East Fork Millicoma River GRAIP Road Assessment and Sediment Reduction Plan

Project Completion Report

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Coos Watershed Association

The **Coos Watershed Association** is a 501(c)(3) non-profit organization whose mission is "to provide a framework to coordinate and implement proven management practices, and test promising new management practices, designed to support environmental integrity and economic stability for communities of the Coos watershed." The Association, founded in 1994, works through a unanimous consensus process to support the goals of the Oregon Plan for Salmon and Watersheds. Our 17 member Board of Director includes representatives from agricultural, small woodland, waterfront industries, fisheries, aquaculture, local government, environmental organizations, industrial timberland managers, and state and Federal land managers.

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Executive Summary

The purpose of this project was to identify fish passage, road drainage, and road erosion hazards in the East Fork Millicoma River, near Allegany, Oregon. The Coos Watershed Association (CoosWA), funded by two grants from the Oregon Watershed Enhancement Board (OWEB), the Confederated Tribes of the Coos, Lower Umpqua and Siuslaw Indians (CTCLUSI), and Weyerhaeuser Company evaluated 793 km of the 853 km road system surrounding the East Fork Millicoma River. We used the Geomorphic Road Analysis and Inventory Package (GRAIP), designed by the U.S. Forest Service, which evaluates surface erosion, gully risk, landslide risk and stream crossing failure risks. Additionally, CoosWA surveyors recorded information on road features to develop a database to be used for long-term-road asset management.

The 793 km of roads surveyed, included a total of 7,477 drainage features that were observed, measured, and recorded. About 29% (2,177) were determined to be connected to and delivering water and sediment to streams. Features that had the greatest length of road segments that drained to streams were: ditch relief culverts (28%), non-engineered drain points (20%), and diffuse drain points (16%).

Using our field measurements to complement the GRAIP model, the model estimated that roads may produce nearly 4 million kg of sediment annually. However, only 23% of the total is anticipated to be delivered to stream channels. As expected, the drainage features with the greatest connected road length had the greatest amount of sediment delivery; with ditch relief culverts having by far the greatest percentage of total sediment delivery (25%).

The 630 stream crossing culverts were further evaluated to determine failure risk based on a combination of the capacity of the existing culvert to pass a 100-year storm event and the volume of road fill that would be delivered to a stream if the culvert failed. Only 76 of the 630 culverts were determined to be undersized; with 5 culverts having a very high failure hazard. Twenty seven of the 76 culverts were measured to have large (>100 yd^3) or very large (>500 yd^3) delivery potential. Seventy of these at-risk culverts were determined to have flow diversion potential if plugged with debris.

We found 43 locations that were identified as full or partial barriers to fish passage. However, only 18 of these culverts are below natural barriers to anadromous fish. All of these culverts at tributary stream that provided access to only a small amount of low intrinsic potential habitat.

Based on the field observations and GRAIP modeling results, we identified road segments and drainage features that are likely to deliver the greatest volume of eroded sediment, and the stream crossings with the highest failure risk. Based on these results, we would recommend two general categories of road work to reduce the sediment delivered to streams: 1) increasing the number of road drainage features (e.g., cross drains), especially on road segments that deliver directly to stream crossings, and 2) install dispersion features at the outfall of ditch relief culverts where adequate buffer don’t currently exist. We developed a simple ranking system that can be used to prioritize these activities based on two criteria: 1) length of road connected to streams, and 2) estimated volume of sediment delivered to streams at a drainage feature. We have provided tables and maps that illustrate the top 10, 50, and 100 sediment-producing road segments and drainage features. Additionally, we have computed that 1,235 new and 356 replacement drainage features need to be installed to entirely reduce sediment delivery.

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Introduction

The purpose this project was to identify fish passage, road drainage and road erosion risks in the East Fork Millicoma. Fish passage, road drainage and road-related sediment inputs are the significant issues effecting aquatic habitats. All salmonids require access to spawning areas, appropriate substrates for reproduction (including substrates that support egg incubation, alevin development, and fry emergence), and suitable water quality (Meehan 1991). Fish passage barriers restrict access of returning anadromous adults fish to upstream spawning grounds, and hinder the ability of juvenile anadromous fish to move upstream, and/or downstream, to obtain food, shelter, or thermal refuge. Insufficient road drainage and road erosion problems can accelerate erosion, promote mass wasting, and alter channel morphology, among other changes to aquatic environments (Meehan 1991).

Most fish passage problems result from perched and/or undersized culverts, and failure of roads at stream crossings is one source of sediment. However, sedimentation can also be chronic when road ditches deliver turbid water and suspended sediments directly to streams. This is generally caused by long ditch lengths that do not have ditch relief culverts before their ditch junction with the live stream. Sedimentation (both suspended fine sediments and turbidity) has numerous adverse effects on survival of juvenile fish. Sediments can lead to embedded gravel that suffocates fish eggs because of inadequate interstitial water flow. After hatching, juveniles need to find food: turbid water hinders a fish’s ability to find food, and reduced oxygen content in the water may reduce a fish’s physical fitness. In addition, many aquatic organisms that juvenile fish rely on for food are adversely affected by high sediment levels.

During the summer of 2014, and through 2015, the Coos Watershed Association completed first phase (two phases) to inventory the entire 804 km (500 mile) road system. The second Phase was started in the 2016 and completed at the end of 2017. A total of 793 km (493 miles) were surveyed, nearly all of the proposed roads to survey. This project was funded by an agreement with the Confederated Tribes of the Coos, Lower Umpqua and Siuslaw Indians (CTCLUSI) using funds from the Pacific Coastal Salmon Recovery Fund (PCSRF), the Oregon Watershed Enhancement Board (OWEB) Grant #214-2011 and 216-2020, Weyerhaeuser Company, and in-kind contributions from the Oregon Department of Fish and Wildlife and the Coos Watershed Association. The result of this project has 3 types of deliverables: (1) estimated road sediment yield and hydrological connectivity; (2) identified needs, prioritization, and designs for road upgrades, or decommissions; (3) a road features database to be used for long term assets management.

Methods

To identify potential road erosion problems, the Coos Watershed Association’s road survey crews systematically examine roads in order to identify fish passage, chronic sediment delivery, and potential catastrophic fill failure sites. The survey protocol we use is the “Geographic Road Analysis and Inventory Package” (GRAIP; Prasad et al. 2007, Cissel et al. 2012A, Black et al. 2012, http://www.fs.fed.us/GRAIP) developed by the U.S. Forest Service. GRAIP uses field data collected with a GPS and a specific data dictionary that is imported into ArcGIS as shapefiles. The data are corrected and then run through the GRAIP toolbar, which also uses inputs from TauDEM (for stream network delineation) and SINMAP (for landslide risk). GRAIP estimates the quantity of sediment generated for each road segment by modifying a base erosion rate with road slope, segment length, flow path vegetation, and road surface type. The sediment at each drain point is routed to the stream network based on field observations of delivery, and output as accumulated sediment in the entire network, direct sediment for each stream segment, and specific sediment per unit contributing area. Observations of delivery at each drainage feature can also be used to calculate road-stream hydrologic connectivity. This report describes each of these steps in sufficient detail that an ArcGIS user with basic skills will be able to perform the analysis. The GRAIP road inventory and model work together to provide a flexible tool box used to quantify the impacts of roads on watersheds and aquatic systems. (Cissel, et al., 2012).

We used a handheld Trimble GPS (GeoXM and Juno 3B) for data collection and storage. Roads were surveyed in segments starting and ending at drain features, road junctions, or end of road points. Length was collected in the field with a measuring wheel, and slopes were measured with clinometer. Drainage points collected included: Stream Crossings, Broad-base Dips, Diffuse Drains, Ditch Reliefs, Lead-off Ditch, Non-Engineered Drainage, and Water Bars (definitions of each drainage feature are in the Glossary). Sediment delivery and/or hydrologic connectivity to streams were determined by field crews who looked for evidence of rills or gullies that leave the road surface or drainage point and extend all the way to a stream without the sediment settling out. Other non-drainage features collected were: Landslides, Gullies, Gates, and Road Hazards.

We modified the GRAIP data dictionary (INVENT5_0_W) to store some additional features along with the other GRAIP attributes. These include: the locations of landings (large >200’, medium 100’, small <100’ sizes in diameter), road closed points (blocked by boulders/tank trap), and road junctions. At each culvert location we noted whether or not a culvert marker was present, and the type of road construction was collected (Full Bench or Balanced Cut and Fill) for each road segment. Each drainage feature was marked with survey flagging (blue/white) with its GRAIP ID numbers.

Data were downloaded and archived at the Coos Watershed Association’s (CoosWA) office, then processed and differentially corrected using GPS Office Pathfinder using the nearest base station (UNAVCO, Coos Bay, OR). The data files were exported to an ArcGIS shapefile format. A 30 meter Digital Elevation Model (DEM) grid was resampled to ten meter to be used as the base DEM for GRAIP. The base DEM was prepared for analysis using TauDEM 4.0 (Tarboton, D.G. 2003). SinMap 2.0 (Pack, R. T., Tarboton, D.G., Goodwin, C.N. and Prasad, A. 2005) also used for processing the DEM for GRAIP. ArcGIS 10.3.1 and GRAIP version 2 was used for analysis.

GRAIP uses the following formula to compute road surface erosion from each of the road segments that we measured in the field:

Sediment Production Estimate (kg) = Base Rate (kg/m/yr) * Segment length (m) * Segment slope (m/m) * Surface Multiplier (unitless) * Flow Path Modifier (unitless)

We used the default base rate of 79 kg/m/yr because the roads in our study area are similar to the roads in the Low Pass Road Sediment Study that was conducted in the Oregon Coast Range (Luce and Black (1999). The surface multiplier varies by the type of road surface recorded in the field; segregating roads into three categories, dirt, gravel, and paved. The factors are 5, 1, and 0.2, respectively for the surface category. The flow path modifier segregates roads into two categories: 1) surfaces with less than 25% vegetation cover, and 2) surfaces with greater than 25% vegetation cover, with factors 1 and 0.14, respectively. The GRAIP model then accumulates and routes the sediment production estimates to the stream network as described above.

The sediment yield values predicted by GRAIP have an inherent, high degree of uncertainty; especially when evaluating the effects of individual road segments for a specific period. The sediment yield values should not be viewed as exact predictions. The GRAIP model is a factor-total model that does not model the actual physical processes or effects due to natural occurrences or management-related activities. The factors and coefficients used in the model are specifically designed to show differences between road conditions. As such, predicted sediment yields are not representative of actual sediment loads delivered to streams; including bedload, suspended sediment concentration, and turbidity. Additionally, the model cannot predict actual instream conditions (e.g., particle size distribution or cobble embeddedness), quality of fish habitat, or water quality. Nor can the model predict actual trends in any of these factors. The GRAIP model results have their primary utility in comparing differences between road segments and the potential effects to streams when those road segments are directly connected.

