WHISKY CREEK
DEMONSTRATION PROJECT

OCC Tasks 16 and 17
FY 1990 319(h) Sub-Task 200(A)
EPA Grant # C9-006704-90-0

Submitted by:

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FINAL REPORT
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Background

The primary objective of this sub-task was to carry out a demonstration project to control agricultural NPS pollution on the small Whisky Creek watershed within the Beaver Creek system above Waurika Reservoir.

The Beaver Creek watershed above Lake Waurika is located in parts of Comanche and Stephens Counties within Water Quality Management Plan Segment 311210. Whisky Creek, a tributary to Beaver Creek, lies in Comanche County and drains the area to the south of the town of Sterling, Oklahoma. In the Section 319 Assessment Report, agriculturally related concerns were documented involving such parameters as suspended solids, siltation, turbidity, and nutrients. These pollutants were likely associated with depressed dissolved oxygen (D.O.) levels in Beaver Creek above Lake Waurika and the concerns over excessive sediment transport and eutrophication within the upper end of the reservoir.

Much of the Beaver Creek watershed area was originally heavily wooded. Land clearance for farming and ranching operations during this century increased erosion rates from agricultural land and led to the depletion of natural filter strip areas along watercourses. The use of major stream courses by livestock as watering sources further aggravates the problems with riparian habitat destruction and associated sediment and nutrient pollution to the system.

The major project activities were as follows:

(1) Inventory the Best Management Practices (BMPs) needed by landowners in the Whisky Creek watershed,
(2) Submit QAPjP and monitoring plan to the EPA,
(3) Solicit landowner sign-up (target of 70% participation),
(4) Monitor water quality, and
(5) Implement BMPs.

The agencies involved included the Oklahoma Conservation Commission, the Comanche County Conservation District, and the Natural Resources Conservation Service.

The Oklahoma Conservation Commission was in charge of the overall coordination of the Whisky Creek project in cooperation with the Comanche County Conservation District. The district undertook primary operational responsibilities for:

(1) soliciting landowner participation in the project with a goal of at least 70% land-owner participation,
(2) implementing detailed landowner specific management plans using appropriate combinations of water quality BMPs,
(3) providing technical assistance in installing the BMPs, and
(4) exercising oversight to assure that BMPs were correctly installed and maintained.

The Oklahoma Conservation Commission coordinated with the district to administer the distribution of project funds to landowners participating in the demonstration project and carried out pre- and post-implementation monitoring work to document the impacts of the project on water quality.

Whisky Creek Pre-Implementation Monitoring

Prior to implementation (July, 1990 to December, 1992), three sites in the Whisky Creek watershed and two sites on Beaver Creek (Table 1) were monitored to determine water quality. Figure 1 shows the locations of all sites monitored during the Whisky Creek project. Pre-implementation water quality data is included in Appendix A. Whisky Creek's beneficial uses are *Agriculture, Industrial and Municipal Process and Cooling Water, Aesthetics, Warm Water Aquatic Community,* and *Primary Body Contact Recreation*. The beneficial uses of Beaver Creek are *Public and Private Water Supply, Warm Water Aquatic Community, Agriculture, Municipal and Industrial Process and Cooling Water, Primary Body Contact Recreation, Aesthetics,* and *Sensitive Public and Private Water Supply*. A *Sensitive Public and Private Water Supply* is prohibited from having any new point source discharge(s) of any pollutant or increased load of specified pollutants from existing point source discharge(s) unless approved by the Oklahoma Water Resources Board. In addition, BMPs should be implemented in the watersheds of waterbodies designated a *Sensitive Public and Private Water Supply* (OWRB 1995).

Table 1. Site numbers, names, and waterbody I.D. numbers for Whisky Creek Demonstration Project.

Site #	Site Name	WBID#
1	Whisky Creek (lower)	OK311210000140G
2	Whisky Creek (upper)	OK311210000140N
3	West Whisky Creek	OK311210000143G
4	Beaver Creek below Whisky Creek	OK311210000010V
5	Beaver Creek above Whisky Creek	OK311210000010W

The lower Whisky Creek site (Site 1) was located on the eastern border of Section 19, Township 3 North, Range 9 West. The ISCO automatic high flow sampler was located just upstream of the State Highway 65 Bridge approximately 2 miles upstream from Whisky Creek's confluence with Beaver Creek. Its watershed encompasses approximately 13,280 acres and stretches north through the western edge of Sterling, Oklahoma to the H.E. Bailey Turnpike (U.S. Highway 44) near the town of Fletcher, Oklahoma. Base flow discharges ranged from 0.5-6.1 cubic feet per second (cfs) and averaged 2.8 cfs during the post-implementation study. Elevation ranges from 350 to 430 meters.

Figure 1. Locations of Whisky Creek Project sampling sites.

The upper Whisky Creek site (Site 2) was located approximately 4.25 miles upstream of Whisky Creek's confluence with Beaver Creek on the north border of Section 7, Township 3 North, Range 9 West. Samples were collected just downstream of the State Highway 17 bridge. It's watershed encompasses approximately 5,280 acres. Instantaneous discharge, which ranged from 0.35-2.50 cfs and averaged 1.4 cfs during post-implementation monitoring, indicated this watershed provides roughly half the discharge measured at the lower Whisky Creek site (Whisky Creek at ISCO). Elevation ranges from 360 to 430 meters.

West Whisky Creek (Site 3) is located approximately 4.5 miles upstream of Whisky Creek's confluence with Beaver Creek on the north border of Section 12, Township 3 North, Range 10 West. Samples were collected downstream of the State Highway 17 bridge. The watershed encompasses approximately 3,840 acres. Instantaneous discharge, which ranged from 0.04-3.10 cfs and averaged 1.2 cfs during post-implementation monitoring, indicates that this watershed accounts for roughly 43% of the discharge measured at the lower Whisky Creek site. Elevation ranges from 360 to 420 meters.

The Beaver Creek above Whisky Creek site (Site 5) is located roughly 1/8 mile upstream of the Whisky Creek confluence and approximately 1/4 mile downstream of the Beaver Creek/Cottonwood Creek confluence. The legal location is the southwest quarter of Section 29, Township 3 North, Range 9 West. Instantaneous discharge ranged from 1-11 cfs and averaged 5.5 cfs during post-implementation monitoring. Elevation in this watershed ranges from 340 to 430 meters.

The Beaver Creek below Whisky Creek site (Site 4) is located roughly 1/4 mile downstream of the Whisky Creek confluence and approximately 3/4 mile downstream of the Beaver Creek/Cottonwood Creek confluence. The sampling site was located adjacent to the section road on the east border of Section 29, Township 3 North, Range 9 West. Instantaneous discharge ranged from 1.3-19.1 cfs and averaged 9.6 cfs during post-implementation monitoring. Elevation in this watershed ranges from 340 to 430 meters. Considerable stream bank erosion was observed between this site and the upper Beaver Creek site. The channel here is deeply entrenched and has a sandy substrate.

Base Flow Monitoring Results

Excluding the D.O. level in West Whisky Creek on August 29, 1991 (1.7 mg/L), all pre-implementation D.O. levels complied with the Oklahoma Water Quality Standards (OWRB 1995). This indicates that the *Warm Water Aquatic Community* beneficial use in West Whisky Creek was threatened by D.O. depletion.

The pH levels indicated the water in the project area was somewhat basic. The observed pH values in both Whisky and Beaver Creek were generally compliant with the Oklahoma Water Quality Standards (OWQS). However on December 3, 1991, the OWQS pH criteria was exceeded at three sites (both Beaver Creek sites and the upper Whisky Creek site). The OWQS pH criterion was also approached at the other Whisky Creek watershed sites. This indicates that the *Warm Water Aquatic Community* beneficial use may be threatened by elevated pH.

Conductivity was primarily used to indicate the levels of total dissolved solids (TDS) in the water. The TDS levels (mg/L) were determined by multiplying the conductivity (uS/cm) by 0.66. The TDS levels in the upper Whisky Creek were highest. In fact, the TDS levels at the upper Whisky Creek site indicated the water was brackish. The TDS levels at the lower Whisky Creek site and West Whisky Creek site were substantially lower than the TDS levels at the upper Whisky Creek site. Dilution from the West Whisky Creek inflow does not account for the reductions observed between the upper and lower Whisky Creek sites. Therefore, it appeared that dissolved solids were being removed from the water due to a geochemical process. Hardness and sulfate levels exhibit similar trends. This may indicate magnesium sulfate or calcium sulfate was precipitating between the upper and lower Whisky Creek sites.

