Key Criteria Summary

Sample Engineering Consulting Industry

801 - Development of a divide wall for a diversion dam

Benchmarks:
Internet searches: 21 sites / articles
Patent searches: 5 patents
Similar prior in-house technologies: 1 products /
Queries to experts: 3 responses

Objectives:
Decrease bedload deposition: 75 %
Reduce downstream scouring : 99 %
Minimize production cost: 25000 $ per unit

Uncertainty: 1 - Environmental Factors

Key Variables: alignment and length and the height of the wall, properties of the river, sediment movement, shape of the intake, structure combination

Activity	Testing Methods	Results - % of Objective	Variables Concluded	Hours	Materials $	Subcontractor $	Fiscal Year
1 - Testing	Analysis / simulation: 1 alternatives Process trials: 60 runs / samples	(none)	structure combination	0.00	0.00	0.00	2008
2 - Upstream Training Works	Physical prototypes: 1 samples	(none)	alignment and length and the height of the wall sediment movement	0.00	0.00	0.00	2008
3 - Low-Flow Channel	Process trials: 10 runs / samples	(none)	structure combination	0.00	0.00	0.00	2008
4 - Performance of Canal Intake	Process trials: 10 runs / samples	Decrease bedload deposition: 80 % (120 %)	sediment movement shape of the intake structure combination	0.00	0.00	0.00	2009
5 - Log Passage	Process trials: 7 runs / samples	(none)	properties of the river	0.00	0.00	0.00	2009
6 - Stilling Basins Downstream of Weir	Process trials: 4 runs / samples	(none)	structure combination	0.00	0.00	0.00	2009
7 - Settling Basin	Process trials: 5 runs / samples	Decrease bedload deposition: 75 % (100 %) Reduce downstream scouring : 91 % (57 %) Minimize production cost: 27000 $ per unit (60 %)	sediment movement shape of the intake	0.00	0.00	0.00	2009

901 - Analysis of river flow properties

Benchmarks:
Internet searches: 36 sites / articles
Patent searches: 6 patents
Similar prior in-house technologies: 1 products /
Potential components: 1 products

Objectives:
Downstream velocity increase: 0 %
Minimize erosion: 1 inches per year
Ability to operate during navigation: 100 %
Minimize environmental impact: 100 %

Uncertainty: 1 - Environment

Key Variables: navigation, sedimentation, stage, surge

Activity	Testing Methods	Results - % of Objective	Variables Concluded	Hours	Materials $	Subcontractor $	Fiscal Year
1 - Modeling	Process trials: 4 runs / samples Physical prototypes: 2 samples	Minimize erosion: 0.9 inches per year (110 %) Ability to operate during navigation: 100 % (100 %) Minimize environmental impact: 100 % (100 %) Downstream velocity increase: 0 % (100 %)	navigation sedimentation stage surge	0.00	0.00	0.00	2009

Project Name:	Development of a divide wall for a diversion dam	**Start Date:**	2008-01-01
Project Number:	801	**Completion Date:**	2009-12-31

902 - Sedimentation Study (Ineligible)

Benchmarks: Similar prior in-house technologies: 1 products /

Objectives: Sediment Discharge: 0 %

Uncertainty: 1 - Water Flow

Key Variables: sedimentation

Activity	Testing Methods	Results - % of Objective	Variables Concluded	Hours	Materials $	Subcontractor $	Fiscal Year
1 - Solutions	Process trials: 6 runs / samples	Sediment Discharge: 0 % (100 %)	sedimentation	0.00	0.00	0.00	2009

903 - Dam Apron Repair

Benchmarks:
Internet searches: 12 sites / articles
Patent searches: 3 patents
Competitive products or processes: 2 products

Objectives:
Growth of crack: 0 ft/yr
reduce the uplift on the apron slab: 600 psi
Maximum cost of remediation plan: 30000 $
Time to accomplish remediation plan: 5 days

Uncertainty: 1 - Modeling

Key Variables: gate opening, uplift pressures, water flow

Activity	Testing Methods	Results - % of Objective	Variables Concluded	Hours	Materials $	Subcontractor $	Fiscal Year
1 - modeling	Process trials: 4 runs / samples Physical prototypes: 1 samples	Growth of crack: 0 ft/yr (100 %) reduce the uplift on the apron slab: 800 psi (66 %) Maximum cost of remediation plan: 31000 $ (103 %) Time to accomplish remediation plan: 5 days (100 %)	uplift pressures water flow gate opening	0.00	0.00	0.00	2009

Project Name: Development of a divide wall for a diversion dam | **Start Date:** 2008-01-01
Project Number: 801 | **Completion Date:** 2009-12-31

1001 - Pipeline - cracking mitigation

Benchmarks:
Internet searches: 11 sites / articles
Patent searches: 7 patents
Similar prior in-house technologies: 1 products /
Queries to experts: 5 responses
Other: 1 current status

Objectives:
SCC predictive model accuracy: 95 %
ability for predictions various models: 20 #
Maximum cost of study: 12000 $
Maximum duration of study: 5 days

Uncertainty: 1 - Pipeline issues

Key Variables: chemical environments, physical environments

Activity	Testing Methods	Results - % of Objective	Variables Concluded	Hours	Materials $	Subcontractor $	Fiscal Year
1 - Current and past studies	Analysis / simulation: 7 alternatives	(none)	chemical environments physical environments	0.00	0.00	0.00	2010
2 - Predictive models	Process trials: 14 runs / samples	SCC predictive model accuracy: 65 % (68 %) ability for predictions various models: 1 # (0 %) Maximum cost of study: 15000 $ (76 %) Maximum duration of study: 5 days (100 %)	chemical environments physical environments	0.00	0.00	0.00	2010

1002 - Development of river diversion dam to power canal

Benchmarks:
Internet searches: 5 sites / articles
Patent searches: 6 patents
Competitive products or processes: 1 products
Similar prior in-house technologies: 1 products /

Objectives:
Sediment Discharge: 0 %
Ability to divert the river to an intake : 100 %
minimize operational restrictions : 100 %
fish facilities to operate successfully : 100 %
Improve the intake flow distribution: 100 %

Uncertainty: 1 - environmental uncertainty

Key Variables: radial gates, walls, weirs

Activity	Testing Methods	Results - % of Objective	Variables Concluded	Hours	Materials $	Subcontractor $	Fiscal Year
1 - Project design 1-3	Analysis / simulation: 5 alternatives Physical prototypes: 3 samples	Improve the intake flow distribution: 100 % (100 %) minimize operational restrictions : 90 % (90 %) Ability to divert the river to an intake : 100 % (100 %)	weirs radial gates walls	0.00	0.00	0.00	2010
2 - Modeling	Process trials: 36 runs / samples	Sediment Discharge: 5 % (85 %) Ability to divert the river to an intake : 100 % (100 %) minimize operational restrictions : 95 % (95 %) fish facilities to operate successfully : 100 % (100 %)	radial gates walls weirs	0.00	0.00	0.00	2010

Engineering Industry

The following guidelines are intended to provide examples of "experimental development" projects which would qualify for Canadian SR&ED (Scientific Research & Experimental Development) tax credits.

Content Summary:

801 - Development of a divide wall for a diversion dam:

Scientific or Technological Objectives:

Measurement	Current Performance	Objective
Decrease bedload deposition (%)	50	75
Reduce downstream scouring (%)	80	99
Minimize production cost ($ per unit)	30000	25000

[NOTE: THIS PROJECT DESCRIPTION IS REPRODUCED FROM FACTS OUTLINED IN THE TAX COURT OF CANADA Docket: 97-531-IT-G, Date: 1998/05/01]

[AUTHOR'S NOTE: IDEALLY THE TAXPAYER WOULD ATTEMPT TO QUANTIFY THE OBJECTIVES THEY ARE TRYING TO ACHIEVE. A QUANTIFIABLE OBJECTIVE HAS BEEN ADDED ABOVE, TO ILLUSTRATE.]

