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DEPARTMENT OF
WATER RESOURCES

BEFORE THE

IDAHO DEPARTMENT OF WATER RESOURCES

IN THE MATTER OF DISTRIBUTION OF WATER TO WATER RIGHT NOS. 36-04103A, 36-04013B AND 36-7148 (Snake River Farm)

(Water District Nos. 130 and 140)

DIRECT TESTIMONY OF CHARLES M. BRENDECKE

SUBMITTED ON BEHALF OF:

THE IDAHO GROUND WATER APPROPRIATOR'S INC.
NORTH SNAKE GROUND WATER DISTRICT
MAGIC VALLEY GROUND WATER DISTRICT

SEPTEMBER 11, 2009

LISTS OF SPONSORED EXHIBITS

DIRECT TESTIMONY OF CHARLES M. BRENDECKE

Q STATE YOUR NAME, BUSINESS ADDRESS AND POSITION.

A My name is Charles M. Brendecke. I am employed by AMEC Earth and Environmental, Inc., 1002 Walnut Street, Suite 200, Boulder, Colorado, 80302, a division of AMEC plc. I am a Principal of the firm.

Q WHO ARE YOU TESTIFYING FOR?

A I am testifying as an expert witness on behalf of the Idaho Ground Water Appropriators, Inc, ("IGWA") North Snake Ground Water District and Magic Valley Ground Water District (collectively "Ground Water Districts"). IGWA and the Ground Water Districts are at times collectively referred to as the "Ground Water Users." I have served as the primary technical consultant and advisor to IGWA and the Ground Water Districts since 1999.

Q WHAT IS YOUR AREA OF EXPERTISE?

A My training is as a civil engineer specializing in hydrology and water resources. This area of study includes hydrogeology and hydrologic modeling. I have over thirty years experience in this field of work.

Q PLEASE DESCRIBE YOUR EDUCATIONAL AND PROFESSIONAL BACKGROUND.

A I received a Bachelor of Science degree in Civil Engineering from the University of Colorado in 1971. I received Master of Science and Doctor of Philosophy degrees in Civil Engineering from Stanford University in 1976 and 1979, respectively. My current resume is provided as **Exhibit 2400.**

Q **HAVE YOU EVER BEEN QUALIFIED AS AN EXPERT WITNESS BEFORE?**

A Yes. I have been qualified as an expert in hydrology and water rights in several Divisions of the Colorado Water Court. I have testified in previous hearings before the Idaho Department of Water Resources. I have been qualified as an expert in hydrology, statistical hydrology and hydrologic modeling in interstate proceedings before the U.S. Supreme Court.

Q **DO YOU HAVE ANY PROFESSIONAL REGISTRATIONS?**

A Yes. I am a registered Professional Engineer in Idaho, Wyoming, Colorado and Oklahoma.

Q **WHAT IS THE PURPOSE OF YOUR TESTIMONY IN THIS PROCEEDING?**

A I will offer testimony in four general areas: 1) the mitigation efforts that have been proposed and implemented by the Ground Water Districts and the relative advantages of the proposed Over-the-Rim plan, 2) the water rights and wells to be used in the Over-the-Rim plan and their historical use, 3) analyses of effects on reach gains of transferring the proposed wells from their historical to proposed locations and manners of use, and 4) the temperature changes anticipated in delivery of well water to Snake River Farm.

Q WHAT MITIGATION MEASURES HAVE THE GROUND WATER DISTRICTS PROPOSED AND IMPLEMENTED FOR SNAKE RIVER FARM?

A The Districts have proposed or implemented a variety of mitigation alternatives in their attempts to meet the water delivery requirements imposed by the Director stemming from his first order dated July 8, 2005 and subsequent orders. I would describe these prior mitigation alternatives generally as being above-the-rim measures, below-the-rim measures and financial measures. All of these have been met with objections of various kinds by Clear Springs. All of them are costly. The proposed Over-the-Rim plan appears at this point to be the most practical approach.

Q CAN YOU PLEASE DESCRIBE THE ABOVE-THE-RIM MEASURES THE DISTRICTS HAVE PURSUED?

A Yes. By above-the-rim measures I mean activities undertaken on the Eastern Snake River Plain to either reduce groundwater withdrawals or add to groundwater storage. These activities include the CREP program, the program to convert irrigated lands from groundwater to surface water supply ("conversions"), and managed recharge.

The CREP program was begun in 2006. Under it, irrigators are paid to take land out of production for a period of not less than 15 years and the associated reduction in irrigation withdrawals from the aquifer translates to improved spring discharges. Current CREP enrollment is approximately 19,000 acres, but only about 10% of these acres lie within the trim line used for the Snake River Farm delivery call.

The conversion program eliminates groundwater irrigation on participating lands and serves those lands with surface water delivered through the North Side Canal Company (NSCC) system. This benefits the aquifer through elimination of groundwater withdrawals and provision of incidental aquifer recharge from conveyance and application losses associated with surface water use. There are approximately 8,800 acres of land presently converted to surface water supply in Water District 130, about 1,000 of which are new as of 2009 and are associated with the Over the Rim plan that is the subject of this proceeding. Projected 2009 delivery of surface water to these existing and new conversion acres is about 15,700 acre-feet.

The Ground Water Districts also have provided water for managed aquifer recharge. This recharge has primarily taken place within the delivery system of the North Side Canal Company (NSCC) and via the Lower Snake Aquifer Recharge District facility served from the Milner-Gooding Canal. Water provided by the Ground Water Districts has been leased storage water, and the NSCC has been paid a delivery fee for diversion and delivery of this water to recharge sites. The amounts and precise locations of recharge have varied from year to year, and in some years the water provided by the Ground Water Districts has been supplemented with water from other sources.

Q HOW WOULD YOU CHARACTERIZE THE EFFECTIVENESS OF THESE ABOVE-THE-RIM MEASURES?

A From a water management perspective I would characterize them is being very inefficient. Each of them requires large amounts of water at substantial acquisition and delivery costs in order to deliver very small amounts of water to Snake River Farm.

In the case of CREP, the 1900 acres within the trim line probably represent at least 4000 acre-feet per year (af/y) of groundwater consumption. Based on modeling done by the Department of Water Resources for the August 7th Curtailment Order, the retirement of these acres results in a delivery of 0.05 cubic feet per second, or 38 af/y, to Snake River Farm. In other words, Snake River Farm receives less than 1% of the foregone groundwater use from CREP lands within the trim line.

In the case of conversions, the delivery of 15,700 acre-feet translates to a continuous flow of about 21.7 cfs. Based on modeling done by the Department of Water Resources for the August 7th Curtailment Order, the benefit to Snake River Farm from these conversions is about 0.63 cfs. In other words, Snake River Farm receives about 2.9% of the water provided for conversions. About one third of this benefit to Snake River Farm stems from just the 1000 acres of conversions immediately above Snake River Farm that are associated with this Over the Rim plan.

Based on a steady-state analysis of 2007 recharge activities conducted by the Department, just over 1% of the water provided for recharge in that year would accrue to Snake River Farm. The efficiency of a more targeted recharge program, that is, one that put water into the aquifer nearer Snake River Farm, would be higher.

Q WHY IS IT SO DIFFICULT FOR THESE MEASURES TO DELIVER WATER TO SNAKE RIVER FARM?

A From a physical perspective, the spring that is the source for Snake River Farm is located at a far corner of the aquifer, distant from most sources of aquifer recharge and at a higher elevation than immediately surrounding springs. There are many other spring outlets between Milner and King Hill through which groundwater can more easily discharge to the river. It's like having a large bucket with many holes in the sides; Snake River Farm is one of the smaller holes nearer the top of the bucket. Most of the water leaking out of the bucket goes out the other holes.

The delivery estimates in the Orders and prior mitigation plans that have been filed are made using the ESPA groundwater model. The model distributes the effects of aquifer stresses, that is, recharge or withdrawals, fairly widely throughout the model domain. This is the result of the basic structure and parameterization of the model. The model simply cannot represent the precise flow pathways that feed specific spring outlets. So the model also makes it appear difficult to deliver water to the Snake River Farm spring.

Q CAN YOU DESCRIBE THE BELOW-THE-RIM MEASURES THE GROUND WATER DISTRICTS HAVE TAKEN?

A The Ground Water Districts have proposed a number of below-the-rim mitigation alternatives. These all involve the development, redirection or exchange of water available in the immediate vicinity of Snake River Farm.

The Ground Water Districts approached the Clear Springs Country Club, which diverts irrigation water from the same spring that serves Snake River Farm, with a proposal to provide the Club with irrigation water from Clear Lake in exchange for the Club delivering its spring water to Snake River Farm. The water in Clear Lake is below all the aquaculture facilities in the area and so could be diverted without any impact to Snake River Farm. The Ground Water Districts were unable to reach an agreement with the Club. Snake River Farm also objected to this proposal.

The Ground Water Districts obtained a lease agreement with the Idaho Department of Fish & Game (IDF&G), which diverts from a series of small springs immediately to the east of Snake River Farm to support a wetland mitigation project related to nearby highway construction. The Ground Water Districts proposed to provide IDF&G with water from Clear Lakes in exchange for IDF&G allowing its spring water to be delivered to Snake River Farm. This proposal is still under consideration by the Ground Water Districts, though the discharge of the IDF&G springs does not appear to be large enough to provide the entire mitigation obligation to Snake River Farm. Snake River Farm has also objected to this proposal.

The Ground Water Districts investigated an alternative to the IDF&G proposal that would involve enhancing the IDF&G spring outlets through shallow and deep wells. This proposal is also still under consideration, though it has been objected to by Snake River Farm.

The Ground Water Districts proposed a pump-back project wherein water being discharged from the Snake River Farm facility would be diverted, treated and delivered back to the top of the facility. Snake River Farm objected to this proposal.

Q WOULD THESE BELOW-THE-RIM MEASURES HAVE BEEN MORE EFFICIENT THAN THE ABOVE THE RIM MEASURES?

A Yes. In every case the amount of water needing to be developed or exchanged would be about the same as the amount needing to be delivered to Snake River Farm.

Q YOU MENTIONED FINANCIAL MEASURES. CAN YOU BRIEFLY DESCRIBE THOSE?

A The Ground Water Districts also proposed a direct monetary (or fish) compensation to Snake River Farm. The amount of the monetary compensation was based on an estimate of the additional profit that would have been made by Snake River Farm. This proposal was objected to by Snake River Farm and the Department dismissed these proposals and it is my understanding that this decision is presently on appeal.

Q CAN YOU SUMMARIZE THE EFFICIENCY OF THESE VARIOUS MITIGATION OPTIONS RELATIVE TO THE PROPOSED OVER-THE-RIM PLAN?

A I would say that the Over-the-Rim plan is among the more efficient of the alternatives. Direct compensation for lost profit (or fish) is probably the most efficient, since it doesn't involve building anything. The below-the-rim exchange with the Country Club would also be quite efficient. The Over-the-Rim plan is less efficient than these, but far more efficient than any of the other above-the-rim plans I've described.

Q NOW LET'S TURN TO THE OVER-THE-RIM PLAN ITSELF. CAN YOU GIVE US AN OVERVIEW OF THE PLAN?

A The layout of the Over-the-Rim plan is shown on **Exhibits 2003** and **2004**, which are contained within the report of SPF Water Engineering, **Exhibit 2000**. The wells and water rights that are part of the plan are shown on **Exhibit 2401**. The wells are all located above the canyon rim but within a few miles of Snake River Farm. The wells all have a record of continuous use for irrigation. The lands served by these wells have been converted to surface water supplies. The water provided by the wells will instead be delivered to Snake River Farm through a pipeline. The details of the plan are described more fully by others but there are two alternate configurations, one which uses the wells in their present locations and one that transfers the pumping to well #4, for example, and a new standby well adjacent to it.

Q WOULD THE USE OF THESE WELLS FOR OVER-THE-RIM DELIVERY REQUIRE CHANGES TO THEIR WATER RIGHTS?

A Yes, it will require changes in nature of use, place of use, and season of use, and in some cases changes in points of diversion. Draft transfer applications are provided as **Exhibits 2402** and **2403**. These draft transfers propose the changes to the water rights that would be consistent with the two proposals contained in the Over-the-Rim plan.

Q HAVE YOU EVALUATED THE WATER RIGHTS INVOVLED IN THE OVER THE RIM PLAN?

A Yes. These water rights are reflected in **Exhibit 2401, 2402, 2403**. The total amount of water authorized for diversion under these water rights is 15.79 cfs and 4216 acre-feet. Accordingly, the total water available under these water rights substantially exceeds the 3 cfs, or 2172 acre-feet delivery requirement to Snake River Farm.

Q HAVE YOU EVALUATED THE HISTORICAL USE OF THE WELLS?

A Yes. I evaluated the historical use of the wells to insure that if they continued to be pumped at their historical levels they could provide adequate water to meet the delivery obligation.

