Annex F

Railroad and Highway Embankment Protection Plan

Annex F: Railroad and Highway Embankment Protection Plan

F.1 General

The term "embankments," used in this annex, refers only to the roadway, railroad, and other manmade embankments along the shores of the reservoirs. It does not include the main dam embankments that form part of each dam structure. The modifications described here are based on information available in design memoranda, contract drawings, and aerial photography document the relocations and typical cross-sectional geometry of highway and railroad embankments.

Approximately 140 kilometers (80 miles) of highway and railroad embankment fills exist along the shores of the four lower Snake River reservoirs. They consist of embankments that existed prior to the raising of reservoirs, new embankments for relocated rail and road beds, and existing embankments that were modified or stabilized to function when subject to higher water surface elevations.

Damage to the embankments can occur in two ways. Displacement of the embankment by sliding and settlement occurs as a result of embankment saturation and a subsequent lowering of the water surface elevation. The proposed rapid drawdown of the reservoir water surface initiates this distress. Annex H: Railroad and Roadway Damage Repair Plan, describes the anticipated repair measures for restoring embankments for rail and road service resulting from rapid drawdown. The second major cause of distress is the erosion of embankment materials due to river contact with the embankment. This annex describes the protection measures necessary to protect exposed embankments from the effects of flowing river water.

Currently, most of the embankments have rockfill or riprap erosion protection on the slopes positions several feet above and below the maximum and minimum reservoir elevations. Reservoir drawdown may expose unprotected portions of the embankments during unregulated normal and flood flows, thereby, subjecting these unprotected embankments to erosion. This annex quantifies the amount of additional erosion protection that would be required, based on Corps erosion protection guidelines and assumptions regarding existing embankment geometry and construction.

F.2 Background

A summary of the activities to stabilize, modify, and relocate railroad and roadway embankments prior to raising the four reservoirs may be useful in understanding the rational for selecting the extent of proposed modifications in anticipation of drawdown of the four reservoirs.

F.2.1 McNary Dam Relocations

The McNary Lock and Dam impounds Lake Wallula that results in slackwater extending into the lower Snake River. Ice Harbor Dam is located on the Snake River, 8 miles from its confluence with the Columbia River. The Spokane, Portland, and Seattle Railway (S, P, & S) was located on the north shore of the Snake River. This portion of this rail line connects Pasco, Washington and Spokane, Washington. Because of the raised water surface of the McNary reservoir, a contract to relocate a section of this rail line was performed in 1947 to raise the grade of the line to its current location.

F.2.2 Ice Harbor Dam Relocations

Three rail lines were impacted by raising a reservoir behind Ice Harbor Dam. In addition to the S, P, & S Railroad located on the north shore of the river, the Northern Pacific Railroad spurs from the S, P, & S Railroad at approximately river mile TBD. The Union Pacific Railroad exists on the south shore of the river.

The S, P, & S Railroad between the end of the McNary relocations and Ice Harbor Dam was relocated to raise the grade to pass Ice Harbor Dam. Contract 57-127 relocated the S, P, & S Railroad from river mile X at a 0.3 percent slope to the axis of the dam and at a zero percent slope thereafter until the line tied into the existing rail line near Levee Park, river mile TBD. The north shore railroads beyond Levee Park required no major relocation of the rail beds. The raised water surface from the future Ice Harbor reservoir were, in most locations, below the railroad grade. However, because of the significant change in water surface elevation and the effect on embankment stability, portions of the rail beds required extensive stabilization and erosion protection. Some raising of the rail grades was done to provide the necessary freeboard for settlement and wave action protection.

Contract 59-108 provided additional embankment stabilization and erosion protection for the rail section between river mile TBD and TBD. The existing rail beds were used. At Snake River Junction, approximately river mile TBD, the Northern Pacific Railroad parallels the S, P, & S line and often share the same embankment. The Northern Pacific Railroad is located on the riverside of the embankment. Contract 61-139 provided for additional embankment stabilization and erosion protection for the rail section between river mile TBD and TBD. Specific reaches were identified and modifications designed accordingly.

Significant modifications to the Union Pacific Railroad, located on the south shore of the Snake River were necessary to maintain rail service after the pool raise. This rail line provided rail service between Hinkle, Oregon and Spokane, Washington. This main line also connects at Ayer, Washington, with the Tekoa-Ayer Branch that in turn connects with the Tucannon Branch and the Camas Prairie Railroad.

