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PNM Fishway Site Visit and Sediment Management Investigation

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Background

Robert Norman, US Bureau of Reclamation Western Colorado Area Office in Grand Junction, CO asked me to investigate a reoccurring sedimentation problem at PNM fishway. The PNM fishway is located on the San Juan River in Fruitland, New Mexico. The fishway provides passage for native fish species past the PNM diversion weir. I visited the site on May 29, 2014 to observe flow in the vicinity of the fishway exit during spring runoff flow conditions. I was met at the site by Chris Cheek from the Navajo Nation Fish and Wildlife. Chris is responsible for operation of the fishway. We were able to visit both sides of the river and diversion weir.

San Juan River

The San Juan River originates largely in northwest New Mexico and southwest Colorado. The river is a predominantly a coarse bed (sands, gravels and cobbles) stream that experiences large pulses of fine sediment during spring runoff and fall thunderstorm events, Heins et al. Since construction of Navajo Dam in 1962 spring river flows are regulated. Large flows capable of scouring the river of fine sediments over its length no longer occur.

PNM Diversion Weir

The PNM diversion weir is owned by Public Service of New Mexico and was constructed to divert water to an off-river storage reservoir. Diversions are made intermittently as water is required to refill the reservoir. The diversion weir is a 170 ft wide broad crested weir, figure 1. The weir cross section (normal to the flow) is a compound trapezoidal shape. From each bank the crest slopes into the river at an 18 percent slope for 40 ft horizontal. The slope then decreases with the center 50 ft of the crest being nearly horizontal. The crest elevation at the lowest point in the center of the weir is 5085.5. The shape of the weir crest forces the river thalweg to the center of the river channel and supports shallow sloping banks upstream of the crest. The weir has a sluice gate adjacent to the PNM diversion channel on the right bank that is used to sluice sediment from in front of the PNM intake. The sluice gate did not appear as if it is frequently used.

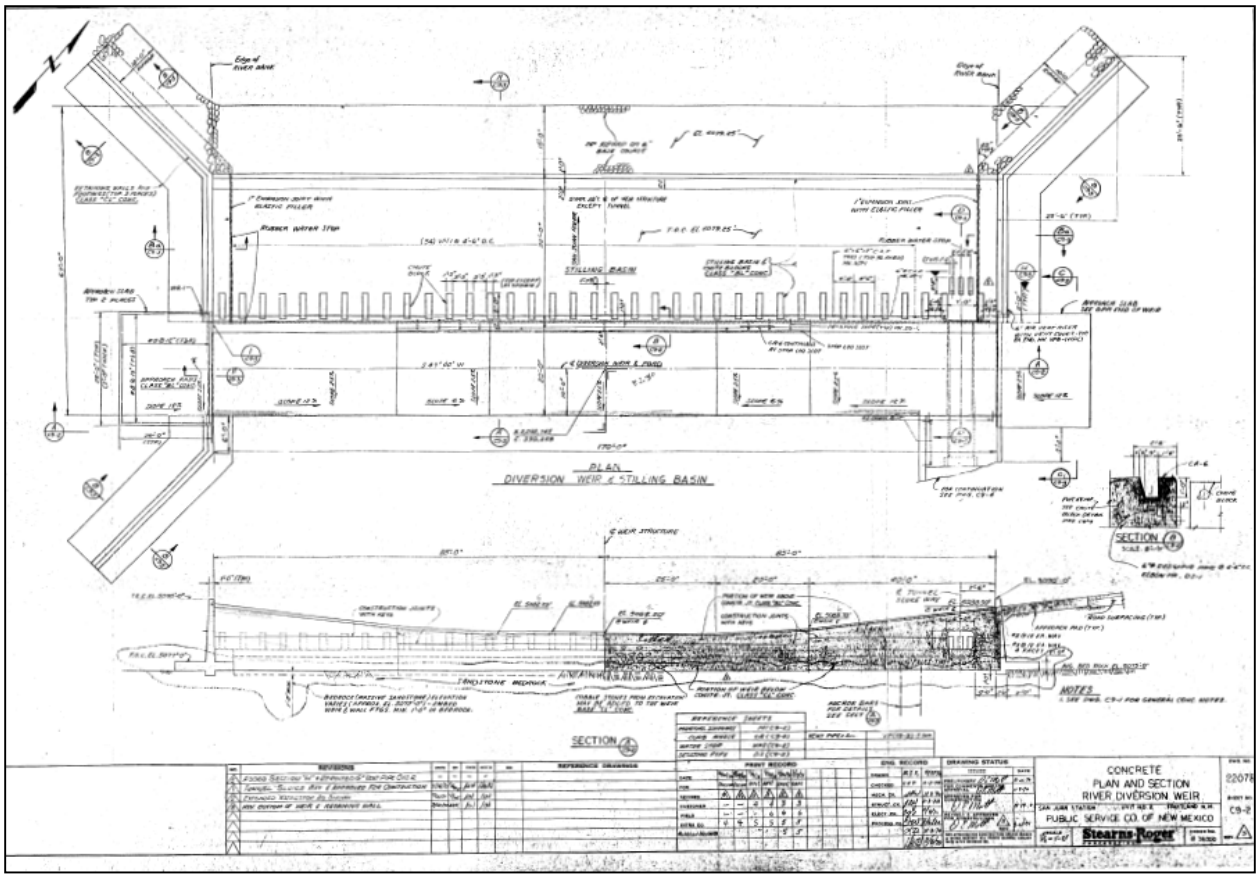


Figure 1 - PNM diversion weir design drawing showing weir plan and profile.

PNM Fishway

The PNM fishway is a low gradient roughened channel passing around the left abutment of the diversion weir, figure 2. The fishway operates as a selective passage facility. The fishway contains a fish trap near the fishway exit that blocks migrating fish from exiting the fishway. The Navajo Nation Fish and Wildlife close the fishway to empty the fish trap twice a day during the operating season of April through October. Native fish are released upstream and exotic fish are removed from the system. The fishway is located on the inside of the river bend. The fishway exit (flow entrance) is located about 150 ft upstream of the diversion weir. The fishway exit elevation is 5085.0 which is 0.5 ft lower than the center elevation of the diversion weir crest. Water surface elevations at the fishway entrance and exit (WSE across the weir) are given in table 1. Fishway flow and depth for a range of river flows are given in table 2. Flow velocity entering the fishway exit varies from about 1.4 ft/s at 57 ft^3/s fishway flow to 4.4 ft/s at 345 ft^3/s fishway flow. During the site visit the river was flowing at 3170 ft^3/s (Chris Cheek provided the river flow) at a water surface elevation at the fishway exit of 5090.08. Average flow for the date is 4470 ft^3/s based on the Farmington NM gauge.

Table 1 - PNM Fish Passage Facility Design Flows in San Juan River (Tetra-Tech, Inc 2000)

FLOW (ft^3/s)	U/S W.S EL.	D/S W.S. EL	DESCRIPTION
500	5087.56	5082.42	Low flow condition for fish passage operation
950	5087.85	5083.03	Average flow in August
4,000	5090.27	5084.99	Average flow one month before peak*
7,000	5092.07	5086.05	Peak flow each year
10,000	5093.29	5087.11	Maximum flow recommendation*
15,300	5095.26	5088.74	25-year return flood event
19,500	5096.71	5089.81	Regulatory 100-year flood event

Table 2 - PNM River and Fish Passage Design Flows (Tetra-Tech, Inc 2000)

RIVER FLOW (ft^3/s)	Passage Flow (ft^3/s)	Depth in Trap (ft)	Vel. in Trap (ft/s)
500	57	2.55	1.40
950	74	2.85	1.62
4,000	235	4.38	3.35
7,000	345*	5.0	4.31
10,000	410*	5.28	4.85
15,300	505*	5.62	5.62
19,500	565*	5.92	5.96

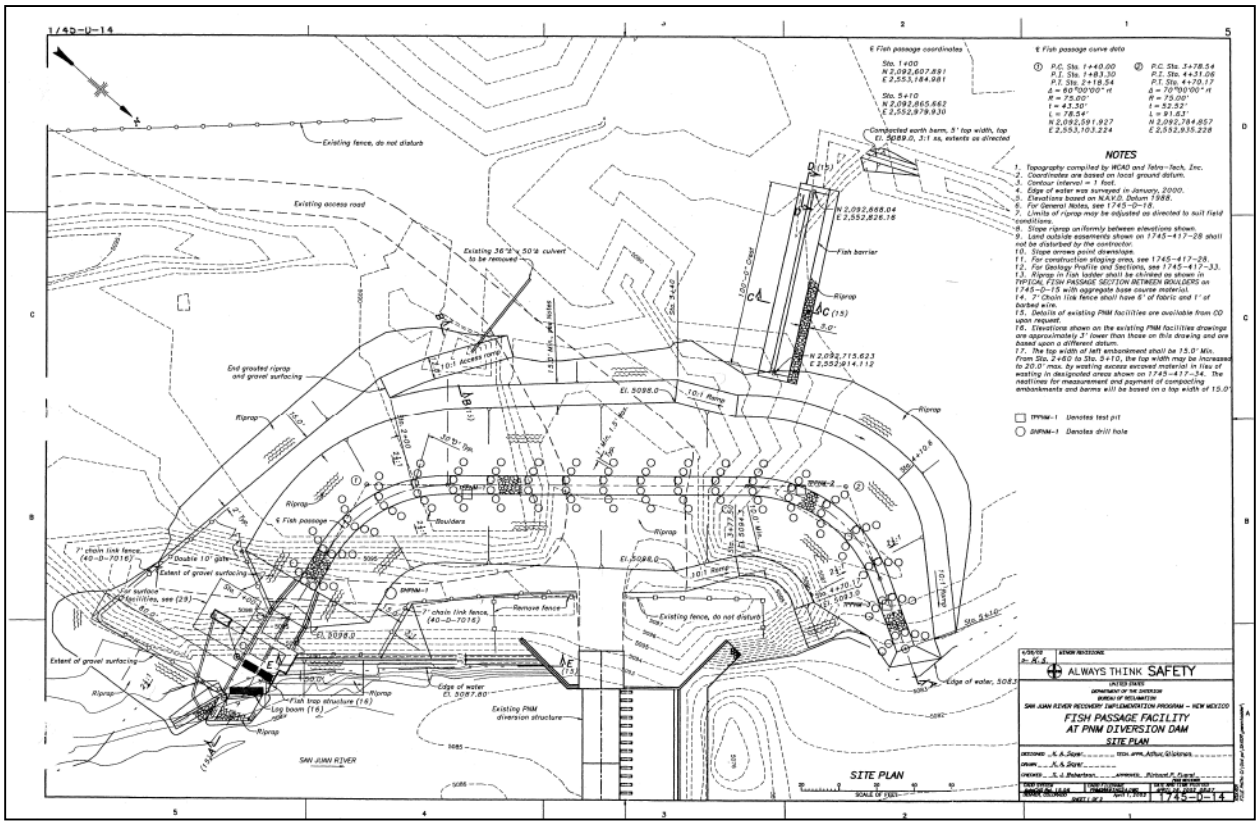


Figure 2 - Design drawing 1745-D-18 showing the PNM fishway. Flow is from left to right.

Sediment Issues Impacting Fishway Operation

Chris described several sediment issues that impact fishway startup and operation. Most are associated with the formation of a silt point-bar that forms along the left bank (looking downstream) upstream of the diversion weir. The weir acts as a node on the river that prevents migration of the river and natural channel development both upstream and downstream of the weir. Following weir construction, the stream slope within its backwater influence dramatically flattened, promoting sedimentation. Over time, sedimentation upstream of the weir has resulted in a gradual steeping of channel slope and likely some loss of channel sinuosity close to the weir. Based on historical aerial and satellite imagery, the river channel appears to be stable upstream of the diversion weir. The weir crosses the river at a point where the river channel plan form transitions from a long shallow left bend upstream of the weir to a sharp left bend downstream of the weir, figure 3. The channel upstream of the weir is nearly straight and aligned with the weir for 5,700 ft. Tortuosity, *Rc/w*, is a term used to define the ratio of the meander radius of curvature, *Rc*, to river width at bank full, *w*. Channel tortuosity values >3 are classified as channels where helicoidal flow is the predominate hydraulic force effecting meander development and bank stability (NRCS, 2005). As tortuosity

increases (channel straightening) the strength of helicodial flow decreases. The tortuosity within a mile upstream of the weir ranges between 6 and 10. Henderson, 1966 suggests values in the 6 to 10 range reflect low strength helicoidal flow capable of moving small bed material.

During low water the river thalweg is visible from Google Earth imagery following the right bank well upstream of the weir, figure 4. Above bank full, the river's right bank upstream of the weir spreads onto a broad, heavily vegetated flood plain within the river's meander belt. Below bank full, the right bank is steeper and does not appear to be armored, figure 5. Upstream of the fishway the left bank follows a steep bluff for about 1 mile with little floodplain. The river's high fine sediment load, mild bend and the influence of the diversion weir all influence the development of a sediment bar along the left bank. The left bank sediment bar can extend for about 1000 ft upstream of the diversion weir. The bar grows during high flows, becoming a broad exposed silt flat as river stage drops, figure 6. The bar can build to the extent that it disconnects the river from the fishway leaving the fishway without water as river flow and stage drop. The problem is most common in the spring when the fishway is opened, in mid-summer following the high flow season and following fall thunderstorms. A fairly extreme example occurred in 2005 when San Juan River experienced high spring and summer flows followed by fall thunderstorms, figure 7. Photographs from the fall of that year show the extent to which the left bank point bar can develop. As flows dropped in September a sediment deposit several feet higher than the fishway invert was exposed, blocking flow from entering the fishway. A long-boom trackhoe was brought in to excavate a channel through the sediment deposit, figure 8. A series of thunderstorm events in October caused a rise in river flow and again sediment sealed off the fishway exit, figure 9. The point bar growth in 2005 was greater than in lower flow years, but sediment bar formation impacts fishway flow in most years. Chris explained that fall thunderstorms can cause a large rise in river sediment load due to activation of flow in upstream arroyos. This process was documented by Heins, et al. as a major contributor of fine sediments to the upper San Juan River. Although no sediment size distribution data close to the fishway was available for this report, photographs of flow cutting through the deposits show the material is largely fine sand and silt, figure 10.

Chris also described finding greater silt deposition immediately in front of the fishway exit with the greatest deposition on the left side of the exit. Elevated deposition in this location is probably caused by two factors; a slow velocity wake zone that forms behind the upstream apron wall and rapid plugging of the fish trap bar racks when the river is transporting significant debris. Both factors reduce flow velocity near the exit and promote deposition. Observation of the normal pattern entering the fishway could not be made during the site visit as the left bay slide gate was shut for repairs and therefore fishway flow was skewed toward the right bay. A strong flow separation was observed off the upstream apron wall that deflected near bank river velocity away from the intake, figure 11.

Figure 3 - Google Earth 2012 view of river channel. Flow is from bottom to top.

Figure 4 - 2006 Google Earth view of the fishway, diversion dam and upstream river during low water. Flow is from bottom to top.

Figure 5 - View of right bank across from the fishway exit during low water. Note shallow depth and silt bar in front of fishway exit. (R. Norman, USBR).

Figure 6 - View looking upstream from fishway exit along the left bank. The riprap slope upstream of the fishway is seen on the right. (R. Norman, USBR)

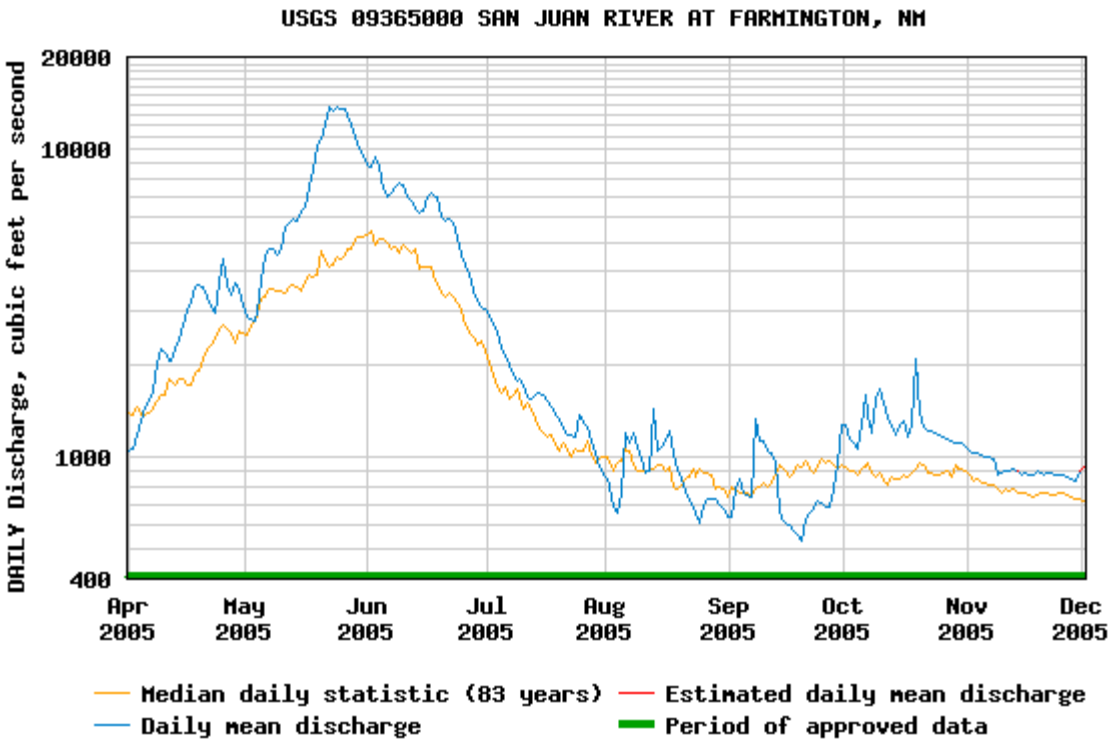


Figure 7- Hydrograph showing San Juan River flows in 2005.

Figure 8 - Trackhoe removing silt from in front of the fishway exit in September 2005. (USBR)

Figure 9 - Silt and sand deposition in October 2005 following thunderstorm events. (USBR)

Figure 10 - View showing the small grain size of the sediment deposit. (R. Norman, USBR)

Figure 11 - View of flow separation off the upstream wing wall during the site visit.

Discussion of Possible Actions

The applicability of a number of sediment management techniques were investigated to address the sediment problem at PMN fishway. These include river management and site management methods found in literature and from personal experience. The objective of this study is to provide the first step in identifying and assessing viability of sediment management alternatives. The discussion provides preliminary design guidance based on available data. Design guidance is presented to facilitate further study, alternative selection and feasibility design. Planning level cost estimates received from manufacturers for equipment discussed herein are presented. Written quotes are attached at the end of this report for reference.

River Management Techniques

Altering formation of the point-bar to the extent that it no longer impacts fishway operation may not be possible as the site is within an urban area and directly across from the PMN water intake facility. There is precedent for using barbs, river training walls and river realignment to alter local thalweg alignment and depositional zones. Barbs are the most common and least intrusive of these methods. Barbs, bendway weirs and reverse sills are all terms used to describe the same type of submerged vane. Barbs are commonly used to prevent erosion of the outer bank of a stream bend by redirecting a portion of the near bank flow toward the center of the channel and altering secondary flow currents within the bend. Barbs are similar to rock jetties except they are sloped downward into the river with the majority of the

structure submerged during high river flows, figure 12. Typically a series of barbs are constructed along a bend to prevent bank cutting, figure 13. Barbs are aligned upriver from 45 degrees to 60 degrees to redirect near bank flow away from the bank and create a low velocity zone behind the barb.

At PNM, properly located barbs along the right bank could be investigated for the purpose of moving the river thalweg to a more river center location in the vicinity of the fishway exit. If successful, the left bank point-bar would be reduced but probably not eliminated. Studies have shown that barb structures can be used to alter thalweg alignment and major depositional patterns (3,15). LaGrone (3) suggests that constructing barbs of length greater than one-third the river width can result in thalweg movement and impacts to the opposite bankline.

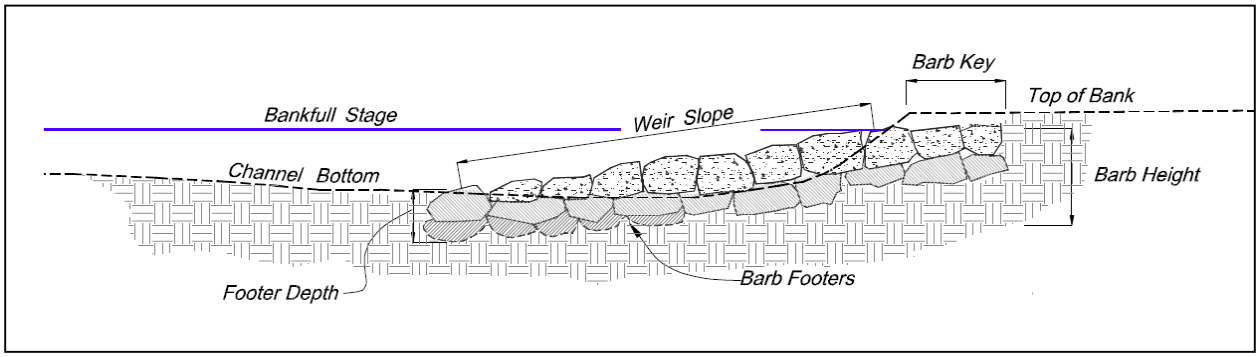


Figure 12 - Schematic showing a barb profile, NRCS Technical Note No. 23.

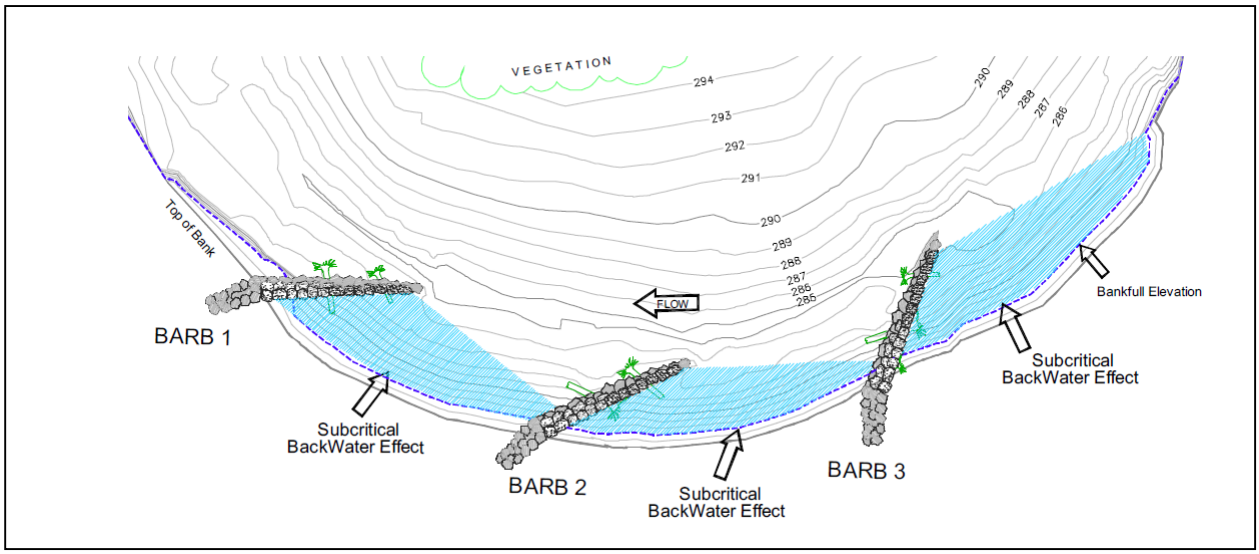


Figure 13 - Schematic showing a series of barbs spaced along the outside of a river bend, NRCS Technical Note No. 23.

Explicit guidance for designing barbs to alter stream thalweg location and opposite bank flow patterns was not found during the literature review for this project. However, laboratory and field studies of barbs designed for bank protection provide some insight for this purpose (3,8,11,15). As a starting point for a more detailed study, the following design guidance is offered. In general barb design should follow NRCS or COE design standards (8,15). Barb designs including deviations from the standards suggested herein should be numerically modeled using preferably 3-dimensional models with movable bed capability (COE and USBR). One to three barbs are likely sufficient to impact thalweg location in the river reach upstream of the fishway. Barb length should be between one-third and one-half the bank full river width and angle upstream at 60 degrees from the bank. The downstream most barb should be located such that a line normal to the barb at its mid-point intersects the opposite bank near the fishway upstream wingwall. Barbs should be spaced at 5 to 6 times the barb length which is on the high side of standard design criteria. Altering the river flow pattern using barbs can result in unexpected consequence, especially during channel forming flows and therefore, must be thoroughly investigated. Changes in the river due to altering the thalweg near the fishway would likely be constrained to the reach between the dam and upstream most barb. At greatest risk for adverse impacts would be the PNM intake located on the right bank and the left bank upstream of the fishway exit. It is possible the PNM water diversion could see an increase in sediment load. It is also possible the left bank adjacent to the steep slope that has a narrow overbank area could experience some bank erosion during bank full or greater flows. This approach would require significant study and cooperation of impacted land owners during construction.

Site Management Techniques

Numerous sediment management techniques for local control of sediment deposition were also investigated. Some of the local control techniques discussed herein would also benefit from field experimentation and/or numerical modeling. The best solution may be arrived at using a combination of approaches.

Modify the Upstream Wing Wall

The alignment of the upstream wing wall appears to deflect flow away from the fishway exit, causing flow entering the fishway to be skewed in favor of the downstream bay. As previously discussed, flow conditions during the site visit were not typical as the left fishway bay was closed for repair to the control gate. This made it impossible to view flow conditions entering the fishway with both bays operating. Chris Cheek said he didn't believe the eddy was as strong as we witnessed with both gates operating, but he felt the right fishway bay always carried

more water due to approach conditions. The wall supports the end of the fish return pipe and the upstream riprap bank protection. Figure 14 uses Google Earth imagery to show a comparison of the 1997 pre-project vegetated bankline with the project bankline in 2013. The vegetated bankline in 1997 is shown by the red line on both images. River flow was higher in the 1997 image than in 2013 as shown by greater inundation of the upstream bank. A comparison of the images shows construction of the fishway facility moved the high flow bankline into the river and created a sharp offset in the bankline at the fishway exit. The changes in the bankline due to the fishway facility and wing wall likely reinforce deposition in the fishway exit but not overall point bar growth.

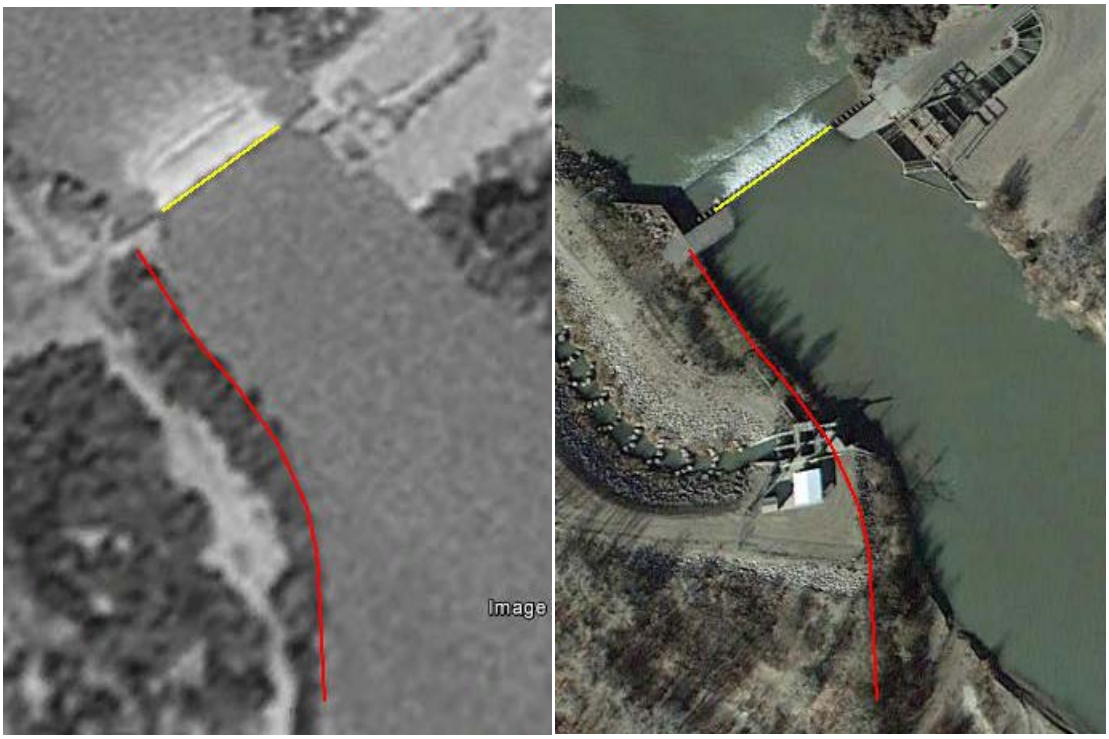
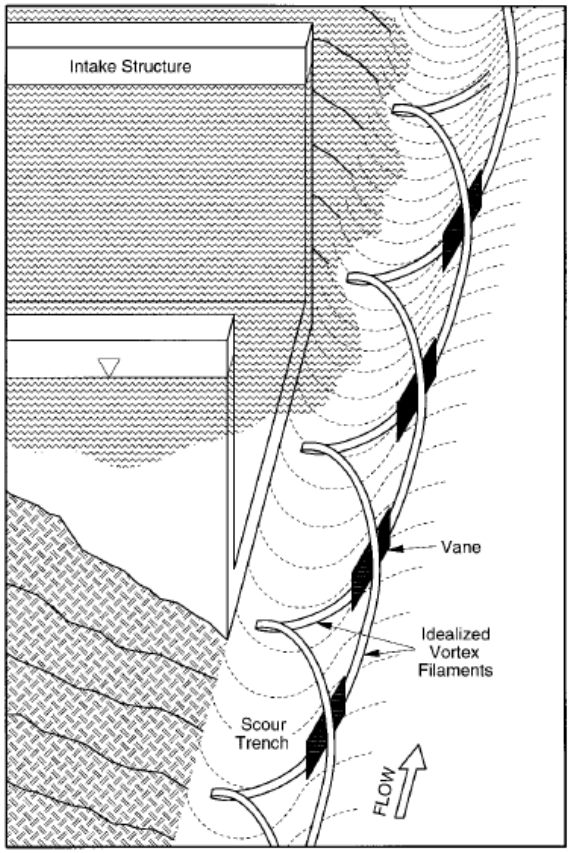


Figure 14- A comparison of Google Earth imagery showing pre-project bankline in 1997 and post project bankline in 2013. The red line shows pre-project bankline in both photographs.

Submerged Vanes

Submerged vanes for managing movement of bed load sediment have been widely studied (1,2,6,7,9,10,12,13). Vanes can be as simple as planks suspended between piles driven in the river bed. They are used to locally alter the secondary flow patterns in a river that drive bed load shoaling. Typically one or more lines of vanes are used to alter the movement of sediment moving along the channel bed. Vanes are aligned at an attack angle to the flow of between 10 and 20 degrees to cause flow circulation around the vanes that moves bed material transverse to the vane alignment, figure 15. Vane height extends from near the channel bottom to 0.2 to 0.5 times the design depth during major shoaling. Vane heights of between 0.4 and 0.5 design depth are most typical. Vane length should be between 2 to 3 times vane height. Vane spacing depends mainly on flow velocity and the dominate bed load particle diameter. Spacing vanes between 1 to 2 vane lengths apart is often cited for sand bed channels. Vane lines are typically spaced apart between 1 to 2 design flow depths. Submerged vanes have been largely used to modify flow conditions in front of water intakes to reduce entrainment of bed load during flow diversion. A physical model study by Nakato et. al. (7) illustrates a typical vane array design, figure 16.



submerged vane line presented by Barkdoll et al., 1999.

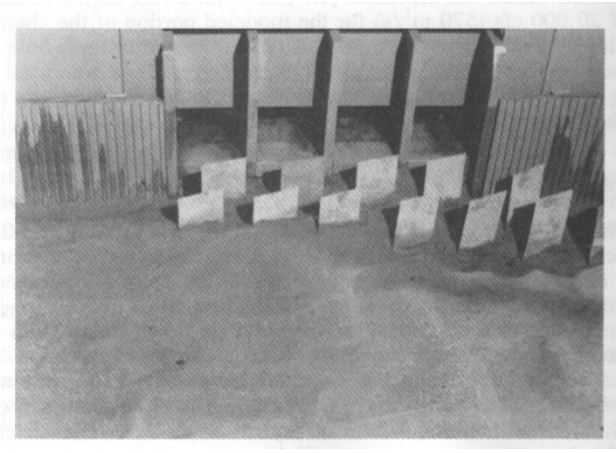


Figure 16 - Photograph of a physical model study of submerged vanes used to reduce bed load entrainment into a diversion intake. (Nakato et al.)

Barkdoll et al. (1) suggests submerged vanes can also be used to intercept bed load upstream of a diversion and move it away from the bank. He recommends using two or more parallel lines of vanes placed upstream of the diversion with the lines angled into the major flow direction at 10 degrees, as shown in figure 17. Figure 18 illustrates what Barkdoll's upstream vane array might look like applied at PNM fishway. The example vane array shown was developed based on the general vane design guidance cited above. The array is composed of 8 ft long vanes 3 ft high set on a 10 degree angle from the bank. The vanes are spaced 16 ft on center with the two lines set 12 ft apart (2 design flow depths). A 15 degree vane attach angle (α) is shown for illustration. The angle should be determined following a site flow survey defining velocity patterns. The design guidance found in the literature gives a range of parameters that are often refined by conducting numerical or physical model studies. At PNM the complex flow patterns that occur near the fishway exit should be modeled along with submerged vane placement to evaluate vane array effectiveness.