Q WHAT ELSE DID YOU DO RELATING TO THE WATER RIGHTS?

A I also evaluated the physical effects of changing the points of diversion and seasons of use, though the changes being contemplated are very small and it may be below the ability of existing tools to accurately portray their effects.

The first evaluation used the steady-state response functions from the ESPA groundwater model. I identified the model cells containing all the wells and obtained the steady-state response functions for those cells for the Buhl-Thousand Springs reach. This is the model reach that contains Snake River Farm. The model cells and response functions are shown on **Exhibit 2404.**

From a steady-state perspective, the only evaluation that is meaningful is one that looks at changing the points of diversion of the wells in the Over-the-Rim plan. The type and season of use changes really cannot be examined using steady-state functions. To look at the point of diversion change, I calculated the effect at

Snake River Farm for the historical average pumping of the wells in their present locations and for the combined historical pumping at the centralized location near well # 4, for example. By consolidating the pumping at a centralized location, the calculated pumping depletion (due to the wells in the plan) to Snake River Farm spring discharge would actually decrease by 6%. With a contemplated constant delivery of 3 cfs, which is somewhat less than the combined historical pumping of the wells, this decrease would be slightly greater.

I also attempted to evaluate the changes in point of diversion and season of use using the Department's transfer tool. The transfer tool is used to look at the effects of changes in groundwater rights, and is normally applied to changes having a greater spatial scope than what it under consideration here. I concluded that the tool is not designed to readily accommodate the simultaneous analysis necessary for the present situation, in which changes in season of use and point of diversion occur for some wells while only change in season of use occurs for others. The analysis may be possible using some post-processing of results from component analyses, and I will continue to investigate this.

The effect of change in points of diversion of the participating wells is readily apparent from the steady-state analysis I described earlier. The effect of change in season of use would be to replace a seasonally varying pumping depletion with a constant, year around depletion of equal or lesser (if delivery is made at a rate less than historical pumping) magnitude. It is my expectation, based on my understanding of variations in spring discharge and on past experience with the model, that this shift to a more constant pumping pattern will tend to reduce somewhat the seasonal variability in spring discharges, possibly increasing them during the summer and fall when they are historically lower.

I would also note that any analysis using the transfer tool assumes completely linear aquifer behavior. In the present case we are working at the very edge of the aquifer where it is thinnest and where subsurface flow is governed more by conduit- or fracture-flow hydraulics than by porous media principles. It is possible, perhaps even likely, that aquifer behavior in this area is non-linear, in which case the transfer tool cannot be used to reliably demonstrate transfer effects.

Q WHAT DID YOU CONCLUDE FROM THESE EVALUATIONS?

A I concluded that the effects of the proposed transfers on gains to the Buhl to Thousand Springs reach, which contains Snake River Farm, are likely to be negligible. If anything, the transfers may slightly benefit spring discharges to Snake River Farm.

Q WHAT OTHER EVALUATION DID YOU PERFORM OF THE OVER-THE-RIM PLAN?

A I evaluated the potential change in water temperature from the Over-the-Rim wells to the point of delivery at Snake River Farm. This was undertaken in response to Snake River Farm's past objections to water quality and temperature characteristics of proposed replacement supplies.

Q CAN YOU PLEASE DESCRIBE THIS TEMPERATURE EVALUATION?

A The methodology used for this evaluation is described in detail in a paper by K.C. Kwon which is reproduced in **Exhibit 2405**. The methodology essentially evaluates the flow of heat between two heat reservoirs, one being the water in the pipe and the other being the soil in which the pipe is buried. Between these two heat reservoirs is the wall of the pipe, which has its own heat-conducting characteristics. The analysis considers the starting temperature of the water, the ambient temperature of the soil, the thermal conductance properties of the pipe material, and the length of time the water is in the pipe.

The starting temperature of the water was assumed to be the observed temperature of water in the wells.

There are no systematic soil temperature records in the vicinity of the wells, but the Bureau of Reclamation AGRIMET station near Aberdeen has a data set of soil temperature measurements that includes daily values back to 1992. This data is summarized in **Exhibit 2406**. I carried out the analysis for a range of soil temperatures, using the maximum of the daily AGRIMET data (i.e., assuming that soil temperature stayed continuously at the maximum historically observed level), the minimum of the daily data, and the median of the daily data.

The amount of time the water was assumed to be in the pipe was based on the velocity of flow in the pipe and the length of the pipe. To be conservative, I assumed that all water was delivered from well #7, the furthest well from Snake River Farm and thus the one that would present the greatest opportunity for water temperature change.

The thermal conductance of the pipe was based on standard data for the materials proposed.

The results of this analysis showed that water delivered through the pipeline from well #7 could potentially be warmed by a maximum of 0.5 degrees Fahrenheit and could potentially be cooled by a maximum of 0.9 degrees Fahrenheit. Using the median value of soil temperature, undoubtedly the more representative situation, the water would be cooled by 0.3 degrees Fahrenheit.

If all water were to be delivered from the consolidated location near well #4 the change in water temperature would be smaller, since the length of time the water has to heat or cool would be less. The maximum warming would be 0.1 degrees Fahreneit and the maximum cooling would be 0.2 degrees Fahrenheit. The median change from this location would be 0.1 degree Fahrenheit cooling.

Q WHAT DID YOU CONCLUDE FROM YOUR TEMPERATURE EVALUATION?

A I concluded that well water temperatures will not be significantly changed by delivery through the pipeline to Snake River Farm. Once the 3 cfs water delivery is blended with the roughly 100 cfs of spring discharge, I expect that the change would be nearly undetectable.

Exhibit 2400

amec

Charles M. Brendecke, Ph.D., P.E.

Principal

Professional summary

Dr. Brendecke has more than 35 years of diverse experience in hydrology, water resources engineering, and water resources planning and management. He has directed or contributed to several river-basin water management studies that involved detailed inventories of basin hydrology and water demands, as well as development of planning models to investigate implications of changes in reservoir systems operation and basin water uses. Several of these studies involved instream flow and endangered species issues. His work as the project manager and lead expert in a variety of water rights proceedings includes historical consumptive use analysis, evaluation of surface/groundwater interactions, stream depletion analysis, development of protective terms and conditions, settlement negotiations, and expert witness testimony. He has been qualified as an expert witness in numerous venues, including the U.S. Supreme Court.

Professional Qualifications

Professional Engineer (PE), CO #17578, WY #6960, OK #21265, ID #11896

Education

Ph.D., Civil Engineering, Stanford University, 1979.

M.S., Civil Engineering, Stanford University, 1976.

B.S., Civil Engineering, University of Colorado, 1971.

Public Policy Mediation Training – CDR Associates, 2004.

Memberships

American Society of Civil Engineers

American Water Resources Association

American Geophysical Union

Languages

English

Location

Boulder, Colorado

Summary of core skills

Hydrology; Water rights; Water supply planning /management; Surface/ground water interaction; Reservoir system operations; computer modeling; Statistical hydrology; Negotiation/litigation support; Expert witness testimony.

Employment History

2007-2008 Principal, AMEC's Earth & Environmental Division. Responsible for management of engineering studies, consultant on water rights and water resources planning projects, expert witness testimony.

1986-2007	Principal and President (1990 to 2007), Hydrosphere Resource Consultants, Inc. Responsible for management of engineering studies, company development and management, consultant on water rights and water resources planning projects.
1985-1986	Senior Project Engineer, Wright Water Engineers Inc. Responsible for engineering analysis and report preparation on water rights and hydrologic studies.
1979-1985	Assistant Professor of Civil Engineering, University of Colorado. Responsible for teaching and research in areas of water resources and systems analysis.
	Faculty Research Associate, Institute for Arctic and Alpine Research. Directed various research studies in alpine hydrology and meteorology.
	Consultant, U.S. Army Corps of Engineers; Western Environmental Analysts, Inc.; Dietze & Davis, P.C.; Copper Mountain, Inc.; Hydrologic Consulting Engineers, Inc.; Westfork Investments, Ltd.
1975-1979	Research Assistant and Lecturer, Stanford University. Responsible for conducting research and lecturing for undergraduate courses in civil engineering.
1973-1975	Design Engineer, Wright-McLaughlin Engineers, Inc. Performed engineering design of water supply and wastewater collection systems.

Publications

Brendecke, C., 2004, "Toward Conjunctive Management of the Eastern Snake Plain Aquifer," poster presentation at Natural Resources Law Center 25th Summer Conference Groundwater in the West, June 16-18, Boulder, CO.

Brendecke, C., 2004, "Interstate Water Conflict: Compacts, Adjudications and Decrees," presentation at Water Policy Seminar: Freshwater Conflicts in the United States, May 19, Stanford, CA.

Brendecke, C., and R.D.Tenney, 2001, "Water Rights, Compact Entitlements and Endangered Fishes of the Yampa River Basin," Proceedings of the Annual Water Resources Conference, American Water Resources Association, November 12-15, Albuquerque, NM.

Brendecke, Charles M., 2001, "Conjunctive Management: Science or Fiction?" presentation to Idaho Water Users Association 18th Annual Water Law and Resource Issues Seminar, November 8-9, Boise, ID.

Tenney, Ray D., and C.M. Brendecke, 1998, "Planning for Water Development and Endangered Species Recovery in the Yampa River Basin." Proceedings of the Wetlands Engineering & River Restoration Conference, 1998, American Society of Civil Engineers, March 26th, 1998, Denver, CO.

Payton, E., C. Brendecke, B. Harding, E. Armbruster, T. McGuckin and C. Huntley. 1997. "Agricultural Water Conservation Planning & Pricing-Tools & Technologies." Proceedings of the Irrigation Association's 18th International Conference, Nov. 2, 1997, Nashville, TN.

Hydrosphere Resource Consultants, Inc., 1996, "Achieving Efficient Water Management: Agricultural Water Conservation Planning," workshop for U.S. Bureau of Reclamation staff, Dec. 16 - 18, Las Vegas, NV.

Brendecke, C., B. Harding and E. Payton, 1996, "PC-Based Decision Support Tools: Lessons from a Dozen Applications," Proceedings of the Fifth Water Resources Operations Management Workshop, Water Resources Planning and Management Division (ASCE). March 4, Arlington, Virginia.

Howe, C.W., M. Smith, L. Bennett, C. Brendecke, J. Flack, R. Hamm, R. Mann, L. Rozaklis, and K. Wunderlich, 1994, "The Value of Water Supply Reliability in Urban Water Systems," Journal of Environmental Economics and Management, 26, 19-30.

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Brendecke, C., 1992, "The Hydrosphere Snake River Operations Model", 9th Annual Water Law and Resource Issues Seminar, Idaho Water Users Association, Boise, Idaho.

Brendecke, C., and B. Harding, 1990, "Logical Intransitivities and Other Administrative Nightmares: Can Models Help?," Proceedings of the 26th Annual AWRA Conference and Symposium, November 4-9, Denver, Colorado.

Harding, B., C. Brendecke, and R. Kerr, 1990, "Legal and Economic Disincentives in the Transfer of Models to Users," Proceedings of the 26th Annual AWRA Conference and Symposium, November 4-9, Denver, Colorado.

Brendecke, C., W. DeOreo, E. Payton, and L. Rozaklis, 1989, "Network Models of Water Rights and System Operations," Journal of the Water Resources Planning and Management Division (ASCE).

Rozaklis, L., E. Payton, C. Brendecke, and B. Harding, 1988, "Modeling Water Allocation Problems Under Complex Hydrologic and Institutional Settings," paper presented at the 24th Annual AWRA Conference and Symposium, November 8, Milwaukee, Wisconsin.

Brendecke, C., W. DeOreo, and L. Rozaklis, 1987, "Water Rights Analysis and System Operation Using Network Optimization Models," paper presented at the 14th Annual ASCE Water Resources Planning and Management Division Conference, March 16-18, Kansas City.

Brendecke, C., E. Payton, and R. Wheeler, 1987, "Network Optimization Models for Water Rights Analysis and System Operating Studies for the City of Boulder," Proceedings of the Colorado Water Engineering and Management Conference, February 17-18, Ft. Collins, Colorado.

Payton, E., and C. Brendecke, 1985, "Rainfall and Snowmelt Frequency in an Alpine Watershed," Proceedings of the 53rd Western Snow Conference, April 16-18, Boulder, Colorado, pp. 25-36.

Brendecke, C., and J. Sweeten, 1985, "A Simulation Model of Boulder's Alpine Water Supply," Proceedings of the 53rd Western Snow Conference, April 16-18, Boulder, Colorado, pp. 63-71.

James, E., and C. Brendecke, 1985, "The Redistribution and Sublimation Loss of Snowpack in an Alpine Watershed," Proceedings of the 53rd Western Snow Conference, April 16-18, Boulder, Colorado, pp.148-151.