For the drainage points and road segments that were determined likely to be delivering sediment to streams, we developed a simple ranking scheme that could be used to prioritize road maintenance activities (e.g., drain point repair/replacement, or road resurfacing). Because there is such a wide range of estimated sediment delivered by each point (range: 0 – 8,465 kg/yr), with the vast majority of the sites having no estimated sediment delivery, we chose to develop ranges by rank groups into five (5) categories: Top 10, Top 50, Top 100, Other Delivery points, and No Delivery points.

Road segment lengths were summarized to evaluate ditch length lengths based on road slope. The “roadlines” table was joined to the “drainpoint” table to show ditch lengths draining to each drain type based on the primary flow path (CTime1). These lengths were summarized (total, minimum, maximum, average), and lengths of over 1000 feet for each drain point were totaled. Using this data, we compared results to the recommended culvert spacing criteria (Table 7. ODF 2003b) in order determine if new drainage structures are needed. The length and the slope of each ditch contributing flows to the site was measured and compared to the BMPs for ditch-length recommendations. Replacement were recommended if the structure was damage or rusted significantly. Maintenance was recommended if a culvert was occluded with debris and/or sediment.

A fish passage assessment was performed to identify areas where a stream crossing culvert creates an unnatural barrier. Any culvert that had an outlet drop of greater that one foot was identified as a potential barrier to fish passage then, used the intrinsic potential for coho winter rearing (Burnett et al., 2007) GIS layer to identify culverts that have anadromous fish use. We looked the outlet drops of these culverts that were measured and recorded during the GRAIP surveys. These outlet drops are barriers to fish migration. From this analysis we identified the 43 culverts considered to be fish passage barriers.

The Stream Crossing At-risk Analysis uses the ODF method from the Oregon Road/Stream Crossing Restoration Guide (Robinson, G. E., Mirati, A. and Allen, M. 1999). Drainage area above each culvert was calculated using StreamStats (USGS 2018). We used the peak flow runoff factor of 150 cfs from the ODF map showing the peak flow 50 year recurrence interval (Robinson, et al 1999, figure 17) and a multiplier of 1.2 for a 100-year recurrence interval. All culverts were sized for 100-year runoff recurrence interval. Flow conveyance capacities for corrugated culverts are from Robinson, et al 1999; Smooth-walled culverts assumed a manning's coefficient of 0.012 and a slope of 2% to calculate flow rates. Road fill volumes were calculated in the field from measurements of the road dimensions. Fill volume classes are: Minimal < 10 yds., Small 10 – 50 yds., Medium 51 – 100 yds., Large 101 – 500 yds., and Very Large > 500 yds. At-risk stream crossing culverts were prioritized by the percentage of the expected runoff that will be drained. Rankings are: Low (76 – 99%), Moderate (51 – 75%), High (26 – 50%), and Very High (0 – 25%).

Results

Field Road surveys began in June 2014 and ended in September 2017. They were focused around the East Fork Millicoma River and the Glenn Creek sub-watershed, one of its largest tributaries. The main hauling roads adjacent to these streams were surveyed (East Fork Millicoma Road, 1000, 2000, 3000, and 4000 roads). Two main ridge roads were surveyed, 2000, and 5040. Mid-slope roads surveyed include, the 0700, 1005, 1006, 1008, 1009, 1020, 1030, 1040, 1050, 1060, 1070, 1080, 1120, 1134, 1145, 1200, 1300, 1330, 1390, 1430, 1450, 1470, 1820, 1840, 1980, 2130, 2150, 2160, and most spurs from these roads.

The Figure 1 shows the roads surveyed on this project compared to the entire road system of the East Fork Millicoma. There are approximately 803 km (500 miles) in the East Fork Millicoma River survey area, of those 793 km (493 miles) was completed during this project. All roads in the project area were surveyed, unless they were they completely over grown with brush and trees, could not be found, or no permission was granted.

Non-Drainage Features

During the surveys we collected 2,280 data points on features not related to drainage (Figure 2, 2a, 2b, 2c). These sites included Landings, Gates, Landslides, Road Closed Points, Road End, Road Hazards, and Road Junctions. There were a total of 506 landings recorded, 83 large, 227 medium, and 197 small sized landings. Eight gates were recorded: one was damaged, the rest were functional. There were 36 Landslides observed, the locations of these were: 19 on the hill-slope;4 on the fill-slope; and 13 on the cut-slope. Our surveyors believed that 4 of these landslides had a high potential for future failure, 23 were medium potential, and the other 6 appeared to be stable; two significant gully was also observed. There were 13 Road Closed points; 12 were fully effective at restricting traffic, one was driven around. Three were closed by boulders; eight were blocked by logs and soil, one blocked by concrete barrier, and one had a trench (Tank Trap) dug in the road. The locations of 1,140 Road Junctions were recorded.

Drainage Features

Figure 2 shows the different types of drainage features recorded during the surveys. A total of 7477 drainage features were observed. There were 236 Broad-based Dips, 1762 Diffuse Drains, 2172 Ditch Relief Culverts, 787 Lead-off Ditches, 1047 Non-Engineered Structures, 630 Stream Crossings, 165 Sumps, 650 Water Bars, and 28 Excavated Stream Crossing (see Glossary for definitions).

Road surfaces

Figures 3 shows the different types of road surfaces observed during the surveys. All the forest roads were either covered with gravel (crushed rock with some amount of vegetation), a native surface (Dirt with some amount of vegetation), or paved asphalt. There were 6,616 road segments of gravel (667 km, 415 miles), 1,279 of native road surface (102 km, 63 miles), and 223 road segments that were paved (23 km, 14 miles).

Hydrologic Connectivity

Using the GRAIP sediment production component we evaluated at road segments and the effective flow path lengths to each drainage point. Connected points are road segments with drain points that lead directly to a live stream. Road segments that end at a stream crossing are considered to be fully connected. ***Of the 7,477 drain points measured, only 2,177 (29%) were found to be directly connected to the stream system; with stream crossings and ditch relief points accounting for 67% of all connected points.*** Ditch Relief Culverts have the most connect drainage points (36.8%), followed by Stream Crossings (30.3%), Diffuse Drains (14.3%), Non-Engineered (9.3%), and Lead-Off Ditches (5.4%), Water Bars (3.0%), and Broad Base Dips (0.9%).

Fish Passage Barriers

There are four significant natural barriers in the survey area (see Figure 5). Golden and Sliver Falls are barriers on Glenn Creek, Jon Hewitt Falls on Matson Creek, and an unnamed falls on East Fork Millicoma River. These falls restrict anadromous fish access to some of the upper parts of these streams. Our survey and analysis process has identified 43 stream crossings that are fish passage barriers to any fish, not only anadromous fish.

Eight stream crossing on Glenn Creek have culvert outlet drops of greater than one foot and allow impede access to upstream habitat, six are above the natural barriers, two below. Matson Creek has nine stream crossing culvert barriers, but all are above the natural barrier. The East Fork Millicoma River has sixteen culvert barriers below the falls and eight above.

Many of the mainstem areas of the East Fork Millicoma River have been upgraded with either bridges or large culverts. All of the barriers identified were on tributaries to a mainstem stream or were at the very headwaters to the main stream. Oftentimes, streams of this size offer very little spawning habitat, and are probably only valuable for rearing or refugia from high water temperatures or stream flows. These barriers only provide access to a small amount of low intrinsic potential habitat.

Stream Crossing Failure Risk

Stream crossing failure is one of the largest catastrophic contributors of sediment to a stream, next to landslides (Robinson et al., 1999). The most frequent cause of stream crossing failure is undersized culverts. A stream crossing capacity analysis was performed to determine whether each culvert is at risk of failure during a peak flood event. It is important to identify the stream crossings to prioritize upgrades based on which stream crossings pose the greatest failure risk to fail.

Overall, there are only a small number culverts that are at-risk of failure in the survey area. Figure 7 displays the locations of at-risk stream crossings. The 630 stream crossing culverts studied in the road surveys were ranked for their ability to properly drain the area upstream during a one hundred year flood runoff event (see Table 6). Seventy six (10.6%) of the stream crossings in this survey are considered at-risk for improper drainage or failure because they are undersized.

In the East Fork Millicoma survey area, there is a total of 10,786 yds^3 of road fill at these seventy six at-risk culverts. Five culverts were ranked as having very high risk of failure, but a fair amount of fill (602 yds^3); Twenty three were ranked as having high risk, potentially releasing 1,606 yds^3 of fill; and twenty six ranked moderate, potentially releasing 4,439 yds^3 of fill. Twenty two culverts ranked low, potentially releasing 4,139 yds^3.

At-risk culverts are further ranked in Table 6 based on the percentage of associated drainage area they can properly drain during a 100-year runoff event. The number of culverts in each failure risk level (left column) spread across the table depending on the associated fill volume size class. It is important to consider both failure risk and fill volume since it is the fill that becomes the sediment source upon failure of the crossing.

Diversion Potential

There are 70 stream crossing culverts that have potential to divert down the road, in the ditch or on to the road surface. In these situations, there is a likelihood of more erosion from a failed stream crossing than just the road fill at the crossing. Of the 76 at-risk culverts, Seventy have diversion potential, and all are undersized. Most of the stream crossing culverts that are at-risk are located on the 1100 and 2000 roads (see figure 5); others are on various spurs that drain to the headwaters of streams.

Recommendations

We developed a simple ranking system that can be used to prioritize these activities based on two criteria: 1) length of road connected to streams, and 2) estimated volume of sediment delivered to streams at a drainage feature. Using this system, we also used the following criteria to develop a set of proposed projects to minimize road related sediment delivery in the East Fork Millicoma River:

1. Address road segments and drain points that have the largest amount of sediment delivery first.
2. Replace undersized Stream Crossings that have the highest failure risk and diversion potential.
3. Stabilize landslides to prevent future erosion.
4. Focus on sediment reduction projects on areas that have the most traffic use.

5. Consider decommissioning roads that are not needed.

Sediment Reduction Projects

- A watershed wide project that will upgrade the top 10 (i.e., greatest sediment delivery) road segments and drain points (based on Figure 4); with follow on projects that will address the next 40 (Top 50) road segments and drain points.
- Replace all 70 undersized culverts; giving priority to the four (4) that has the greatest sediment delivery hazard and the four (4) that have the greatest diversion potential.
- Investigate the 30 landslides that have further potential for delivering sediment, and develop plans to remediate these areas. Stabilize the 4 landslides that have a high risk of future failure.
- Focusing on sediment reduction projects on areas that have the most traffic and use, develop a multi-year project that focuses on specific road systems; working on one project per phase.

Conclusions

The results of the ditch length and slope analysis are an attempt to quantify the number of new structures needed to meet BMPs. However, the main goal of the BMPs is to reduce sedimentation in streams. The purpose of the guidelines for culvert spacing to reduce ditch flows so that road sediment filters into the forest floor and is not hydrologically connected to a stream. In some situations, this spacing cannot be applied at these intervals on steep slopes because it could create a high landslide hazard location (ODF 2003a). Oftentimes, culvert spacing needs to be site specific to reduce sediment from roads.

