Appendix 1. Protocol for Road Hazard Inventories

Road Hazard Inventory

Background
The most common sources of sediment in rural and forested areas are from unsurfaced roads. Monitoring source areas of sediment can identify inputs of sediment to the stream system that may need to be mitigated. Ideally this should be done on a watershed scale. There are undoubtedly other sources of sediment in the watershed. This protocol only addresses road-related sources of sediment. Erosion associated with roads and ditches typically includes both surface erosion and landslides. Road construction disturbs and compacts soils and prevents revegetation. Therefore, in the forested landscape, roads are the greatest potential source of sediment outside the stream channels. This can occur in the form of surface erosion or landsliding. Past monitoring indicates three major areas of concern for road erosion. One concern is excess spacing of cross drainage on steep gradient roads. Another is a side ditch routed over long distances with direct discharge into channels. Finally, road-related landslides are typically associated with steep sidecast material. There are three major elements (Table F-1) of the road hazard inventory that address these road concerns.

Table F-1. Elements of road hazard inventory

<table>
<thead>
<tr>
<th>Inventory Elements</th>
<th>Area of concern</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stream crossing structures</td>
<td>Washouts of crossings and fish passage through culverts</td>
</tr>
<tr>
<td>Sidecast fill on steep slopes</td>
<td>Sidecast-related landslides entering channels</td>
</tr>
<tr>
<td>Road surface drainage systems</td>
<td>Muddy drainage waters delivered to streams</td>
</tr>
</tbody>
</table>

In order to use this protocol, several terms need to be understood by monitoring participants:

Road prism
Cross section of roadway from the top of the excavated area (cut) to the toe of the fill.

Cutslope
Slope created by excavation into the natural hillslope, is steeper than the natural slope.

Sidecast
Unconsolidated excavated material pushed to the slope below the road, generally not used as part of the road, and steeper than the natural slope.

Fillslope
Excavated material placed below the road and intended to serve as part of the road.

Inslope
Road surface that is sloped so that all water drains toward the ditch or cutslope.

Outslope
Road surface that is sloped so that all water drains toward the fillslope or sidecast.

Berm
A continuous pile of fill and/or aggregate, usually on the outside edge of a road which prevents surface water from leaving the road.
**Cross drain culvert**
A culvert installed under and across a road to carry ditch water to the downslope side of a road.

**Stream crossing culvert**
A culvert installed in a stream channel intended to carry stream flow under the road.

**Bridge**
A structure intended to carry vehicles over a stream or other feature, usually consisting of a span and abutments.

**Log puncheon**
A drainage structure made of logs (often cedar) and no longer in common use.

**Ford**
A stream crossing where stream flow covers the crossing for all or part of the year.

**Waterbar**
A constructed ditch and berm designed to direct water across the road.

**Dips**
A cross drainage structure where a low spot is excavated along the profile of the road and where surface water of stream flow is directed across the road.

**Grade break**
Location where road grade reverses (typically on a saddle or ridge) and surface water automatically is drained away from the road surface in question.

**Ditch**
Trench constructed at the toe of a cutslope and intended to keep water off the road surface. Ditch water is drained down slope along the road to some point of relief or cross drain.

**Landing**
An area constructed for logging equipment and log handling operations. Landings may be at the end of roads, or constructed as wide spots in the road. They are typically wider than the rest of the logging road.

**Ridge Road**
Ridge roads are located on or near the ridgeline (most or all of the road on the top one-third of the slope).

**Midslope Road**
A road located between a ridge and stream channel

**Valley Road**
Any road which generally parallels a stream in places, usually in the former riparian area of the stream.

