Introduction: Currently, the Forest Service has many standard plans and design aids for the construction of trail bridges. Most are out of date and have no formal written guidelines accompanying them on how and when to use. Thus, Northern and Northwest Regions have developed new standard plans and design aids to be accompanied with these instructions to be used for the design and construction of many standard trail bridges. The following provides guidance on when the design aids are applicable and how to use effectively. These instructions are to be used only as additional guidance to FSH 7709.56b, Transportation Structure Handbook, with respect to preliminary and final design requirements associated with bridge work. The objective to issuing these standard plans, design aids and instructions is to promote efficient and effective trail bridge design and construction at the forest level. For all successful designs, the customer needs must be identified, thus we recommend close coordination with the Forest Recreation staff so they become familiar with the standards plans and design aids and their appropriate uses.

Design Specifications: The standard plans / design aids have been designed and developed in accordance with FSM and FSH direction.

Design Authorities: In accordance with FSM 7722.04a, trail bridge design authority is the responsibility of the Regional Director of Engineering or those delegated authority. FSH 2309.18, 3.16, b, 7 (Trail Management Handbook) delegates trail bridge design approval to the Forest Engineer if standard plans are available. The intention of these new standard plans, design aids, and instructions are to replace all existing standard plans and provide direct authority of the use for the new standard plans and design aids to the Forest Engineers without the signature and approval of each project by the Director of Engineering. The Regional Director of Engineering signature with a date has been placed on a hard copy of each of the standard plan/design aid sheets identifying them as a standard plan prepared and approved by the Regional Office. Electronic files (AutoCAD drawing files) of the standard plan/design aid sheets are also provided, however, the signature block has been left blank. The electronic files are being provided so forests may place the details on their own title blocks, or make revisions as needed. We recommend the Forests add a signature block identifying who a drawing is prepared by or revised by with a date. It is the responsibility of the Forest Engineer to:

1. Verify preliminary and final design requirements of FSH 7709.56b have been completed (site survey, location, hydraulic design, etc).
2. Determine if standard plans are adequate for the proposed bridge site.
3. Ensure any forest revisions to the standard plans/design aids maintain the design integrity of the original standard plans/design aids.
4. Sign the cover sheet identifying the project and other specific project design information.

The Regional Structures Group is available for assistance in preliminary design or reviewing final trail bridge packages using the standard plans.
Current Standard Trail Bridge Plans: Currently the Northern Region has three standard plans circulating that are to be eliminated and no longer used:

1. Log Stringer..........................................................Drawing No. R1790
2. Open Web Joist..........................................................Drawing No. R1791
3. Glued Laminated – Nail Laminated Slab......................Drawing No. R1792

New replacement plans have been developed for the Log Stringer and the Glued and Nail Laminated slab bridges. The Open Web Joist Bridge is rarely used and in many instances has been found to be too light and easily damaged and thus is being eliminated. If a forest has a specific site that may warrant an Open Web Joist Bridge, contact the Regional Structures Group.

New Trail Bridge Standard Plan / Design Aids: Each trail bridge standard plan / design aid includes a title sheet with a schematic of the bridge, and superstructure detail sheets. Each sheet is discussed further below.

- **Title Sheet and Project Design Criteria:** The Forest must revise this sheet to incorporate the proper project name, signatures and identify the Project Design Criteria. The criteria to be established or identified includes design loading, span, width, member size, railings, treatments, etc. Also included is a signature line for the Forest Engineer approving the project and use of the plans.

- **Design Aid Sheets:** The Design Aid sheets typically detail the superstructure and include the design table with member sizes corresponding to various spans and loadings and all details needed to build the bridge superstructure and applicable connection/bearing details. The sheets are applicable for the spans and loadings shown in the design tables. For longer spans or heavier design loads, contact the Regional Structures Group. The sheets were developed without specific bridge spans or widths dimensioned and alternative railing details. By identifying the bridge span, width, handrail, treatment and other options in the Project Design Criteria, persons building the bridge will be able to identify the proper details for the superstructure. The superstructure detail sheets are generic to span and width and the intent is they are **NOT** to be revised or altered for each project.