The problems were to maintain a low flow channel near the intake during the dry season, to exclude sediment from entering the intake and reduce downstream scouring (erosion of materials due to high velocity).

The concept of a divide wall is not new, but this is an entirely different application when the following are taken into account: it's a highly braided river, the shape of the intake works, the alignment and the length and the height of the wall in combination with the gates that were used. Also the development of methods for maintaining this low-flow channel for the intake in this highly sediment laden river is an advance.

Technology or Knowledge Base Level:

Benchmarking methods & sources for citings:

- Internet searches: 21 sites / articles -- No solution found
- Patent searches: 5 patents -- various methods did not meet the performance requirement
- Similar prior in-house technologies: 1 products / processes -- The concept of a divide wall is not new, but this is an entirely different application.
- Queries to experts: 3 responses -- from sediment specialists

The East Rapti river is 1,800 meters wide and carries large amounts of sediment. The channel is "braided", that is to say it consists of a number of channels. The bank of the river in subject to erosion and is highly unstable. Moreover, the slope is steep giving rise to unusually high velocity.

[NOTE: EACH CHARACTERISTIC TAKEN ALONE AND IN ISOLATION WOULD UNQUESTIONABLY HAVE PRESENTED DIFFICULTIES. CUMULATIVELY THEY MAGNIFIED EACH OTHER.]

Field of Science/Technology:

Civil Engineering (2.01.01)

Intended Results:

- Develop new materials, devices, or products

Work locations:

Analysis, Research Facility, on-site, on-site

Scientific or Technological Advancement:

Uncertainty #1: Environmental Factors

How will the properties of the river affect the proposed dam? The unknown effect of heavy sediment movement and complicated structure combination (including weir, sluiceway, headgate, ejector, settling basin, fish ladder, log passage and river training works).

In the result three models were required:

(a) A model of the river; this required a distortion of the scale;

(b) an intake model; and

(c) a settling basin model.

For this purpose it is necessary to develop geometry for upstream training dikes and spurs, and an alignment for the intake structure. The capacity of the sluice gate has to be increased and a flow divide wall has to be added. A downstream scour protection scheme has to be devised and a settling basin has to be modified to improve flushing.

The most significant underlying key variables are:
properties of the river, sediment movement, structure combination, shape of the intake, alignment and length and the height of the wall

Activity #1-1: Testing

Work performed in Fiscal Year 2008:

Methods of experimentation:

- Analysis / simulation: 1 alternatives - A model was used to simulate the effects of the weir design.
- Process trials: 60 runs / samples - 10 tests each in 6 categories of tests, as outlined below.

[AUTHOR'S NOTE: THE DESCRIPTIONS BELOW WERE PROVIDED IN THE EXAMPLE. THE DATA ABOVE (# TRIALS/ALTERNATIVES) IS PROVIDED TO ILLUSTRATE SOME OF THE ADDITIONAL DETAILS THAT WOULD IDEALLY BE INCLUDED.]

Baseline tests

- The baseline tests conducted before installation of the weir showed good simulation of a braided river.
- The high flow rates eroded the incised narrow channel system generated by low flows.

Downstream Degradation

- Extended tests with the weir indicated that degradation downstream from the weir will occur during the early years of the project when bedload transported by the Rapti river is trapped behind the weir, and sediment-free flow passes downstream. This degradation resulted in water surface elevations lowered by approximately 1.5 m.

[NOTE: IDEALLY, THE TESTS DONE WOULD BE EXPLAINED AND CONCLUSIONS COULD BE DRAWN FROM EACH TEST]

Upstream Aggradations and Water Levels

- Aggradation occurring upstream from the weir was exaggerated in the model with the result that water elevations measured far upstream from the weir are conservatively high. Water elevations measured upstream near the weir agree closely with levels computed with the assumption that their weir functions hydraulically as a broad-crested weir. The difference between computed and measured elevations 1,800 m upstream from the weir for 2,250 m3/s was 1.7 m.
- Water elevations measured upstream near the weir agree closely with levels computed with the assumption that their weir functions hydraulically as a broad-crested weir.

Crest

- The crest shape for the weir produces smooth flow conditions. Tests with a simplified crest for the gated sections showed flow separation for the higher flows with some accompanying instability. This was eliminated for the undersluice with a change to a curved shape.

[NOTE: IDEALLY, THE TESTS AND RESULTS FROM EACH ONE WOULD BE EXPLAINED. IT WOULD ALSO BE EXPLAINED WHY THE CREST WAS ELIMINATED AND WHAT THE RESULT WAS.]

Stilling Basins and Launching Aprons Downstream of Gates

- Stilling basins and launching aprons were tested downstream from the gated sections. The launching aprons were tested in both level and sloping positions. Velocities and water levels were measured. The sloping launching apron reduces or eliminates the drop in water from the apron to the river, particularly for degraded conditions. A launching apron design is proposed for final design.

[NOTE: IDEALLY, THE TESTS AND RESULTS FROM EACH ONE WOULD BE EXPLAINED. IT WOULD ALSO BE EXPLAINED WHY A LAUNCHING APRON WAS PROPOSED.]

Sediment Ejector

- Tests with the sediment ejector indicated effective removal of bed sediments for 6 and 8 m3/s. The location and size of the ejector may require further consideration, as they do not conform to published recommendations. It may be more efficient if it is located with a long straight upstream reach to allow for uniform flow to be attained. The recommendations suggest that ejected flow be limited to approximately 25 percent of the canal flow rate.

Results:

No results have been recorded for this Activity.

[NOTE: IF THERE WERE ANY TEST RESULTS FROM THIS ACTIVITY THAN THESE SHOULD BE STATED HERE]

Conclusion:

[NOTE: THE CONCLUSIONS FOR THESE TESTS WOULD BE STATED HERE]

Key variables resolved: structure combination

Activity #1-2: Upstream Training Works

Work performed in Fiscal Year 2008:

Methods of experimentation:

- Physical prototypes: 1 samples - An upstream training scheme consisting of three open dyke elements plus T-spur dykes both upstream and downstream from the open dyke sections was developed.

Tests with the weir indicated that upstream left-side training works are needed to protect the guidebank immediately upstream from the weir from erosive attack, prevent erosion of the left bank (Chitwan Park), and to direct approach flow to the intake.

An upstream training scheme consisting of three open dyke elements plus T-spur dykes both upstream and downstream from the open dyke sections was developed.

Results:

No results have been recorded for this Activity.

[NOTE: SIMILARLY, IF THERE WERE ANY TEST RESULTS FROM THIS ACTIVITY THAN THESE SHOULD BE STATED HERE]

Conclusion:

The training scheme provided the required protection, helped direct low flows to the intake, and allowed the area behind the dyke to be preserved as wetlands.

This system performed well, but the three spur configuration was also adequate. The final layout will be the decision of the project designers. A minimum of two spurs is recommended, if limited funding does not permit construction of the tested schemes.

Key variables resolved: alignment and length and the height of the wall, sediment movement

Activity #1-3: Low-Flow Channel

Work performed in Fiscal Year 2008:

Methods of experimentation:

- Process trials: 10 runs / samples

[AUTHOR'S NOTE: THE DESCRIPTIONS BELOW WERE PROVIDED IN THE CRA'S EXAMPLE. THE DATA ABOVE (# TRIALS/ALTERNATIVES) IS PROVIDED TO ILLUSTRATE SOME OF THE ADDITIONAL DETAILS THAT WOULD IDEALLY BE INCLUDED.]

Bars built up in the 400 m wide approach channel during floods that isolated the intake during low flows. A series of tests [HOW MANY?] were conducted using submerged inner guide banks to create a low flow channel. A 1 m high guidebank forming a channel 1/4 the width of the weir achieved acceptable results [NOTE: A DEFINITION OF ACCEPTABLE RESULTS WOULD BE BENEFICIAL]. Because the inner guide bank scheme concentrates flow and causes higher upstream water levels, a scheme using floodway gates was adopted for further study.

Results:

No results have been recorded for this Activity.