The results of the At-Risk Stream Crossing Evaluation give estimates of potential catastrophic sediment delivery from a washout of the road fill at each stream crossing. Overall, there is a relatively small amount of road fill that could be delivered to stream from a culvert failure. However, actual sediment yields may be larger than these amounts if a stream diverts down the road (Park et al. 1998). Even larger sediment amounts may be delivered to a stream if a culvert failure causes additional mass wasting on downhill slopes or roads. These risks can be reduced by proper sizing of culverts, armoring the fill slopes in case of an overflow, and creating broad-based dips to contain stream diversions.

The GRAIP results estimate the amount of road sediment using a base erosion rate, road length and slope, road surface, and road vegetation. The base rate is from a local, coastal Oregon study area (Triangle Lake). The road length and slope, road surface, and road vegetation were recorded in the field. However, the model doesn't account for the aggregate durability of graveled road surfaces, or traffic intensity and duration on different types of roads.

The sediment results from GRAIP are <u>estimates</u>. They should be used for identifying roads, drainage points, and streams that have the greatest modelled sediment values. The GRAIP results can help prioritize areas will have the "best bang for the buck". Scaling the results can help pinpoint areas of low, medium, high sediment which can help land managers make decisions that can improve road and stream conditions. If accurate sediment values are needed, they must be measured directly.

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Glossary

Excavated Stream Crossing – old location of a stream crossing culvert. Normally, the road fill has been sloped back to prevent future erosion.

Gate – metal or chain structure that can be opened or closed to control access to a road.

Landing – an area used to store logs before transport, can be used to store unstable sediment.

Landside – a small to large scale erosion event, or mass wasting, oftentimes caused by unstable slopes. Failure can be accelerated by water saturation.

Mile Marker – a sign post that shows the distance traveled on a road. Traffic uses CB radios to report location and direction of travel.

Road Closed – a point where the road is blocked by boulders, rootwads, trees, or a Tank Trap.

Road Hazard– a point on a road that has the potential to be dangerous to drivers.

Road Junction – a point where two roads intersect.

Tank Trap – a large trench dug perpendicular to stop access to the rest of the road.

GRAIP Terminology - Cissel, et al. (2012)

Broad based dip - ***Constructed:*** Grade reversal designed into the road for the purpose of draining water from the road surface or ditch (also called dip, sag, rolling grade, rolling dip, roll and go, drainage dip, grade dip). ***Natural:*** A broad based dip point is collected at the low point where two hillslopes meet, generally in a natural swale or valley. This is a natural low point in the road that would cause water on the surface of the road to drain out of the road prism.

Cross drain - This is not a feature collected specifically in GRAIP, and it can refer to a number of other drainage features. It is characterized by any structure that is designed to capture and remove water from the road surface or ditch. Ditch relief culverts, waterbars, and broad based dips can all be called cross drains.

Diffuse drain - This is a point that is characterized by a road segment that does not exhibit concentrated flow off the road. Outsloped roads or crowned roads often drain half or all of the surface water diffusely off the fillslope. Although collected as a drain point, this feature is representative of an area or a road segment rather than a concentrated point where water is discharged from the road prism. A drop of water that lands on a diffuse road segment will not flow down the road or into the ditch, but more or less perpendicular to the centerline off the road surface and out of the road prism. Also called sheet drainage or inter-rill flow.

Ditch relief culvert - This drain point is characterized by a conduit under the road surface, generally made of metal, cement, or wood, for the purpose of removing ditch water from the road prism. This feature drains water from the ditch or inboard side of the road, and not from a continuous stream channel.

Flow path - This is the course flowing water takes, or would take if present, within the road prism. It begins where water is concentrated and flows along the road or it enters the road prism, and ends where water leaves the road prism. This can be either on the road surface, or in the ditch. Flow path types in GRAIP are ditch, diffuse, and concentrated.

Lead off ditch - This drain point is characterized by a ditch that moves flow from the roadside ditch and leads it onto the hillslope. Occurs most often on sharp curves where the cutslope switches from one side of the road to the other. Also known as a daylight ditch, mitre drain, or a ditch out (though this term can also describe other types of drainage features).

Non-engineered drainage - This drain point describes any drainage feature where water leaves the road surface in an unplanned manner. This can occur where a ditch is dammed by debris, and the water from the ditch flows across the road, where a gully crosses the road, where a wheel rut flow path is diverted off the road due to a slight change in road grade, or where a berm is broken and water flows through. This is different from a diffuse drain point, which describes a long section of road that sheds water without the water concentrating, whereas this point describes a single point where a concentrated flow path leaves the road.

Orphan drain point - This is any drain point that does not drain any water from the road at the time of data collection. Examples include a buried ditch relief culvert, or a water bar that has been installed on a road that drains diffusely.

Stream crossing - This drain point is characterized by a stream channel that intersects the road. This feature may drain water from the ditch or road surface, but its primary purpose is to route stream water under or over the road via a culvert, bridge, or ford. A stream for the purposes of GRAIP has an armored channel at least one foot wide with defined bed and banks that is continuous above and below the road and shows evidence of flow for some part of most years.

Sump - ***Intentional:*** A closed depression where water is intentionally sent to infiltrate. ***Unintentional:*** Any place where road water enters and infiltrates, such as a cattle guard with no outlet, or a low point on a flat road.

Waterbar - This drain point is characterized by any linear feature that is perpendicular to the road that drains water from the road surface and/or ditch out of the road prism or into the ditch. Waterbars may be constructed by dipping the grader blade for a short segment, or adding a partly buried log or rubber belt across the road. Some road closure features may also act as a waterbar, such as a tank trap (also known as a closure berm or Kelly hump). Cattle guards that have an outlet that allows water to flow out are also considered to be water bars. These features may also be known as scratch ditches if they drain water into the ditch.

Figures

Figure 1. Roads Surveyed.

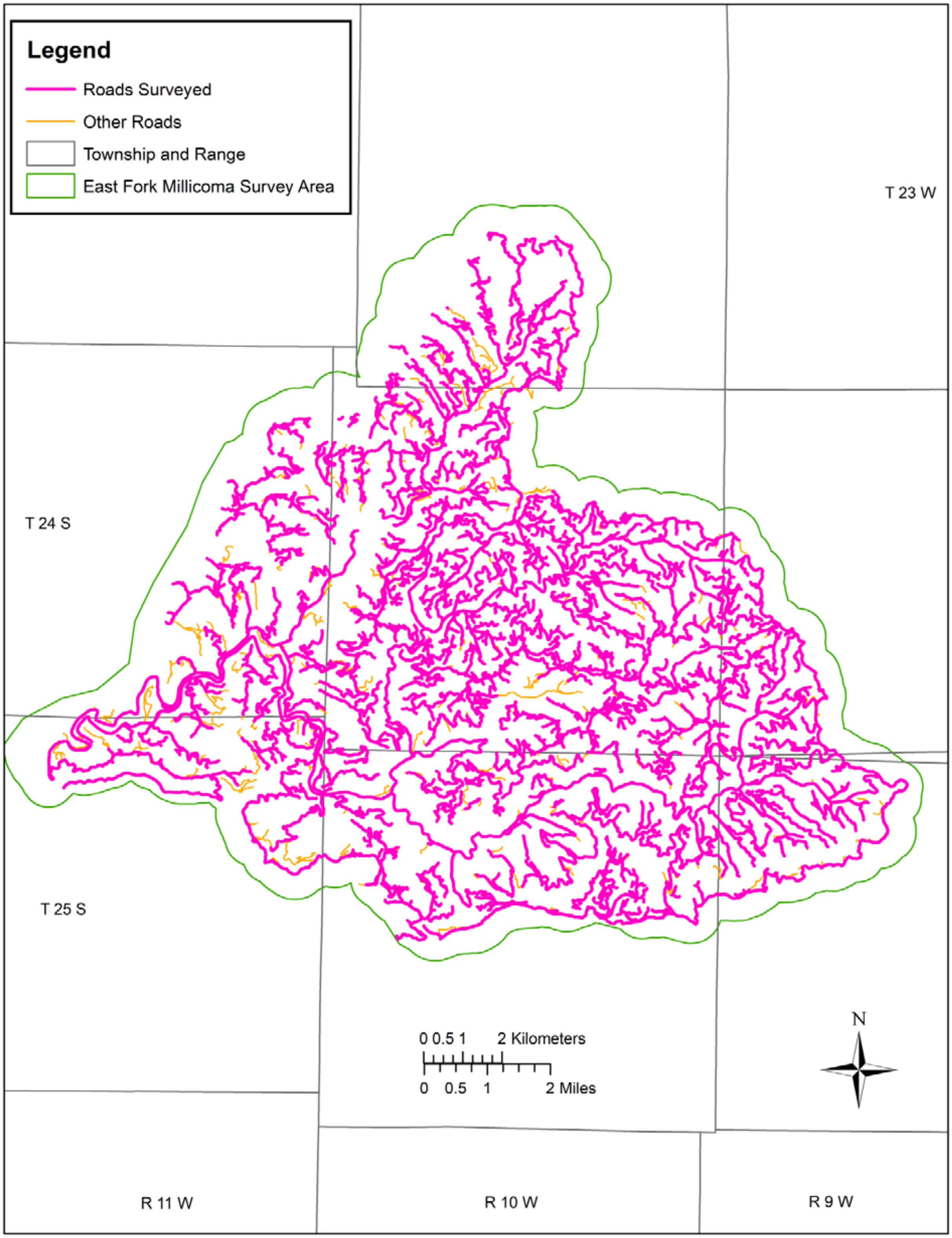


Figure 2. Overall feature map.