In addition to the Title Sheet and Superstructure Detail Sheets, abutment details must be developed for a complete trail bridge package. The abutment detail sheets must be prepared by the forest for each specific project. Example abutment details have been developed and will provide guidance to the forest on preparing proper foundation details for trail bridges.

Below lists the standard plan bridge types included in this issuance.

- **Solid Sawn Timber Stringer Trail Bridge, R1920:** This is a new standard plan / design aid that uses solid sawn timber stringers with a plank deck. The plan
detail either a handrail or curbs only. Applicable spans are from 10 feet to 40 feet and any width.

- **Log Stringer Trail Bridge, R1921:** This is a replacement of R1790. The bridge uses log stringers with a plank deck. Preservative treatment to the log stringers is recommended, but the plan can be used for native (untreated) log bridges (see Preservative Treatments discussion below). The plans provide details for both sawn and pole handrail and curbs. Applicable spans are from 10 feet to 40 feet and any width.

- **Glued-Laminated Timber Stringer Trail Bridge, R1922:** This is a new standard plan / design aid that uses glued-laminated timber stringers with a plank deck. The plan details either a handrail or curbs only. Applicable spans are from 25 feet to 60 feet and any width. The plan includes superstructure and detail sheets for stringers spaced at 4-feet or 2-feet maximum spacing. Access, weight, etc., may influence the size and number of stringers.

- **Glued-Laminated Longitudinal Slab Trail Bridge, R1923:** This standard plan / design aid is a replacement for the glued-laminated option of R1792. The plans detail longitudinal glued-laminated slab panels with transverse tie rods. Applicable spans are from 10 feet to 35 feet and any width.

- **Single Log Stringer Trail Bridge, R1924:** This is a new standard plan that uses a single log stringer and single handrail. Preservative treatment to the log stringer is recommended, but the plan can be used for native (untreated) log bridges (see Preservative Treatments discussion below).

- **Nail Laminated Longitudinal Slab Trail Bridge, R1925:** This standard plan is a replacement for the nail-laminated option of standard drawing R1792. In many instances, the use of the old nail-laminated trail standard (R1792) resulted in bridges with incorrect lamination staggers that developed deflection problems and reduced capacities. The new standard requires 12 inch longitudinal nail laminated panels to be built and sandwiched together with tie rods, similar to the glued-laminated slab panel trail bridges, standard plan R1923. Applicable spans are from 12 feet to 30 feet and any even foot width (4, 5, 6…). The Sheet 2 of the plans provides an isometric view of the bridge with an exploded view of a single 12 inch panel showing the length of all panel laminations. This sheet is duplicated for each applicable span and must be selected and inserted into the final drawing package. Preservative treatment is always strongly encouraged, thus a Bill of Materials is recommended for each project with all lamination pieces identified and ordered and treated to length. Remember, if any piece is cut after treatment, the preservative treatment is essentially compromised and the life of the structure has been reduced. The plans include details for curbs only and handrail.
• **Prefabricated Steel Truss Bridge Spans 100 feet of less, R1926:** This is a new standard plan / design aid that provides guidance for purchasing a prefabricated steel truss bridge and minimum size and detail requirements for a concrete grade beam abutment foundation. The plans require the contractor to provide a design prepared by a professional engineer for the steel truss superstructure and abutment foundation. Current manufacturer’s are Continental Bridge, Big R, and Steadfast although the plans allow for local AISC certified steel fabricators to compete. All contracts using these plans are to require design and shop drawing submittals. The span length has been limited to 100 feet. Above 100 feet, the design requirements for various loadings and the superstructure movements due to temperature require special consideration in the design of the abutments and bearings. A concrete grade beam abutment foundation is a minimum requirement. Timber sills or gabions are not to be approved. Erection of a prefabricated steel truss bridge may require intermediate, in-stream bents or shoring and must be identified as an option in the Project Design Criteria. For spans greater than 60 feet, the notes require the manufacturer to design and detail bearings to accommodate the increased temperature movements. Please contact the Regional Structures Group for assistance.