Conclusion:

A modified design using two 20 m wide gated floodways and one 20 m undersluice was effective in producing a low flow channel to the intake [NOTE: CITING MAX FLOW RATES WOULD HELP]. This was accomplished primarily with open floodway gates and a closed undersluice.

A larger radius right-side guidewall [NOTE: CITING HOW MUCH LARGER WOULD BE HELPFUL IN ADDING A DEGREE OF QUANTIFICATION TO THE TESTING] improves flow conditions when flow is guided by the right guidewall.

Key variables resolved: structure combination

Activity #1-4: Performance of Canal Intake

Work performed in Fiscal Year 2009:

Methods of experimentation:

- Process trials: 10 runs / samples - 5 tests with each of the two orientations.

  [AUTHOR'S NOTE: THE DESCRIPTIONS BELOW WERE PROVIDED IN THE EXAMPLE. THE DATA ABOVE (# TRIALS/ALTERNATIVES) IS PROVIDED TO ILLUSTRATE SOME OF THE ADDITIONAL DETAILS THAT WOULD IDEALLY BE INCLUDED.]

  Tests with canal intakes oriented at 140 and 90 degrees indicated more uniform [NOTE: A DEFINITION OF UNIFORM FLOW WOULD PROVIDE CONTEXT] flow distribution with the 90 degree intake, although both intakes had more flow enter through the left side of the intake. The 90 degree intake was adopted for final design.

Results:

- Decrease bedload deposition: 80 % (120% of objective)

Conclusion:

Although both orientations were studied for bedload deposition, only the results of the 90 degree intake will be discussed herein. Flow conditions with the floodway and undersluice gates open 0.5 m resulted in considerable [NOTE: "CONSIDERABLE" IS A SUBJECTIVE TERM UNLESS DEFINED BY QUANTIFIABLE/MEASURABLE PARAMETERS] bedload entering the canal headworks area. Flows with the floodway gates open 1 m and the undersluice closed also resulted in considerable deposition in the headworks area.

The addition of a 40 m long divide wall that extended above the water surface effectively prevented bedload from entering the canal headworks area when tested for the 1 m floodway gate opening with the undersluice closed. When canal flow is also eliminated, prevention of bedload entering the headworks area is further enhanced. [NOTE: BY ADDING AN ENHANCEMENT FACTOR, IT WOULD HELP PROVIDE A MEASURABLE BENCHMARK INDICATIVE OF R&D]

Flushing tests conducted with a wide open undersluice indicated that flushing with the divide wall is much more effective than without the wall. [NOTE: AGAIN, BY QUANTIFYING THE DIFFERENCE, IT PROVIDES A QUANTIFIABLE CONTEXT TO THE WORK]

Key variables resolved: sediment movement, shape of the intake, structure combination

Activity #1-5: Log Passage

Work performed in Fiscal Year 2009:

Methods of experimentation:

- Process trials: 7 runs / samples - Different log diversion wall designs.

  [AUTHOR'S NOTE: THE DESCRIPTIONS BELOW WERE PROVIDED IN THE EXAMPLE. THE DATA ABOVE (# TRIALS/ALTERNATIVES) IS PROVIDED TO ILLUSTRATE SOME OF THE ADDITIONAL DETAILS THAT WOULD IDEALLY BE INCLUDED.]

  Log passage tests were conducted with the premise that log accumulation in the pocket area upstream from the undersluice should be minimized [NOTE: IS THERE A MAX LIMIT?]. This was accomplished to a large extent by closing the undersluice but operating the floodway. This operation resulted in log accumulation upstream from the floodway, but minimal accumulation in the pocket.

  Logs of 20 m size were capable of being flushed by completely opening the gates (floodway or undersluice). Larger logs of 30 m size frequently became jammed.

  Several log diversion walls were tested to explore the potential for improving the effectiveness of diverting logs into the floodway. The best scheme involved a solid skimmer wall that allowed flow to pass underneath the wall and the logs were re-directed away from the pocket area.

  [NOTE: IDEALLY, THESE DIFFERENT LOG DIVERSION WALLS THAT WERE TESTED WOULD BE QUANTIFIED AND EXPLAINED]

Results:

No results have been recorded for this Activity.

Conclusion:

The elimination of all canal flow combined with no undersluice flow resulted in more favourable conditions for diverting logs from the pocket.

Key variables resolved: properties of the river

Activity #1-6: Stilling Basins Downstream of Weir

Work performed in Fiscal Year 2009:

Methods of experimentation:

- Process trials: 4 runs / samples - Stilling basin designs.

  Four stilling basin designs were tested downstream of the weir: Types 3 and 4 at basin elevations of 224.7 and 226.7 m. The two higher basins produced downstream water levels that were much higher [NOTE: QUANTIFY "HIGHER"] than the tailwater level. This caused scouring conditions downstream as high velocities were generated by the drop in water level. The Type 3 basin at 224.7 m elevation was adopted for final design.

Results:

No results have been recorded for this Activity.

Conclusion:

The adopted basin was tested with and without stone accumulation in the stilling basin. The presence of stones caused some additional mounding of the water above the floor blocks for the higher flows and an exaggerated vertical eddy that tended to rotate stones back to the face of the spillway, where they may accelerate erosion of the concrete. Many of these stones, however, will wash out at the higher flows.

Key variables resolved: structure combination

Activity #1-7: Settling Basin

Work performed in Fiscal Year 2009:

Methods of experimentation:

- Process trials: 5 runs / samples - 2 different flushing schemes, followed by 3 different elevation drops tested.

  Flushing with the four-channel scheme was unsuccessful because insufficient downstream channel capacity resulted in subcritical flow through much of the downstream section of the basin. This scheme would function adequately if more downstream capacity were provided.

  Flushing with the single-channel scheme with the slope through the flushing ports continuing at the 1:100 basin slope was not satisfactory as a hydraulic jump formed in the basin. Elevation drops of 20, 30 and 45 cm through the ports were then tested. Supercritical flow through the ports, and thus effective flushing, was maintained for flow rates from 2 to 6 m3/s for the three tested drops.

Results:

- Decrease bedload deposition: 75 % (100% of objective)
- Reduce downstream scouring : 91 % (57% of objective)
- Minimize production cost: 27000 $ per unit (60% of objective)

Conclusion:

Approach flow patterns to the settling basin appear satisfactory as the upstream transition adequately spreads the flow so that all basin segments are used effectively. There is slower moving flow along the diverging sidewall that would be improved by rounding the upstream corner of the transition. Deposition in the basin was fairly well distributed among the basin segments.

Key variables resolved: sediment movement, shape of the intake

901 - Analysis of river flow properties:

Scientific or Technological Objectives:

Measurement	Current Performance	Objective
Downstream velocity increase (%)	25	0
Minimize erosion (inches per year)	2	1
Ability to operate during navigation (%)	0	100
Minimize environmental impact (%)	0	100

[NOTE: THIS PROJECT DESCRIPTION IS REPRODUCED FROM FACTS OUTLINED IN THE TAX COURT OF CANADA Docket: 97-531-IT-G, Date: 1998/05/01]

[AUTHOR'S NOTE: IDEALLY THE TAXPAYER WOULD ATTEMPT TO QUANTIFY THE OBJECTIVES THEY ARE TRYING TO ACHIEVE. A QUANTIFIABLE OBJECTIVE HAS BEEN ADDED ABOVE, TO ILLUSTRATE.]

Specific ACOE objectives included the following:

- Establish baseline performance of the existing configuration including navigation conditions, water surface profiles, and sediment transport characteristics in the vicinity of the lower lock approach. Also, document velocities over the entire modeled reach of the river, in the lock approaches, near the affected structures and adjacent bank lines (navigation model).

- Ensure that the proposed hydropower project, under steady-state operation, does not have an adverse impact on either the navigation conditions or the bank line velocities. Develop modifications required to eliminate any unsatisfactory conditions during and after construction (navigation model).

- Assess the backwater effects of the project modifications, both during and after construction, and develop designs to eliminate any unsatisfactory conditions (navigation model).

