

Indiana DNR Division of Forestry

Classified Forest & Wildlands

1997 through 2014

Forestry Best Management Practices Monitoring Results

By: Duane A. McCoy and Jennifer Sobecki

**1996 through 2014
Classified Forest & Wildlands BMP Report**

- I. Executive Summary
- II. Introduction
- III. Methods
 - A. BMP Monitoring Objectives
 - B. Monitoring Team Selection
 - C. Site Selection
 - D. Monitoring Process
- IV. Results
 - A. Overall Application and Effectiveness
 - B. BMP Application & Effectiveness by Section
 - 1. Access Roads
 - 2. Log Landings
 - 3. Skid Trails
 - 4. Stream Crossings
 - 5. Riparian Management Zones
 - C. Overall Site Ratings
- V. Discussion
- VI. Recommendations
- VII. Conclusions
- Appendix A Map of Classified Forests Monitored for BMPs 2009-2014
- Appendix B Indiana Forestry BMP Monitoring Worksheet (2000)

I. Executive Summary

The purpose of this report is to quantify the application and effectiveness of forestry BMPs on Classified Forest and Wildland (CFW) sites, based upon guidelines laid out in the Indiana Forestry BMP Field Guide. This report includes 326 CFW timber harvests monitored for Forestry Best Management Practices (BMPs) between November 1996 and December 2014 ranging in size from 1 to 785 acres.

85.62% of the Forestry BMPs were applied as directed in the BMP guidelines, 12.3% had minor departures as defined in the monitoring sheet (Appendix). There have been 251 major departures, and they add up to 2.03% of all practices monitored. Of the total 326 sites monitored on CFW, 7 practices have scored “Total Negligence” for 0.06%.

Effectiveness rates are used to evaluate the success of the forestry BMPs applied to a site. The CFW effectiveness rate for the 326 sites monitored is 90.53%. Indirect and temporary impacts to water quality were found 3.16% of the time, indirect and prolonged impacts were found to occur 1.18% of the time, 2.89% of the time direct and temporary impacts occurred and there were 2.24% direct and prolonged impacts to water quality.

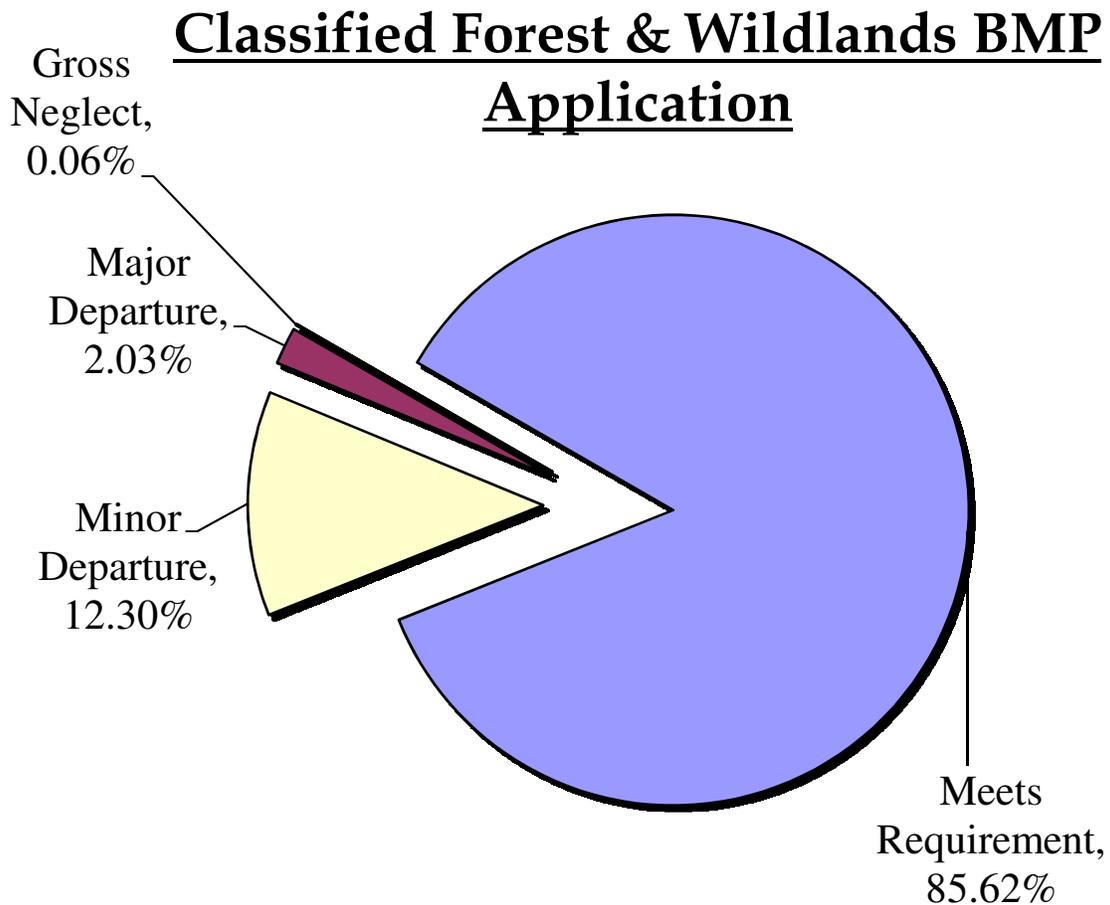


Figure 1: Overall CFW BMP application percentages.

Classified Forest & Wildlands

BMP Effectiveness

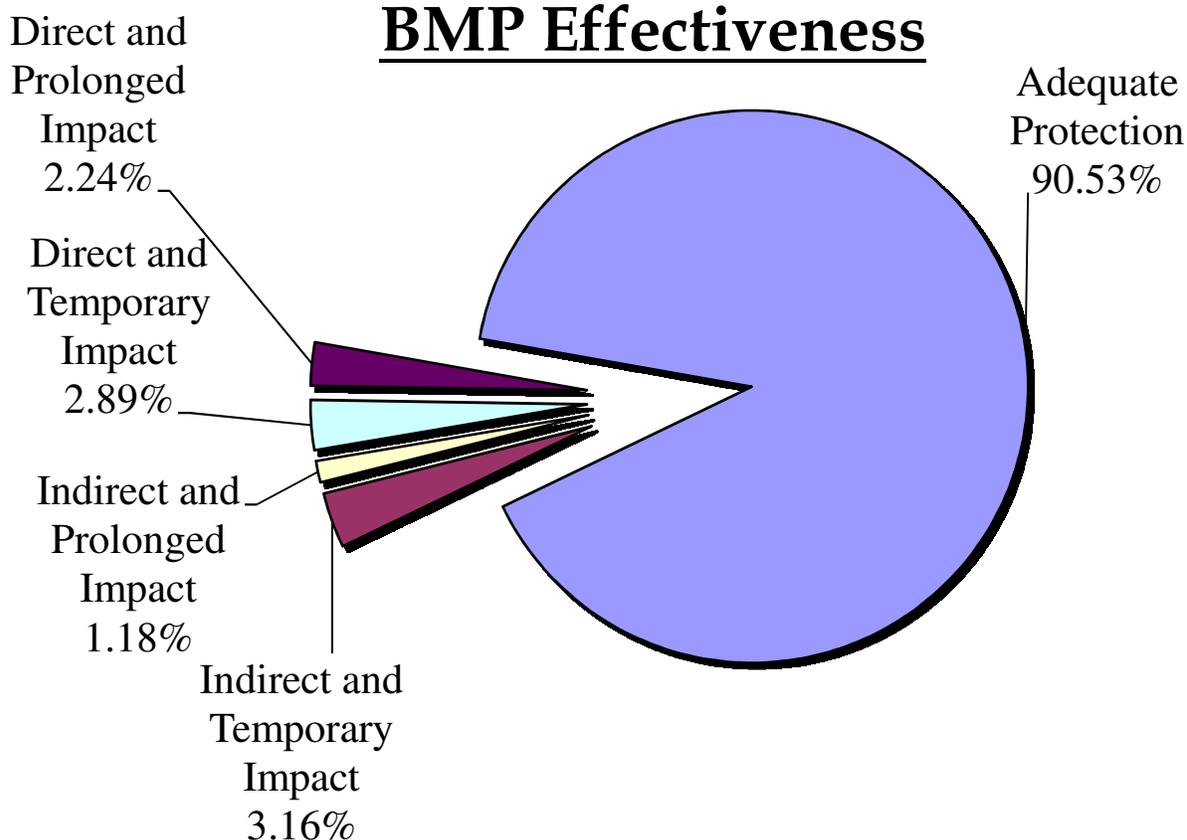


Figure 2: Overall CFW BMP effectiveness percentages.