Contract 60-117 provided major relocation of the railbed and embankment stabilization of existing segments. Relocation work was done between river miles 12 and 27. Contract 60-142 provided major relocation of the railbed and embankment stabilization of existing segments. Relocation work was done between river miles 27 and 38.

Numerous agreements with the various railroads were made for the removal of abandoned railbeds and the installation of ties and rails. In addition, some sections of the railroad requiring a grade raise, were done by the railroad rather than with a construction contract. Details of some of these agreements and consequent design and construction activities are difficult to find.

F.2.3 Lower Monumental Dam Relocations

The Seattle District Corps did portions of the design of Lower Monument relocations. The historical record for this work is not readily available. The S, P, & S Railroad was diverted north at Lower Monumental Dam through Devils Canyon to Kahlotus, Washington. The Northern Pacific rail line along the north shore above Lower Monumental was abandoned. The Union Pacific Railroad on the south shore was relocated. This work included raised and relocated railbeds along the river and new branch lines connecting with the Camas Prairie Railroad and the Tucannon Branch line.

F.2.4 Little Goose Dam Relocations

The branch line connection to the Camas Prairie railroad is located at the Snake River Bridge, river mile TBD. Previous relocations contracts provided the grade raise to river mile 67. Two major contracts provided all the railroad relocations for the Little Goose reservoir. Contract 67-104 provides for relocation of the rail beds between river miles 67 and 82. Contract 68-86 provides for relocation of the rail beds between river miles 84 and 101. No rail service exists on the south shore of the river.

F.2.5 Lower Granite Dam Relocations

Five major contracts provide all the railroad relocations for the Lower Granite reservoir. Contract 69-19 provides for relocation of the rail beds approaching the downstream of Lower Granite dam and extending through the dam construction zone. This is between river miles 100 and 111. Contract 73-89 provides for relocation of the rail beds between river miles 110 and 119. Contract 73-26 provides for relocation of the rail beds between river miles 118 and 126. Contract 73-96 provides for relocation of the rail beds between river miles 126 and 128. Contract 73-102 provides for relocation of the rail beds between river miles 131 and 139. No rail service exists on the south shore of the river.

F.3 Development of Methodology

The initial approach to quantifying the extent of embankment modification was to perform a field reconnaissance of the embankments. In additional to a visual survey of the embankments, information was collected from aerial survey photographs, U.S. Geological Survey (USGS) 7.5 minute series topographic maps, National Oceanic and Atmospheric Administration (NOAA) navigational maps, and Corps design memoranda and contract drawings. Little information was located on the existence of submerged structures and whether pre-pool structures could be utilized for this drawdown event.

Later interviews with individuals who participated in the contract work for railroad and highway relocations indicated that significant infrastructure existed in each reservoir that may be useful for construction access. Some of pre-reservoir embankments and the temporary construction embankments provide a significant level of erosion protection. Further research confirmed that this was in fact the case and the embankment modification plan was revised.

Aerial photographs of each reservoir were located that clearly showed the pre-reservoir configuration of the Snake River and the on-going construction of railroad relocations. From the photographs, embankment reaches were determined that required protection. The photographs clearly showed where embankments were in contact with the water surface of the river. Most of the photographs were taken when water surface elevations were at minimal levels. Visual determinations of the location of the water surface at 100-year flow levels, 9,056 m^3/s (320,000 cfs) was done and affected embankments identified.

In many cases the reaches requiring embankment protection corresponded to reaches where temporary railroad sections were constructed. These temporary railroad bypasses are termed shooflys. The shooflys provided a temporary bypass so that railroad modifications could proceed on the main line without rail traffic interruptions. In many cases the riverside slopes of the shooflys are protected with riprap or rockfill for flows up to 5,268 m^3/s (186,000 cfs). Long-term stabilization requires the addition of riprap above that flow elevation and the upgrading of rock protection that was designed for only temporary service.

Other segments of new embankment installed during the relocation era serve the purpose of stabilizing the existing embankments. These embankments are reinforced with good riprap in the new reservoir water surface range, but have only marginal rock protection in the natural river water surface elevations.