- Investigate the magnitude of upstream and downstream surges (water levels and velocities) resulting from powerhouse start-up and shut-down (navigation model).

- Determine the effect of any site excavation or soil disposal on the upstream flood stages and flow distribution, and investigate designs required to eliminate unsatisfactory conditions (navigation model).

- Provide a qualitative assessment of the movement of sediment into the lower lock approach for the proposed powerhouse conditions and compare with the baseline conditions. Develop design modifications to eliminate adverse conditions as required (navigation model).

- Ensure that the flow over and around the powerhouse does not induce erosion or threaten the integrity of the existing dam (navigation and section models).

- Assess the environmental aspects of the project. In particular, the velocities and flow patterns produced by powerhouse flows in the downstream river channel (navigation and section models).

In addition to the concerns of the ACOE, the model study was also used to:

- Aid in the layout of the recreational facilities downstream of the proposed powerhouse with input from the appropriate resource agencies (navigation model).

- Evaluate the hydraulic performance of alternative approach channel configurations designed to minimize unsymmetrical flow conditions that would adversely affect plant efficiency (navigation and section models).

- Evaluate the hydraulic performance of alternative tailrace channel geometries with emphasis on minimizing head losses and draft tube instabilities (navigation and section models).

[NOTE: THIS IS A GOOD LIST OF OBJECTIVES SINCE MOST INCLUDE QUANTIFIABLE PARAMETERS SUCH AS VELOCITIES, FLOW RATES, ETC. ADDING SPECIFIC NUMERICAL TARGETS OR CRITERIA WOULD BE IDEAL]

Technology or Knowledge Base Level:

Benchmarking methods & sources for citings:

- Internet searches: 36 sites / articles -- no solution found
- Patent searches: 6 patents -- Current methods did not reveal the solution
- Similar prior in-house technologies: 1 products / processes -- Previous work did not have to deal with effects on navigation.
- Potential components: 1 products -- The technological problem and the hypotheses formulated to solve the problem are set out in the draft

This project was owned and operated by the U.S. Corps of Engineers. It is located on the Ohio River at Belleville, West Virginia. The river was primarily used for navigation. A private developer proposed the construction of a hydroelectric powerhouse on the opposite bank of the river. The appellant was retained to evaluate the initial design and, if necessary, to develop design modifications to improve the performance. The objective was to develop a design that would permit the powerhouse to be constructed and operate in a manner that would not interfere with navigation. The technological problem and the hypotheses formulated to solve the problem are set out in the draft report prepared by the appellant.

Field of Science/Technology:

Civil Engineering (2.01.01)

Intended Results:

- Improve existing materials, devices, or products

Work locations:

Research Facility

Scientific or Technological Advancement:

Uncertainty #1: Environment

Need to determine the effect of cofferdam works and powerhouse discharge on navigation, stage, surge and sedimentation that was observed. The powerhouse is located in a deep recess in the left bank.

Conventional engineering will not be adequate to deal with the variables and the uncertainties that are inherent in the major disruption and diversion of the flow of the river resulting from the construction.

The most significant underlying key variables are:
navigation, stage, surge, sedimentation

Activity #1-1: Modeling

Work performed in Fiscal Year 2009:

Methods of experimentation:

- Process trials: 4 runs / samples - 3 series of tests on the first model, and a subsequent series of tests on the second model, as outlined below.
- Physical prototypes: 2 samples - Scale models used to test effect of proposed design.

Three test series were performed using the 1:120 scale navigation model. The first series of tests addressed ACOE concerns regarding the effect of the proposed powerhouse addition both during and after construction on existing navigation, sedimentation, stage, erosion, and surge. The second series of tests used upstream and downstream flow patterns to develop a hydraulically-efficient and cost-effective design of the civil works. The third series of tests collected additional velocity data to help layout an appropriate recreational facility downstream of the powerhouse.

Two models were required. One problem that emerged was the flow pattern that would have resulted from the initial design would have adversely affected the navigation downstream. As a result the tailrace channel was realigned to obviate the problem with the initial design and the approach channel was realigned. It would be easy to say, after the event, that these solutions are obvious and routine. They are not. They required a number of methodical and systematic experiments and progressive modifications to meet problems that could not have been predicted.

[NOTE: IDEALLY, THE DIFFERENCES BETWEEN EACH MODEL WOULD BE DESCRIBED AND CONCLUSIONS COULD BE DRAWN. MOREOVER, PROVIDING KEY SPECIFIC PARAMETERS AND NUMERICAL BOUNDARIES WOULD HELP TO SOLIDIFY THE DESCRIPTION.]

Results:

- Downstream velocity increase: 0 % (100% of objective)
- Minimize erosion: 0.9 inches per year (110% of objective)
- Ability to operate during navigation: 100 % (100% of objective)
- Minimize environmental impact: 100 % (100% of objective)

Conclusion:

Each river is different and each project of this sort adds to the body of knowledge.

With this, and pretty much every project, we learn something. Some of the earlier lock and dam projects, for instance, we had used a different type of feature to help spread this flow. In this case we developed a feature in this direction, which we hadn't used in previous ones. In our early part of our development testing we tried to take that knowledge from our previous projects and apply it here. It didn't prove as beneficial as it did in the previous cases, so we had to develop some other modifications. In this case, for example, this feature here was able to meet the objectives.

High left bank velocities and increased bed mobility were noted downstream from the powerhouse, requiring design changes in the powerhouse tailrace channel.

Design improvements were made, the uncertainties were removed and project development facilitated.

[NOTE: THE CONCLUSION COULD BE TIGHTENED UP BY SPECIFYING THE DIFFERENCE IN THE RESULTANT CONCEPT FROM PREVIOUS CONCEPTS.]

Key variables resolved: navigation, sedimentation, stage, surge

902 - Sedimentation Study (Ineligible):

Scientific or Technological Objectives:

Measurement	Current Performance	Objective
Sediment Discharge (%)	35	0

[NOTE: THIS PROJECT DESCRIPTION IS REPRODUCED FROM FACTS OUTLINED IN THE TAX COURT OF CANADA Docket: 97-531-IT-G, Date: 1998/05/01]

[AUTHOR'S NOTE: IDEALLY THE TAXPAYER WOULD ATTEMPT TO QUANTIFY THE OBJECTIVES THEY ARE TRYING TO ACHIEVE. A QUANTIFIABLE OBJECTIVE HAS BEEN ADDED ABOVE, TO ILLUSTRATE.]

The problem was to devise a solution that would eliminate the deposit of sediment in front of the club. It was decided that the best way of doing so was the construction of a physical model.

Technology or Knowledge Base Level:

Benchmarking methods & sources for citings:

- Similar prior in-house technologies: 1 products / processes -- But sedimentation can not be explained by traditional modeling.

This study was conducted by the appellant for the City of Philadelphia. The problem was that the Schuylkill River, which flowed in front of Boathouse Row, a rowing club, was depositing sediment in front of the club. As the river flowed around a bend immediately upstream from the club the surface water flowed fairly uniformly, following the contours of the right-hand bank of the river and over a dam downstream on the right. The water near the bed of the river went into a helical flow and veered off to the left toward the rowing club, which was situated on the bank of a river in an indentation or recess in the left bank that could be described as a bay or perhaps more accurately as a cove. The water in the cove is virtually still. The below surface water in the current of the river that goes into a helical flow after coming around the bend moves much more slowly with the result that suspended sediment that was carried along so long as the river was moving rapidly, drops down to the bed from the slower helical flow of the below surface water and is deposited in front of the club, making access difficult or impossible.

Field of Science/Technology:

Civil Engineering (2.01.01)

Intended Results:

- Develop new materials, devices, or products

Work locations:

Research Facility

Scientific or Technological Advancement:

Uncertainty #1: Water Flow

- The particular characteristic of the flow of current around a bend in a river, the formation of a helix and the differing velocities of the surface and below surface water were well known in the profession.