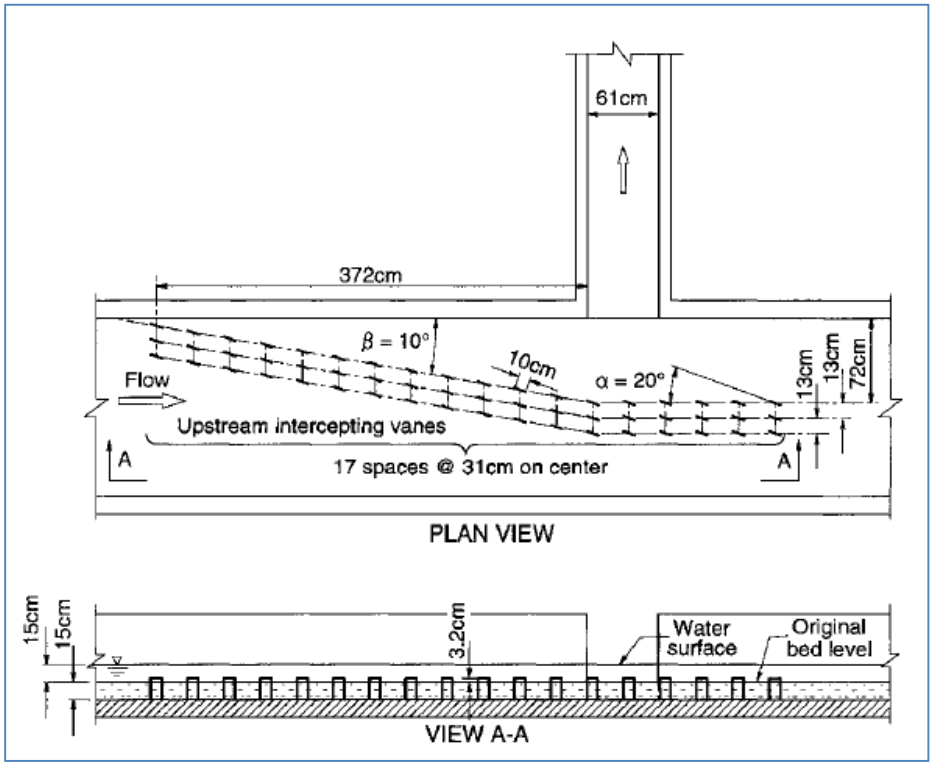


Figure 17 - Drawing of a submerged vane design for intercepting bed sediment upstream of a diversion intake and moving it away from the intake. (Barkdoll)

Figure 18 - A conceptual view of two submerged vane lines designed to intercept bed load upstream of the PNM fishway moving it away from the intake.

High Pressure Air/Water Silt Resuspension System

High pressure air burst, water jetting or combination systems are used in large tanks, settling ponds and around hydraulic structures to resuspend fine sediments during system flushing or as a routine sediment management practice in raw water diversions. Resuspension systems use a pipe system containing orifices or nozzles to release air or water under pressure near the invert. Figure 19 shows an air burst system used to resuspend fine sediment that deposits in the low velocity zone behind a large fish screen. Manifold pipe arrangements are often used to achieve a wide coverage area of flow turbulence as the pressurized fluid is released. Pressurized air in the range of 90 to 120 psi or water pumped at 40 to 90 psi is typically used. The sediment must be light enough to be entrained by vertical turbulence generated during the sudden release of the pressurized fluid near the bed. Material must also stay in suspension long enough for flow currents to transport the material downstream. A 1 mm dia. sand grain has a settling velocity of 0.36 ft/s in standing water. Assuming a system is designed to lift 1 mm sand material 1 ft off the bottom, flow velocity into the fishway or down the river would need to be on the order of 2 ft/s or greater to achieve a reasonable displacement of material per operation. Orifice or nozzle sizes typically range between 0.5 to 1 inch diameter. A minimum water depth above the sediment of about 20 orifice or nozzle diameters is recommended to achieve a strong turbulent flow field. Greater submergence depth is desirable for air burst systems which rely on the sudden displacement of water due to the rapid expansion of air as it

Figure 19 - Photograph of a compressed air sediment resuspension system used behind fish screens at RD108 in California. (USBR)

enters the water column. Greater depth allows the air cavities greater time to expand and move upward while entraining the surrounding water. Re-suspension systems are not well suited for sediment deposition areas where sediment largely moves as bed load. Systems are normally operated at regular intervals to resuspend sediment before sediment deposition depths become large. Air burst or water jetting several times a day may be required during periods when sediment deposition rates are high. Water jetting systems may be preferable where sediments require greater force to resuspend bed material and where coverage area is relatively small, as pumped flow requirements can be large. An example of the minimum flow requirements for a water re-suspension system for medium sands and silts would be 0.1 ft^3/s pumped flow per discharge port at a pressure of 40 psi or greater. This is based on using 0.5 inch diameter full-cone spray nozzles with a 30 degree spray angle and one nozzle per square foot of treatment area. Air burst systems are better suited when coverage areas are large and access to debris free water for pumping is not available. Air burst systems require an air compressor and pressure tank sized to meet the air flow requirements of the air distribution manifold and desired air release duration. A cautionary note on this approach is warranted. If the sediment contains significant amounts of large bed material that is too heavy to be resuspended, the turbulent action will simply result in a layer of coarse bed material overlying the pipe manifold which would require removal by hand. A number of sediment samples should be taken following several high flow events to determine the sediment size distribution. Further evaluation of this type of system should include an onsite pilot study on a small area to determine appropriate port spacing, orientation, release pressure and flow rate for resuspending the sediments.

Dredging

Hand operated dredges designed specifically for managing sediment accumulation around in-water facilities like docks, pump intakes and diversion structures are commercially available. These types of dredges are typically designed to remove small gravel and finer material using a combination hydraulic jetting and strong suction. Most do not have a mechanical cutter head found on larger dredges, therefore they are not recommended for highly cohesive sediments. They are most effective for removal of non-cohesive materials or deposits containing sand, silt and clay that disperse when hit by a strong water jet. Small dredges require the dredging head be submerged a minimum of about one foot to maintain pump suction and are typically limited to about 20 to 25 ft of suction pipe length. Dredges can be shoreline or boat mounted units. A boat mounted dredge would provide the greatest flexibility but would require a number of safety issues to be addressed due to the close proximity of the downstream weir. An example of a shoreline application would be a dredging unit mounted on a movable platform supported on piles located near the end of the fishway exit channel. The platform could be raised to the fishway deck level for storage and lowered to the water surface for dredging using the overhead crane. An operator would wade in the river while guiding the dredge head. A shoreline facility would limit the dredging reach to the maximum suction pipe length specified for the dredge (~20 to 25 ft). Commercial vendors contacted estimated a small dredge designed to pump large sediment loads would require four to eight hours to dredge a 40 ft by 20 ft channel 3 ft deep. Maintaining a channel through the point bar would likely require dredging in the spring and fall as the river stage drops and prior to the sediment bar being exposed. A small dredge manufactured by Piranha Pumps & Dredges in Albuquerque, New Mexico is shown in figure 20. Their small series sediment dredges cost between $8,000 and $10,000 depending on size and if a raft is included.

Figure 20- Photograph of a small dredge designed for excavating small gravel, sand and silt. (Piranha Pumps & Dredges)

Sluice Gate at Fishway Exit with Buried Pipe between Fishway and the River Downstream of the Diversion Weir

A water surface difference of about 5 ft or more occurs between the fishway exit and tailwater below the diversion weir for all river flows. The head is sufficient to consider the benefits of adding a sluice gate in the fishway exit. Sluicing sediment is a common technique used to manage sediment deposition in slow velocity areas near water diversions. Sluice gates are set close to the water intake with the sluice gate invert typically set several feet below the elevation of the diversion. The intake area where sediment is effectively sluiced depends mainly on the bed shear stress required to scour sediment deposits, intake geometry and the interaction of the resident flow field and that of the sluice generated flow field. A sluice located at the fishway entrance would require about 175 ft of pipe running between the fishway exit and downstream side of the diversion weir. The pipe invert would have to run from about elevation 5083 upstream to elevation ~5082 downstream. The diversion weir is a major obstacle to constructing a pipeline. The pipe would have to pass around the diversion weir following the right fishway berm, requiring about a 15 ft deep trench, or pass through the left edge of the weir. For the purposes of assessing feasibility, a 24 inch diameter pipe is assumed. A 24 inch dia. pipe would convey 20 to 25 ft^3/s flow from the fishway exit to downstream of the diversion weir. The sluice would generate a flow velocity at the entrance of > 6 ft/s or about double that of flow entering the fishway when unimpeded by sediment. A sluiceway gate located on the downstream wall of the fishway entrance would likely prevent major sediment deposition in the fishway entrance if it could be operated continuously. Operating a sluice in the fishway entrance during the fish passage season would require moving the fishtrap fish return to a location upstream of the fishway exit to prevent entraining fish from the fishway. To determine if sluiceway flow in combination with the fishway flow would maintain a channel through the point bar during high sediment laden flows would require modeling of the river and fishway flow field.

Winter Fishway Operation with Fish Barrier in Fishway

Winter operation of the fishway could reduce sediment deposition upstream of the fishway exit in the spring by having continuous fishway flow and sediment entrainment during the winter. This alternative would require a fish barrier be installed in the fishway during the normal winter shutdown and removed in the spring prior to passage startup. Preventing passage from October through mid-February could likely be accomplished with a 2 ft high inclined bar rack installed about 150 ft downstream of the exit structure or at about station 2+70. A bar rack inclined downstream at about a 30 to 45 degree angle from vertical is recommended. Inclining the bar rack increases fish barrier performance by allowing fish to swim under the inclined bar rack to the upstream toe where it is anchored to the bed. A bar rack with 3/4 inch openings

between bars conforming to the fish trap barrier is recommended. The barrier could be designed in sections to allow manual installation. The upstream toe of the barrier should be anchored in the fishway rock or mounted to a permanently installed concrete or steel sill. Legs running from the barrier top at an angle to the downstream channel bed provide support. Should the barrier become plugged with debris or ice, flow would pass over the top while maintaining a 1 ft water surface differential for river flow less than about 2000 ft^3/s. After mid-February the chance of flows exceeding 2000 ft^3/s increases. A plugged barrier operating as an over flow weir (plugged) at river flows above 2000 ft^3/s would provide less than 1 ft of water surface differential due to submergence of the barrier toe. Consultation with the fish recovery team would be needed to determine if an inclined barrier providing a worst case 1 ft differential would be an acceptable fish barrier for winter operation when water is cold and fish activity is low**.** This alternative would not significantly change sediment deposition that occurs during summer and fall. Figure 21 shows a temporary bar rack fish barrier used to block fish from entering a rock fishway at Pyramid Lake near Reno, Nevada.

Figure 21 - A temporary fish barrier deployed in the Pyramid Lake fishway to control fish entry. (B. Heiner, USBR)

Deck Mounted Backhoe

Deck mounted backhoes are used to clean trashracks and sediment from water intakes. They are typically custom designed to meet the needs of each facility. A rail mounted backhoe used at Rosa Dam in Yakima Washington is shown in figure 23. The unit is used to clean the

trashrack. The deck of the PMN fishway exit channel would have to be extended out in front of the trashrack to support a deck mounted backhoe. To clean the PNM fishway apron area a boom reach of about 30 ft would be needed. It was not possible for this study to determine if a deck mounted backhoe with sufficient reach was feasible.

Figure 22 - Deck mounted backhoe trashrake cleaner at Rosa Dam, Yakima WA.

Active Cleaning of the Fish Trap Upstream Bar Racks

The fishway exit channel contains two identical fish trap bays separated by a center pier wall. Upstream of the fish traps are a slide gate in each bay and a coarse trashrack with 4 inch openings. Fish traps provide for selective fish passage which is a critical function of the fishway. Each trap consists of an upstream and downstream bar rack. The upstream bar rack is a flat panel designed to prevent upstream passage of fish larger than the bar spacing, figure 23A. The downstream bar rack is an upstream pointing "Vee" shaped bar rack designed to allow fish to swim through a narrow center slot into a pool between bar racks, figure 23B. The trap bar racks have 1.5 inch wide by 3/16 inch thick bars on 15/16 inch centers providing a 3/4 inch clear opening between bars and an 80 percent open area, see drawing 1745-D-22. Reference drawings are attached at the end of this report. The upstream racks are supported on angle guides inclined downstream at about 14 degrees off vertical. The racks seat on an embedded steel angle set at 14 degrees off horizontal. The angle is recessed 4 inches on the angle such that the bar racks set flush with the channel invert, see drawing 1745-D-20.

The bar racks are cleaned by hand during fish recovery operations. Chris Cheek stated that the upstream bar racks are frequently found to have large water surface differentials across them. He also pointed out the problem can occur throughout the spring, summer and fall as debris loads are often highest during thunderstorm events. During periods of high debris load the racks can become totally plugged within minutes. In a two hour period during the site visit a water surface differential across the right side bar rack of about 1.5 ft developed under what appeared to be a low to normal debris load for spring runoff. Even partial plugging of the fish trap bar racks can significantly reduce fishway flow, impacting both fish passage performance and sedimentation upstream of the trap.

Figure 23A - View of upstream fish trap bar rack.

Figure 23B - View of downstream fish trap Vee shaped bar rack.

Maintaining high fishway flow is important for effective fish passage, fishway attraction at the entrance and moving sediment through the fishway. Unlike most water diversions where bed load entrainment into the diversion intake is highly undesirable, the fishway can convey high sediment loads through it without major problems as long as fishway flows remain high. It would require detailed modeling to quantify the impact of fishway flow on sediment bar growth in front of the fishway. Without further study we simply know bed load entrained into the fishway is no longer available for sediment bar building in the fishway exit.

Cleaning the racks should include a method that can remove debris as opposed to passing it downstream ahead of the downstream Vee rack. The upstream trap bar racks extend from the channel floor up 6.875 ft on a 4:1 slope (V:H). The top of the racks are about 7 ft below the top of deck. Two common methods for mechanically removing debris are traveling belt screens or trash rakes. Both types would need a debris sluice, conveyor or debris collection area.

Traveling Belt Screen

Traveling belt screens are commonly used to screen debris and, in many cases, fish from diversion flows. Traveling screens are composed of a porous screen belt that rotates around horizontal rollers or fixed guides. The belt rotates moving upward on the upstream screen face. Water is filtered as it passes through the upstream screen face. Water then passes a second time through the screen as it passes out the downstream screen face. Debris is carried up the screen face and typically swept or sprayed off into a conveyor or hopper. There are several manufacturers of traveling debris screens. Screens with no bearings or moving guides within the water are best suited for locations with high sand and silt loads. A traveling fish screen built by Hydrolox Screens is shown in figure 24. The screen belt is the only moving part below the water surface.

Figure 24 - Photograph of an inclined Hydrolox traveling fish screen.

There are several issues that must be considered for using a traveling screen at PMN. These are: screen location, screen angle, bottom blanking area, screen headloss, screen height, screen cleaner and debris removal method.

Screen location- A traveling screen would likely have to be located upstream of the trap bar rack. The downstream faces of traveling screens are not designed to be fish friendly. Replacing the bar rack with a traveling screen would require specialized screen seals on the downstream face designed to be fish friendly. Fish protection would be a significant concern along the invert as the screen belt is moving downward and creates a pinch point along the bottom guide. Placing a traveling screen upstream of the bar rack would require removing the upstream access ladder and designing a debris removal system on the back side of the the screen that would allow for removing the upstream fish trap bar rack.

Screen angle- Locating screens upstream of the trap bar rack would limit the screen angle to the 14 degree angle of the trap bar rack. Debris screens are typically sloped to allow debris to ride up the screen face. The steep slope required for a screen at PMN may require a belt with horizontal flights (cleats) to prevent debris from continuously rolling back down the front face of the screen.

Bottom blanking area- Bottom blanking area refers to the area (height of blockage multiplied by width of screen) at the bottom of the screen taken up by the screen frame, lower screen guide and seals that do not provide for flow passage. The typical blocked height at the bottom of a traveling screen is between 0.5 ft and 1.0 ft depending on screen frame design. Where possible, screens are often recessed below the channel invert to eliminate blocking of flow. Recessing a traveling screen at PMN would require saw cutting slots wider than the screens the full width of each bay. The concrete floor in the PMN fishway exit channel is 1.5 ft thick with a #6 rebar mat several inches below the concrete surface. A structural assessment of the structure would be required to determine if the structural modifications required to slot the floor for flush mounting screens is possible. Not flush mounting the screens would reduce flow area and likely result in sediment deposition upstream.

Screen headloss- Headloss is the energy required to pass water through the screen expressed as change in water surface elevation from upstream to downstream of a screen. Increased screen headloss requires higher upstream pool elevation to pass a set flow or flow is reduced. Headloss is a function of the screen belt porosity, screen frame blockage and flow velocity. To prevent excessive headloss the traveling screen should have a percent open area similar to the 80 percent open area of the trap bar rack and cause minimal flow blockage. The headloss of different traveling screens varies and many are poorly documented. Headloss values documented for traveling belt fish screens should be increased to account for the much higher flow velocity in the PNM channel compared to most fish screen applications.

Screen height- A standard traveling screen installation would extend from the channel invert several feet above the structure deck depending on the debris removal method. PNM would require screens between 15 and 17 ft in length. Installing screens that do not extend above the deck would require a specially designed screen drive and debris capture system.

Screen cleaner- High pressure water spray is the most common form of screen cleaner used on traveling screens, however, brushes and scraper bars can also be used on some screens. Debris impinged on the screen belt is passed over the top of the screen and washed, brushed or scraped off on the back side. High pressure water spray systems are typically used on vertical or near vertical screens to dislodge debris from the screen. An even spray over the screen surface spray is achieved using a horizontal pipe the width of the screen with evenly spaced spray nozzles (3 to 4 inch spacing is typical). Commonly the spray bar is positioned inside the screen spraying outward through the screen belt. In addition to the screen, a pump

sized to provide the spray flow at the design pressure is also required. Spray pressure is typically between 40 and 90 psi depending on the debris type and load. In addition, a water strainer is required to remove particles large enough to plug the spray nozzles when raw water is pumped for the spray wash. If the debris at PMN is largely saturated woody material, a 40 psi pressure spray wash system possibly utilizing the existing sump pump would be sufficient. A flow strainer would be required on the pump discharge line to prevent plugging of spray nozzles.

Debris removal method- After being removed from the screen, debris must be transported away or collected and periodically removed. Water sluices or conveyors are frequently mounted on the back side of traveling debris screens to collect and carry the debris away from the screen. At PMN a water sluice system serving both screen bays would provide a simple means of removing screen debris. Debris could be flushed across the deck and wasted over the downstream wall.

A traveling screen installed in a PMN fishway exit bay would look approximately as shown in figure 25.

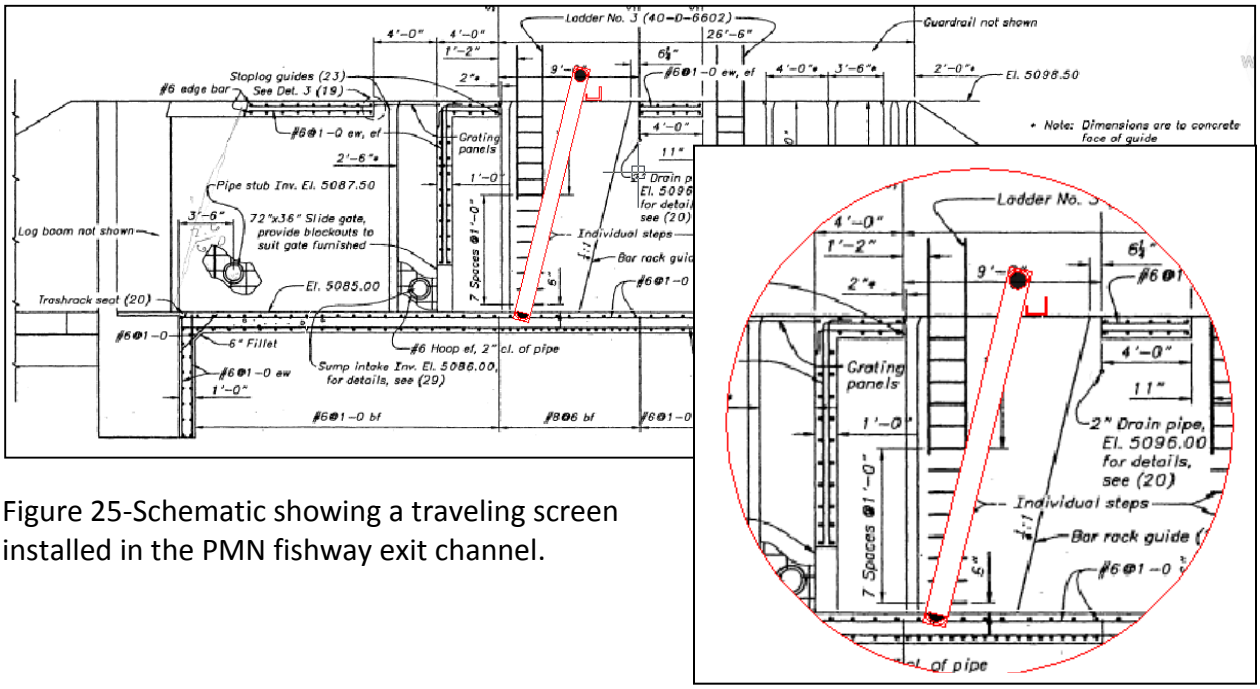


Figure 25-Schematic showing a traveling screen installed in the PMN fishway exit channel.

Hydrolox is a leading manufacturer of traveling screens with a good history of operation in sediment laden flow. Hydrolox provided an estimated cost of approximately $100,000 for two 15 ft long by 94 inch wide screens with a 20 ft long debris sluice. The cost does not include installation. The costs are intended for alternative comparison and should not be used as a final cost. Several factors needing further investigation that will impact costs are:

- The cost estimate provided uses Hydrolox's S1800 mesh belt material which is used on fish screens. Due to the high approach velocity in the fishway exit channel, belting with a larger mesh size may be necessary to control headloss through the screen.
- Identifying available site power.
- Determining bottom flow blockage due to the screen and evaluate slotting the channel floor.
- Select a debris removal method and the corresponding required screen height above the deck.

The complete Hydrolox quote is attached following this report.

Trashrake Cleaner

Trashrakes are mechanical systems designed to rake debris to the top of the trashrack for disposal. Numerous manufactures and types of automated rakes are commercially available. Many are designed for handling large debris that may collect on head-of-diversion trashracks similar to the PMN fishway trashrack. For the fish trap bar rack, a light duty rake is preferable for handling the small debris that passes through the upstream trashrack. A good example of a rake cleaner designed for smaller debris is the STL9000 Atlas Polar Rake shown in figure 26. The rake head enters the water upstream of the bar rack then moves against the rack bottom and is pulled upward. When the head reaches the rack top, debris is ejected onto a collection area. The rake automatically traverses across the rack to clean all surfaces. A single rake can traverse the full width of the fishway and clean the racks in both fishway bays. The simplest system would periodically rake the bar racks using a programmable time period between raking operations. Debris would accumulate behind the rake on the fishway deck for manual removal. A conveyor or sluice system could also be used in place of manual debris removal. A trash raking system would not require any significant modifications to the existing concrete structure. Assuming debris was raked to the top of the facility deck, the bar racks would have to be lengthened or blank panels added above the bar racks to provide a continuous surface to the top of deck. An option not requiring lengthening the bar racks would be to add a debris basket mounted behind the existing bar racks level with the rack top. Debris would then be removed manually during fish salvage operations.

Figure 26 - Photograph of an Atlas Polar light duty debris rake. (G. Mackey, Atlas Polar Corporation)

A budgetary price estimate for a debris rake capable of cleaning the fishway bar racks in both bays was requested from Atlas Polar Corporation, a well known manufacturer of trashrakes. They quoted a cost of about $131,000 FOB factory for their ST9000 trashrake. Installation cost is not included. Power availability on site and clearances with existing structures on the deck would need to be investigated. The complete quote is attached following this report.

Recommendations

Alternatives were evaluated based on the headings listed in table 3. The rankings are the opinion of the author based on the preliminary alternative investigation conducted for the study. The ratings are meant as broad indicators for alternative comparison. The alternatives highlighted in red are approaches requiring in-river structures or bankline modifications. The alternatives presented in green focus on managing sediment deposition in the near field to the fishway exit. The last two alternatives shown in black are grouped separately because they could improve both sediment deposition near the fishway exit and fish passage efficiency.

Of the alternatives shown in red, barbs and submerged flow vanes likely have the highest probability of effecting major changes in the sediment deposition patterns surrounding the fishway exit. Removing or modifying the fishway guidewall would require substantial effort while likely only improving deposition in the area of the exit apron downstream of the wingwall.

All three of the red alternatives would require further study, including modeling to develop performance based designs. The cost of constructing these alternatives at this level of study is highly uncertain. Barbs are typically relatively low cost structures, however, land ownership issues and right-of-way costs for construction could be significant in an urban area. Submerged flow vanes constructed adjacent to the fishway would likely generate fewer public concerns and could be installed on a trial basis. Between the three red alternatives, submerged flow vanes appear to offer a higher probability of success with the lowest chance of unintended consequences.

The group of alternatives presented in green offer potential improvements for sediment management close to the fishway exit. Implementing more than one of these alternatives should be considered. These alternatives can complement each other or alternatives from other groups. Between the green alternatives dredging stands out in table 3. It offers the greatest flexibility to react to changing river conditions and sediment bar development at a modest cost. It is also the most labor dependent of the alternatives. The availability of labor to operate a small dredge during the periods of receding river flows is a requirement of the alternative.

The last group is specific to maintaining strong fishway flow by frequent cleaning of the upstream fish trap bar rack. This issue impacts sediment deposition in the fishway exit when bar rack plugging significantly slows flow entrance velocity. Both traveling debris screens and trashrakes are viable alternatives with long histories of good performance on similar water intake structures. For PMN installing a trashrake is likely the best option. A trashrack fits best with the facility design and was likely considered an option in the design (16). A trashrake would be completely out of the flow when not cleaning and therefore would not impact flow during between cleaning operations. A traveling screen would require modifications to the exit channel and/or screen to operate with minimal impact on flow conditions.

Table 3 - Alternative evaluations

Sediment Management Alternative	Probability of Achieving Sediment Management Goal	Need for Further Study	O&M Cost	Capital Cost	Difficulty of Implementing
Barbs	M-H	H	M-H	M-H	H
Modifying wing wall	L-M	H	L	H	H
Submerged vanes	M-H	M-H	L	L-M	L-M
Sediment resuspension system	M	M	L-M	M-H	M-H
Dredging	H	L	M	L	L
Sluice	L-M	M	L-M	H	H
Winter operation	L-M	L-M	L	M	L
Deck mounted backhoe	M-H	M	M	H	H
Traveling Screens	M-H	L-M	L-M	M	L-M
Trashrake	H	L	L-M	M	L

L=Low, M=Medium, H=High

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15. U.S. Army Corps of Engineers, 1995. “Bendway Weir Design Guidance." Omaha District.

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Equipment Budgeting Quotes for Traveling Screen and Trashrack Rake

Budgeting quote received from Atlas Polar Corporation

Jul 3

Gary Mackey (ATLAS POLAR CO)

Hi Brent,

Thank-you for the photos and drawings. As usual the burec drawings are well detailed. I'm going to recommend the ST9000 trashrake for this application. The single machine can traverse to clean both screens. I've attached a photo of an installation with similar side pier (wall) mounting and a photo of our latest rake head incorporating a trailing brush that has proven to be quite effective.

The raked debris would be deposited on the existing 4 ft. deck for manual removal. Our latest PLC control system features a HMI touch screen for all unit functions as needed. Timed operation is fully adjustable as well as standard start contacts accepting a remote or differential signal.

Supply to Include:
- ST9000 Trashraking System
- Running rail system w/supports
- Auto/manual PLC controls w/ HMI touch screen (see photo)
- Outdoor weatherproof control enclosure w/ heat shields
- Wireless pendant for manual operation
- Festoon power/control cables
- Access/maintenance platform
- Spare parts kit
- O/M manuals (3) w/ as built drawings

Estimate.....$130,745.00

The above complete system FOB factory, exclusive of delivery, installation and taxes, if applicable.

Brent, review the above and if I can be of any further assistance with additional data or info please advise. Although premature at this time, I would like to visit the facility before submitting a formal proposal when appropriate. Have a good July 4th.

Regards,

Gary

Gary D. Mackey, Div. Mgr.
Atlas Polar Company Limited

Budgeting quote received from Hydrolox for two traveling screens

hydrolox®
ENGINEERED POLYMER SCREENS

6/5/2014

Brent Mefford
Wild Fish Engineering LLC 1900 Hoyt St
Lakewood, CO 80215

Subject: PNM Diversion Dam Navaho Nation Project Hydrolox Water Screen Budgetary Estimate
Date Issued: 06/05/2014

Pursuant to your recent request, we are pleased to submit our Budgetary Estimate for the Hydrolox Water Screen for the above-referenced project. This is not a binding formal offer and proposal to sell. A budgetary estimate price is provided solely for your planning and budgeting purposes. Please do not issue a Purchase Order until you have received and signed the formal contract proposal.
Summary Description: Hydrolox Water Screen(s) for PNM Diversion Dam Navaho Nation. General Hydrolox Water Screen Specifications
Type: Environmental Fish Exclusion
Quantity: 2
Screen Specifications: S1800, Mesh Top, UV Resistant Acetal Frame Material: Coated Carbon Steel
Screen Height: 15 feet (shaft centerline to shaft centerline) Screen Width (in.): 94
Belt Width (in.): 82 Filtering Width (in.): 79.5
Total Screen Weight (lbs.): 3190
Spray Bar: Stainless Steel with flush out valve-- Quantity: 1
Takeup: Manual
Debris / Fish Sluice: 5052 Aluminum -- Quantity: 1. Length: 20 feet each. Belt Pullers: Yes (2 Sets Total)

Warranty: 3 years from installation or 90 days after delivery, Intralox will repair or replace, at its sole option, the following components found to be defective in materials or workmanship: the screen frame, the Hydrolox mesh screen and sprockets.

Budgetary Estimate Price:

$98,900

Project Schedule: To be shipped no sooner than 6 - 8 weeks from receipt of signed Proposal and PO (subject to prompt customer approval of approval drawings).

We trust this meets your immediate needs. Should you have any questions, please do not hesitate to call.

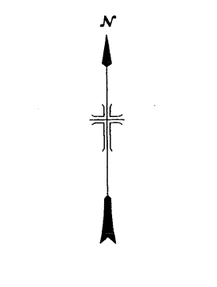
Thank you for your continued interest in Hydrolox Water Screens and the **Intralox Optimization Services Group**.