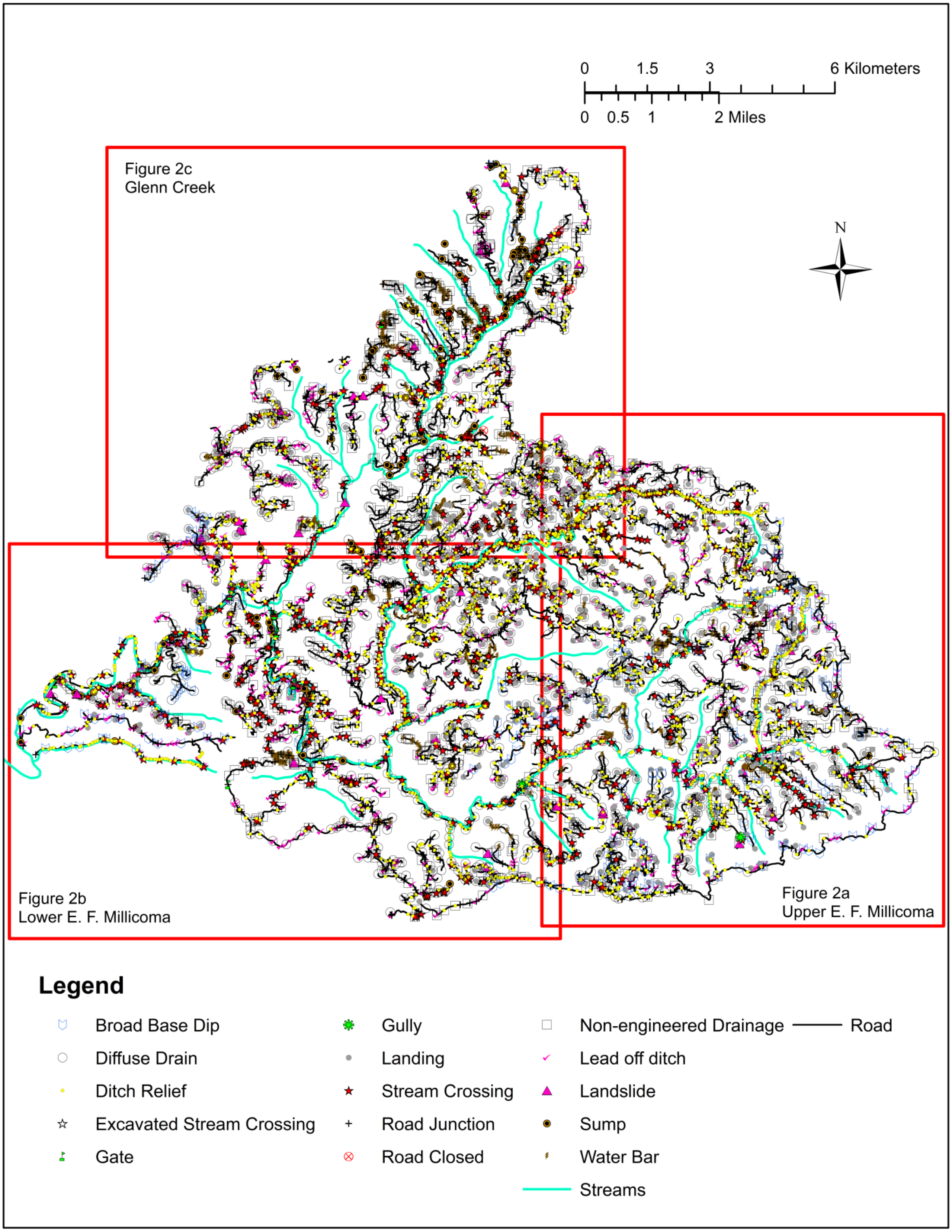


Figure 2a. Drainage feature map 1 – Glenn Creek.

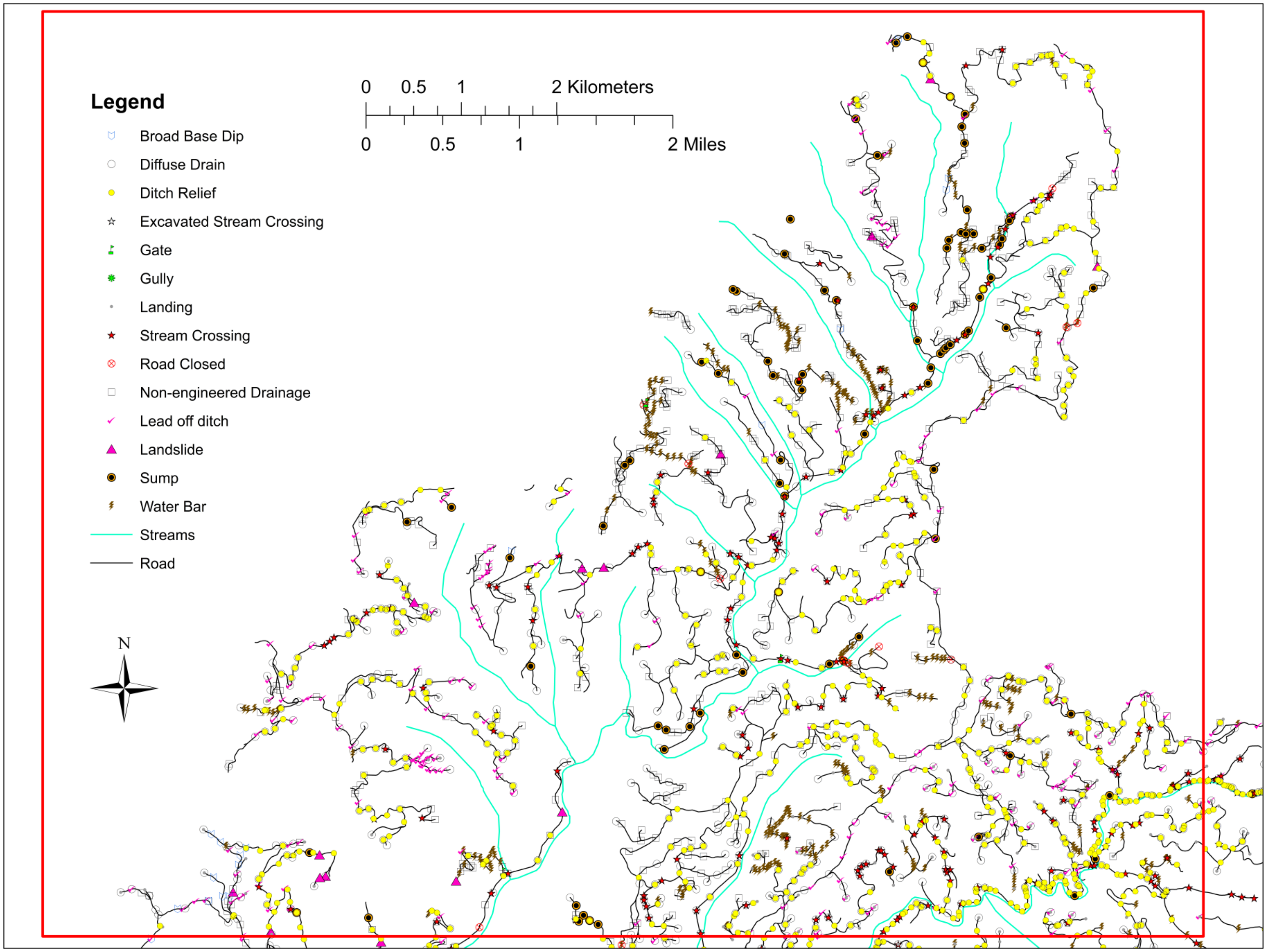


Figure 2b. Drainage feature map 2 – Lower E.F. Millicoma River.

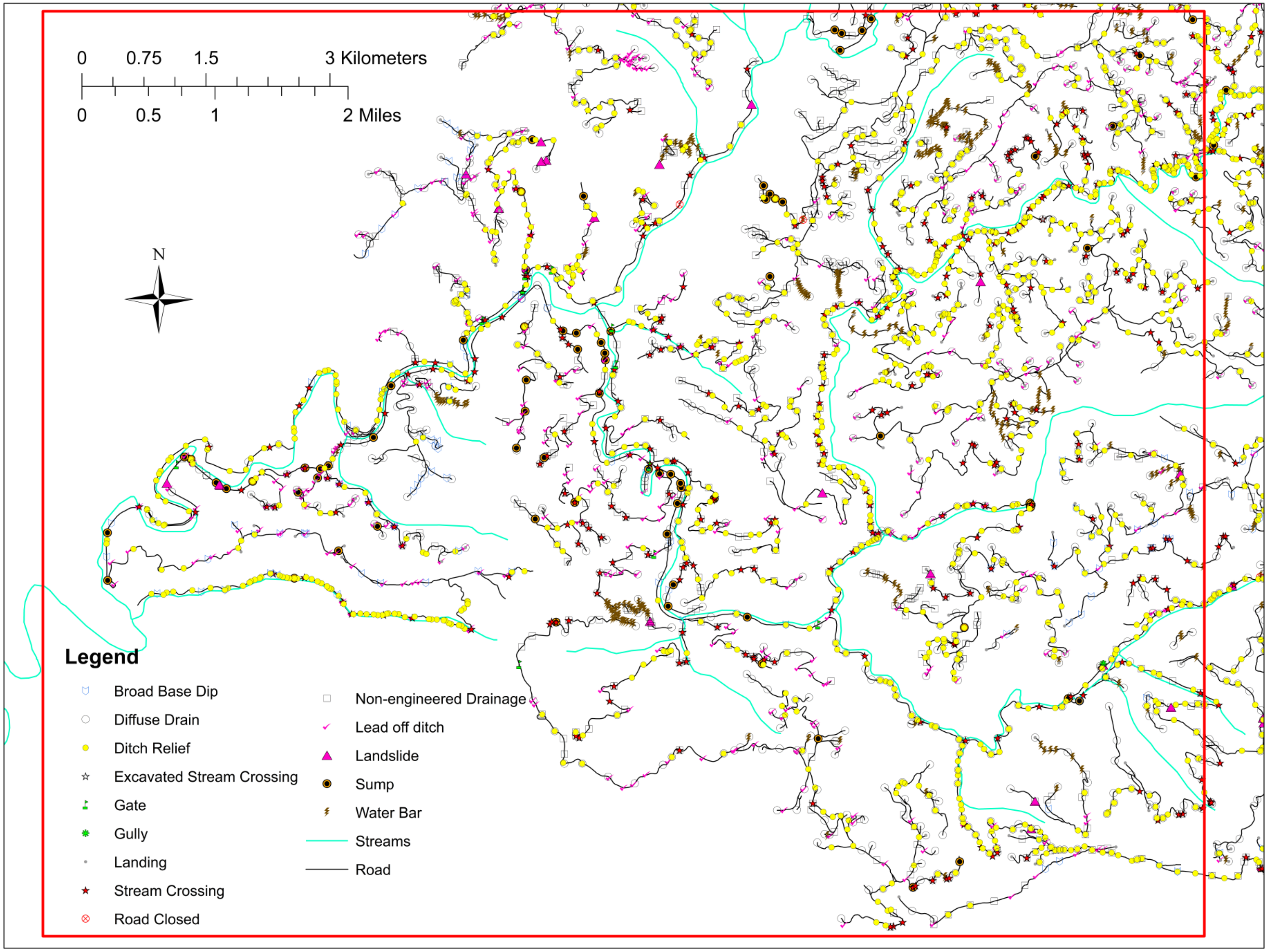


Figure 2c. Drainage feature map 3 – Upper E.F. Millicoma River.