Brendecke, C., D. Laiho, and D. Holden, 1985, "Comparison of Two Daily Streamflow Simulation Models of an Alpine Watershed," Journal of Hydrology, 77, pp. 171-186.

Brendecke, C., D. Laiho, and J. Sweeten, 1984, "Management of a Municipally Owned Alpine Watershed Using Continuous Simulation," Proceedings of the 11th International Symposium on Urban Hydrology, Hydraulics, and Sediment Control, July 23-26, Lexington, Kentucky, pp. 79-87.

Lewis, W., D. Crumpacker, J. Saunders, and C. Brendecke, 1984, Eutrophication and Land Use, Ecological Studies Vol. 46, Springer-Verlag, New York, 202 pp.

Brendecke, C., D. Laiho, and D. Holden, 1984, "A Comparative Evaluation of Streamflow Simulation Models in a Colorado Alpine and Subalpine Environment," Proceedings of the American Geophysical Union Front Range Branch Hydrology Days, April 24-26, Ft. Collins, Colorado, pp. 40-55.

Baker, F., and C. Brendecke, 1983, "Seepage from Oilfield Brine Disposal Ponds in Utah," Groundwater, 21(3), pp. 317-324.

Brendecke, C., and L. Ortolano, 1981, "Environmental Considerations in Corps Planning," Water Resources Bulletin, 17(2), pp. 248-254.

Detailed Skills by Representative Project

Conjunctive Administration of Ground Water Rights. Project manager and testifying expert for Idaho Ground Water Appropriators, Inc., in proceedings related to administration of surface and ground water rights. Work has involved oversight of regional ground water model development of the Eastern Snake Plain Aquifer, ground water modeling in support of management and mitigation plans, and analysis of historical water use data.

Rio Grande Basin Confined Aquifer Use Rules. Testifying expert for the State of Colorado regarding the use of the RGDSS ground water model in developing rules governing new withdrawals from the confined aquifer system of the San Luis Valley.

Columbia River Basin Reservoir Operations. Project manager for studies of the impact of modified reservoir operations on agricultural interests in the Kootenai River basin.

New Mexico Surface Water Studies. Project manager for a program of surface and ground water studies on the Pecos River in support of State initiatives.

Interstate Compact Litigation. Expert witness in litigation between Kansas and Colorado regarding Arkansas River water uses.

Interstate Compact Litigation. Project manager and expert witness in litigation between Nebraska and Wyoming regarding storage project operations and water deliveries to agricultural users on the North Platte River.

Snake River Water Rights. Project manager for studies of historical irrigation practices and modeling of surface/ground water interaction on the eastern Snake River Plain, Idaho.

Rio Grande Decision Support System. Quality assurance officer on development of comprehensive surface water model of the Rio Grande River basin in Colorado.

Agricultural Water Conservation. Project manager for development of a water conservation guidebook for use by irrigation districts. The guidebook describes planning approaches and methods for evaluating specific conservation measures.

Colorado City Metropolitan District. Project manager for water supply planning studies and water rights litigation support for municipal water provider.

Gunnison Basin Planning Model. Project manager for development of an interactive PC-based computer model of the Gunnison River basin. The model uses a network solution algorithm and incorporates a Windows™-based interface.

Boulder Creek Water Rights. Lead expert in a variety of water rights proceedings for the City of Boulder related to applications, changes, and transfers of agricultural rights in the Boulder Creek basin.

Yampa River Basin Planning Studies. Project manager for comprehensive water supply planning study that included demand forecasting, development of a basin computer model, and evaluation of potential water storage project operations.

Snake River Basin Water Supply Study. Project manager for a comprehensive review of water use in the Snake River basin and computer model evaluation of potential water management strategies, including agricultural water conservation, to enhance anadromous fisheries.

Columbus Ditch Transfer. Performed engineering analysis of the historical use of irrigation rights located on the Blue River, determining the portion of consumptive use made possible by Green Mountain Reservoir releases.

Muddy Creek Water Rights. Analyzed the historical consumptive use of the irrigation water rights associated with the Gary Hill Ranch on Muddy Creek, in support of water rights acquisition associated with the construction of Muddy Creek Reservoir.

Summit County Small Reservoir Study. Project manager for a Blue River basin water management study involving development of a hydrologic model and evaluation of new storage facilities for instream flow maintenance.

Gunnison Basin Planning Study. Project manager for development of a detailed hydrology and water rights model of the 8000 square mile Gunnison River basin as part of a comprehensive river basin planning study.

Windy Gap Delivery Study. Developed detailed computer models of Colorado-Big Thompson Project operations to support analysis of the yields of the Windy Gap Project, which shares common facilities.

Superconducting Super Collider Water Supply. Determined industrial water needs and developed the water supply strategy for a proposed Department of Energy physics research facility.

Boulder Raw Water Master Plan. Prepared a comprehensive report concerning water rights holdings and water supply system operating policies for a Front Range municipality of 100,000 persons.

Standley Lake Pollutant Loading. Developed hydrologic and pollutant loading model of Standley Lake to assess relative effects of non-point sources and a proposed effluent exchange by a major industrial water user.

Pecos River Compact. Consultant to the Special Master of the U.S. Supreme Court on technical issues in a lawsuit between Texas and New Mexico concerning river depletions and water deliveries.

Rocky Ford Ditch Transfer. Performed engineering analyses of historic irrigation practices and Arkansas River depletions associated with a 4100-acre tract in southeastern Colorado.

Buena Vista Water Rights. Analysis of the historic use of irrigation water rights and development of engineering data supporting their transfer to municipal use.

Dillon Clean Lakes Study. Development of a comprehensive hydrologic monitoring network to determine lake inflow patterns and non-point source pollutant loadings from various land uses.

Restoration of West Tenmile Creek. Performed hydrologic and hydraulic analysis and design of comprehensive stream habitat improvements at Copper Mountain ski area.

Exhibit 2401

Water Rights and Historical Use of Participating Wells

Well ID	Owner	Water Rights	Historical Average Pumping 2003-2007 (AF/yr)
1	Box Canyon Dairy	36-10044 36-2426	322.9
2	Mary Jane and Thomas Heida	36-7682 36-2228B 36-2228A 36-7597B 36-7597A 36-2493B 36-2493C 36-8276	222.8
4	Mary Jane and Thomas Heida	36-2493B	501.4
5	Box Canyon Dairy	36-16282 36-16280 36-16278 36-16276 36-16274 36-16272 36-16270 36-16268 36-16266 36-16264 36-16262 36-16260 36-16258 36-16256 36-16284	446.2
6	Box Canyon Dairy	Same as Well 5 & 7	500.3
7	Box Canyon Dairy	Same as Well 5 & 6	211.9
8	Van Dyk & Sons A General Partnership	36-7319 36-7454	255.0

The total authorized amount of water under these water rights is 15.79 cfs and 4,216 acre-feet.

Rev. 06/09

Exhibit 2402

STATE OF IDAHO
DEPARTMENT OF WATER RESOURCES

Transfer No. ____________________

MINIMUM REQUIREMENTS CHECKLIST

TO BE SUBMITTED WITH APPLICATION FOR TRANSFER

An application for transfer must be prepared in accordance with the minimum requirements listed below to be acceptable for processing by the Department. Incomplete applications will be returned. The instructions, fee schedule, Part 2A reports and additional Part 2B forms are available from any Department office or on the Department's website at http://www.idwr.idaho.gov/ .

Check whether each item below is *attached* (Yes) or *not applicable* (N/A) for the proposed transfer.

Yes	N/A	* Means the item is always required and must be included with the application.
☑	*	Completed Application for Transfer of Water Right form, Part 1.
☑	*	Signature of applicant(s) or applicant's authorized representative on Application for Transfer Part 1. Include evidence of authority labeled Attachment #3 (see below) if signed by representative.
☑	*	Application for Transfer Part 2A. Attach a Part 2A report describing each water right in the transfer as currently recorded.
☐	☑	Complete and attach an Application for Transfer Part 2B for each water right for which only a portion is proposed to be changed through this transfer application
☑	*	Application for Transfer Part 3A is always required (see Attachment #7a below); Parts 3B and 3C must be completed for transfer applications proposing to change the nature of use of the water right(s) or proposing changes to supplemental right(s).
☑	*	Correct fee submitted with transfer application form. (Fee schedule is on website and instructions for application for transfer.)
		Attachments to Application - Label each attachment with the corresponding number shown below as Attachment #1-9.
☐	☑	**#1** If the applicant is a business, partnership, organization, or association, and not currently registered in the State of Idaho as a business entity, attach documentation identifying officers authorized to sign or act on behalf of right holder. (See Part 1.)
☑	☐	**#2a** Water Right ownership documentation if Dept. records do not show the transfer applicant as the current water right owner.
☐	☑	**#2b** If the ownership of the water right will change as a result of the proposed transfer to a new place of use, attach documentation showing land and water right ownership at the new place of use. Include documentation for all affected land and owner(s).
☐	☑	**#3** Documentation of authority to make the change if the applicant is not the water right owner.
☐	☑	**#4** Power of Attorney or documentation providing authority to sign or act on the applicant's behalf. (See Part 1.)
☐	☑	**#5** If the transfer application proposes to change the point of diversion for a water right affecting the Eastern Snake Plain Aquifer (ESPA), attach the results of an ESPA analysis and a detailed mitigation plan to offset any depletions to hydraulically connected reaches of the Snake River. ESPA transfer spreadsheet and model grid labeled cells are available on the Department's website at http://www.idwr.idaho.gov/water/rights/ .
☐	☑	**#6** Notarized statement of agreement or a statement on official letterhead signed by an authorized representative from each lien holder or other entity with financial interest in the water right(s) or land affected by the proposed transfer. (See Part 1.5.c.)
☑	*	**#7a** Attach a map identifying the proposed point(s) of diversion, place(s) of use, and water diversion and distribution system details as described on the application. Include legal description labels. If only a portion of the right is proposed to be changed, identify the current location of the part of the existing right(s) proposed to be changed. (See Part 3A.)
☑	☐	**#7b** If the transfer application proposes to change the place or purpose of use of an irrigation right attach a Geographic Information System (GIS) shape file, or an aerial photo or other image clearly delineating the location and extent of existing acres and changes to the place of use.
☑	☐	**#8a** If the transfer application proposes to change the nature of use or period of use for one or more rights, provide documentation describing the extent of historic beneficial use for the water rights proposed to be transferred and document how enlargement will be avoided. (See Part 3B.)
☐	☑	**#8b** If the transfer application proposes to change the place of use of a supplemental irrigation right, provide documentation regarding the historic use of the supplemental right(s) and availability or reliability of the primary right(s) being supplemented, both before and after the proposed change. (See Part 3C.)
☐	☐	**#9** Other. Please describe: ____________________

STATE OF IDAHO
DEPARTMENT OF WATER RESOURCES

Transfer No. ____

APPLICATION FOR TRANSFER OF WATER RIGHT
PART 1

Name of Applicant(s) North Snake GWD & Magic Valley GWD Phone 208-232-6101

Mailing address c/o Randall Budge PO Box 1391 Pocatello, ID 83204-1391 Email rcb@racinelaw.net

☐ If applicant is not an individual and not registered to do business in the State of Idaho, attach documentation identifying officers authorized to sign or act on behalf of the applicant. Label it **Attachment #1.**

☐ Attach water right ownership documentation if Department records do not show the transfer applicant as the current water right owner. Label it **Attachment #2a.**

☐ If the ownership of the water right will change as a result of the proposed transfer to a new place of use, attach documentation showing land and water right ownership at the new place of use. Include documentation for all affected land and owner(s). Label it **Attachment #2b.**

☑ Attach documentation of authority to make the proposed change if the applicant is not the water right owner. Label it **Attachment #3.**

Provide contact information below if a consultant, attorney, or any other person is representing the applicant in this transfer process.
☐ No Representative

Name of Representative Randall C. Budge and Candice M. McHugh Phone 208-232-6101

Mailing address PO Box 1391, Pocatello, ID 83204 Email rcb@racinelaw.net

☑ Send all correspondence for this application to the representative and not to the applicant.
OR
☐ Send original correspondence to the applicant and copies to the representative.

☐ The representative may submit information for the applicant but is not authorized to sign for the applicant.
OR
☐ The representative is authorized to sign for the applicant. Attach a Power of Attorney or other documentation providing authority to sign for the applicant and label it **Attachment #4.**

I hereby assert that no one will be injured by the proposed changes and that the proposed changes do not constitute an enlargement in use of the original right(s). The information contained in this application is true to the best of my knowledge. I understand that any willful misrepresentations made in this application may result in rejection of the application or cancellation of an approval.