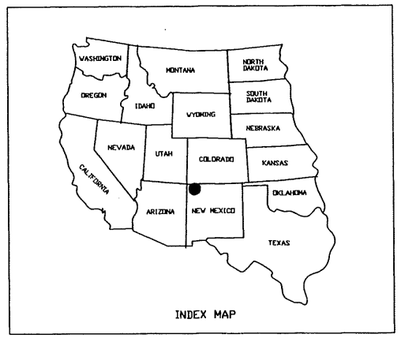
Sincerely,
Intralox, L.L.C., d.b.a. Hydrolox

Reference Drawings of PMN Fishway

1745-417-26

FISH PASSAGE FACILITY AT PNM DIVERSION DAM (see General Location Map 1745-417-27





ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

SAN JUAN RIVER RECOVERY IMPLEMENTATION PROGRAM – NEW MEXICO

FISH PASSAGE FACILITY AT PNM DIVERSION DAM

REGIONAL LOCATION MAP

DESIGNED Kevin Moser CHECKED Larry Bynum
DRAWN Larry Board TECHNICAL APPROVAL Mark Wenk
APPROVED Bart R. Silverman

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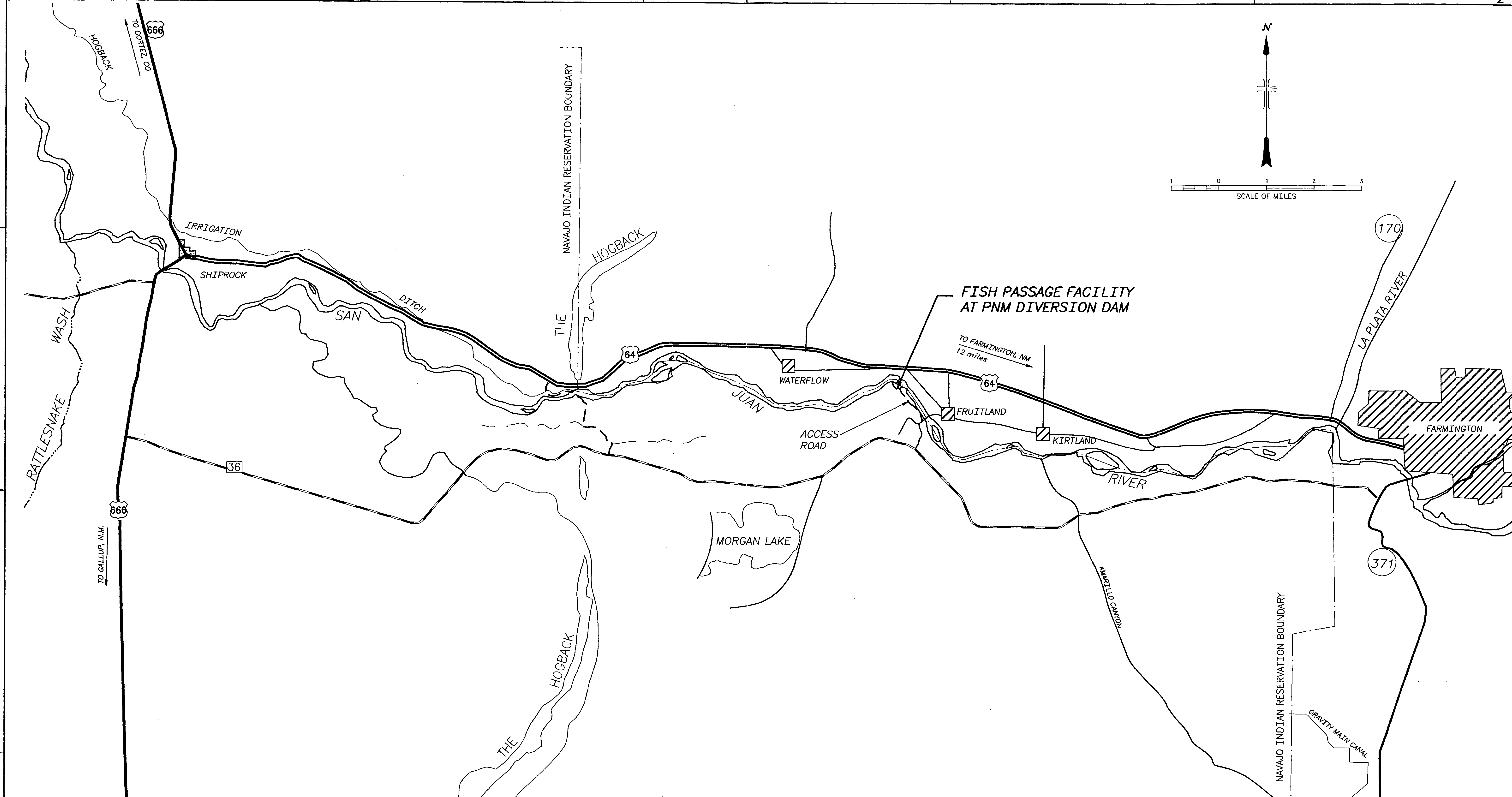
1745-417-26



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UNITED STATES
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BUREAU OF RECLAMATION

SAN JUAN RIVER RECOVERY IMPLEMENTATION PROGRAM – NEW MEXICO

FISH PASSAGE FACILITY
AT PNM DIVERSION DAM
GENERAL LOCATION MAP

DESIGNED — CHECKED
DRAWN — TECHNICAL APPROVAL
APPROVED

CADD SYSTEM	CADD FILENAME	DATE AND TIME PLOTTED
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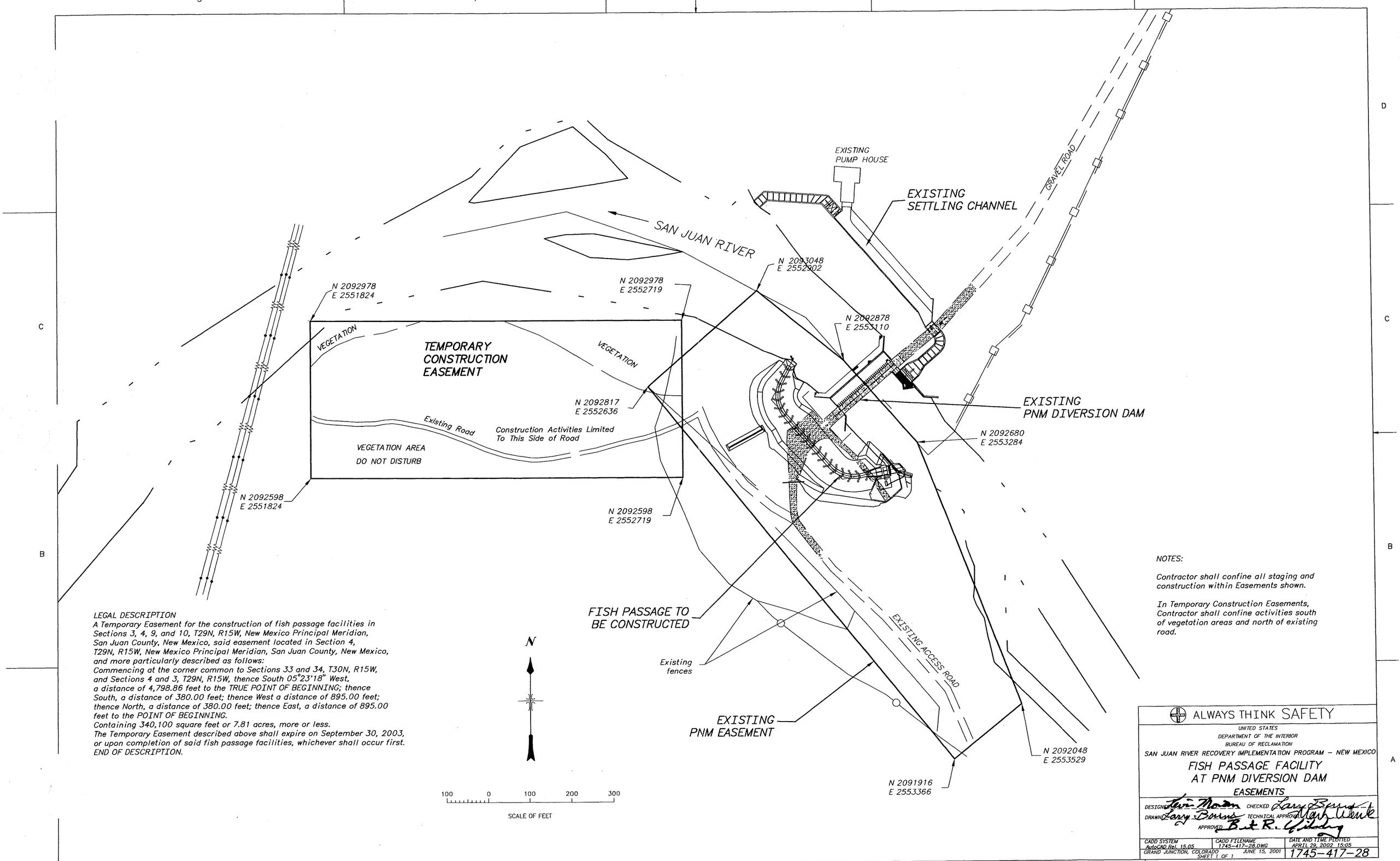

LEGAL DESCRIPTION
A Temporary Easement for the construction of fish passage facilities in Sections 3, 4, 9, and 10, T29N, R15W, New Mexico Principal Meridian, San Juan County, New Mexico, said easement located in Section 4, T29N, R15W, New Mexico Principal Meridian, San Juan County, New Mexico, and more particularly described as follows:
Commencing at the corner common to Sections 33 and 34, T30N, R15W, and Sections 4 and 3, T29N, R15W, thence South 05°23'18" West, a distance of 4,798.86 feet to the TRUE POINT OF BEGINNING; thence South, a distance of 380.00 feet; thence West a distance of 895.00 feet; thence North, a distance of 380.00 feet; thence East, a distance of 895.00 feet to the POINT OF BEGINNING.
Containing 340,100 square feet or 7.81 acres, more or less.
The Temporary Easement described above shall expire on September 30, 2003, or upon completion of said fish passage facilities, whichever shall occur first.
END OF DESCRIPTION.

NOTES:

Contractor shall confine all staging and construction within Easements shown.

In Temporary Construction Easements, Contractor shall confine activities south of vegetation areas and north of existing road.

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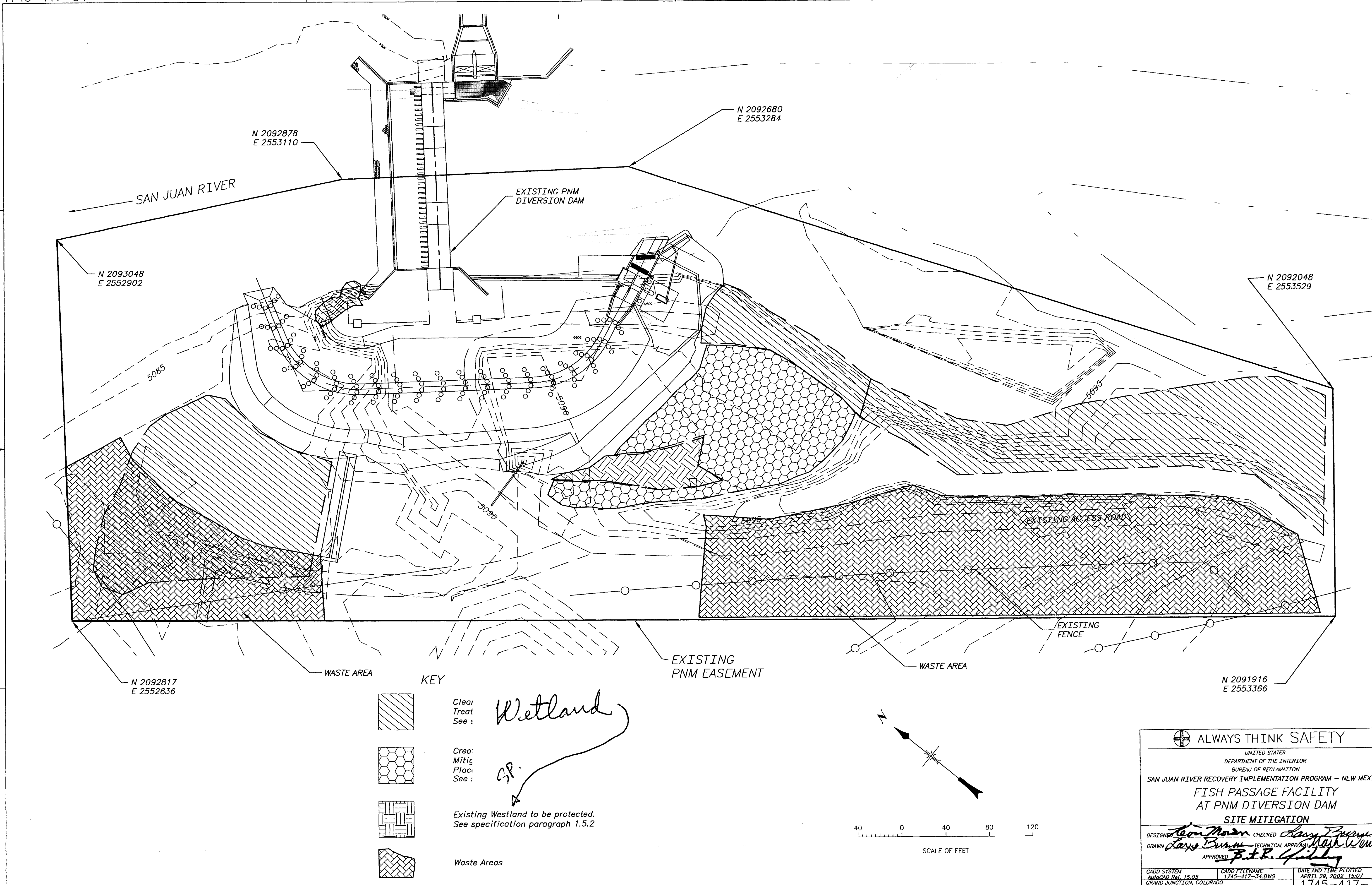
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

SAN JUAN RIVER RECOVERY IMPLEMENTATION PROGRAM – NEW MEXICO

FISH PASSAGE FACILITY AT PNM DIVERSION DAM

EASEMENTS

DESIGNED Kevin Moran	CHECKED Larry Burns	
DRAWN Larry Burns	TECHNICAL APPROVAL Mark Wernke	
APPROVED Burt R. Gibson		
CADD SYSTEM AutoCAD Rel. 15.05	CADD FILENAME 1745-417-28.DWG	DATE AND TIME PLOTTED APRIL 29, 2002 15:05
GRAND JUNCTION, COLORADO	JUNE 15, 2001 SHEET 1 OF 1	1745-417-28



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UNITED STATES
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SAN JUAN RIVER RECOVERY IMPLEMENTATION PROGRAM – NEW MEXICO

FISH PASSAGE FACILITY
AT PNM DIVERSION DAM

SITE MITIGATION

DESIGNED Leon Moran CHECKED Larry Burrus
DRAWN Larry Burrus TECHNICAL APPROVAL Mark Wendt
APPROVED Bert R. Gilding

CADD SYSTEM	CADD FILENAME	DATE AND TIME PLOTTED
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1745-D-14

℄ Fish passage coordinates

Sta. 1+00
N 2,092,607.891
E 2,553,184.981

Sta. 5+10
N 2,092,865.662
E 2,552,979.930

℄ Fish passage curve data

① P.C. Sta. 1+40.00
P.I. Sta. 1+83.30
P.T. Sta. 2+18.54
Δ = 60°00'00" rt
R = 75.00'
t = 43.30'
L = 78.54'
N 2,092,591.927
E 2,553,103.224

② P.C. Sta. 3+78.54
P.I. Sta. 4+31.06
P.T. Sta. 4+70.17
Δ = 70°00'00" rt
R = 75.00'
t = 52.52'
L = 91.63'
N 2,092,784.857
E 2,552,935.228

NOTES

1. Topography compiled by WCAO and Tetra-Tech, Inc.
2. Coordinates are based on local ground datum.
3. Contour interval = 1 foot.
4. Edge of water was surveyed in January, 2000.
5. Elevations based on N.A.V.D. Datum 1988.
6. For General Notes, see 1745-D-18.
7. Limits of riprap may be adjusted as directed to suit field conditions.
8. Slope riprap uniformly between elevations shown.
9. Land outside easements shown on 1745-417-28 shall not be disturbed by the contractor.
10. Slope arrows point downslope.
11. For construction staging area, see 1745-417-28.
12. For Geology Profile and Sections, see 1745-417-33.
13. Riprap in fish ladder shall be chinked as shown in TYPICAL FISH PASSAGE SECTION BETWEEN BOULDERS on 1745-D-15 with aggregate base course material.
14. 7' Chain link fence shall have 6' of fabric and 1' of barbed wire.
15. Details of existing PNM facilities are available from CO upon request.
16. Elevations shown on the existing PNM facilities drawings are approximately 3' lower than those on this drawing and are based upon a different datum.
17. The top width of left embankment shall be 15.0' Min. From Sta. 2+60 to Sta. 5+10, the top width may be increased to 20.0' max. by wasting excess excaved material in lieu of wasting in designated areas shown on 1745-417-34. The neatlines for measurement and payment of compacting embankments and berms will be based on a top width of 15.0'

□ TPPNM-1 Denotes test pit
○ DHPNM-1 Denotes drill hole

Existing fence, do not disturb
Existing access road
Existing 36"± x 50'± culvert to be removed
End grouted riprap and gravel surfacing
10:1 Access ramp
15.0' Min., see Notes
Sta. 3+40
100'-0" Crest
Compacted earth berm, 5' top width, top El. 5089.0, 3:1 ss, extents as directed
N 2,092,668.04
E 2,552,826.16
Fish barrier
Riprap
5.0'
N 2,092,715.623
E 2,552,914.112
El. 5098.0
10:1 Ramp
1' Min. 1.5' Max. Typ.
30'-0" Typ.
Sta. 2+00
Sta. 4+10.6
Sta. 3+77.50
El. 5094.3
10.0' Min.
Sta. 4+70.17
El. 5093.0
Sta. 5+10
Edge of water, 5083
Riprap
15.0'
2' Typ.
Boulders
℄ Fish passage
TPPNM-1
TPPNM-2
TPPNM-3
DHPNM-1
7' chain link fence, (40-D-7016)'
Double 10' gate
Extent of gravel surfacing
For surface facilities, see (29)
Sta. 1+00
80.0'
Remove fence
Edge of water El. 5087.80
Existing PNM diversion structure
Fish trap structure (16)
Log boom (16)
50.0'
SAN JUAN RIVER
SITE PLAN
SCALE OF FEET 0 20 40 80

4/26/02 D- K.S.	MINOR REVISIONS.

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UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

SAN JUAN RIVER RECOVERY IMPLEMENTATION PROGRAM - NEW MEXICO

FISH PASSAGE FACILITY AT PNM DIVERSION DAM

SITE PLAN

DESIGNED K. A. Sayer TECH. APPR. Arthur Glickman
DRAWN K. A. Sayer
CHECKED S. J. Robertson APPROVED Richard P. Everett
PEER REVIEWER

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SHEET 1 OF 2

1745-D-14

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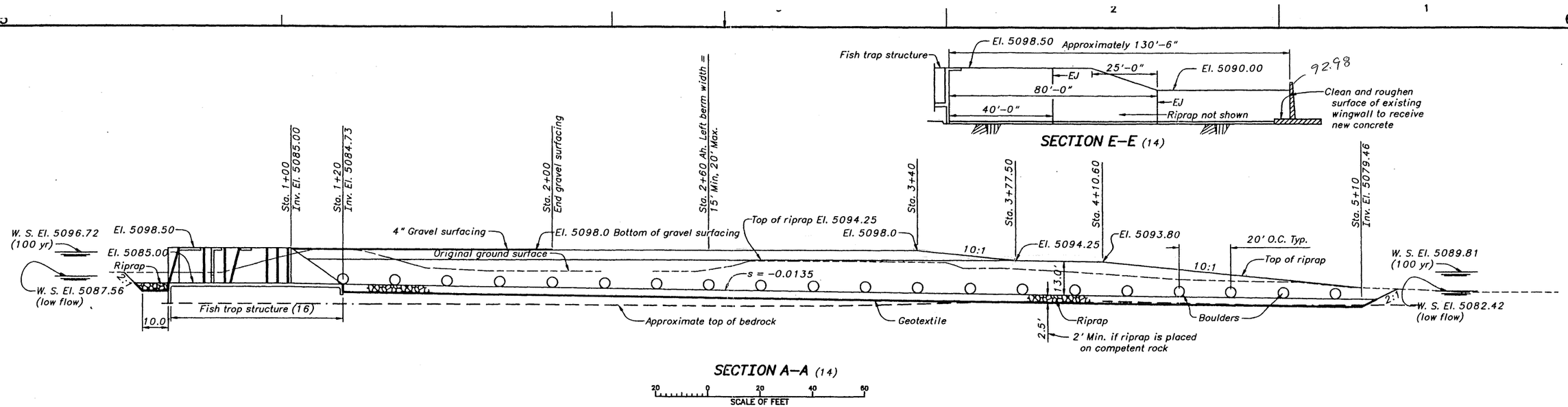

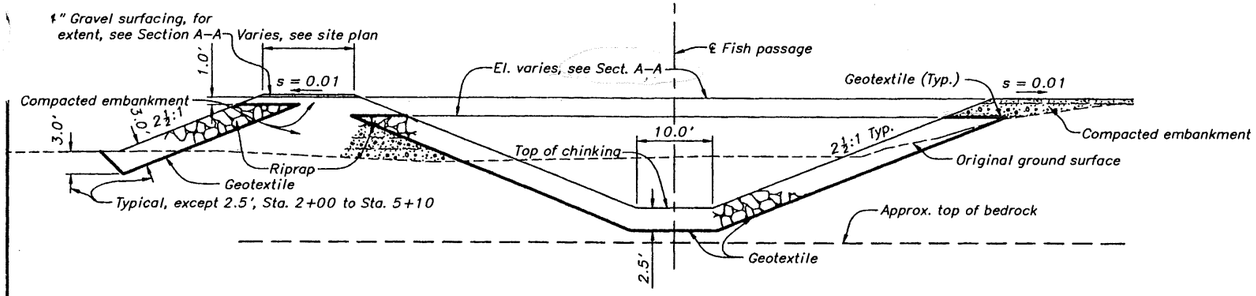

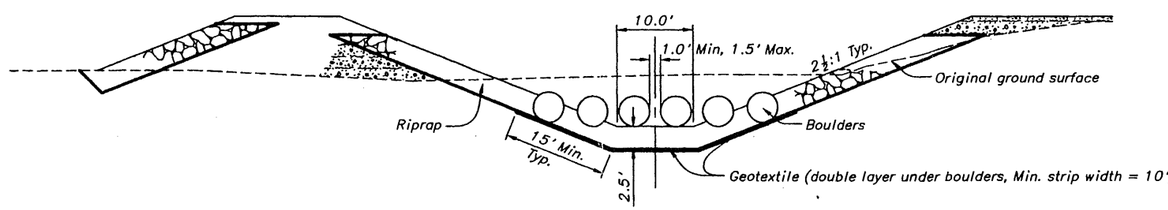

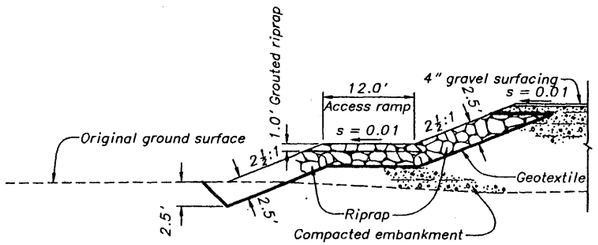

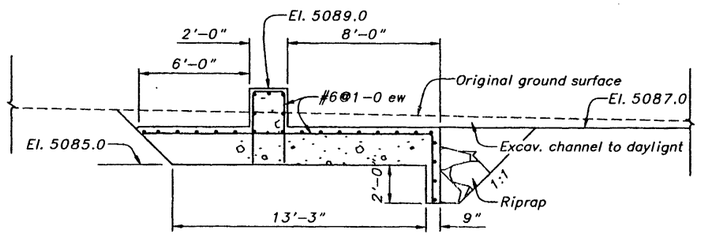

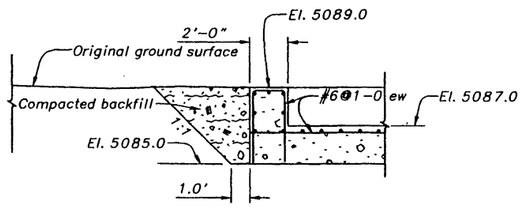

NOTE

Riprap in fish ladder shall be chinked as shown in TYPICAL FISH PASSAGE SECTION BETWEEN BOULDERS with aggregate base course material. Chinking shall fill voids in surface of riprap on invert.

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SAN JUAN RIVER RECOVERY IMPLEMENTATION PROGRAM – NEW MEXICO

FISH PASSAGE FACILITY AT PNM DIVERSION DAM

SITE PLAN – SECTIONS

DESIGNED K. A. Sayer TECH. APPR. Arthur Glickman
DRAWN K. A. Sayer
CHECKED S. J. Robertson APPROVED Richard P. Everett
FIELD REVIEWER

CADD SYSTEM	CADD FILENAME	DATE AND TIME PLOTTED
AutoCAD Rel. 15.06 DENVER, COLORADO	PNMDRAWING1A.DWG SHEET 2 OF 2	APRIL 1, 2002 APRIL 26, 2002 10:56

1745-D-15

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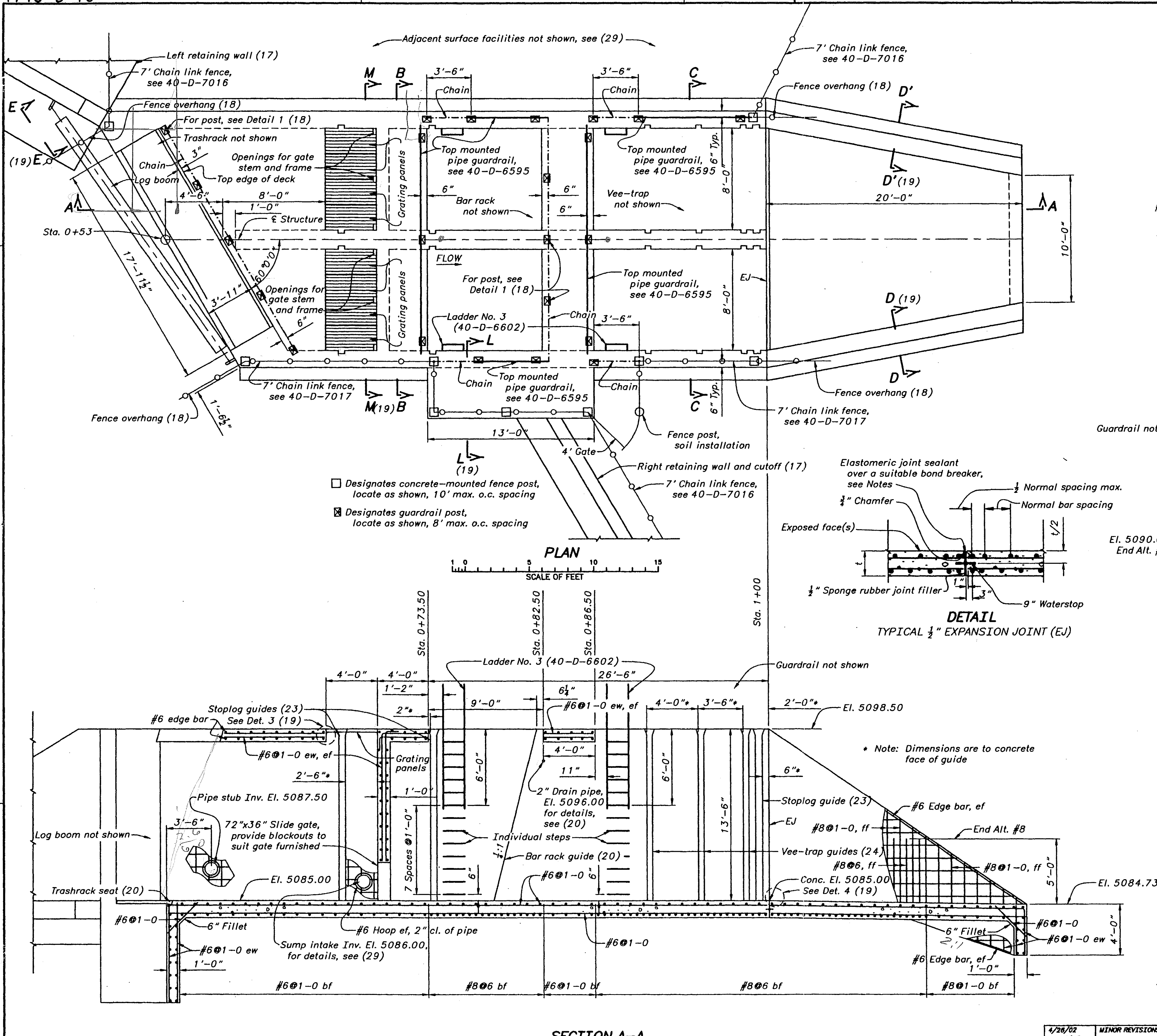

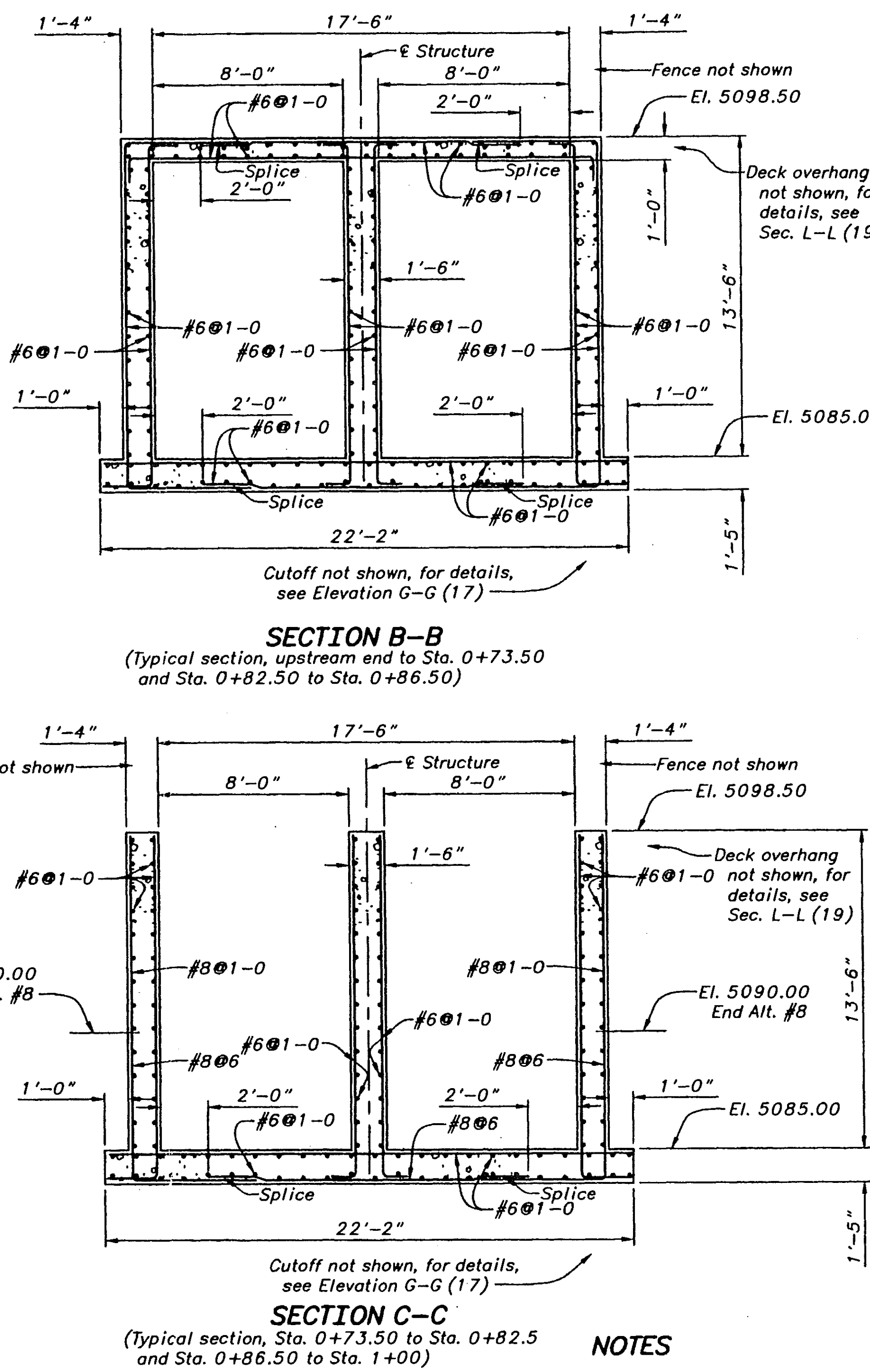

NOTES

Bond breaker shall be an approved smooth surface adhesive tape of the same width as, and applied to exposed sponge rubber filler.
For details of trashracks, see 1745-D-21.
For details of stoplogs, see 1745-D-23.
For details of bar racks, see 1745-D-22.
For details of vee-trap, see 1745-D-24.
For details of reinforcement at stoplog and vee-trap guides, see 40-D-6263.