II. Introduction

Indiana contains 4.7 million acres of forestland that provides many benefits to Indiana’s people and wildlife. 87% of the forestland in the state is privately owned. At the end of 2014, CFW program had 746,357 acres and makes up approximately 16% of the total forestland in the state. CFW are generally high quality woodlands that are important for timber production, wildlife habitat, watershed protection as well as other non-tangible benefits. This profits not only the forest owner, but all residents. Forests are known to be the best way to reduce nonpoint source pollution (NPS) to waterways. However, when forest soils are exposed there is opportunity for NPS pollution to occur.

Forestry BMPs are the foundation for water quality protection during forest operations. This report is a summary of the application and effectiveness of BMPs for timber harvests conducted on 326 CFW sites from 1996-2014. In the 1996 and 1997 BMP Monitoring reports, there were more sites that were understood to be CFW sites, but this cannot be confirmed by the records that have survived, so we have included only those sites that were confirmed to be CFW at the time they were harvested and monitored.

BMP Monitoring is a site evaluation based on the Indiana Logging and Forestry Best Management Practices: BMP Field Guide (BMP Field Guide) and Indiana’s Forestry BMP Monitoring Worksheet (Appendix). 58 BMP

specifications are evaluated under the 5 forestry operation categories: 1) Forest access roads, 2) Log landings, 3) Skid trails, 4) Stream crossings, and 5) Riparian management zones. Each BMP specification is rated for application of the BMP and its effectiveness in protecting the water quality. Seven general questions are posed on the evaluation dealing with the cause of the noted failures and successes, and records other land uses on the site that could affect water quality.

III. Methods

A. BMP Monitoring Objectives

The objectives of BMP monitoring are: 1) to assess the effectiveness of the BMP guidelines in protecting water and soil quality, 2) provide information on the extent of BMP implementation, past and current, 3) identify areas to focus future program training and educational efforts to improve BMP implementation and effectiveness, 4) identify BMP specifications which may need technical modification, 5) identify improvements needed in future monitoring efforts and, 6) to maintain certification of CFW through the Forest Stewardship Council (FSC).

B. Monitoring Team Selection

In the monitoring rounds from 1996 to 2004, an assortment of technical backgrounds was the basis for monitoring team selection. Each team was led by an IDNR forester to provide technical and logistic support. Team members also included individuals from the forest industry, the environmental community, landowners, planning and development staff, wildlife biology, hydrology, loggers, and soil conservation. Team size was 4-5 individuals, often with team members possessing multiple areas of expertise.

In the 2009-2013 monitoring of CFW sites, the District Forester and one or more of the BMP monitoring staff monitored each site. If the landowner or harvesting professional came, they were included.

C. Site Selection

From 1996 through 2004 monitoring, sites were selected by their geographic position. The 1996 and 1997 rounds were in the Lake Monroe Watershed; the 1999 round was in 5 randomly selected counties throughout the state (Ohio, Jefferson, Clay, Martin and Stueben); and the 2000 round monitored sites in 7 of the 13 counties that have watersheds flowing into the Great Lakes (Adams, Allen, Elkhart, Lagrange, LaPorte, Noble, Steuben). One site in 1996, 6 sites in 1997, and 5 sites in 1999 were recorded as being CFW. All others were recorded as being in another type of ownership or their ownership type was unknown.

The 2009 round of monitoring focused on CFW. In 2008 there were approximately 374 harvests from the tracts in the CFW Program from which the Division of Forestry had to monitor at least 10%. From the total 374 sites reported to have been harvested in 2008, the Division monitored 40 randomly selected sites, 10.69% of the total sites harvested.

For the 2010 round of CFW monitoring, sites reported to be harvested in 2009 were randomly selected. In 2009 there were approximately 366 harvests from the tracts in the CFW Program from which the Division of Forestry had to monitor at least 10%. From the total 366 sites harvested in 2009, the Division monitored 45 for a 12.3% of the total sites harvested.

The 2011 round of CFW monitoring consisted of 60 sites that were randomly selected from the 519 sites that were reported to have harvests in 2010. The 60 sites that were reviewed made up 11.6% of the CFW sites were reported to have been harvested in 2010.

The 2012 round of monitoring involved 56 sites randomly chosen from a total of 467 sites that reported a harvest in 2011. A total of 12% of sites reported to have been harvested in 2011 were monitored in the 2012 round of monitoring.

2013 CFW monitoring consisted of 53 sites chosen randomly from 422 sites that reported a harvest in 2012. A total of 12.6% of reported 2012 harvest sites were randomly chosen for monitoring in 2013.

The 2014 monitoring round included 60 sites randomly chosen from 515 sites that reported a harvest in 2013. A total of 11.6% of sites reporting harvests chosen randomly for the 2014 round of monitoring.

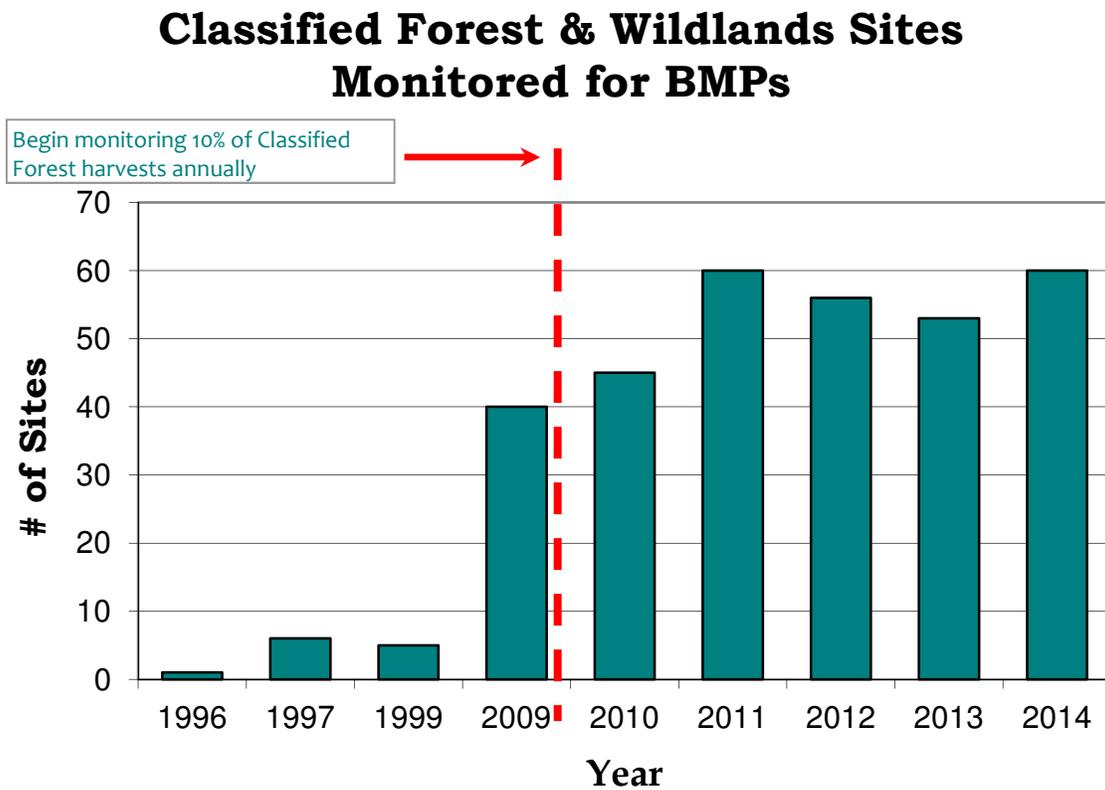


Figure 3: 1 CFW site was monitored in 1996, 6 in 1997, 5 in 1999, 40 in 2009, 45 in 2010, 60 in 2011, 56 in 2012, 53 in 2013 and 60 in 2014.