The following assumptions and conclusions for embankment protection were established for this study:

- Since specific topographic information is not available and detailed surveys are not practical at this phase, the toe elevation for riprap placement was estimated. The toe was assumed to be located, on average, midway between the elevation of the center river channel and the water surface elevation at flows of 566 m^3/s (20,000 cfs).
- Based on information obtained from design memoranda and contract drawings, most slopes were assumed to be 2.0h:1.0v, although there were a few specifically designated as 2.5h:1.0v and 3.0h:1.0v.
- The study team assumed no filter or bedding would be required since most below-reservoir fills are granular or rockfill and do not contain significant fine material to migrate through the riprap.
- No erosion protection is required if the toe of an embankment is located above the natural river (post-drawdown) 100-year flood level (9,056 m^3/s or 320,000 cfs).
- Erosion protection should be provided wherever the embankment toe is located below the natural river (post-drawdown) 100-year flood level (9,056 m^3/s or 320,000 cfs). The erosion protection should extend up from the embankment toe elevation to 1.5 meters (5 feet) above the flood elevation or the crest of the embankment, whichever is less. A diagram illustrating this embankment protection criteria is shown in Figure F1.
- Erosion protection should average in thickness from 8 meters to 9 meters (27 inches to 30 inches). Detailed reach water velocities were not determined for this study.

Tables F1 to F4 summarize the specific embankment reaches that have been identified to require additional riprap protection. Quantities of riprap for slope protection and surfacing materials for vehicle access are shown in the tables. Figure F2 show several proposed modifications utilized for modification of existing embankments.

Table F1. Ice Harbor Reservoir Embankment Modification Reaches

Reach Number	Railroad Highway Designation	Approximate Location (river mile)	Reach Length (feet)	Riprap Volume (cy)	Base Volume (cy)
N1	S, P, & S RR	11	2,950	27,213	983
N2	S, P, & S RR	25	700	4,348	233
N3	S, P, & S RR	24	1,100	7,516	367
N4	S, P, & S RR	24	1,300	8,882	433
N5	S, P, & S RR	21	2,000	16,978	667
N6	S, P, & S RR	19	500	3,209	167
N7	S, P, & S RR	14	700	5,073	233
N8	NPRR	27	1,750	13,044	583
N9	NPRR	28	4,075	27,842	1,358
S1	UPRR	14	11,740	0	3,913
S2a	UPRR	15	400	1,926	133
S2b	UPRR	15	439	2,113	146
S3	UPRR	16	5,232.57	25,188	1,744
S4	UPRR	23	7,624.3	39,069	2,541
S5	UPRR	26	1,874.2	11,059	625
S6	UPRR	29	2,500	1,941	833
S7	UPRR	32	6,119.2	32,307	2,040
S8	UPRR	34	4,700	16,056	1,567
			55,704	**243,763**	**18,568**

Table F2. Lower Monumental Reservoir Embankment Modification Reaches

Reach Number	Railroad Highway Designation	Approximate Location (river mile)	Reach Length (feet)	Riprap Volume (cy)	Base Volume (cy)
S1	UPRR	43	6,180	26,306	2,060
S2a	UPRR	48	7,520	32,009	2,507
S2b	UPRR	50	5,560	24,363	1,853
S3	UPRR	52	1,750	8,763	583
S4	UPRR	56	7,443	34,477	2,481
S5	UPRR	63	4,900	20,857	1,633
S6	County Road	66	9,680	22,621	3,227
S7	County Road	70	10,920	35,545	3,640
N1	CPRR	65	4,940	20,409	1,647
N2	CPRR	67	3,190	13,578	1,063
			62,083	**238,928**	**20,694**

Table F3. Little Goose Reservoir Embankment Modification Reaches

Reach Number	Railroad Highway Designation	Approximate Location (river mile)	Reach Length (feet)	Riprap Volume (cy)	Base Volume (cy)
N1	CPRR	72	4,900	14,723	1,633
N2	CPRR	74	11,000	36,723	3,667
N3	CPRR	78	2,847	9,267	949
N4	CPRR	80	7,576	33,196	2,525
N5	CPRR	89	11,496	50,373	3,832
N6	CPRR	93	6,086	25,905	2,029
N7	CPRR	99	4,086	20,973	1,362
N8	CPRR	103	7,521	34,838	2,507
N9	CPRR	105	7,277	31,886	2,426
S1	Central Ferry				
S2	County Road				0
			62,789	**257,884**	**20,930**