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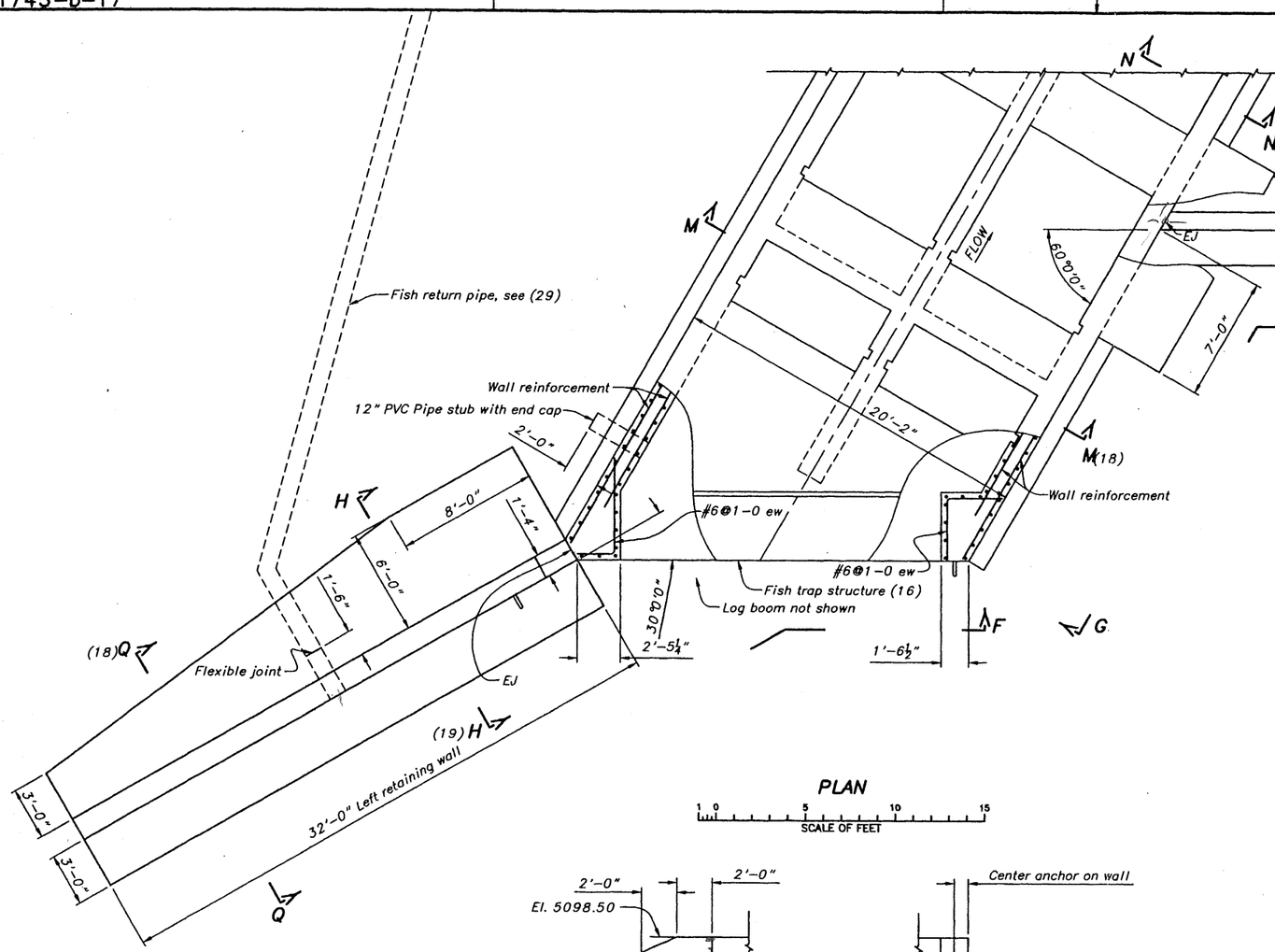
SAN JUAN RIVER RECOVERY IMPLEMENTATION PROGRAM – NEW MEXICO

FISH PASSAGE FACILITY AT PNM DIVERSION DAM
FISH TRAP STRUCTURE
PLAN, SECTIONS AND DETAIL

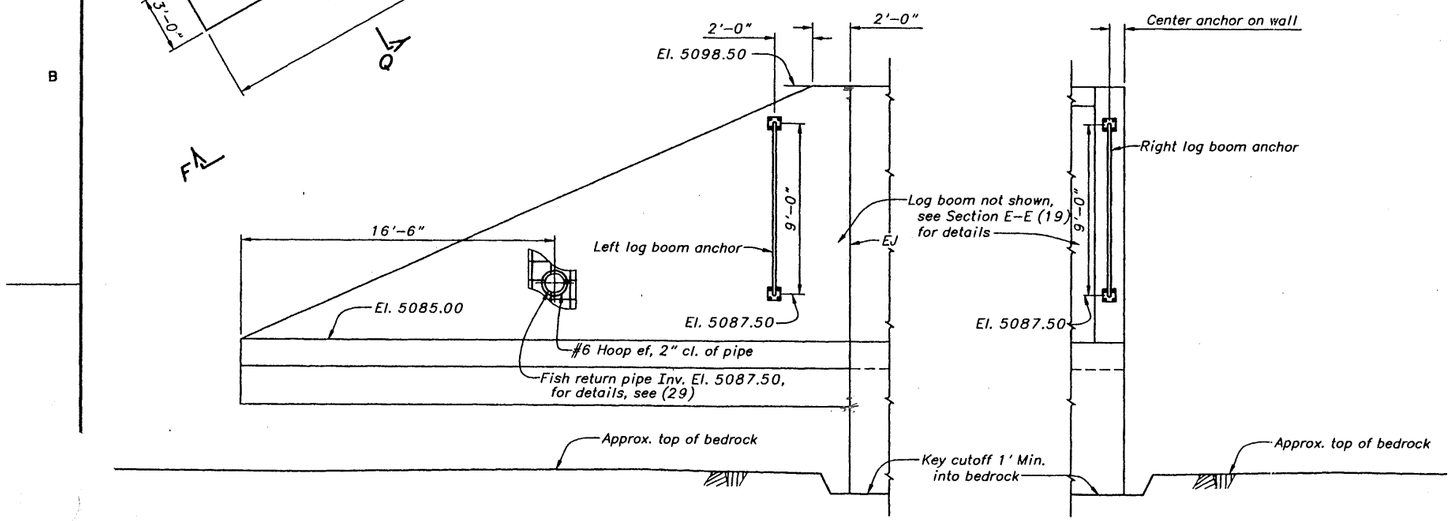
DESIGNED K. A. Sayer TECH. APPR. Arthur Glickman
DRAWN K. A. Sayer
CHECKED S. J. Robertson APPROVED Richard P. Everst
CADD SYSTEM AutoCAD Rel. 15.0B
DENVER, COLORADO
APRIL 1, 2002
SHEET 1 OF 4
1745-D-16

4/26/02 MINOR REVISIONS. K.S.

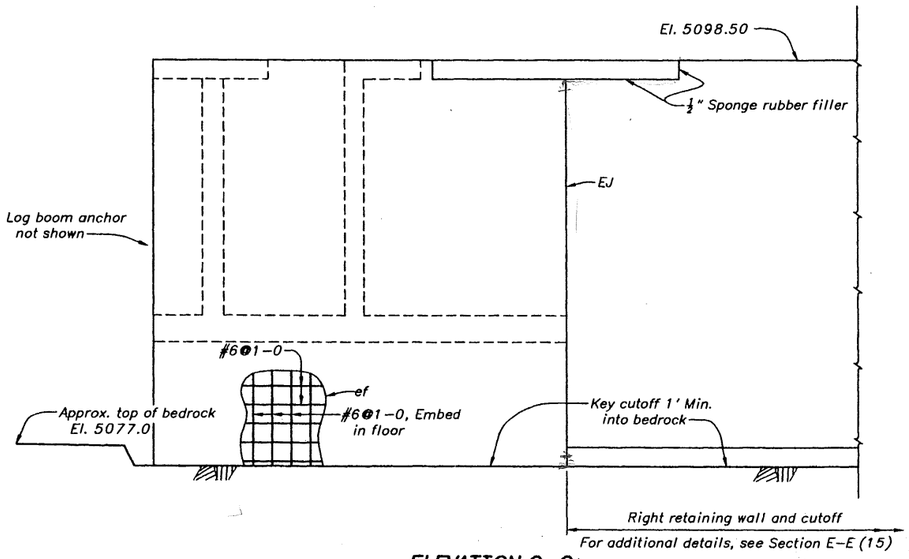


PLAN

1 0 5 10 15
SCALE OF FEET



ELEVATION F-F



ELEVATION G-G

NOTE

A rubber "O" ring shall be positioned on the exterior of all pipe penetrations at the midpoint of structure walls.

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SAN JUAN RIVER RECOVERY IMPLEMENTATION PROGRAM – NEW MEXICO

FISH PASSAGE FACILITY AT PNM DIVERSION DAM

FISH TRAP STRUCTURE

PLAN AND ELEVATIONS

DESIGNED K. A. Sayer TECH. APPR. Arthur Glickman
DRAWN K. A. Sayer
CHECKED S. J. Robertson APPROVED Richard P. Everst
FIELD REVIEW

CADD SYSTEM	CADD FILENAME	DATE AND TIME PLOTTED
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1745-D-17

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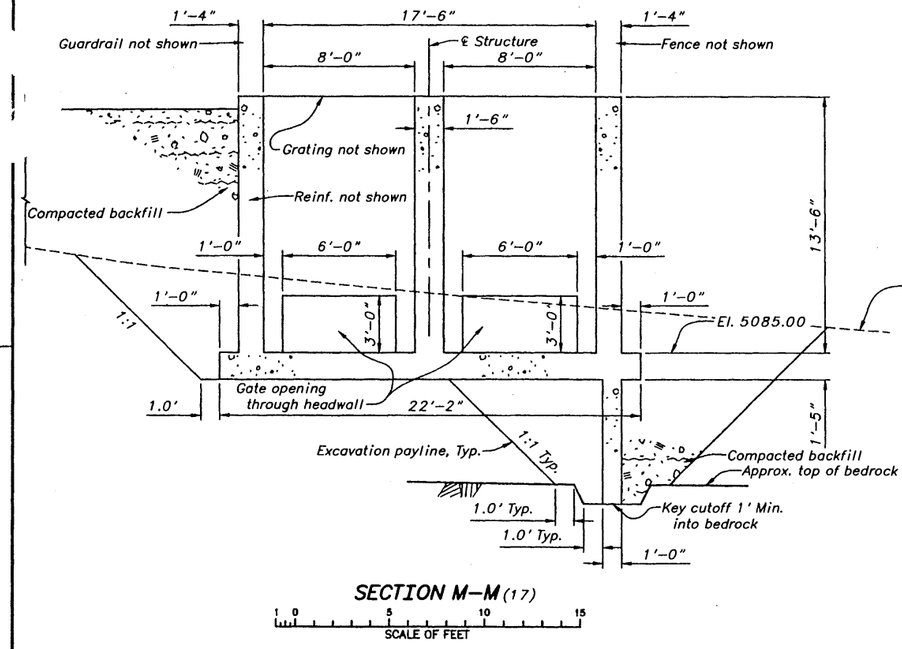
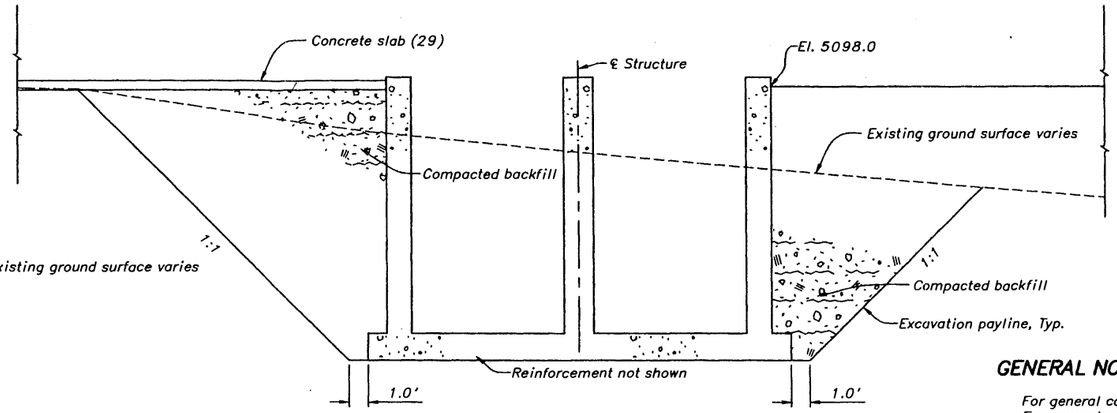
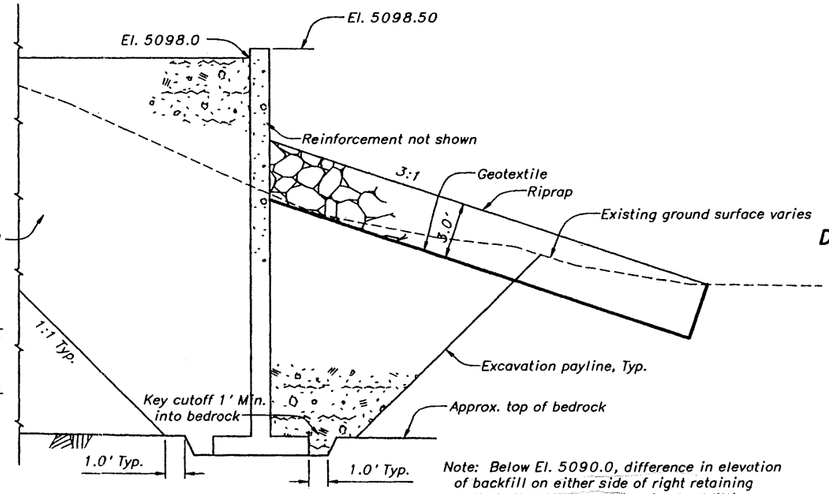


SECTION M–M (17)

1 0 5 10 15
SCALE OF FEET

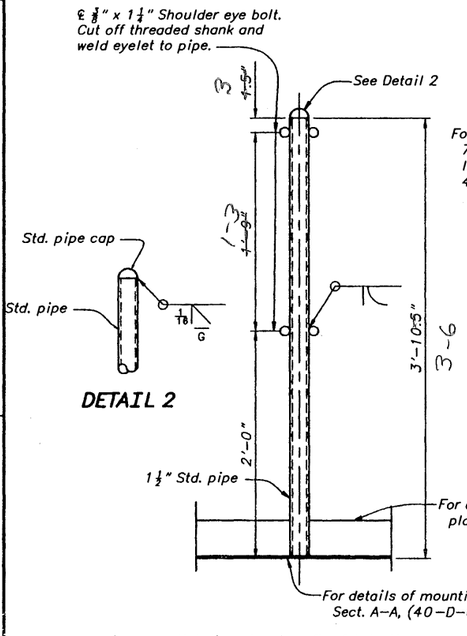


SECTION N–N (17)
(Fish trap structure)



Note: Below El. 5090.0, difference in elevation of backfill on either side of right retaining wall shall not exceed 1' during backfilling.

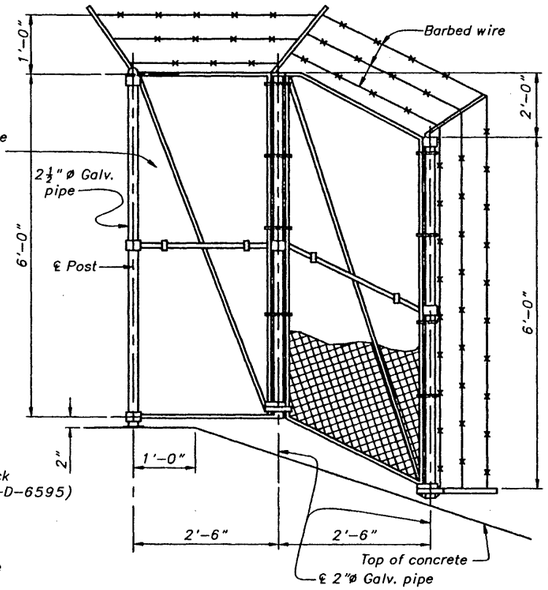
SECTION P–P (17)
(Right retaining wall)



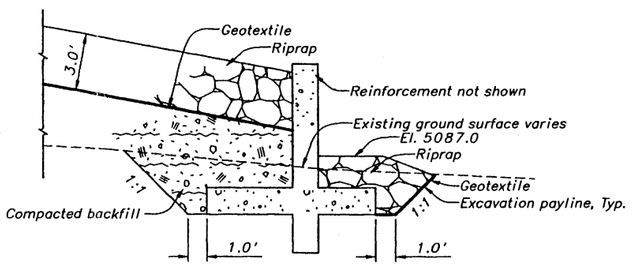
Hot dip galvanize after fabrication

DETAIL 2

DETAIL 1 (16)



FENCE OVERHANG
For locations, see (16)



SECTION Q–Q (17)
(Left retaining wall)

GENERAL NOTES FOR CAST-IN-PLACE CONCRETE

For general concrete outline notes, see 40-D-7012.
For general notes and minimum requirements for detailing reinforcement, see 40-D-6263.
Where concrete with varying thickness is shown on structural drawings, vary thickness of concrete uniformly between dimensions shown.
Reinforcement shall be continuous through construction joints (CJ).
Dimensions are to centerline of joint unless otherwise shown.
Structural design is based on 4,000 psi specified compressive concrete strength (f'c) at 28 days and reinforcement with a specified minimum yield strength (fy) of 60,000 psi.
Backfill shall not be placed against structure until concrete has attained 4,000 psi min. compressive strength.
Unless otherwise shown, all exposed concrete edges are to be chamfered ¾".
Foundation for concrete structures shall be prepared as shown on the drawings and as described in the specifications paragraphs.

DESIGN LOADS FOR FISH TRAP STRUCTURE

Hydrostatic water load: Assuming clogged trash racks, 12-foot maximum difference in water surface acting against upstream faces.

Trash rack dead load on deck: 220 lb. per lin. ft.

Deck live load: 150 lb. per sq. ft. plus 8,000 lb. point load

Future Conveyor
dead load: 100 lb. per lin. ft.
live load: 100 lb. per lin. ft. plus 1,500 lb. point load

Future trash rakes
dead load: 5,000 lb. each plus 30 lb. per lin. ft. rails
live load: 1,500 lb. each

Earth – active horizontal
Dry: 35 lb. per sq. ft. per ft. depth
Saturated: 87.5 lb. per sq. ft. per ft. depth

Earth – vertical
Compacted: 120 lb. per cubic ft.
saturated: 130 lb. per cubic ft.

Seismic – negligible

Where construction or operating equipment may come close to a structure a surcharge equal to 2 feet (80 lb. per sq. ft.) is added to dry horizontal earth loading.

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SAN JUAN RIVER RECOVERY IMPLEMENTATION PROGRAM – NEW MEXICO

FISH PASSAGE FACILITY AT PNM DIVERSION DAM

FISH TRAP STRUCTURE

SECTIONS AND DETAILS

DESIGNED K. A. Sayer TECH. APPR. Arthur Glickman
DRAWN K. A. Sayer
CHECKED S. J. Robertson APPROVED Richard P. Evarst
PEER REVIEWER

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DENVER, COLORADO	APRIL 1, 2002	1745-D-18

SHEET 3 OF 4

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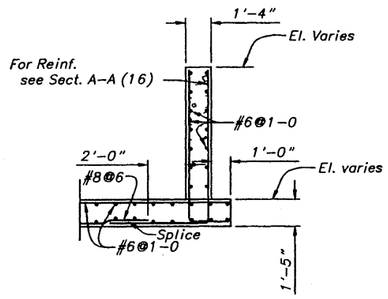
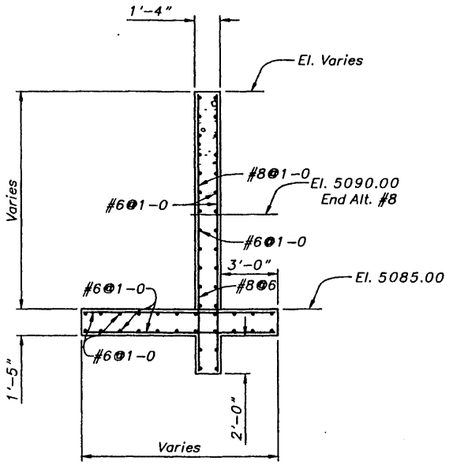
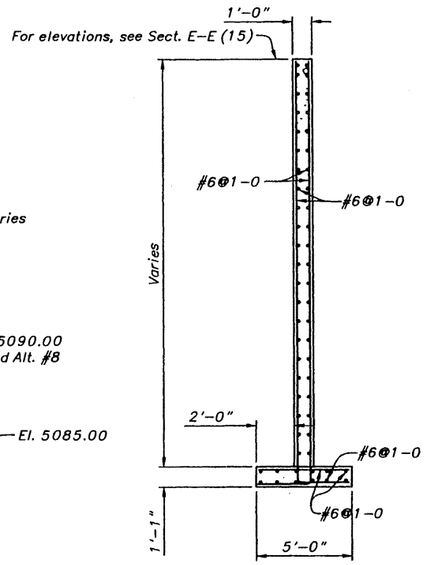


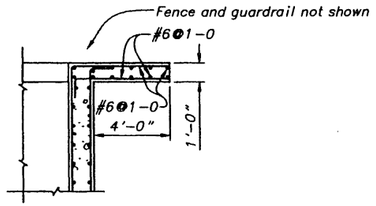
SECTION D-D (16)
(Section D'-D' opposite hand)



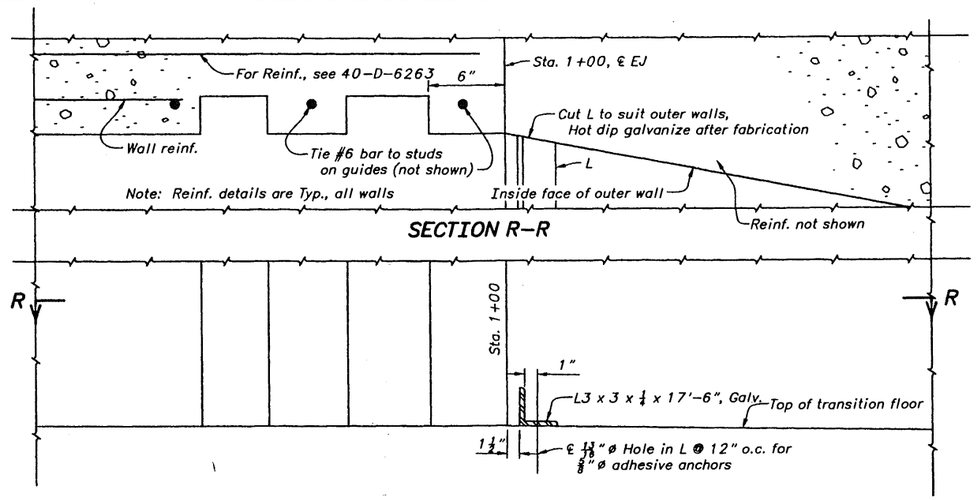
SECTION H-H (17)



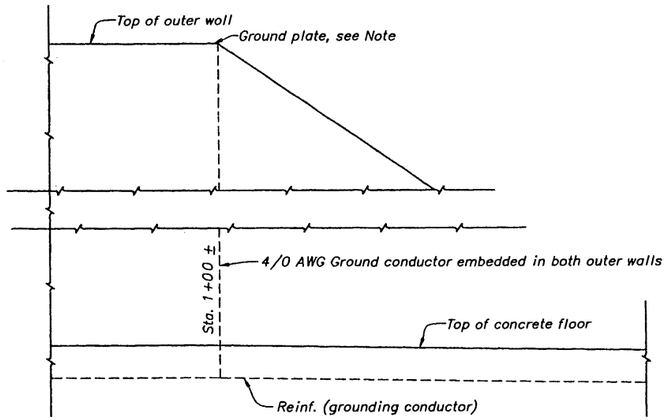
SECTION J-J (17)
(Typical, length of right retaining wall)



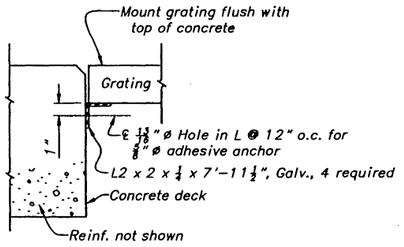
SECTION L-L (16)



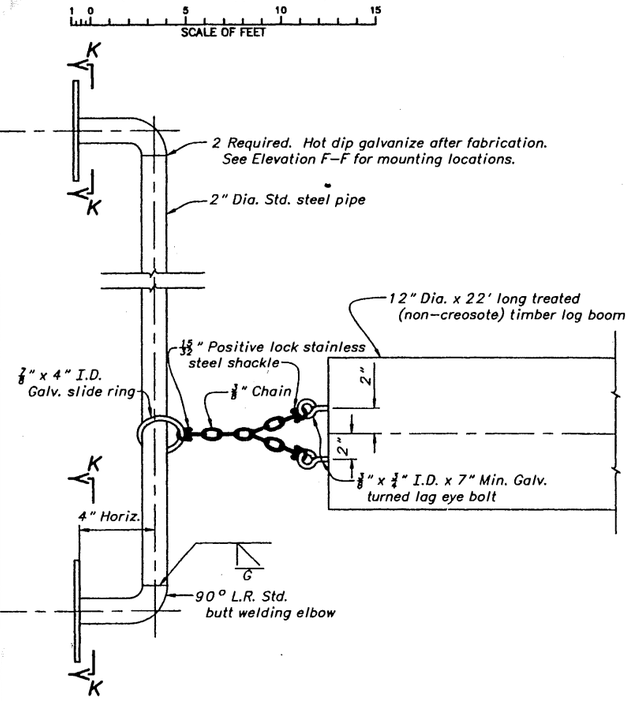
DETAIL 4 (16)
(Fish trap downstream sill)



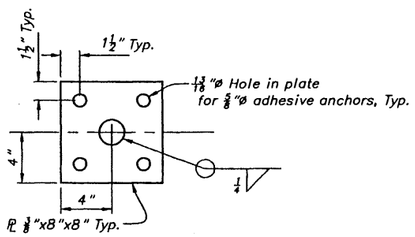
GROUNDING DETAILS



DETAIL 3 (16)



SECTION E-E (16)
(Log boom anchor rotated for clarity)



SECTION K-K

NOTES

Install four-hole grounding plates flush with tops of walls in approved locations. Ground metal guardrails to grounding plates as approved.
For details of grounding chain link fence, see 40-D-6376.

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SAN JUAN RIVER RECOVERY IMPLEMENTATION PROGRAM – NEW MEXICO

FISH PASSAGE FACILITY AT PNM DIVERSION DAM

FISH TRAP STRUCTURE

SECTIONS AND DETAILS

DESIGNED K. A. Sayer TECH. APPR. Arthur Glickman
DRAWN K. A. Sayer
CHECKED S. J. Robertson APPROVED Richard P. Juerst
PEER REVIEWER

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SHEET 4 OF 4

1745-D-19

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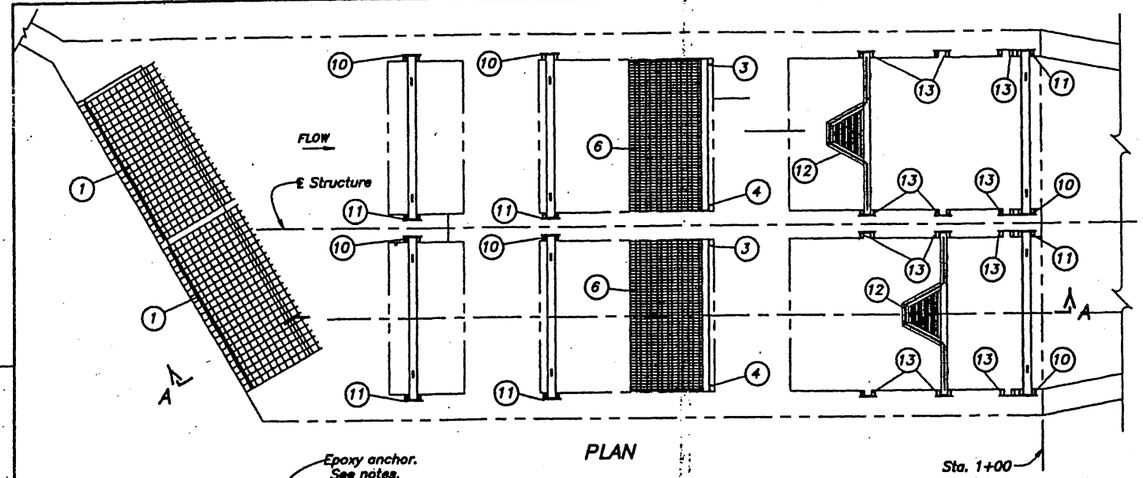

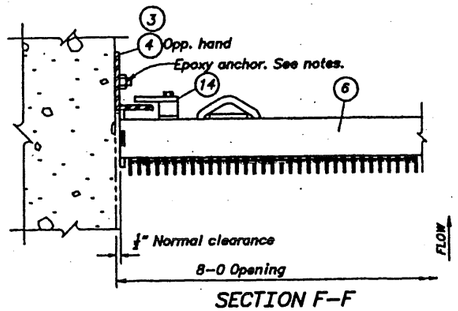

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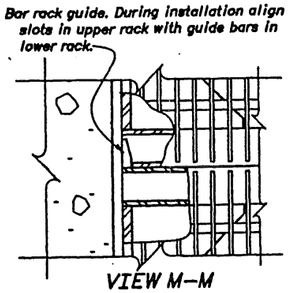
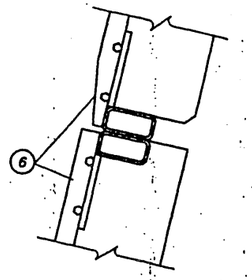
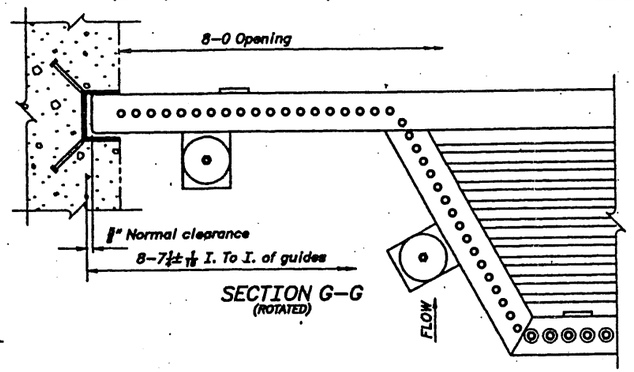


VIEW M-M



DETAIL N



SECTION G-G
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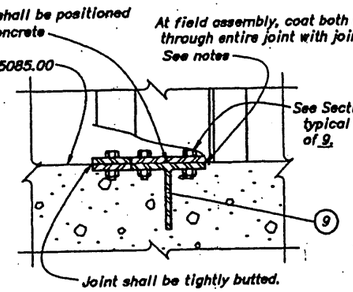
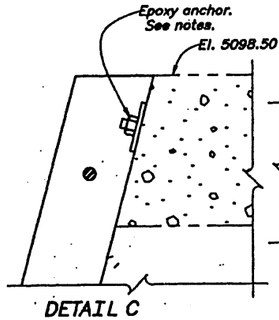
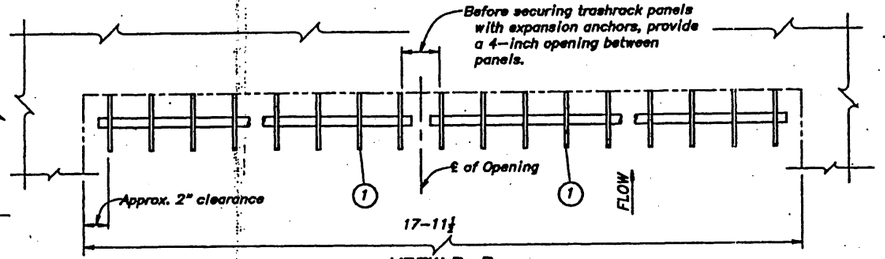


DETAIL P
(STOPLOG NOT SHOWN)



DETAIL C



VIEW B-B

NOTES

Joint sealant shall be Permatex No. 2, Permatex Industrial Corp., 10 Tower Lane, Avon Park South, Avon CT. 06001; or equal.

¾" x 9" Epoxy anchors shall be stainless steel, all-thread, with stainless steel hex. nut and washer. Install with HS-200 epoxy paste manufactured by Williams Forms Engineering Corp. P.O. Box 7389 Grand Rapids, Michigan 49510; or equal.

See drawing (1745-D-16) for positioning of metal work.

Handling weight (one part):

Trashrack part 1	3750 lbs.
Bar rack part 6	1500 lbs
Stoplog part 7	700 lbs.
Stoplog part 8	300 lbs.
V trap part 12	300 lbs.

Total weight:

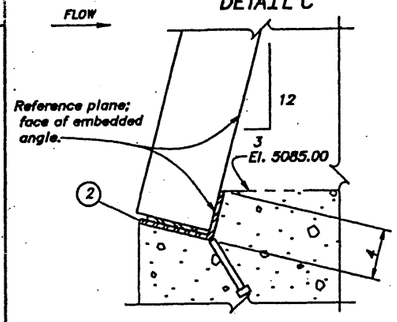
Steel	28,500 lbs.
Aluminum	600 lbs.

LIST OF DRAWINGS

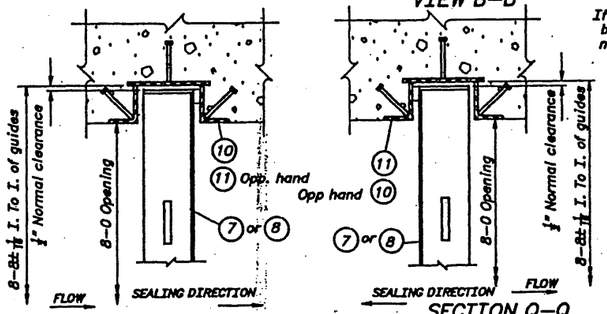
INSTALLATION - DETAILS	1745-D-20
TRASHRACK PANEL - BAR RACK SUPPORT - DETAILS	1745-D-21
BAR RACK - DETAILS	1745-D-22
STOPLOG - SEAT- GUIDES - DETAILS	1745-D-23
V TRAP -V TRAP GUIDE - DETAILS	1745-D-24

REFERENCE DRAWING

FISH TRAP STRUCTURE PLAN AND SECTIONS	1745-D-16

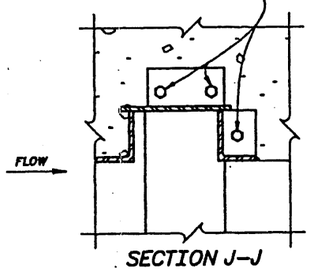


DETAIL D

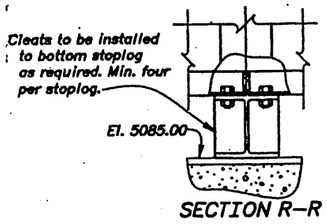


SECTION E-E

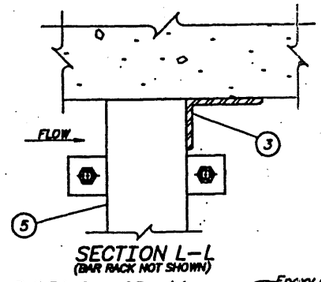
SECTION Q-Q



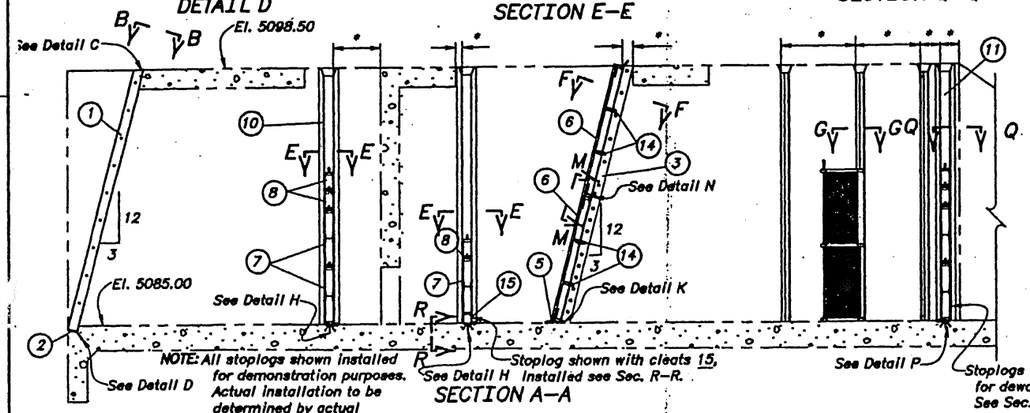
SECTION J-J



SECTION R-R



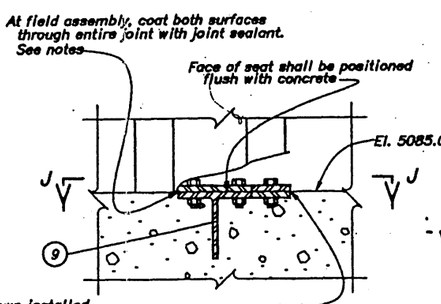
SECTION L-L
(BAR RACK NOT SHOWN)



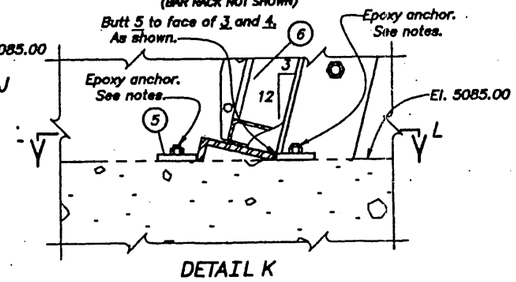
SECTION A-A

NOTE: All stoplogs shown installed for demonstration purposes. Actual installation to be determined by actual field conditions.