D. Monitoring Process

BMP monitoring is based on the evaluation of each specific practice for application and effectiveness. Application is the installation of a practice and the condition of the practice at the time of monitoring. Effectiveness is the level of success a practice has in the prevention of pollutants entering a water body or the level of impact the pollutant is having on the water body at the time of monitoring. It is possible to apply all of the BMPs properly and get a good score in application, but still have soil entering a stream, which would call for a lower score in effectiveness, and the opposite may be possible as well.

The team meets at the site to conduct the BMP monitoring on a harvest that is completed and closed. The team walks each part of the harvest area inspects all of the access roads, log landings, skid trails, riparian management zones, and stream crossings as directed in the Indiana BMP Monitoring Protocol. They also comment on successes and departures from the BMP guidelines.

The monitoring team also inspects adjacent and interior intermittent or larger streams. This time allows each team member to evaluate the BMPs on the site for themselves. Once all members have inspected the harvest area, the team comes together at the vehicle or other gathering place and each question on the BMP monitoring form is discussed until consensus is reached on the scores that go with each question.

IV. Results

A. Overall application and effectiveness

Of the 326 sites monitored, there was an 85.62% application rate with a 90.53% effectiveness rate. This means the BMPs that were needed were correctly implemented 85.62% of the time and were effective at protecting water quality from NPS 90.53% of the time.

More detailed definitions can be found on the FORESTRY BMP MONITORING WORKSHEET (Appendix).

B. BMP Application & Effectiveness by Section

1. Access roads

Access road BMPs were correctly applied 94.5% of the time. All of the access road BMP specifications employed had a 98.3% effectiveness rate.

Table 1: Application and effectiveness of BMP specifications for access roads.

| Access Roads | % Application | % Effective |
|--|---------------|-------------|
| A1. Uses existing routes where appropriate | 99.1 | 100.0 |
| A2. Adequate buffer strip next to watercourses and sensitive areas | 92.7 | 98.6 |
| A3. Avoids unstable gullies, seeps, very poorly drained areas | 95.6 | 98.7 |
| A4. Road grades are within standards | 99.6 | 100.0 |
| A5. Amount of roads minimized | 100.0 | 100.0 |
| A6. Stream crossings minimized | 99.5 | 99.5 |
| A7. Road excavation minimized | 99.1 | 100.0 |
| A8. Excavated and fill materials placed properly | 99.5 | 99.5 |
| A9. Roads constructed to drain well | 89.9 | 96.0 |
| A10. Appropriate road stabilization, drainage and diversions installed | 87.0 | 93.1 |
| A11. Water diversions functioning properly | 95.3 | 95.8 |
| A12. Runoff diverted onto stable forest floor areas | 93.1 | 95.5 |
| A13. Public road drainage system maintained | 100.0 | 99.5 |
| A14. Public road's drainage maintained | 99.5 | 99.5 |
| A15. Traffic barriers installed | 67.4 | 98.2 |
| Overall Access Road | 94.5 | 98.3 |

The following areas of access road application need greater attention: appropriate road stabilization, drainage and diversions installed, 87% and traffic barriers installed 67.4% The reason for the low incidence of traffic barriers was

that many of these roads are frequently used by the landowner to access other parts of their property or their or other's homes. Even with relatively low application rates in the above areas, the effectiveness rates are still very high, 93.1% or higher. Therefore these departures in application appear to have a minimal impact upon the soil and water resources of these sites.

2. Log Landings

Log landing BMPs were correctly applied 93.5% of the time. All log landing BMP specifications employed were 97.3% effective at protecting the water resources of the site.

Table 2: Application and effectiveness of the BMP specifications for log landings.

| Log Landings | % Application | % Effective |
|--|----------------------|--------------------|
| Y1. Suitable number and size of landings | 98.5 | 100.0 |
| Y2. Landings located outside RMZ | 86.9 | 97.3 |
| Y3. Landings located on stable areas | 93.6 | 96.6 |
| Y4. Excavation of site minimized | 97.0 | 99.6 |
| Y5. Landings avoid concentrating or collecting runoff | 85.7 | 95.9 |
| Y6. Landing's runoff enters stable area | 90.5 | 94.3 |
| Y7. Proper water diversions in working order | 92.4 | 94.6 |
| Y8. Landing smoothed and soil stabilized | 92.3 | 95.4 |
| Y9. Landings free of fuel and lubricant spills and litter | 98.9 | 99.3 |
| Y10. Landing location suitable for equipment fueling and maintenance | 98.9 | 99.6 |
| Overall Log Landings | 93.5 | 97.3 |

Two log landing specifications had application issues. 13.1% of sites had landings located within the RMZ, but with other BMP practices to minimize the impacts of this kind of departure, there appears to have been minimal impacts with an effectiveness of 97.3%. The avoidance of concentrating or collecting runoff and runoff entering a stable area had application scores of 85.7%. However, with other practices such as placing cut offs into low areas just off the landing to help slow down and filter these concentrated flows, the effectiveness of this specification is 95.9%, showing very little impact on the resources of the site.

3. Skid Trails

Skid trail BMPs were correctly applied 80.3% of the time. Skid trail BMP specifications employed were 88.2% effective at protecting the water resources of the sites.

Table 3: Application and effectiveness of BMP specifications for skid trails.

| Skid Trails | % Application | % Effective |
|---|----------------------|--------------------|
| S1. Uses existing routes were appropriate | 97.5 | 98.7 |
| S2. Adequate buffer strip next to water courses and sensitive areas | 73.6 | 90.8 |
| S3. Avoids steep and long straight grades (>20% for >200') | 89.0 | 95.7 |
| S4. Avoids unstable gullies, seeps, poorly drained areas | 82.4 | 92.3 |
| S5. Amount of skid trails minimized | 90.2 | 95.4 |
| S6. Trail excavation minimized | 88.3 | 92.0 |
| S7. Appropriate drainage and diversions installed | 44.8 | 65.3 |
| S8. Water diversions in working order | 75.5 | 83.3 |
| S9. Runoff diverted onto stable forest floor areas | 73.5 | 79.3 |
| S10. Streams not used as skid trails (except for crossings) | 85.4 | 86.1 |
| Overall Skid Trail | 80.3 | 88.2 |

Appropriate drainage and diversions installed (S7) has an application rate of 44.8%, which may seem poor, but is not. Question S7 has historically been the lowest score in every BMP Monitoring Report. The 2012 Comprehensive BMP Monitoring Report across all ownership types since the beginning of BMP monitoring in Indiana had an application of 40.9%. The 2012 version of the CFW report had 36.1% application rate for S7, and in the first year of the CFW BMP program, 2008, there was a 23.8% application for S7. Although 44.8% leaves room for improvement, it is a sign of steady improvement since the beginning of the BMP program in Indiana and for CFW specifically. Application scores showed that RMZs, unstable gullies, and other sensitive areas were adequately buffered or avoided (S2 and S4), 73.6% and 82.4%, respectively. However, both of these specifications had minimal impact to water quality with 90.8% and 92.3% effectiveness ratings. Water diversions that were in place were found to be fully functioning 75.5% of the time, and had an effectiveness percentage of 83.3%. The purpose of water diversions is to divert overland runoff onto the stable forest floor instead of concentrating flow down trails and access roads, which can cause soil erosion. Runoff was diverted properly 73.5% of the time and the effectiveness of these efforts was 79.3%.

4. Stream Crossings

Stream crossing BMPs were correctly applied 73.2% the time. All stream crossing BMP specifications employed were 75.2% effective at protecting the water resources of the sites.