**Equipment Needs**
In order to successfully and efficiently collect road data, the following equipment is needed.
- **Vehicle**—a vehicle (pick-up or utility rig) is preferred for road access, although a mountain bike can also be used where access is poor.
- **Two person crew**—a single person can collect the necessary data, although a crew of two can be more effective. The inventory person or crew can also be used to mark culverts and to flag locations needing immediate maintenance attention.
- **Distance Measuring Instrument (DMI) and Hip Chain (String Box)**—a DMI or other device that records vehicle travel distance in feet is recommended to accurately record distances while traveling along roads. Impassable roads are measured with a hip chain (string box).
- **Clinometer**—a clinometer is used to determine average road gradient and hillslope steepness. More accurate measurement tools (engineer’s level) are required for any actual repair activity.
- **Scaled rod or staff and a measuring (loggers) tape**—lengths of culverts and bridges will be measured with these tools.
- **ODF stream classification maps**—on USGS 7.5 minute quad maps and/or other maps showing roads and streams are also needed.
- **Global Positioning System (GPS)**—GPS may be used to map road features. However, use of GPS to date has significantly slowed data collection, and is not an essential component of this protocol. GPS efficiency is poor in areas of narrow canyons or when the canopy is wet.
• Data Logger—direct data entry into a field data-logger as it is being collected can be very efficient.

• Computer System and Software—inventory information should be entered into relational databases. Relational databases are probably the most effective tool for making sense of large amounts of information. Commonly available software can be used to query the database to find high erosion hazards or barriers to fish migration.

• Geographic Information System (GIS)—data can be entered into a GIS system without GPS data using dynamic segmentation. If GPS has been used, the locations of features can be directly input to a GIS system.

Site Selection
The road hazard inventory is designed to assess all roads under a given ownership or within a given watershed. The protocol provides information to help landowners identify roads of concern and prioritize repair activities. It does not provide all the information necessary to implement those repairs. Timely inspection and subsequent maintenance or repair activity on forest roads will benefit fish and fish habitat. Therefore, it should eventually be conducted on all road miles that potentially affect fish habitat. Prioritizing site selection depends on the monitoring question being asked. However, in general, road inventories should first be conducted in areas where roads pose higher risk to anadromous fish and their habitats. This can be determined from:

• Landowner knowledge
• Topographic maps showing:
  − stream crossings of fish bearing streams,
  − midslope roads on steep slopes, and/or
  − steep, long road grades leading to channel crossing

Landowners are encouraged to use this protocol for road management purposes other than erosion hazard reduction. Possible uses include routine maintenance and surfacing decisions.

Road Hazard Field Methods

Overall Methodology
Begin at a road junction or other landmark. Take measurements described in the Surface Drainage Section below. As you travel along the road, measure the distance (DMI or other device starting at 0), until encountering a drainage feature and or stream crossing. This is referred to as road stationing. Record distance traveled, repeat surface drainage measurements and take Culvert/Bridge and/or Stream Crossing Details (described below), whichever are applicable. Record observations of general road characteristics (described in next section) for the entire road.

General Road Characteristics
Each road should be identified by name or number, according to the system normally used by the landowner. General characteristics are normally collected only once for each road. The following observations are used to classify each road and can be documented on a form as in Table F-2:

Road identification by name, numbering system or other means.
Road use by management activity.
  active roads: have been used for timber haul in the past year
  inactive roads: include all other roads used for management since 1972; and
  orphaned roads are overgrown roads or railroad grades not used since 1972.

Surfacing material is described as asphalt, clean rock (new quarry rock); old rock (more common); or dirt.

Road location is described as ridge, midslope, or valley as the location of most of the road.
Width of the entire road is estimated (from the outside edge to the base of the cutslope).
For ownerships where georegion, geology or soils are variable and have a great influence on erosion, these classifications should also be documented. Record whether the road is outslipped or has a ditch. Record the location of the road with respect to a landmark. This may be done with the GPS unit or on a map.
Surface Drainage

Between drainage features, information is collected on the erosion potential and sediment delivery potential of the roadway. The typical road conditions between each drainage feature are categorized to identify erosion problems. The following observations and measurements are made to identify symptoms of high erosion on road segments that best describe the condition of the entire segment:

**Road Grade**

Road grade (slope) is measured in percent, with an estimated average when the slope changes. Slope is recorded as positive if the direction is up from the measuring point or feature, and negative when the direction is down from the feature. A positive slope drains toward the feature, a negative slope drains away from the feature.

**Road Surface Condition**

Road surface condition is described as good, rutted, bermed, or eroded (gullied).

**Ditch**

Ditch is described by function as good (capable of holding runoff without serious erosion), cutting, diverted, or full.

**Cutslope**

Cutslope is described as good (stable), ravel problems, or slides into the road.