Stoplogs shown installed for dewatering structure. See Sec. Q-Q for proper stoplog installation.



DETAIL H
(STOPLOG NOT SHOWN)



DETAIL K

ALWAYS THINK SAFETY

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BUREAU OF RECLAMATION

SAN JUAN RIVER RECOVERY IMPLEMENTATION PROGRAM - NEW MEXICO

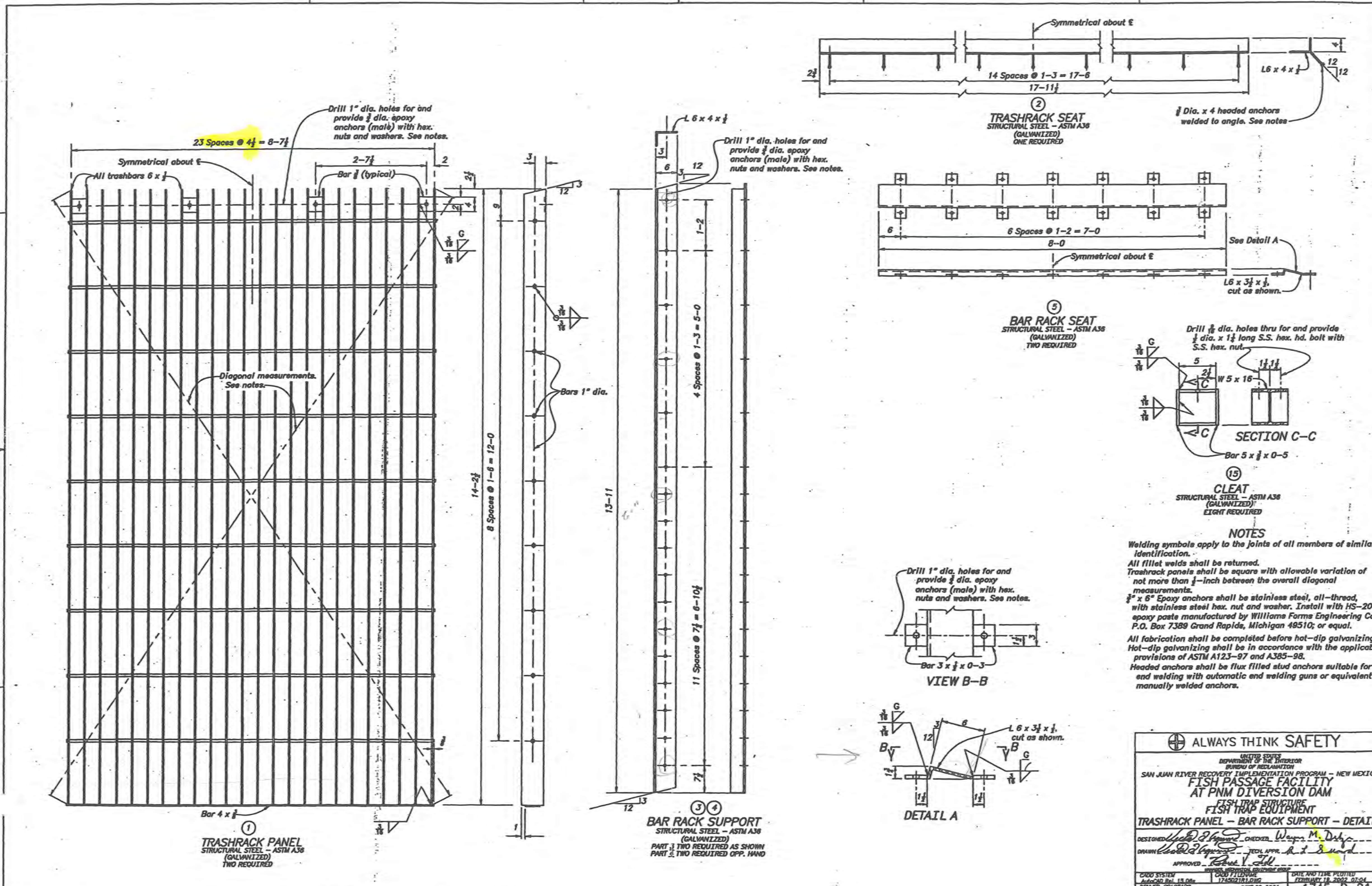
FISH PASSAGE FACILITY AT PNM DIVERSION DAM
FISH TRAP STRUCTURE
FISH TRAP EQUIPMENT INSTALLATION - DETAILS

DESIGNED — CHECKED Wayne M. Dirks
DRAWN — TECH. APPR.
APPROVED — MANAGER, MECHANICAL EQUIPMENT GROUP

CADD SYSTEM	CADD FILENAME	DATE AND TIME PLOTTED
AutoCAD Rel. 15.06s DENVER, COLORADO	1745D20R1.DWG JUNE 28, 2001	FEBRUARY 19, 2002 08:28

SHEET 1 OF 3

1745-D-20



NOTES

Welding symbols apply to the joints of all members of similar identification.
All fillet welds shall be returned.
Trashrack panels shall be square with allowable variation of not more than ½–inch between the overall diagonal measurements.
¾" x 6" Epoxy anchors shall be stainless steel, all–thread, with stainless steel hex. nut and washer. Install with HS–200 epoxy paste manufactured by Williams Forms Engineering Corp. P.O. Box 7389 Grand Rapids, Michigan 49510; or equal.
All fabrication shall be completed before hot–dip galvanizing.
Hot–dip galvanizing shall be in accordance with the applicable provisions of ASTM A123–97 and A385–98.
Headed anchors shall be flux filled stud anchors suitable for end welding with automatic end welding guns or equivalent manually welded anchors.

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SAN JUAN RIVER RECOVERY IMPLEMENTATION PROGRAM – NEW MEXICO

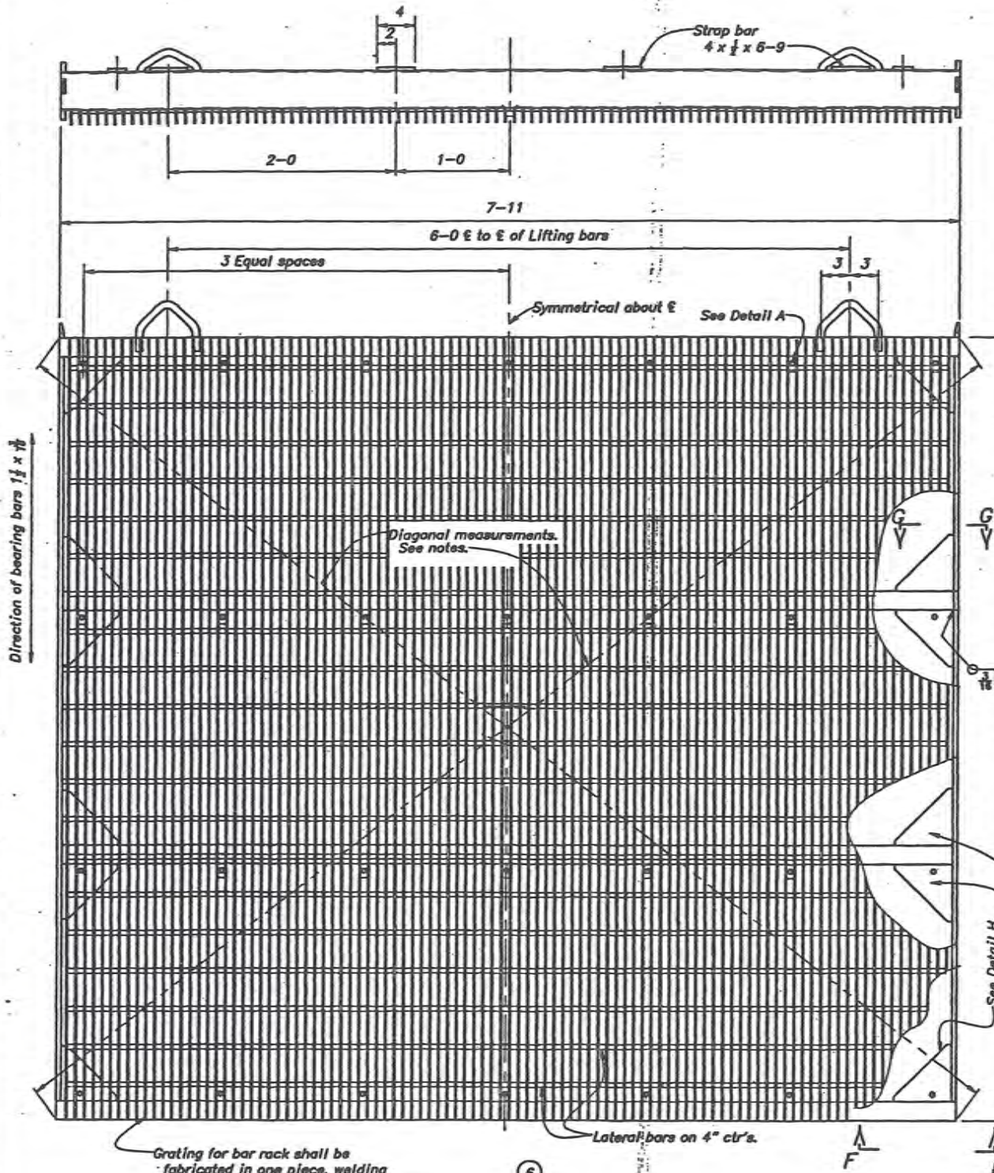
FISH PASSAGE FACILITY AT PNM DIVERSION DAM

FISH TRAP STRUCTURE
FISH TRAP EQUIPMENT
TRASHRACK PANEL – BAR RACK SUPPORT – DETAILS

DESIGNED [signature] CHECKED [signature]
DRAWN [signature] TECH. APPR. [signature]
APPROVED [signature]

CADD SYSTEM AutoCAD Rel. 15.06a — CADD FILENAME 174502181.DWG — DATE AND TIME PLOTTED FEBRUARY 19, 2002 07:04
DENVER, COLORADO — JUNE 28, 2001 — SHEET 2 OF 5 — 1745–D–21

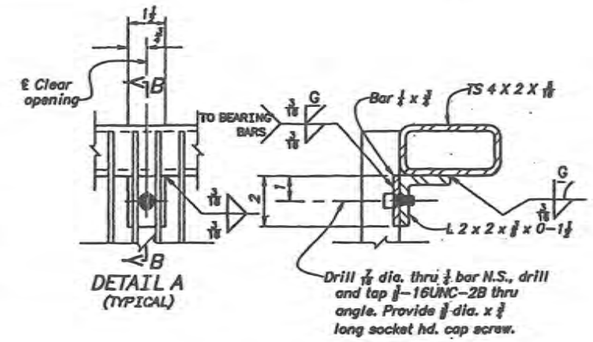
3/4" openings



Grating for bar rack shall be fabricated in one piece, welding several panels together if necessary. Grating shall have bearing bars $1\frac{1}{2} \times \frac{3}{16}$ on $\frac{13}{16}$ centers, with lateral bars on 4" centers, see notes.

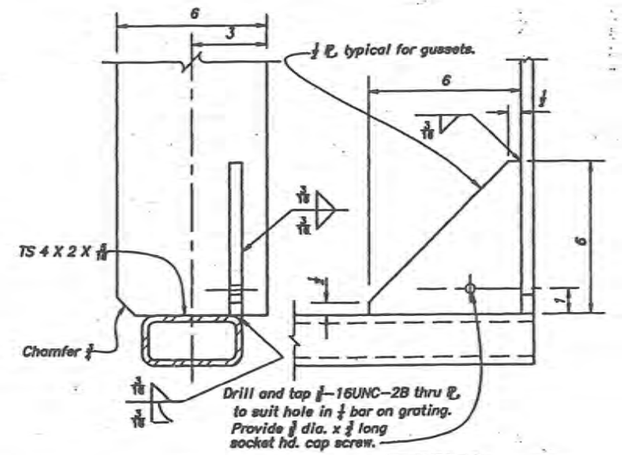
3/4" openings

⑥ BAR RACK
STRUCTURAL STEEL – ASTM A36
STRUCTURAL TUBING–ASTM A501
(GALVANIZED)
FOUR REQUIRED

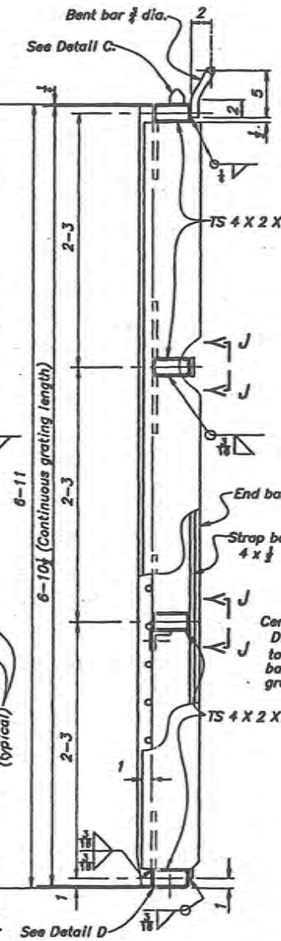


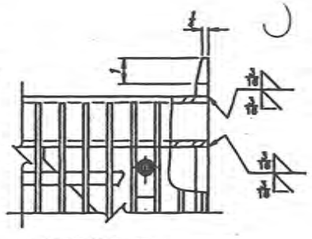
DETAIL A
(TYPICAL)

SECTION B–B

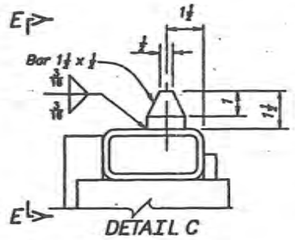


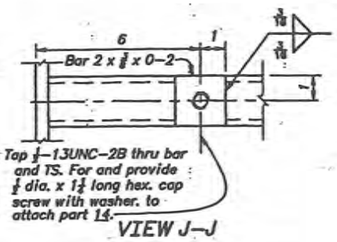
DETAIL H
(TYPICAL GUSSET PLATE DETAIL)



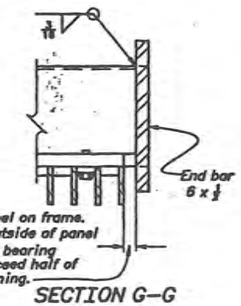


VIEW E–E

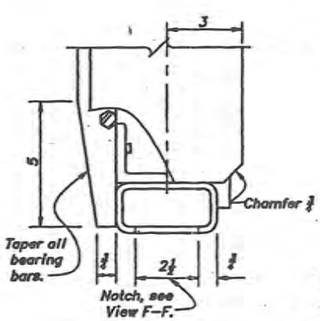




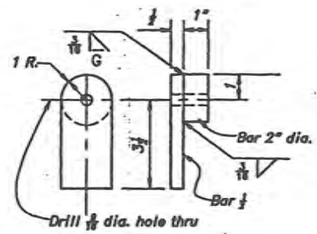
VIEW J–J



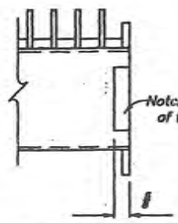
SECTION G–G



DETAIL D



⑭ RETAINER BAR
STEEL
(GALVANIZED)
16 REQUIRED



VTFW F–F

NOTES

1. Welding symbols apply to the joints of all members of similar identification.
2. Grating shall be all welded construction. Lateral bars shall be twisted rods.
3. All fillet welds shall be returned.
4. Metal work shall have no rough edges or sharp corners and shall be free from burrs and irregularities. All welds shall be ground smooth.
5. Bar rack shall be square with allowable variation of not more than 1/4-inch between the overall diagonal measurements.
6. All fabrication shall be completed before hot-dip galvanizing.
7. Hot-dip galvanizing shall be in accordance with the applicable provisions of ASTM A123-97 and A385-98.

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UNITED STATES
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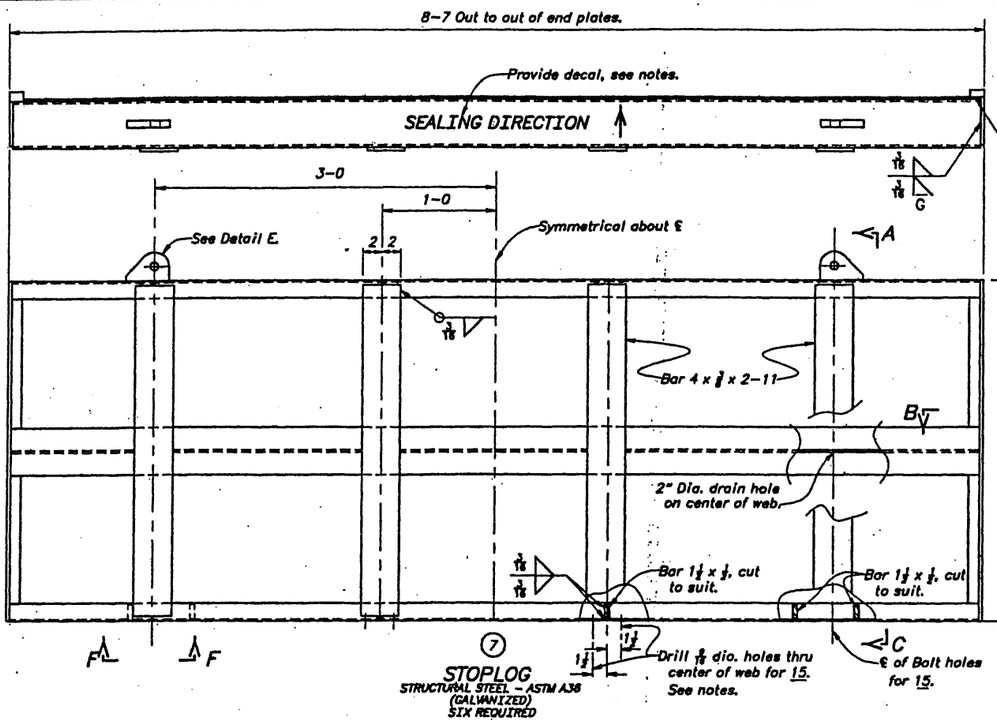
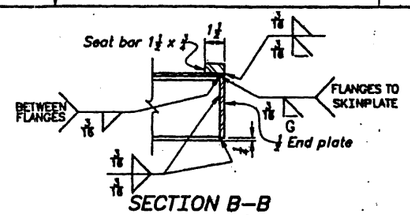
SAN JUAN RIVER RECOVERY IMPLEMENTATION PROGRAM – NEW MEXICO

FISH PASSAGE FACILITY
AT PNM DIVERSION DAM
FISH TRAP STRUCTURE
FISH TRAP EQUIPMENT
BAR RACK – DETAILS

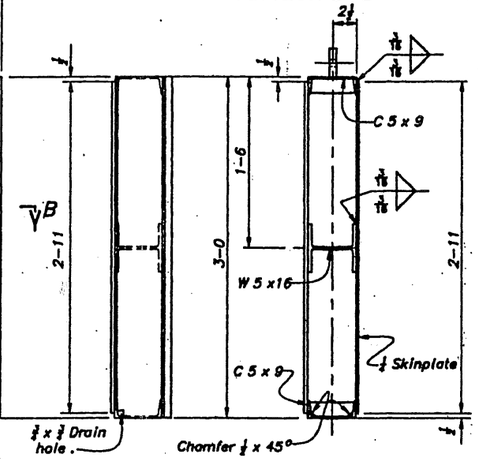
DESIGNED Walter D. Laymon CHECKED Wayne M. Delp
DRAWN Walter D. Laymon TECH. APPR. R. J. Durand
APPROVED Robert V. Jill
MANAGER, RECLAMATION MANAGEMENT GROUP

CADD SYSTEM	CADD FILENAME	DATE AND TIME PLOTTED
AutoCAD Rel. 15.06c DENVER, COLORADO	1745D2281.DWG SHEET 3 OF 5 JUNE 28, 2001	FEBRUARY 15, 2002 06:18 1745-D-22

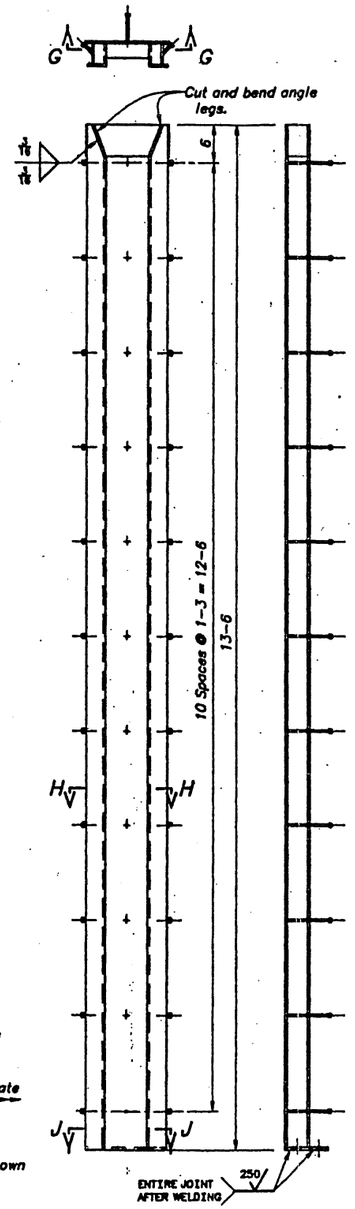




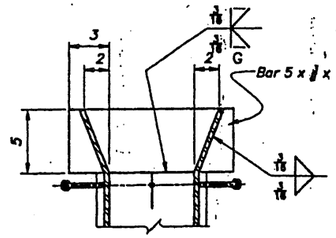
SECTION B-B



SECTION A-A



STOPLOG GUIDE
STRUCTURAL STEEL - ASTM A36 (GALVANIZED)
PART 10 SIX REQUIRED AS SHOWN
PART 11 SIX REQUIRED OPP. HAND



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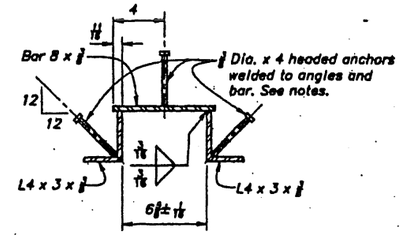
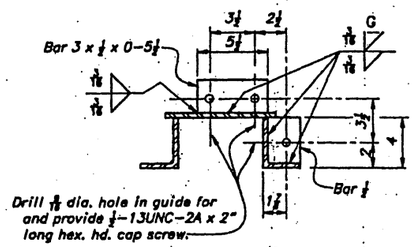
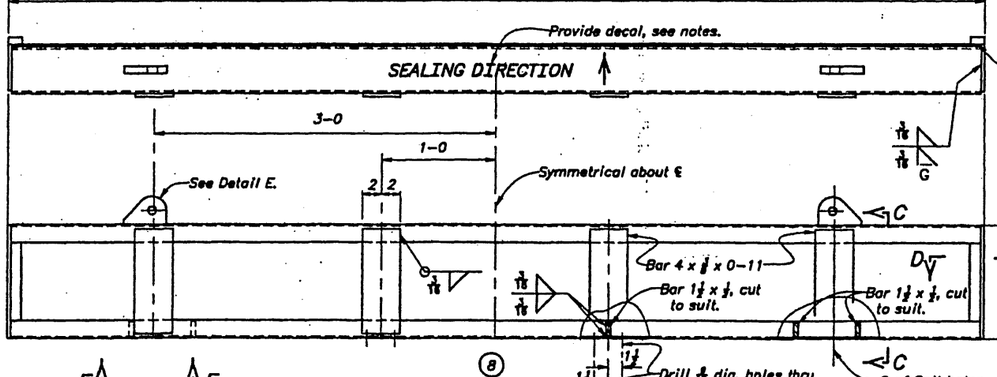
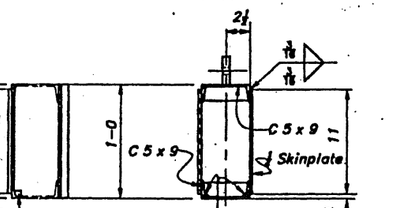


SECTION H-H



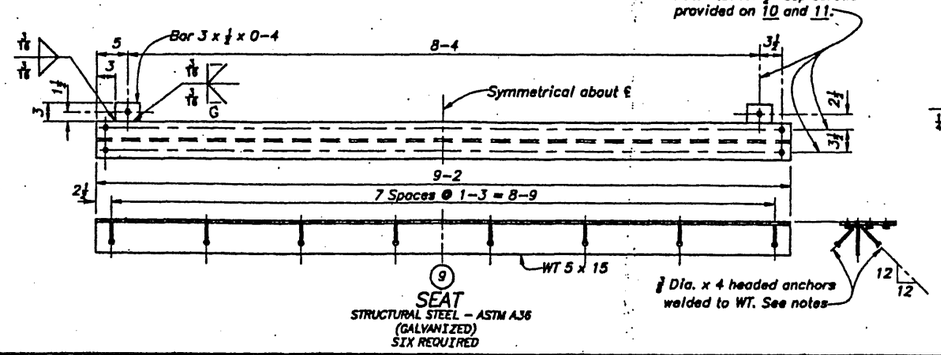
SECTION J-J



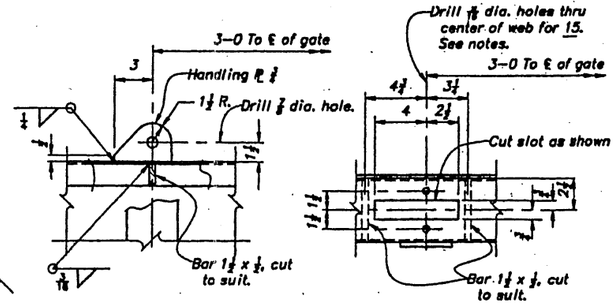


SECTION D-D

SECTION C-C



SEAT
STRUCTURAL STEEL - ASTM A36 (GALVANIZED)
SIX REQUIRED



DETAIL E

VIEW F-F

NOTES

Welding symbols apply to the joints of all members of similar identification.
Unless otherwise noted, joints not covered by a weld symbol shall be seal welded, wherever possible, to exclude water.
All fillet welds shall be returned.
Headed anchors shall be flux filled stud anchors suitable for end welding with automatic end welding guns or equivalent manually welded anchors.
All fabrication shall be completed before hot-dip galvanizing.
Hot-dip galvanizing shall be in accordance with the applicable provisions of ASTM A123-97 and A385-98.
Decals shall be made of UV resistant plastic, suitable for immersion in water. The block lettering shall be a min of 2" high, and easily visible, with a contrasting background. Decals shall be attached with a suitable waterproof adhesive.
Use a template to locate holes in stoplogs 7, 8 and cleats 15 to ensure interchangeability.