Table 4: Application and effectiveness of BMP specifications for stream crossings.

| Stream Crossing | % Application | % Effective |
|--|----------------------|--------------------|
| X1. Number of crossings minimized | 91.9 | 92.8 |
| X2. Crossings minimize disturbance to the natural bed and banks | 59.1 | 61.3 |
| X3. Streambank approaches properly designed and stabilized | 52.2 | 55.8 |
| X4. Water runoff diverted from road prior to crossing | 50.0 | 58.1 |
| X5. Crossing as close to 90 degrees as practicable | 91.3 | 94.2 |
| X6. Crossing does not unduly restrict water flow | 85.5 | 86.2 |
| X7. Soil has not been used as fill in the stream (except culverts) | 72.3 | 73.0 |
| X8. Ford constructed of non erosive materials | 75.8 | 75.8 |
| X9. Fords have stable banks and streambeds | 57.5 | 58.3 |
| X10. Culverts are properly sized and installed | 95.8 | 95.8 |
| X11. Culverts clear of significant flow obstructions | 95.7 | 95.7 |
| X12. Temporary structures properly anchored | 88.2 | 82.4 |
| X13. Temporary structures and resulting obstructions removed | 72.2 | 72.2 |
| Stream Crossing | 73.2 | 75.2 |

Stream crossings are always dealing directly with water bodies. Therefore, even if there are no departures of application, there may be some impact to the water quality, and it will almost always be a direct impact. The avoidance of stream crossings by sale administrators and loggers is reflected in the statistic for stream crossings. 60% of sites (195 sites) had no stream crossings; there were 131 sites (40%) that had at least 1 stream crossing, out of 326 sites monitored. There were 56 (42.7% of sites with crossings) sites that had only 1 crossing, 36 (27.5%) sites with 2 crossings, 14 (10.7%) sites with 3 crossings, 11 (8.4%) sites with 4 crossings, 3 (2.3%) sites with 5 crossings, 4 (3.1%) sites with 6 crossings, 1 (0.8%) site with 7 crossings, 1 (0.8%) site with 9 crossings, 2 (1.5%) sites with 11 crossings, and 1 (0.8%) site with 14 crossings to make a total of 305 crossings on CFW sites monitored over this 18-year period. 85 of the 305 stream crossings occurred on unmapped intermittent streams. This means they were classified as intermittent streams on the ground, but the USGS quadrangle maps did not map them as intermittent streams. There were 186 crossings on intermittent streams identified on the USGS maps. There were 34 crossings on perennial streams.

Areas of the stream-crossing category that had the lower application and effectiveness scores in CFW are minimization of disturbance to natural bed and banks (X2), proper design and stabilization of stream bank approaches (X3), diversion of water from road prior to crossing (X4), construction of fords with non erosive materials (X7, X8), stable banks and streambeds of fords (X9) and removal of temporary structures and resulting obstructions (X13). These questions deal more directly with closing out stream crossings at the end of their use, which would give a focus area for training in the future.

5. Riparian Management Zones

Riparian management zone (RMZ) BMPs were correctly applied 77.8% of the time. All of the RMZ BMP specifications employed were 83.6% effective at protecting the water resources of the sites.

Table 5: Application and effectiveness of BMP specifications for Riparian Management Zones.

| Riparian Management Zones | % Application | % Effective |
|--|----------------------|--------------------|
| Z2. Perennial & large intermittent streams clear of obstructing debris | 60.6 | 63.3 |
| Z3. Tree tops and cutoffs placed back from water course to prevent movement into streams during floods | 90.0 | 95.2 |
| Z4. RMZ free of excavated material & debris (other than above) | 93.7 | 96.4 |
| Z5. Less than 10% bare mineral soil exposed within RMZ (not including crossings) | 96.8 | 98.0 |
| Z6. Adequate tree stocking in primary RMZ next to perennial streams | 96.5 | 97.6 |
| Z7. RMZ free of roads and landings (except crossing) | 59.9 | 82.5 |
| Z8. Water diverted from roads before entering RMZ | 64.0 | 74.9 |
| Z9. Water diverted onto stable areas of the forest floor | 73.5 | 78.5 |
| Z10. Road and trail surfaces stabilized as needed within RMZ | 79.0 | 82.9 |
| Z11. Ephemeral channels free of excavated material | 72.1 | 71.7 |
| Riparian Management Zones | 77.8 | 83.6 |

Out of 326 sites, 256 had a water body of some type that had a RMZ. In specification Z2, “streams clear of obstructing debris,” the application rate was 60.6% and the effectiveness rate was 63.3%. Of the 61 sites that had departures in effectiveness for obstructing debris, 9 were indirect and temporary, 6 were indirect and prolonged, 18 had direct and temporary impacts and 37 had a direct and prolonged impact to the water quality of the site. The nature of the debris would be prolonged unless it could be removed or mitigated in some way; mitigation by removing the debris is the standard recommendation. Roads and landings in the RMZ scored lower in application with a 59.9% but had 82.5% effectiveness. Twenty of the sites with departures in Z7 had indirect and temporary impact to water quality, one had indirect and prolonged impact, and 19 sites had direct and temporary impacts, while 4 sites had direct and prolonged impacts due to roads and or landings in the RMZ. More attention is needed in the diversion of water from roads before entering the RMZ (Z8). This is supported by the 64% application rate for this specification, and the effectiveness rate for Z8 was 74.9%. Road and trail surfaces were stabilized as needed within the RMZ with a 79% application rate and 82.9% effectiveness rate. Keeping soil out of ephemeral channels (Z11) needs more attention with an application rate of 72.1% and effectiveness rate of 71.6%.

C. Yearly Monitoring Trends

Breaking down data by years can be a useful way to interpret it. CFW sites have only been monitored on a consistent basis since 2009, therefore it is difficult to draw any conclusions about yearly trends yet. However, continuing to examine the data in this way will be useful for the Division of Forestry to determine if any interventions or further education is needed to continue a high level of BMP implementation and success on CFW grounds.

Table 7. Number of CFW sites monitored by year and the application and effectiveness rates broken down by year.

| Number of Sites | Year | Application % | Effectiveness% |
|-----------------|------|---------------|----------------|
| n=1 | 1996 | 97.96% | 97.78% |
| n=6 | 1997 | 80% | 75.56% |
| n=5 | 1999 | 95.42% | 97.71% |
| n=40 | 2009 | 82.52% | 91.70% |
| n=45 | 2010 | 85.32% | 91.71% |
| n=60 | 2011 | 87.86% | 92.85% |
| n=56 | 2012 | 81.68% | 86.73% |
| n=53 | 2013 | 85.80% | 88.44% |
| n=60 | 2014 | 88.31% | 92.65% |

CFW Application and Effectiveness Rates by Year

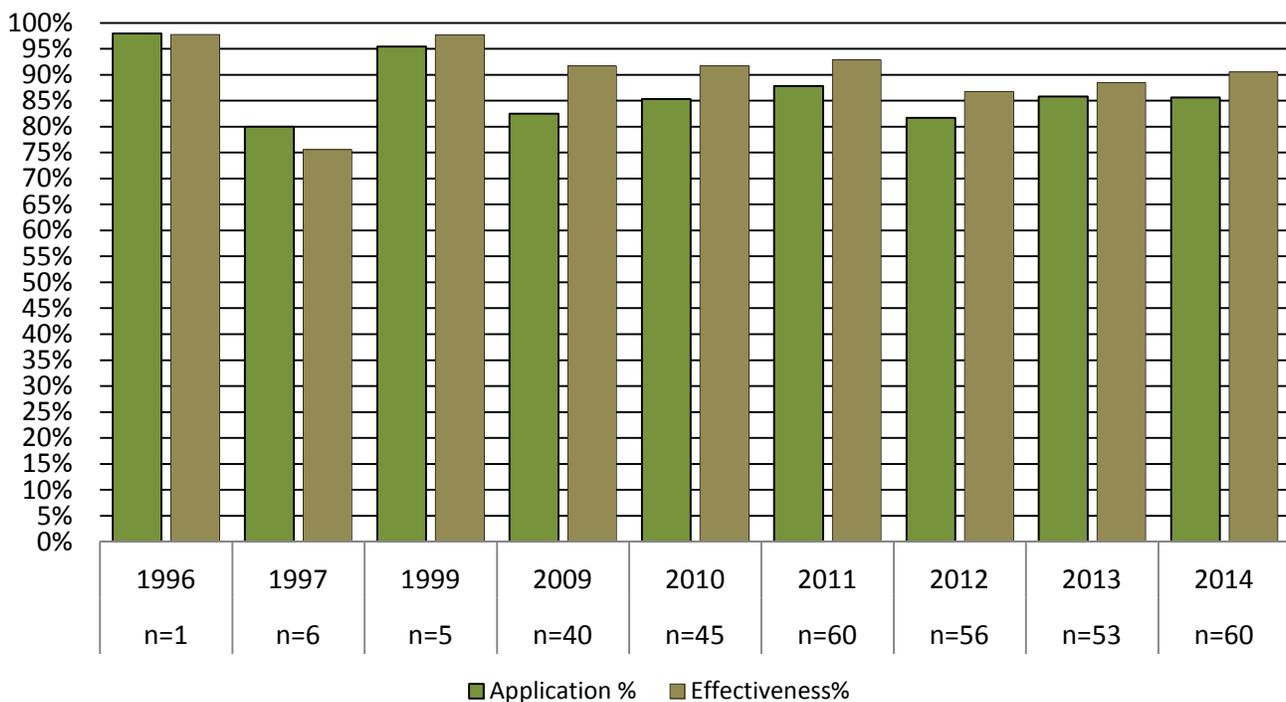


Figure 4. Application and effectiveness scores by year of all CFW sites.