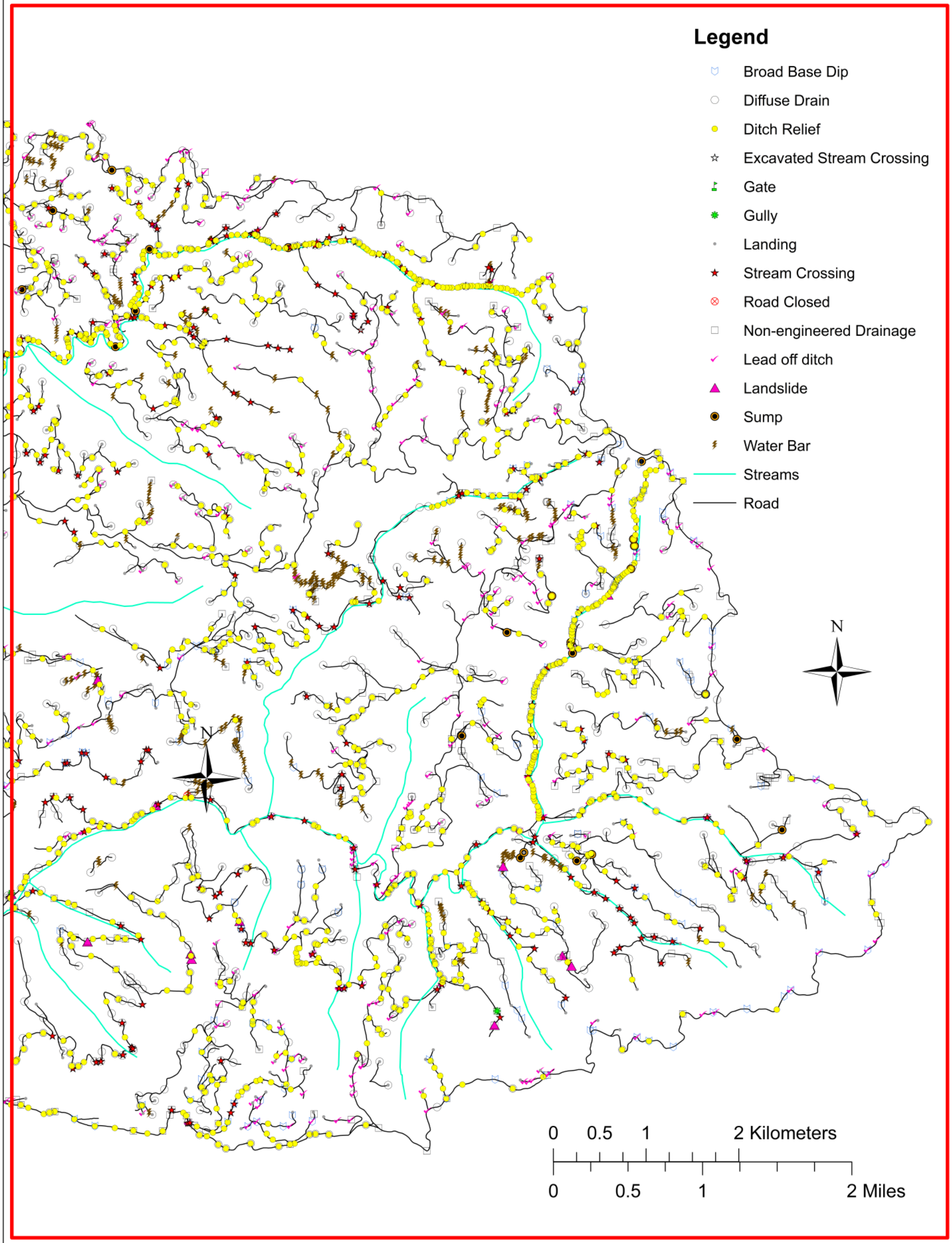


Figure 3. Road Surface Map.

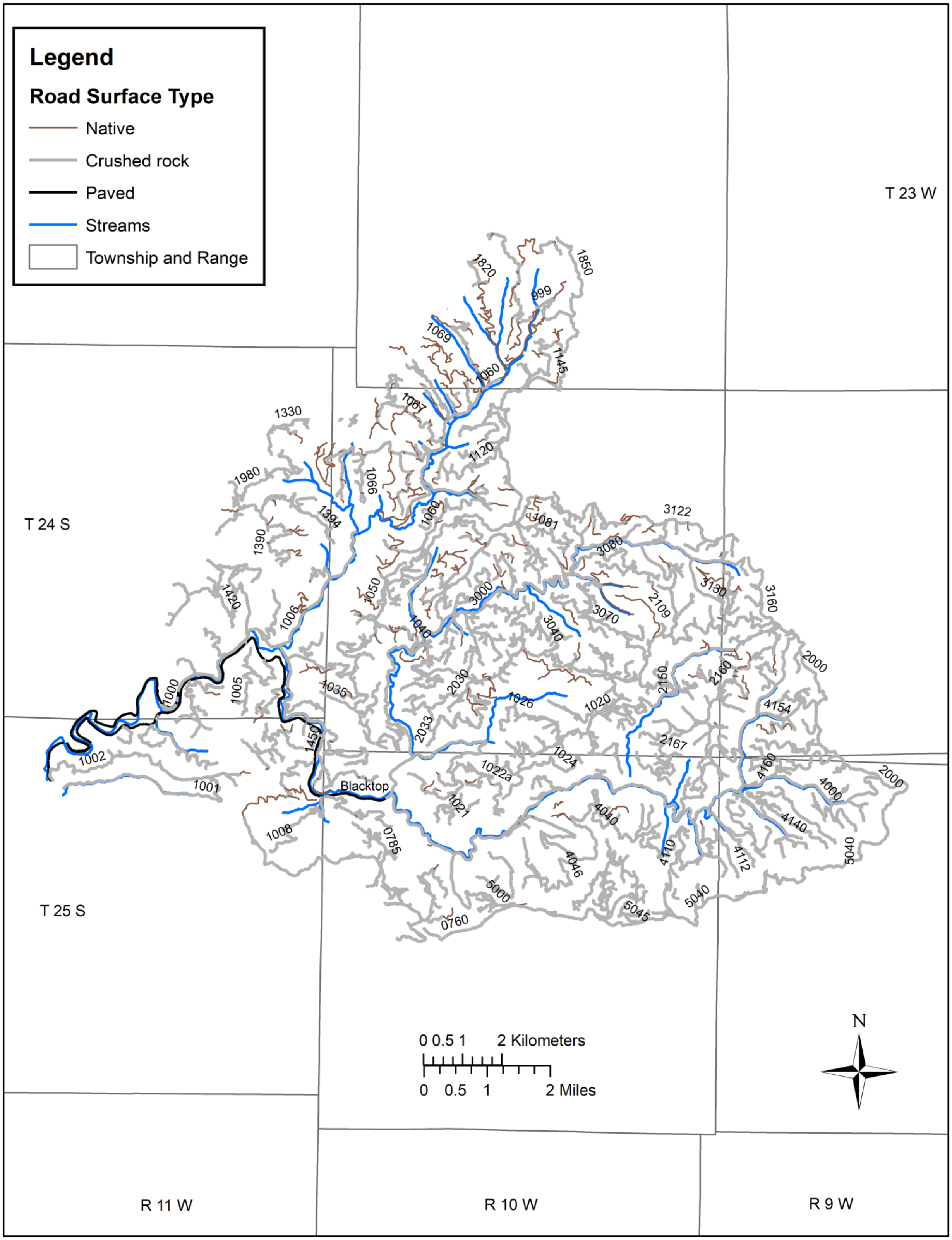


Figure 4. Estimated sediment delivery to streams.

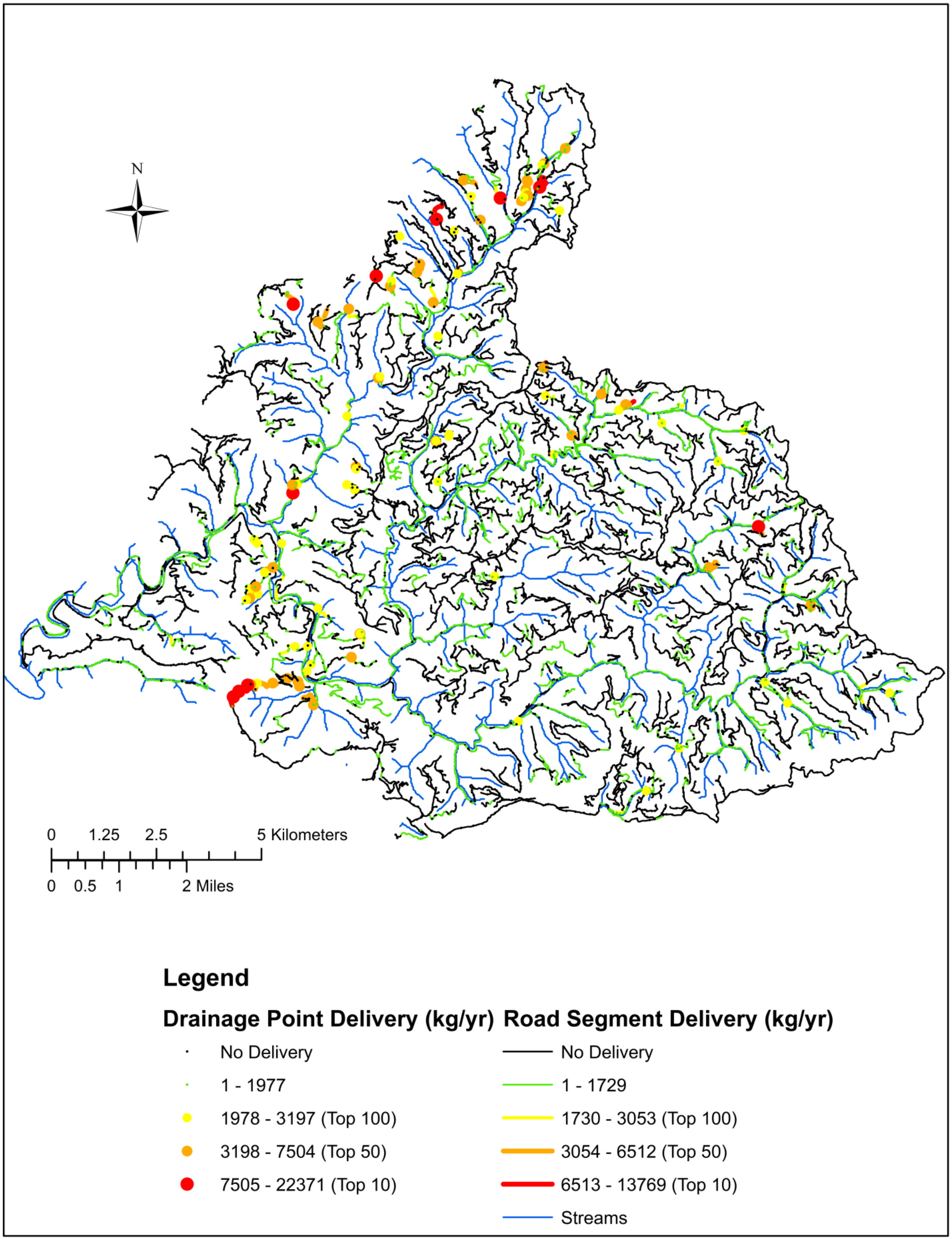


Figure 5. Estimated direct sediment input to streams.

