad-based dips, settlement basin, etc.).	X	
Keep grade slopes to X0 percent or less when conditions allow.		X
Limit height of side / cut banks to 5 feet or less when conditions allow.		X
Limit road segment lengths to 200 feet or less for steeper grades.		X
Minimize road width. Heavy-duty roads: X4 - 20 ft wide.		X
Minimize road width. Light-duty roads: X0 - X4 ft wide.		X
Minimize soil disturbance and the amount of road at any stream crossing.		X
Stabilize and/or harden the road surface - using geotextile fabric beneath - as needed.	X	
Stabilize bare soil areas using suitable technique (e.g., seed, mulch, riprap, etc.).		X
Use full-bench construction in sloping terrain where soil is loose and prone to sliding or accelerated erosion.	X	
Use insloping, outsloping and/or crowning techniques as needed.	X	
Use rock, stone, wooden mats, or other suitable materials for at least 50 feet from public road.		X

Metric code: RDMAINT **Roads - Maintaining Existing**

Metric Question	Overall	AU
Clean out built-up silt and sediment from retention areas as needed.	X	

Close access to roads when suitable to minimize unnecessary use.	X	
Maintain a road surface that provides good runoff control, water quality protection, and vehicle access.	X	
Maintain an open daylight corridor.	X	
Perform road and ditch maintenance during times when heavy precipitation is not expected.	X	
Rehabilitate and stabilize the road and side / cut banks according to the standards of FPG .0209.	X	
Take prompt action to protect water quality if BMPs are not properly functioning.	X	

Metric code: RDOLP **Roads - Overall Layout and Planning**

Metric Question	Overall	AU
Construct road to drain naturally - not into streams or waterbodies.	X	
Construct roads at least one year before use.	X	
Establish roads along the land contours.	X	
In steep terrain, construct outsloped road with broad-based dips when conditions allow.	X	
In steep terrain, establish road along gentle hill slopes - just below the ridgeline.	X	
Keep road atop firm, well-drained soils.	X	
Minimize soil disturbance and road placement within ephemeral drainages.	X	
Minimize the number of stream crossings. Avoid crossings.	X	
Plan adequate right-of-way width to daylight the road for drying.	X	
Plan the road to minimize the amount of cut and/or fill needed.	X	
Use information resources to exam site and determine best location for the road.	X	

Metric code: REHABCA **Rehab - Controlling Access**

Metric Question	Overall	AU
Close-off access to roads and trails until stabilized.		X
Install water diversion structures to deter access as needed.	X	

Metric code: REHABRCC **Rehab - Runoff Control and Capture**

Metric Question	Overall	AU
Install appropriate methods of runoff control and/or sediment capture.	X	
Mat logging debris atop critical bare soil areas, particularly during operation.		X

Metric code: REHABSTB **Rehab - Stabilization**

Metric Question	Overall	AU
Apply mulch cover over approximately 50 to 75 percent of the seeded area.		X
Prepare soil using disking or tilling where needed. Minimize to the extent practicable.		X
Spread seed evenly across the area when soil moisture and site conditions are suitable.		X
Spread woodbark or chips over approximately 50 to 75 percent of the seeded area.		X
Spread woodbark or chips several inches thick when used as primary temporary groundcover (no seed).		X

Use erosion control matting when/where needed.	X	
Use fertilizer, lime, or organic matter were needed to promote seed germination.	X	
Use seed or mixtures adapted for the site, soil, and time of year.	X	

Metric code: REHABSTRX **Rehab - Stream Crossings**

Metric Question	Overall	AU
If temporary culvert crossing, remove all fill material or prevent material from entering stream.		X
If temporary, remove the stream crossing itself.		X
Install BMPs to control, divert, and/or capture runoff/sediment along approachways - preventing entry to stream.	X	
Re-contour the streambank edges and approachways to resemble natural conditions pre-installation.		X
Remove debris from the stream channel to meet FPGs and GSs.		X