D. Overall Site Ratings

On the final page of the monitoring form there is an opportunity for each monitor to rank his or her overall subjective impression of the site's BMP application & effectiveness (Appendix). Sites can be rated from 1 to 4 or any number in between. The ratings are decided by the following scale for application: 1=above average, 2=average, 3=poor, 4=total negligence. The rating scale for effectiveness is as follows: 1= no visible impact, 2=slight, 3=moderate, 4=severe. Table 6 shows the average ratings for all the sites monitored on the CFW. The overall site rating is an average of the application and effectiveness ratings for all sites.

Table 6. The average site ratings for application, effectiveness and the overall site rating.

| Overall Application | Overall Effectiveness | Overall Site Rating |
|---------------------|-----------------------|---------------------|
| 1.55 | 1.55 | 1.56 |

Monitors found overall application to be between above average and average. They found overall effectiveness to be between no visible impact and slight impact.

V. Discussion

The BMP application rate on CFW sites monitored was 85.62%. Minor departures in application accounted for 12.3%, major departures accounted for 2.03%, 7 practices were considered “total negligence” 0.06%. Forestry BMPs on CFW sites were 90.53% effective at protecting water quality, 3.16% of practices had indirect and temporary impacts, 1.18% had indirect and prolonged impacts, 2.89% had direct and temporary impacts, and 2.24% had direct and prolonged impacts to water quality. The application and effectiveness scores show that there are many sound practices taking place on CFW timber harvest sites resulting in few negative impacts to the soil and water resources. When there are problems in either application or effectiveness, they are minor and short term.

BMPs in access roads and log landings had little to no effect upon the water quality. Roads and landings are established with the knowledge that these are areas where the concentration and amount of repeated traffic will be highest. During site planning and layout, managers will put roads and landings on the most stable areas outside RMZs (92.7 % (A2) and 86.9% (Y2) application respectively). Sometimes site landform and characteristics force the roads to cross streams or be in a RMZ or force landings to be within a RMZ, in which case managers are more thoughtful and careful about how the harvest and closeout are carried out (98.6% and 97.3% effectiveness, respectively). The results of the monitoring show the above inferences to be true by having all of effectiveness scores in both categories above 97%.

Skid trail overall application rate was 80.3%, and the effectiveness score is 88.2% showing a difficulty in implementing some practices within the guidelines, but still protecting water quality. Skid trails can have a spectrum of disturbance levels depending on the amount of times the equipment drives over a particular point on the ground. The main trail just off the landing would have a higher disturbance level because all harvested logs have to be moved to the landing. An area that is traveled over only twice, once to get to access logs and the other pulling the logs out has a much lower level of disturbance. Also, skid trails go to areas that other equipment cannot access. They may cross drainages, travel down or across hill slopes, or go into areas that are wet most of the time. Therefore, most of the application and effectiveness issues of a site are from skid trails. Also, most of the closeout practices are put in place within limited space as landforms and adjacent vegetation will often limit the equipment’s ability to place structures where they would be most effective. This causes minor departures in application (16.9% of skid trail application scores are minor departures) with little to no effect on water quality. However, the 44.8% application rate on “Appropriate drainage and diversions installed” is concerning and is constantly addressed in trainings with landowners and loggers and through publications. This particular BMP did improve 2.7% in application this year and by 6% the year before, so that is demonstrating continual improvement.

Stream crossings are difficult to make or utilize without impacting water quality. Any impact is either direct and temporary or direct and prolonged. Because of this fact, the BMP guidelines emphasize the avoidance of stream crossings if possible. Out of 326 sites, only 40% (131 sites) had stream crossings. Of those 101 sites with crossings, there were a total of 305 crossings: 186 on mapped intermittent streams, 85 on unmapped intermittent streams, 34 on perennial streams. In the application of stream crossings, 73.2% of the practices were implemented within the guidelines, and 75.2% of the time had a no impact to water quality. As earlier mentioned, if there is an impact from

stream crossings, they can have a direct effect according to the definitions in the effectiveness scoring, 13% of the effectiveness scores had a 4 (direct and temporary impacts) and 9.5% had a score of 5 (direct and prolonged impacts).

RMZs, like stream crossings, are in close proximity to water bodies. Problems often lead to direct impacts to water quality. Problems can be averted by avoidance placing high impact infrastructure like access roads or landings in RMZs. RMZ BMP application of Z7 was 59.9% and RMZ BMP effectiveness was 82.5%. There were 256 sites with at least one RMZ and 101 of those sites had roads or landings in them. Out of the 101 with roads or landings in the RMZ, 57 had no impact upon water quality. Twenty with roads and or landings in the RMZ had an indirect and temporary impact, 1 sites had an indirect and prolonged impact, 19 sites had a direct and temporary impact, and 4 sites had direct and prolonged impacts to water quality.

VI. Recommendations

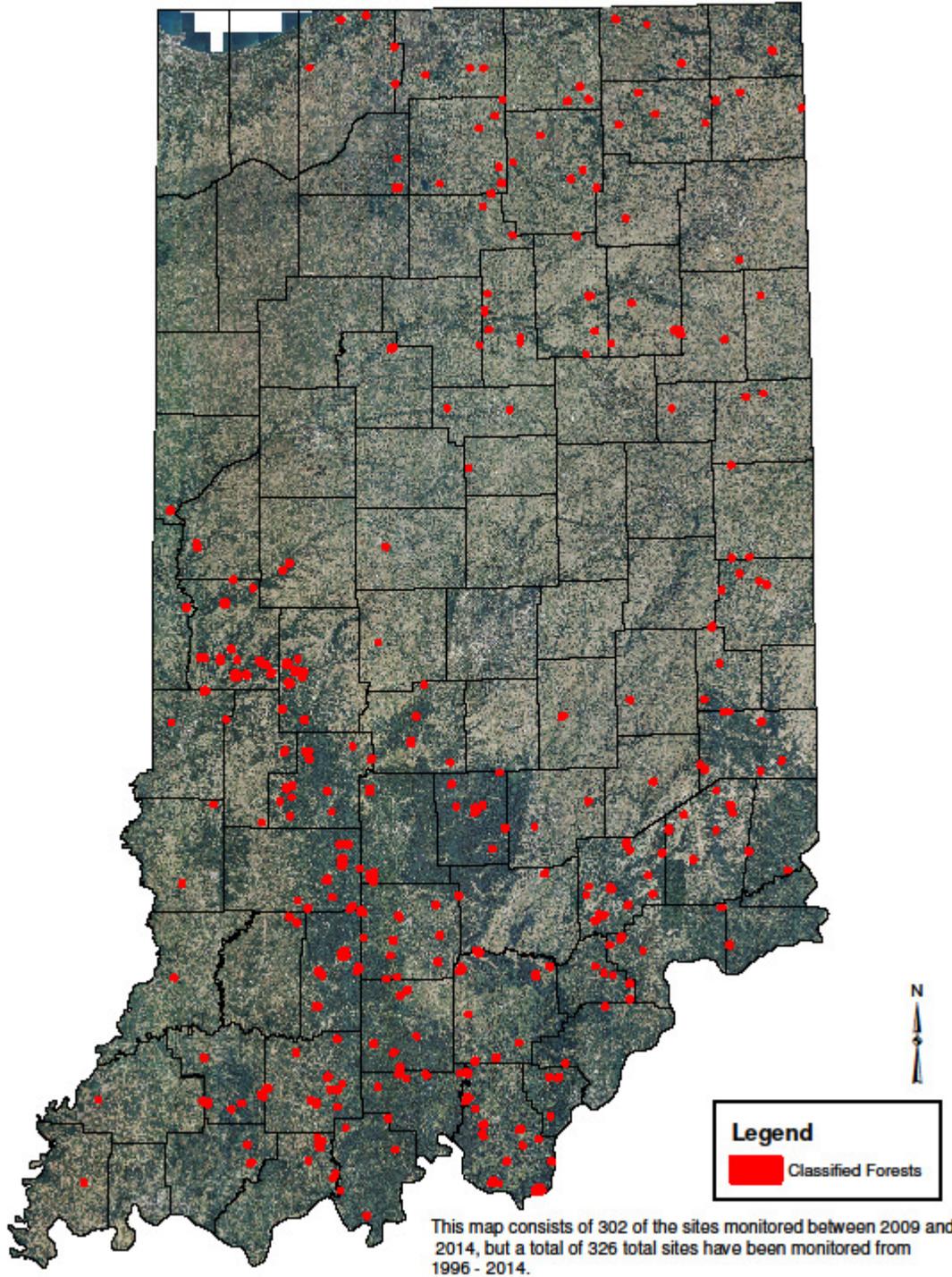
- Focus on areas where problems are more common, such as skid trails, RMZs, and stream crossings.
- Training for landowners and loggers needs to emphasize the utilization of water diversions.
- Continue to emphasize importance of diverting water before it concentrates on roads, landings, skid trails and enters streams and RMZs.
- Continue providing BMP educational information and programs for loggers and resource professionals that work on private properties.