The TDS, sulfate, and hardness levels in Beaver Creek were reduced somewhat due to the Whisky Creek inflow. The water was very hard at all sites. Alkalinity levels, which exhibited a converse trend than that of hardness, indicated the water has a substantial buffering capacity at all sites. Alkalinity levels in Beaver Creek were increased somewhat due to the Whisky Creek inflow.

The TDS levels in Whisky and Beaver Creek indicated their suitability for irrigation was dependent on the crop grown, soil type, climate, and other factors (*Class II Agricultural Irrigation*). Excluding the upper Whisky Creek site, the TDS levels in the water at all sites would be considered safe for watering all classes of livestock and poultry. The TDS levels at the upper Whisky Creek site indicated the water was satisfactory for watering all classes of livestock (except poultry); however, it may cause mild, temporary cases of diarrhea. Over 90% of the observed TDS levels exceeded the Safe Drinking Water Act (SDWA) TDS Secondary Maximum Contaminant Level (SMCL) of 500 mg/L indicating that Whisky and Beaver Creeks may not be acceptable sources of drinking water.

Chloride levels, which varied little throughout the study area, complied with the OWQS yearly mean standard, the OWQS sample standard, and the SMCL. Sulfate levels at the lower Whisky Creek site and Beaver Creek below Whisky Creek complied with both the OWQS yearly mean standard and sample standard. In West Whisky Creek, sulfate levels complied with the OWQS yearly mean standard; however, the OWQS sample standard was exceeded once. Sulfate concentrations in the upper Whisky Creek and Beaver Creek above Whisky Creek exceeded both the OWQS yearly mean standard and sample standard.
Sulfate concentrations at the upper Whisky Creek site were, by far, the highest in the study area. Except for the samples collected from West Whisky Creek, most samples contained sulfate levels exceeding the SMCL (250 mg/L) listed in the SDWA. Even in West Whisky Creek, 22% of the samples contained sulfate levels exceeding the SMCL. This provides further indication that Whisky and Beaver Creek may not be acceptable sources of drinking water.

Turbidity and total suspended solids (TSS) levels in both Whisky Creek and Beaver Creek were generally present at low to moderate levels during base flow. The OWQS turbidity criterion was exceeded only twice (on August 29, 1991 in West Whisky Creek and on October 8, 1990 in Beaver Creek below Whisky Creek). This indicates that the *Warm Water Aquatic Community* and *Aesthetics* uses were threatened by turbidity in both West Whisky and Beaver Creek.

In the Whisky Creek watershed, phosphorous levels were generally lowest in West Whisky Creek and highest at the lower Whisky Creek site. Phosphorous concentrations increased substantially between the two upper Whisky Creek sites and the lower Whisky Creek site. Due to the inflow from Whisky Creek, the phosphorous concentrations in Beaver Creek were reduced considerably. Based on the mean discharges and phosphorous concentrations at the two Beaver Creek sites, it was estimated that the mean discharge from Whisky Creek was 4.1 cfs and the mean phosphorous concentration was 0.026 mg/L. This indicates that discharge increased considerably between the lower Whisky Creek site and its confluence with Beaver Creek. Concurrently, phosphorous levels decreased in Whisky Creek. No major tributaries flow into Whisky Creek between the lower site and the confluence; therefore, it was suspected that groundwater inflow of water containing relatively low phosphorous levels results in this increase in discharge and decrease in phosphorous levels. Base flow data indicates that implementation efforts should focus primarily on Whisky Creek between the lower site and the West Whisky / Whisky Creek confluence. The upper Whisky Creek watershed would also benefit from nutrient reduction measures.

The Environmental Protection Agency (EPA) suggests that to prevent the development of plant nuisances in streams, total phosphorous concentrations should not exceed 0.100 mg/L. At the two upper Whisky Creek watershed sites, observed total phosphorous levels exceeded this criteria in 16% of the samples, while levels in 25% of the samples collected from the lower Whisky Creek site exceeded this criteria. In Beaver Creek, 39% of the samples above the Whisky Creek confluence and 28% of the samples below the confluence exceeded this criterion. The trend in exceedances followed a similar trend to that of the mean total phosphorous concentrations, which indicated an increase in phosphorous between the West Whisky / upper Whisky confluence and the lower Whisky Creek site. It also indicated a decrease in total phosphorous concentrations in Beaver Creek due to the inflow of Whisky Creek. Summarily, the *Aesthetic* value and *Warm Water Aquatic Community* in both Whisky Creek and Beaver Creek were threatened by elevated levels of phosphorous.

Phosphate phosphorous was measured in only the last seven base flow samples. Phosphate typically comprised from 33% to 67% of the phosphorous. The lowest percentage was observed in West Whisky Creek indicating that organic phosphorous comprised roughly two-thirds of the phosphorous. The highest percentage was found at the upper Whisky Creek site indicating that a majority of the phosphorous there was biologically available.

Nitrite levels complied with the proposed Maximum Contaminant Level (MCL) of 1 mg/L listed in the SDWA (1986). Nitrite/nitrate concentrations indicated nitrate complied with the OWQS Public and Private Water Supply raw water criteria (10 mg/L). Observed ammonia levels complied with the EPA standards listed in the *Gold Book.*

In the Whisky Creek watershed, nitrate/nitrite and total nitrogen concentrations were typically highest in West Whisky Creek. Total nitrogen and nitrate/nitrite concentrations at the lower Whisky Creek site were generally lower due to dilution from the upper Whisky Creek inflow. Conversely, total Kjeldahl nitrogen levels were generally highest at the upper Whisky Creek site. The total Kjeldahl nitrogen levels at the lower Whisky Creek site were typically lower due to dilution from the West Whisky Creek inflow. The levels of all forms of nitrogen were reduced in Beaver Creek due to dilution from the Whisky Creek inflow.

High Flow Monitoring Results

High flow water quality was routinely monitored at Site 1 (lower Whisky Creek) only. Due to insufficient data, comparisons of high flow and low flow levels of D.O., pH, and temperature could not be made. High flow conductivity, alkalinity, chloride, sulfate, hardness, and TDS levels were substantially lower than base flow levels. High flow conductivity, alkalinity, chloride, sulfate, hardness, and TDS levels were 68%, 65%, 64%, 77%, 65%, and 68% lower, respectively. These measurements provided a good indication of the dilution resulting from rainfall, which contains relatively low levels of dissolved substances.

Conversely, high flow turbidity and TSS levels were 2-3 orders of magnitude higher than base flow levels indicating that sediment runoff from nonpoint sources was considerable. High flow nutrient levels were also considerably higher in high flow samples indicating their runoff from nonpoint sources. Total phosphorous and phosphate levels were 480% and 464% higher, respectively. Nitrite, ammonia, total Kjeldahl nitrogen, and total nitrogen levels were 259%, 552%, 204%, and 92% higher, respectively. Of the nutrient levels measured, only the high flow nitrate/nitrite levels were lower (28%).

Conclusions From Pre-Implementation Monitoring

Pre-implementation base flow monitoring indicated Whisky Creek's *Warm Water Aquatic Community* was threatened by D.O. depletion, elevated pH, and excessive levels of nutrients. The *Warm Water Aquatic Community* in Beaver Creek was threatened by elevated pH and excessive levels of nutrients, as well. Total dissolved solids levels in both Whisky Creek and Beaver Creek caused the water to be suitable for only *Class II Agricultural Irrigation*. However, the TDS levels indicated the water was satisfactory for watering livestock (except poultry), but it may cause mild, temporary cases of diarrhea. In addition, the TDS levels, along with the sulfate levels, severely impaired Beaver Creek's *Public and Private Water Supply* beneficial use. Pre-implementation high flow monitoring indicated excessive levels of sediment and nutrients entered the stream due to runoff.

The TDS and sulfate appeared to originate from natural sources. The sources of the nutrients were attributed to nonpoint source pollution and septic systems. The source of the sediment was attributed to stream bank erosion and NPS runoff from surrounding agricultural land. Implementation activities were aimed at addressing these issues.