- Need to determine the cause of existing sedimentation problems at Boathouse Row, and remediation measures needed to correct the existing undesirable and unsafe conditions.

[NOTE: SINCE THE FLOW PATTERNS ARE 'WELL KNOWN IN THE PROFESSION' THIS IS NOT A GOOD UNCERTAINTY. WOULD BE IMPROVED IF THE SECOND ITEM WAS EMPHASIZED, I.E., THE EXISTING SEDIMENTATION PROBLEMS OBSERVED AT BOATHOUSE ROW CANNOT BE EXPLAINED BY TRADITIONAL MODELING. IT WAS UNCERTAIN WHAT COMBINATION OF FACTORS WAS RESPONSIBLE FOR THE SEDIMENTATION. THIS REQUIRED DETAILED INVESTIGATION AND MODELING OF THE SITE SPECIFIC CONDITIONS TO DEVELOP A REMEDIATION PLAN.]

The most significant underlying key variables are:
sedimentation

Activity #1-1: Solutions

Work performed in Fiscal Year 2009:

Methods of experimentation:

- Process trials: 6 runs / samples - Six different potential remediation scenarios were developed and tested using bench-scale hydrometric equipment.

[AUTHOR'S NOTE: THE DESCRIPTIONS BELOW WERE PROVIDED IN THE EXAMPLE. THE DATA ABOVE (# TRIALS/ALTERNATIVES) IS PROVIDED TO ILLUSTRATE SOME OF THE ADDITIONAL DETAILS THAT WOULD IDEALLY BE INCLUDED.]

- One obvious solution was dredging. This was considered expensive and impermanent. Others were the construction of river training walls - spurs or rock fills off the shore - to intercept the flow pattern or the construction of a river dividing wall parallel to the bank to create scour and prevent sediment from reaching the area.

- The river training walls were rejected because of the degree of the bend and velocity of the current. Such structures would have had to be excessively large.

- The creation of a division in the river by means of a parallel wall was the most promising idea. It fell into three alternatives:

- The flushing concept which involved a parallel dividing wall which would increase the velocity.

- The deadpond concept, which involved the building of a long wall that would in effect isolate the area in front of the club. This was rejected for both safety and aesthetic reasons. A large wall in the middle of a river in front of a rowing club is unattractive.

- The extended peninsula. Essentially this involved the extension of the existing peninsula which combined the features - and results - of the other two ideas - the isolation of the area and the counteracting of the helical effect by a redirection of the main flow and the increase of the velocity.

[NOTE: WHILE THESE PROVIDE AN INDICATION OF THE DIFFERENT REMEDIATION SCENARIOS, IT DOES NOT OUTLINE THE TESTING WHICH WAS CONDUCTED. CITING SPECIFIC TESTS USING SMALL-SCALE MODELS (FLOW TESTS, SEDIMENTATION, RANGES OF PARTICLE SIZES MEASURED) ETC. WOULD HELP TO PROVE SR&ED ELIGIBILITY.
FOR EXAMPLE:

SIX DIFFERENT POTENTIAL REMEDIATION SCENARIOS WERE DEVELOPED AND TESTED USING BENCH-SCALE HYDROMETRIC EQUIPMENT. THESE INCLUDED: CITE THE SIX SCENARIOS
THEN ADD A BRIEF DESCRIPTION OF THE TEST MATRIX (RANGE OF FLOWS, SEDIMENT LOADINGS AND SEDIMENT PARTICLE SIZE RANGES) OR THE BOUNDARIES OF THE BENCH-SCALE TESTS TO BETTER ILLUSTRATE THE EXPERIMENTAL WORK CONDUCTED.]

Results:

- Sediment Discharge: 0 % (100% of objective)

Conclusion:

There was no doubt a measure of uncertainty as to the best method of dealing with the problem and there was also methodical experimentation. However the solutions that were tested and the one that was ultimately adopted were well within accepted engineering techniques. There was nothing particularly innovative. It could not have failed to be obvious that sooner or later, using established techniques, a solution would be found.

The sedimentation pattern caused by the bend effect was corrected by a dividing wall.

[THEREFORE THIS PROJECT IS INELIGIBLE FOR SR&ED CREDITS. ON THE OTHER HAND, IF THE UNCERTAINTY IS EXPRESSED IN PHYSICAL QUANTIFIABLE TERMS (e.g., acceptable ranges of flow rates expressed as +/- sediment loads) AND ONE ALTERNATIVE SCENARIO WAS SELECTED AS BEING SUPERIOR BASED ON QUANTIFIABLE TARGET PARAMETERS/CRITERIA, THIS WOULD BE ACCEPTABLE. IN SHORT, THE PROJECT DOES NOT NECESSARILY NEED TO BE INNOVATIVE, AS LONG AS IT DEMONSTRATES THE EVALUATION OF ALTERNATIVES TO DETERMINE THE BEST MEANS TO MEET TARGET SPECIFICATIONS (COULD BE THE MOST COST EFFECTIVE APPROACH).]

Key variables resolved: sedimentation

903 - Dam Apron Repair:

Scientific or Technological Objectives:

Measurement	Current Performance	Objective
Growth of crack (ft/yr)	2	0
reduce the uplift on the apron slab (psi)	1200	600
Maximum cost of remediation plan ($)	0	30000
Time to accomplish remediation plan (days)	0	5

[NOTE: THIS PROJECT DESCRIPTION IS REPRODUCED FROM FACTS OUTLINED IN THE TAX COURT OF CANADA Docket: 97-531-IT-G, Date: 1998/05/01]

[AUTHOR'S NOTE: IDEALLY THE TAXPAYER WOULD ATTEMPT TO QUANTIFY THE OBJECTIVES THEY ARE TRYING TO ACHIEVE. A QUANTIFIABLE OBJECTIVE HAS BEEN ADDED ABOVE, TO ILLUSTRATE.]

It was unknown what corrective action would be suitable to prevent further damage to the apron. To determine the best means to develop a remediation plan, the engineering characteristics of the system had to be determined.

The primary objectives of the model study:

1. Reproduce the conditions that led to the apron damage.
2. Determine the maximum uplift pressures.
3. Determine the water flow and/or gate opening combination which results in the maximum uplift pressure.
4. Document if the maximum uplift is a transitory phenomenon.

A secondary objective for the study would be to document the effect of a plunge pool. While this is a potential approach to reduce the uplift on the apron slab, the design and construction of a downstream weir is probably not justifiable when compared to an anchored slab.

Technology or Knowledge Base Level:

Benchmarking methods & sources for citings:

- Internet searches: 12 sites / articles -- No solution found
- Patent searches: 3 patents -- different environment
- Competitive products or processes: 2 products -- Previous repairs, which had both failed to eliminate the problem.

The Walters dam was built in 1930 and the damage from the falling water was repaired in 1972 and 1990. The Dam is an arched dam with 14 gated bays. Water passes over a short crest section at the top through the gates and plunges 180 feet into a concrete basin. During periods of flooding when large volumes of water pass over the dam, the concrete apron on which it falls is damaged.

Analysis of Failure

The damage-producing processes:

- High pressure created by the impact of the water falling 180 ft on the concrete apron finds a path to the underside of the apron through both open grout pipes and construction joints.
- The original uplift has a perimeter bounded by a large crack, having an approximate diameter of 40 ft, and occurred as a result of excessive shear stresses.
- The crack was produced by vertical uplift forces that exceeded the combined tensile strength of the concrete, the weight of the concrete slab, and the impact force of the water.
- The uplift either delaminated the apron from the foundation, or of the newer, upper apron slab from the original lower apron. This resulted in uplift of the slabs at the downstream end of the apron with the uplift force transmitted from one slab to the next through the steel reinforcing bars.
- The average pressure required to generate this uplift is estimated to be slightly more than half the reservoir pressure.

Field of Science/Technology:

Civil Engineering (2.01.01)

Intended Results:

- Improve existing materials, devices, or products

Work locations:

Commercial Facility

Scientific or Technological Advancement:

Uncertainty #1: Modeling

Determine the cause of the failure of the existing apron, and the nature of corrective action required to avoid future problems.

