

STATE OF IDAHO
DEPARTMENT OF WATER RESOURCES
APPLICATION FOR PERMIT

To appropriate the public waters of the State of Idaho

1. Name of Applicant Walters Ready Mix, Inc. Phone (208) 356-5491 / (Fax) 356-5553
 Mailing address 342 W 4TH N, REXBURG, ID 83440 Email wrm@ida.net
c/o Keith C. Wilson Rocky Mountain Environmental Associates, Inc. Email kwilson@rockymountainenvironmental.com
482 Constitution Way, Ste 303, Idaho Falls ID 83402 (208) 524-2353 Fax 208) 524-1795
2. Source of water supply Groundwater which is a tributary of _____
3. Location of point of diversion is Township 6N Range 40E Sec. 19, in the _____ ¼,
SE ¼, NW ¼, Govt. Lot _____, B.M., Madison County;
 additional points of diversion if any: SW¼NE¼, Sec 19, T6N, R40E
4. Water will be used for the following purposes:
 Amount 4.99 cfs for Industrial purposes from 04/01 to 10/31 (both dates inclusive)
(cfs or acre-feet per year)
5. Total quantity to be appropriated is (a) 4.99 cfs and/or (b) _____
cubic feet per second acre feet per year
6. Proposed diverting works:
 - a. Describe type and size of devices used to divert water from the source Existing sub-water pond (ground water) with a pump located on a barge that is moved around in the pond as needed, with mainline to gravel/sand washing facility. After use, the water is discharged back into the sub-water pond.
 - b. Height of storage dam _____ feet; active reservoir capacity _____ acre-feet;
 total reservoir capacity _____ acre-feet
 - c. Proposed well diameter is _____ inches; proposed depth of well is _____ feet
 - d. Is ground water with a temperature of greater than 85°F being sought? No
 - e. If well is already drilled, when? _____; Drilling firm _____;
 Well was drilled for (well owner) _____; Drilling Permit No. _____
7. Time required for completion of works and application of water to proposed beneficial use is 5 years (minimum 1 year)
8. Description of proposed uses (if irrigation only, go to item 9):
 - a. Hydropower; show total feet of head and proposed capacity in kW. _____
 - b. Stockwatering; list number and kind of livestock. _____
 - c. Municipal; show name of municipality. _____
 - d. Domestic; show number of households. _____
 - e. Other; describe fully. Gravel and sand washing facility. Facility will use a Kolberg Series 1800 Screening-Washing Plant, Model 1830PH (See Attachment #4)

RECEIVED

APR 02 2009



Rocky Mountain
ENVIRONMENTAL
ASSOCIATES, INC.

(208) 524-2353

Fax (208) 524-1795

Walters Ready Mix – Application for Permit-Rex

Prepared by Keith C. Wilson

Page 1 of 9

Rocky Mountain Environmental Associates Inc.

482 Constitution Way, Suite 303, Idaho Falls, ID 83402
 Department of Water Resources
 Eastern Region

22-13967

9. Description of place of use:

- a. If water is for irrigation, indicate acreage in each subdivision in the tabulation below.
b. If water is used for other purposes, place a symbol of the use (example: D for Domestic) in the corresponding place of use below. See instructions for standard symbols. (I = Industrial)

Twp	Rge	Sec	NE ¼				NW ¼				SW ¼				SE ¼				Totals
			NE ¼	NW ¼	SW ¼	SE ¼	NE ¼	NW ¼	SW ¼	SE ¼	NE ¼	NW ¼	SW ¼	SE ¼	NE ¼	NW ¼	SW ¼	SE ¼	
6N	40E	19			I				I	I									

Total number of acres to be irrigated: _____

10. Describe any other water rights used for the same purposes as described above. Include water delivered by a municipality, canal company, or irrigation district. If this application is for domestic purposes, do you intend to use this water, water from another source, or both, to irrigate your lawn, garden, and/or landscaping? Recommended adjudication right 22-11666 for 0.04 cfs from the same ground water source is used for industrial use and is insufficient to wash sand and gravel on a commercial scale.