Signature of Applicant or Authorized Representative	Randall C. Budge, Attorney Print Name and Title if applicable	9/11/2009 Date
Signature of Applicant or Authorized Representative	Print Name and Title if applicable	Date

A. PURPOSE OF TRANSFER

1. ☐ Change point of diversion ☐ Add diversion point(s) ☑ Change place of use
☑ Change nature of use ☑ Change period of use ☐ Other ____

2. Describe your proposal in narrative form, including a detailed description of non-irrigation uses to justify amounts transferred (i.e. number of stock, etc.), and provide additional explanation of any other items on the application. Attach additional pages if necessary and label it **Part 1A.2.** See 2009 Replacement Water Plan and Third Mitigation Plan (Over-the-Rim) of NSGWD and MVGWD March 12, 2009 on file with IDWR.

STATE OF IDAHO
DEPARTMENT OF WATER RESOURCES

APPLICATION FOR TRANSFER OF WATER RIGHT
PART 1 Continued

B. DESCRIPTION OF RIGHTS AFTER THE REQUESTED CHANGES. IF THE RIGHTS ARE BEING SPLIT, DESCRIBE PORTIONS TO BE CHANGED AS THEY WOULD APPEAR AFTER THE REQUESTED CHANGES.

1.

All	or Part	Right Number	Amount (cfs/ac-ft)	Nature of Use	Period of Use			Source & Tributary
☑	☐	36-2426	1.47 cfs	Mitigation & Fish	1/1	to	12/31	Groundwater/Snake River
☑	☐	36-10044	0.55 cfs	Propagation	1/1	to	12/31	" "
☑	☐	36-2493B	0.36 cfs	" "	1/1	to	12/31	
☑	☐	36-7682	1.24 cfs	" "	1/1	to	12/31	" "
☑	☐	36-2228B	0.4 cfs	" "	1/1	to	12/31	" "
☑	☐	36-7597B	1.18 cfs	" "	1/1	to	12/31	" "
☑	☐	36-2228A	1.58 cfs	" "	1/1	to	12/31	" "
☑	☐	36-7597A	0.7 cfs	" "	1/1	to	12/31	" "
☑	☐	36-2493C	2.38 cfs	" "	1/1	to	12/31	" "

Total authorized under rights 20.94 cfs and/or 4216 ac-ft continued on attachment B.1

2. Total amount of water proposed to be transferred or changed 15.79 cubic feet per second and/or 4216 acre-feet per annum.

3. Point(s) of Diversion:

☑ No changes to point(s) of diversion are proposed-the following chart is therefore not completed. (Proceed to #4.)
☐ Attach Eastern Snake Plain Aquifer analysis if this transfer proposes to change a point of diversion affecting the ESPA. Label it **Attachment** #5.

New ?	Lot	¼	¼	¼	Sec	Twp	Rge	County	Source	Local name or tag #

4. Place of use: (If irrigation, identify with number of acres irrigated per ¼ ¼ tract.)
☐ No changes to place of use are proposed-the following chart is therefore not completed. (Proceed to #5.)

Twp	Rge	Sec	NE ¼				NW ¼				SW ¼				SE ¼				Acre Totals
			NE	NW	SW	SE	NE	NW	SW	SE	NE	NW	SW	SE	NE	NW	SW	SE	
9S	14E	1			X	X									X	X			

Total Acres (for irrigation use) ____

STATE OF IDAHO
DEPARTMENT OF WATER RESOURCES

APPLICATION FOR TRANSFER OF WATER RIGHT
PART 1 Continued

5. General Information:

a. Describe the complete diversion system, including how you will accommodate a measuring device and lockable controlling works should they be required now or in the future: The diversion system consists of wells, pumps and pipes as described in the Ground Water Districts' Third Mitigation Plan. The Plan includes a detailed description of how the water will be measured tested and controlled for mitigation and fish propagation purposes.
See Exh. 3 of the 2009 Replacement Water Plan.

b. Who owns the property at the point(s) of diversion? See attached list of landowners.
If other than the applicant, describe the arrangement enabling the applicant to access the property for the diversion system: The Ground Water Districts have entered into long-term leases with the water rights owners to use these water rights for mitigation purposes under the Ground Water Districts' over-the-rim mitigation plan. See p.p. 6-9 of the Plan.

c. Are the lands from which you propose to transfer the water right subject to any liens, deeds of trust, mortgages, or contracts?
If yes, ☐ Attach a notarized statement from the holder of the lien, deed of trust, mortgage or contract agreeing to the proposed changes on official letterhead signed by an authorized representative. Label it **Attachment #6.** List the name of the entity and type of lien: Not to the Ground Water Districts' knowledge.

It is the applicant's responsibility to provide notice to lien holder, trustee, mortgagor, or contract holder of the proposed changes that may impact or change the value of the water rights or affected real property. Any misrepresentation of legal encumbrance on this application may result in rejection of the application or cancellation of an approval.

d. Describe the effect on the land now irrigated if the place or purpose of use is changed pursuant to this transfer: The land will no longer be irrigated from these water rights as these water rights will be used for mitigation and fish propagation purposes.

e. Describe the use of any other water right(s) for the same purpose or land, or the same diversion system as right(s) proposed to be transferred at both the existing and proposed point(s) of diversion and place(s) use: The lands have been converted from groundwater irrigation to surface water irrigation. The surface water is delivered via the North Side Canal Company system and is leased from reservoir space holders pursuant to leases with the space holders and the Idaho Ground Water Appropriators, Inc.

f. To your knowledge, has/is any portion of the water right(s) proposed to be changed:

Yes	No	
☐	☑	undergone a period of five or more consecutive years of non-use,
☐	☑	currently leased to the Water Supply Bank,
☐	☑	currently used in a mitigation plan limiting the use of water under the right, or
☐	☑	currently enrolled in a Federal set-aside program limiting the use of water under the rights?

If yes, describe: ____

STATE OF IDAHO
DEPARTMENT OF WATER RESOURCES

APPLICATION FOR TRANSFER OF WATER RIGHT
PART 2

A. DESCRIPTION OF RIGHT(S) AS RECORDED

For each water right listed in Part 1B.1 of the application, attach a **Part 2A** report obtained from any Department office or from the Department's website @ http://www.idwr.idaho.gov/ , Water Right Transfers, Step 1.
Insert Part 2A reports into the application following Part 1.

B. IF ONLY A PORTION OF THE RIGHT IS PROPOSED TO BE CHANGED, DESCRIBE THE PORTION BEING CHANGED AS IT APPEARS BEFORE THE REQUESTED CHANGES

☐ Complete and attach one copy of Part 2B for each right for which only a portion is proposed to be changed. If the entire right is proposed to be changed, Part 2B is not applicable. Additional copies of the **Part 2B** form can be obtained from any Department office or from the Department's website @ http://www.idwr.idaho.gov/ , Water Right Transfers, Step 3, or Water Right Forms, Changes in Use. Insert completed Part 2B forms into the application following Part 2A of the same water right.

Right Number: N/A

1. amount ________ (cfs/ac-ft) for ________ purposes from ________ to ________
   amount ________ for ________ purposes from ________ to ________
   amount ________ for ________ purposes from ________ to ________
   amount ________ for ________ purposes from ________ to ________
   amount ________ for ________ purposes from ________ to ________
   amount ________ for ________ purposes from ________ to ________
   amount ________ for ________ purposes from ________ to ________
   amount ________ for ________ purposes from ________ to ________

2. Lands irrigated or place of use: (If irrigation, identify with number of acres irrigated per ¼ ¼ tract.)

Twp	Rge	Sec	NE ¼				NW ¼				SW ¼				SE ¼				Acre Totals
			NE	NW	SW	SE	NE	NW	SW	SE	NE	NW	SW	SE	NE	NW	SW	SE	

Total Acres (for irrigation use) ________

STATE OF IDAHO
DEPARTMENT OF WATER RESOURCES

APPLICATION FOR TRANSFER OF WATER RIGHT
PART 3

A. PLAT MAP (See Part 3A of Instructions for application for transfer for complete requirements.)

☐ Attach a map of the diversion, measurement, control, and distribution system. Label it **Attachment #7a.**

☑ If the transfer application proposes to change the place or purpose of use of an irrigation right attach a Geographic Information System (GIS) shape file, or an aerial photo or other image clearly delineating the location and extent of existing acres and changes to the place of use. Label it **Attachment #7b.** If the place of use currently consists of a permissible place of use, then the attachment is not required if the application contains a clear statement that the boundaries for the place of use are not proposed to be changed by the transfer and the total number of irrigated acres within the place of use before and after the transfer is clearly stated.

B. CHANGES IN NATURE OF USE (Water Balance)

☑ If you propose to change the nature of use or period of use of all or part of the rights(s) listed in this application, attach documentation describing the extent of historic beneficial use of the portion of the right(s) proposed to be changed. Also attach documentation showing that the portion of the right(s) to be changed will not be enlarged in rate, volume, or consumptive use through the proposed change. Label it **Attachment #8a.**

C. PLACE OF USE CHANGES TO SUPPLEMENTAL IRRIGATION RIGHTS

☐ If you propose to change the place of use of a supplemental irrigation right, answer below and attach supporting documentation. Label it **Attachment #8b.**

1. Describe how the supplemental water rights have been used historically in conjunction with other water rights at the existing place of use. Describe the time during the irrigation season that the supplemental rights have been used. Include information about the availability or reliability of the primary right(s) being supplemented, both before and after the change. If the applicant is proposing to change a supplemental irrigation right to a primary right, provide the information required on Part 3B above.: ____

FOR DEPARTMENT USE ONLY

Transfer contains ____ pages and ____ attachments.

Received by ____ Date ____ Prelim. Check by ____ Date ____

Fee Paid ____ Date ____ Receipted by ____ Receipt # ____

Add'l Fee Paid ____ Date ____ Receipted by ____ Receipt # ____

THE REQUIRED ATTACHMENTS TO THE TRANSFER APPLICATION(S) WILL BE COMPLETED AND SUBMITTED TO IDWR UPON APPROVAL OF THE OVER-THE-RIM MITIGATION PLAN

Rev. 06/09

Exhibit 2403

STATE OF IDAHO
DEPARTMENT OF WATER RESOURCES

Transfer No. ____________________

MINIMUM REQUIREMENTS CHECKLIST

TO BE SUBMITTED WITH APPLICATION FOR TRANSFER

An application for transfer must be prepared in accordance with the minimum requirements listed below to be acceptable for processing by the Department. Incomplete applications will be returned. The instructions, fee schedule, Part 2A reports and additional Part 2B forms are available from any Department office or on the Department's website at http://www.idwr.idaho.gov/ .

Check whether each item below is *attached* (Yes) or *not applicable* (N/A) for the proposed transfer.

Yes	N/A	* Means the item is always required and must be included with the application.
☑	*	Completed Application for Transfer of Water Right form, Part 1.
☑	*	Signature of applicant(s) or applicant's authorized representative on Application for Transfer Part 1. Include evidence of authority labeled Attachment #3 (see below) if signed by representative.
☑	*	Application for Transfer Part 2A. Attach a Part 2A report describing each water right in the transfer as currently recorded.
☐	☑	Complete and attach an Application for Transfer Part 2B for each water right for which only a portion is proposed to be changed through this transfer application
☑	*	Application for Transfer Part 3A is always required (see Attachment #7a below); Parts 3B and 3C must be completed for transfer applications proposing to change the nature of use of the water right(s) or proposing changes to supplemental right(s).
☑	*	Correct fee submitted with transfer application form. (Fee schedule is on website and instructions for application for transfer.)

Attachments to Application - Label each attachment with the corresponding number shown below as Attachment #1-9.