**Delivery**

Delivery of sediment to streams from that length of road is described as “yes,” “possible,” “no,” or “bypassed” (water flows past the drainage feature and not off of the road).

**Road length draining to drainage.**

The length of road draining to each drainage feature can be calculated by use of several commonly available database or spreadsheet programs. For properly functioning outsloped roads there are no cross drainage features, only stream crossing features.

**Drainage and Stream Crossings**

Drainage data is collected at each drainage feature where collected drainage water is directed away from or under the roadway, and also at drainage divides. Drainage features include: stream crossing culverts, bridges, log puncheons, fords, cross-drain culverts, waterbars, dips, other relief, landings, and grade breaks. For each drainage feature, record the distance from road stationing and the type of feature so that drainage spacing can be determined. Landowners may also choose to locate features such as gates and water pump chances. A typical length of road with drainage patterns and features is shown in Figure F-1.
Appendix 1

A. Cross-drain culvert, sediment filtered and not delivered to stream.
B. Cross-drain culvert with sediment delivery from segment 2 to stream.
C. Stream-crossing culvert, sediment from road segments 3 and 4 delivered to stream.
D. Drainage divide.
E. Cross-drain culvert, possible sediment delivery to stream.

Figure F-1. Typical road surface drainage and drainage features.
Culvert (and bridge) Detail
The following information is collected for all culverts (stream crossing and cross drain) and bridges.

Diameter/Span
Diameter/span of the culvert (diameter for round, rise and span for arch) or span length (for bridge) is measured in inches (for culverts) and feet (for bridges).

Condition
Condition of the culvert is described as good; mechanical damage, sediment blockage, rusted, bottom out, collapse, animal (beavers), wood blockage, natural bottom (gravel) [more than one description may be appropriate in this category].

Inlet Opening
Inlet opening is estimated as a percent or original (design) opening.

Stream Crossing Detail
Stream crossings are an extremely important part of the road system. Improperly functioning stream crossings can result in loss of the roadway through washouts and channel diversions. Stream crossings can also be barriers to fish movement. At each crossing structure, information should be collected by getting out of the vehicle and taking measurements at the inlet end and near the outlet end of the structure. In addition to the culvert detail, the following information should be collected at each stream-crossing culvert (Figure F-2).

Figure F-2. Stream-crossing culvert with key dimensions.

Fish Presence
Fish presence (species, if known, from ODF classification maps or other sources) as fish use known; unknown fish use; no fish use; or anadromous fish use.

Diversion Potential
Diversion potential (for streamflow directed down and eroding the roadway) is described as high, medium or low.

Culvert Slope
Culvert slope is measured for fish use, or unknown fish use streams only.

Fill Height
Fill height is estimated from the channel bottom to the road surface at the downstream end.

Outlet Drop
Outlet drop is the distance from the bottom of the pipe to the elevation of the pool, in feet (countersunk outlets get a negative drop). This can vary with discharge so measurement should generally be taken during summer flow.

Resting Pool
Resting Pool below the pipe is categorized for fish use, or possible fish use streams only as good (at least two feet deep and six feet long); fair (at least one foot deep and four feet long); or absent.

Sediment Filtering
Sediment filtering opportunities around the crossing are noted as utilized, not utilized, or not available.
**Sidecast Detail**

Sidecast-related landslides are reasonably expected along particularly steep sections of road (Table F-3). Depending on georegion, geology, soil, and drainage, the natural slopes (below the road) for a steep section can be as gentle as 50% (in wet areas with weak sidecast and drainage problems). In areas with well-drained materials with uniform slopes and no or very limited signs of old slides, the appropriate slope may be 65 or 70%. Sections of road which have experienced past sidecast-related landslides should also be inventoried. The beginning and ending points used to characterize sidecast stability will be different than those used to characterize drainage. Therefore, a separate database is used (Figure F-3). Begin characterizing sidecast stability at the point in the road where steepness indicates there is a slope failure hazard. This may be, and usually is, at some distance between drainage features. Record this station distance from the road junction or landmark the same as the drainage features. Also record the ending point in the same manner. The following features are then used to describe typical conditions over the steep sections:

**Average Natural Slope Steepness**

Average natural slope steepness under the sidecast (if present).