11. a. Who owns the property at the point of diversion? Applicants
b. Who owns the land to be irrigated or place of use? Applicants
c. If the property is owned by a person other than the applicant, describe the arrangement enabling the applicant to make this filing: N/A

12. Describe your proposal in narrative form, and provide additional explanation for any of the items above. Attach additional pages if necessary. The source of water for this application is sub-water (ground water) that naturally fills an existing gravel pit to form a pond located on the applicants property. Right 22-11666 also uses this same ground water source. This application is for a non-consumptive diversion rate to operate a gravel and sand washing facility. After washing the gravel and sand, the waste water will be discharged back into the sub-water pond. The sub-water pond covers approximately 35 acres with an average depth of ~25 feet. The diversion pump (P/D is mounted on a barge that is moved around in the pond as needed. The facility operates an average 10 hours per day, 6 days per week for 7 months of the year. The sand and gravel remain on site and any water retained by the sand and gravel will drain back into the sub-water pond.

The existing sub-water pond (i.e. gravel pit) already has an existing consumptive use component due to evapotranspiration. This application will not result in an increase in consumption use hence, mitigation should not be required.

13. **MAP OF PROPOSED PROJECT REQUIRED** - Attach an 8½"x11" map clearly identifying the proposed point of diversion, place of use, section #, township & range. (A photocopy of a USGS 7.5 minute topographic quadrangle map is preferred.) - [See Attachment #1]

BE IT KNOWN that the undersigned hereby makes this application for permit to appropriate the public waters of the State of Idaho as herein set forth.