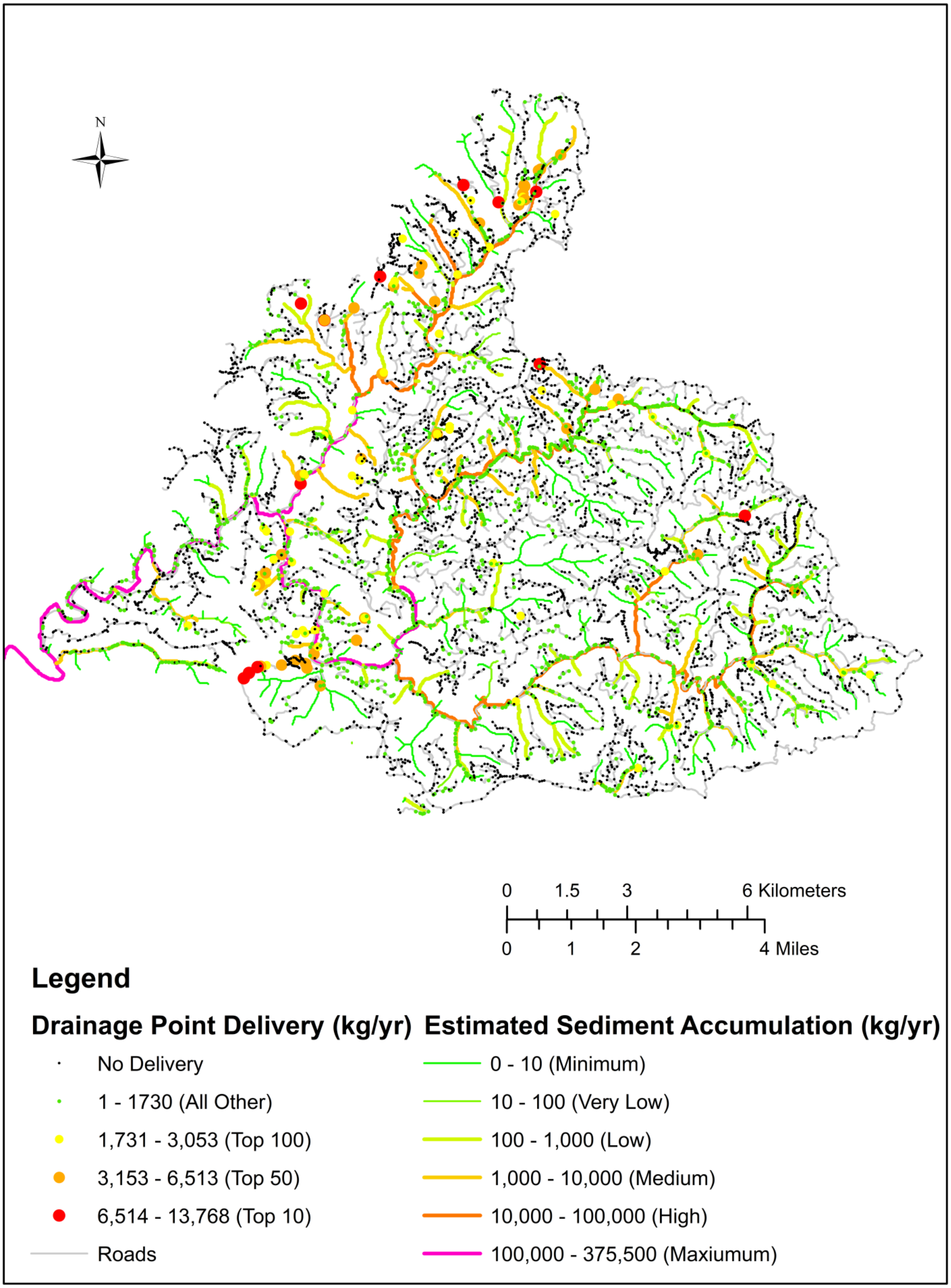


Figure 6. Fish passage culvert barriers.

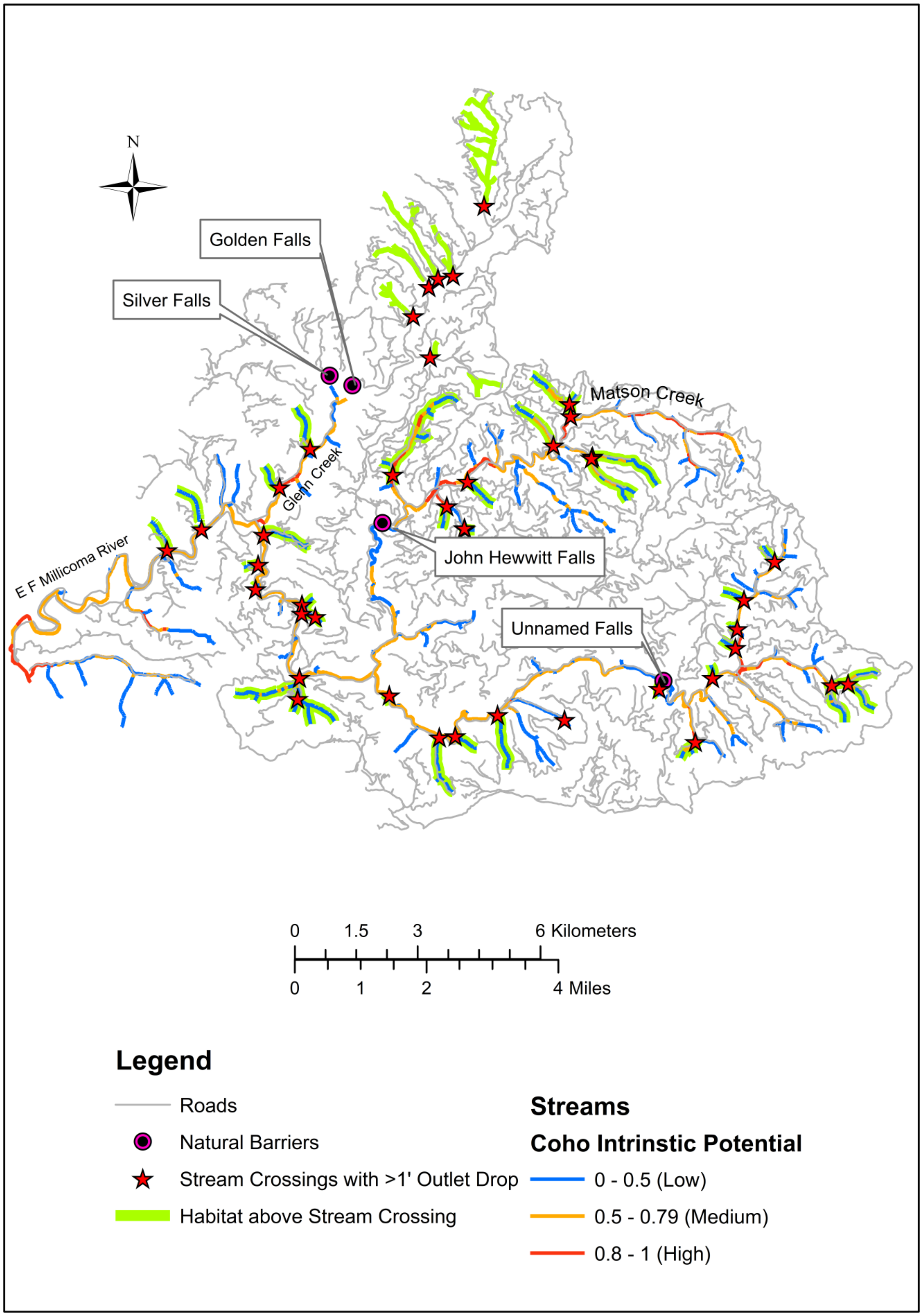


Figure 7. Potential failure locations of undersized stream crossing culverts.

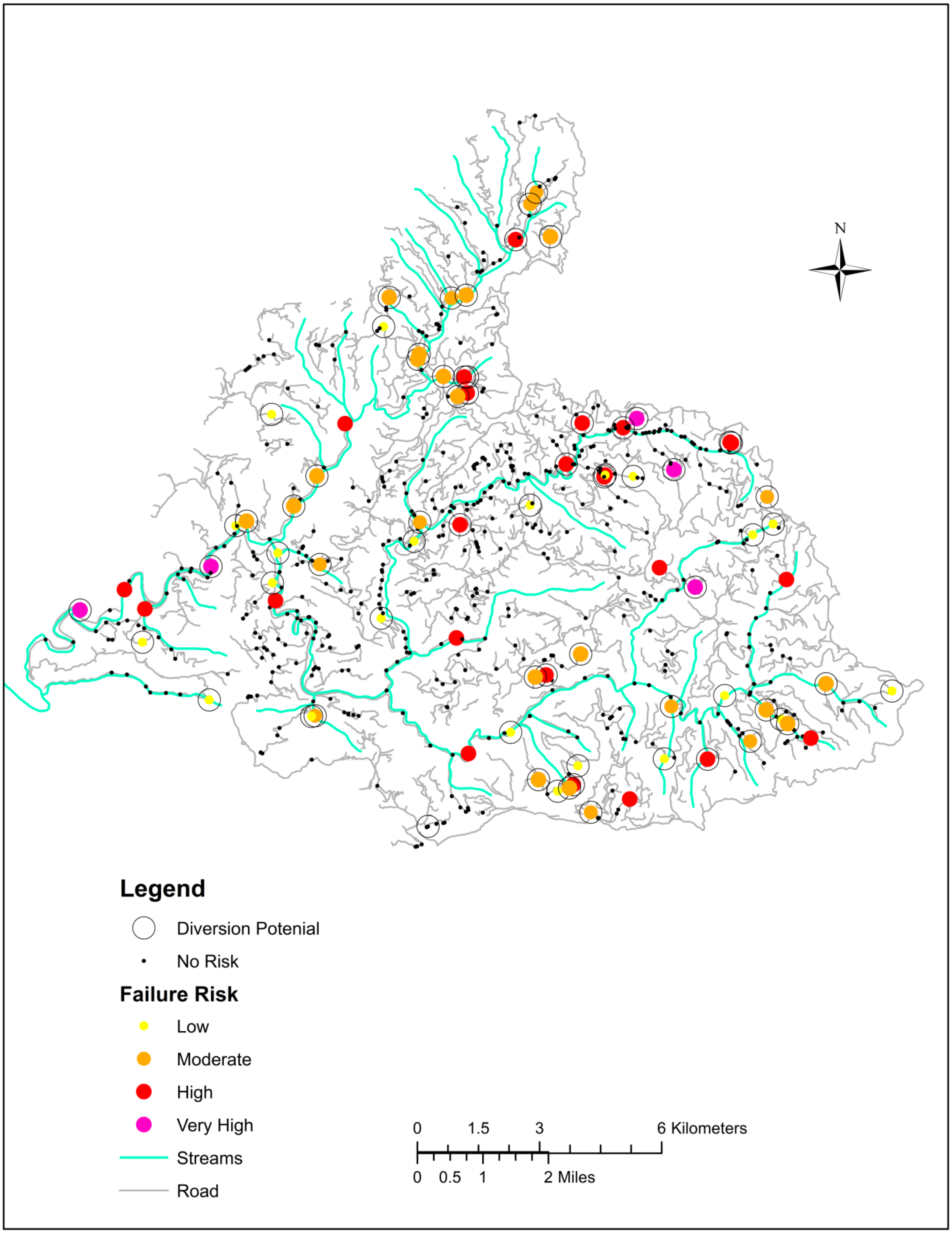
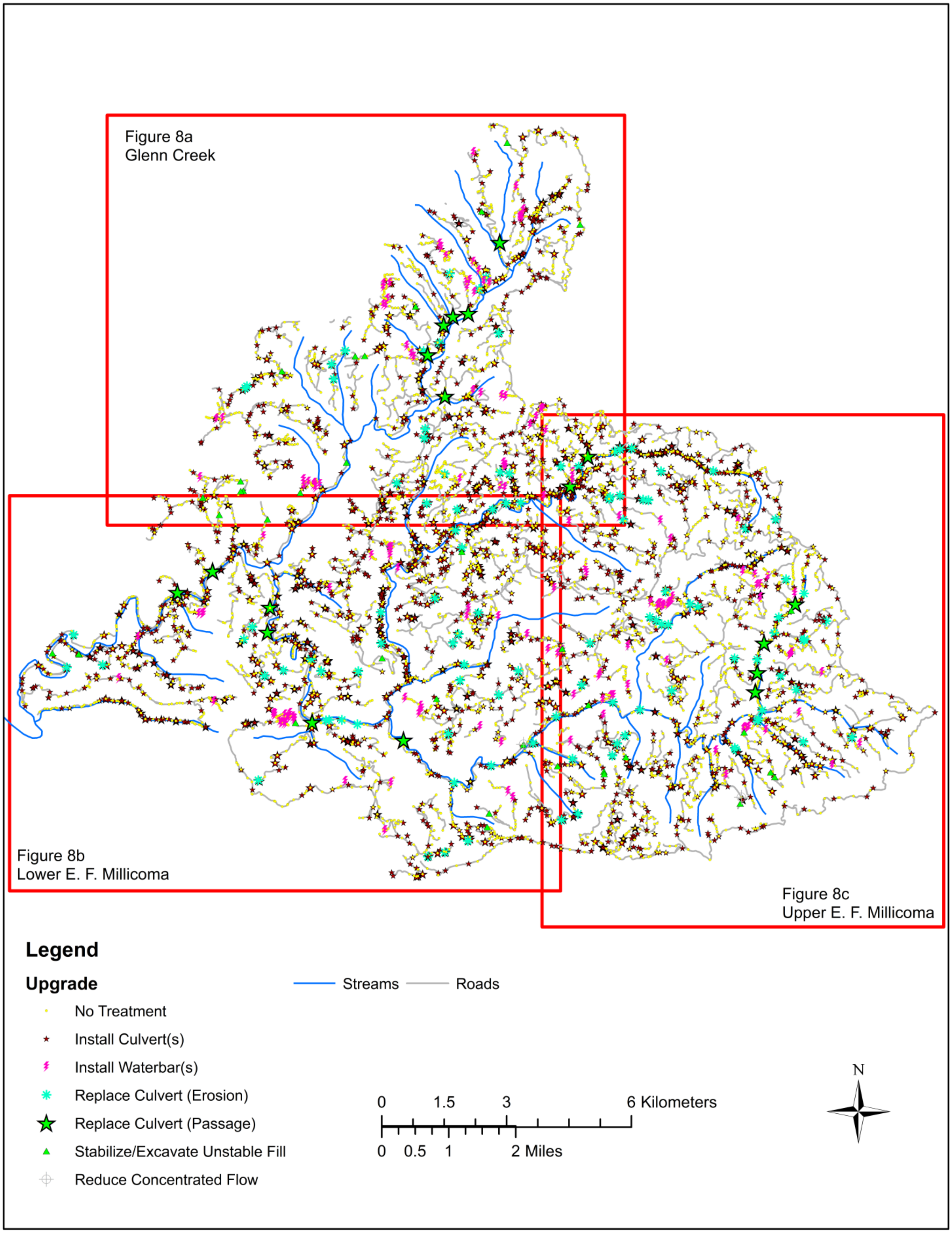