**Indicators of Movement**

Indicators of movement described as none; cracks, a drop in the outside of the prism; or signs of old sidecast slides.

**Vegetation**

Vegetation on the sidecast is described as none, cover (grass or brush), reproduction (plantation), or forest.

**Fill Condition**

Fill condition is described as “at least 15% steeper than the natural slope,” logs exposed, or good.

**Fill Depth**

Fill depth at the outside edge of the road is estimated to the nearest foot, vertical measurement.

**Downslope Risk**

Downslope risk to streams is described by a qualitative rating of slope to nearest stream channel low, moderate, or high based on the presence and size of bench terrain between the site and the nearest channel.

**Forms**

Example data sheets suitable for relational databases are shown in Tables F-2 and F-3. There is one data sheet for surface drainage and stream crossings (Table F-2), and another data sheet for sidecast (Table F-3), since the beginning and ending points of areas of sidecast concern rarely coincide with drainage location. Codes for the data sheet are explained on the pages following the data sheets. The codes have been designed with one or two digits (underlined) to reduce the size of the code sheets.
Table F-2. Field data sheet for surface drainage and stream crossing details and examples of collected data. In this example attention is required on the last entry because the culvert is partially blocked.

<table>
<thead>
<tr>
<th>Road name/number</th>
<th>Road Use</th>
<th>Surfacing</th>
<th>Ditch</th>
<th>Outslope</th>
<th>Inventoried by</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Road Location</th>
<th>Avg. Width</th>
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<th></th>
<th></th>
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<tbody>
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<table>
<thead>
<tr>
<th>Geology/Soils</th>
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</table>

<table>
<thead>
<tr>
<th>Surface Drainage</th>
<th>Culvert Detail</th>
<th>Stream Crossing Detail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Station</td>
<td>Feature</td>
<td>Attn.</td>
</tr>
<tr>
<td>--------</td>
<td>---------</td>
<td>-------</td>
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<td>2026</td>
<td>SC</td>
<td>Y</td>
</tr>
</tbody>
</table>

Feature codes:
- SC = stream crossing culvert
- CC = cross drain culvert
- BR = bridge
- JN = road junction
- GB = grade break
- PN = log puncheon
- DR = any other ditch relief
- I = features requiring immediate attention
- WB = waterbar
- DP = dip
- LD = landing
- G = gate
Table F-3. Field data sheets for sidecast details. Example included.

Road name/Number:____________________   Date________________
Inventoried by____________________

<table>
<thead>
<tr>
<th>Station Start (ft)</th>
<th>Station end (ft)</th>
<th>% slope Below</th>
<th>Movement Indicators</th>
<th>Vegetation</th>
<th>Fill condition</th>
<th>Fill depth</th>
<th>Downslope Risk</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>3413</td>
<td>3814</td>
<td>70</td>
<td>S</td>
<td>F</td>
<td>C</td>
<td>2</td>
<td>H</td>
<td>Stream has washed out road.</td>
</tr>
</tbody>
</table>

Codes:  
Cracks: None, Steep 15, Low  
Drop: Veg., Logs, Moderate  
Slide Activity: Reprod., Good, High  
None, Forested
Road Data Analysis
Road data should be analyzed to determine which roads, drainage systems, and/or stream crossings:

- are not functioning properly,
- may be delivering sediment to fish-bearing streams,
- do not pass fish (calculated from the data collected, refer to ODF&W fish passage protocol),
- and/or pose a risk to fish bearing streams (road-related landslides).

There are a number of red flags to look for. Examples include:
- Average distance to first cross drain is over 500 feet and road grade is greater than 6%,
- Culverts that are more than 50% blocked,
- Logs in fills,
- Steep sidecast with high downslope risk,
- Fish bearing streams with culverts that have a >0 foot outlet drop, gradient over 1%, and are not retaining sediment or do not have baffles.

Calculations of the road data can be done with a spreadsheet or database to address these road maintenance, sediment, and fish-passage related concerns.
Road-related results can be combined with turbidity and channel information to understand erosion and sediment processes in your watershed. It is important to recognize that a correlation between the three measurements may not reflect cause-and-effect relationships. In general such relationships can only be achieved with a properly designed and controlled study. However, over time the data will be useful for understanding environmental trends.