David Z. Walters

Signature of Applicant

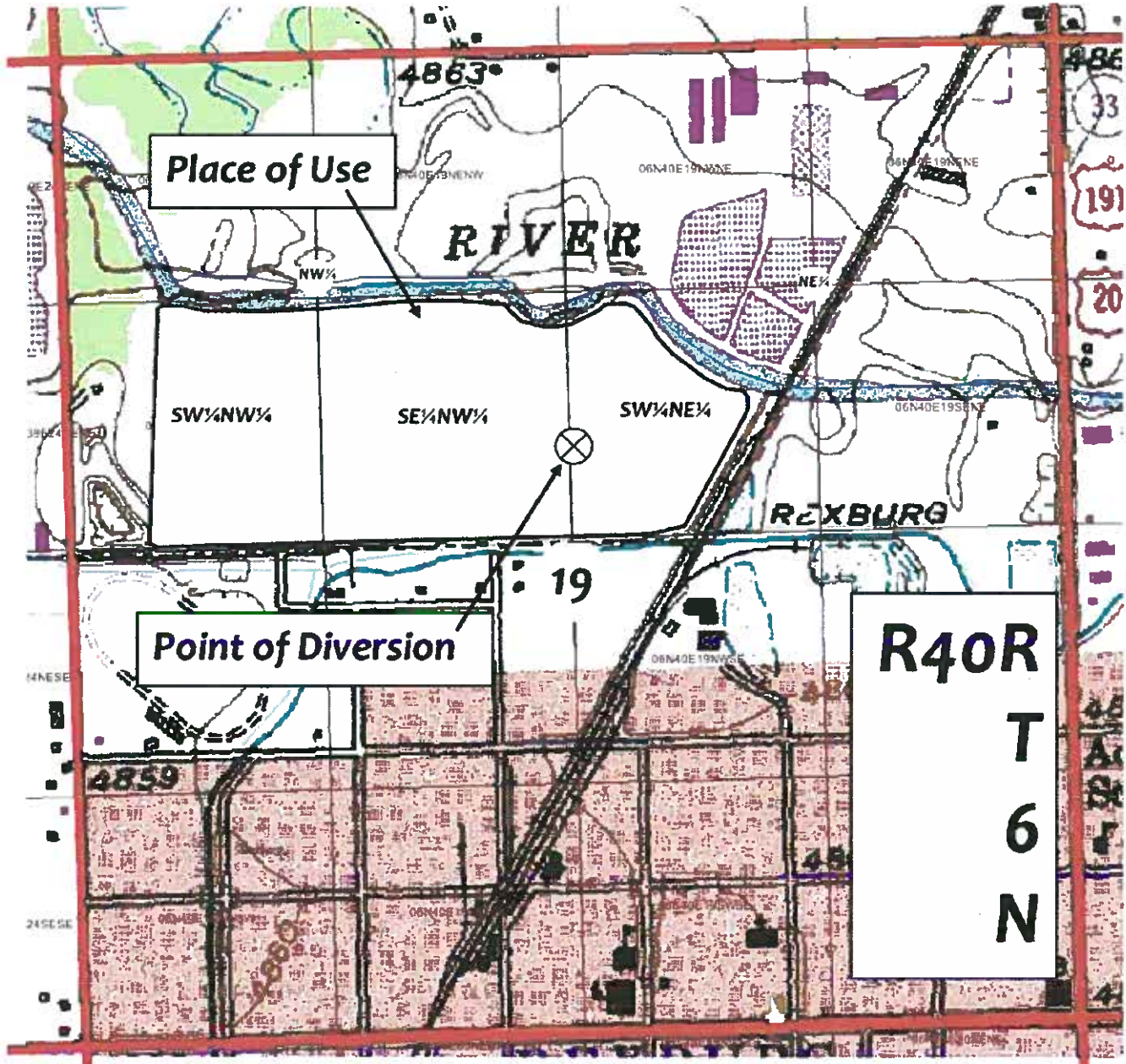
DAVID Z. WALTERS PRESIDENT

Print Name (and title, if applicable)

For Department Use:

Received by _____ Date _____ Time _____ Preliminary check by _____
Fee \$ 410.0 Received by Blair Receipt No. E034961 Date 4/21/09

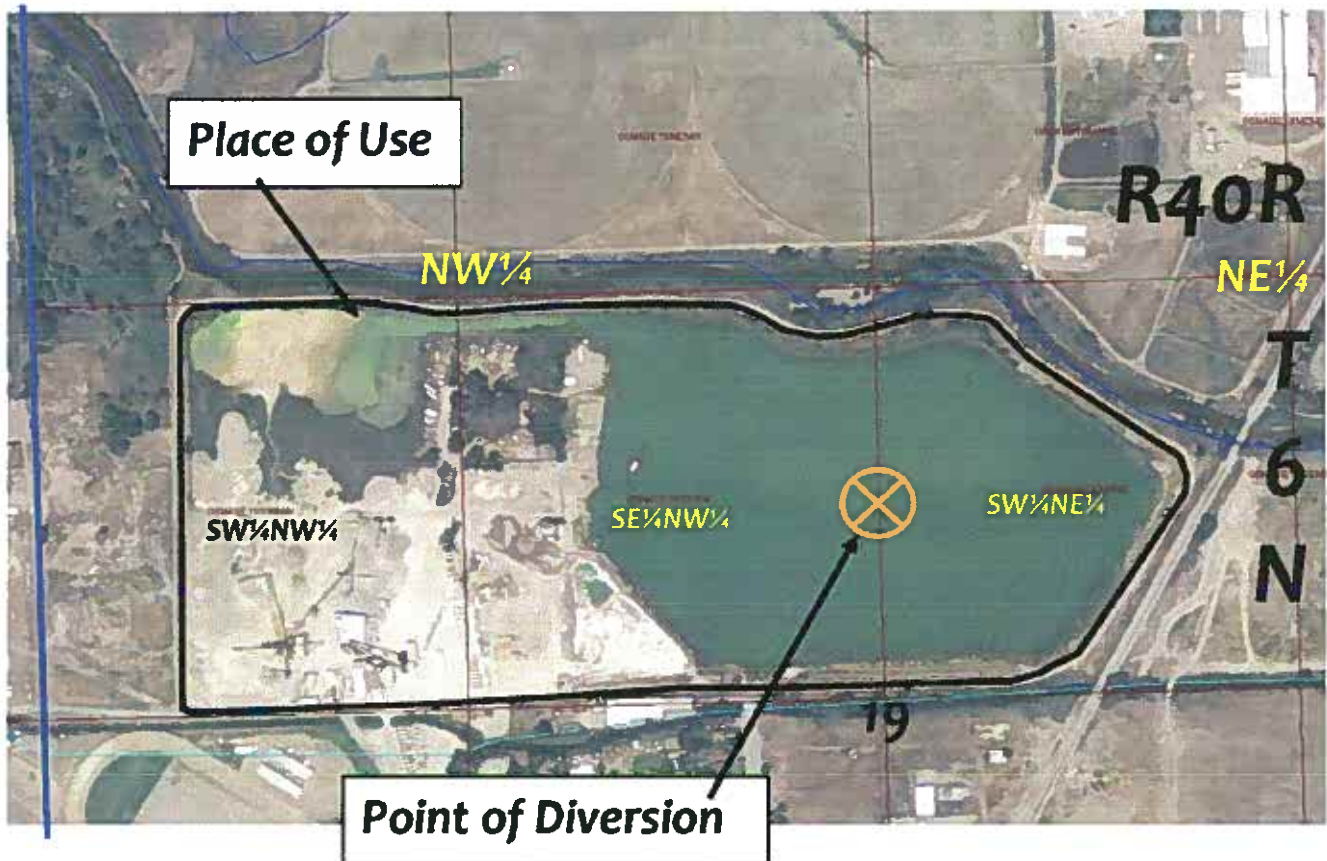
Walters Ready Mix, Inc.