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SAN JUAN RIVER RECOVERY IMPLEMENTATION PROGRAM - NEW MEXICO

FISH PASSAGE FACILITY AT PNM DIVERSION DAM

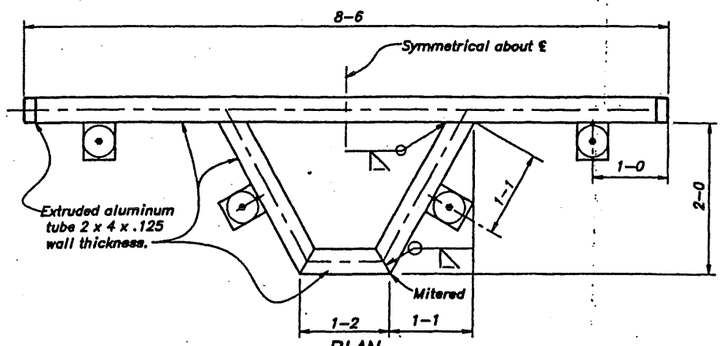
FISH TRAP STRUCTURE
FIAH TRAP EQUIPMENT
STOPLOG - SEAT - GUIDES - DETAILS

DESIGNED [signature] CHECKED Wayne M. Dahy
DRAWN [signature] TECH. APPR. R. L. Lund
APPROVED Robert V. Dill
MANAGER, MECHANICAL EQUIPMENT GROUP

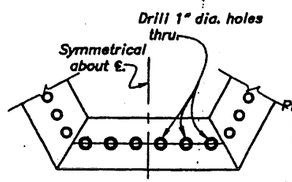
CADD SYSTEM	CADD FILENAME	DATE AND TIME PLOTTED
AutoCAD Rel. 14.0 DENVER, COLORADO	1745D23R1.DWG JUNE 28, 2001	FEBRUARY 11, 2002 07:24

SHEET 4 OF 5

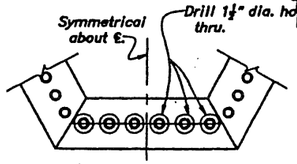
1745-D-23



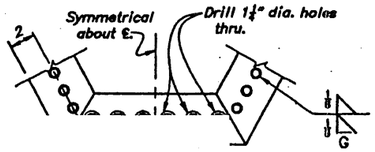
PLAN
(V-TRAP FRAME)
(TYPICAL FOR TOP, MIDDLE AND BOTTOM)
(PIPES AND HOLES NOT SHOWN)

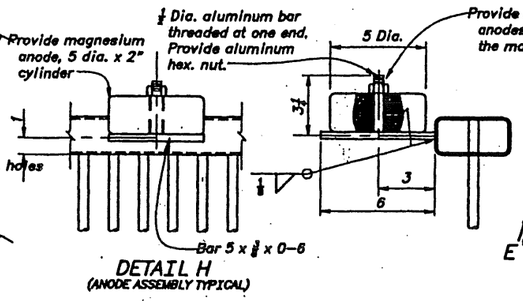


SECTION A-A

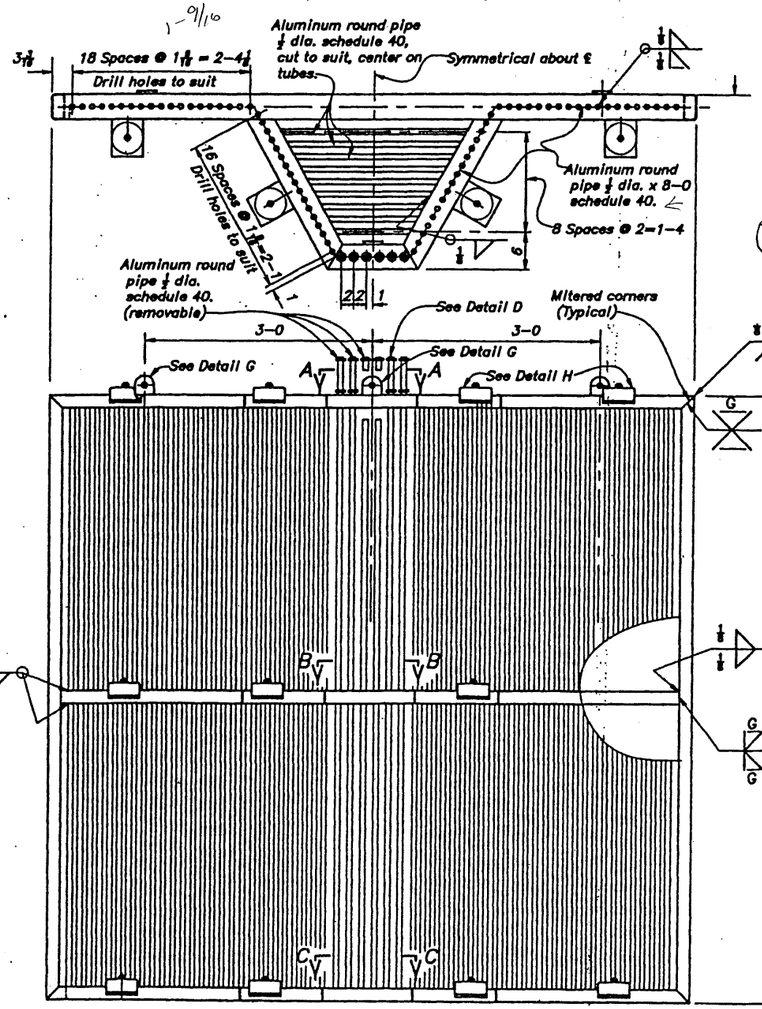


SECTION B-B

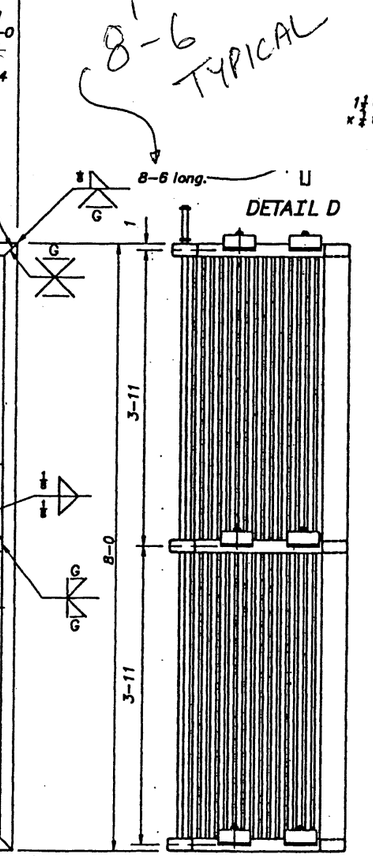




DETAIL H
(ANODE ASSEMBLY TYPICAL)

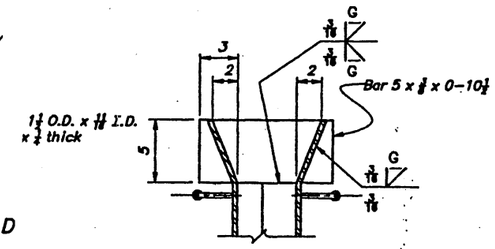


(12)
V-TRAP
ALUMINUM ALLOY 6061-T6.
TWO REQUIRED

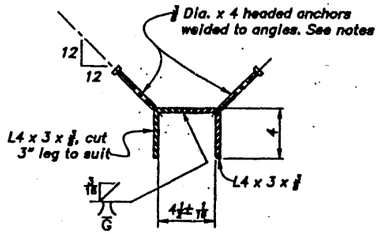


DETAIL D

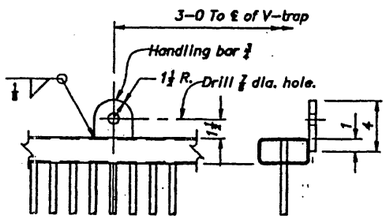
8'-6 TYPICAL



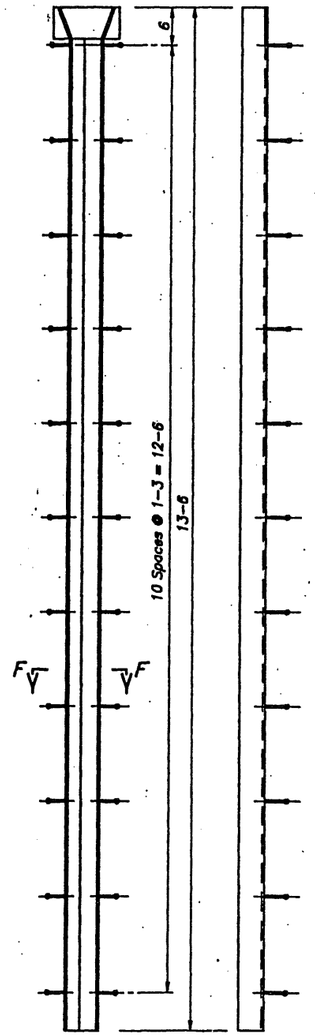
SECTION E-E



SECTION F-F



DETAIL G



(13)
V-TRAP GUIDE
STRUCTURAL STEEL - ASTM A36
(GALVANIZED)
12 REQUIRED

1-9/16

½" Sch 40
OD = 0.840
t = 0.109

NOTES

Welding symbols apply to the joints of all members of similar identification.
All fillet welds shall be returned.
Metal work shall have no rough edges or sharp corners and shall be free from burrs and irregularities. All welds shall be ground smooth.
Headed anchors shall be flux filled stud anchors suitable for end welding with automatic end welding guns or equivalent manually welded anchors.
All fabrication shall be completed before hot-dip galvanizing.
Hot-dip galvanizing shall be in accordance with the applicable provisions of ASTM A123-97 and A385-98.

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SAN JUAN RIVER RECOVERY IMPLEMENTATION PROGRAM - NEW MEXICO

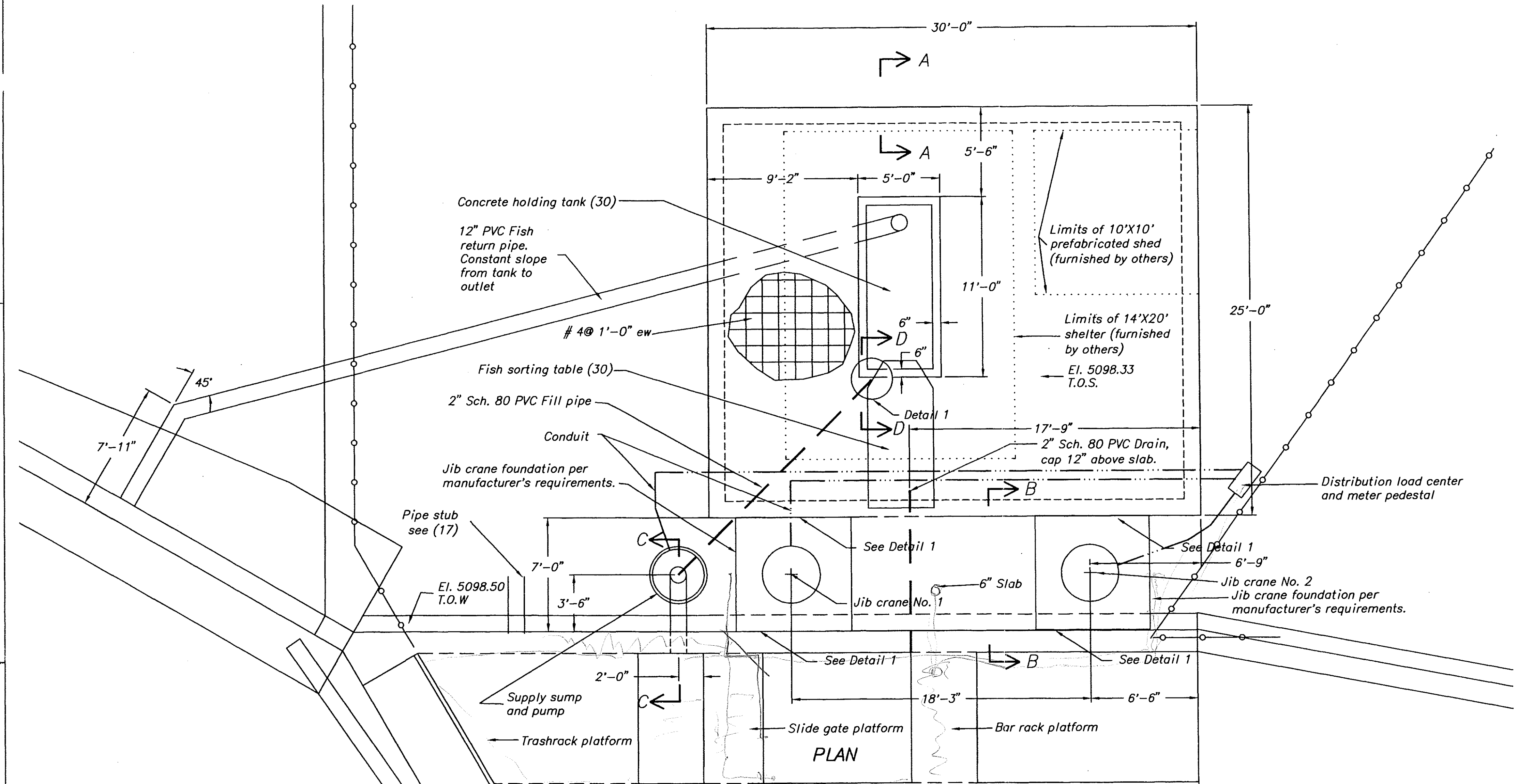
FISH PASSAGE FACILITY AT PNM DIVERSION DAM

FISH TRAP STRUCTURE
FISH TRAP EQUIPMENT
V-TRAP - V TRAP GUIDE- DETAILS

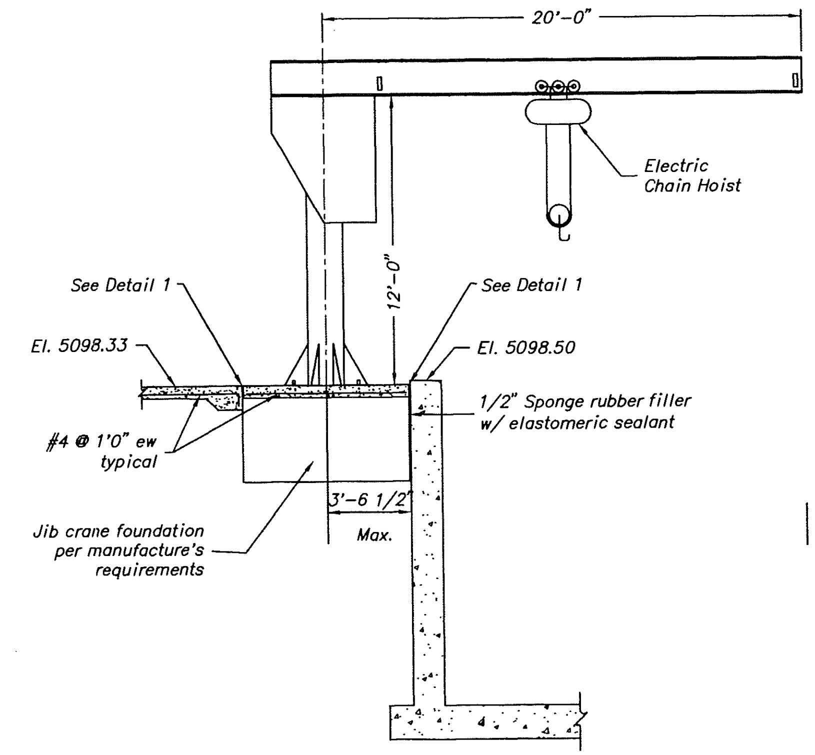
DESIGNED — CHECKED
DRAWN — TECH. APPR.
APPROVED
MANAGER, IMPLEMENTATION EQUIPMENT GROUP

CADD SYSTEM	CADD FILENAME	DATE AND TIME PLOTTED
AutoCAD Rel. 15.06s	1745D24R1.DWG	FEBRUARY 19, 2002 08:24
DENVER, COLORADO	JUNE 28, 2001	1745-D-24

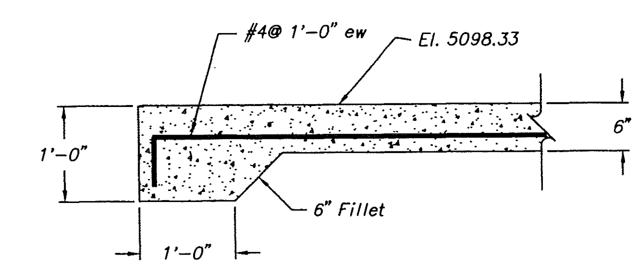
SHEET 5 OF 5



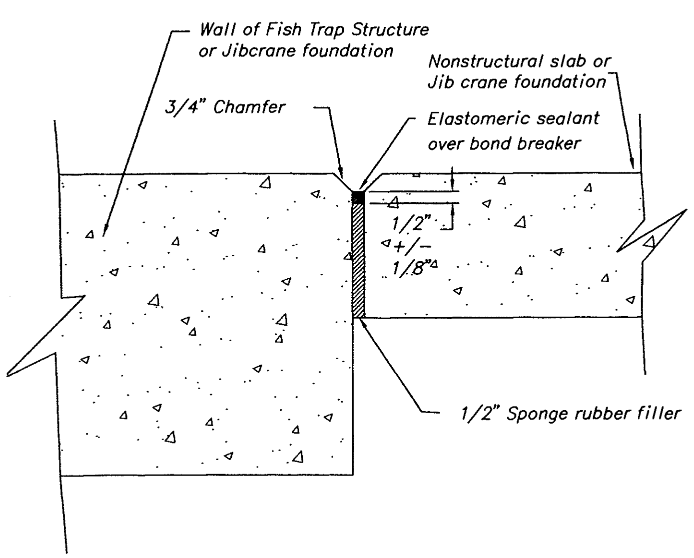
PLAN



SECTION B–B

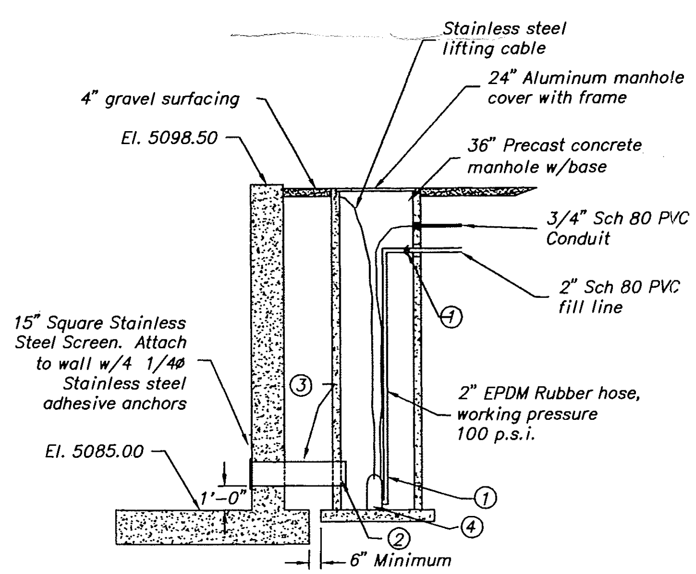


SECTION A–A



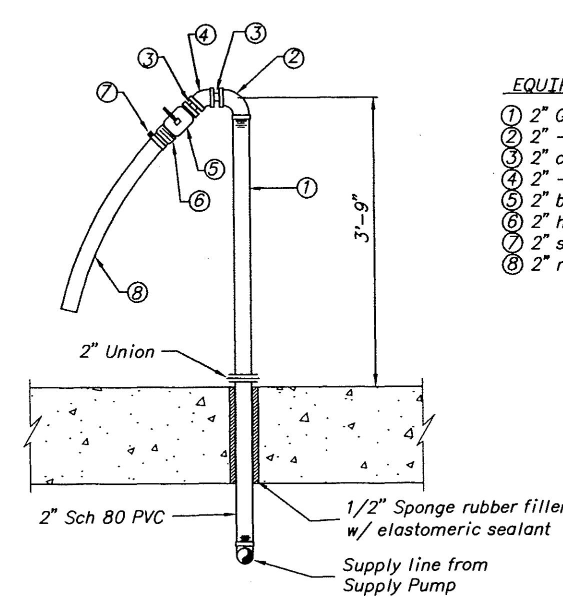
DETAIL 1

N.T.S.



SECTION C–C

1. 2" Bronze, female cam and groove couplings
2. Provide rubber boot for 12" PVC pipe
3. 12" PVC Pipe
4. Supply pump

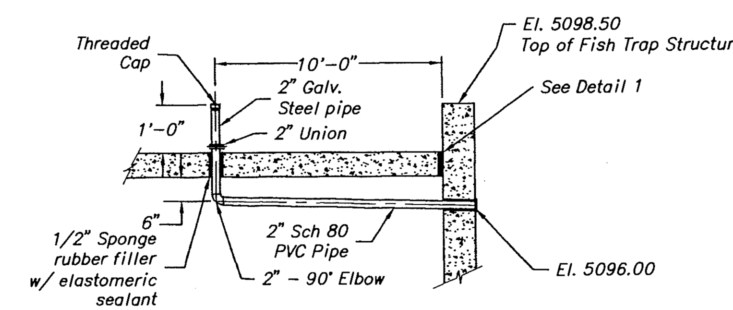


SECTION D–D

N.T.S.

EQUIPMENT SCHEDULE

1. 2" Galv. steel pipe
2. 2" – 90° elbow
3. 2" close nipple
4. 2" – 45° elbow
5. 2" ball valve
6. 2" hose adaptor
7. 2" stainless steel clamp
8. 2" rubber hose, 2' long



SORTING TABLE DRAIN STUB-UP

N.T.S.

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SAN JUAN RIVER RECOVERY IMPLEMENTATION PROGRAM – NEW MEXICO

FISH PASSAGE FACILITY AT PNM DIVERSION DAM

SURFACE FACILITIES

PLAN, SECTIONS AND DETAILS

DESIGNED [signature] CHECKED [signature]
DRAWN [signature] TECHNICAL APPROVAL [signature]
APPROVED [signature]

CADD SYSTEM	CADD FILENAME	DATE AND TIME PLOTTED
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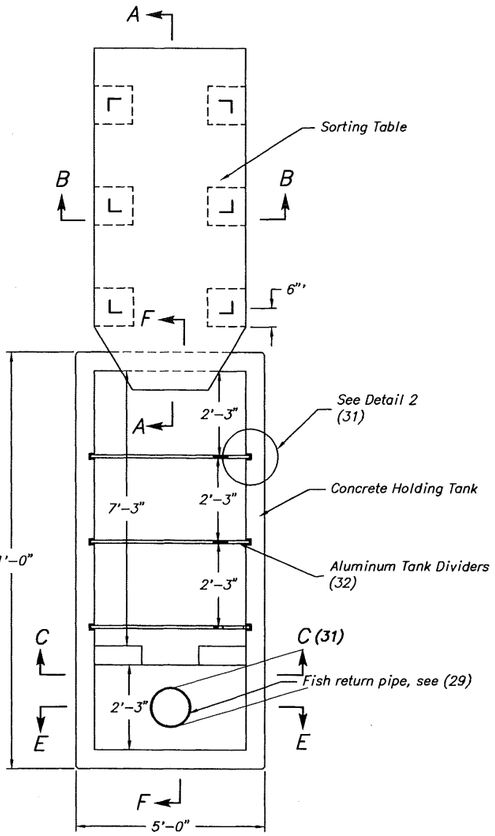
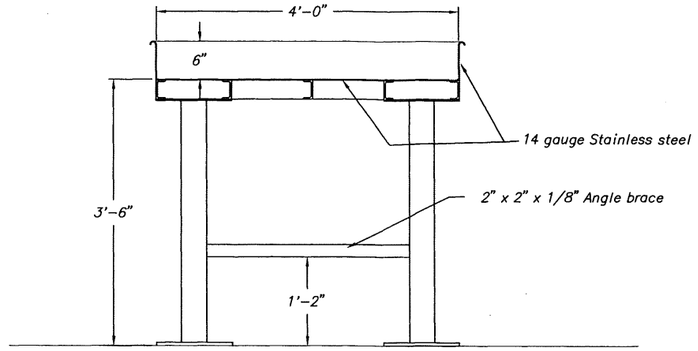
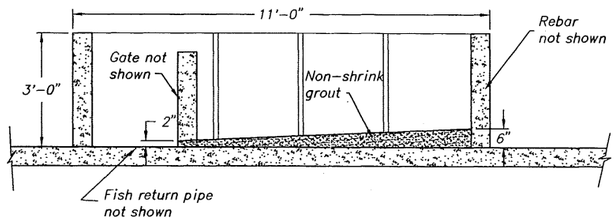
	JUNE 27, 2001 SHEET 1 OF 1	1745-417-29



SORTING TABLE AND HOLDING TANK
PLAN VIEW



SECTION B–B
(Typical at each support)



SECTION F–F
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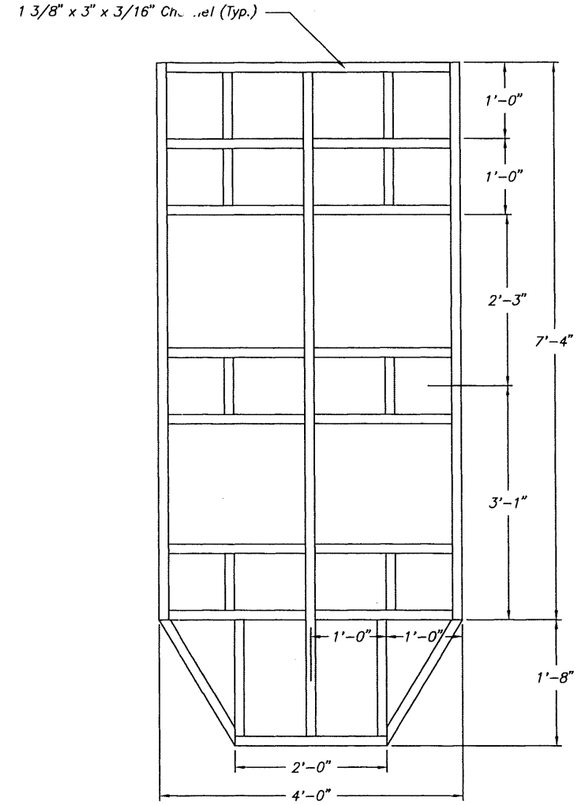
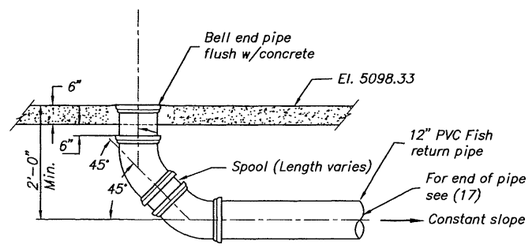


SORTING TABLE FRAME
PLAN VIEW



SECTION E–E
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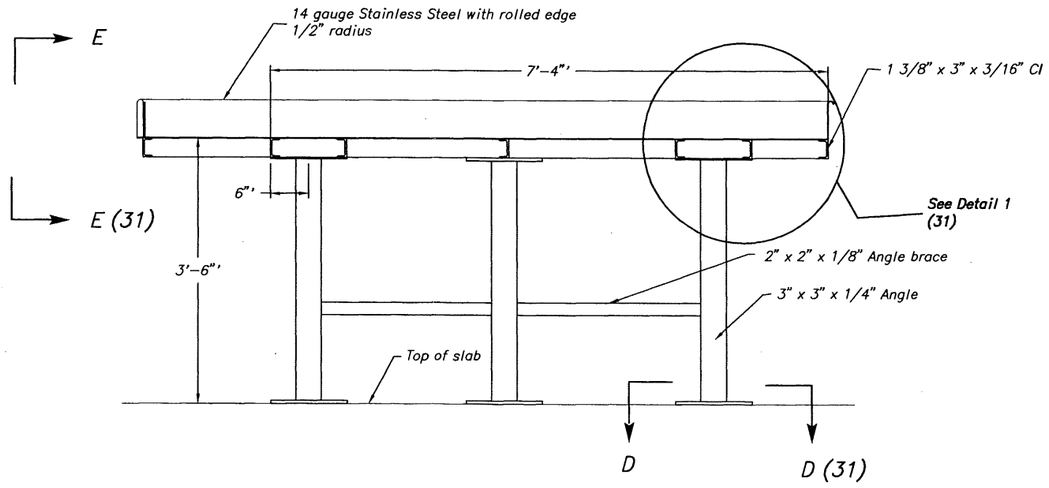

SECTION A–A

NOTE:

Unless otherwise shown, sorting table shall be fabricated from stainless steel. Stainless steel construction shall be in accordance with AISI Type 304 and ASTM A–167.

All stainless steel members shall be welded to provide a rigid construction. Weld locations, types and size shall be determined by the fabricator.

Grind smooth all welds.

Bolt table to slab with 1/2"ø adhesive anchors.

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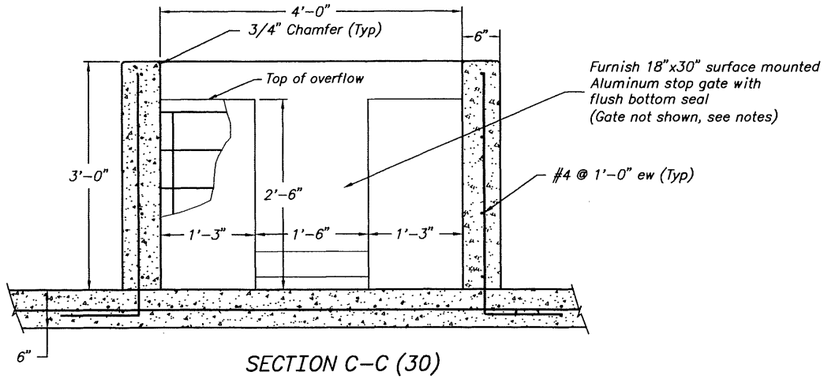
FISH PASSAGE FACILITY AT PNM DIVERSION DAM

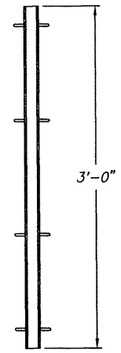
SORTING TABLE AND HOLDING TANK

PLAN AND SECTIONS

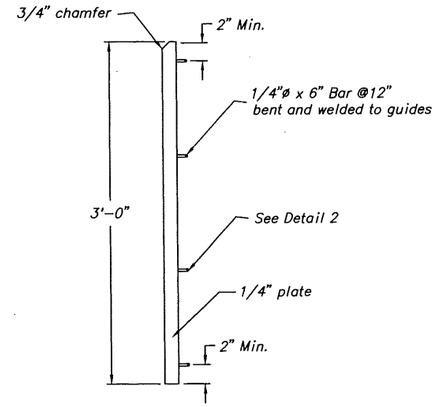
DESIGNED Gary Burns	CHECKED Kevin Mosier		
DRAWN Gary Burns	TECHNICAL APPROVAL Mark Wernke		
APPROVED Bart R. Gibbons			
CADD SYSTEM AutoCAD Rel. 15.05	CADD FILENAME 1745–417–30.DWG JUNE 20, 2001	DATE AND TIME PLOTTED APRIL 15, 2002 10:41	1745–417–30



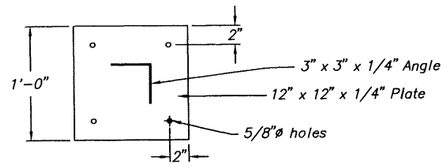
SECTION C–C (30)



DIVIDER GUIDES FRONT VIEW



DIVIDER GUIDES SIDE VIEW



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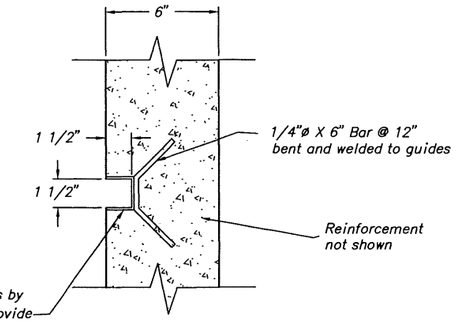
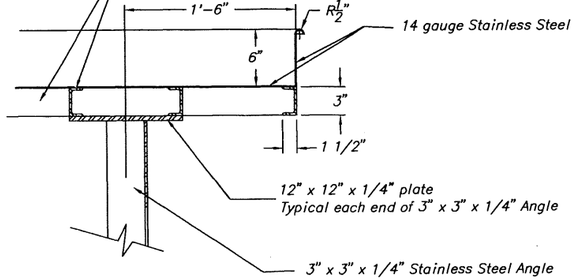
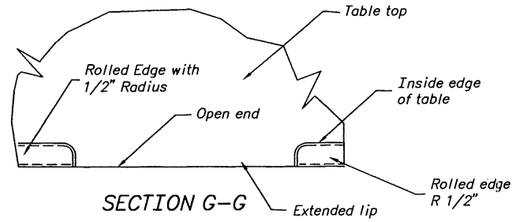


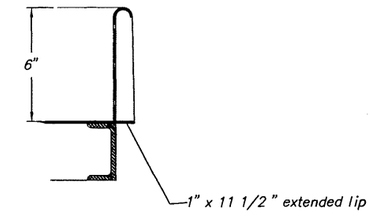
DETAIL 2 (30)
(Six Required)



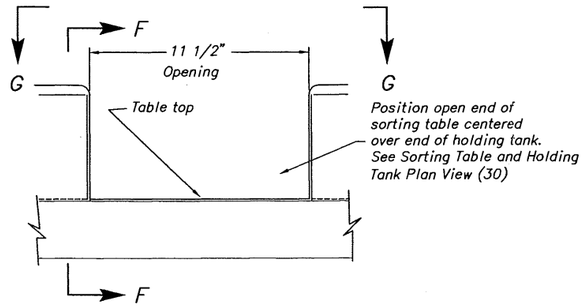
DETAIL 1 (30)



SECTION G–G



SECTION F–F



SECTION E–E (30)

NOTE:

Unless otherwise shown, sorting table shall be fabricated from stainless steel. Stainless steel construction shall be in accordance with AISI Type 304 and ASTM A–167.

All stainless steel members shall be welded to provide a rigid construction. Weld locations, types and size shall be determined by the fabricator.

Grind smooth all welds.

Mount aluminum stop gate in accordance with manufacturer's instructions.

Bolt table to slab with 1/2 "ø adhesive anchors.

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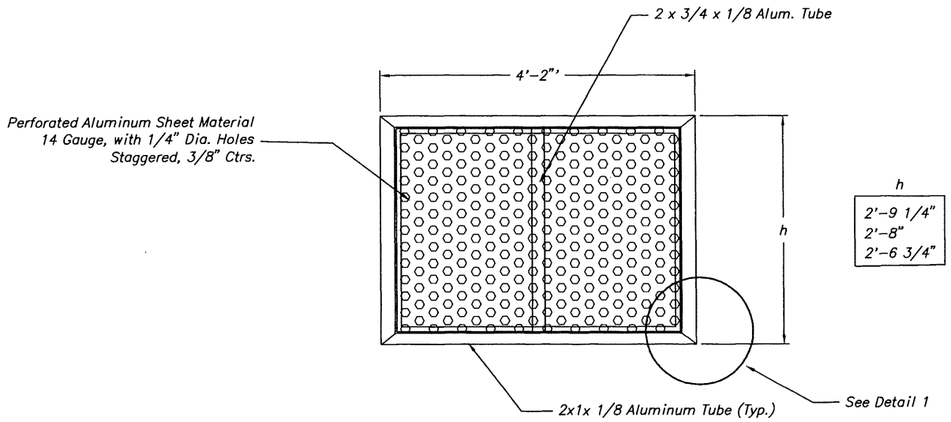
SAN JUAN RIVER RECOVERY IMPLEMENTATION PROGRAM – NEW MEXICO

FISH PASSAGE FACILITY AT PNM DIVERSION DAM

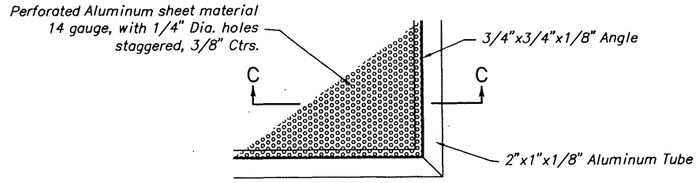
SORTING TABLE AND HOLDING TANK SECTIONS AND DETAILS

DESIGNED	Larry Burns	CHECKED	Kevin Morgan
DRAWN	Larry Burns	TECHNICAL APPROVAL	Mark Usdale
APPROVED	Burt R. Silverman		

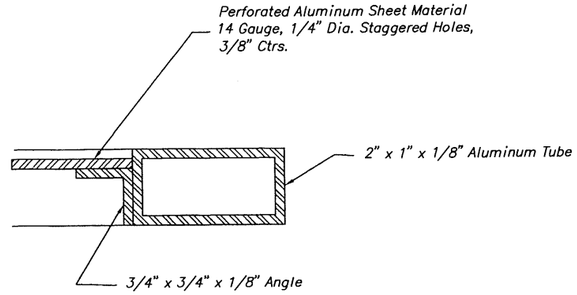
CADD SYSTEM	CADD FILENAME	DATE AND TIME PLOTTED
AutoCAD Rel. 15.05	1745-417-31.DWG MAY 9, 2001 SHEET 1 OF 1	APRIL 15, 2002 12:03 1745-417-31



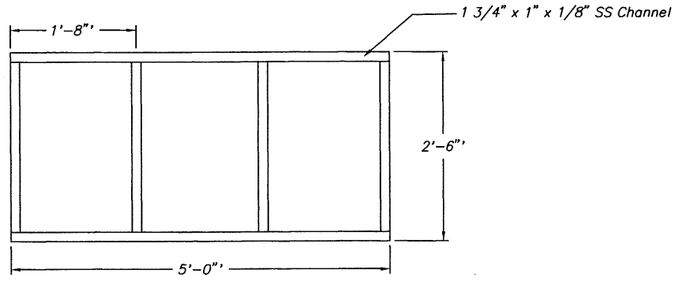
ALUMINUM TANK DIVIDERS (30)
(Three required)



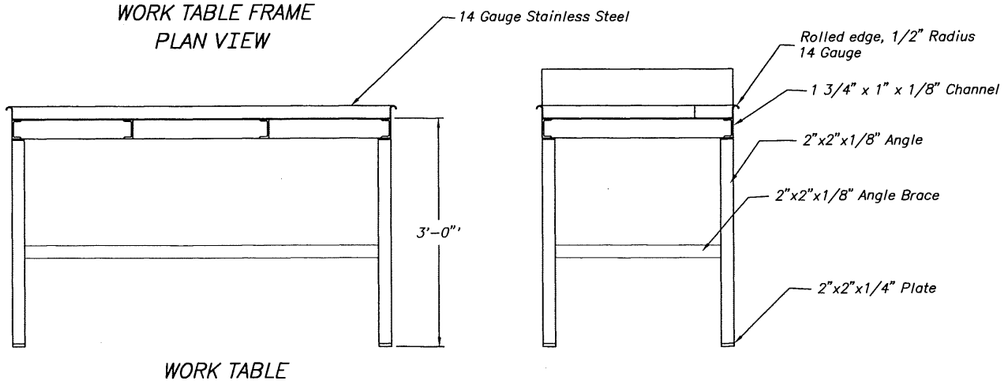
DETAIL 1



SECTION C-C



WORK TABLE FRAME
PLAN VIEW



WORK TABLE

NOTE:

Tank dividers shall be constructed of Aluminum. Aluminum construction shall be in accordance with ASTM Specifications for structures of Aluminum Alloy 6061-T6 for Shapes and Tubes, and 5052-A32 or A34 for Plates.