Implementation Activities

As the pre-implementation monitoring showed, there was a definite need for BMP implementation in this area. To address the identified problems, the Whisky Creek demonstration project promoted the installation of water quality oriented BMPs designed to eliminate critical erosion sites on cropland through the use of contouring, terraces, and the establishment of permanent vegetative cover on critically eroded areas. BMPs leading to better pasture and range management were also promoted. Filter strips were established along stream courses. Stream bank protection BMPs were promoted, as was livestock exclusion (including the construction of alternative watering sources for cattle).

This project drew from the water quality BMPs listed in Table 2 and contained in the agricultural component of Oklahoma's Section 319 NPS Management Plan.

Table 2. BMPs promoted for implementation in Whisky Creek project.

BMP Description	**BMP # from 319 Management Plan**
Contour Farming	6
Filter Strips	8
Range and Pasture Management	13
Terraces	16
Diversions	18
Livestock Exclusion	19
Grade Stabilization Structures	20
Stream Bank Protection	22
Critical Area Erosion Control	27

The funds originally budgeted for this sub-task were as follows:

BMP Implementation	$162,650
Education/Technical Assistance/Technical Transfer	$ 41,014
Monitoring	$ 41,013
Administration	$ 8,310
Total Funds for Project	$252,987

Of these funds, the federal share was $151,793 and the non-federal share was $101,194. Implementation began in the fall of 1990. The funding allowed the implementation of the BMPs listed in Table 3 in the Whisky Creek watershed.

Table 3. BMPs implemented in Whisky Creek watershed.

Best Management Practice	**# of jobs**	**Area**
Pasture Planting	29	864.3 acres
Grade Stabilization Structures	11	N/A
Terraces	3	16,113 linear feet
Dairy Lagoons	3	N/A
Ponds	11	N/A
Diversions	11	6,693 cubic yards
Septic Systems	9 + 1 lagoon	N/A
Fences	3	9,327 feet
Critical Area Treatment	2	0.5 acres
Pipeline	1	1,500 feet
Tanks	3	N/A
Pasture Management	21	1865.1 acres
Conservation Cropping Sequence	3	145 acres
Nutrient Management	19	25,536 acres
Pest Management	4	186 acres
Waste Utilization	3	297 acres
Proper Grazing Use	8	963 acres

Transferring funds from sub-task 200(B) to this sub-task increased the funds available for this project. The final amount of funds available for this project after the transfer of funds from sub-task 200(B) were as follows:

BMP Implementation	$211,934
Education/Technical Assistance/Technical Transfer	$ 41,014
Monitoring	$ 62,397
Administration	$ 8,310
Total Funds for Project	$323,655

Of these funds, the federal share was $194,194 and the non-federal share was $129,461.

With the additional funds transferred to this sub-task from Sub-Task 200(b), a stream bank stabilization effort was initiated. In order to exclude livestock from Whisky Creek, 1,390 feet of electric fence and 4,730 feet of four strand, barbed wire fence was installed. To stabilize the banks, 4,158 trees (primarily black locust and willow) were planted. Reedgrass was planted over a 2,647 feet area to stabilize the banks. In addition, 177 cattle panels were placed in the stream to help stabilize the stream banks. These cattle panels were placed in the stream to trap debris, which in turn traps sediment.

Whisky Creek Post-Implementation Monitoring

Following implementation (August, 1994 to October, 1996), water quality monitoring was performed at the Whisky Creek and Beaver Creek sites listed in Table 1 and shown in Figure 1. In addition, a Rosgen survey was performed on Whisky Creek approximately 0.25 miles upstream of the lower Whisky Creek site. Post-implementation water quality is included in Appendix A along with the pre-implementation data.

Rosgen Survey

A "Rosgen" survey was conducted on Whisky Creek site (Site 1) by Russ Dutnell, OCC Environmental Engineer to classify the stream and obtain information for a potential stream bank restoration project. The survey (Figure 2) indicated the bankfull cross-sectional area is 108.1 square feet, the bankfull width is 31.8 feet, and the bankfull mean depth is 3.4 feet. The slope of this reach is 0.001346 feet/foot. The drainage area above this site is approximately 12,640 acres or 19.75 square miles. The bankfull dimensions at Whisky Creek were comparable to the bankfull dimensions calculated from the drainage area using the regional curve developed by the NRCS. Based on the "Rosgen" survey, the stream was classified as a G5c (sandy gully) at the cross-section.

The G5c stream type is sand dominated, entrenched, moderately meandering, and deeply incised in gentle terrain. This stream type is extremely sensitive to disturbance and has a very poor recovery potential once it is disturbed. The sediment supply is very high due to the very high stream bank erosion potential. Vegetation has a high controlling influence on stream stability; therefore, season long grazing of their riparian areas should be avoided. The best structures for improving fish habitat and stream stability in this stream type are bank placed boulders, vortex rock weirs, and bank placed root wads (Rosgen, 1996).

Figure 2. Cross-section of Whisky Creek showing bankfull and flood prone area.

Base Flow Monitoring Results

All post-implementation D.O. and pH levels complied with the OWQS (OWRB 1995). The pH indicated the water in the project area was somewhat basic. Conductivity was primarily used to indicate the levels of TDS in the water. Just as before implementation, the upper Whisky Creek post-implementation TDS levels were substantially higher than those found at the other sites and indicated the water at the upper Whisky Creek site was brackish. The TDS levels at the lower Whisky Creek site and West Whisky Creek site were substantially lower than the TDS levels at the upper Whisky Creek site. Just as before, dilution from the West Whisky Creek inflow did not account for the reductions observed between the upper and lower Whisky Creek sites. Therefore, it appeared that dissolved solids were being removed from the water due to a geochemical process. Hardness and sulfate levels exhibited similar trends. This may indicate magnesium sulfate or calcium sulfate was precipitating between the upper and lower Whisky Creek sites.

Just as before implementation, the post-implementation TDS, sulfate, and hardness levels in Beaver Creek were reduced somewhat due to the Whisky Creek inflow. Hardness indicated the water was very hard at all sites. Alkalinity levels, which generally exhibited a converse trend to that of hardness, indicated the water had a substantial acid-neutralizing or buffering capacity at all sites. The alkalinity level in Beaver Creek was increased somewhat due to the Whisky Creek inflow.

The TDS levels in Whisky and Beaver Creek indicated their suitability for irrigation was dependent on the crop grown, soil type, climate, and other factors (*Class II Agricultural Irrigation*). Except for the upper Whisky Creek site, the post-implementation TDS levels at all sites were considered safe for watering all classes of livestock and poultry. The TDS levels at the upper Whisky Creek site indicated the water was satisfactory for watering all classes of livestock (except poultry); however, it may cause mild, temporary cases of diarrhea. Nearly 94% of the post-implementation TDS levels exceeded the SMCL (500 mg/L) listed in the SDWA indicating that Whisky and Beaver Creeks may not be suitable sources of drinking water.

Chloride levels, which varied little throughout the study area, complied with the OWQS yearly mean standard, the OWQS sample standard, and the SMCL (250 mg/L) listed in the SDWA. Sulfate levels at West Whisky Creek, the lower Whisky Creek site, and Beaver Creek below Whisky Creek complied with both the OWQS yearly mean standard and sample standard. Sulfate concentrations in the upper Whisky Creek and Beaver Creek above Whisky Creek exceeded both the OWQS yearly mean standard and sample standard. However, the sulfate concentrations at the upper Whisky Creek site were, by far, the highest in the study area. Except for the samples collected from West Whisky Creek, most post-implementation samples contained sulfate levels exceeding the SMCL (250 mg/L) listed in the SDWA. Even at West Whisky Creek, 29% of the samples contained sulfate levels exceeding the SMCL. This provides further indication that Whisky and Beaver Creek may not be acceptable sources of drinking water.

Turbidity and TSS levels both Whisky and Beaver Creek were generally present at low concentrations during base flow. The OWQS turbidity criterion was not exceeded during post-implementation monitoring. In both Whisky and Beaver Creek, turbidity and TSS levels

increased somewhat as the water moved downstream. The increased turbidity in Beaver Creek downstream of Whisky Creek was attributed to the Whisky Creek inflow.

In the Whisky Creek watershed, post-implementation phosphorous levels were generally lowest in West Whisky Creek and highest at the upper Whisky Creek site. Phosphorous concentrations increased substantially between the confluence of West Whisky Creek and the lower Whisky Creek site. Due to the inflow from Whisky Creek, the phosphorous concentrations in Beaver Creek were reduced considerably. Based on the mean discharges and phosphorous concentrations at the two Beaver Creek sites, it was estimated that the mean discharge from Whisky Creek was 4.1 cfs and the mean phosphorous concentration was 0.060 mg/L. This indicates that discharge increased considerably between the lower Whisky Creek site and its confluence with Beaver Creek. Concurrently, phosphorous concentrations decreased in Whisky Creek somewhat. No major tributaries flow into Whisky Creek between the lower site and the confluence; therefore, it was suspected that groundwater inflow that contained relatively low phosphorous levels resulted in this increase in discharge and decrease in phosphorous concentrations.