Metric code: SKTR **Skid Trails**

Metric Question	Overall	AU
Avoid widespread or random skidding patterns with repeated passes.	X	
Concentrate skidding on as few skid trails as needed.	X	
Establish skid trails along land contours and keep slopes to a 25% grade.		X
Install waterbars, brush barriers, turnouts or use other methods as needed.	X	
Lap and pack down leftover logging debris atop primary skid trails - ideally during operation.		X
Limit primary skid trails to X0 percent of the total working area.		X
Minimize placement and use of skid trails in ephemeral drainages.	X	
Minimize skid trail width and avoid two-lane trails.		X
Minimize the extent of gouges or trenches on the ground surface.		X

Metric code: SMZBO **Streamside Management Zone - Biomass Operations**

Metric Question	Overall	AU
Avoid harvesting dead coarse wood when present in SMZ.		X
Avoid harvesting snags when present in SMZ.	X	
Avoid harvesting tree roots, stumps, or existing duff liter in SMZ.	X	

Metric code: SMZBRD **Streamside Management Zone - Braided**

Metric Question	Overall	AU
Avoid heavy equipment use when braided channels are close together.		X
Conduct operation during dry soil conditions when possible, limiting heavy equipment use.		X
Establish SMZ from the outermost channel limits, not from innermost channel bank.		X
Use matting systems for skid trails and/or roads.	X	

Metric code: SMZDTCH **Streamside Management Zone - Ditches**

Metric Question	Overall	AU
During temporary ditch crossing installation and use, avoid altering water flow.		X
During temporary ditch crossing installation and use, minimize erosion and sediment runoff.	X	
Limit heavy equipment use along ditch edge, maintaining structural integrity.	X	

Metric code: SMZEPH **Streamside Management Zone - Ephemeral**

Metric Question	Overall	AU
Minimize disturbance to the soil and groundcover within the ephemeral stream area.		X

Metric code: SMZO **Streamside Management Zone - Operations**

Metric Question	Overall	AU
Allow no more than 20 percent evenly distributed bare soil surface within the SMZ.	X	
Avoid gouging the soil in a manner that could funnel runoff and transport sediment to the waterbodies.		X
Avoid roads, skid trails, decks, and portable sawmills inside the SMZ.		X
Fell and remove trees away from the stream or waterbody.		X
Keep logging debris out of stream or remove promptly if introduced when operating in the SMZ (not at crossing).		X
Keep roads, skid trails, decks, and portable sawmills at least X0 feet away from the stream when placement in SMZ is unavoidable.		X
Limit heavy equipment use within X0 feet of the edges of streams and waterbodies.		X
Maintain approximately half of the pre-harvest vegetative canopy cover within the SMZ.		X
Mark SMZs perimeter clearly using paint, flagging, or other means.		X
Minimize disturbance to the mid-level and understory if removing significant overstory.		X
Service and refuel equipment outside of the SMZ, unless mechanical failure requires repair. Control fluids as needed.		X

Metric code: SMZW **Streamside Management Zone - Width**

Metric Question	Overall	AU
SMZ width sufficient to filter upslope pollutants and prevent stream or waterbody sedimentation/contamination.		X
SMZ width sufficient to provide stream shade and prevent adverse temperature fluctuations.		X
Wrap SMZ around the head of the intermittent or perennial stream, at the ephemeral transition.		X

Metric code: TCRBBD **Tools to Control Runoff - Broad-Based Dips**

Metric Question	Overall	AU
Avoid siting the outlet onto soft soil or fill material, unless other BMPs are utilized to prevent erosion.		X
Capture the sediment from the outlet as needed.		X
Construct and compact a slight hump across the downhill edge of the dip.		X
Excavate a shallow dip approximately X5 to 20 feet long into the uphill travel surface.		X
Harden the travel surface with stone or other material on slopes greater than 8%, otherwise as needed.		X

Lay out and construct the broad-based dip at right angle to the travel surface and across the full width of the road.		X
Number and distance between dips follows spacing guidance (at a minimum).	X	
Outslope the bottom of the dip at enough of an angle to turn away water and runoff - approximately 2-3% angle.		X
Reverse grade of the hump does not exceed 2 to 3 percent slope down toward the base of the dip.		X
Situate the broad-based dip outlet in a manner that prevents runoff from flowing directly into streams or waterbodies.		X