Work table shall be fabricated from stainless steel. Stainless steel construction shall be in accordance with AISI Type 304 and ASTM A-167.

All members shall be welded to provide a rigid construction. Weld locations, types and size shall be determined by the fabricator.

Grind smooth all welds.

Bolt table to slab with 1/2"ø adhesive anchors.

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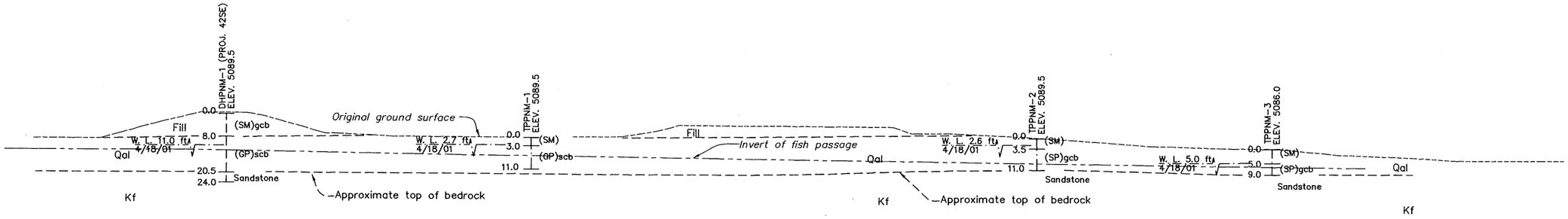
SAN JUAN RIVER RECOVERY IMPLEMENTATION PROGRAM - NEW MEXICO

FISH PASSAGE FACILITY AT PNM DIVERSION DAM

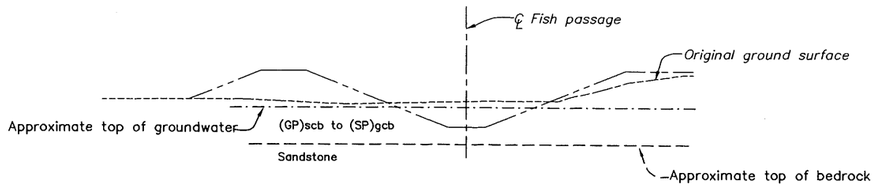
WORK TABLE AND TANK DIVIDERS

PLAN AND SECTIONS

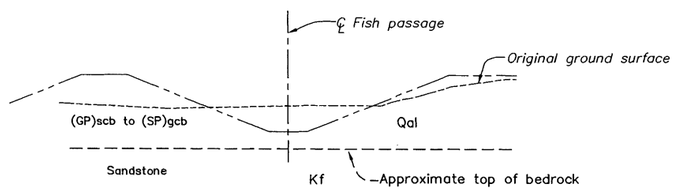
DESIGNED Larry Burns	CHECKED Tom Moron		
DRAWN Larry Burns	TECHNICAL APPROVAL Mark Wernke		
APPROVED Pat R. Tibbets			
CADD SYSTEM AutoCAD Rel. 15.05	CADD FILENAME 1745-417-32.DWG	DATE AND TIME PLOTTED MAY 9, 2002 09:12	1745-417-32



PROFILE ON APPROXIMATE ℄ FISH PASSAGE



TYPICAL SECTION (groundwater)



TYPICAL SECTION (geology)

NOTES

For site plan of fish passage, see 1745-D-14.
For typical sections of fish passage, see 1745-D-15.

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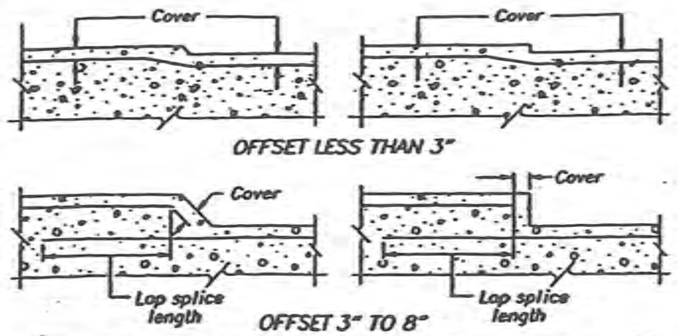
FISH PASSAGE FACILITY AT PNM DIVERSION DAM

GEOLOGY PROFILE AND SECTIONS

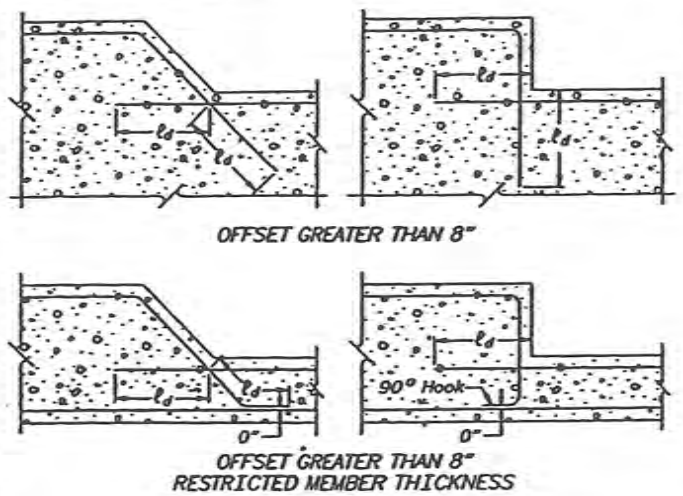
DESIGNED L. STONE	CHECKED		
DRAWN L. STONE	TECHNICAL APPROVAL		
APPROVED			

CADD SYSTEM	CADD FILENAME	DATE AND TIME PLOTTED
AutoCAD Rel. 15.05	1745-417-33.DWG	APRIL 29, 2002 15:06

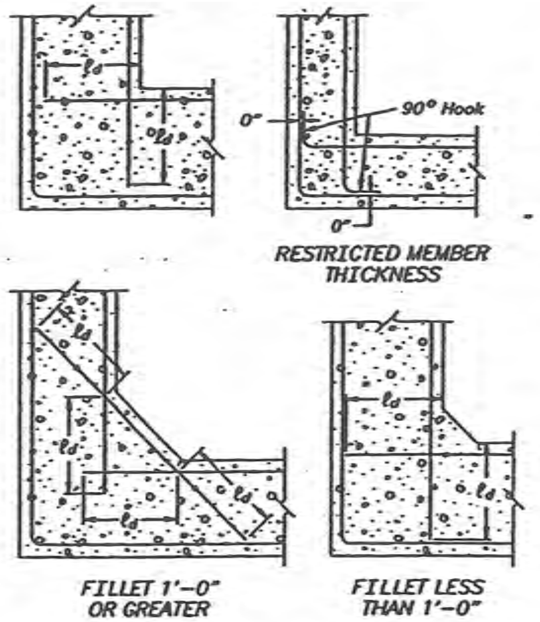
1745-417-33



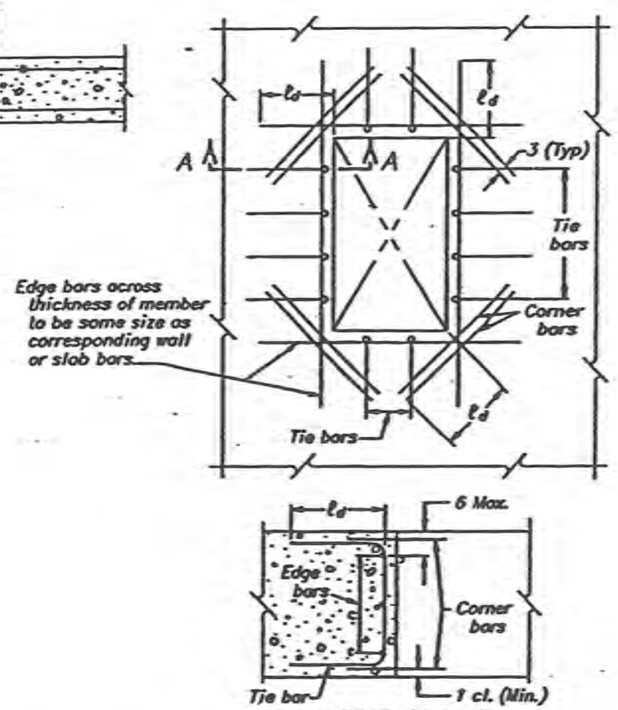
NOTE TO DESIGNERS AND DETAILERS: This detail may not be appropriate for tension areas of shallow structural members. If in doubt, use detail for offset greater than 8". See limits for noncontact lap splices in General Notes, Splices.



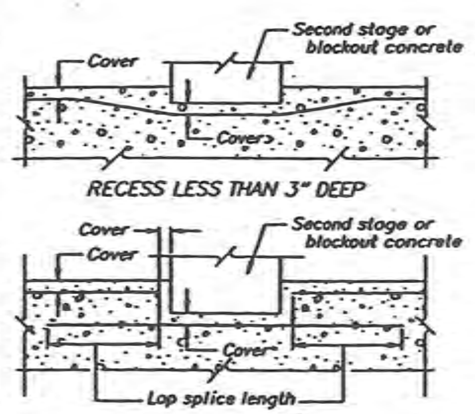
TYPICAL OFFSET DETAILS



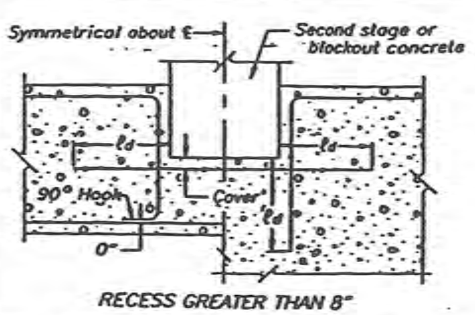
TYPICAL CORNER DETAILS



SECTION A–A



NOTE TO DESIGNERS AND DETAILERS: This detail may not be appropriate for tension areas of shallow structural members. If in doubt, use detail for recess greater than 8". See limits for noncontact lap splices in General Notes, Splices.



TYPICAL BLOCKOUT RECESS DETAILS

(Second stage concrete shown)

OPENINGS :

TABLE FOR ADDITIONAL REINFORCEMENT

MEMBER THICKNESS	TIE BARS	EDGE BARS	CORNER BARS
Less than 10	None	1 – ctr.	2 – #4 ctr.
10 thru 1–6	None	2 – (1 ef)	4 – #4 (2 ef)
1–7 thru 3–0	#4 @ 1–0	3 – eq. spc.	4 – #4 (2 ef)
Over 3–0	#6 @ 1–0	Spc. @ 1–0	4 – #5 (2 ef)

Omit edge and tie bars along sides of openings where dimension is less than 1'–6".
Omit corner bars at sides of openings adjacent to floors, walls, or beams.
Omit corner bars if both dimensions of opening are less than 1'–6".

RECESSES :
Use corner bars in face of recesses deeper than 4" if either dimension of recess is equal to or greater than 1'–6".

ADDITIONAL REINFORCEMENT AROUND OPENINGS AND RECESSES

GENERAL NOTES 1/

UNLESS OTHERWISE SHOWN ON THE REINFORCEMENT DESIGN DRAWINGS, THE DETAILS AND NOTES SHOWN ARE MINIMUM REQUIREMENTS AND TYPICAL FOR ALL REINFORCEMENT DRAWINGS THAT REFER TO THIS DRAWING

ABBREVIATIONS :

bf = bottom face	br = bottom row	bl = bottom layer
tf = top face	tr = top row	tl = top layer
nf = near face	nr = near row	ml = middle layer
ff = far face	fr = far row	ns = near side
ef = each face	er = each row	fs = far side
if = inside face	ir = inside row	es = each side
of = outside face	or = outside row	ew = each way
	mr = middle row	ec = each corner

spc. = space or spaces
eq. spc. = equally spaced, equal spaces
d_b = nominal diameter of reinforcing bar
uv = uniformly varying lengths of bars between lengths shown
cl. = clear
ctr. = center or centers
add'l = additional
ℓ_d = development length

SYMBOLS :

Bars shown thus #8@1–0 or #6@8 indicate a group of the same size bars equally spaced.
An open circle at the end of a bar indicates a bend with the bar turned away from the observer.
A closed circle at the end of a bar indicates a bend with the bar turned towards the observer.
Splices shown thus indicate a lap splice, not a bend in the bar.

DIMENSIONS :

Dimensions are to the centerline of the bars except for embedment of hooks, which are dimensioned to the outside of the bar.
Clear cover dimensions are marked "cl." and are dimensioned to the outside of the bar.

COVER :

Place the reinforcement so that the clear distance between face of concrete and nearest reinforcement is 1½" for #5 bars and smaller, 2" for #6 bars through #8 bars and 3" for #9 bars through #11 bars. Provide 3" clear distance from face of concrete for all bars when the concrete is placed against earth or rock. Clear distance is to the design dimension line.
Reinforcement parallel to construction joints shall have a minimum of 2" clear cover.

PLACING :

Reinforcement at small openings (max 1'–6") in walls and slabs may be spread apart not more than 1.50 times the bar spacing.
Reinforcement may be adjusted laterally to maintain a clear distance of at least 1" between the reinforcement and keys, waterstops, anchor bolts, form ties, conduits, and other embedded materials. In heavily reinforced areas, relocation of the embedded material must be considered.
When bars are bent due to offsets less than 3" and recesses less than 3" deep, the slope of the inclined portion must not exceed 6 to 1.
Reinforcement parallel to anchor bolts or other embedded material shall be placed to maintain a clear distance of at least 1.33 times the maximum size aggregate.

SPACING :

The first and last bars in walls and slabs, stirrups in beams, and ties in columns are to start and end at a maximum of one half of the adjacent bar spacing. The minimum edge spacing shall be the smaller of either $2.5d_b$ or 0.5 of the adjacent bar spacing.

STANDARD HOOKS :

1. 180–degree bend plus $4d_b$ extension, but not less than 2½" at the free end of the bar.
2. 90–degree bend plus $12d_b$ extension at free end of the bar.

STIRRUP AND TIE HOOKS :

1. #5 bar and smaller, 90–degree bend plus $6d_b$ extension at the free end of the bar.
2. #6, #7, and #8 bars, 90–degree bend plus $12d_b$ extension at the free end of the bar.
3. #8 bars and smaller, 135–degree bend plus $6d_b$ extension at the free end of the bar.

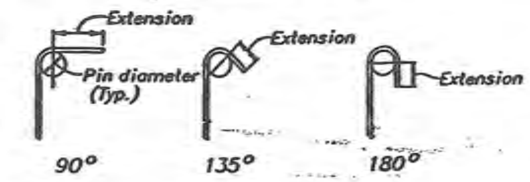


TABLE OF PIN DIAMETERS IN INCHES

BAR NO.	3	4	5	6	7	8	9	10	11
Standard bends	2¼	3	3¾	4½	5¼	6	9½	10¾	12
Stirrup and tie bends	1½	2	2½	4½	5¼	6			

REINFORCEMENT DOWELS :

Dowels indicated on the drawing, such as #8(d), shall be embedded a length equal to ℓ_d and shall have a projection equal to that required for lap splicing to a bar of the same diameter.

PLAIN DOWELS :

Plain dowels across contraction joints shall be smooth bars uniformly coated with a film of oil before concrete placement. Viscosity of the oil shall have a SAE rating of not less than 250.

ACCESSORIES :

Bar supports, spacers, and other accessories are not shown on the design drawings. The recommendations of the ACI Detailing Manual–1994, or other approved supporting systems may be used.

DRAWING REFERENCES :

Numerals in parentheses ( ) following notes and section letters or numbers indicate the number of the drawing upon which the section or detail is shown; for example (524) denotes Drawing No. 557–D–524.

CODE AND DETAILING REFERENCES :

ACI Building Code Requirements for Structural Concrete (ACI 318–95).
ACI Detailing Manual – 1994.

NOTES TO DESIGNERS AND DETAILERS :

Splice lengths shown in the tables on this drawing are for Class B tension lap splices in accordance with ACI 318–95. Assumed conditions for these tables in addition to the requirements shown on this drawing are uncoated reinforcement, normal weight concrete, and the transverse reinforcement index (K_{tr}) equal to zero. Splices or development lengths other than those shown in the tables must be detailed on the reinforcement design drawings.
Some factors which require additional consideration are: Beams or columns with ties, lightweight aggregate concrete, epoxy–coated reinforcement, excess reinforcement, bars in compression, bundled bars, and seismic considerations.

SPLICES :

The minimum length of lap for splicing parallel bars shall be as given in the applicable table.
Staggered splices shall be separated to give 12 inches clear between ends of adjacent splices.
Bars spliced by noncontact lap splices shall not be spaced transversely farther apart than one–fifth the required lap splice length, nor 6" on centers.
When reinforcing bars of different size are to be spliced, the length of lap shall be governed by the smaller diameter bar.
Splices are to be made so that the required clear distances to face of concrete will be maintained.

f'c = 3000 psi	TABLE 3 – 60		fy = 60,000 psi		
BAR SIZE NO.	MINIMUM ℄ to ℄ BAR SPACING (INCHES)	LAP SPLICE LENGTH (INCHES)		DEVELOPMENT LENGTH ℓ_d (INCHES)	
		TOP BARS *	OTHER BARS	TOP BARS *	OTHER BARS
3	3	17	16	13	12
4	3	23	18	18	14
5	4	28	22	22	17
6	5	34	26	26	20
7	6	49	38	38	29
8	6	56	43	43	33
9	7	63	49	49	38
10	8	71	55	55	42
11	9	79	61	61	47
9	6	63 **	49 **	49	38
10	6	75 **	58 **	58	45
11	6	93 **	71 **	71	55

f'c = 4000 psi	TABLE 4 – 60		fy = 60,000 psi		
BAR SIZE NO.	MINIMUM ℄ to ℄ BAR SPACING (INCHES)	LAP SPLICE LENGTH (INCHES)		DEVELOPMENT LENGTH ℓ_d (INCHES)	
		TOP BARS *	OTHER BARS	TOP BARS *	OTHER BARS
3	3	16	16	12	12
4	3	20	16	15	12
5	4	25	19	19	15
6	5	29	23	23	18
7	6	43	33	33	25
8	6	49	37	37	29
9	7	55	42	42	33
10	8	62	47	47	37
11	9	68	53	53	41
9	6	55 **	42 **	42	33
10	6	65 **	50 **	50	39
11	6	80 **	62 **	62	48

* Top bars are all horizontal bars so placed that more than 12 inches of fresh concrete is cast below the development length or splice.
** Splices must be staggered.

1/ Unless otherwise shown on the reinforcement design drawings or this drawing, follow the recommendations established by the ACI Detailing Manual – 1994.

8–1–97 D – [illegible]	CONVERTED TO AUTOCAD DRAWING. REVISED TO CONFORM TO ACI 318–95. OTHER MINOR REVISIONS.
2–29–92 D – R.D.A.	TOP BAR DEFINITION REVISED AND MINOR PUNCTUATION REVISION IN PLACING NOTE.
12–7–90 D – J.B.S.	REDRAWN TO NEW DRAFTING STANDARDS, REVISED CONCRETE COVER, NOTES TO DESIGNERS, TABLES, REINFORCEMENT AROUND OPENINGS, AND OTHER MINOR REVISIONS. REVISED TO CONFORM TO ACI 318–89.
9–27–84 D – WP DB	REVISED PIN DIAMETER TABLE, REFERENCED THE ACI DETAILING MANUAL 1980, ADDED NOTES UNDER PLACING AND STANDARD HOOKS.
12–8–78 D – [illegible]	MINOR REVISIONS

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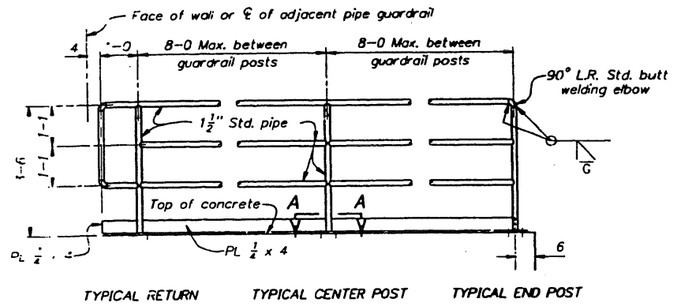
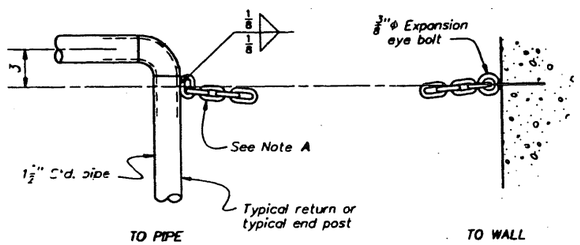
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
STANDARD DESIGNS

GENERAL NOTES AND MINIMUM REQUIREMENTS FOR DETAILING REINFORCEMENT

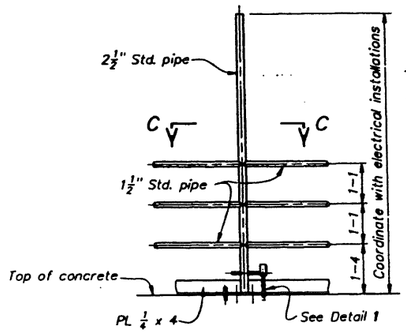
CHECKED GAYLE A. ERICKSON
APPROVED H. G. ARTHUR



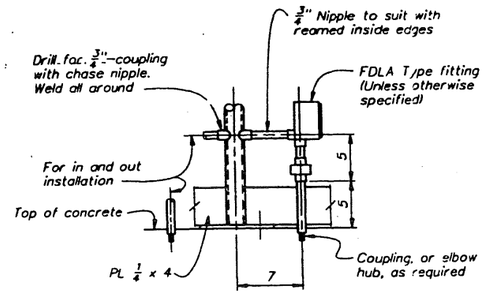
TOP MOUNTED PIPE GUARDRAIL



TYPICAL CHAIN DETAILS
AS REQUIRED

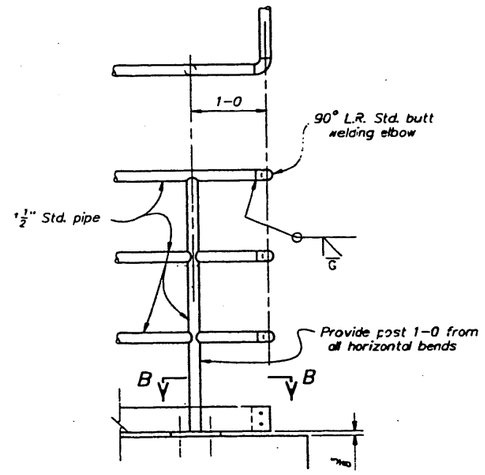


TYPICAL LIGHT POST

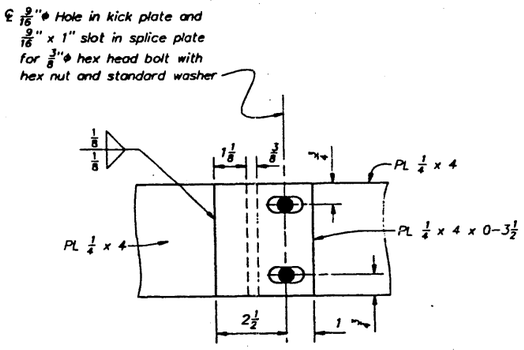


DETAIL 1

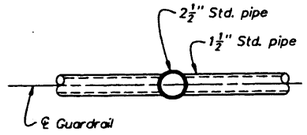
Note A: ¼" ϕ Galvanized chain with maximum sag of 2-inches. Provide "S" hook and heavy duty swivel snap at one end. Weld single chain link to opposite end.



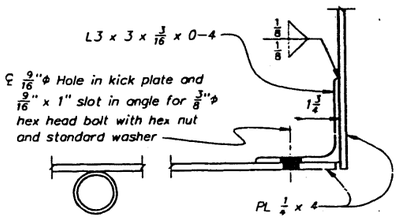
TYPICAL GUARDRAIL
HORIZONTAL BEND



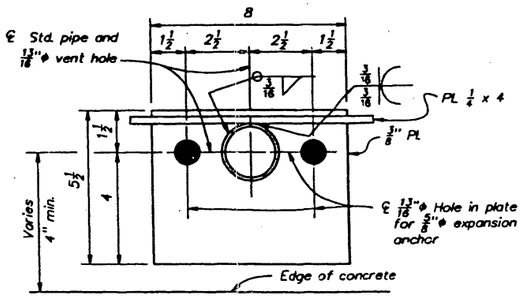
KICK PLATE SPLICE



SECTION C-C



SECTION B-B



SECTION A-A

NOTES

Not all information shown on this drawing may be needed for every job. Use information on this drawing as required.
Galvanize all ferrous metalwork after fabrication. Provide vent holes as required in bottom of pipe.
All material is steel unless otherwise noted.
Splice guardrail as required with splice locks. Provide expansion joint in guardrail and kick plate at 50 foot centers maximum and at expansion joints in concrete. Provide splice lock suitable for expansion joint in guardrail.
Contractor determines guardrail lengths based on dimensions of structures. See structure drawings for location and extent of guardrails.
Grind all welds smooth.
Details, welds, and other connections shown are typical for all similar conditions.

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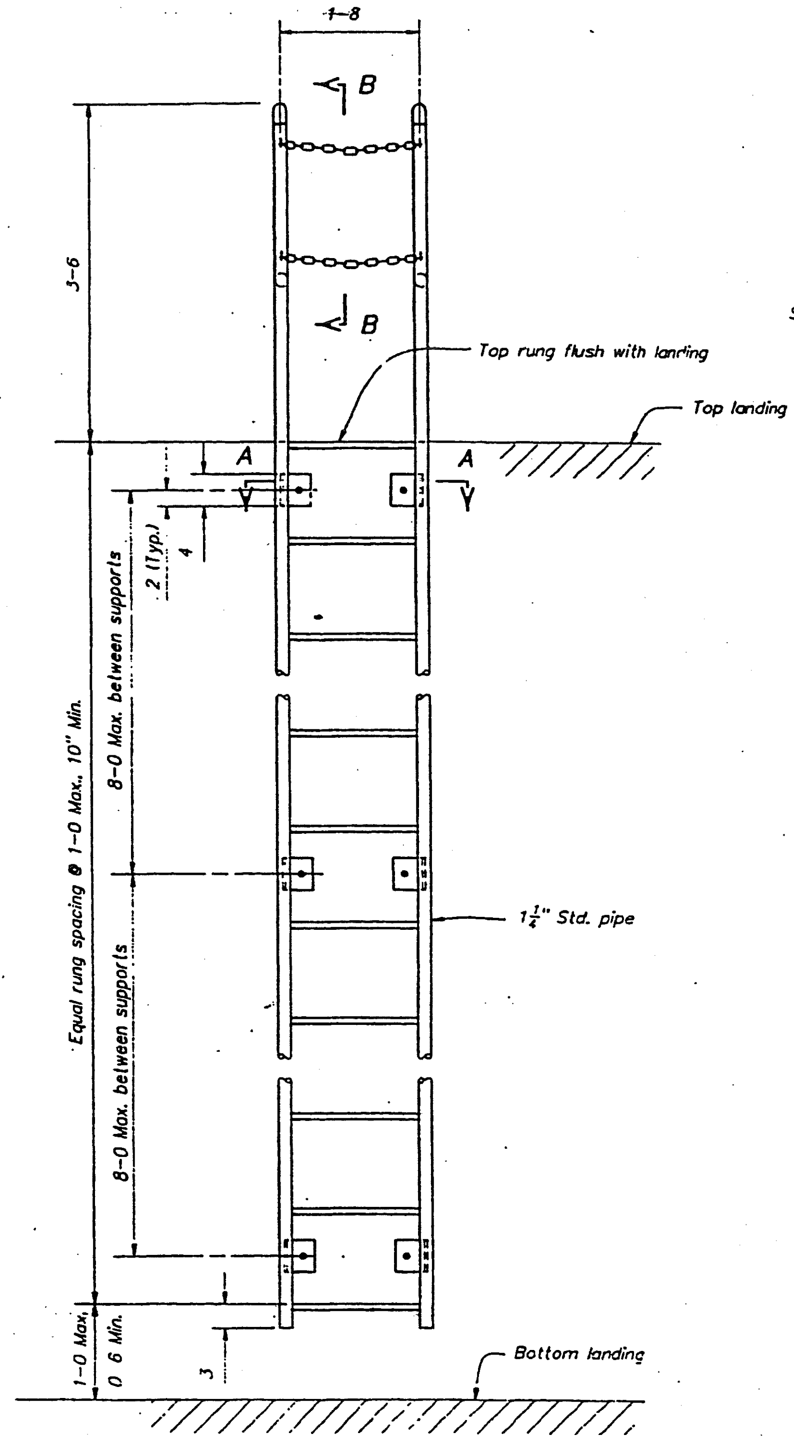
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
STANDARD DESIGN

MISCELLANEOUS METALWORK
TOP MOUNTED PIPE GUARDRAILS WITH KICK PLATE

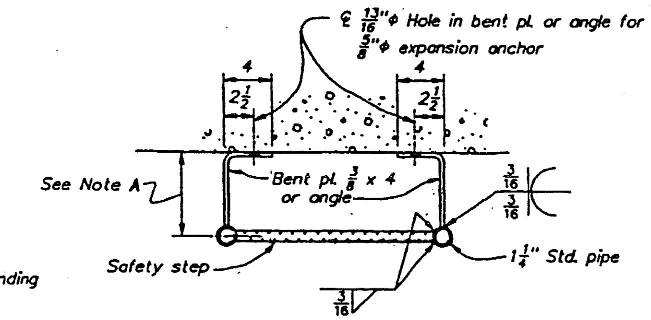
DESIGNED	T.E. SADUSKY	TECHNICAL APPROVAL	
DRAWN	A.M. TUCKER	SUBMITTED	
CHECKED	T.C. GRABER / DCD	APPROVED	CHIEF, CIVIL ENG. DIVISION

CADD SYSTEM: Cosmo Release 9.0 DENVER, COLORADO	DETAC6595.M2:10 Drawing No. 26595 JANUARY 8, 1993	Date and time plotted: JAN 8, 1993 2:03
		40-D-6595

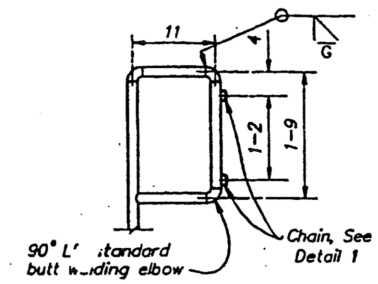
Note A: 7 inches unless noted otherwise on structure drawing.



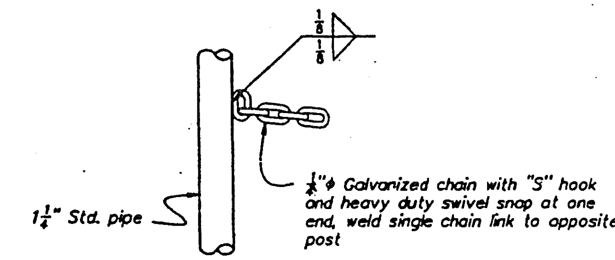
LADDER – TYPE 3



SECTION A–A



SECTION B–B



DETAIL 1

NOTES

All material is steel unless otherwise noted.
Details, welds, and other connections shown are typical for all similar conditions.
Dimensions shown are typical for similar details.
Galvanize all ferrous metalwork after fabrication. Provide vent holes as required.
Contractor determines length of ladders and rung spacings based on elevation difference. See structure drawings.
Grind all welds smooth.

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UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

STANDARD DESIGNS

MISCELLANEOUS METALWORK

LADDER – TYPE 3

DESIGNED A. M. TUCKER — TECHNICAL APPROVAL [signature]
DRAWN A.M. TUCKER — SUBMITTED [signature]
CHECKED T. E. SADUSKY / DCD — APPROVED [signature]
CHIEF, CIVIL ENG. DIVISION

CADD SYSTEM Sigma Release 8.0 — DENVER, COLORADO — JANUARY 8, 1993

40-D-6602

GENERAL NOTES

UNLESS OTHERWISE SHOWN, THESE NOTES ARE TYPICAL FOR ALL DRAWINGS THAT REFER TO THIS DRAWING.