• **Packable Timber Trail Bridge, R1927:** This is a new standard plan / design aid is based on the recently developed spliced timber stringer design that can be used for wilderness trail bridges or any remote access trail bridge that requires all materials to be packed to the site by mules. The plan uses 4-foot and 8-foot glued-laminated stringer members, stitch bolted and spliced together with a timber plank deck. The plan details either a handrail or curbs only. If handrail is needed the 15” deep glued-laminated members are required. Applicable spans are from 12 feet to 36 feet and any width.

The packable trail bridge design has been packed and constructed successfully but please note the following:

1. The logistics for successfully packing and constructing a packable timber trail bridge requires careful planning and experience. Provide adequate time to schedule all the necessary arrangements. The RO group has several project summaries that can help with new project planning. Bob Hoverson of the Nine Mile Pack String can provide guidance on proper packing methods and equipment.

2. Costs for the materials are approximately 2 times the costs for full-length solid sawn or glued-laminated stringers designs.

3. The costs for packing and assembling the stringers versus flying the materials and full-length stringers in with helicopters must be determined for each individual project.

4. The fabrication of the stringers is critical. Please comply with the stringer fabrication notes without exception when ordering and accepting the materials from fabricators.

   - The stringers were designed with a maximum weight of 100 lbs. The largest member sized in the design table is an 8-foot piece of
the 3-1/8 “ x 15” stringer size. These members have been packed successfully but can be cumbersome for the mules. Please contact Bob Hoverson of the Nine Mile Pack String for guidance.

- **Typical Abutment Details, R1930 - R1934:** Abutment plans and details will need to be developed by the forest as part of the package for every trail bridge. Abutment plans are too site specific to develop standard plans, however, typical, recommended details can be provided that can then be incorporated into the abutment plans. The typical abutment sheets provided illustrate a recommended example of an properly detailed abutment sheet and recommended typical details. The sheets illustrate:
  - An example of an abutment detail sheet, R1930.
  - Foundation alternatives for Geocell and Rock Gabions, R1933. (Use of geocell will require an SPS that is included with this package.)
  - Foundation alternatives for a concrete leveling pad and timber cribbing, R1934.

The details are adequate for the design loadings and the spans identified in the superstructure design tables.

**General Instructions for Use:** The standard plans / design aids are typical superstructure designs and abutment details commonly used. However, proper bridge design includes many other aspects, some of which are discussed further below.

- Location and access.
- Design loading determination
- Site survey.
- Hydraulic analysis.
- Foundation capacity.
- Abutment Details.
- Span length.
- Width requirements.
- Preservative Treatments.
- Handrail or curbs only.
- ADA Compliance.
- Special project specifications.

Proper attention to these aspects will determine a successful design. FSH 7709.56b provides direction on these aspects and will not be reiterated here. The below discussions are instructions and guidance on how to use the standard plans with respect to these aspects and the possible variables and decisions to be made.

**Location and Access:** The location and access to a trail bridge project is the single most influential factor in selecting a bridge type and ultimately costs. Prior to selection of a bridge type, the location and access must be considered with respect to equipment, tools, force account crew or contractor skills. Bridges located so that materials, equipment and
Design Loading: Each trail bridge type (except Prefabricated Steel Truss) includes a design table identifying member sizes with respect to spans and design loadings. Each table lists two pedestrian live loads, 65 and 85 psf and three snow loads, 120, 150, and 200 psf. The Forest Engineer must determine and identify the design pedestrian and snow loading and the corresponding member size for the bridge span within the Project Design Information. Please note that design code requirements allow different factor of safety for pedestrian and snow loads and thus some member sizes for 120 psf snow load are smaller than required member sizes for 85 psf pedestrian live load.