Figure 8. Overall treatment recommendations.



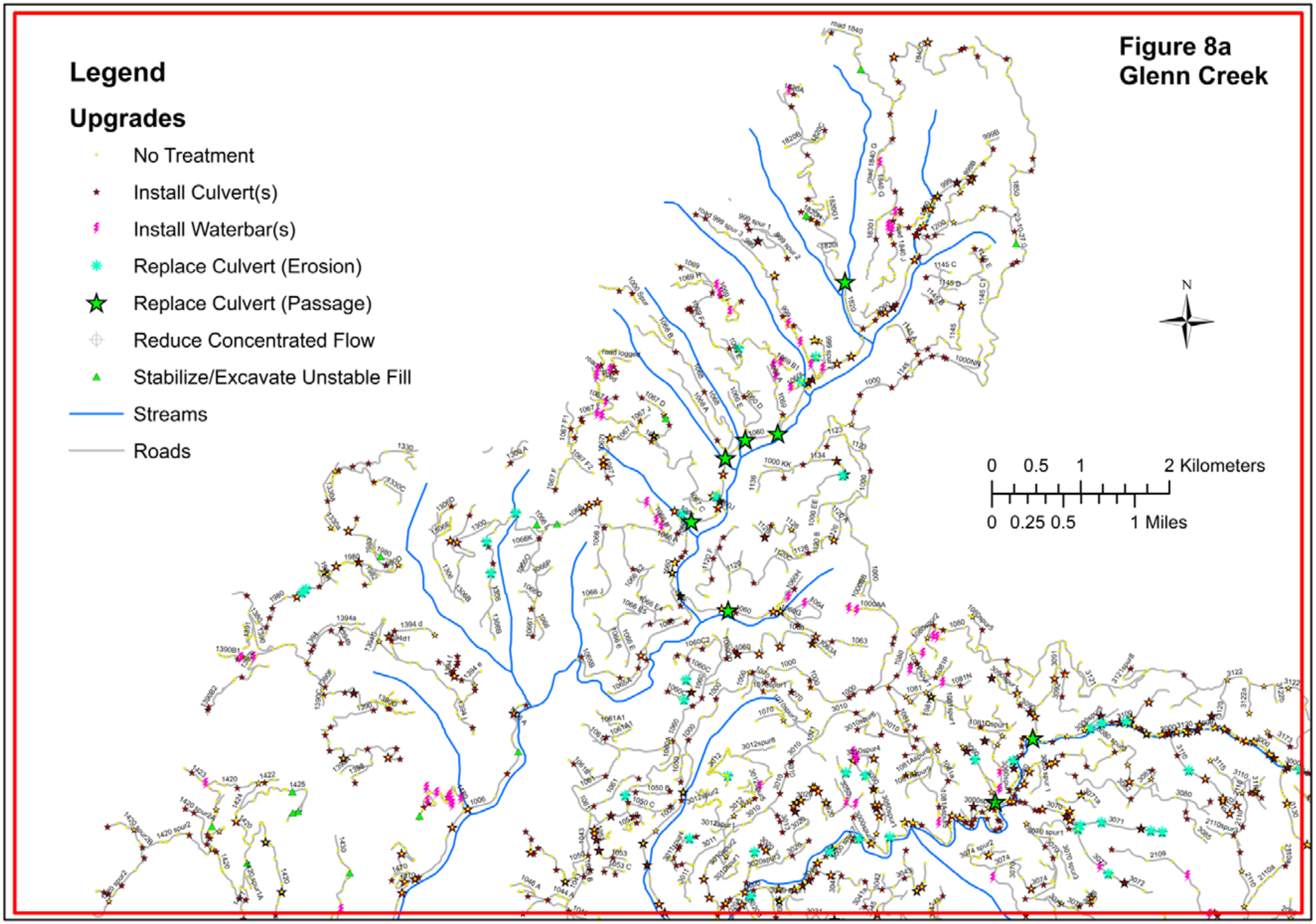


Figure 8a
Glenn Creek
Legend
Upgrades
No Treatment
Install Culvert(s)
Install Waterbar(s)
Replace Culvert (Erosion)
Replace Culvert (Passage)
Reduce Concentrated Flow
Stabilize/Excavate Unstable Fill
Streams
Roads
N
0 0.5 1 2 Kilometers
0 0.25 0.5 1 Miles
road 1840
1000
1060
1145
3000
1006

