

EROSION CONTROL ON A STEEP SLOPE  
PIPELINE CROSSING OF THE SIKANNI CHIEF RIVER  
NORTHERN BRITISH COLUMBIA

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WESTCOAST REPLACED THE 30" NATURAL GAS PIPELINE ACROSS THE SIKANNI CHIEF RIVER IN NORTHERN BRITISH COLUMBIA DURING THE SUMMER AND EARLY FALL OF 1987. THE RUGGED TERRAIN AT THE SITE REQUIRED THAT SOME UNUSUAL TECHNIQUES BE USED TO INSTALL THE PIPE, AND TO GROOM AND SEED THE RIGHT-OF-WAY FOLLOWING PIPE INSTALLATION TO ENSURE THAT THE PIPELINE WOULD REMAIN SECURE AND THE STEEP SLOPE WOULD NOT ERODE.

THE SIKANNI CHIEF RIVER, A TRIBUTARY OF THE LIARD SYSTEM, FLOWS THROUGH A DEEP VALLEY CUT INTO HORIZONTALLY-BEDDED SHALES AND SANDSTONES TYPICAL OF THAT PORTION OF BRITISH COLUMBIA. FOR LONG STRETCHES OF THE RIVER, THE NATURAL RIVER BANK HAS SLOPES IN EXCESS OF  $45^{\circ}$ ; THERE ARE NO CROSSING SITES AVAILABLE THAT OFFER GENTLER APPROACH SLOPES. THE EXISTING FORT NELSON PIPELINE ON THE NORTH SLOPE OF THE SIKANNI CHIEF RIVER CROSSING LIES IN AN OPEN TRENCH BECAUSE OF THE STEEP ( $45^{\circ}$ ) SLOPE. IN THE 23 YEARS THAT THIS PIPELINE HAS BEEN IN SERVICE, EROSION HAS WEAKENED THE GROUND SUPPORT OF THIS PIPE SECTION. THE PURPOSE OF THE PROJECT WAS TO RELOCATE THE CROSSING OF THE SIKANNI CHIEF RIVER- TO A POINT UPSTREAM WHERE A LESS PRECARIOUS AND STABLE SLOPE HAS BEEN LOCATED AND THEREBY PROVIDE GREATER PROTECTION TO THE PIPELINE. IN 1987 THE DECISION WAS MADE TO CONSTRUCT A MORE STABLE REPLACEMENT PIPELINE AT A POINT UPSTREAM FROM THE ORIGINAL CROSSING.

FOLLOWING THE ISSUANCE OF DETAILED DRAWINGS AND SPECIFICATIONS, THE GENERAL CONTRACT WAS AWARDED TO MAJESTIC CONTRACTORS LTD. OF EDMONTON. WESTCOAST INSPECTION STAFF WERE PRESENT ON SITE THROUGHOUT THE PROJECT.

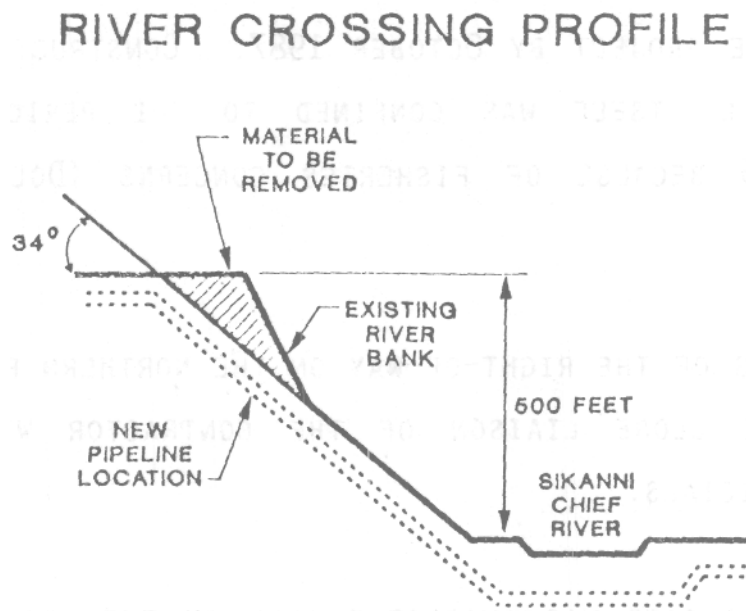
THE CONTRACTOR BEGAN MOBILIZATION IN MID-JULY 1987 AND HAD COMPLETED THE PROJECT BY OCTOBER 1987. CONSTRUCTION WITHIN THE RIVER CHANNEL ITSELF WAS CONFINED TO THE PERIOD JULY 15 TO SEPTEMBER 15 BECAUSE OF FISHERIES CONCERNS (DOLLY VARDEN AND WHITEFISH).

SOME CLEARING OF THE RIGHT-OF-WAY ON THE NORTHERN PLATEAU SECTION REQUIRED THE CLOSE LIAISON OF THE CONTRACTOR WITH PROVINCIAL FORESTRY OFFICIALS.