VII. Conclusions

CFWs are privately owned and have a diverse usage. Private lands provide a great service to the citizens of this state by producing clean water and air, and increasing biodiversity. Forestry BMPs are the means by which soil erosion from harvesting areas is minimized and thus soil and water quality are maintained. Minimal soil erosion allows for quick recovery of the site because the topsoil is still in place to allow for natural succession to take place. Limited sedimentation to the water resources of the forest protects water quality. BMPs allow the forest to remain a “working” timberland while still providing the environmental benefits that are necessary to our state.

While there are BMP applications that need improvement, the negative environmental impact is short term for most sites. By allowing these forests to provide an income for the landowner through timber management, there is an incentive for the landowner to keep that land in forest rather than converting to grazing, row cropping, or development; all of which have a larger and more sustained impact on the environment. Indiana Forestry BMPs are in place to minimize sedimentation in the waters of Indiana.

Classified Forests Monitored for BMPs 2009-2014



Appendix B
FORESTRY BMP MONITORING WORKSHEET
 (2000)

DATE INSPECTED: _____ TEAM: _____
 OWNER: _____ PHONE: _____

COUNTY: _____ Site #: _____ ACRES HARVESTED: _____
 CIVIL TWP: _____ USGS QUAD: _____
 SEC: _____ TWP: _____ RANGE: _____
 MAJOR WATERSHED: _____
 DATE OF ACTIVITY: _____
 HARVEST EQUIPMENT USED: Dozer: __ Skidder: __ Horses: __ Other: __
 TYPE OF HARVEST: Diameter limit: __ Single Tree: __ Group Selection: __ Clear Cut: __ Other: __

SITE CONDITIONS

TERRAIN: BOTTOMLAND _____ % RIDGES _____ % SIDE SLOPES _____ %
 SLOPE STEEPNESS: (2-6%) _____ (6-12%) _____ (12-20%) _____ (20+%)
 LAKES PRESENT: name: _____ shore length: _____
 PERENNIAL STREAMS PRESENT: name: _____ width: _____ length: _____
 SINKHOLES PRESENT: Yes _____ No _____ FLOWING SPRINGS PRESENT: Yes _____ No _____
 OPEN WATER WETLANDS PRESENT: Yes _____ No _____ .

FOR OFFICE USE – DO NOT COMPLETE

OPERATOR/FORESTER: (leave blank) _____

TYPE OF OWNERSHIP: nipf: __ clf: __ industry: __ state: __ fed: __ county: __ other: __

APPLICATION

- 0--The Practice Not Needed or Applied on Site
- 1--Operation Meets Requirement of Bmp
- 2--Minor Departure from Bmp
- 3--Major Departure from Bmp
- 4--Gross Neglect of Bmp

EFFECTIVENESS

- 1--Adequate Protection of Water Resources.
- 2--Indirect and Temporary Impacts on Water Resources.
- 3--Indirect and Prolonged Impacts on Water Resources.
- 4--Direct and Temporary Impacts on Water Resources.
- 5--Direct and Prolonged Impacts on Water Resources.

APPLICATION DEFINITIONS (BY EXAMPLE)

MINOR DEPARTURE: Practice not clearly needed; attempted practice but poorly applied; small potential for soil to reach streams.
MAJOR DEPARTURE: Practice clearly needed; common departures from practice; large potential for soil to reach streams.
GROSS NEGLECT: No attempt at application; total disregard for water quality; large and direct impacts.

EFFECTIVENESS DEFINITIONS (BY EXAMPLE)

ADEQUATE: Small amount of material eroded; material does not reach drainages, streams, lakes or sinkhole openings.
INDIRECT IMPACT: Erosion and delivery of material to drainages (including ephemerals) but not to intermittent or perennial streams, lakes or sinkhole openings.
DIRECT IMPACT: Erosion and subsequent delivery of sediment to intermittent or perennial streams, lakes or sinkhole openings.
TEMPORARY IMPACT: Impacts lasting one year or less; no more than one runoff season; small amount of material involved.
PROLONGED IMPACT: Impacts lasting more than one year; large amount of material involved.

*It is possible to have a departure from BMPs and still have adequate protection.

| ACCESS ROADS | | | | APPLICATION (0-4) | | | |
|--|--|--|--|-------------------|--|--|---------------------|
| | | | | | | | EFFECTIVENESS (1-5) |
| | | | | COMMENTS | | | |
| There is no access road present _____ (If true, do not answer questions below) | | | | | | | |
| A1. Uses existing routes where appropriate | | | | | | | |
| A2. Adequate buffer strip next to watercourses and sensitive areas | | | | | | | |
| A3. Avoids unstable gullies, seeps, very poorly drained areas | | | | | | | |
| A4. Road grades are within standards | | | | | | | |
| A5. Amount of roads minimized | | | | | | | |
| A6. Stream crossings minimized | | | | | | | |
| A7. Road excavation minimized | | | | | | | |
| A8. Excavated and fill materials placed appropriately | | | | | | | |
| A9. Roads constructed to drain well | | | | | | | |
| A10. Appropriate road stabilization, drainage & diversions installed | | | | | | | |
| X=applied | water bars _____ dips/rolls _____ outsoles _____ berms cut _____ culverts _____ geotextile _____ rock _____ seed _____ mulch _____ | | | | | | |
| A11. Water diversions are in working order (_____ % working) | | | | | | | |
| Failure due to: installation, damage, location, timing, weather, other | | | | | | | |
| A12. Runoff diverted onto stable forest floor areas | | | | | | | |
| A13. Mud kept off public roadways | | | | | | | |
| A14. Public road drainage system maintained | | | | | | | |
| A15. Appropriate traffic barriers installed | | | | | | | |

APPLICATION

- 0--The Practice Not Applicable
- 1--Operation Meets Requirement of Bmp
- 2--Minor Departure from Bmp
- 3--Major Departure from Bmp
- 4--Gross Neglect of Bmp

EFFECTIVENESS

- 1--Adequate Protection of Water Resources.
- 2--Indirect and Temporary Impacts on Water Resources
- 3--Indirect and Prolonged Impacts on Water Resources.
- 4--Direct and Temporary Impacts on Water Resources.
- 5--Direct and Prolonged Impacts on Water Resources.

APPLICATION DEFINITIONS (BY EXAMPLE)

MINOR DEPARTURE: Practice not clearly needed; attempted practice but poorly applied; small potential for soil to reach streams
 MAJOR DEPARTURE: Practice clearly needed; common departures from practice; large potential for soil to reach streams
 GROSS NEGLECT: No attempt at application; total disregard for water quality; large and direct impacts

EFFECTIVENESS DEFINITIONS (BY EXAMPLE)

ADEQUATE: Small amount of material eroded; material does not reach drainages, streams, lakes or sinkhole openings.
 INDIRECT IMPACT: Erosion and delivery of material to drainages (including ephemerals) but not to intermittent or perennial streams, lakes or sinkhole openings.
 DIRECT IMPACT: Erosion and subsequent delivery of sediment to intermittent or perennial streams, lakes or sinkhole openings.
 TEMPORARY IMPACT: Impacts lasting one year or less; no more than one runoff season; small amount of material involved.
 PROLONGED IMPACT: Impacts lasting more than one year; large amount of material involved.