Yes	N/A		
☐	☑	**#1**	If the applicant is a business, partnership, organization, or association, and not currently registered in the State of Idaho as a business entity, attach documentation identifying officers authorized to sign or act on behalf of right holder. (See Part 1.)
☑	☐	**#2a**	Water Right ownership documentation if Dept. records do not show the transfer applicant as the current water right owner.
☐	☑	**#2b**	If the ownership of the water right will change as a result of the proposed transfer to a new place of use, attach documentation showing land and water right ownership at the new place of use. Include documentation for all affected land and owner(s).
☐	☑	**#3**	Documentation of authority to make the change if the applicant is not the water right owner.
☐	☑	**#4**	Power of Attorney or documentation providing authority to sign or act on the applicant's behalf. (See Part 1.)
☐	☑	**#5**	If the transfer application proposes to change the point of diversion for a water right affecting the Eastern Snake Plain Aquifer (ESPA), attach the results of an ESPA analysis and a detailed mitigation plan to offset any depletions to hydraulically connected reaches of the Snake River. ESPA transfer spreadsheet and model grid labeled cells are available on the Department's website at http://www.idwr.idaho.gov/water/rights/ .
☐	☑	**#6**	Notarized statement of agreement or a statement on official letterhead signed by an authorized representative from each lien holder or other entity with financial interest in the water right(s) or land affected by the proposed transfer. (See Part 1.5.c.)
☑	*	**#7a**	Attach a map identifying the proposed point(s) of diversion, place(s) of use, and water diversion and distribution system details as described on the application. Include legal description labels. If only a portion of the right is proposed to be changed, identify the current location of the part of the existing right(s) proposed to be changed. (See Part 3A.)
☑	☐	**#7b**	If the transfer application proposes to change the place or purpose of use of an irrigation right attach a Geographic Information System (GIS) shape file, or an aerial photo or other image clearly delineating the location and extent of existing acres and changes to the place of use.
☑	☐	**#8a**	If the transfer application proposes to change the nature of use or period of use for one or more rights, provide documentation describing the extent of historic beneficial use for the water rights proposed to be transferred and document how enlargement will be avoided. (See Part 3B.)
☐	☑	**#8b**	If the transfer application proposes to change the place of use of a supplemental irrigation right, provide documentation regarding the historic use of the supplemental right(s) and availability or reliability of the primary right(s) being supplemented, both before and after the proposed change. (See Part 3C.)
☐	☐	**#9**	Other. Please describe: ____________________

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STATE OF IDAHO
DEPARTMENT OF WATER RESOURCES

Transfer No. ____________

APPLICATION FOR TRANSFER OF WATER RIGHT
PART 1

Name of Applicant(s) North Snake GWD & Magic Valley GWD Phone (208) 232-6101

Mailing address c/o Randall Budge, PO Box 1391 Pocatello, ID 83201-1391 Email rcb@racinelaw.net

☐ If applicant is not an individual and not registered to do business in the State of Idaho, attach documentation identifying officers authorized to sign or act on behalf of the applicant. Label it **Attachment #1.**

☑ Attach water right ownership documentation if Department records do not show the transfer applicant as the current water right owner. Label it **Attachment #2a.**

☐ If the ownership of the water right will change as a result of the proposed transfer to a new place of use, attach documentation showing land and water right ownership at the new place of use. Include documentation for all affected land and owner(s). Label it **Attachment #2b.**

☑ Attach documentation of authority to make the proposed change if the applicant is not the water right owner. Label it **Attachment #3.**

Provide contact information below if a consultant, attorney, or any other person is representing the applicant in this transfer process.
☑ No Representative

Name of Representative Randall C. Budge and Candice M. McHugh Phone (208) 232-6101

Mailing address PO Box 1391, Pocatello, ID 83204 Email rcb@racinelaw.net

☑ Send all correspondence for this application to the representative and not to the applicant.
OR
☐ Send original correspondence to the applicant and copies to the representative.

☐ The representative may submit information for the applicant but is not authorized to sign for the applicant.
OR
☐ The representative is authorized to sign for the applicant. Attach a Power of Attorney or other documentation providing authority to sign for the applicant and label it **Attachment #4.**

I hereby assert that no one will be injured by the proposed changes and that the proposed changes do not constitute an enlargement in use of the original right(s). The information contained in this application is true to the best of my knowledge. I understand that any willful misrepresentations made in this application may result in rejection of the application or cancellation of an approval.

Signature of Applicant or Authorized Representative	Print Name and Title if applicable	Date
	Randall C. Budge, Attorney	9/11/2009

Signature of Applicant or Authorized Representative	Print Name and Title if applicable	Date

A. PURPOSE OF TRANSFER

1. ☑ Change point of diversion ☑ Add diversion point(s) ☑ Change place of use
 ☑ Change nature of use ☑ Change period of use ☐ Other ____________

2. Describe your proposal in narrative form, including a detailed description of non-irrigation uses to justify amounts transferred (i.e. number of stock, etc.), and provide additional explanation of any other items on the application. Attach additional pages if necessary and label it **Part 1A.2.** See 2009 Replacement Water Plan and Third Mitigation Plan (Over-the-Rim) of NSGWD and MVGWD dated March 12, 2009 on file with IDWR.

STATE OF IDAHO
DEPARTMENT OF WATER RESOURCES

APPLICATION FOR TRANSFER OF WATER RIGHT
PART 1 Continued

B. DESCRIPTION OF RIGHTS AFTER THE REQUESTED CHANGES. IF THE RIGHTS ARE BEING SPLIT, DESCRIBE PORTIONS TO BE CHANGED AS THEY WOULD APPEAR AFTER THE REQUESTED CHANGES.

1.

All	Part	Right Number	Amount (cfs/ac-ft)	Nature of Use	Period of Use			Source & Tributary
☑	☐	36-2426	1.47 cfs	Mitigation & Fish	1/1	to	12/31	Groundwater
☑	☐	36-10044	0.55 cfs	Propogation	1/1	to	12/31	"
☑	☐	36-2493B	0.36 cfs	"	1/1	to	12/31	"
☑	☐	36-7682	1.24 cfs	"	1/1	to	12/31	"
☑	☐	36-2228B	0.40 cfs	"	1/1	to	12/31	"
☑	☐	36-7597B	1.18 cfs	"	1/1	to	12/31	"
☑	☐	36-2228A	1.58 cfs	"	1/1	to	12/31	"
☑	☐	36-7597A	0.70 cfs	"	1/1	to	12/31	"
☑	☐	36-2493C	2.38 cfs	"	1/1	to	12/31	"

Total authorized under rights 20.94 cfs and/or 4216 ac-ft

2. Total amount of water proposed to be transferred or changed 15.79 cubic feet per second and/or 4216 acre-feet per annum.

3. Point(s) of Diversion:

☐ No changes to point(s) of diversion are proposed-the following chart is therefore not completed. (Proceed to #4.)
☑ Attach Eastern Snake Plain Aquifer analysis if this transfer proposes to change a point of diversion affecting the ESPA. Label it **Attachment #5.**

New ?	Lot	¼	¼	¼	Sec	Twp	Rge	County	Source	Local name or tag #
N		SE	SW	SE	36	8S	14E	Gooding	Groundwater	Well 4
Y		SE	SW	SE	36	8S	14E	Gooding	Groundwater	Well 4A

4. Place of use: (If irrigation, identify with number of acres irrigated per ¼ ¼ tract.)
☐ No changes to place of use are proposed-the following chart is therefore not completed. (Proceed to #5.)

Twp	Rge	Sec	NE ¼				NW ¼				SW ¼				SE ¼				Acre Totals
			NE	NW	SW	SE	NE	NW	SW	SE	NE	NW	SW	SE	NE	NW	SW	SE	
9S	14E	1			X	X									X	X			

Total Acres (for irrigation use) ____________

STATE OF IDAHO
DEPARTMENT OF WATER RESOURCES

APPLICATION FOR TRANSFER OF WATER RIGHT
PART 1 Continued

5. General Information:

a. Describe the complete diversion system, including how you will accommodate a measuring device and lockable controlling works should they be required now or in the future: The diversion system consists of wells, pumps and pipes as described in the Ground Water Districts' Third Mitigation Plan. The Plan includes a detailed description of how the water will be measured tested and controlled for mitigation and fish propagation purposes.

b. Who owns the property at the point(s) of diversion? See attached list of landowners.

If other than the applicant, describe the arrangement enabling the applicant to access the property for the diversion system: The Ground Water Districts have entered into long-term leases with the water rights owners to use these water rights for mitigation purposes under the Ground Water Districts' over-the-rim mitigation plan.

c. Are the lands from which you propose to transfer the water right subject to any liens, deeds of trust, mortgages, or contracts?

If yes, ☐ Attach a notarized statement from the holder of the lien, deed of trust, mortgage or contract agreeing to the proposed changes on official letterhead signed by an authorized representative. Label it **Attachment #6.** List the name of the entity and type of lien: Not to the Ground Water Districts' knowledge.

It is the applicant's responsibility to provide notice to lien holder, trustee, mortgagor, or contract holder of the proposed changes that may impact or change the value of the water rights or affected real property. Any misrepresentation of legal encumbrance on this application may result in rejection of the application or cancellation of an approval.

d. Describe the effect on the land now irrigated if the place or purpose of use is changed pursuant to this transfer: The land will no longer be irrigated from these water rights as these water rights will be used for mitigation and fish propagation purposes.

e. Describe the use of any other water right(s) for the same purpose or land, or the same diversion system as right(s) proposed to be transferred at both the existing and proposed point(s) of diversion and place(s) use: The lands have been converted from groundwater irrigation to surface water irrigation. The surface water is delivered via the North Side Canal Company system and is leased from reservoir space holders pursuant to leases with the space holders and the Idaho Ground Water Appropriators, Inc.

f. To your knowledge, has/is any portion of the water right(s) proposed to be changed:

Yes	No	
☐	☑	undergone a period of five or more consecutive years of non-use,
☐	☑	currently leased to the Water Supply Bank,
☐	☑	currently used in a mitigation plan limiting the use of water under the right, or
☐	☑	currently enrolled in a Federal set-aside program limiting the use of water under the rights?

If yes, describe: N/A

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STATE OF IDAHO
DEPARTMENT OF WATER RESOURCES

APPLICATION FOR TRANSFER OF WATER RIGHT
PART 2

A. DESCRIPTION OF RIGHT(S) AS RECORDED

For each water right listed in Part 1B.1 of the application, attach a **Part 2A** report obtained from any Department office or from the Department's website @ http://www.idwr.idaho.gov/ , Water Right Transfers, Step 1.
Insert Part 2A reports into the application following Part 1.

B. IF ONLY A PORTION OF THE RIGHT IS PROPOSED TO BE CHANGED, DESCRIBE THE PORTION BEING CHANGED AS IT APPEARS BEFORE THE REQUESTED CHANGES

☐ Complete and attach one copy of Part 2B for each right for which only a portion is proposed to be changed. If the entire right is proposed to be changed, Part 2B is not applicable. Additional copies of the **Part 2B** form can be obtained from any Department office or from the Department's website @ http://www.idwr.idaho.gov/ , Water Right Transfers, Step 3, or Water Right Forms, Changes in Use. Insert completed Part 2B forms into the application following Part 2A of the same water right.

Right Number: N/A

1. amount ________ (cfs/ac-ft) for ________ purposes from ________ to ________
amount ________ for ________ purposes from ________ to ________
amount ________ for ________ purposes from ________ to ________
amount ________ for ________ purposes from ________ to ________
amount ________ for ________ purposes from ________ to ________
amount ________ for ________ purposes from ________ to ________
amount ________ for ________ purposes from ________ to ________
amount ________ for ________ purposes from ________ to ________

2. Lands irrigated or place of use: (If irrigation, identify with number of acres irrigated per ¼ ¼ tract.)

Twp	Rge	Sec	NE ¼				NW ¼				SW ¼				SE ¼				Acre Totals
			NE	NW	SW	SE	NE	NW	SW	SE	NE	NW	SW	SE	NE	NW	SW	SE	

Total Acres (for irrigation use) ________

STATE OF IDAHO
DEPARTMENT OF WATER RESOURCES

APPLICATION FOR TRANSFER OF WATER RIGHT
PART 3

A. PLAT MAP (See Part 3A of Instructions for application for transfer for complete requirements.)

- ☐ Attach a map of the diversion, measurement, control, and distribution system. Label it **Attachment #7a.**
- ☑ If the transfer application proposes to change the place or purpose of use of an irrigation right attach a Geographic Information System (GIS) shape file, or an aerial photo or other image clearly delineating the location and extent of existing acres and changes to the place of use. Label it **Attachment #7b.** If the place of use currently consists of a permissible place of use, then the attachment is not required if the application contains a clear statement that the boundaries for the place of use are not proposed to be changed by the transfer and the total number of irrigated acres within the place of use before and after the transfer is clearly stated.

B. CHANGES IN NATURE OF USE (Water Balance)

- ☑ If you propose to change the nature of use or period of use of all or part of the rights(s) listed in this application, attach documentation describing the extent of historic beneficial use of the portion of the right(s) proposed to be changed. Also attach documentation showing that the portion of the right(s) to be changed will not be enlarged in rate, volume, or consumptive use through the proposed change. Label it **Attachment #8a.**

C. PLACE OF USE CHANGES TO SUPPLEMENTAL IRRIGATION RIGHTS

- ☐ If you propose to change the place of use of a supplemental irrigation right, answer below and attach supporting documentation. Label it **Attachment #8b.**

1. Describe how the supplemental water rights have been used historically in conjunction with other water rights at the existing place of use. Describe the time during the irrigation season that the supplemental rights have been used. Include information about the availability or reliability of the primary right(s) being supplemented, both before and after the change. If the applicant is proposing to change a supplemental irrigation right to a primary right, provide the information required on Part 3B above.: ____________________

FOR DEPARTMENT USE ONLY

Transfer contains ______________ pages and ___________ attachments.