Note:

The diversion pump is mounted on a barge and is moved around within the SE 1/4 NW 1/4 & SW 1/4 NE 1/4.

Walters Ready Mix, Inc.



Note:

The diversion pump is mounted on a barge & is moved around the pond (SE 1/4 NW 1/4 & SW 1/4 NE 1/4) as needed.

Mitigation Walters Ready Mix

The gravel washing facility is located within the S½NW¼ & SW¼NE¼, Sec 19, T06N, R40E. Water will be used for industrial use for the washing of aggregate at the facility. The waste water will then be discharged back into the sub-water pond (ground water). The sub-water pond is ground water that naturally fills and existing gravel pit, and is identified as ground water in the recommended adjudication claim 22-11666. The sub-water pond covers approximately 35 acres with an average depth of 25 feet.

The industrial use of water to wash aggregate is a non-consumptive use and with the aggregate stored on site any water retained in the aggregate due to washing will drain back into the sub-surface pond. Without a consumptive use component no mitigation should be required.

Even without this application the existing evaporative loss for the ground water (sub-water) pond has been calculated to be 80.5 ac-ft annual (see Pond calculations next page).

Attachment # 2 (PG 2 of 2)

Current Existing Consumptive Use Due to Evapotranspiration

Pond Consumptive Use Calculations

Climate Station: **Rexburg Ricks College (NWS NOAA-107644)**
Project Name: **Walters Ready Mix, Inc - Rexburg**

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Annual FWS Evaporation (inches)	40	40	40	40	40	40	40	40	40	40	40	40	40
Monthly Distribution (%) # 1	1	2	4	7	12	15	19	16	11	6	4	3	100
Monthly FWS Evaporation (in/mo)	0.40	0.80	1.60	2.80	4.80	6.00	7.60	6.40	4.40	2.40	1.60	1.20	40.00
Avg. Total Precipitation (in/mo) # 2	1.09	1.02	1.04	1.21	1.8	1.42	0.86	0.69	0.89	1.17	1.03	1.08	13.29
Pond Loss [(Evap.) - (Precip., in.)] # 3	0.00	0.00	0.56	1.59	3.00	4.58	6.74	5.71	3.51	1.23	0.57	0.12	27.61
Pond Surface Area (acres)	35	35	35	35	35	35	35	35	35	35	35	35	35
Total Pond Loss (ac-in)	0.00	0.00	19.60	55.65	105.00	160.30	235.90	199.85	122.85	43.05	19.95	4.20	966.35
Total Pond Loss (ac-ft)	0.00	0.00	1.63	4.64	8.75	13.36	19.66	16.65	10.24	3.59	1.66	0.35	80.53