*It is possible to have a departure from BMPs and still have adequate protection.

| LOG LANDINGS | | | | | | | | | | | |
|--|--|--|--|--|--|--|----------------------|---------------------|----------|--|--|
| | | | | | | | APPLICATION (0-4) | | | | |
| | | | | | | | | EFFECTIVENESS (1-5) | | | |
| | | | | | | | | | COMMENTS | | |
| Y1. Suitable number and size of landings | | | | | | | | | | | |
| Y2. Landings located outside RMZ | | | | | | | | | | | |
| Y3. Landings located on stable areas | | | | | | | | | | | |
| Y4. Excavation of site minimized | | | | | | | | | | | |
| Y5. Landings avoid concentrating or collecting runoff | | | | | | | | | | | |
| Y6. Landing's runoff enters stable area | | | | | | | | | | | |
| Y7. Proper water diversions in working order | | | | | | | | | | | |
| Y8. Landing smoothed and soil stabilized | | | | | | | | | | | |
| Y9. Landings free of fuel and lubricant spills and litter | | | | | | | | | | | |
| Y10. Landing location suitable for equipment fueling and maintenance | | | | | | | | | | | |
| Number of log landings _____ | | | | | | | Size: (acres) _____. | | | | |

APPLICATION

- 0--The Practice Not Applicable
- 1--Operation Meets Requirement of Bmp
- 2--Minor Departure from Bmp
- 3--Major Departure from Bmp
- 4--Gross Neglect of Bmp

EFFECTIVENESS

- 1--Adequate Protection of Water Resources.
- 2--Indirect and Temporary Impacts on Water Resources.
- 3--Indirect and Prolonged Impacts on Water Resources.
- 4--Direct and Temporary Impacts on Water Resources.
- 5--Direct and Prolonged Impacts on Water Resources.

APPLICATION DEFINITIONS (BY EXAMPLE)

- MINOR DEPARTURE: Practice not clearly needed; attempted practice but poorly applied; small potential for soil to reach streams
- MAJOR DEPARTURE: Practice clearly needed; common departures from practice; large potential for soil to reach streams
- GROSS NEGLECT: No attempt at application; total disregard for water quality; large and direct impacts

EFFECTIVENESS DEFINITIONS (BY EXAMPLE)

- ADEQUATE: Small amount of material eroded; material does not reach drainages, streams, lakes or sinkhole openings.
- INDIRECT IMPACT: Erosion and delivery of material to drainages (including ephemerals) but not to intermittent or perennial streams, lakes or sinkhole openings.
- DIRECT IMPACT: Erosion and subsequent delivery of sediment to intermittent or perennial streams, lakes or sinkhole openings.
- TEMPORARY IMPACT: Impacts lasting one year or less; no more than one runoff season; small amount of material involved.
- PROLONGED IMPACT: Impacts lasting more than one year; large amount of material involved.

*It is possible to have a departure from BMP's and still have adequate protection.

| SKID TRAILS | | | | | | | |
|--|--|--|--|---------------------|--|--|--|
| | | | | APPLICATION (0-4) | | | |
| | | | | EFFECTIVENESS (1-5) | | | |
| | | | | COMMENTS | | | |
| S1. Uses existing routes where appropriate | | | | | | | |
| S2. Adequate buffer strip next to watercourses & sensitive areas | | | | | | | |
| S3. Avoids steep and long straight grades (>20% for >200') | | | | | | | |
| S4. Avoids unstable gullies, seeps, poorly drained areas | | | | | | | |
| S5. Amount of skid trails minimized | | | | | | | |
| S6. Trail excavation minimized | | | | | | | |
| S7. Appropriate drainage and diversions installed | | | | | | | |
| X= applied | water bars ___ outslopes ___ dips/rolls ___ berms cut ___ culverts ___ seed ___ mulch ___ rock ___ other ___ | | | | | | |
| S8. Water diversions in working order (___ % working) | | | | | | | |
| Failure due to: installation, damage, location, timing, weather, other | | | | | | | |
| S9. Runoff diverted onto stable forest floor areas | | | | | | | |
| S10. Streams not used as skid trails (except crossings) | | | | | | | |
| Types of streams involved and length of disturbance: perennial _____, mapped intermittent _____. | | | | | | | |
| Unmapped intermittent _____, ephemeral _____. | | | | | | | |

APPLICATION

- 0--The Practice Not Needed or Applied on Site
- 1--Operation Meets Requirement of Bmp
- 2--Minor Departure from Bmp
- 3--Major Departure from Bmp
- 4--Gross Neglect of Bmp

EFFECTIVENESS

- 1--Adequate Protection of Water Resources.
- 2--Indirect and Temporary Impacts on Water Resources.
- 3--Indirect and Prolonged Impacts on Water Resources.
- 4--Direct and Temporary Impacts on Water Resources.
- 5--Direct and Prolonged Impacts on Water Resources.

APPLICATION DEFINITIONS (BY EXAMPLE)

- MINOR DEPARTURE: Practice not clearly needed; attempted practice but poorly applied; small potential for soil to reach streams
- MAJOR DEPARTURE: Practice clearly needed; common departures from practice; large potential for soil to reach streams
- GROSS NEGLECT: No attempt at application; total disregard for water quality; large and direct impacts

EFFECTIVENESS DEFINITIONS (BY EXAMPLE)

- ADEQUATE: Small amount of material eroded; material does not reach drainages, streams, lakes or sinkhole openings.
- INDIRECT IMPACT: Erosion and delivery of material to drainages (including ephemerals) but not to intermittent or perennial streams, lakes or sinkhole openings.
- DIRECT IMPACT: Erosion and subsequent delivery of sediment to intermittent or perennial streams, lakes or sinkhole openings.
- TEMPORARY IMPACT: Impacts lasting one year or less; no more than one runoff season; small amount of material involved.
- PROLONGED IMPACT: Impacts lasting more than one year; large amount of material involved.

*It is possible to have a departure from BMPs and still have adequate protection.

| STREAM CROSSINGS | | APPLICATION (0-4) | |
|---|--|---------------------|--|
| | | EFFECTIVENESS (1-5) | |
| | | COMMENTS | |
| X1. Number of crossings minimized | | | |
| X2. Crossings minimize disturbance to the natural bed & banks | | | |
| X3. Streambank approaches properly designed and stabilized | | | |
| X4. Water runoff diverted from road prior to crossing | | | |
| X5. Crossing as close to 90 degree angle as practicable | | | |
| X6. Crossing does not unduly restrict water flow | | | |
| X7. Soil has not been used as fill in the stream (except culverts) | | | |
| X8. Ford constructed of non erosive materials that will not degrade water quality | | | |
| X9. Fords have stable banks and streambed | | | |
| X10. Culverts are properly sized and installed | | | |
| X11. Culverts clear of significant flow obstructions | | | |
| X12. Temporary structures properly anchored | | | |
| X13. Temporary structures and resulting obstructions removed | | | |
| <p>Number of perennial crossings _____ widths _____.</p> <p>Number of intermittent crossings _____ widths _____ Number of unmapped intermittents widths _____.</p> | | | |

APPLICATION

- 0--The Practice Not Needed or Applied on Site
- 1--Operation Meets Requirement of Bmp
- 2--Minor Departure from Bmp
- 3--Major Departure from Bmp
- 4--Gross Neglect of Bmp

EFFECTIVENESS

- 1--Adequate Protection of Water Resources.
- 2--Indirect and Temporary Impacts on Water Resources.
- 3--Indirect and Prolonged Impacts on Water Resources.
- 4--Direct and Temporary Impacts on Water Resources.
- 5--Direct and Prolonged Impacts on Water Resources.

APPLICATION DEFINITIONS (BY EXAMPLE)

- MINOR DEPARTURE: Practice not clearly needed; attempted practice but poorly applied; small potential for soil to reach streams
- MAJOR DEPARTURE: Practice clearly needed; common departures from practice; large potential for soil to reach streams
- GROSS NEGLECT: No attempt at application; total disregard for water quality; large and direct impacts

EFFECTIVENESS DEFINITIONS (BY EXAMPLE)

- ADEQUATE: Small amount of material eroded; material does not reach drainages, streams, lakes or sinkhole openings.
- INDIRECT IMPACT: Erosion and delivery of material to drainages (including ephemerals) but not to intermittent or perennial streams, lakes or sinkhole openings.
- DIRECT IMPACT: Erosion and subsequent delivery of sediment to intermittent or perennial streams, lakes or sinkhole openings.
- TEMPORARY IMPACT: Impacts lasting one year or less; no more than one runoff season; small amount of material involved.
- PROLONGED IMPACT: Impacts lasting more than one year; large amount of material involved.