Metric code: TCRCRDR **Tools to Control Runoff - Cross Drains**

Metric Question	Overall	AU
Avoid siting the outlet onto soft soil or fill material, unless other BMPs are utilized to prevent erosion.		X
Capture the sediment below the outlet as needed.		X
For culvert pipes, cover the pipe with at least one foot of fill and harden the crossing location.		X
For culvert pipes, use at least a X2-inch diameter pipe if only needed for groundwater seeps or minimal runoff volume.		X
For culvert pipes, use at least a X5-inch diameter pipe on heavy flow areas.		X
Install cross-drains at an approach angle suitable to allow free flow of runoff into and through the cross-drain.		X
Install drop-inlet where the elevation of the cross-drain inlet is lower than the ditchline, as needed.		X
Match the base level of the cross-drain inflow to the base elevation of the ditchline.		X
Match the cross-sectional area of the pipe to the area of the contributing ditchline.		X
Minimize erosion on both ends of the cross-drain so the ditchline.		X
Number and distance between cross-drain culverts follows spacing guidance (at a minimum).	X	
Set cross-drains on a 2 to 4 percent downslope angle.		X
Situate the cross-drain outlet in a manner that prevents runoff from flowing directly into streams or waterbodies.		X
Where needed, harden the inflow headwall of the cross-drain with stone, sandbags, geotextiles, vegetation, drop-inlet, or other suitable materials.		X

Metric code: TCRINSD **Tools to Control Runoff - Inside Ditchlines**

Metric Question	Overall	AU
Avoid siting the outlet onto soft soil or fill material, unless other BMPs are utilized to prevent erosion.		X
Capture the sediment below the outlet as needed.		X
Control runoff speed and volume.	X	
Excavate the ditchline to the minimum depth and width needed.	X	
Install geotextiles, matting, stone or other suitable material as needed to prevent downcutting.		X
Install turnouts or cross-drains at intervals adequate to carry the expected runoff.	X	
Match the cross-sectional area of the pipe to the area of the contributing ditchline.		X
Match the ditchline cross-sectional area to a minimum equivalent of a X5 inch culvert.		X
Situate outlet in a manner that prevents runoff from flowing directly into streams or waterbodies.		X

Metric code: TCRIOC **Tools to Control Runoff - Insloping, Outsloping, and Crowing**

Metric Question	Overall	AU
For freshly graded outsloped or crowned roads, install a temporary low berm along the outside (downslope side) edge of the	X	

road as needed.		
If a temporary berm is installed, provide outlets or gaps so runoff can move away from the road surface		X
Maintain the road surface as needed to minimize or repair ruts, holes, or depressions that hold water.	X	
On insloped roads, excavate and maintain inside ditchlines and cross-drains.	X	

Metric code: TCRTURN **Tools to Control Runoff - Turnouts**

Metric Question	Overall	AU
Avoid siting the outlet onto soft soil or fill material, unless other BMPs are utilized to prevent erosion.		X
Begin the inflow of the turnout at the same grade level as the road, skid trail, fireline or ditch.		X
Capture the sediment below the outlet as needed.		X
Construct using a turnout angle between X5 to 30 degrees downslope.		X
Excavate the turnout with enough outlet gradient angle so runoff can drain in a controlled manner, generally from X to 3 percent is adequate.		X
For use in roadside ditches, minimize erosion within that ditch so the inflow of the turnout does not create a gully.		X
Number and distance between turnouts follows spacing guidance (at a minimum).	X	
Situate outlet in a manner that prevents runoff from flowing directly into streams or waterbodies.		X

Metric code: TCRWTRB **Tools to Control Runoff - Waterbars**

Metric Question	Overall	AU
Avoid siting the outlet onto soft soil or fill material, unless other BMPs are utilized to prevent erosion.		X
Capture the sediment below the outlet as needed.		X
Establish groundcover or harden the waterbar with stone or other material, as needed.		X
Excavate and construct using equipment/techniques that assure proper angles and a firm waterbar hump.	X	
Excavate the trench with enough gradient to allow adequate flow of water runoff.		X
Number and spacing between waterbars follows spacing guidance (at a minimum).	X	
Situate outlet in a manner that prevents runoff from flowing directly into streams or waterbodies.		X
Tie the uphill end of the waterbar into the side / cut slope, and angle the waterbar downhill towards the outfall edge.		X
Use an angle ranging from X5 to 30 degrees (downslope) for the waterbar.		X