EPA suggests that to prevent the development of plant nuisances in streams, total phosphorous concentrations should not exceed 0.100 mg/L. Post-implementation total phosphorous levels exceeded this criterion in 14% of the samples from the upper Whisky Creek site and in 13% of the samples from the lower Whisky Creek site. This criterion was never exceeded in West Whisky Creek. In Beaver Creek, 69% of the samples above the Whisky Creek confluence and 56% of the samples below the confluence exceeded this criterion. The trend in exceedances followed a similar trend to that of the mean total phosphorous concentrations. Summarily, the *Aesthetic* value and *Warm Water Aquatic Community* in Whisky Creek and especially Beaver Creek were threatened by elevated levels of phosphorous.

Observed nitrite levels complied with the proposed MCL (1 mg/L) listed in the SDWA (1986). Observed nitrate concentrations complied with the OWQS Public and Private Water Supply raw water criteria (10 mg/L).

Mean total Kjeldahl nitrogen and nitrite levels were fairly consistent throughout the Whisky Creek watershed. The post-implementation nitrate and total nitrogen levels were typically highest in West Whisky Creek just as was seen before implementation. However, the total nitrogen and nitrate concentrations at the lower Whisky Creek site were generally comparable to those at the upper Whisky Creek site. The levels of all forms of nitrogen were reduced in Beaver Creek due to dilution from the Whisky Creek inflow.

<u>High Flow Monitoring Results</u>

High flow water quality was routinely monitored at Site 1 (lower Whisky Creek) only. However, on May 31, 1995, high flow samples were inadvertently collected at all sites. Therefore, much of the following discussion will focus on the lower Whisky Creek site. Due to insufficient data, comparisons of high flow and low flow levels of D.O., pH, and temperature could not be made. High flow conductivity, alkalinity, chloride, sulfate, hardness, and TDS levels were substantially lower than base flow levels. High flow conductivity, alkalinity, chloride, sulfate, hardness, and TDS levels were 36%, 44%, 38%, 40%, 53%, and 36% <u>lower</u>,

respectively. These measurements provided a good indication of the dilution resulting from rainfall, which typically contains low levels of dissolved substances.

Conversely, post-implementation high flow turbidity and TSS levels were 5,000-10,000% higher than base flow levels indicating that sediment runoff from nonpoint sources was still considerable, but vastly improved when compared to pre-implementation levels. High flow nutrient levels were also considerably higher indicating their continued runoff from nonpoint sources. Total phosphorous levels were 211% higher in high flow samples; however, this accounts for less than half the increase seen prior to implementation. Total Kjeldahl nitrogen, nitrate/nitrite, and total nitrogen levels were 1219%, 33%, and 480% higher, respectively. Increases in nitrogen levels due to runoff were much higher following implementation than before.

Analysis of the high flow data collected at all sites on May 31, 1995 showed that phosphorous concentrations were fairly consistent throughout the Whisky Creek watershed. Nitrogen and TSS levels in the upper Whisky Creek and West Whisky Creek watersheds were similar, but an increase in both was observed at the lower Whisky Creek site. Nitrogen, phosphorous, and TSS concentrations increased considerably in Beaver Creek between the upper and lower sites. Stream bank erosion and NPS runoff were the most probable sources. Additional efforts are needed in the Whisky Creek watershed (especially downstream from the confluence of West Whisky Creek) and in Beaver Creek to address these concerns.

Conclusions From Post-Implementation Monitoring

Post-implementation monitoring indicated D.O., pH, turbidity, and TSS levels were improved (no OWQS violations were observed). Whisky Creek's inflow continued to impact Beaver Creek. Due to Whisky Creek's inflow, TDS, sulfate, hardness, and phosphorous levels in Beaver Creek were reduced, while turbidity increased somewhat.

Post-implementation base flow total phosphorous levels were improved in Whisky Creek (fewer samples exceeded 0.10 mg/L), while phosphorous levels in Beaver Creek worsened (more samples exceeded 0.10 mg/L). Following implementation, phosphorous, turbidity, and TSS levels did not increase as much during high flow as they did prior to implementation. However, larger increases in nitrogen concentrations were observed during high flow than were observed prior to implementation. Although great strides have been made, additional efforts are needed in the Whisky Creek and especially Beaver Creek watersheds to address nutrient and sediment loading.

Precipitation During Pre- and Post-Implementation Periods

Annual precipitation at the Lawton rain gage averages 29.55" (2.46" per month on average). Monthly rainfall amounts are listed in Appendix B. During the 30 month period (July, 1990 - December, 1992) over which pre-implementation monitoring was conducted 95.68", of precipitation fell averaging 3.19" of precipitation per month. During the 27 month period (August, 1994 - October, 1996) over which post-implementation monitoring was conducted, 75.65" of precipitation fell, averaging 2.80" per month. Above average rainfall occurred during both the pre- and post-implementation periods; however, rainfall was greatest during the pre-implementation monitoring period. This difference in rainfall may explain some of the changes observed during the study.

Comparison of Pre- and Post-Implementation Monitoring Data

The percent changes between mean pre-and post-implementation concentrations are summarized in Table 4.

Base Flow Monitoring Comparison

Beaver Creek above Whisky Creek was used as the control to determine the significance of observed changes in base flow water quality and whether the changes were due to climatic conditions or implementation. Mean base flow D.O., conductivity, TDS, and sulfate concentrations did not exhibit any trend. A small, but statistically significant, decrease in mean pH values was observed at all sites indicating that it was not due to implementation activities. This small decrease may be due to an increase in the acidity of rainfall. Jay Wright (1994) found a downward pH trend at 59 ambient trend monitoring stations across the state of Oklahoma. Turbidity decreased at all sites; however, the reduction was statistically significant at only Beaver Creek above Whisky Creek. Because turbidity decreased at all sites, it was likely that the observed decreases in turbidity resulted from natural climatic variation (the lower rainfall during post-implementation perhaps).

Table 4. Percent Change

Reductions in average alkalinity were also observed at all sites. The reductions in alkalinity in the Whisky Creek watershed were statistically significant. This indicated the reduced alkalinity levels might have resulted from implementation measures. Reductions in chloride were observed at all sites; however, none of the reductions were significant. Because decreased base flow chloride concentrations were observed at all sites, it can be assumed that these insignificant reductions resulted from natural climatic variability (i.e., lower post-implementation rainfall). Hardness increased slightly in the Whisky Creek watershed and decreased slightly in the Beaver Creek watershed; but none of the changes were significant.

No trend was observed in the mean TSS. However, a large, statistically significant decrease was observed in the West Whisky Creek watershed. This reduction may have resulted from implementation activities. In the Whisky Creek watershed, no trend in the mean base flow phosphorous concentrations was observed. Conversely, a large increase in total phosphorous concentrations was observed at both Beaver Creek sites indicating increasing levels of NPS pollution in the Beaver Creek watershed. Nitrite and nitrate/nitrite levels decreased in Whisky Creek and in Beaver Creek below Whisky Creek. In contrast, nitrite and nitrate/nitrite concentrations increased in West Whisky Creek. Mean total Kjeldahl nitrogen concentrations decreased at all sites during base flow; however, the observed decreases were statistically significant at only the sites below the treated area. Because the reductions observed in the implementation area were substantially greater than those observed outside of the implementation area, it was likely that these reductions resulted from BMP implementation activities. Total nitrogen concentrations decreased as well at all sites, but the reductions were statistically significant at only the upper and lower Whisky Creek sites. Because the reductions observed in the implementation area were substantially greater than those observed outside of the implementation area, it was likely that these reductions resulted from BMP implementation activities.

High Flow Monitoring Data Comparison

Comparisons of changes in high flow concentrations were only possible at the lower Whisky Creek site. At this site, large, statistically significant increases in conductivity, alkalinity, chloride, sulfate, hardness, and TDS were observed. It was suspected that the 11 ponds built during implementation resulted in these increases. It was postulated that evaporation from the ponds, which is roughly twice the precipitation rate, increases the levels of dissolved solids in the ponds. During runoff events, this water with higher levels of dissolved solids is then flushed from the ponds resulting in the observed increase.