Table F4. Lower Granite Reservoir Embankment Modification Reaches

Reach Number	Railroad Highway Designation	Approximate Location (river mile)	Reach Length (feet)	Riprap Volume (cy)	Base Volume (cy)
N1	CPRR	109	17,180	77,429	5,727
N2	CPRR	113	5,000	15,440	1,667
N3	CPRR	117	8,567	35,393	2,856
N4	CPRR	120	4,878	24,428	1,626
N5	CPRR	123	10,026	56,483	3,342
N6	CPRR	124	1,593	8,974	531
N7	CPRR	127	12,765	65,522	4,255
N8	CPRR	133	9,493	51,104	3,164
N9	CPRR	138	6,600	17,627	2,200
S1	Highway 12	135	18,600	51,229	
LL1	N Lewiston Levee				
LL2	W Lewiston Levee				
			57,502	**352,400**	**25,367**

F.4 Construction Scenario

Protection of the existing embankment structures on the lower Snake River reservoirs provide some logistical challenges in preparing design approaches and staging construction operations. The embankments to be protected span 220 kilometers (140 miles) of reservoir, offer difficult land access, and require placement of bands of riprap extending along steep slopes. The major construction operations are:

- Quarry development and production
- Stockpile riprap and other materials
- Develop and upgrade access roads to the river
- Treat and modify to river access roads
- Place riprap
- Place drainage modifications.

F.4.1 Quarry Development and Production

The drawdown of the four lower Snake River reservoirs would require about 750,000 m^3 (1 million cy) of riprap material for protection of embankments, drainage modifications, and bridge abutments. The size and gradation requirements for this material, ranging from 0.3 meter (1 foot) to 0.8 meter (2.5 foot), is generally available from existing quarry sites in the Lower Granite reservoir and other potential sites in the Ice Harbor and Lower Monumental reservoirs. Based on past experience and the general practice of quarry development within the Lower Granite reservoir area, about two and one-half times as much material must be processed as can be used for riprap. If 0.75 million m^3 (1 million cy) is to be used, about 1.8 million m^3 (2.5 million cy) will have to be processed.

Identification of specific quarry sources requires extensive explorations to ascertain rock quality and quantity. Without those explorations, the study team assumed general locations for major quarries in the Ice Harbor and Lower Monumental reservoirs and utilized previously developed quarries for the Lower Granite relocations.

Since dam breaching will be done over a period of two consecutive construction seasons, not all quarries need to be developed at the same time. Embankments in the Lower Granite and Little Goose reservoirs are scheduled to be modified during the first breach season. This requires at least 1 land-based quarry along the Lower Granite reservoir be developed and sufficient material stockpiled at each quarry for use following drawdown. In addition, the designated quarry near the confluence with the Palouse River in the Lower Monumental reservoir must be developed and riprap loaded, barged, and stockpiled at eight underwater stockpile locations in the two reservoirs. These underwater locations will later become accessible when the water surface is drawdown. Overland transportation of rock materials to all the necessary reaches would be a monumental task of developing haul roads and hauling great distances.

In preparation for the following breach season at Lower Monumental and Ice Harbor Dams, an additional quarry must be developed in the Ice Harbor reservoir. Riprap from this quarry and the Lower Monumental quarry will be loaded barged, and stockpiled at 13 underwater stockpile locations in the two reservoirs. These underwater locations will later become accessible when the water surface is drawdown. Overland transportation of rock materials to all the necessary reaches would be a monumental task of developing haul roads and hauling great distances.

Use of a commercial source of riprap was assumed for required stabilization of levee sections in the vicinity of Lewiston, Idaho.

Steps in quarry development and material processing are generally as follows:

1. Establish access and haul roads.
2. Establish stockpile and disposal areas (these will change throughout the life of the quarry).
3. Establish loading, weighing, and traffic control facilities (usually one-time set-up for the life of the quarry).
4. Strip off and dispose of overburden from the usable rock formation (infrequent cycles).
5. Drill and shoot rock into manageable size material (periodic cycles).
6. Load and haul shotrock to grisly and bar screens (continuous process).
7. Crush oversize material, drill and shoot boulders, send to grisly and bar screens (periodic cycles).
8. Stockpile according to material size (continuous).
9. Load and haul finished product (frequent cycles or continuous).

Overland transportation of riprap from the quarries along the Lower Granite reservoir is a standard operation similar is scope to the pre-reservoir relocations contract work. Transporting the large volumes of material needed for the other three reservoirs in one or two construction seasons would provide a severe strain on the existing infrastructure and road system around the lower Snake River reservoirs. This factor, plus the very limited access to placement sites along the reservoirs, forces the more practical and economical choice of barging the riprap to placement locations.