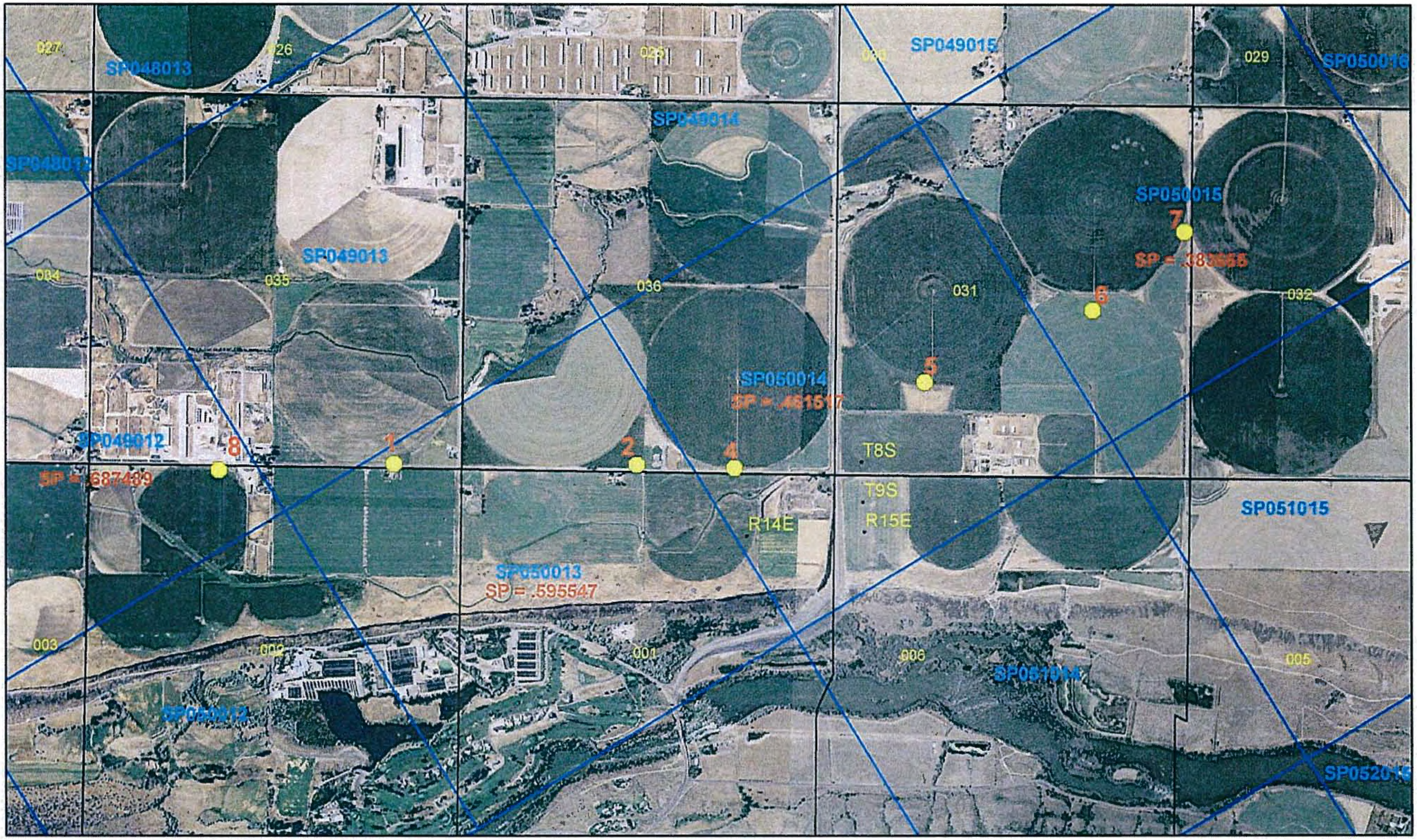
Received by ________________ Date ______________ Prelim. Check by ________________ Date ____________________

Fee Paid ____________________ Date ______________ Receipted by ________________ Receipt #__________________

Add'l Fee Paid ________________ Date ______________ Receipted by ________________ Receipt #__________________

THE REQUIRED ATTACHMENTS TO THE TRANSFER APPLICATION(S) WILL BE COMPLETED AND SUBMITTED TO IDWR UPON APPROVAL OF THE OVER-THE-RIM MITIGATION PLAN

Exhibit 2404



Plan Wells and ESPA Model Cells

Legend

Over-the-Rim Wells

Model Cells

N

Miles
0 0.125 0.25 0.5

Exhibit 2405

WSRC-MS-98-00318

Heat Transfer Model of Above and Underground Insulated Piping Systems

CONF-980816--

by
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MASTER

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Heat Transfer Model of Above and Underground Insulated Piping Systems

Ki C. Kwon
Westinghouse Savannah River Company
Aiken, South Carolina

ABSTRACT

A simplified heat transfer model of above and underground insulated piping systems was developed to perform iterative calculations for fluid temperatures along the entire pipe length. It is applicable to gas, liquid, fluid flow with no phase change. Spreadsheet computer programs of the model have been developed and used extensively to perform the above calculations for thermal resistance, heat loss and core fluid temperature.

NOMENCLATURE

A, Ai = surface area (sf)
Ain = inner surface area of hollow cylinders, pipes, or insulation (sf)
Aou = outer surface area of hollow cylinders, pipes, or insulation (sf)
Am = logarithmic mean area of heat transfer (sf)
Ç = specific heat of the core pipe fluid (Btu/lbF)
Ch = pipe constant (use 1.016 for horizontal and 1.235 for vertical pipe)
d, di = diameter (ft)
do = pipe covering or insulation OD (ft)
dn = ID of of hollow cylinder pipes or insulation (ft)
dt = OD of hollow cylinder pipes or insulation (ft)
dh = burial depth of pipe centerline (ft)
e = surface emittance of pipe covering or insulation
H = total thermal transmittance (Btu/ hr F)=1/R
h, hi = film coefficient (Btu/hr sf F)
i = subscripts 1,2,3,4,5,6,7,8 or a,b,c,d
Examples, i of Ti,Ri,Ai,hi,ki
k, ki = conductivity (Btu/hr ft F)
ks = soil conductivity (Btu/hr ft F)
L = pipe length of one interval or one element (ft)
La = starting fluid location, Example, La = 0 ft
Le = ending fluid location, Example, Le= 9100 ft
Lt = total pipe length (ft)
Lk = conduction wall thickness of pipes, insulation and soil (ft)
M = mass of core fluid per one interval pipe length (lbs)
n = number of pipe elements or intervals
Example, n = 100
Q = heat flow (Btu/hr)
R, Ri = resistance (hr F / Btu)
r, ri = radius (ft)
ro = do/2 = outer radius of pipe covering or insulation (ft)
t = time for moving fluid to travel the distance of pipe interval L (hr)
tc = time interval for stagnant fluid to cool a given temperature drop (hr)

T, Ti = temperature (F or C)
T1 = Tf = core pipe fluid temperature (F or C)
T2 = average temperature of ambient air film (F or C)
T3 = core pipe id temperature (F or C)
T4 = core pipe OD temperature (F or C)
T5 = jacket pipe ID temperature (F or C)
T6 = jacket pipe OD temperature (F or C)
T7 = pipe covering or insulation OD temp (F or C)
T8 = Ts = soil or ambient air temperature (F or C)
To = initial or starting interval temperature (F or C)
Te = ending interval temperature (F or C)
Tend = end temperature of travel (F or C)
Ts = soil or ambient air temperature (F or C)
U = overall heat transfer coefficients (Btu/hr sf F)
Xi = fluid location at the start of interval (ft)
Xe = fluid location at the end of interval (ft)
wind = wind velocity (mph)

BASIC EQUATIONS

(1) inner surface area of heat transfer for pipes or insulation (sf) = Ain = (π) (dn) (L)
(2) outer surface area of heat transfer for pipes or insulation (sf) = Aou = (π) (dt) (L)
(3) logarithmic mean area of heat transfer for pipes or insulation (sf)= Am = (Aou - Ain) / Logn (Aou / Ain)

(4) aboveground ambient air convective film coefficient (Btu/hr sf F) per Ref. [1].
ha=(Ch)*(1/dc)^0.2*(1/T2)^0.181*(1+1.277*wind)^0.5
where Ch=1.016 for horizontal cylinders or pipes
Ch = 1.235 for longer vertical pipes

(5) aboveground radiation surface coefficient (Btu/hr sf F) per Ref. [1].
hb = (e)*(0.1713)*10^(-8)*[(Ts+459.6)^4 - (T7+459.6)^4] / (Ts-T7)
(6) total aboveground thermal coeff. (Btu/hr sf F) per Ref. [3] = h7 = ha +hb

(7) thermal resistance of film convection (hr F / Btu) per Ref. [3].
Ri = 1/(hi*Ai) for core fluid and air
R1 = 1/(h1*A1) = core fluid resistance (hr F/Btu)
R4 = 1/(h4*A4) = annular air resistance (hr F/Btu)
R7 = 1/(h7*A7) = ambient air resistance (hr F/Btu)

(8) thermal resistance of wall conduction (hr F/Btu) per Ref. [3].
Ri = Lk/(ki*Am) for pipes and insulation
R2 = Lk2/(k2*Am2) = core pipe inner fouling
R3 = Lk3/(k3*Am3) = core pipe wall resistance
R5 = Lk5/(k5*Am5)= outer pipe wall resistance
R6 = Lk6/(k6*Am6)= external insulation resistance

(9) resistance of soil for underground pipe (hr F / Btu) per Ref. [1]. R7 = Lk7 / (k7*Am7) or
R7 = Logn { (dh/ro) + [(dh/ro)^2 - 1]^0.5 } / (2*πi*ks*L)

(10) total or resultant resistance (hr F / Btu).
R = R1+R2+R3+R4+R5+R6+R7

(11) ending fluid temperature of pipe interval (F)
Te = To - (Tf-Ts)(t) / (M)(C)(R)

(12) mean fluid temperature of typical interval (F)
Tf = (To+Te)/2
Tf = (2*M*C*R*To + Ts*t) / (2*M*C*R + t)

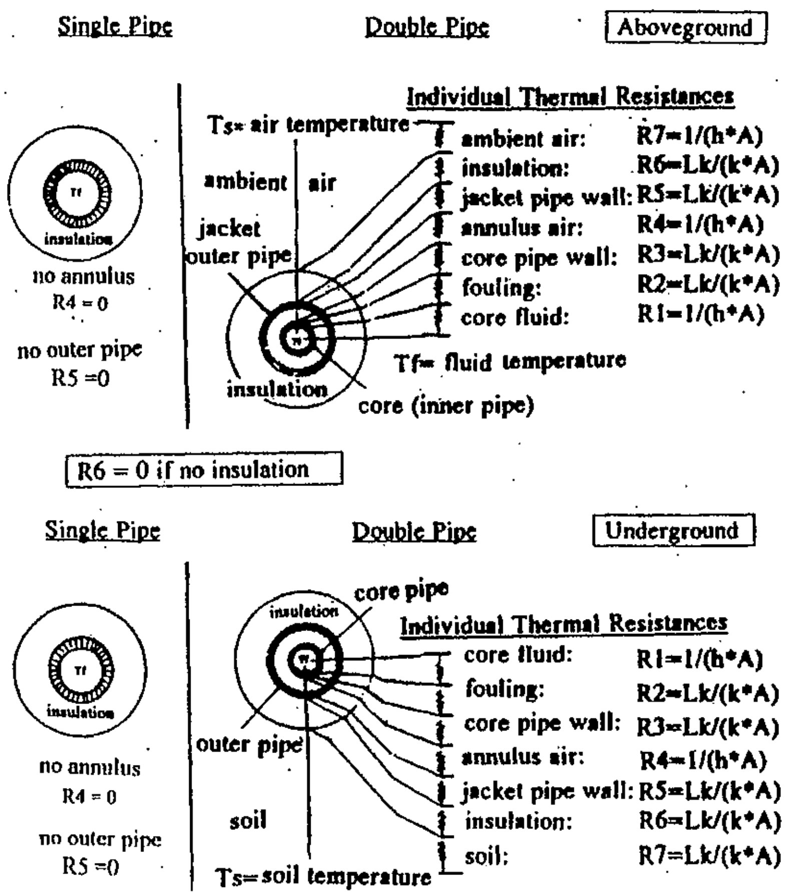
(13) core pipe mean or average temperature (F)
Ta = 0.5 [2T1- (1/R) (2R1 + 2R2 + R3) (T1-T8)]

(14) annulus air mean or average temperature (F).
Tb = 0.5 [2T1- (1/R) (2R1 + 2R2 + 2R3 + R4) *(T1-T8)]
(15) outer-jacket pipe mean temperature (F)
Tc = 0.5 [2T1- (1/R) (2R1 + 2R2 + 2R3 + 2R4 + R5) (T1-T8)]
(16) external insulation mean temperature (F)
Td = 0.5 [2T1- (1/R) (2R1+2R2+2R3+2R4 +2R5+R6) (T1-T8)]

INTRODUCTION

Heat gain, heat loss and temperature change of transfer pipe lines are significantly influenced by (a) insulation, (b) surrounding environment - ambient air for above-ground pipe or soil for underground pipe and (c) pipe structure - single pipe or double pipe. A heat transfer model of above and underground insulated piping systems are shown in Figure 1.