- **Pedestrian Live Load:** Manual direction establishes 85 psf as the pedestrian live load. Pedestrian live loads for backcountry or wilderness trail bridges (bridges on trails other than Rural or Urban ROS classifications), may justify a reduction from the 85 psf. The pedestrian live load for backcountry or wilderness trail bridges with a low probability of being fully loaded may be reduced, but not less than the 65 psf. However, designers are cautioned that the 85 psf live load provides significant overload capacity and long-term durability benefits that a reduction to 65 psf will reduce.

- **Ground Snow Load:** The 50 year recurrence design ground snow load is to be determined for each site. If local values are unavailable, the following publications are recommended:
  - Montana: Recommended Snow Loads For Montana Structures, March 1978, Montana State University, Bozeman, MT.
  - Idaho: Ground and Roof Snow Loads for Idaho, 1986, University of Idaho, Moscow, Idaho

Foundation Capacity and Abutment Details: The Forest Engineer must develop abutment details specifically for the bridge. The example abutment details assume good well-drained subgrade material free of clays and silts with an allowable soil bearing pressure of 4000 psf. If little foundation information is available, it is recommended to install gabions or geocell below a timber or concrete abutment sill to help distribute loads and provide added stability and protection against settlement and scour. The intent of the abutment details is to provide positive attachment of the superstructure to the substructure, adequate bearing on the subgrade, proper drainage, treatment of materials to prevent decay, and protection against scour.

Span Length: The Forest Engineer must identify a span length for the bridge in the Project Design Information. A hydraulic analysis is needed to determine the required span length. Trail bridge designs should be designed to pass 100 year flood events with
adequate freeboard clearance for debris. If using standard abutment details, the bridge should provide additional clearance or protection against stream scour. In general, the two biggest problems seen with existing Northern Region trail bridges are the spans are too short and the clearance too low creating a high potential for flood damage.

**Bridge Width:** The Forest Engineer must identify a bridge clear width in the Project Design Information. The width determines the number of stringers needed. Trail bridge widths vary with the type of use but typical widths are 4, 6, or 8 feet. The width of the bridge should be determined in cooperation with the Forest Recreation staff.

**Stringer, Log, Slab Panel Number and Size:** The Forest Engineer must identify number and size of stringers, logs, or slab panels needed in the Project Design Criteria (if applicable). The number of stringers, logs, or slab panels must be determined from the bridge width, the required edge distances and the maximum spacing requirements shown on the typical section. The stringer, log or slab panel size is to be selected in the design table with the span and loading known.

**Handrails or Curbs:** Forest Engineer must identify whether handrail or curbs will be used with the bridge in the Project Design Criteria. There has been much discussion of this issue and we recommend the Forest Engineer work with the Forest recreation personnel to make the decision. In general, rails shall be required for all trail and pedestrian bridges. However, railings may be eliminated and/or curbs substituted for rails when an appropriate analysis as described below has been completed.

- An analysis has identified and evaluated the potential users and determined that the potential hazards of the trail is the same or greater than that of a bridge without a rail. The analysis should include the possibility of using a rail on only one side of the bridge. In general, rural and urban ROS settings with systems with difficulty levels described as “easiest” will have small children and more inexperienced users. Thus, a railing is warranted in most instances. In backcountry or wilderness settings with the trail system difficulty being “more” or “most difficult”, the users will be experienced and curbs may be adequate.

**Bridge Rail Max. Opening (Prefabricated Steel Truss only):** Forest Engineer must identify if additional safety rails are required, or if a timber rub rail is adequate. The same criteria shown above for Handrails and Curbs should be applied.