Metric code: TCSBB **Tools to Capture Sediment - Brush Barriers**

Metric Question	Overall	AU
Avoid removing the brush barrier once it is established.		X
Cut large pieces of material into smaller chunks, as needed.	X	
Pile and pack down brush to achieve close contact with the ground surface.		X
Use additional BMP measures if brush barriers fail to capture sediment.	X	

Metric code: TCSCD **Tools to Capture Sediment - Check Dams**

Metric Question	Overall	AU

Contruct check dam such that the center is lower than the outer edges.		X
Lay down geotextile fabric before placing check dam material, as needed.		X
Provide ample support at the base of the check dam.		X
Remove built-up sediment as needed from the check dam.	X	
Space check dams such that the top of the downslope most dam matches the elevation of the bottom of the next dam up the slope.		X
Tie-in the base of the check dams with the soil.		X
Total height of check dam does not exceed 3 feet.		X

Metric code: TCSFA **Tools to Capture Sediment - Filter Areas**

Metric Question	Overall	AU
Establish permanent groundcover.		X
If unstable soils must be used for a filter area, install treatments such as erosion matting or other methods to stabilize the soil.		X
Minimize intensive soil disturbance.		X
Use stable, well-drained soils for filter areas when available.		X

Metric code: TCSSB **Tools to Capture Sediment - Straw Bales**

Metric Question	Overall	AU
Adjust BMPs accordingly if sediment is built-up behing bales.	X	
If stacking square bales, stagger to provide overlap - similar to brick laying.		X
Install measures upslope and downslope of bales as needed.	X	
Monitor bales and take prompt action if not sufficient.		X
Set bales tightly against the ground surface and anchor.		X

Metric code: TCSSF **Tools to Capture Sediment - Silt Fence**

Metric Question	Overall	AU
Adjust BMPs accordingly if sediment is built-up behing fence.	X	
Bury the bottom 4 to 6 inches of silt fence securely into the ground.		X
Ends of fencing gently turned like a sideways "J", with the hook facing uphill.		X
Install measures upslope and downslope of silt fence as needed.	X	
Install the fence so that the buried portion is along the upslope face of the fence.		X
Limit drainage area to X00 feet of fence for every one-quarter acre of land.		X
Monitor fence and take prompt action if not sufficient.	X	
Reinforce the silt fencing from being knocked over or blown out as needed.		X
Set fencing along the land contours and extend the fencing far beyond the expected pathway(s) of runoff flow.		X

Metric code: TCSSTP **Tools to Capture Sediment - Sediment Traps or Pits**

Metric Question	Overall	AU
Avoid using the spoil to build up the sides of the pit.		X
Clean out accumulated sediment as needed and dispose of appropriately (with stabilization as needed).		X
Create a reinforced outlet for overflow capacity.		X
Dispose or stabilize the excavated spoil material.	X	
Excavate the pit with a suitable opening and depth to capture the expected sediment runoff, minimizing disturbance.		X
Harden the walls of the pit to minimize the risk of structural failure.		X
If the pit must be situated within unstable soils, install additional measures to provide soil stabilization around the pit.		X
Locate the pit within stable, well-drained soils when available.		X
Revegetate exposed soil around the perimeter of the pit.		X

Metric code: WETHARV **Wetlands - Harvesting**

Metric Question	Overall	AU
Concentrate heavy equipment use to primary skid trails and decks. Minimize rutting, i.e., single pass produces more than 6 inch rut.	X	
Minimize harvesting activity in sensitive areas, i.e., wetter than normal areas or near waterbodies.	X	
Minimize heavy equipment use along the edge of ditches.	X	
Operate equipment during dry periods if possible. Minimize operations on saturated soils and near waterbodies.	X	
Rehabilitate areas of significant soil disturbance.	X	
Use appropriate harvesting equipment, methods, and/or techniques, i.e., shovel-mat systems.	X	

Metric code: WETPREP6 **Wetlands - 6 Mandatory BMPs for Pine Site Prep in Wetlands**

Metric Question	Overall	AU
Arrange windrows to limit erosion, overland flow, and runoff.	X	
Maintain natural topography, preventing immediate or gradual conversion of wetland to non-wetland.	X	
Minimize dragging and pushing of soil while moving logs and debris.	X	
Minimize excessive soil compaction and rutting - maintain soil physical health.	X	
Prevent disposal or storage of logs or debris in SMZs.	X	
Utilize water management techniques to minimize off-site water quality impacts as needed.	X	