Fig. 1 Above and Underground Insulated Piping System Model



Overall Resistance (hr F/Btu):

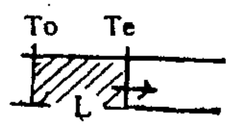
R = R1+R2+R3+R4+R5+R6+R7

Heat Flow / dT (Btu/hr F):

Q/dT = Q/(Tf-Ts)= 1/R = (U)(A)

Equation of Heat Balance of Pipe Interval Element (Btu/hr):

Tf = To to Te



one of 100 intervals

(M) (C) (To-Te) / t = (Tf-Ts) / R
= (U) (A) (Tf-Ts)

Table 1. Steady State Pipe Flow - Heat Loss (9100 ft, 93.3 gpm, starting 107C at 0 ft)

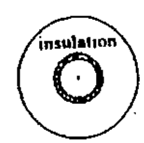
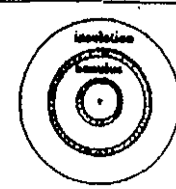
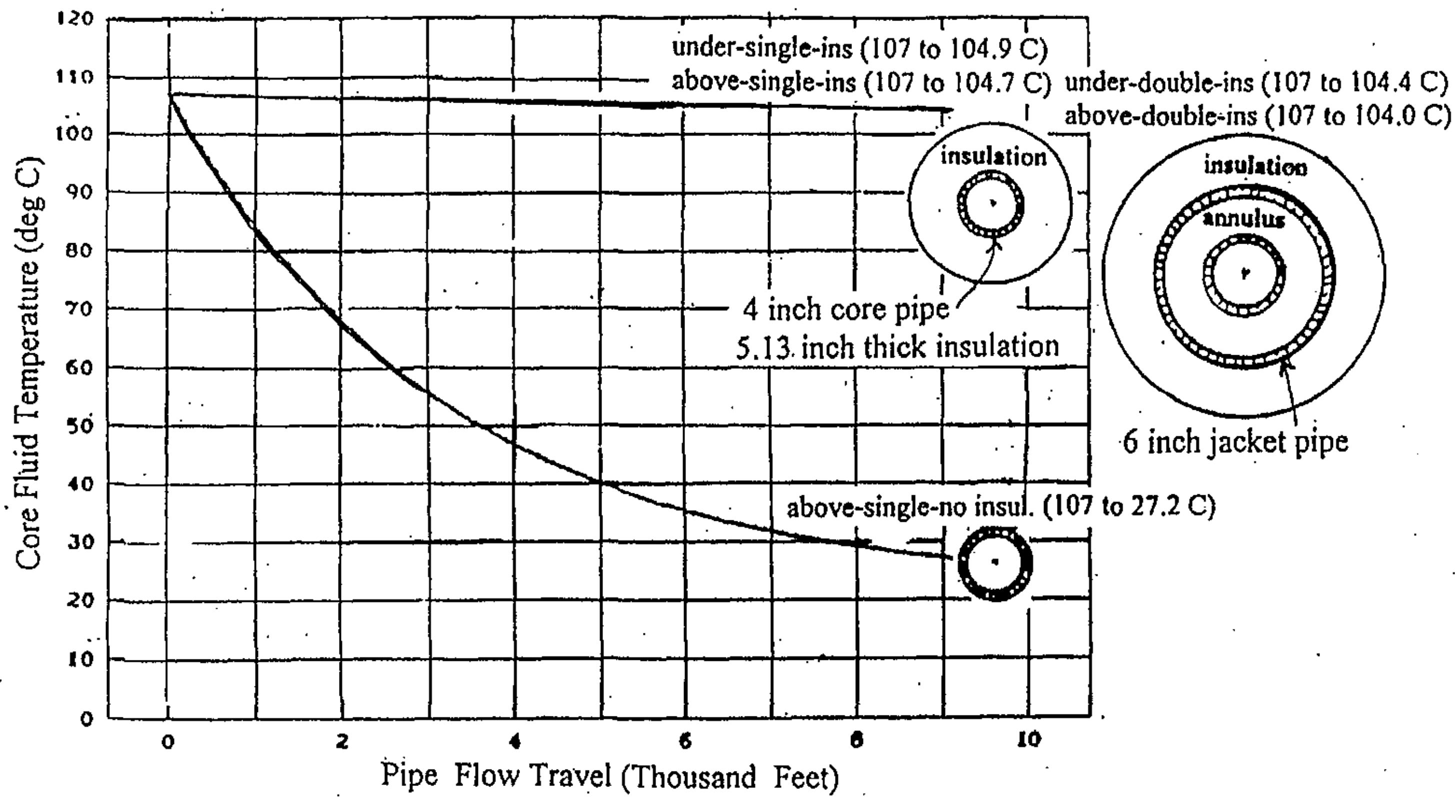
single or double	single pipe			double	pipe
above or underground	above	above	under	above	under
unisulated or insulated	uninsul.	insul.	insul.	insul.	insul.
core fluid (hr F/Btu): **R1=1/(h*A)**	0.000029	0.000029	0.000029	0.000029	0.000029
core fouling (hr F/Btu): **R2=Lk/(k*A)**	0.000031	0.000031	0.000031	0.000031	0.000031
4" core pipe (hr F/Btu): **R3=Lk/(k*A)**	0.000023	0.000023	0.000023	0.000023	0.000023
annular air space (hr F/Btu): **R4=1/(h*A)**	0	0	0	0.002211	0.002211
6" outer pipe (hr F/Btu): **R5=Lk/(k*A)**	0	0	0	0.000005	0.000005
5.13" insulation (hr F/Btu): R6 = Lk/(k*A)	0	0.077905	0.077905	0.058178	0.061372
Ambient Air, Soil (hr F/Btu): R7=1/(h*A), Lk/(k*A)	0.000705	0.000705	0.007930	0.000607	0.007447
total resistance (hr F/Btu): R	0.000788	0.078693	0.085918	0.061084	0.071118
heat flow=U*A=1/R (Btu/hr F): Q/dT	1269.0	12.7	11.6	16.4	14.1
fluid temp. at 9100 ft (C): Tend	27.2	104.7	104.9	104.0	104.4
avg. fluid temp. (C)= Tf = (107+Tend) / 2	67.1	105.8	105.9	105.5	105.7
ambient (25C), soil (22C): Ts	25.0	25.0	22.0	25.0	22.0
avg.temp.diff.= Tf-Ts (F): dT	75.7	145.5	151.1	144.9	150.7
average heat loss (Btu/hr) Q	96,112	1,849	1,758	2,372	2,118
order of effective insulation	5th	2nd	1st	4th	3rd
The most effective insulation can be obtained by maximizing R6=Lk/(k*A): **a) maximum insulation thickness (Lk)** **b) minimum conductivity (k)** **c) minimum conduction area (A)**					

Fig. 2 Steady State Pipe Flow - Core Fluid Temperature Changes



As shown in Fig. 1 the heat transfer of aboveground pipe is very similar to that of the underground pipe. The only difference in heat transfer between the above and underground pipes is thermal resistance, R7. Thermal resistance (R7) of aboveground pipe is mainly affected by radiation and convection by ambient air. It can be calculated by using the preceding Basic Equations (4), (5), (6), and (7) or R7 = 1/(h7*A7).

Thermal resistance (R7) of underground pipe is affected by conduction of soil. It can be calculated by using the preceding Basic Equation (9) which is a form of
R7 = Lk7 / (k7*Am7) or
R7 = Logn { (dh/ro) + [(dh/ro)^2 - 1]^0.5 } / (2*πi*ks*L)

Other thermal resistances such as R1, R2, R3, R4, R5, R6 of Basic Equations. (7) and (8) are the same between above and underground pipes.

For hot temperature service such as superheated steam or hot water transfer, the outer surface temperatures of aboveground pipes should be at or below a predetermined value for personnel safety and equipment protection. For cold temperature service such as coolant or chilled water transfer, insulation outer surface temperature should be above the dew point temperature of the surrounding air to prevent condensation.

Most of city water, sewage and liquid waste are usually transferred through single or double underground pipe lines.

The important variables of the underground pipe heat transfer are:

1) Type of fluid flow affecting the inner-most core pipe film coefficient
2) Pipe material affecting the pipe wall conduction.
3) Type of soil affecting dissipation of heat away from the pipeline.
4) Moisture content of the soil affecting dissipation of heat through soil
5) Wind velocity and ground soil surface characteristics around pipeline

The basic pipe flow data used in the heat transfer model calculation are:

a) 4" stainless steel single or inner core pipe, sch.40
b) 6" carbon steel jacket outer pipe, schedule 40
c) 5.13" thick insulation with thermal conductivity of 0.0267 Btu/hr ft F
d) 6 ft deep of buried pipe soil with thermal conductivity of 0.5 Btu/hr ft F
e) 93.3 gal/min core pipe fluid flow with film coefficient of 1182 Btu/hr ft2 F
f) starting fluid temperature at 107 C
g) average core fluid specific gravity is 0.98
h) total pipe flow travel is 9100 feet

Figure 2 shows steady state pipe flow-fluid temperature change during the total pipe flow travel of 9100 feet. The heat loss from the moving fluid to the surrounding ambient air or underground soil varies as it travels along the whole pipe length. The greater temperature difference between the fluid and surrounding, the more heat loss occurs. The calculation results of steady state pipe flow heat loss of various pipes is shown in Table 1.

The average heat loss (Q: Btu/hr) shown in Table 1 is based on the difference between average core fluid (Tf) temperature and surrounding ambient air or soil temperature Ts).

1) <u>aboveground uninsulated single pipe</u>
core fluid temperature = 107 to 27.2 C
heat loss = Q = 96,112 Btu/hr

2) <u>aboveground insulated single pipe</u>
core fluid temperature = 107 to 104.7 C
heat loss = Q = 1,849 Btu/hr

3) <u>underground insulated single pipe</u>
core fluid temperature = 107 to 104.9 C
heat loss = Q = 1,758 Btu/hr

4) <u>aboveground insulated double pipe</u>
core fluid temperature = 107 to 104.0 C
heat loss = Q = 2,372 Btu/hr

5) <u>underground insulated double pipe</u>
core fluid temperature = 107 to 104.4 C
heat loss = Q = 2,118 Btu/hr

UNDERGROUND DOUBLE PIPE MODEL

In a steady state condition when the environment condition is constant, we can assume that the soil or ambient air temperature (Ts) remains constant.

Consider a underground horizontal insulated double pipe as shown in the lower right position of Figure 1. It is 9100 feet long and its 4" core pipe carries a hot fluid starting 107C from one end and moving toward the other end. As the fluid moves inside the core pipe, the fluid temperature (Tf) will gradually decreases. The changing temperatures of core fluid can be calculated in the following procedure.

(A) Moving Fluid Calculation Procedure

1. Subdivide the entire pipe length into many intervals or elements. If the number of intervals or pipe elements selected is n = 100, we have a length of each pipe interval (L) = 9100 ft / 100 = 91 ft.
   The initial temperature (To) of the first interval at Xi=0 ft is known but the unknown ending temperature (Te) at Xe=91 ft is to be calculated.

2. Calculate individual thermal resistance (R1,R2,R3,R4,R5,R6 and R7) and total resistance (R) by using the previously shown Basic Equations (1) through (10).

2. From the heat balance equation,
   (M)(C)(To-Te) / t = (Tf - Ts) / R
   the ending temperature (Te) of the first interval (Te) can be calculated.
   Te = To - (Tf-Ts)(t)/(M)(C)(R) ----- Eq. (11).

   Average or mean fluid temperature of the first or typical interval be
   Tf = (To+Te)/2
   2 Tf = To + [To - (Tf-Ts)(t)/(M)(C)(R)]
   Tf = (2*M*C*R*To + Ts*t) / (2*M*C*R + t)

3. The second interval starting temperature (To2) is the same as the ending temperature of the first interval (Te).

   Average or mean fluid temperature of the second interval becomes
   Tf2 = (To2+Te2)/2
   2 Tf2 = To2 + [To2 - (Tf2-Ts)(t)/(M)(C)(R)]
   Tf2 = (2*M*C*R*To2 + Ts*t) / (2*M*C*R + t)

4. The third interval starting temperature (To3) is the same as the ending temperature of the second interval (Te2).

   Average or mean fluid temperature of the third interval becomes
   Tf3 = (To3+Te3)/2
   2 Tf3 = To3 + [To3 - (Tf3-Ts)(t)/(M)(C)(R)]
   Tf3 = (2*M*C*R*To3 + Ts*t) / (2*M*C*R + t)

5. Continuing this way we can calculate the fluid temperature from the first interval to the last 100th interval from Xi=9009 ft to Xe=9100 ft.