Current Total Pond Loss (ac-ft) = 80.53 ac-ft

(# 1) **Monthly Distribution (%) # 1: Monthly Shallow Lake Evaporation percentages for Idaho**

Area	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	1	2	3	9	12	14	19	18	11	6	4	2
2	1	2	3	8	12	15	19	17	11	6	4	3
3	1	2	4	8	14	15	17	16	10	6	5	3
4	1	2	4	7	12	15	19	16	11	6	4	3
5	1	3	5	10	12	14	16	15	10	6	5	3

(# 2) **REXBURG RICKS COLLEGE, IDAHO (107644)**

Period of Record Monthly Climate Summary

Period of Record : 7/ 1/1977 to 12/31/2007

Data as of 03/17/2009

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	29.1	33.4	46.3	57.3	66.1	74.9	84.0	84.3	73.6	60.0	41.7	30.3	56.7
Average Min. Temperature (F)	10.4	14.0	23.6	30.8	38.6	45.0	49.5	47.4	38.8	30.1	20.6	11.7	30.0
Average Total Precipitation (in.)	1.09	1.02	1.04	1.21	1.80	1.42	0.86	0.69	0.89	1.17	1.03	1.08	13.29
Average Total Snowfall (in.)	14.0	10.7	3.9	2.2	0.5	0.0	0.0	0.0	0.1	1.1	7.0	15.4	55.0
Average Snow Depth (in.)	8.0	7.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	5.0	2.0

#1 - Molnau, Myron, Kporde, Kajo C.S., and Craine, Katherine L., 1993. Monthly shallow pond evaporation in Idaho. ASAE paper PNW 93-111.

#2 - Data collected from the Western Regional Climate Summary, Monthly Climate Summary @ <http://www.wrcc.dri.edu/summary/Climsmsid.html>. See attached:

#3 - [(Monthly FWS Evap.) - (Avg. Total Precip.)] = Value (Value < 0 = 0) Note: Where Avg. Total Precipitation exceeds Monthly FWS Evaporation, the resultant pond loss (Value < 0 = 0) is set to zero.

#4 - <http://www.kimberly.uidaho.edu/ETIdaho/> Precipitation Deficit values used synonymously w/mean irrigation requirement. Values from Allen, Richard G. & Clarence W. Robison, 2006 (Revised 2007). Evapotranspiration & Consumptive Irrigation Water Requirements - Idaho, Research Technical Completion Report, Kimberly Research & Extension Center,

#5, 6, 7 & 8 - Computed values based on #1, 2, 3 & 4

Attachment # 3



IDAHO SECRETARY OF STATE

Viewing Business Entity

Ben Ysursa, Secretary of State

WALTERS READY-MIX, INC.

P O BOX 390
REXBURG, ID 83440-0390

Type of Business: CORPORATION, GENERAL BUSINESS
Status: GOODSTANDING, ANREPT SENT 02 May 2008
State of Origin: IDAHO
Date of Origination/Authorization: 11 Jul 1979
Current Registered Agent: DAVID Z WALTERS
 342 WEST FOURTH NORTH
 REXBURG, ID 83440
Organizational ID / Filing Number: C61583

No. C 61583		Due no later than July 31, 2008 Annual Report Form		2. Registered Agent and Office NO PO BOX	
Return to: SECRETARY OF STATE 450 NORTH FOURTH STREET PO BOX 83720 BOISE, ID 83720-0080		1. Mailing Address - Correct in this box, if applicable WALTERS READY-MIX, INC. DAVID A. WALTERS P O BOX 390 REXBURG, ID 83440-0390		DAVID Z WALTERS 342 WEST FOURTH NORTH REXBURG, ID 83440	
NO FILING FEE IF RECEIVED BY DUE DATE				3. New Registered Agent Signature	
4. Corporations: Enter Names and Business Addresses of President, Secretary and Directors.					
<u>Office held</u>	<u>Name</u>	<u>Street or P.O. Address</u>	<u>City</u>	<u>State</u>	<u>Zip</u>
President	David Z. Walters	P.O. Box 390	Rexburg	ID	83440
Secretary	Charlene Walters	P.O. Box 390	Rexburg	ID	83440
5. Organized Under the Laws of: IDAHO C 61583			6. Signature <i>David Z Walters</i> Date 5/15/08		
			Name (Typed or Printed) David Z. Walters Title President		
			200807000585		