ACCESS TO THE SITE WAS AVAILABLE ONLY ON THE NORTH SIDE OF THE RIVER. HELICOPTERS WERE FREQUENTLY USED TO TRANSPORT WORKERS TO AND FROM THE WORK SITE LARGELY BECAUSE WET WEATHER CONDITIONS MADE THE ROADS IMPASSABLE THROUGHOUT MUCH OF THE WORK PERIOD.

AT A LOCATION UPSTREAM FROM THE ORIGINAL CROSSING, THE NEW PIPE-LINE RIGHT-OF-WAY WAS PREPARED BY REDUCING THE GRADE TO A 34° SLOPE. THE WORK PROCEEDED FROM THE TOP OF THE SLOPE IN A SERIES OF BENCHES, THEN THE RIGHT-OF-WAY WAS GRADED BACK TO THE DESIRED ANGLE (AS SHOWN IN THE RIVER CROSSING PROFILE). SOME 80 270 CUBIC

METRES OF ROCK AND OVERBURDEN WERE MOVED TO PREPARE THE RIGHT-OF-WAY. THE SLOPE GRADE WAS APPROXIMATELY 70% RIPPABLE ROCK AND 30% REQUIRED BLASTING, HENCE THIS PART OF THE WORK WAS NOT UNDULY AFFECTED BY THE HEAVY RAINS. THE RIVER CROSSING SECTION WAS GRAVEL, AND SUPPORTED EQUIPMENT WITH NO PROBLEMS.



THE SOFT SHALE ROCK FACES ON EACH SIDE OF THE RIGHT-OF-WAY WERE A CONTINUING SAFETY PROBLEM THROUGHOUT THE PROJECT. INITIALLY THE CONTRACTOR USED A SIDE SLOPE CUT OF 70°, BUT ROCK FALLS OCCURRED FREQUENTLY, AND IT WAS NECESSARY TO GRADE BACK THE SLOPES TO AN ANGLE OF 50°± WHICH APPEARED TO BE THE ANGLE OF REPOSE. HEAVY RAINS DURING THE CONSTRUCTION PERIOD ADDED TO THE SLOPE INSTABILITY PROBLEMS. A CONSTANT PROGRAM OF SCALING WAS MAINTAINED TO ENSURE THE SAFETY OF WORKERS, AND NO INJURIES OCCURRED.

A TRENCH FOR THE PIPE WAS THEN EXCAVATED UP THE SLOPE; THE PIPE ON THE NORTH SLOPE WAS INSTALLED USING THE "STOVE PIPE" METHOD. A BOTTOM SLED CONSISTING OF A SPLIT SLEEVE SUPPORT ON TWO 4" PIPE RUNNERS WAS ATTACHED TO EACH DOUBLE JOINT. A JOINTING STATION WAS SET UP AT THE TOP OF THE SLOPE AT WHICH WELDING, RADIOGRAPHY AND WRAPPING WAS COMPLETED BEFORE PIPE WAS SLID DOWN THE SLOPE. THE SLEDS WERE LEFT IN PLACE ON THE PIPE. THIS WAS THE FIRST TIME SUCH AN OPERATION HAS BEEN USED, AND IT WAS VERY SUCCESSFUL. THE EXTERNAL COATING OF THE PIPE CONSISTED OF FUSION-BONDED EPOXY WITH HAND-WRAPPING BEING DONE, USING POLYKEN TAPE. THE 30" O.D. X .433" W.T. PIPE USED ON THE NORTH SLOPE OF THE CROSSING WAS COATED WITH 1" OF CONCRETE. THE 30" O.D. X .362" W.T. PIPE USED ON THE RIVER SECTION WAS COATED WITH 5" OF CONCRETE.

TO CONSTRUCT THE RIVER SECTION, PIPE AND ALL OTHER MATERIALS WERE TAKEN DOWN THE STEEP SLOPE BY TRUCK. FOR THIS OPERATION, A PIPE TRUCK CARRYING THREE SECTIONS OF PIPE WAS CABLED TO A D9 TRACTOR AT THE TOP OF THE SLOPE, AND THE LOAD WAS THEN CAREFULLY LOWERED TO THE VALLEY BOTTOM. WINCHES AND SAFETY CABLES WERE ALSO USED BY INDIVIDUAL WORKERS TO ASCEND AND DESCEND THE SLOPES. ALL OTHER EQUIPMENT DESCENDED TO THE BOTTOM IN THIS MANNER. NO ACCIDENTS WERE RECORDED ON THE PROJECT.

AFTER THE PIPE WAS PLACED IM THE TRENCH, POLYURETHANE FOAM BREAKERS WERE CONSTRUCTED AT 20 METRE INTERVALS ACROSS THE TRENCH.