Increases in nitrate/nitrite, total Kjeldahl nitrogen, and total nitrogen were also observed in post-implementation high flow samples. Of these, only the mean total Kjeldahl nitrogen and total nitrogen increases were statistically significant. This indicates that implementation activities were unsuccessful at reducing the runoff of nitrogen.

In contrast, high flow turbidity, TSS, total phosphorous, and nitrite levels decreased significantly following implementation. Caution should be used when interpreting the decreased turbidity due to the small number of samples this was based on. Not enough pre-implementation turbidity measurements were made to determine if a statistically significant change resulted from implementation activities. In addition, it was likely that differences in sampling methods (ISCO

vs. grab) and rainfall amounts also contributed to these decreases, although BMP implementation was at least partly responsible.

Conclusion

Success of the Whisky Creek project was determined from comparisons of pre- and post-implementation data. The goal was for at least a fifty- percent reduction in average high flow levels of turbidity, suspended solids, total phosphorus, and total nitrogen. This goal was met for all parameters except total nitrogen. Based on the Universal Soil Loss Equation (USLE) and channel erosion formula, soil savings due to implementation were approximately 9,293 tons. In addition, a high landowner participation rate was achieved.

Other indications of success include:

1) elimination of violations of OWQS pH, D.O., and turbidity criteria;
2) fewer base flow phosphorous concentrations in Whisky Creek exceeded 0.10 mg/L;
3) base flow TKN levels were reduced significantly below the treated area; and
4) base flow total nitrogen levels were significantly reduced in Whisky Creek.

Evaluation of the bank stabilization method is ongoing. Initial observations indicated this method might work on certain areas of streams, but certainly not all. Observations on June 23, 1997 indicated some areas were catching debris as they were designed to do. However, several large areas, which had eroded behind the cattle panels, were observed. In addition, it appeared that a couple of cattle panels had been ripped out by a previous high flow event.

Post-implementation monitoring indicated great strides had been made; however, it also indicated more work is needed. Runoff of nitrogen increased significantly following implementation. Base flow levels of phosphorous did not change considerably in Whisky Creek, but in Beaver Creek the phosphorous levels increased substantially. The data indicated additional efforts are needed in Whisky Creek below the West Whisky Creek confluence and a major implementation effort is needed to address nutrients and suspended sediment concerns in Beaver Creek.

APPENDIX A

WATER QUALITY DATA:
WHISKY CREEK PROJECT

Site	Date	D.O. mg/l	pH S.U.	Cond us/cm	Temp *C	Turb NTU	Alk mg/l	Flow cfs	Cl mg/l	SO4 mg/l	Hard mg/l	TDS mg/l	TSS mg/l	TP mg/l	PO4-P mg/l	NO3-N mg/l	NO2-N mg/l	NO2+NO3 mg/l	TKN mg/l	TN mg/l	NH3-N mg/l	Remarks
West Whisky Cr	09/13/90	8.3	8.26		24.5		293		14.5	54	346		21	0.050		6.73		6.73	0.750	7.480		
West Whisky Cr	10/08/90	7.2	7.62	723	15.5	3.1	311		16.0	191	322	477	**1**	**0.003**				0.60	0.425	1.025		
West Whisky Cr	11/14/90	8.4	7.90	849	9.5	2.0	359		74.0	93	386	560	**1**	0.231				**0.25**	0.762	1.012		
West Whisky Cr	12/11/90	11.4	8.10	1058	6.5	3.0	339		21.0	197	525	698	1	**0.003**				1.00	1.588	2.588		
West Whisky Cr	01/16/91	12.3	7.80	1143	2.0	4.9	371		19.0	248	624	754	20	**0.003**				1.00	1.714	2.714		
West Whisky Cr	02/15/91	10.8	7.90	1059	4.1	5.0	322		**5.0**	249	544	699	3	**0.003**				0.90	0.329	1.229		
West Whisky Cr	03/20/91	10.2	8.00	1125	13.7	6.0	325		18.0	238	570	743	8	0.015				3.60	1.050	4.650		
West Whisky Cr	04/16/91	8.9	7.77	1044	14.0	10.0	342		25.0	280	533	689	4	0.005				0.20	1.380	1.580		
West Whisky Cr	05/20/91	6.4	8.10	590	22.1	32.0	433		17.0	102	449	389	34	0.105				1.50	0.648	2.148		
West Whisky Cr	06/20/91	8.7	8.20	1012	24.7	7.7	318		17.0	209	495	668	10	0.103				0.40	0.477	0.877		
West Whisky Cr	07/16/91	6.9	8.00	576	24.8	26.0	240		**5.0**	139	289	380	20	0.009				1.10	0.862	1.962		
West Whisky Cr	08/29/91	1.7	7.80	582	24.6	64.0	258		20.0	33	279	384	70	**0.003**				**0.05**	1.030	1.080		
West Whisky Cr	09/12/91	10.9	8.20	756	23.2	10.0	315		23.0	91	374	499	7	0.030	0.01		0.03	1.70	0.500	2.200	**0.01**	
West Whisky Cr	10/22/91		8.20	1087	14.5	2.7	360		21.5	156	540	717	7	0.020	**0.01**		0.02	0.73	0.200	0.930	0.03	
West Whisky Cr	11/19/91	9.3	8.90	1054	11.3	9.8	330		16.5	215	550	696	8	0.050	0.02		**0.01**	0.76	0.400	1.160	0.02	
West Whisky Cr	12/03/91	11.3	8.70	1186	3.5	4.8	336		18.0	285	630	783	1	0.020	**0.01**		**0.01**	0.75	0.400	1.150	**0.01**	
West Whisky Cr	01/09/92	13.6	8.66	1282	5.8	4.5	363					846	6	0.020	**0.01**		0.02	0.87	0.200	1.070	0.02	
West Whisky Cr	02/11/92			1286		3.1			23.5	612	950	849	16	0.010	**0.01**		0.01	0.92	0.200	1.120	0.02	
West Whisky Cr	03/24/92		8.10	1343		5.0			17.0	377	750	886	3	**0.005**	**0.01**		0.01	0.84	**0.100**	0.940	0.02	
	Mean	9.1	8.12	986	14.4	11.3	330		20.6	209	509	651	13	0.036	0.01	6.73	0.01	1.26	0.685	1.943	0.02	
	Std Dev	2.8	0.34	248	8.3	15.4	44		14.4	134	170	164	17	0.057	0.01		0.01	1.53	0.479	1.634	0.01	
	n	16	18	18	17	18	17		18	18	18	18	19	19	7	1	7	19	19	19	7	
	F Test	0.45	0.46	0.10	0.76	0.00	0.46		0.03	0.21	0.01	0.10	0.00	0.00			0.02	0.56	0.00	0.53		
	T Test	0.19	0.02	0.65	0.21	0.15	0.02		0.84	0.68	0.69	0.65	0.02	0.71			0.50	0.82	0.00	0.62		
Signficant Difference			**R**				**R**						**R**						**R**			
	Percent Change	14%	**-3%**	-3%	-25%	-52%	**####**		-4%	-8%	4%	-3%	**####**	-14%			38%	9%	**-56%**	-14%		
West Whisky Cr	11/01/94	7.4	7.59	765	11.2	5.8	306	0.3	22.0	67	430	505	2	0.080		0.99	0.02	1.01	0.450	1.460		
West Whisky Cr	11/30/94	12.2	7.94	886	4.6	3.2	336	1.1	24.0	118	472	585	1			1.50	**0.01**	1.51	0.110	1.615		
West Whisky Cr	01/05/95	13.5	7.81	935	0.9	2.5	324	2.2	22.0	183	500	617	1	0.020		1.80	0.01	1.81	0.200	2.010		
West Whisky Cr	02/01/95	11.5	7.90	981	3.6	5.0	321	1.07	19.0	182	500	647	4	0.020		1.36	0.01	1.37	0.300	1.670		
West Whisky Cr	03/01/95	12.4	7.97	937	3.3	2.8	304	1.1	20.0	196	486	618	3	0.020		1.24	**0.01**	1.25	0.150	1.395		
West Whisky Cr	03/30/95	13.5	8.06	1033	10.2	3.2	302	2.1	40.0	197	576	682	6	0.020		0.50	**0.01**	0.51	0.310	0.815		
West Whisky Cr	05/02/95	10.2	7.96	1068	12.7	3.6	316	1.3	19.0	240	580	705	3	0.030		0.71	0.02	0.73	0.390	1.120		
West Whisky Cr	06/28/95	7.7	7.85	1082	20.9	10.6	295	0.8	18.0	255	592	714	2	0.040		0.09	0.01	0.10	0.180	0.279		
West Whisky Cr	08/01/95	8.1	7.50	716	24.7	6.0	299	1.6	17.5	87	420	473	8	0.050		1.14	0.02	1.16	0.340	1.500		
West Whisky Cr	09/07/95	6.6	7.84	670	23.5	2.5	284	0.04	15.0	38	400	442	2	0.030		5.35	0.11	5.46	0.630	6.090		
West Whisky Cr	10/04/95	8.5	7.38	767	14.9	23.6	224	3.1				506										
West Whisky Cr	11/30/95	10.9	8.60	1119	5.0	3.0	205	0.5	3.0	257	600	739	3	0.020		1.08	0.01	1.09	0.120	1.211		
West Whisky Cr	01/11/96	12.2	7.85	1116	5.5	3.1	315	0.7	17.0	184	580	737	2	0.030		1.95	0.02	1.97	0.270	2.240		
West Whisky Cr	02/14/96	11.9	7.82	1149	5.7	3.7	309	0.7	19.0	395	630	758	5	0.022		1.09	0.02	1.11	0.290	1.400		
West Whisky Cr	03/14/96	9.3	7.66	1082	13.9	3.6	274	0.7	22.0	289	610	714	1	0.020		0.15	0.01	0.16	0.450	0.610		
	Mean	10.4	7.85	954	10.7	5.5	294	1.2	19.8	192	527	629	3	0.031		1.35	0.02	1.37	0.299	1.673		
	Std Dev	2.3	0.28	160	7.6	5.4	36	0.8	7.7	95	78	105	2	0.017		1.27	0.03	1.30	0.147	1.373		
	n	15	15	15	15	15	15	15	14	14	14	15	14	13		14	14	14	14	14		
West Whisky Cr	05/31/95	8.6	7.72	591	18.5	187.0	178	5.11	9.2	146	300	390	148	0.290		0.56		0.56	1.480	2.040		High Flow (Grab)