Metric code: WETRDX5 **Wetlands - X5 Mandatory BMPs for Roads in Wetlands**

Metric Question	Overall	AU
Avoid discharge into breeding and nesting areas of migratory waterfowl, spawning areas, and wetlands.	X	
Locate roads and skid trails sufficiently far from waters of the US.	X	
Minimize encroachment of equipment into the waters of the US during road construction.	X	
Minimize number, width, and total length of permanent and temporary roads and skid trails.	X	
Minimize vegetation disturbance in the waters of the US.	X	
Provide sufficient drainage to prevent restriction of water flow.	X	
Remove temporary fills completely and restore to original elevation.	X	

Shall not discharge in a component of the National Wild and Scenic River System.	X	
Shall not discharge in areas of concentrated shellfish production.	X	
Shall not disrupt the migration or other movement of aquatic life.	X	
Shall not locate discharges in the proximity of a public water supply intake.	X	
Shall not take or jeopardize the continued existence of T&E species.	X	
Stabilize and maintain fill during and following construction.	X	
Take borrow material from upland sources whenever feasible.	X	
Use suitable material for discharge/fill that is free from toxic pollutants in toxic amounts.	X	

Metric code: WETRDFL **Wetlands - Fill Roads**

Metric Question	Overall	AU
Construct road during dry period and in advance to allow for settling.	X	
Do not connect the borrow ditch to an outlet.		X
Install or maintain roadside berms with openings to release flow.	X	
Minimize amount of organic matter within the fill material.	X	
Minimize depth, width, and length of borrow ditch.	X	
Minimize excavation and disturbance in nearby wetland areas.	X	
Place unsuitable fill in small piles adjacent to the borrow ditch with small opening to release flow.		X
Provide adequate cross drainage.	X	
Use fill material from non-wetland areas where practical.	X	

Metric code: WETRDFLD **Wetlands - Fill Roads with Adjacent Collector Ditch**

Metric Question	Overall	AU
Install flow control devices within roadside collector ditch as needed.		X
Install or maintain grader ditch, roadside berm, and/or vegetative groundcover alongside road edges.	X	
Maintain a crowned road surface or use other appropriate BMPs to control runoff and promote drying of road surface.	X	
Protect or maintain groundcover 4 to 5 feet adjacent to ditch on the opposite side of the road.		X

Metric code: WETRDFT **Wetlands - Flat Roads**

Metric Question	Overall	AU
Establish and maintain a grader ditch if needed.	X	
Install water control structures within the roadside grader ditch where needed.	X	
Keep road grade as close to original land surface grade as possible.		X
Stabilize and/or harden the road surface with suitable material where high surface flows are expected.		X

Metric code: WETRDGEN **Wetlands - Roads General**

Metric Question	Overall	AU
After construction is completed, stabilize disturbed areas of the roadbed with vegetation as needed.	X	

As needed, apply stabilizing materials atop the culvert crossing, on each culvert headwall, and within each crossing approach floodway.		X
Construct roads during periods of relatively dry soils when possible.	X	
Construct the crossing in a way that prevents floodwaters from flowing over the road at the culvert.		X
Create shallow depressions in the road on each approach to the culvert.		X
Establish and maintain groundcover vegetation along road shoulders.	X	
If fill material is generated by the road construction process, place suitable mineral soil fill on the road surface or remove it from the wetland to a non-wetland area, if feasible.	X	
Install culverts of adequate number and/or capacity to handle floodwaters.		X
Maintain a daylight corridor to allow more rapid drying of the road.	X	
Minimize the lateral extent of wetland disturbance during construction.	X	
On frequently used roads, apply gravel or other suitable stabilizing material on areas where erosion and sedimentation may occur.	X	
On lightly used roads, establish and maintain vegetative groundcover or other suitable stabilizing materials upon the road surface.	X	
Plan and implement road designs, locations, alignments and water management devices as needed to minimize hydrologic alterations.	X	