Other factors that influence the overall duration of reservoir construction activities are productivity rates for quarrying rock, barge loading, barge transport, barge unloading, stockpiling, and placement of materials. For the development of unit prices, productivity rates for these activities were assumed based on the selection of a piece of “prime equipment” around which a crew of support equipment and labor were assembled. Typical construction activities, prime equipment, and corresponding productivity rates for riprap construction were determined and are summarized in Table F5.

When the supply requirements exceed the average productivity of a “prime equipment” set-up, then additional crew set-ups can be added, as long as working space is sufficient. Based on these assumptions and the use of multiple crew set-ups and multiple sources of suitable riprap, coupled with the already existing water shipping capabilities of the four lower Snake River reservoirs, the riprap supply needs can be met in one construction season and the riprap placement completed in one season.

Table F5. Typical Riprap Productivity Rates

Activity	Prime Equipment	Average Productivity
Quarrying rock	RT loader with 10.7 m^3 bucket	612 m^3/hr
Barge loading	RT loader with 10.7 m^3 bucket	612 m^3/hr
Barge transport	Barge with 1,200-hp tug (1,150 m^3/barge)	16 km/hr
Riprap placement	CAT 235D excavator with 1.6 m^3 bucket	30 m^3/hr

F.4.2 Stockpiling of Riprap and other Materials

Because of the poor overland access to many of the placement sites below Lower Granite Dam, a logical approach is to utilize barge transportation of riprap to those sites. For purposes of developing a complete plan and realistic estimate, in-water stockpile sites conveniently located to placement sites have been determined. These sites are situated such that after drawdown, they are above the low water elevation and allow vehicle loading operations to be staged at the stockpile site. The location of these sites has been coordinated with projected locations of spawning and rearing areas in the natural river to minimize impacts to those favorable areas. Since stockpile locations must be above the low water elevation and the work will done soon after drawdown before sediment transport in the river system has stabilized, the impacts resulting from in-water stockpiling should be minimal.

Prior to the respective reservoir drawdown, riprap and base materials are to be stockpiled. This work should be scheduled to be completed prior to the spring runoff in approximately March of the year that drawdown occurs.

F.4.3 Development and Upgrading of Access Roads to the River

Overland vehicle access to the Snake River can be extremely difficult in some locations. County and state roads parallel the river is some locations, there are a number of roads that access farms, grain elevators, and recreational areas. A number of the existing roads will require improvements and more frequent maintenance to provide access for large construction equipment. While the bulk of the materials will be pre-placed by barge, other materials, equipment, and personnel must access the work areas via these existing roads. Upgrades include regrading, resurfacing, widening at selected points, and adding turnouts. Maintenance activities include continued grading and pothole repair, dust control, and rock additions to maintain all-weather access.

Access to the Lower Granite reservoir will be primarily from Highway 193, a Whitman Country Road. This roadway parallels the reservoir from near Lewiston to Wawawai, within 3 miles of Lower Granite Dam. Access below Wawawai will be attained along the inundated road and railbeds from the either end.

Major roadways to the Little Goose reservoir include Highway 12 at Central Ferry and Almota Creek Road at Almota. Several minor roads provide intermediate access to the Little Goose reservoir. These minor roads will require modifications as described above.

Major roadways to the Lower Monumental reservoir include Highway 261 at Lyons Ferry and the Little Goose project access road just upstream. Several minor roads provide intermediate access to the Lower Monumental reservoir. These minor roads will require modifications as described above.

Access to the Ice Harbor reservoir is possible via a number of existing county and private roadways. Agricultural development is greatest in the lower 15 miles of this reservoir and access along this reach is available.

F.4.4 Treatment and modifications to river access roads

Modifications to the local infrastructure described above provides access to the river at numerous locations. Further access is necessary to travel along the river to all the reaches the require embankment stabilization and modifications to drainage structures. Access will be provided on existing, currently inundated, construction access roads, abandoned rail and road beds. Many of these road and rail beds were not removed after construction of the new rail and road sections. These will once again be available for use after drawdown.

Several treatments will be necessary to make these roadways serviceable. Many will require grading to remove sediments that have accumulated on the surfaces. The conditions of the aggregate surfacing on these road sections is not known. It is assumed that many of these sections will require the addition of material. Sections must be widened, turnouts added, and other modifications for construction operations.