Bold = below detection thus half the detection limit was used

Site	Date	D.O. mg/l	pH S.U.	Cond us/cm	Temp *C	Turb NTU	Alk mg/l	Flow cfs	Cl mg/l	SO4 mg/l	Hard mg/l	TDS mg/l	TSS mg/l	TP mg/l	PO4-P mg/l	NO3-N mg/l	NO2-N mg/l	NO2+NO3 mg/l	TKN mg/l	TN mg/l	NH3-N mg/l	Remarks
Whisky Cr (lower)	05/24/91					152	113		**5.0**	**10**	222		489	0.182				1.00	1.494	2.494		High Flow
Whisky Cr (lower)	08/30/91								10.0	37	167		4064	0.099				1.60	4.108	5.708		High Flow (ISCO)
Whisky Cr (lower)	09/16/91			252		***1800***	108		**5.0**	47	257	166	1830	0.076				**0.05**	2.272	2.322		High Flow (ISCO)
Whisky Cr (lower)	09/19/91			312					**5.0**	58	188	206	1812	0.987				**0.25**	0.994	1.244		High Flow (ISCO)
Whisky Cr (lower)	10/28/91												3420	0.520	0.08		0.02	0.44	1.900	2.340	0.08	High Flow (ISCO)
Whisky Cr (lower)	12/20/91			295					8.0	58	150	195	4370	1.100	0.14		0.07	0.29	2.700	2.990	0.13	High Flow (ISCO)
Whisky Cr (lower)	04/16/92								7.0	105	214		2760	0.290	0.04		0.03	0.43	1.300	1.730	0.11	High Flow (ISCO)
Whisky Cr (lower)	05/28/92								4.0	9	129		1300	0.130	0.14		0.06	0.30	0.600	0.900	0.11	High Flow (ISCO)
Whisky Cr (lower)	06/05/92			424					6.0	147	204	280	2330	0.130	0.06		0.02	0.24	0.600	0.840	0.05	High Flow (ISCO)
Whisky Cr (lower)	11/13/92												267	0.650	0.12		0.06	0.25	2.800	3.050	0.03	High Flow (ISCO)
Whisky Cr (lower)	11/21/92													0.260	0.11		0.04	0.29	1.100	1.390	0.07	High Flow (ISCO)
Whisky Cr (lower)	12/13/92								7.5	62	176		1040	2.000	0.47		0.11	0.64	6.100	6.740	0.65	High Flow (ISCO)
	Mean			321		976	111		6.4	59	190	212	2153	0.535	0.15		0.05	0.48	2.164	2.646	0.15	
	Std Dev			73		1165	4		1.9	44	39	48	1381	0.578	0.14		0.03	0.43	1.613	1.842	0.20	
	n			4		2	2		9	9	9	4	11	12	8		8	12	12	12	8	
	F Test			0.35		0.03	0.15		0.11	0.11	0.02	0.35	0.37	0.00			0.14	0.04	0.40	0.52		
	T Test			0.00		0.62	0.10		0.03	0.01	0.08	0.00	0.07	0.09			0.06	0.39	0.09	0.09		
Signficant Difference				**R**			**R**		**R**	**R**	**R**	**R**	**R**	**R**			**R**		**R**	**R**		
Percent Change				**107%**		-56%	**49%**		**51%**	**156%**	**37%**	**107%**	**-49%**	**-58%**			**-54%**	26%	**67%**	**60%**		
Whisky Cr (lower)	07/10/90	11.6	8.47	510	27.3	24	292		14.2	170	510	337	4	0.210		0.45		0.45	0.400	0.850		
Whisky Cr (lower)	09/13/90	11.2	8.33		25.5		315		12.0	61	348		2	0.060		0.52		0.52	0.520	1.040		
Whisky Cr (lower)	10/08/90	8.1	7.88	766	15.8	19	288		10.0	187	333	506	17	0.037				0.50	0.637	1.137		
Whisky Cr (lower)	11/14/90	9.6	8.00	1070	12.0	3	331		77.0	271	556	706	**1**	0.264				**0.25**	0.637	0.887		
Whisky Cr (lower)	12/11/90	11.8	7.90	1078	7.0	4	320		19.0	232	525	711	1	0.006				0.50	1.787	2.287		
Whisky Cr (lower)	01/16/91	12.6	7.90	1180	5.0	4	326		15.0	302	624	779	5	0.008				0.70	1.559	2.259		
Whisky Cr (lower)	02/15/91	13.1	8.10	1030	5.5	4	309		**5.0**	275	544	680	3	0.020				0.60	0.417	1.017		
Whisky Cr (lower)	03/20/91	12.4	8.30	1147	13.4	5	288		14.0	280	606	757	9	0.061				3.70	1.360	5.060		
Whisky Cr (lower)	04/16/91	10.6	8.08	1041	17.0	5	268		24.0	358	548	687	2	0.035				0.10	1.358	1.458		
Whisky Cr (lower)	05/20/91	8.1	8.06	700	23.5	4	485		13.0	270	562	462	5	0.150				0.30	0.709	1.009		
Whisky Cr (lower)	06/20/91	8.1	8.10	1085	25.4	15	308		15.0	261	536	716	12	0.526				0.50	0.791	1.291		
Whisky Cr (lower)	07/16/91	6.8	7.90	787	28.2	23	270		**5.0**	243	408	519	24	0.007				0.60	1.180	1.780		
Whisky Cr (lower)	08/29/91	9.5	8.10	630	25.3	3	315		12.0	132	325	416	3	0.112				0.60	0.460	1.060		
Whisky Cr (lower)	09/12/91	6.9	8.20		22.9	5	243		15.0	143	438		15	0.070	0.04		0.02	0.40	0.600	1.000	**0.01**	
Whisky Cr (lower)	10/22/91		8.50	1137	15.8	5	338		17.0	206	572	750	**1**	0.060	0.03		0.02	0.37	0.300	0.670	0.03	
Whisky Cr (lower)	11/19/91	8.4	8.20	1089	11.4	18	330		16.0	332	600	719	12	0.090	0.04		**0.01**	0.52	0.500	1.020	0.03	
Whisky Cr (lower)	12/03/91	10.9	8.90	1196	7.5	6	322		17.0	352	670	789	1	0.040	0.02		**0.01**	0.52	0.300	0.820	0.02	
Whisky Cr (lower)	01/09/92	12.4		1253	5.9	8	341		18.0	381	672	827	8	0.040	0.02		0.01	0.75	0.200	0.950	0.03	
Whisky Cr (lower)	02/11/92			1245		5			17.0	318	660	822	17	0.040	0.01		0.02	0.76	0.300	1.060	0.02	
Whisky Cr (lower)	03/24/92		8.00	1279		6	321		18.5	354	720	844	5	0.010	0.02		0.02	0.71	0.200	0.910	0.03	
	Mean	10.1	8.16	1012	16.4	9	316		17.7	256	538	668	7	0.092	0.03	0.49	0.01	0.67	0.711	1.378	0.02	
	Std Dev	2.1	0.26	231	8.3	7	48		14.7	86	115	152	7	0.123	0.01	0.05	0.01	0.73	0.477	0.973	0.01	
	n	17	18	18	18	19	19		20	20	20	18	20	20	7	2	7	20	20	20	7	
	F Test	0.81	0.98	0.20	0.86	0.28	0.00		0.00	0.58	0.44	0.20	0.84	0.00		0.34	0.43	0.00	0.00	0.00		
	T Test	0.81	0.02	0.77	0.27	0.81	0.07		0.52	0.92	0.62	0.77	0.13	0.48		0.81	0.09	0.23	0.00	0.01		
Signficant Difference			**R**				**R**										**R**		**R**	**R**		
Percent Change		-2%	**-3%**	2%	-19%	-7%	**-7%**		-12%	-1%	3%	2%	49%	-22%		-8%	**-35%**	-32%	**-61%**	**-47%**		
% difference btwn hi & lo flow				-68%		11176%	-65%		-64%	-77%	-65%	-68%	29392%	480%	464%		259%	-28%	204%	92%	552%	