Metric code: WETWM **Wetlands - Water Management**

Metric Question	Overall	AU
Conduct excavation and other operations during periods of relatively dry soils, if conditions allow.	X	
Design, construct, and maintain drainage system to minimize surface runoff from entering into the ditch(es).	X	
Do not convert a wetland to a non-wetland during, water management activities, including minor drainage,	X	
For initial construction or maintenance, deposit excavated material (spoil) atop existing roads or on top of old spoil locations, if possible.		X
If piling is necessary, use small piles with frequent gaps between them.		X
Install and maintain flow control devices as needed to manage water velocity and volume.		X
Limit the depth, width and length of new minor drainage ditches to only that which is needed to provide effective minor drainage.	X	
Ronsider re-filling or plugging the minor drainage ditch(es) once sivilcultural objectives have been met.		X
Stabilize the spoil material as needed.		X
Start excavation near the discharge end while leaving a plug of soil in place to serve as a temporary dam within the newly excavated ditch.		X

Metric code: XBRDGMAT **Stream Crossing - Bridgemat**

Metric Question	Overall	AU
Create a solid-surface with panels butted tightly together.		X
Keep equipment out of the channel during installation and removal unless unavoidable.		X
Minimize over-hang from logs, trees, or trucks/trailers.		X

Select a stream crossing location that has high, level ground on each side.		X
Select a stream crossing location that has solid footing to support mats and equipment.		X
Select a stream crossing location with a narrow channel width.		X
Select a stream crossing location with firm, stable streambanks.		X

Metric code: XCULV **Stream Crossing - Culvert**

Metric Question	Overall	AU
Backfill material atop culvert at least X2 inches.		X
Install crossing to allow floodwaters to flow around crossing as needed.		X
Minimize the height that water drops from the outlet of the culvert.		X
Pack backfill material down tightly, avoiding material with excessive debris.		X
Place culvert in the center of existing or expected water flow.		X
Protect the inlet/outlet of the culvert/fill material with suitable stabilization measures.		X
Set culvert(s) with appropriate downslope grade.		X
Use appropriate number/size of culverts.		X
Use at least a X5 inch culvert.		X
Use culvert that extends at least X2 inches beyond the edge of the fill material. If shorter, inlet/outlet headwalls adequately protected.		X
Use surface hardening materials on the culvert and approachways as needed.		X

Metric code: XFORD **Stream Crossing - Ford**

Metric Question	Overall	AU
Do not use ford crossings on skid trail crossings. Use only for truck access.		X
Establish permanent groundcover over at least 80% of the approachway area within the first 50 feet.		X
Install at location with relatively low streambanks.		X
Install at location with solid and level stream bottom.		X
Install at straight section of stream channel.		X
Install ford to allow passage of natural streamflow, particularly for low-flow or dry periods.		X
Spread hardening materials evenly - avoid dips, humps, or ruts.		X
Use clean hardening materials on vehicle traffic surface.		X
Use geotextile fabric as underlayment as needed.		X

Metric code: XOLPP **Stream Crossing - Overall Layout, Planning, and Performance**

Metric Question	Overall	AU
Avoid stream crossings when possible.	X	
Consider crossing site when selecting crossing type.		X
Construct, install, and remove crossing during low-flow if possible.		X
Designate stream crossing location(s) using flagging, paint, or other suitable marking.		X

Install crossing at a right-angle to the stream channel.		X
Install crossing at relatively straight stream section.		X
Minimize alteration of stream depth, width, gradient, and capacity.		X
Minimize approachway slope/grade.		X
Minimize the number of crossings.	X	
Rehabilitate crossing area as soon as possible.		X
Stabilize approachways using appropriate means (e.g., slash, laps, rock, etc.).		X

Metric code: XPOLE **Stream Crossing - Pole**

Metric Question	Overall	AU
Do not place soil within or on top of the pole crossing.		X
Install pole crossing to an elevation higher than the adjacent channel or bank.		X
Maintain water flow through the pole crossing.		X
Pack down limbs, tops, slash, or other woody material atop the approachways.		X
Protect the integrity of the channel banks (intact and stable).		X
Remove the pole crossing immediately following use or when high-flows are expected.		X
Use logs large enough to stack loosely.		X
Use logs that are de-limbed and topped.		X
Use logs that are free of soil or other debris.		X