The major problem with sequencing the work as a post-drawdown operation is the slow draining of the inundated embankments. Drawdown occurs between the months of August and December. Obviously, vehicle access to the old roadways is not possible until the materials “dry out.” Spring runoff between March and July prevents in-water placement of riprap. Work on the placement of riprap will not begin until approximately August. This allows 9 to 12 months for the embankments to drain and allow vehicle access to the river.

F.4.5 Placement of Riprap

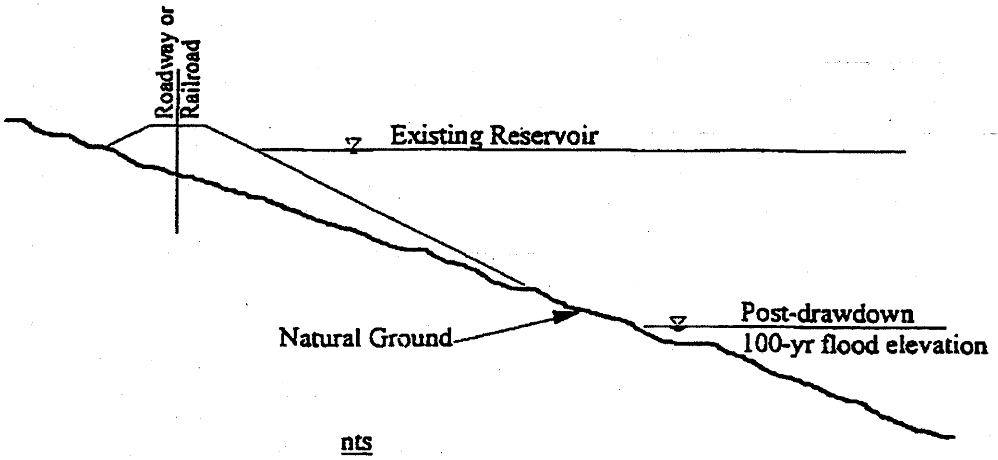
Riprap placement is a tedious and time-consuming operation. It generally requires the use of an excavator to place the rock and key the rock mat together. Areas that are difficult to access will require a dozer to pioneer a road to the placement area so the excavator can reach the placement area and haul vehicles can deposit rock near the excavator. Bedding material under the riprap will not be necessary for most of the reaches since the underlying material is rockfill, gravel materials, or a smaller riprap. The riprap must be keyed into the river channel to prevent undermining of the rock when high velocity flows occur. Because of the slow production rate for riprap placement, work must occur at many placement sites concurrently to get the work done at the projected schedule.

F.4.6 Placement of drainage modifications

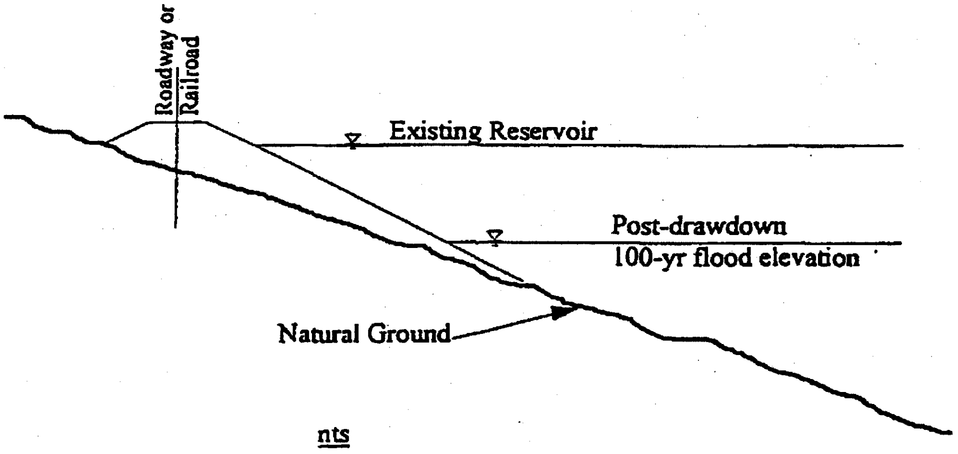
A detailed discussion of drainage system modifications is presented in Annex G – Drainage Structures Modifications.

Embankment Protection Criteria

1. No Protection Required: Post-drawdown 100-yr flood (320,000 cfs, or 9,056 cms) elevation below toe of embankment.



2. Erosion Protection Required: Post-drawdown 100-yr flood (320,000 cfs, or 9,056 cms) elevation above toe of embankment.