6. The last interval starting temperature (To100) is the same as the ending temperature of the 99th interval (Te99).

   Average or mean fluid temperature of the 100th interval becomes
   Tf100 = (To100+Te100)/2
   2 Tf100 = To100 + [To100 - (Tf100-Ts)(t)/(M)(C)(R)]
   Tf100 = (2*M*C*R*To100 + Ts*t) / (2*M*C*R + t)

SINGLE PIPE MODEL

The heat transfer modeling of single pipe can be made in the same method and procedure as that of double or core-jacket pipe.

The following individual thermal resistances are zeros for single pipes:

annular air thermal resistance, R4 = 0
jacket or outer pipe wall resistance, R5 = 0

Total resistance of a single pipe system is
R = R1 + R2 + R3 + R6 + R7

The heat balance equation of a single pipe is
(M)(C)(To-Te) / t = (Tf - Ts) / R

(B) Stagnant Fluid Calculation Procedure

Most of above and underground transfer pipe lines are almost fully or partially filled with fluid during the time of valve closing or pump-off. If the ambient air or surrounding soil temperature is lower than the core fluid temperature, the natural pipe cooling will continue with stagnant fluid. The pipe and insulation will be also cooled down in the stagnant flow. It is important to analyze the significance of pipe cooling during the stop.

Consider the previous underground horizontal double pipe containing a horizontal double pipe containing hot fluid with initial temperature of 107 C.

1. Complete a previous calculation procedure for steady state moving fluid before the fluid stops.
   The total thermal resistance (hr F/Btu) = R
   The total thermal transmittance (Btu/hr F) = H = 1/R

2. Estimate the percent of stagnant fluid filling the core pipe inner space.
   (% fill) = 100%, 50%, or 0 % as needed.

   Note: 100% was used in the calculation for Fig.4.

3. Calculate the heat to be removed for 1 deg C drop of core fluid temperature per pipe interval.

   Fluid heat content (Btu/C) per interval
   = (M) (C) (1.8 degF) = (1.8*M*C)

4. Select a temperature drop increment (dT) as needed (0.1, 0.25, 0.5 or 1): For Example, dT= 1 C.

   The smaller dT selected, the higher accuracy can be achieved.

   Calculate the cooling Btu to drop dT of fluid (Btu)
   = 1.8*M*C*dT

5. Calculate the first temperature difference between fluid and soil.

   Tf1 = (107+106)/2 = 106.5 C
   (Tf1-Ts) = 106.5 C - 22 C = 84.5 C = 152.1 F

   Heat Loss (Btu/hr) = (H)*(Tf1-Ts) = (Tf1-Ts) / R

   Time interval for stagnant fluid to cool dT or 1 C temperature drop (hr)
   tc1 = (1.8*M*C*dT) / [H*(Tf1-Ts)]

6. Calculate the second temperature difference between fluid and soil.

   Tf2 = (106+105)/2 = 105.5 C
   (Tf2-Ts) = 105.5 C - 22 C = 83.5 C = 150.3 F

   Heat Loss (Btu/hr) = (H)*(Tf2-Ts) = (Tf2-Ts) / R

   Time interval for stagnant fluid to cool dT or 1 C temperature drop (hr)
   tc2 = (1.8*M*C*dT) / [H*(Tf2-Ts)]

7. Continuing this way we can calculate the time interval for stagnant fluid to cool continuing gradual temperature drop dT.

8. Calculate the last temperature difference between the fluid (Tend) and soil (Ts) = (Tend - Ts)

   Heat Loss (Btu/hr) = (H)*(Tend-Ts) = (Tend-Ts) / R

   Time interval for stagnant fluid to cool dT temperature drop (hr)
   tc end = (1.8*M*C*dT) / [H*(Tend-Ts)]

9. Total time to cool down the fluid temperature from 107 to Tend.

   Total tc time (hr)
   = tc1 + tc2 + tc3 + ----------+ tc end

10. By using Basic Equations (13) through (16) and spreadsheet computer calculations, we can calculate the mean temperatures of core pipe, annular air, outer jacket pipe, and insulation or pipe covering.

Figure 3 shows the calculation results of 168 hour cooling analysis of above underground double pipe.

In the calculation for Figure 3, we selected dT= ~0.25C to achieve a higher degree of accuracy instead of 1C as shown in step 4.

Fig. 3

168 Hour Cooling Analysis Of Underground Double Pipe

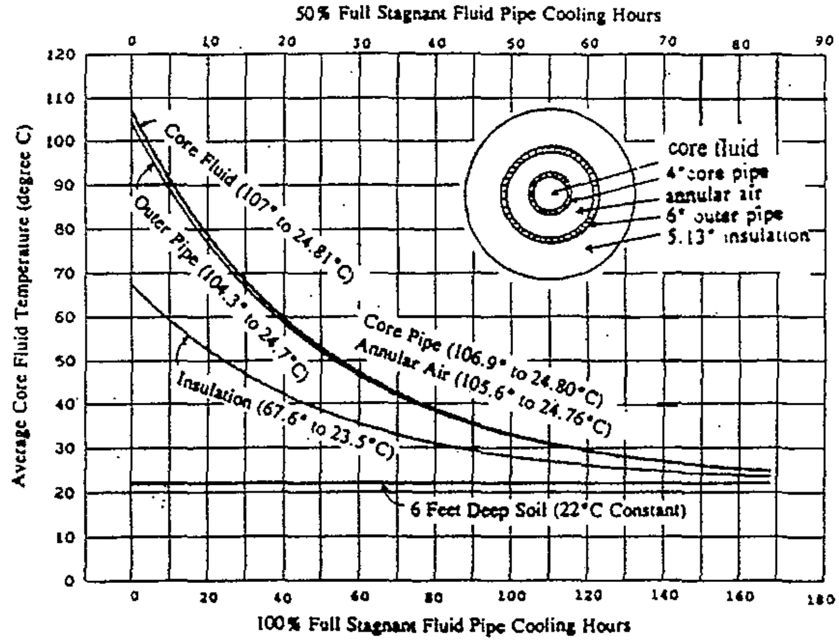
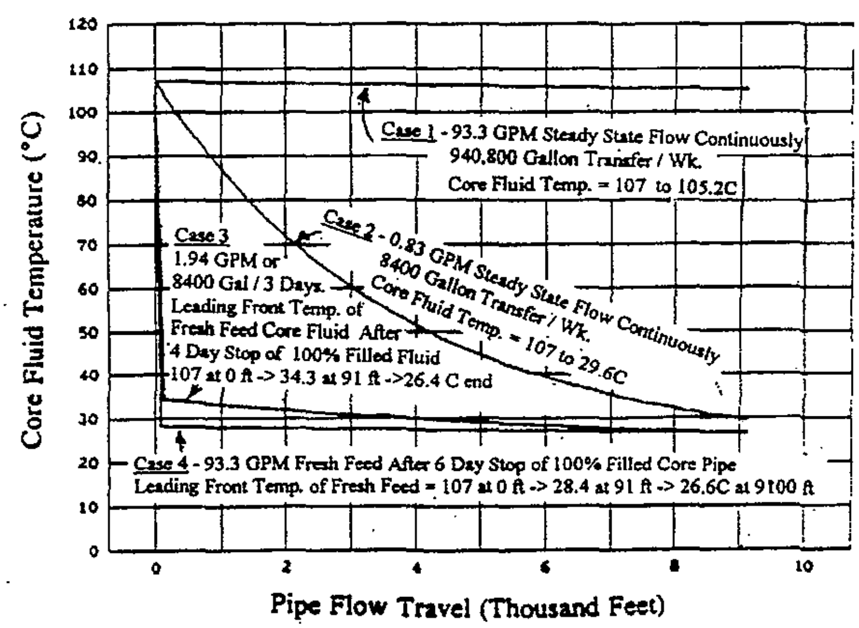


Fig. 4

Thermal Analysis of Underground Double Pipe (9100 Feet)



COMBINED MOVING AND STAGNANT FLUID MODELING

The following actual case of batch flow condition was analyzed by using two previous calculation procedures for moving fluid and stagnant fluid (see Figure 4).

Actual Batch Flow Condition:
Stop 4 days and subsequent Intermittent Flow

1400 gallon for 15 minutes (93.3 GPM) Every 12 Hours for 3 days / week.

(a) Cumulative Stop (stagnant fluid)
= 4 days + 11.75 hours x 6
= 166.5 hours /week
= 6.9375 days / week
= almost 7 days / week

(b) Cumulative Flow (moving fluid)
= 93.3 GPM for 90 minutes / wk
= 8,400 gallon transfer / wk

(c) Actual Batch Flow Case is close to Cases 2, 3, or 4
Case 2 is a quick steady state approximation method.
Case 3 or Case 4 is more accurate calculation method including unsteady cooling of stagnant fluid.

DISCUSSION

Case 1 is steady state full flow 93.3 gpm for 7 days and results in 104.4 C at the end of 9100 ft travel.

Case 2 is steady state flow of 0.83 gpm for 7 days and results in 29.6 C at the end of 9100 ft travel.

Case 3 is a combined stagnant fluid (4 days) and moving fluid (3 days) at 1.94 gpm and results in 26.4 C at the end of 9100 ft travel.

Case 4 is also a combined stagnant fluid (6 days) and moving fluid (1 day) at 93.3 gpm and results in 26.6 C at the end of 9100 ft travel.

For simplicity, the transition effect of mixing existing old fluid and new fluid is excluded in Case 3 and Case 4.

CONCLUSION

The most common pipe flow is unsteady batch type flow or combination of moving fluid and stagnant fluid. The calculation method shown in Case 4 is most likely the most accurate. Calculating core fluid temperature changes and pipe heat loss by using Case 2 steady state condition formula is probably good enough to most plant engineers who need quick approximation.

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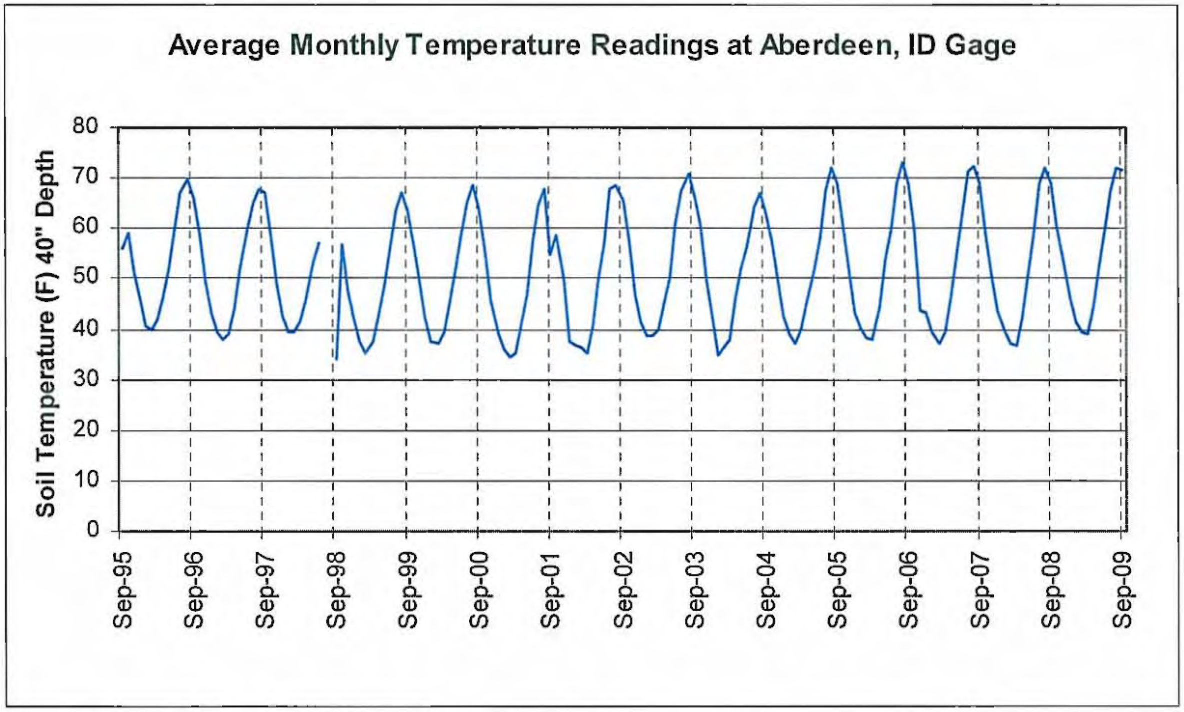
Exhibit 2406

Soil Temperature at Aberdeen



Source: USBR Pacific Northwest Region, Hydromet System Data Access