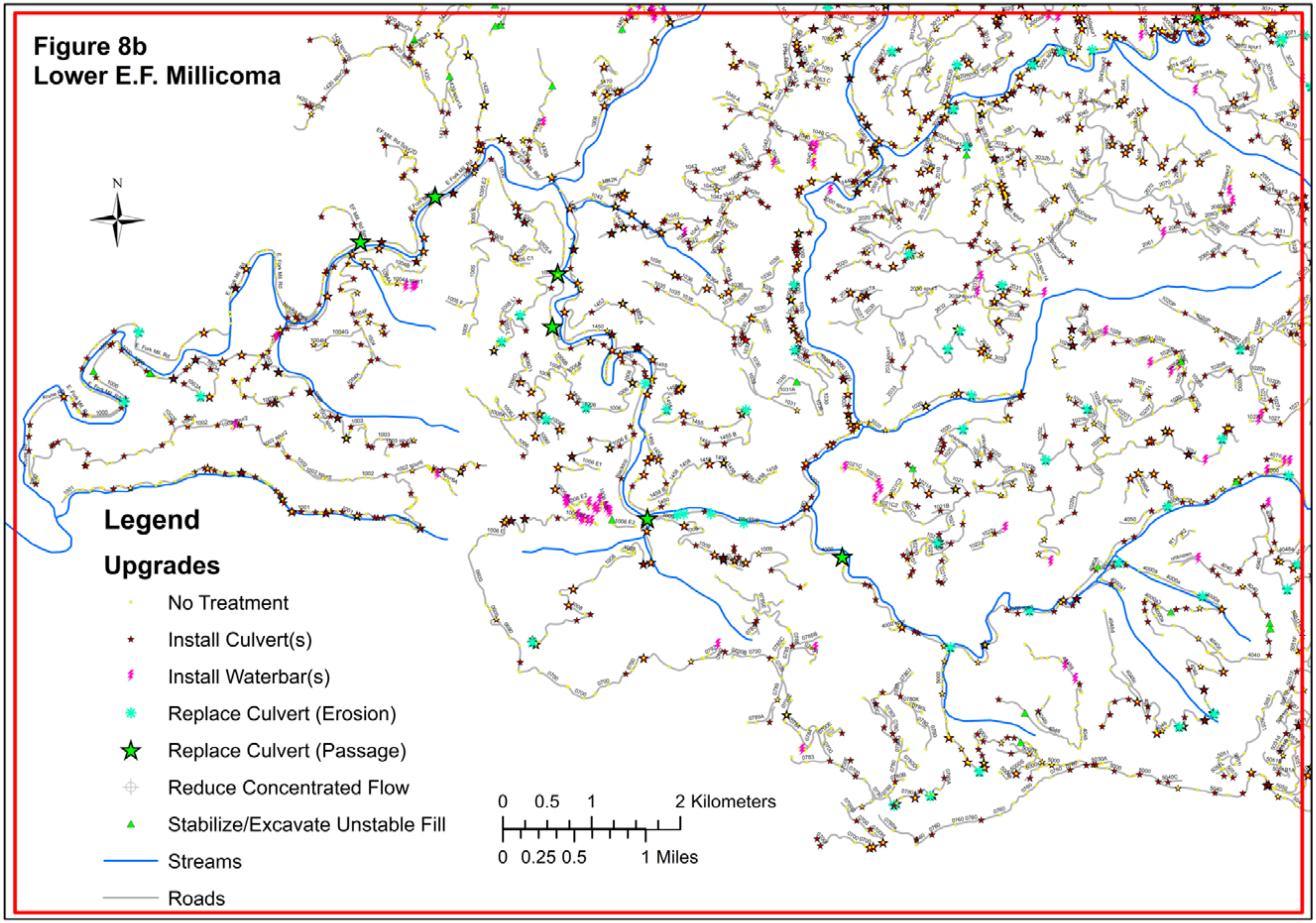


Figure 8b
Lower E.F. Millicoma

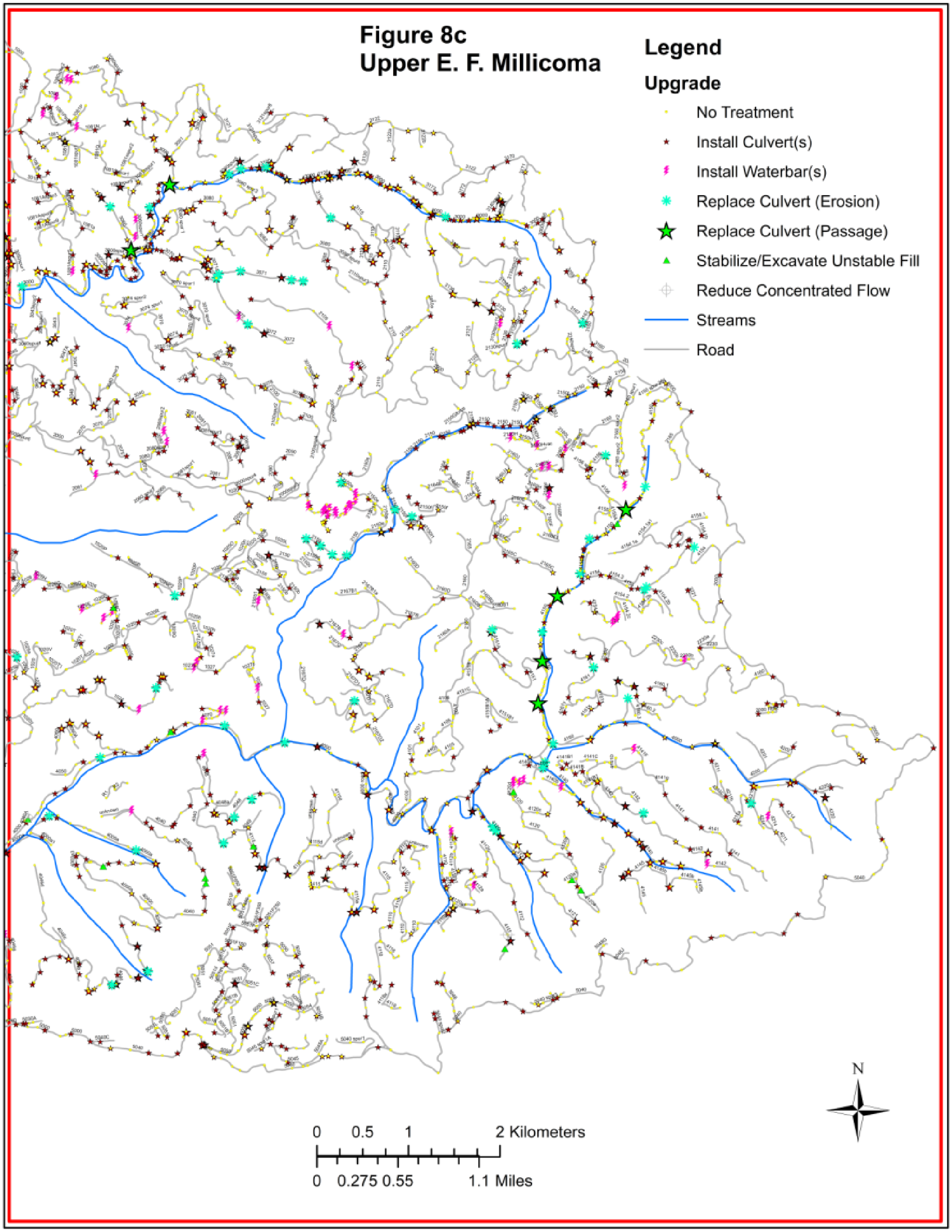


Figure 8c
Upper E. F. Millicoma

Tables

Table 1. Summary of ditch lengths leading to each type of drainage feature.

Drainage Features	Number of Sites	Minimum (feet)	Maximum (feet)	Average (feet)	Number of Lengths over 1000'
Broad Base Dip	236	67	3678	423	9
Diffuse Drain	1762	13	2621	329	54
Ditch Relief	2172	2	1917	305	37
Excavated Stream X-ing	28	50	1002	367	1
Lead-off Ditch	787	21	1460	285	9
Non-Engineered Drainage	1047	29	2340	340	26
Stream Crossing	630	34	1311	350	14
Sump	165	60	1579	379	5
Water Bar	650	41	1504	326	12
Total	7477				167

Table 2. Summary table of hydrologically connected drainage points.

DrainType	All Drain Points			Connected Drain Points			Not Connected Drain Points			% Length Connected
	Count	Average Effective Length (m)	∑ Effective Length (m)	Count	Average Effective Length (m)	∑ Effective Length (m)	Count	Average Effective Length (m)	∑ Effective Length (m)	
Broad Based Dip	236	320	39,271	20	128	2,552	216	170	36,719	6.5%
Diffuse Drain	1,762	238	227,988	311	118	36,599	1,451	132	191,389	16.1%
Ditch Relief Culvert	2,172	66	187,621	802	802	53,177	1,370	98	134,444	28.3%
Excavated Stream Crossing	28	138	3,855	28	138	3,855	0	0	0	100%
Lead Off Ditch	787	180	75,513	118	76	8,994	669	99	66,519	11.9%
Non-Engineered	1,047	209	121,258	203	118	23,896	844	115	97,362	19.7%
Stream Crossing	630	81	50,818	630	81	50,818	0	0	0	100%
Sump	165	124	20,445	0	0	0	165	124	20,445	0%
Waterbar	650	136	46,443	65	69	4,496	585	72	41,947	9.7%
All Drains	**7,477**	**166**	**773,212**	**2,177**	**170**	**184,388**	**5,300**	**90**	**588,824**	**23.8%**

Table 3. Summary table of estimated sediment production and delivery.

DrainType	Count	Length Connected (m)	% Length Connected	% of Total Delivery	∑ Estimated Sediment Production (kg)	∑ Estimated Sediment Delivery (kg)	% Estimated Sediment Delivery
Broad Based Dip	236	2,552	6.5%	0.5%	125,064	4,596	3.7%
Diffuse Drain	1,762	36,599	16.1%	18.6%	1,097,234	163,395	14.9%
Ditch Relief Culvert	2,172	53,177	28.3%	15.7%	546,491	137,282	25.1%
Excavated Stream Crossing	28	3,855	100.0%	6.7%	58,780	58,780	100.0%
Lead Off Ditch	787	75,513	11.9%	2.7%	23,988	23,988	100.0%
Non-Engineered	1,047	23,896	19.7%	27.8%	1,003,333	243,376	24.3%
Stream Crossing	630	50,818	100.0%	22.1%	194,015	194,015	100.0%
Sump	165	20,445	0.0%	7.5%	122,148	0	0.0%
Waterbar	650	4,496	9.7%	1.7%	701,028	51,087	7.3%
All Drains	**7,477**	**271,352**	**35.1%**	**103.4%**	**3,872,083**	**876,518**	**22.6%**

Table 4. Stream connection and estimated sediment delivery by road.

Road Name	Total Distance (m)	Connected Distance (m)	Percent Road Connected	Estimated Sediment Delivery (kg/yr)	Percent Total Estimated Sediment
1000	35,012	15,980	45.6%	20,718	14.3%
1001	4,431	3,543	79.9%	1,671	1.2%
1002	6,670	449	6.7%	396	0.3%
1008	3,763	2,136	56.8%	8,808	6.1%
1020	11,221	4,466	39.8%	4,593	3.2%
1060	11,066	7,115	64.3%	14,844	10.2%
2000	23,759	350	1.5%	327	0.2%
3000	11,476	10,564	92.1%	14,925	10.3%
4000	18,353	17,741	96.7%	5,676	3.9%
4150	4,729	1,833	38.8%	3,053	2.1%
5000	4,442	1,702	38.3%	1,833	1.3%
EF County Rd	10,319	1,702	38.3%	2,409	1.7%
Totals	**145,242**	**67,580**			

Table 5. Ranking categories for estimated sediment delivery points.

Class	Range (kg/yr)	Number of Points
Top 10	22371 - 7505	10
Top 50	7504 - 3198	40
Top 100	3197 - 1978	50
All Other Points Delivering	1977 - 1	2019
Points with No Delivery	0	5358

100-Yr. Runoff Fill Failure Risk	Fill Volume Size Class (Total Yds^3 for each class)											
	Minimal		Small		Medium		Large		Very Large		Total	
	Sites	Yds^3	Sites	Yds^3	Sites	Yds^3	Sites	Yds^3	Sites	Yds^3	Sites	Yds^3
Low	-	-	8	313	7	553	5	1098	2	2175	22	4139
Moderate	1	3	9	351	8	578	8	1433	3	2074	26	4439
High	2	5	10	254	4	333	7	1014	-	-	23	1606
Very High	1	161	-	-	2	153	2	288	-	-	5	602
Total	4	169	27	918	21	1617	22	3833	5	4249	76	10786

Failure Risk based on percentage of expected capacity drained, Low = 76% - 99%; Moderate = 51% - 75%; High = 26% - 50%; Very High = 0% - 25%

For *Fill Volumes*, Minimal = ≤ 10 yds.^{3}; Small = 10 - 50 yds.^{3}; Medium = 51 - 100 yds.^{3}; Large = 101 - 500 yds.^{3}; and Very Large = > 500 yds.^{3}. Shows number of sites and total Yds^3 in each class.

Table 7. Culvert spacing table

Typical Minimum Culvert Spacing for Erosion Control for Culverts Draining to Forest Floor

Road Grade	Distance
0 to 1 % dry season	1000 feet
0 to 1 % wet season*	300 feet
2 to 5 %	700 feet
6 to 12 %	400 feet
13 to 19 %	250 feet
over 20 %	150 feet

* water ponds on flat grades so extra drainage is needed for roads used during wet periods

Table 8. New and replacement structures need.

Site Type	New Drainage Stuctures Needed to Meet BMP	Replacement Drainage Stuctures Needed
Broad-base Dip	87	45
Ditch Relief	274	148
Excavated Stream Crossings	22	0
Lead-off Ditches	238	0
Non_engineered	316	0
Stream Crossings	28	72
Sumps	70	79
Water Bar	200	12
All Sites	1235	356