*It is possible to have a departure from BMPs and still have adequate protection.

| RIPARIAN MANAGEMENT ZONES | | | |
|--|--------------------------|----------------------------|-----------------|
| | APPLICATION (0-4) | | |
| | | EFFECTIVENESS (1-5) | |
| | | | COMMENTS |
| Z1. RMZ present on this site include: _____ lakes, _____ rivers, _____ perennial streams, _____ intermittent streams, _____ sinkhole openings (specify), _____ open water wetlands, _____ unmapped intermittent streams | | | |
| Z2. Perennial & large intermittent streams clear of obstructing logging debris | | | |
| Z3. Logging debris placed back from watercourse to prevent movement into streams during floods | | | |
| Z4. RMZ free of piled slash, debris and fill | | | |
| Z5. Less than 10% bare mineral soil scattered within RMZ - not including crossing | | | |
| Z6. Adequate tree stocking in primary RMZ next to perennial streams | | | |
| Z7. RMZ free of roads and landings (except crossings) Were roads pre-existing? _____ | | | |
| Z8. Water diverted from roads before entering RMZ | | | |
| Z9. Water diverted onto stable areas of the forest floor | | | |
| Z10. Road and trail surfaces stabilized as needed within RMZ | | | |
| Z11. Ephemeral channels free of excavated material | | | |
| | | | |

APPLICATION

- 0--The Practice Not Needed or Applied on Site
- 1--Operation Meets Requirement of Bmp
- 2--Minor Departure from Bmp
- 3--Major Departure from Bmp
- 4--Gross Neglect of Bmp

EFFECTIVENESS

- 1--Adequate Protection of Water Resources.
- 2--Indirect and Temporary Impacts on Water Resources.
- 3--Indirect and Prolonged Impacts on Water Resources.
- 4--Direct and Temporary Impacts on Water Resources.
- 5--Direct and Prolonged Impacts on Water Resources.

APPLICATION DEFINITIONS (BY EXAMPLE)

- MINOR DEPARTURE: Practice not clearly needed; attempted practice but poorly applied; small potential for soil to reach streams
- MAJOR DEPARTURE: Practice clearly needed; common departures from practice; large potential for soil to reach streams
- GROSS NEGLECT: No attempt at application; total disregard for water quality; large and direct impacts

EFFECTIVENESS DEFINITIONS (BY EXAMPLE)

- ADEQUATE: Small amount of material eroded; material does not reach drainages, streams, lakes or sinkhole openings.
- INDIRECT IMPACT: Erosion and delivery of material to drainages (including ephemerals) but not to intermittent or perennial streams, lakes or sinkhole openings.
- DIRECT IMPACT: Erosion and subsequent delivery of sediment to intermittent or perennial streams, lakes or sinkhole openings.
- TEMPORARY IMPACT: Impacts lasting one year or less; no more than one runoff season; small amount of material involved.
- PROLONGED IMPACT: Impacts lasting more than one year; large amount of material involved.

*It is possible to have a departure from BMPs and still have adequate protection.

SUPPLEMENTAL QUESTIONS AND SUMMARY

1) WHAT WENT RIGHT ON THIS SITE? (SUMMARIZE HIGHLIGHTS)

2) WHAT WENT WRONG ON THIS SITE? (SUMMARIZE PROBLEMS)

3) HAVE OTHER ACTIVITIES OCCURRED ON THIS SITE THAT POTENTIALLY IMPACT WATER QUALITY? (E.G. ATV use, vehicle traffic, grazing, etc.)
If so, please explain.

4) WERE TRAFFIC BARRIERS IN PLACE TO PREVENT TRESPASS DAMAGE? _____.
WHAT KIND OF TRESPASS DAMAGE WAS OBSERVED?

5) ARE THERE MITIGATING ACTIVITIES THAT SHOULD TAKE PLACE ON THIS SITE OR IS CORRECTIVE ACTION ALREADY BEING TAKEN.

| | | | |
|--|-----------|----------|----------------|
| 6) -HAS THE SALE ADMINISTRATOR RECEIVED BMP TRAINING? | Yes _____ | No _____ | Unknown _____. |
| - HAS THE OPERATOR (LOGGER) RECEIVED ANY BMP TRAINING? | Yes _____ | No _____ | Unknown _____. |
| - WAS THE SALE ADMINISTERED BY A FORESTER? | Yes _____ | No _____ | Unknown _____. |
| - IS THE LANDOWNER AWARE OF BMPs? | Yes _____ | No _____ | Unknown _____. |

7) GIVE THIS SITE AN OVERALL RATING OF 1-8 COMBINING APPLICATION OF BMPs WITH IMPACT TO WATER QUALITY.

RATE THIS SITE FROM 1-4 FOR THE OVERALL APPLICATION OF BMPs _____
1=above average 2=average 3=poor 4=total negligence

RATE THIS SITE FROM 1-4 FOR ITS OVERALL IMPACT TO WATER QUALITY _____
1= no visible impact 2=slight 3=moderate 4=severe

SITE RATING _____/2=_____

Note: These numbers do not necessarily need to directly reflect the worksheet ratings for application or effectiveness

Field Guide Cross Reference

On this page is each question in the monitoring sheet and the corresponding pages on the subject in the BMP Field Guide.

ACCESS Roads == Section II, pages 8-16

- A1 == pages 4, 8, 10
- A2 == pages 8, 9, 12, Section V page 32, 33, Table 4 page 34, 35
- A3 == page 8
- A4 == page 8
- A5 == page 10
- A6 == page 8 and Section IV page 24 – 30
- A7 == pages 8, 10
- A8 == pages 10, 12, 24, 29
- A9 == pages 8, 10, Table 1 page 11, 12
- A10 = pages 8, 10 Table 1 page 11, 12, 14, 15, Table 2 page 21, 22
- X=Applied == (waterbars, pages 21-22), (dips/rolls, pages 21-22), (outslopes, Glossary), (berms cut, Glossary), (culverts, pages 27-28), (geotextile, Glossary), (rock, page 10), (seed, Appendix A), (mulch, Appendix A).
- A11 = pages 14, 15, Table 1 page 11, 18, Table 2 page 21
- A12 = page 10
- A13 = pages 13, 14
- A14 = page 14

LOG LANDINGS == Section IV, pages 36-40

- Y1 == pages 36, 39
- Y2 == Table 4 page 34, 36
- Y3 == page 36
- Y4 == page 38
- Y5 == pages 36, 38-40
- Y6 == pages 38-40
- Y7 == pages 38-40
- Y8 == pages 38-40
- Y9 == pages 39, 40
- Y10 = page 39

SKID TRAILS == Section III, pages 18-22

- S1 == pages 4, 18
- S2 == pages 18, 20, Section V pages 32-35
- S3 == page 18
- S4 == page 18
- S5 == page 18
- S6 == page 18
- S7 == Table 1 page 11, pages 18-20, Table 2 page 21, 22, 27, 28
- X=Applied == (waterbars, pages 21-22), (dips/rolls, pages 21-22), (outslopes, Glossary), (berms cut, Glossary), (culverts, pages 27-28), (geotextile, Glossary), (rock, page 10), (seed, Appendix A), (mulch, Appendix A).
- S8 == Table 1 page 11, pages 14, 15, 20 Table 2 page 21
- S9 == page 20
- S10 = pages 18-20, Section IV pages 24-30
- Types of Streams == page 24, Glossary, and Section V pages 32-35

STREAM CROSSINGS == Section IV, pages 24-30

- X1 == page 24
- X2 == page 24
- X3 == pages 24, 25
- X4 == pages 24, 25
- X5 == page 24
- X6 == pages 24-26, 28
- X7 == pages 24, 29
- X8 == pages 24, 29
- X9 == pages 24, 25, 29
- X10 = pages 25, 27, Table 3 page 28
- X11 = pages 24, 27, 28
- X12 = pages 25, 26
- X13 = pages 25-29

RIPARIAN MANAGEMENT ZONES == Section V, pages 32-35

- Z1 == pages 32, 34, Glossary
- Z2 == page 33
- Z3 == pages 32-34
- Z4 == pages 32-34
- Z5 == pages 32-34
- Z6 == pages 32-34
- Z7 == pages 32, 34
- Z8 == pages 33, 34
- Z9 == pages 32-34
- Z10 = pages 33, 34
- Z11 = page 35