Site	Date	D.O. mg/l	pH S.U.	Cond us/cm	Temp *C	Turb NTU	Alk mg/l	Flow cfs	Cl mg/l	SO4 mg/l	Hard mg/l	TDS mg/l	TSS mg/l	TP mg/l	PO4-P mg/l	NO3-N mg/l	NO2-N mg/l	NO2+NO3 mg/l	TKN mg/l	TN mg/l	NH3-N mg/l	Remarks
Whisky Cr (lower)	03/15/95		7.82	854		65	219		14.0	278	440	564	167	0.240	0.07	0.50	0.02	0.52	1.330	1.850		High Flow (Grab)
Whisky Cr (lower)	04/18/95		7.40	625		253	151		5.0	134	295	413	480	0.270		0.27	0.02	0.29	2.630	2.920		High Flow (Grab)
Whisky Cr (lower)	06/05/95			537		637	131		8.0	154	256	354	978	0.170		0.48		0.48	2.440	2.920		High Flow (Grab)
Whisky Cr (lower)	09/19/95					750	141		14.0	44	142		788	0.040		0.80		0.80	3.740	4.540		High Flow (Grab)
Whisky Cr (lower)	04/22/96								11.1	157	324		754	0.420		0.55	0.05	0.60	3.810	4.410		High Flow (ISCO)
Whisky Cr (lower)	05/31/95	8.4	7.69	642	18.9	424	181	10	13.0	159	335	424	406	0.290		0.58		0.58	2.310	2.890	0.14	High Flow (Grab)
Whisky Cr (lower)	08/29/96								7.5	56	135		1169	0.240		0.60	0.01	0.61	2.550	3.160		High Flow (ISCO)
Whisky Cr (lower)	09/06/96								6.0	265	250		1688	0.190		0.56	0.01	0.57	5.450	6.020		High Flow (ISCO)
Whisky Cr (lower)	10/01/96								8.0	118	168		3473	0.150		0.96	0.03	0.99	8.300	9.291		High Flow (ISCO)
	Mean		7.64	665		426	165		9.6	152	261	439	1100	0.223	0.07	0.59	0.02	0.60	3.618	4.222		
	Std Dev		0.22	134		278	36		3.5	80	101	89	997	0.105		0.20	0.02	0.20	2.115	2.263		
	n		3	4		5	5		9	9	9	4	9	9	1	9	6	9	9	9		
Whisky Cr (lower)	08/30/94	8.9	8.02	640	26.5	3	309	0.5	8.0	24	336	422	7	0.080		**0.25**	0.01	0.26	0.240	0.500		
Whisky Cr (lower)	10/04/94	7.6	7.89	667	20.8	4	326	0.5	10.8	36	343	440	3	0.065		0.26	**0.01**	0.27	0.350	0.615		
Whisky Cr (lower)	11/01/94	7.5	7.76	1085	13.0	11	301	1.6	16.0	272	610	716	21	0.100		0.42	**0.01**	0.43	0.320	0.745		
Whisky Cr (lower)	11/30/94	11.3	7.80	1116	6.9	7	321	4.2	18.0	283	630	737	11	0.100		0.44	**0.01**	0.45	0.030	0.475		
Whisky Cr (lower)	01/05/95	13.1	7.91	1055	2.0	4	297	2.57	17.0	264	570	696	3	0.040		0.85	0.01	0.86	0.190	1.050		
Whisky Cr (lower)	02/01/95	11.4	7.90	1140	5.4	6	295	5.35	14.2	300	590	752	16	0.040		0.60	0.01	0.61	0.130	0.740		
Whisky Cr (lower)	03/01/95	11.8	7.99	1074	3.9	4	280	2.5	16.0	304	572	709	7	0.050		0.36	**0.01**	0.37	0.260	0.625		
Whisky Cr (lower)	03/30/95	10.6	8.09	1106	11.9	5	295	4.5	19.0	274	580	730	19	0.050		0.36	**0.01**	0.37	0.290	0.655		
Whisky Cr (lower)	05/02/95	9.3	7.95	1141	13.4	7	294	3.5	14.0	320	630	753	18	0.080		0.45	0.02	0.47	0.300	0.770		
Whisky Cr (lower)	06/28/95		7.96	1149	22.1	7	289	3.4	18.0	299	620	758	19	0.070		0.54	**0.01**	0.55	0.220	0.765		
Whisky Cr (lower)	08/01/95	7.1	7.89	1006	25.1	12	301	3.5	14.0	276	555	664	23	0.120		0.27	**0.01**	0.28	0.420	0.695		
Whisky Cr (lower)	09/07/95	7.6	7.84	827	23.5	3	311	0.94	15.0	134	450	546	3	0.110		0.36	0.01	0.37	0.260	0.630		
Whisky Cr (lower)	10/04/95	8.1	7.43	962	16.2	42	241	6.1				635										
Whisky Cr (lower)	11/30/95	11.8	8.80	1167	6.3	6	259	2.2	17.0	321	600	770	6	0.040		0.44	0.01	0.45	0.130	0.580		
Whisky Cr (lower)	01/11/96	11.7	7.93	1163	6.6	5	304	1.9	17.0	320	600	768	5	0.060		0.98	0.02	1.00	0.440	1.440		
Whisky Cr (lower)	02/14/96	11.7	7.89	1127	7.5	6	297	3.2	16.0	319	600	744	9	0.070		0.48	0.02	0.50	0.360	0.860		
Whisky Cr (lower)	03/14/96	9.9	7.84	1121	14.7	5	256	1.5	18.0	308	610	740	8	0.074		**0.05**	0.00	0.05	0.450	0.504		
	Mean	10.0	7.93	1032	13.3	8	293	2.8	15.5	253	556	681	11	0.072		0.44	0.01	0.45	0.274	0.728		
	Std Dev	2.0	0.26	166	7.9	9	23	1.6	2.9	98	94	110	7	0.025		0.23	0.01	0.23	0.118	0.239		
	n	16	17	17	17	17	17	17	16	16	16	17	16	16		16	16	16	16	16		
% difference btwn hi & lo flow				-36%		5217%	-44%		-38%	-40%	-53%	-36%	9989%	211%		33%	152%	33%	1219%	480%		