SHEET MAIN SCALE:

US Army Corps
of Engineers
Walla Walla District

LOWER SNAKE RIVER JUVENILE SALMON MIGRATION FEASIBILITY STUDY
EMBANKMENT PROTECTION CRITERIA

Figure:
F1

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SHEET MAIN SCALE:

US Army Corps of Engineers
Walla Walla District

LOWER SNAKE RIVER JUVENILE SALMON MIGRATION FEASIBILITY STUDY

EMBANKMENT PROTECTION DETAILS

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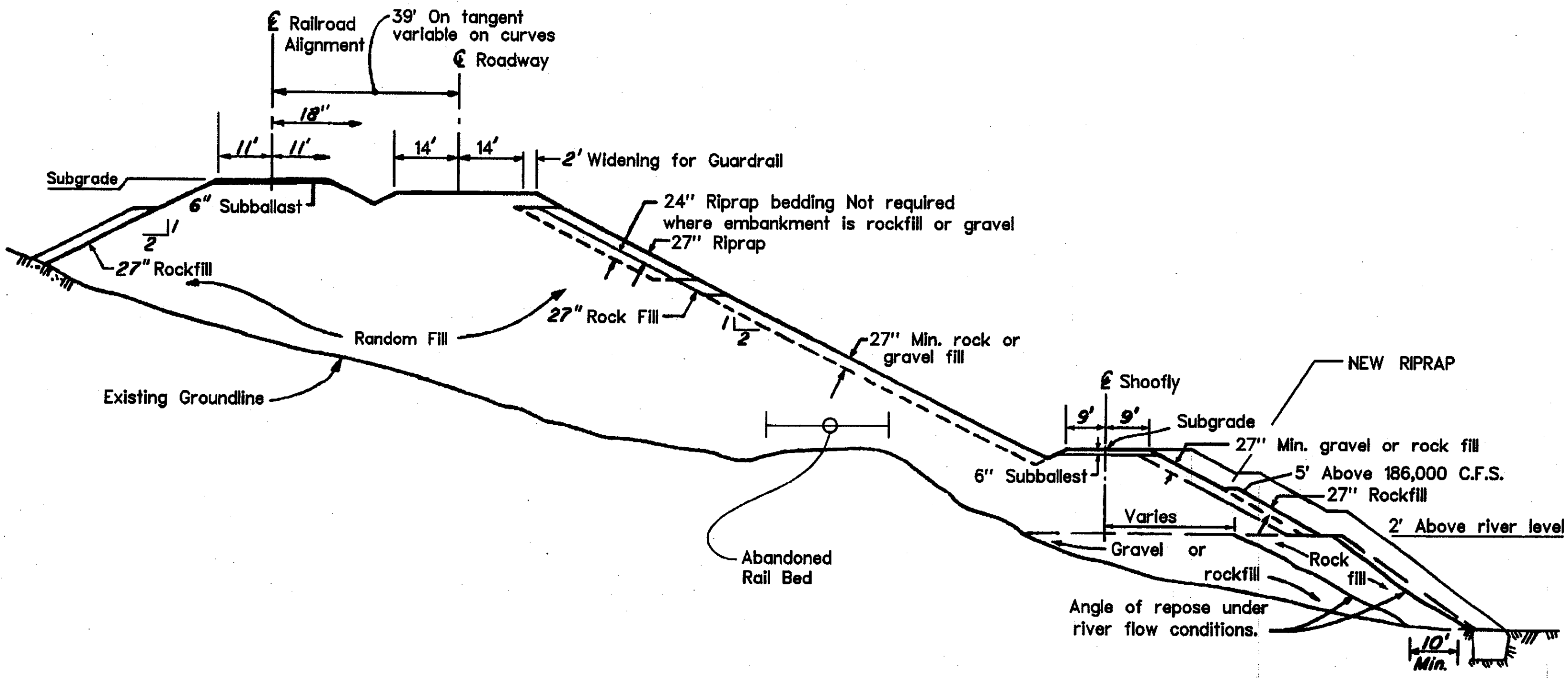
Figure:
F2



TYPICAL COMBINED EMBANKMENT SECTION

NOTES:

1. SHOOFLY IS A TEMPORARY RAILROAD EMBANKMENT TO DIVERT RAIL TRAFFIC DURING CONSTRUCTION OF NEW RAIL BEDS.