ABBREVIATIONS

El. = Elevation
HP = High point
LP = Low point
WP = Working point
bf = bottom face
ef = each face
ff = far face
nf = near face
tf = top face
SP = Sewer pipe
TW = Tailwater
WS = Water surface, waterstop
CJ = Construction joint
EJ = Expansion joint
OCJ = Optional construction joint
VCJ = Vertical construction joint
Cr.J = Contraction joint
Ct.J = Control joint

WSA = Waterstop--Type A
WSB = Waterstop--Type B
WSD = Waterstop--Type D
WSE = Waterstop--Type E
WSF = Waterstop--Type F
WSG = Waterstop--Type G
WSH = Waterstop--Type H
MSN1 = Metal seal--Type N1
MSN2 = Metal seal--Type N2
MSZ = Metal seal--Type Z

CHAMFER

Chamfer edges of permanently exposed concrete surfaces with a 45° bevel, $\frac{3}{4}$" x $\frac{3}{4}$".

CONCRETE PLACEMENT

Before placing concrete, see all drawings released to the contractor as suitable for construction, including manufacturer's drawings, for all embedded material which is required in the placement.

CONCRETE SYMBOLS

The different concrete placements are indicated by the following symbols:

Concrete -- First stage
Concrete -- Second stage
Concrete -- Blockout
Existing concrete or concrete in adjacent structures
Grout

DIMENSIONS

All dimensions to a joint are to the centerline of the joint unless otherwise shown.
Dimensions to beams, columns, and walls are from reference lines or other control points.
Dimensions in parentheses ( ) on plans are beam depths.
Beam and slab depths shall be measured from the top of the structural slab. Dimensions given for the depth of recesses are from the surface of the structural concrete.
Thicknesses shown for walls and slabs placed against soil or rock are minimum dimensions.

EMBEDDED MATERIALS

Before placing concrete, care shall be taken that all embedded items are in position and securely fastened in place. Anchor bolt locations and settings are shown on the structural steel, miscellaneous metal, concrete, and equipment drawings. Conduits and grounding cables are shown on the manufacturer's drawings and the electrical drawings. All projecting waterstops and metal seats shall be supported and protected from damage and exposure.

FINISHES

For location and classes of finishes for formed and unformed concrete surfaces, see the specifications drawings and/or paragraphs.

JOINTS

All construction joints, identified as CJ, shall be provided where shown on the drawings. All optional construction joints, identified as OCJ, are to reduce the volume of placements or to facilitate construction. If optional joints are provided they shall be only at the locations shown. Additional construction joints may be used subject to approval.

REFERENCES

Numerals in parentheses that follow notes, details and section letters or numbers indicate the number of the drawing upon which the section or detail is indicated or shown. For example, (524) denotes Drawing No. XXX-D-524. The letters XXX shown here will be numbers denoting the project.

THIS DRAWING SUPERSEDES DRAWING 40-D-7006

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DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

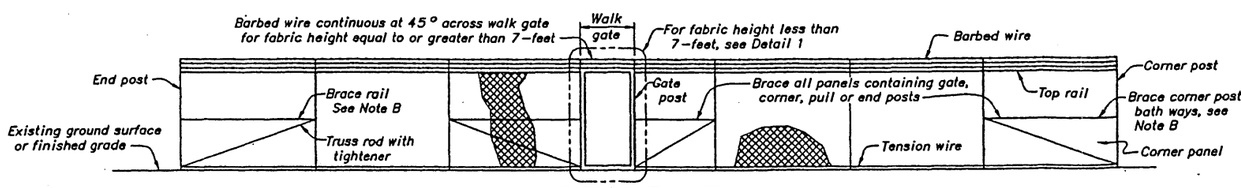
STANDARD DESIGN

GENERAL CONCRETE OUTLINE NOTES

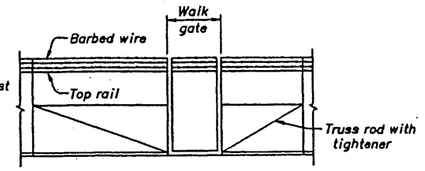
DESIGNED DL BORING TECH. APPR.
DRAWN DL BORING
CHECKED GARY SNYDER APPROVED
STRUCTURAL AND ARCHITECTURAL GROUP

CADD SYSTEM	CADD FILENAME	DATE AND TIME PLOTTED
AutoCAD Rel. 13 c4 DENVER, COLORADO	4007012.DWG MARCH 23, 1998	MARCH 24, 1998 16:55

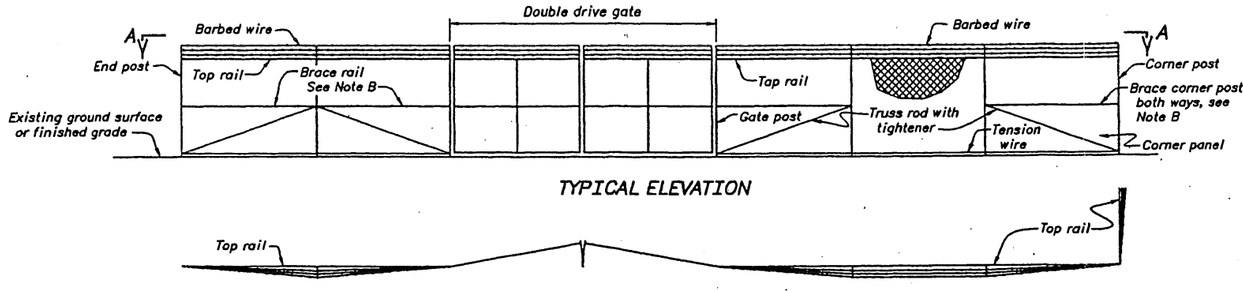
40-D-7012



TYPICAL ELEVATION



DETAIL 1



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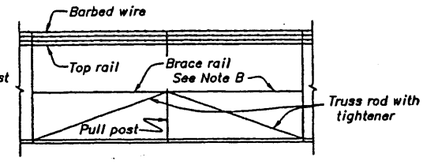
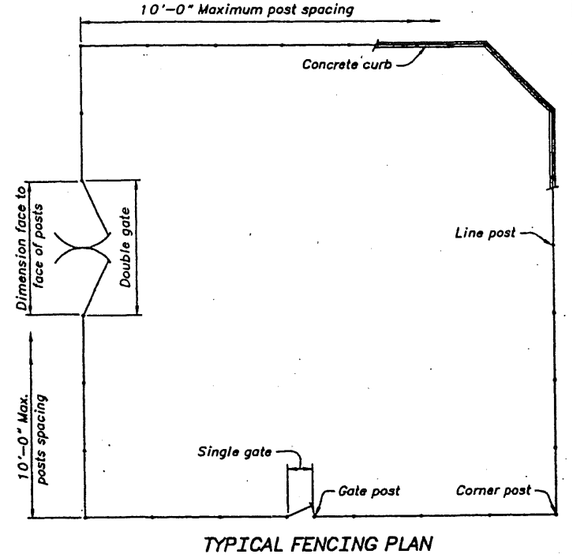
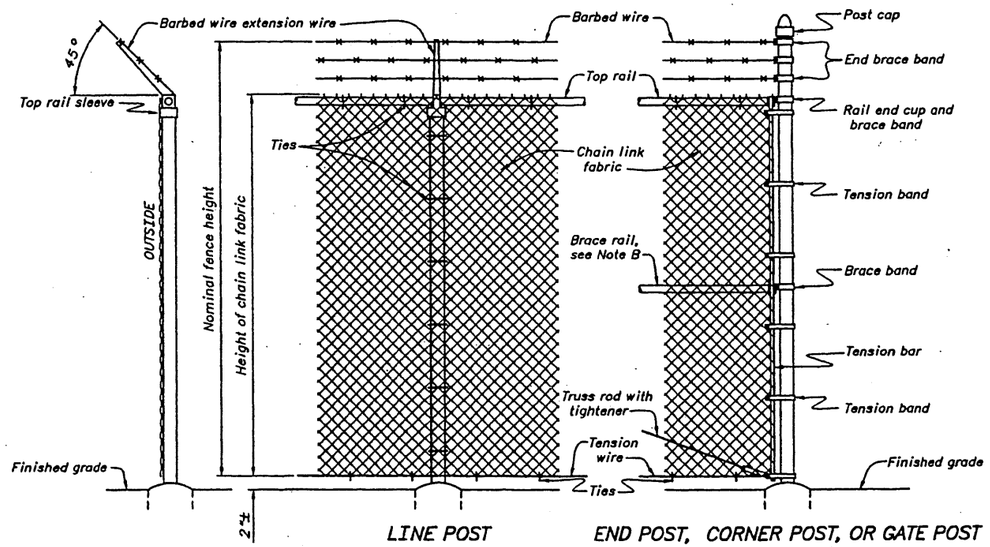


PANELS ADJOINING PULL POST

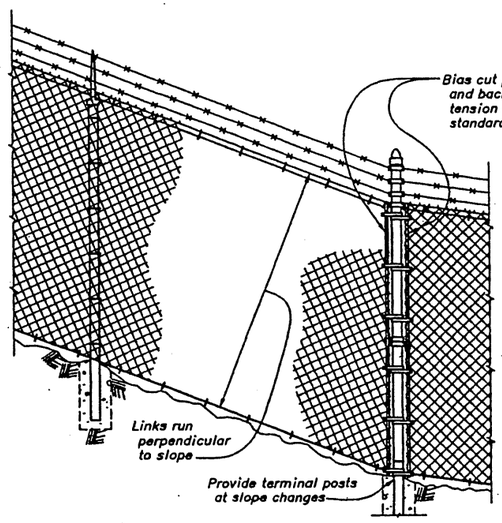
VIEW A-A



TYPICAL FENCING PLAN



LINE POST END POST, CORNER POST, OR GATE POST



FENCE INSTALLATION ON STEEP SLOPES

NOTES

See specific site plan for overall fence dimensions and size, location and swing of gates.

Install pull posts at the end of each run, at maximum intervals of 500 feet, and at vertical and horizontal changes in alignment greater than 30 degrees.

Weld all joints between tubular gate frame members or use heavy fittings to provide rigid and watertight connections.

Gate dimensions are face to face of gate posts.

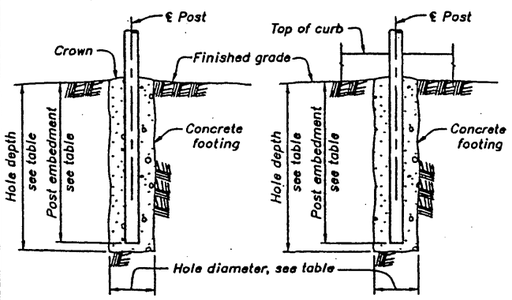
Provide latches, stops and keepers for all gates as specified.

End post, corner posts, and pull posts, are designated as terminal posts.

See site plans for curb details and locations where curb is required.

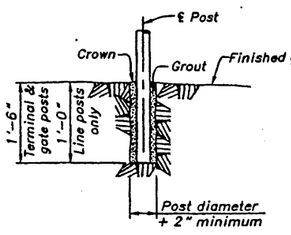
Chain link fabric shall be attached to fence framework in accordance with the Chain Link Fence Manufacturer's Institute (CLFMI) Product Manual.

Chain link fences are 6 foot high fabric unless otherwise noted on specific site plans.

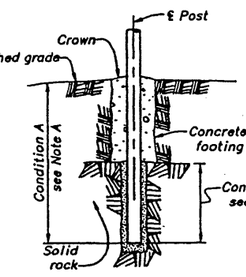


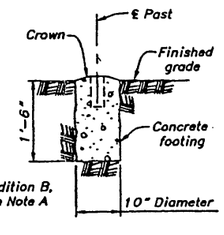
SOIL OR LOOSE ROCK

POST FOOTING UNDER CURB



SOLID ROCK





GATE STOP FOOTING

POST FOOTING IN SOLID ROCK WITH OVERBURDEN OF SOIL OR LOOSE ROCK

POST FOOTING SIZES IN SOIL OR LOOSE ROCK				
POST	FABRIC HEIGHT OR GATE LEAF WIDTH	HOLE DIAMETER	HOLE DEPTH	POST EMBEDMENT
Line	3 ft. to 4 ft.	6 inches	24 inches	22 inches
Line	5 ft.	8 inches	30 inches	28 inches
Line	6 ft. to 12 ft.	9 inches	38 inches	36 inches
Terminal	3 ft. to 5 ft.	10 inches	32 inches	30 inches
Terminal	6 ft. to 12 ft.	12 inches	38 inches	36 inches
Gate	≤ 6 ft.	12 inches	38 inches	36 inches
Gate	6 ft. to 13 ft.	16 inches	44 inches	42 inches
Gate	> 13 ft.	26 inches	50 inches	48 inches

Condition A: Depth required for footing in soil or loose rock.
Condition B: Depth required for embedment in rock.
Note A: Satisfy the minimum requirements for Condition A or Condition B.
Note B: Brace rails and truss rods are not required for fabric height of 6 feet or less.

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UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
STANDARD DESIGN

CHAIN LINK FENCING

CHAIN LINK FENCING REQUIREMENTS SOIL INSTALLATION

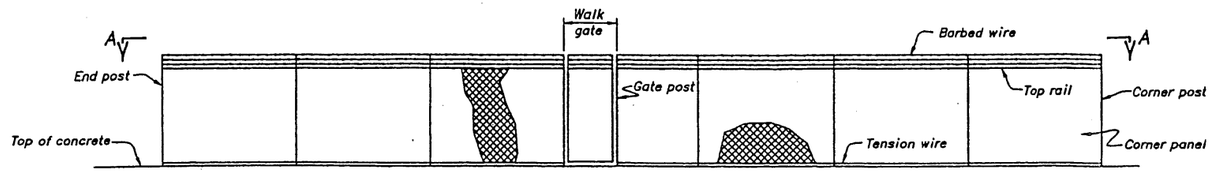
DESIGNED G.F. SHEWARD TECH. APPR. T.C. Graber
DRAWN DL BORING
CHECKED T.C. GRABER APPROVED M.R. O'Shea
STRUCTURAL AND ARCHITECTURAL GROUP

CADD SYSTEM	CADD FILENAME	DATE AND TIME PLOTTED
AutoCAD Rel. 14.01 DENVER, COLORADO	40D7016.DWG MAY 1, 1998	NOVEMBER 26, 1998 09:14

40-D-7016

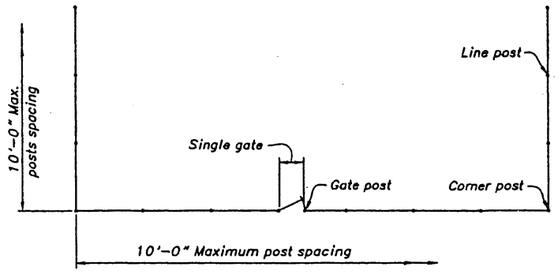
DRAFTING

40-D-7017

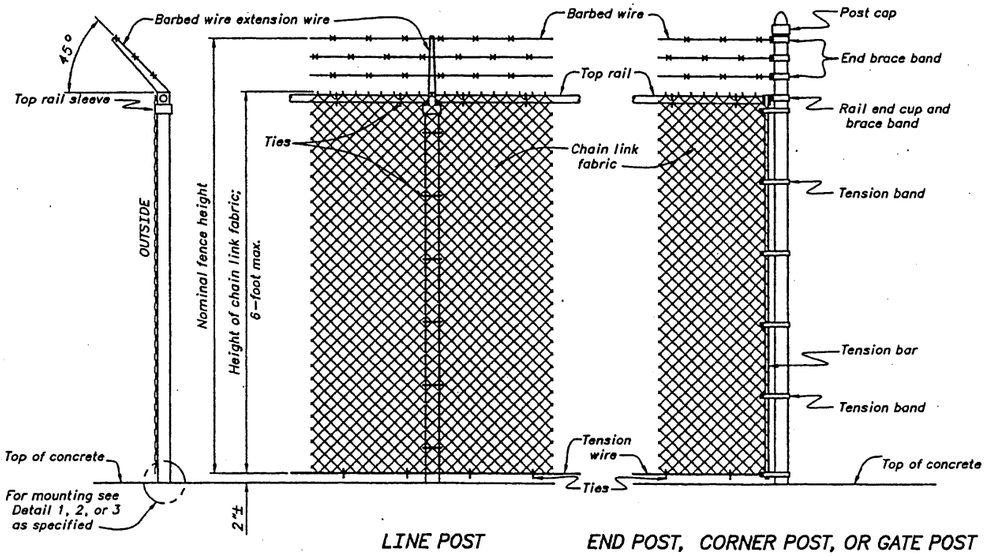


TYPICAL ELEVATION

VIEW A–A

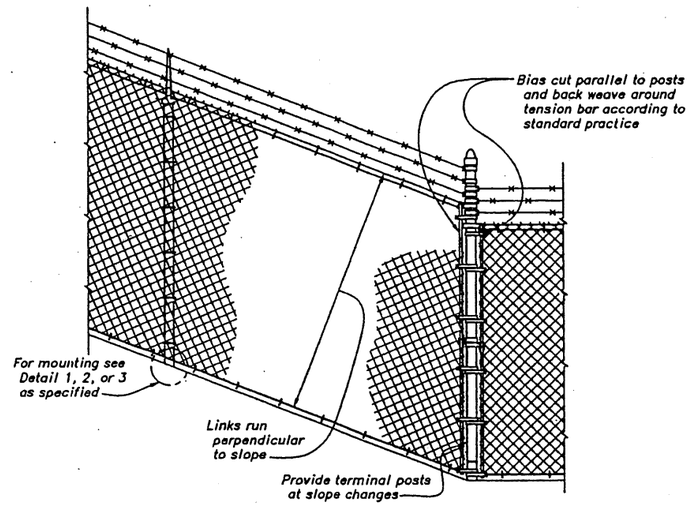


TYPICAL FENCING PLAN



LINE POST

END POST, CORNER POST, OR GATE POST



FENCE INSTALLATION ON STEEP SLOPES

NOTES

See specfic site plan for overall fence dimensions and size, location and swing of gates.

Install pull posts at the end of each run, at maximum intervals of 500 feet, and at vertical and horizontal changes in alignment greater than 30 degrees.

Weld all joints between tubular gate frame members or use heavy fittings to provide rigid and watertight connections.

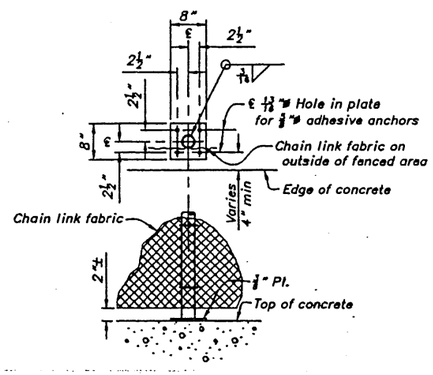
Gate dimensions are face to face of gate posts.

Provide latches, stops and keepers for all gates as specified.

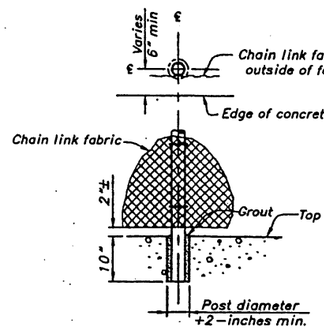
End post, corner posts, pull posts, and gate posts are designated as terminal posts.

Chain link fabric shall be attached to fence framework in accordance with the Chain Link Fence Manufacturer's Institute (CLFMI) Product Manual.

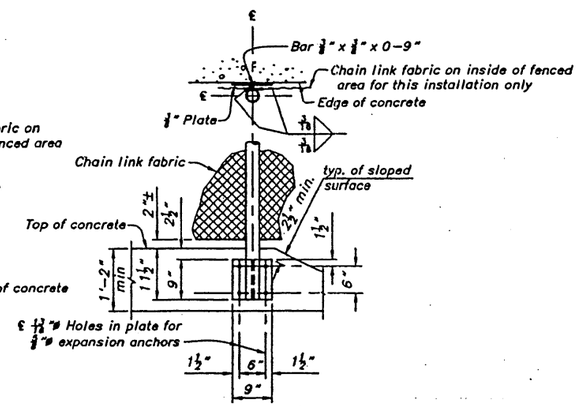
Chain link fences are 6 foot high fabric unless otherwise noted on specific site plans.



DETAIL 1
SURFACE MOUNTED POST



DETAIL 2
EMBEDDED POST



DETAIL 3
SIDE MOUNTED POST
(For slabs 1'–2" thick or greater or wall surfaces)

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DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
STANDARD DESIGN

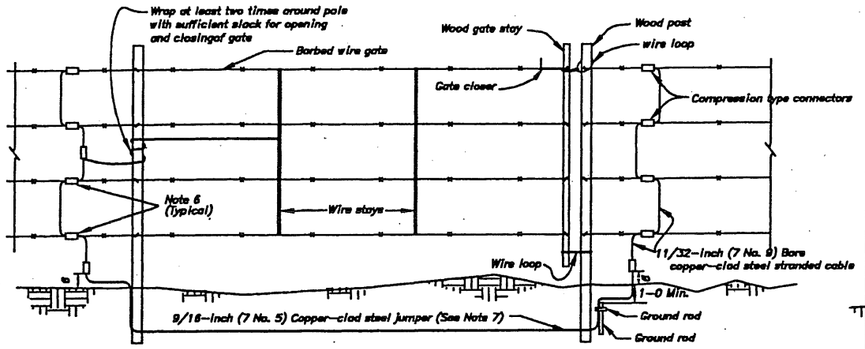
CHAIN LINK FENCING

CHAIN LINK FENCING REQUIREMENTS CONCRETE INSTALLATION

DESIGNED G.E SHEWARD	TECH. APPR. T.C. Gruber	
DRAWN DL BORING		
CHECKED T.C GRUBER	APPROVED M.E. Ostler	STRUCTURAL AND ARCHITECTURAL GROUP
CADD SYSTEM AutoCAD Rel. 14.01 DENVER, COLORADO	CADD FILENAME 40D7017.DWG MAY 1, 1999	DATE AND TIME PLOTTED NOVEMBER 28, 1998 09:56

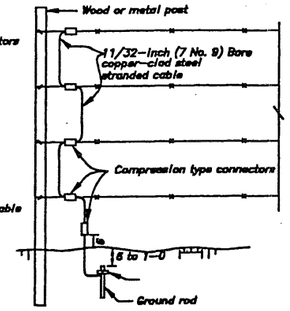
DRAFTING

40-D-7017



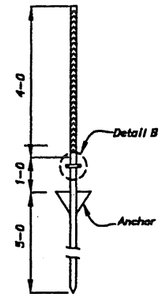
BARBED WIRE FENCING AND GATE

(Grounding Detail)

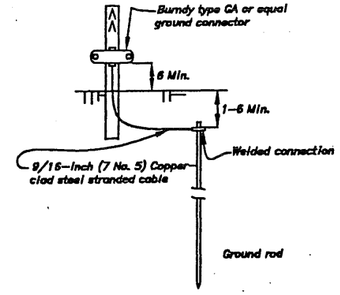


BARBED WIRE FENCING

(Grounding Detail)



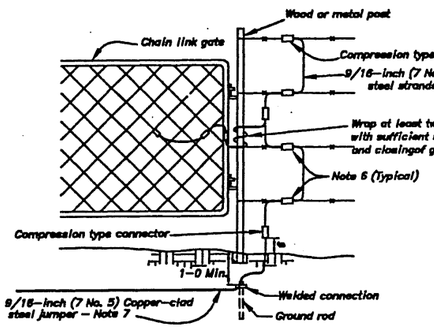
STEEL FENCE POST



DETAIL B

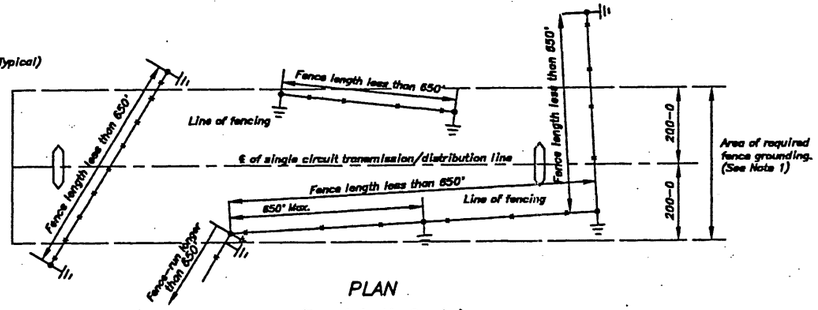
NOTES

1. Ground all fencing located within 200 feet of the transmission line center line as shown in plan. If fencing is interrupted by a gate, ground fencing and gate as shown.
2. For fences less than 650 feet, provide a ground at each end of the fence.
3. For fence longer than 650 feet, ground each end of fence-run and provide a fence ground where the fence-run crosses the area of required grounding.
4. The maximum interval between ground connections is 650 feet.
5. Non-continuous intervals of fence run shall be grounded at each end of the continuous interval. Ground wire jumpers 11/32-Inch (7 No. 9) may be provided.
6. All grounding connections shall be as close as possible to the fence post.
7. Where a ground rod is located near a gate or a gate post, the fence shall be grounded around the gate opening to the fence on the opposite side with a 9/16-Inch (7 No. 5) copper-clad steel stranded ground cable.
8. Fence grounding shall not be connected to the existing transmission line grounding system.
9. Ground all gates or each half of all double gates to the gate post with flexible braid.
10. Ground cable size listed are minimum size allowable.



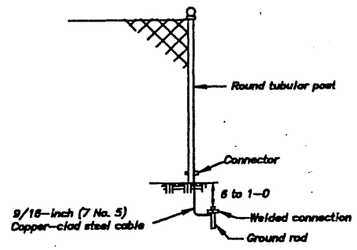
BARBED WIRE FENCING AND CHAIN LINK GATE

(Grounding Detail)



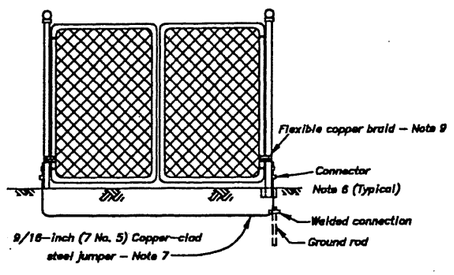
PLAN

(Transmission Line Crossing)



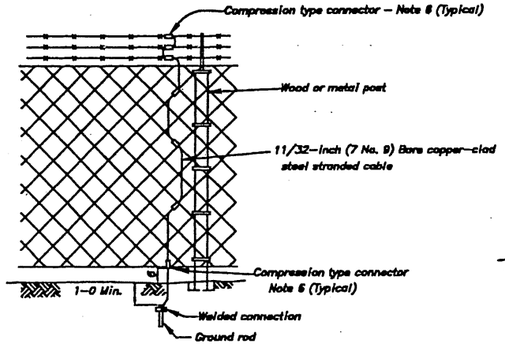
TUBULAR POST FENCING

(Grounding Detail)



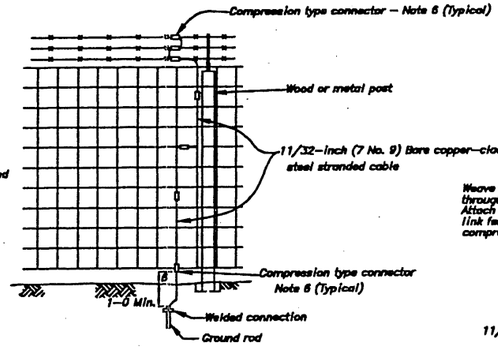
CHAIN LINK FENCE GATE

(Grounding Detail)



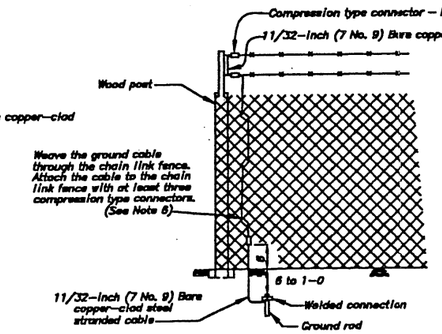
CHAIN LINK FENCING

(Grounding Detail)



WIRE MESH FENCING

(Grounding Detail)



WOOD POST CHAIN LINK FENCING

(Grounding Detail)

2-7-98 D - T.L.W.	REDRAWN ON AUTOCAD REL. 12 REVISED TITLE BLOCK , AND MADE MINOR REVISIONS
1-18-90 D - M.A.M.	AS BUILT BY 330, LTR. 5-31-89
6-8-83 D - D.A.R.	REVISED TITLE BLOCK
3-31-81 D - D.A.R.	ADDED NOTE 11

ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

STANDARD DESIGNS

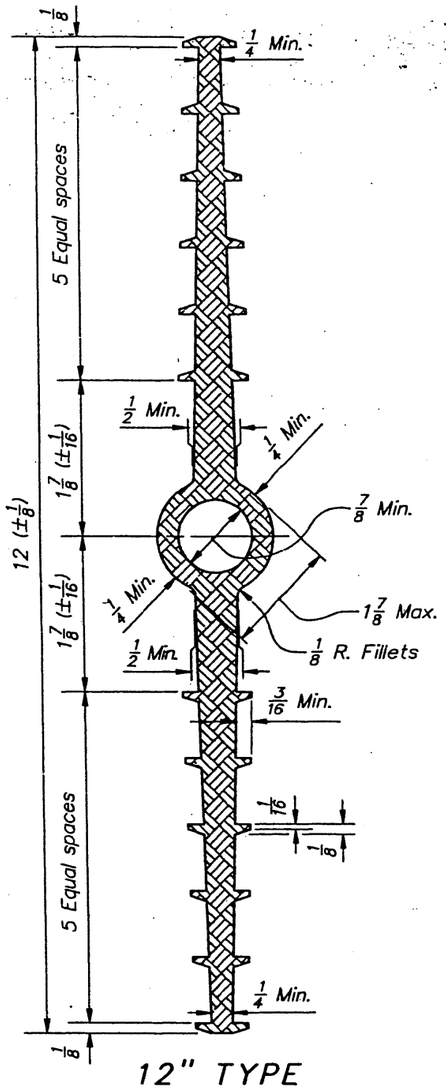
FENCE GROUNDING DETAILS

GROUNDING INSTALLATION

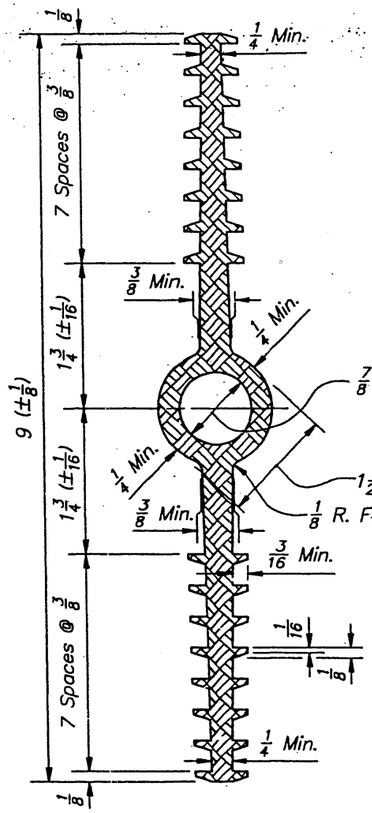
DESIGNED EUGENE A. MOISEY — TECHNICAL APPROVAL R. R. FILLEMENG
DRAWN J. VETSOM — SUBMITTED E. M. TOMASIC
CHECKED D. GREEN J.BUCKINGHAM — APPROVED W. M. R. GROSECLOSE
ACTING SUPERINTENDENT OF DESIGN AND CONSTRUCTION

Cadd Systems: AutoCAD Release 12 c2
Filenames: P:\...\230XTLTDA 40D6376
Date and Time Plotted: APRIL 29, 1997 14:42
DENVER, COLORADO — JULY 16, 1977

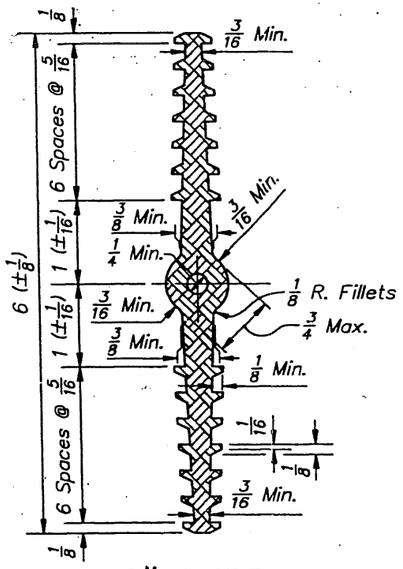
40-D-6376



12" TYPE



9" TYPE



6" TYPE

NOTE

Tips of fins may be rounded provided they meet the minimum dimensions shown.

9-15-92 D- PMP	REDRAWN TO INCLUDE 12" TYPE.
8-15-91 D- M.A.M.	AS BUILT BY 303, LTR. 7-26-91.
12-9-80 D- W.C.S.	REVISED FINS ON 6" TYPE.

ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

STANDARD DESIGNS

PVC WATERSTOPS

6" TYPE, 9" TYPE AND 12" TYPE

DESIGNED	W. C. STEVENSON	SUBMITTED	M. J. BORNSTEIN
DRAWN	M.WORTHY/M.ALBRECHT/M.L.B.	RECOMMENDED	W. R. ANDERSON
CHECKED	W. C. STEVENSON	APPROVED	H. W. ANDERSON
			ACT. CHIEF, DIVISION OF DESIGN
DENVER, COLO.		JUNE 13, 1979	40-D-6463

B (11 X 17)