Bold = below detection thus half the detection limit was used

Bold, Italics, Underline = greater than the listed value

Site	Date	D.O. mg/l	pH S.U.	Cond us/cm	Temp *C	Turb NTU	Alk mg/l	Flow cfs	Cl mg/l	SO4 mg/l	Hard mg/l	TDS mg/l	TSS mg/l	TP mg/l	PO4-P mg/l	NO3-N mg/l	NO2-N mg/l	NO2+NO3 mg/l	TKN mg/l	TN mg/l	NH3-N mg/l	Remarks
Whisky Cr (upper)	09/13/90	10.2	8.22		24.5		260		16.0	250	875		2	0.100		0.13		0.13	1.270	1.400		
Whisky Cr (upper)	10/08/90	8.1	7.75	1468	15.0	4.7	237		15.0	619	757	969	4	0.060				**0.25**	3.989	4.239		
Whisky Cr (upper)	11/14/90	9.6	7.90	1721	9.5	1.5	268		71.0	626	932	1136	1	0.217				**0.25**	0.610	0.860		
Whisky Cr (upper)	12/11/90	12.1	8.20	1646	7.5	2.0	267		21.0	545	911	1086	3	0.008				**0.05**	1.597	1.647		
Whisky Cr (upper)	01/16/91	14.2	7.70	1719	2.0	4.2	261		20.0	702	980	1135	4	**0.003**				0.40	1.509	1.909		
Whisky Cr (upper)	02/15/91	12.6	8.00	1651	4.2	5.0	235		**5.0**	596	940	1090	8	0.008				**0.05**	0.351	0.401		
Whisky Cr (upper)	03/20/91	12.4	8.40	1692	13.9	3.0	256		19.0	613	913	1117	3	0.008				3.20	0.950	4.150		
Whisky Cr (upper)	04/16/91	10.0	7.98	1615	15.0	1.0	230		25.0	635	931	1066	2	**0.003**				0.20	1.299	1.499		
Whisky Cr (upper)	05/20/91	7.4	8.00	1050	22.2	2.3	250		17.0	754	871	693	9	0.144				0.30	0.664	0.964		
Whisky Cr (upper)	06/20/91	8.0	8.20	1642	25.7	7.9	245		18.0	687	865	1084	15	0.066				0.30	0.511	0.811		
Whisky Cr (upper)	07/16/91	8.0	8.20	1587	25.3	6.0	230		19.0	1606	891	1047	4	0.019				**0.05**	0.955	1.005		
Whisky Cr (upper)	08/29/91	5.4	8.10	869	25.9	20.0	403		20.0	56	380	574	18	0.146				0.20	2.486	2.686		
Whisky Cr (upper)	09/12/91	7.7	8.10	847	25.0	40.0	320		20.0	696	910	559	26	0.090	0.070		**0.01**	**0.03**	0.500	0.525	0.02	
Whisky Cr (upper)	10/22/91		8.20	1744	14.5	1.8	286		20.0	684	960	1151	8	0.080	0.060		**0.01**	**0.03**	**0.100**	0.125	0.02	
Whisky Cr (upper)	11/19/91	9.3	8.80	1605	10.9	6.9	320		20.0	734	890	1059	3	0.090	0.050		**0.01**	0.27	0.400	0.670	0.04	
Whisky Cr (upper)	12/03/91	11.0	9.40	1630	3.2	5.0	314		18.0	656	925	1076	1	0.040	0.020		**0.01**	0.37	0.300	0.670	0.04	
Whisky Cr (upper)	01/09/92	12.8		1685	4.8	5.5	289		23.0	635	865	1112	11	0.040	0.030		0.02	0.77	0.300	1.070	0.05	
Whisky Cr (upper)	02/11/92			1675		3.0			17.0	354	740	1106	14	0.030	0.020		0.02	0.81	0.300	1.110	0.04	
Whisky Cr (upper)	03/24/92		8.00	1690		3.0			22.5	731	1010	1115	1	0.010	0.020		0.02	0.69	**0.100**	0.790	0.02	
	Mean	9.9	8.19	1530	14.7	6.8	275		21.4	641	871	1010	7	0.061	0.039	0.13	0.01	0.44	0.957	1.396	0.03	
	Std Dev	2.4	0.40	289	8.7	9.3	45		12.7	295	136	191	7	0.059	0.021		0.01	0.71	0.958	1.145	0.01	
	n	16	17	18	17	18	17		19	19	19	18	19	19.000	7.000	1	7	19	19	19	7	
	F Test	0.95	0.00	0.00	0.65	0.00	0.06		0.00	0.00	0.60	0.00	0.15	0.278			0.39	0.00	0.00	0.00		
	T Test	0.73	0.00	0.31	0.14	0.21	0.06		0.34	0.53	0.25	0.27	0.95	0.444			0.49	0.46	0.01	0.01		
Signficant Difference			**R**				**R**												**R**	**R**		
Percent Change		3%	**-5%**	5%	-30%	-43%	**-9%**		-14%	7%	7%	5%	-2%	0.239		129%	-19%	-30%	**-71%**	**-58%**		
Whisky Cr (upper)	11/01/94	7.1	7.79	1710	10.5	5.2	258	0.35	17.0	782	1090	1129	6	0.090		**0.13**	**0.01**	0.13	0.210	0.340		
Whisky Cr (upper)	11/30/94	11.8	8.05	1728	3.1	2.1	271	1.8	22.0	760	1045	1140	2	0.060		**0.13**	**0.01**	0.13	0.040	0.170		
Whisky Cr (upper)	01/05/95	14.0	7.69	1639	0.6	2.0	242	1.1	19.0	788	975	1082	1	0.029		0.46	**0.01**	0.47	0.280	0.745		
Whisky Cr (upper)	02/01/95	11.2	7.75	1660	2.9	4.3	246	1.25	18.5	764	950	1096	7	0.040		0.50	0.01	0.51	0.300	0.810		
Whisky Cr (upper)	03/01/95	10.7	7.80	1638	4.5	4.8	235	2	18.0	726	950	1081	9	0.040		**0.13**	**0.01**	0.13	0.260	0.390		
Whisky Cr (upper)	03/30/95	11.4	7.92	1560	9.4	4.7	249	2	24.0	657	918	1030	15	0.050		**0.13**	**0.01**	0.13	0.360	0.490		
Whisky Cr (upper)	05/02/95	9.2	7.65	1571	13.0	6.2	263	2.3	18.0	606	910	1037	9	0.090		0.24	0.02	0.26	0.500	0.760		
Whisky Cr (upper)	06/28/95	7.8	7.68	1688	20.1	4.7	264	1.1	21.0	647	990	1114	12	0.090		0.36	0.01	0.37	0.170	0.540		
Whisky Cr (upper)	08/01/95	7.6	7.85	1588	24.1	3.2	252	2.5	15.0	700	1040	1048	4	0.110		0.11	**0.01**	0.12	0.260	0.375		
Whisky Cr (upper)	09/07/95	6.3	7.63	1419	23.5	2.8	281	0.5	11.0	491	430	937	6	0.200		0.24	**0.01**	0.25	0.450	0.695		
Whisky Cr (upper)	10/04/95	9.0	7.44	1454	14.4	7.8	239	2.4				960										
Whisky Cr (upper)	11/30/95	11.7	7.90	1654	4.3	1.8	168	0.7	16.0	717	960	1092	4	0.040		0.31	0.01	0.32	**0.005**	0.323		
Whisky Cr (upper)	01/11/96	13.2	7.82	1612	4.7	3.4	260	1.2	20.0	717	910	1064	16	0.060		0.82	0.02	0.84	0.020	0.860		
Whisky Cr (upper)	02/14/96	13.2	7.82	1612	4.5	3.7	275	1.2	19.0	590	920	1064	7	0.101		0.58	0.02	0.60	0.400	1.000		
Whisky Cr (upper)	03/14/96	9.2	7.65	1620	13.4	2.2	233	0.9	20.0	673	930	1069	2	0.060		**0.05**	0.01	0.06	0.580	0.636		
	Mean	10.2	7.76	1610	10.2	3.9	249	1.4	18.5	687	930	1063	7	0.076		0.30	0.01	0.31	0.274	0.581		
	Std Dev	2.4	0.15	85	7.7	1.7	27	0.7	3.2	84	154	56	5	0.044		0.22	0.01	0.23	0.177	0.242		
	n	15	15	15	15	15	15	15	14	14	14	15	14	14		14	14	14	14	14		
Whisky Cr (upper)	05/31/95	8.6	7.76	979	18.4	107.0	186	7.8	13.0	364	518	646	163	0.260		0.43		0.43	1.640	2.070		High Flow (Grab)

Bold = below detection thus half the detection limit was used