Our primary objectives for the model study are as follows:

1. Reproduce the conditions that led to the apron damage.
2. Determine the maximum uplift pressures.
3. Determine the water flow and/or gate opening combination which results in the maximum uplift pressure.
4. Document if the maximum uplift is a transitory phenomenon.

The most significant underlying key variables are:
uplift pressures, water flow, gate opening

Activity #1-1: modeling

Work performed in Fiscal Year 2009:

Methods of experimentation:

- Process trials: 4 runs / samples - Proposed solutions tested using our scale model.
- Physical prototypes: 1 samples - A 1:40 modeled was constructed to test design modifications considered.

  A model on a scale of 1:40 was constructed.

  - The first solution considered was to construct radial divide walls, the purpose and effect of which was to simulate the effect of opening all of the gates at once in that it deflected the falling jet of water.

  - The second solution was simply to change the sequence of the gates, or pass the water through more gates. Essentially the purpose of this solution was to dissipate the water falling on the concrete.

  - Other solutions involved the reshaping of the apron and the sealing of apron joints. The idea of repairing the apron in itself is hardly innovative. Repairs are an inevitable concomitant of damage. The solution suggested went beyond mere repair. It involved not merely the construction of four foot layers of concrete, but rather a large mass of concrete which pressures from below could not move.

Results:

- Growth of crack: 0 ft/yr (100% of objective)
- reduce the uplift on the apron slab: 800 psi (66% of objective)
- Maximum cost of remediation plan: 31000 $ (103% of objective)
- Time to accomplish remediation plan: 5 days (100% of objective)

Conclusion:

There was clearly a technological uncertainty that conventional engineering could not remove. Imaginative and innovative hypotheses were tested methodically and a technological advance was made in understanding the effect of the falling jet, and the spreading of flow through the change in the sequence of opening the gates as well as through the divide wall system.

The technological advance was not spectacular but, what may seem routine in hindsight involved innovative hypotheses as well as considerable experimentation.

[NOTE: IDEALLY CONCLUSIONS WOULD BE DRAWN FOR EACH SOLUTION - IT IS IMPORTANT TO EXPLAIN FAILURES AS WELL AS SUCCESSES]

The apron failure was caused by uplift pressure related to the design and operation of the existing structure.

A gate sequence operation to reduce uplift force on the apron was determined, and a set of radial divide walls was devised for the basin to improve flow distribution.

Key variables resolved: gate opening, uplift pressures, water flow

1001 - Pipeline - cracking mitigation:

Scientific or Technological Objectives:

Measurement	Current Performance	Objective
SCC predictive model accuracy (%)	0	95
ability for predictions various models (#)	1	20
Maximum cost of study ($)	25000	12000
Maximum duration of study (days)	13	5

[NOTE: THIS PROJECT DESCRIPTION IS REPRODUCED FROM FACTS OUTLINED THE TAX COURT OF CANADA Docket: 96-4369-IT-G I, (TCC), Date: 1999/09/15]

[AUTHOR'S NOTE: IDEALLY THE TAXPAYER WOULD ATTEMPT TO QUANTIFY THE OBJECTIVES THEY ARE TRYING TO ACHIEVE. A QUANTIFIABLE OBJECTIVE HAS BEEN ADDED ABOVE, TO ILLUSTRATE.]

The objective was to determine the cause of stress corrosion cracking (SCC) and meal corrosion in 24" steel pipeline based on evaluation of SCC site specific characteristics (soil type, pH, drainage conditions, cover depth, topography, etc.) and thereby develop methods to prevent such occurrences.

The company claimed that its "process" was determining the cause and effect of SCC even if there were only "incremental improvements" to that process. And that it performed, "work with respect to engineering, operations research, data collection and testing commensurate with the needs, and directly in support, of its [experimental development] work."

Technology or Knowledge Base Level:

Benchmarking methods & sources for citings:

- Internet searches: 11 sites / articles -- search resulted with no solutions
- Patent searches: 7 patents -- different conditions
- Similar prior in-house technologies: 1 products / processes -- Although the company is confident SCC is occurring, it does not have a good model of this process.
- Queries to experts: 5 responses -- to identify, by aerial survey, sites that might be SCC susceptible, and characterize SCC
- Other: 1 current status -- inspection discovered 523 defects, which were caused by SCC and/or metal corrosion.

Rainbow Pipeline Company Ltd. (Rainbow) had operated the 24-inch trunk line (approximately 300 km long) for 26 years (1967 to 1993) without any pipeline ruptures. In February and July 1993, it had two significant ruptures in the 24-inch portion of its pipeline. Those two ruptures were believed to be caused by a combination of Stress Corrosion Cracking ("SCC") and metal corrosion. Further inspection discovered 523 defects, which were caused by SCC and/or metal corrosion.

Rainbow had also retained an expert consultant to identify, by aerial survey, sites that might be SCC susceptible, and characterize SCC at such excavation site using onsite investigation techniques. In several instances dig sites believed to be susceptible to SCC, additional soil, environmental and other data [NOTE: IT WOULD BE ADVANTAGEOUS TO PROVIDE SPECIFIC PARAMETERS (PREFERABLY QUANTIFIABLE PARAMETERS) TO PROVIDE CONTEXT TO CRA] was gathered to enhance knowledge about how soil type, drainage, and topography might influence the existence of SCC.

The company identified about 140 different expenditures where they had consulted with subcontractors to determine what portion of their work was SR&ED vs. non-SR&ED repairs.

In its taxation year ending December 31, 1994, the company spent $19,600,000 on projects connected with and resulting from pipeline leaks. In addition to issues as to whether certain payments were current expenses or capital outlays, the CRA contested the taxpayer's claim that $2,081,325 of these expenditures were "scientific research and experimental development," with a resultant federal investment tax credit of $416,265.

[NOTE: IT WOULD BE EXPECTED THAT 26 YEARS OF EXPOSURE TO ENVIRONMENTAL CONDITIONS WOULD RESULT IN DETERIORATION OF THE PIPELINE. CITING SPECIFIC SR&ED EXPENDITURES ON CHARACTERIZING THE INTRINSIC PROPERTIES OF THE SCC SITES (AS PER A LIST OF TANGIBLE PARAMETERS) AND SUBSEQUENT EVALUATION OF THE DATA WOULD BE ACCEPTABLE TO THE CRA AS SR&ED ELIGIBLE. HOWEVER, COSTS ON REPAIRING OR IDENTIFYING AREAS REQUIRING REPAIRING WOULD BE CONSIDERED INELIGIBLE (I.E., AERIAL SURVEY OF SUSCEPTIBLE SITES) AS THE WORK WOULD BE THE RESULT OF THE DEVELOPED RESEARCH INFORMATION AND EXPENDED ON CONTINUED PRODUCTION.]

Field of Science/Technology:

Civil Engineering (2.01.01)

Intended Results:

- Improve existing materials, devices, or products

Work locations:

Commercial Facility, on-site

Scientific or Technological Advancement:

Uncertainty #1: Pipeline issues

There are technical uncertainties as to the exact cause(s) of the Stress Corrosion Cracking. The evaluation process could be developed based on known engineering/environmental chemistry precepts, however, it is unknown if a standard application of these factors would be successful in identifying the specific cause or combination of causes. This may require consideration of multi-discipline concepts. The initial evaluation process includes:

- characterize the chemical and/or physical environments responsible for SCC;
- evaluate the underlying engineering principles related to physical stresses;
- develop a valid database on the environmental/physical conditions which may be responsible for SCC:
- assess and identify areas which may be susceptible to SCC based on the conclusions of the database.

The most significant underlying key variables are:
chemical environments, physical environments

Activity #1-1: Current and past studies

Work performed in Fiscal Year 2010:

Methods of experimentation:

- Analysis / simulation: 7 alternatives - Analysis of 7 studies, assessing effect of soil type, pH, drainage, topography on SCC.