THE PRIMARY PURPOSE OF THE BREAKERS IS TO PREVENT WATER FROM FLOWING DOWNSLOPE ALONG THE PIPE AND ERODING THE PIPE SUPPORT. SECONDLY, THE BREAKERS ANCHOR THE PIPE TO THE HILLSIDE AND PREVENT LATERAL PIPE MOVEMENT.

SPRAYED-IN-PLACE RIGID POLYURETHANE FOAM DITCH BREAKERS HAVE BEEN USED SUCCESSFULLY IN THE PIPELINE INDUSTRY FOR SEVERAL YEARS. THE TECHNIQUE IS PARTICULARLY VALUABLE FOR DIFFICULT SLOPES SUCH AS THE SIKANNI CHIEF RIVER CROSSING. IT IS ALSO USED AS ROCK SHIELD IN ROCKY TERRAIN. THE FOAM ADHERES TO THE PIPE AND HAS EXCELLENT COMPRESSIVE STRENGTH TO SUPPORT THE PIPELINE. THE FOAM MATERIAL IS RESISTANT TO EROSION AND MOST CHEMICALS, AND DOES NOT DECOMPOSE WHEN BURIED IN THE SOIL. IT IS ALSO MORE ECONOMICAL AND CONVENIENT TO USE ON A STEEP SLOPE THAN THE CONVENTIONAL METHOD USING SANDBAGS, WHICH IS VERY LABOUR-INTENSIVE.

POLYURETHANE FOAM IS A MIXTURE OF TWO CHEMICALS: ISOCYANATE 100 AND RESIN 901. WHEN MIXED AND SPRAYED, THE CHEMICALS EXPAND TO APPROXIMATELY 3 TIMES THEIR ORIGINAL VOLUME. THE FOAM IS APPLIED WITH SPRAY EQUIPMENT; ONE FOAM UNIT AND A TWO-MAN CREW IS ADEQUATE FOR A CONSTRUCTION PROJECT SUCH AS THIS. THE MATERIAL CAN BE PUMPED SOME DISTANCE FROM THE FOAM UNIT. FOR THE SLKANNI PROJECT, ONE UNIT AT THE TOP OF THE SLOPE WAS ADEQUATE TO CONSTRUCT BREAKERS ALONG THE 380 M LONG HILLSIDE.

FOAM BREAKERS SHOULD BE INSTALLED BY EXPERIENCED CREWS USING SUITABLE PROTECTIVE CLOTHING AND EYE PROTECTION. IF PROPERLY HANDLED, THE MATERIALS DO NOT PRESENT A SIGNIFICANT HEALTH HAZARD. THE FOAMING REACTION GENERATES CONSIDERABLE HEAT, AND CARE MUST BE TAKEN TO BUILD UP THE BREAKER GRADUALLY WITH THIN LAYERS OF FOAM TO PREVENT EXCESSIVE HEAT BUILDUP AND SUBSEQUENT EXPLODING OF THE BREAKER.

COST OF THE POLYURETHANE BREAKERS FOR THE SLKANNI RIVER PROJECT WERE AS FOLLOWS:

- A TOTAL OF 27 BREAKERS WERE INSTALLED
  - 383.2 CUBIC METRES OF FOAM MATERIAL WERE UTILIZED
  - COST PER CUBIC METRE OF FOAM = \$255
  - TOTAL COST OF FOAM BREAKERS = \$97,716
  - USING SANDBAGS: THE COST = \$306,500
- SAVING OF \$208,844.

THE SUBCONTRACTOR FOR THE FOAM INSTALLATION WAS PEDERO PLPE SUPPORT SYSTEMS LTD. OF EDMONTON.

FOLLOWING INSTALLATION OF THE BREAKERS, THE PIPE TRENCH WAS BACK-FILLED AND THE ENTIRE RIGHT-OF-WAY GRADED AND CLEANED UP. SURFACE BREAKERS, CONSISTING OF LOGS LINED WITH SANDBAGS, WERE ANCHORED TO

THE HILLSIDE WITH METAL RODS AND CONSTRUCTED AT AN ANGLE ACROSS THE SLOPE TO DEFLECT SURFACE RUNOFF TO THE LOW SIDE OF THE RIGHT-OF-WAY.

THE AREA WAS HYDROSEEDING WITH GRASSES AND LEGUMES IN THE SPRING OF 1988. HYDROSEEDING WAS CARRIED OUT BY HELICOPTER, AN INFREQUENTLY-USED APPLICATION METHOD THAT WAS PARTICULARLY SUITED TO THE REMOTE SIKANNI RIVER SITE.

THE TOTAL INSTALLATION COST OF THIS PROJECT WAS \$3,323,660 OR \$941.55 PER FOOT.

THE PROJECT WAS SUCCESSFUL DUE TO THE DETAILED GEOTECHNICAL WORK ON SITE PRIOR TO DESIGN, AND THE ADHERENCE TO DESIGN AND SPECIFICATIONS DURING INSTALLATION.