**ADA Compliance (Prefabricated Steel Truss only):** Forest Engineer must determine with recreation if the trail and bridge are to meet ADA requirements. If ADA compliance is required, the handrail detail shown is to be used. Other details may be substituted. In addition, running planks may need to be full width or not included.

**Preservative Treatments:** Forest Engineer must identify a timber preservative treatment in the Project Design Criteria. Preservative treatment is strongly recommended for all timber abutment and superstructure members. Proper preservative treatment will provide a 50 year or longer life for the members. If no treatment is used the expected life is 10 to
15 years. In most instances, a life cycle analysis will show a treated bridge is significantly more cost effective than an untreated bridge.

There are a number of preservative treatments identified as options in the Project Design Criteria. At this time, there are no laws disallowing any treatments for our facilities or bridges. However, there is increasing concern of exposing pedestrians to preservative treatments. Handrails appear to be the main element of concern. If exposure to any treatment type on handrails is an issue, treatment of handrails may be eliminated. Untreated handrails will weather and decay over time, but they can be replaced easily. Another recommended option in lieu of using treated handrails is using redwood or cedar for the rails. This option has also been outlined in the Project Design Criteria.

The preservative treatment industry is changing rapidly and thus if more information is needed in selecting a preservative treatment, contact the Regional Structures Group

Running Planks: Forest Engineer must identify whether running planks are to be included or not, treated or untreated in the Project Design Criteria. We recommend running planks for bridges with stock use. Preservative treatment is recommended only if the stock use is light and damage from wear is minimal. If stock use is heavy, and damage from wear is significant, untreated planks are recommended. If ADA compliance is required, running planks should be full width of the bridge or not included.

Construction and Special Project Specifications: The standard plans / design aids have been developed utilizing the current adopted Forest Service Specifications for Construction of Roads and Bridges (currently August 1996 version). The Standard Specifications for Construction and Maintenance of Trails is not an adequate specification to build a trail bridge and should not be used. Attached with this document are Special Project Specifications that are to be included with trail bridge packages as described below:

- **SPS 106 – Measurement and Payment.** This SPS is to be added to all construction packages that have been prepared using the 1996 Standard Specifications and are using English units. The 1996 Standard Specification is metric and this SPS provides for the use of English units for the drawings and pay items.

- **SPS 557 – Timber Structures.** This SPS is a simplified, more applicable specification for timber structures than the current 557 section in the Standard Specifications. This SPS should be added in all trail bridge packages using timber.

- **SPS 260 – Geocell Abutment Stabilization and 726 – Geocell.** Any time geocell is included in the design package, these two SPS’s need to be included in the package.
Construction Cost Estimates: Estimating trail bridge construction costs can be difficult due to the variability of location and access. Bridges located so that materials, equipment and workers can easily access, can be constructed quickly and efficiently. Bridges located in backcountry or wilderness areas that require helicopter use, mule packing, traditional tools, and etc. will have high costs associated with the logistics of access. The following provides some guidelines for estimating trail bridge costs. The Northern Region Cost Guide can be used for applicable work, but each project must be carefully considered.

Estimating trail bridge costs by the typical unit price method is many times not applicable. An alternate method used that may seem more logical and more accurate is to think like a contractor and consider each aspect of work with respect materials needed, equipment and labor. This method easily works with trial bridges especially with unusual access or conditions. Below describes in more detail this method.

Materials takeoffs need to be accurate. With materials quantities, suppliers can be called and for price quotes.

Consider how the bridge will be constructed at the site and the equipment needed; small tools, excavators, cranes, helicopters, compressors, generators, etc. All equipment used on a job can be given a rental price per hour, day or week.

Labor can be considered in crew days. Consider the size of the project and reasonable size crew to do the work. Work items can then be considered and crew days and thus costs applied. Pre-work, project management, mobilization and demobilization must also be considered.

Once material, equipment and labor costs are determined, unit prices for bid items can be calculated.