  [AUTHOR'S NOTE: THE DESCRIPTIONS BELOW WERE PROVIDED IN THE EXAMPLE. THE DATA ABOVE (# TRIALS/ALTERNATIVES) IS PROVIDED TO ILLUSTRATE SOME OF THE ADDITIONAL DETAILS THAT WOULD IDEALLY BE INCLUDED.]

  Rainbow's evidence included studies from the late 1980's suggesting "significant" SCC on a pipeline was strongly related to the terrain conditions where there was the potential for pipe coatings to have disbonded. In 1995-1996, the NEB [National Energy Board] held an inquiry into SCC on Canadian oil and gas pipelines.

  [NOTE: THE EXAMPLE ABOVE IS TOO VAGUE. THIS REQUIRES MORE TECHNICAL INFORMATION. A SUMMARY OF THE PARAMETERS ASSESSED (e.g., identification of soil type, pH, drainage, topography, etc.), OUTLINE OF THE PROCESS USED TO EVALUATE THE CRITERIA, AND THE RESULTS OF THE ASSESSMENT WOULD BE ADVANTAGEOUS.]

Results:

No results have been recorded for this Activity.

Conclusion:

The inquiry confirmed that, "there was very little research on SCC failures in pipelines prior to 1993-1994." Rainbow was invited by the NEB to participate in its public inquiry concerning SCC on Canadian oil and gas pipelines. Rainbow participated in the SCC inquiry and made available the results of its research into SCC as a result of the pipeline ruptures in February and July, 1993.

[NOTE: A SUMMARY OF WHAT THE RESEARCH CONCLUDED SHOULD BE PROVIDED]

Key variables resolved: chemical environments, physical environments

Activity #1-2: Predictive models

Work performed in Fiscal Year 2010:

Methods of experimentation:

- Process trials: 14 runs / samples - Developed 2 different models that were each tested at 7 different site locations, which were selected to cover the range of environmental conditions.

  [AUTHOR'S NOTE: THE DESCRIPTIONS BELOW WERE PROVIDED IN THE CRA'S EXAMPLE. THE DATA ABOVE (# TRIALS/ALTERNATIVES) IS PROVIDED TO ILLUSTRATE SOME OF THE ADDITIONAL DETAILS THAT WOULD IDEALLY BE INCLUDED.]

  At the time of the Inquiry, six CEPA (Canadian Energy Pipeline Association) member companies were using predictive models to assess the SCC-susceptibility of their systems, or portions thereof, and five other member companies were developing predictive models.

  [NOTE: THE PURPOSE OF DEVELOPING THE PREDICTIVE MODELS IS TO PREVENT OR MINIMIZE SCC OVER LONGER PERIODS OF TIME. THE WORK INVOLVED IN DEVELOPING THE PREDICTIVE MODELS, INCLUDING ANY TESTING OR EXPERIMENTATION UNDER SPECIFIED ENVIRONMENTAL CONDITIONS SHOULD BE THE FOCUS OF THE DESCRIPTION.]

Results:

- SCC predictive model accuracy: 65 % (68% of objective)
- ability for predictions various models: 1 # (no improvement)
- Maximum cost of study: 15000 $ (76% of objective)
- Maximum duration of study: 5 days (100% of objective)

Conclusion:

These models had further established that, while the information on terrain conditions known to promote SCC susceptibility may be applied to all pipelines in the same area, because the data about each pipeline -- its coating, its year of construction, its operating history - an accurate predictive model can be used only for the pipeline for which it was developed.

[NOTE: IN SHORT, BY IDENTIFYING THE SITE SPECIFIC PARAMETERS DEEMED RESPONSIBLE, THERE IS DIRECT CONTEXT TO THE SR&ED WORK.]

Key variables resolved: chemical environments, physical environments

1002 - Development of river diversion dam to power canal:

Scientific or Technological Objectives:

Measurement	Current Performance	Objective
Sediment Discharge (%)	35	0
Ability to divert the river to an intake (%)	0	100
minimize operational restrictions (%)	0	100
fish facilities to operate successfully (%)	0	100
Improve the intake flow distribution (%)	0	100

[NOTE: THIS PROJECT DESCRIPTION IS REPRODUCED FROM FACTS OUTLINED IN THE TAX COURT OF CANADA Docket: 97-531-IT-G, Date: 1998/05/01]

[AUTHOR'S NOTE: IDEALLY THE TAXPAYER WOULD ATTEMPT TO QUANTIFY THE OBJECTIVES THEY ARE TRYING TO ACHIEVE. A QUANTIFIABLE OBJECTIVE HAS BEEN ADDED ABOVE, TO ILLUSTRATE.]

The purpose of the dam is to divert the river to an intake that leads to a power canal for the purpose of generating hydro electric power. Dr. Babb put the purpose as follows: Developing an engineering design to keep the bed material, the sands and the gravels, out of the intake, and also the establishment of favorable fish attraction currents to these entrances.

There are fish facilities at the diversion dam on both banks, which must continue to operate successfully with the new design. These include a fish trap facility on the left bank operated by the Corps of Engineers to collect upstream migrants and transport them above Mud Mountain Dam and a fish hatchery on the right bank operated by the Muckleshoot Indian Tribe. In addition, the fisheries agencies have imposed operational restrictions on the diversion related to: minimum flow releases, and the rate at which flow changes are imposed (ramping rates), and may impose operational restrictions on sediment releases.

Operation requires an attendant 24 hours per day. The facility is to be automated.

Technology or Knowledge Base Level:

Benchmarking methods & sources for citings:

- Internet searches: 5 sites / articles -- search resulted with no solutions
- Patent searches: 6 patents -- Insufficient info. Different conditions
- Competitive products or processes: 1 products -- Existing structure is allowing unacceptable sediment deposition.
- Similar prior in-house technologies: 1 products / processes -- The existing dam is a timber crib structure with 7-foot high flashboards

This involved the modification of the design of a diversion dam on the White River.

The White River Diversion Dam was constructed in 1910. It is owned by the Puget Sound Power and Light Co. NHC was retained by a firm of engineers, HDR Engineering Inc. of Bellevue, Washington

The existing dam is a timber crib structure with 7-foot high flashboards that maintain water levels during normal flows but can be removed or will wash out at high flows. These are to be replaced by operational gates of some kind.

The river transports a significant bedload of sand, gravel and cobbles that collects upstream of the diversion dam and enters and deposits in the intake and interferes with the operation of the intake gates and obstructs the flow. According to samples taken from the bed below any armoring, this material is composed of about 75% gravel, 20% sand and 5% fines. The median size of the gravel fraction is about 80 mm. The largest size sampled is about 100 mm. The river also transports, in suspension, a large quantity of sand that is transported through the intake along with the flow going to the Lake Tapps storage reservoir. This sand is deposited in intermediary basins and is removed periodically. The river transports significant quantities of floating debris that collects in front of, or enters, the intake and disrupts operations.

The existing dikes that protect development along the right bank of the river from flooding during high flows need to be raised and upgraded and protected from erosion by floods.

Field of Science/Technology:

Civil Engineering (2.01.01)

Intended Results:

- Improve existing materials, devices, or products

Work locations:

Commercial Facility

Scientific or Technological Advancement:

Uncertainty #1: environmental uncertainty

The primary uncertainties are:
- What constitutes the optimal combination of weirs, radial gates & walls to control sediment and debris flows at the intake?
- How to ameliorate the problems associated with flood passage during construction?

The most significant underlying key variables are:
weirs, radial gates, walls

Activity #1-1: Project design 1-3

Work performed in Fiscal Year 2010:

Methods of experimentation:

- Analysis / simulation: 5 alternatives - Initial analysis of 5 design options.
- Physical prototypes: 3 samples - Of the 5 design alternatives outlined above, 3 were selected for physical modeling. Details of these 3 designs are outlined below.

Identified 5 project design options for evaluation [NOTE: IT WOULD BE HELPFUL TO PROVIDE AN OUTLINE OF THE EVALUATION CRITERIA] - 3 for physical observation with respect to effects of these choices on various performance parameters of the overall system.

The 3 options examined included the optimal integration of:
1 - radial sluices & free ogee crest
2 - flow release control by collapsible rubber dams
3 - the use of sediment sluices separated by an overflow section with gates

[NOTE: THE DESCRIPTION ABOVE LACKS AN OUTLINE OF THE TARGET PARAMETERS FOR DEFINING AN "OPTIMAL DESIGN". IF TARGET PARAMETERS OR RANGES ARE PROVIDED, IT PROVIDES TECHNICAL BENCHMARKS THAT ARE INDICATIVE OF ELIGIBLE SR&ED PROJECTS.]

Additionally, the company identified specific technical uncertainties with respect to optimal layouts & which supported the "need for physical vs. numeric modeling."

Design I

This option includes radial gated sluices and a free ogee crest arranged from left to right across the dam as follows:

- 3 sluice bays, each 50 feet long with floor at El 660 ft controlled by 11-foot high radial gates on a sill at El 660.5 ft. These bays would be separated upstream and downstream by training walls extending vertically to El 666 ft.

- free ogee crest El 671.5 extending from the sluice bays to the right abutment to operate only if flows exceeded 18,000 cfs. [NOTE: THIS CITING OF SPECIFIC FLOW CAPACITIES HELPS TO PLACE BOUNDARIES ON THE ASSESSMENT]

Design II

This option includes flow release control by collapsible rubber dams with arrangement from left to right across the dam as follows:

- a narrow sediment sluice with floor at El 660 ft and a 20-foot sluice gate 11 feet high.

- 3 bays, each 50 feet long with floor at El 660 ft controlled by 11-foot high collapsible rubber dams fastened to a sill at El 660.5 ft. These bays are separated, downstream only, by training walls.

- free ogee crest to El 671.5 extending to the right abutment.

Design III

This option was included in the FERC license application and includes four sediment sluices separated by overflow sections with bascule gates with arrangement from left to right as follows:

- overflow section 28 feet long with crest at El 666 ft and controlled by a bascule gate to El 671 ft.
- a narrow sediment sluice with floor at El 660 ft and a 20-foot sluice gate 11 feet high.
- overflow section 28 feet long with crest at El 666 ft and controlled by a bascule gate to El 671 ft.
- a narrow sediment sluice with floor at El 660 ft and a 20-foot sluice gate 11 feet high.
- overflow section 65 feet long with crest at El 666 ft and controlled by a bascule gate to El 671 ft.
- a narrow sediment sluice with floor at El 660 ft and a 20-foot sluice gate 11 feet high.
- overflow section 65 feet long with crest at El 666 ft and controlled by a bascule gate to El 671 ft.
- a narrow sediment sluice with floor at El 660 ft and 20-foot sluice gate 11 feet high.
- overflow section 65 feet long crest at El 666 ft and controlled by a bascule gate to El 671 ft extending to the left abutment.

[NOTE: THESE OUTLINES PROVIDE CONTEXT TO THE DIFFERENT OPTIONS. HOWEVER, AN OUTLINE OF THE TESTS USED TO MEASURE PERFORMANCE IS LACKING. IT WOULD BE ADVANTAGEOUS TO PROVIDE AN OUTLINE OF THE WORK CONDUCTED AND THE LIST OF EVALUATION CRITERIA.]

Results:

- Ability to divert the river to an intake : 100 % (100% of objective)
- minimize operational restrictions : 90 % (90% of objective)
- Improve the intake flow distribution: 100 % (100% of objective)

Conclusion:

The result of the numerous tests that were performed was that a design was developed that resolved the uncertainties associated with the initial design. Sediment entering the canal was reduced, the intake flow distribution was improved, the accumulation of debris was reduced and downstream scour was reduced. Significant benefits of the physical model included: design refinement, gate sizing, scour prediction, bedload behaviour prediction, and agency demonstration and consensus building.

The most significant difference in the final design from the initial design was the construction of radial gates, the inflatable rubber weirs, and three walls, (excluder, divide and deflector) adjacent to the intake to the power canal.

[NOTE: THESE "CONCLUSIONS" PROVIDE AN OUTLINE OF THE END RESULT. CAREFUL ATTENTION SHOULD BE PAID TO ENSURING THAT THE CONCLUSIONS FOLLOW DIRECTLY FROM THE RESULTS IN THE ACTIVITY SECTION.]

Flow patterns and bed load movement for several gate alternatives and intake arrangements were observed, and downstream scour patterns were observed. A divide wall was required for the intake structure.

The cofferdam arrangement for construction was devised and the gate sequence operations for sediment evacuation were determined. The uncertainties were removed.

While it is true that any one of the features of the final design may have been known - rubber weirs, radial gates and walls of different types were known - it was the innovative combination and alignment of these factors that makes this project unique.

Key variables resolved: radial gates, walls, weirs

Activity # 1-2: Modeling

Work performed in Fiscal Year 2010:

Methods of experimentation:

- Process trials: 36 runs / samples - 12 series of tests performed on each of the 3 models, as outlined below.

  The performance of the three structure options were evaluated on the basis of a model testing program. The program was designed to determine:
  - Capacity of the structure to pass bedload without allowing it to enter the canal, deposit in the vicinity of the canal intake, or interfere with the downstream fish passage facilities [NOTE: SPECIFYING THE QUANTIFIABLE TARGETS WOULD BE BENEFICIAL];

- Capacity of gated outlets to remove sediments deposited immediately upstream from the dam [NOTE: SPECIFYING THE SIZE OF SEDIMENT PARTICLES AND FLOW RATES PLACES CONTEXT ON THE EVALUATION];
- Capacity to release flows downstream from the structure that produce acceptable scour and deposition patterns [NOTE: CITE MAX OR MIN FLOW RATE REQUIREMENTS] and safe, controlled dissipation of kinetic energy [NOTE: RANGE OF ACCEPTABLE FLOW RATES TIED TO VOLUMETRIC FORCES WOULD BE HELPFUL];
- Sensitivity of structure performance to shifts in upstream approach-flow direction caused by channel instability;
- Water levels corresponding to floods;
- Uniformity of flow entering canal. Any tendency for uneven flows producing dead areas or upstream-directed currents are conducive to settling of suspended sediment and increased head loss, and should be avoided.
- Head losses for flow entering through the canal intake, to determine if the required off take capacity can be achieved within design water-level differences between forebay and canal;
- Capability to manage floating debris by preventing it from entering the intake area, and guiding it to preferred collection areas.

[NOTE: THE 3 OPTIONS EVALUATED SHOULD BE OUTLINED]

In addition to the above criteria established for comparison of the options, the following model objectives will be achieved for the preferred option:
- Measurement of velocities for use in upstream dike design;
- Establishing a detailed strategy of dam gate operation for effective passage of bedload;
- Determination of number, extent, alignment and top elevation of any needed divide walls;
- Assessment of feasibility of near-field sediment excluder near canal intake (optional).

Results:

- Sediment Discharge: 5 % (85% of objective)
- Ability to divert the river to an intake : 100 % (100% of objective)
- minimize operational restrictions : 95 % (95% of objective)
- fish facilities to operate successfully : 100 % (100% of objective)

Conclusion:

The appellant is very familiar with numerical modeling and rejected it as a reliable form of testing its hypotheses. Numerical modeling is an alternative to physical modeling only where "flow conditions and sediment - transport processes are simple enough to be represented by a numerical simulation". In a complex project of this sort a form of testing that is essentially two-dimensional is simply inadequate and in fact risky.

[NOTE: SUGGEST THAT NUMERICAL MODELING IS SIMILAR IN CONTEXT TO ECONOMIC MODELING. WOULD ARGUE THAT COMPARISON OF A MATRIX OF MODELED DATA TO EXPERIMENTALLY DETERMINED CRITERIA IS NECESSARY TO VALIDATE THE MODEL AND MAKE IT SR&ED ELIGIBLE.]

Key variables resolved: radial gates, walls, weirs