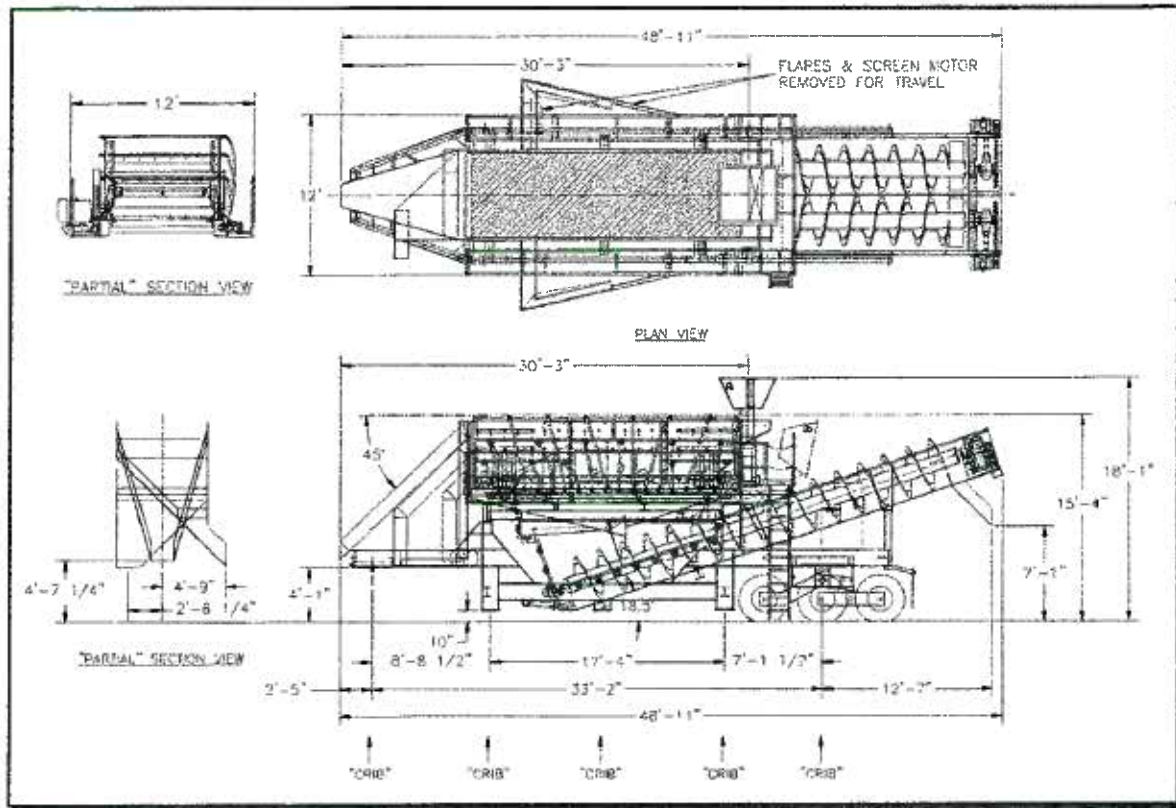
Issued 05/02/2008

Do Not Tape or Staple

22-13967



**SERIES 1800 SCREENING/WASHING PLANT
Model 1830PH Spec Sheet**



SCREEN:

Kolberg-Pioneer Inc. horizontal 6' x 20' triple deck vibrating screen featuring 40 HP v-belt drive (1200 RPM motor), huck bolted assembly, 1/4" plate steel side plates, 160 mm double-roll spherical self-aligning bearings, triple shaft vibrating mechanism complete with keyless hold-fast hub locking assembly, stroke amplitude (9/16"-3/4") and angle (30°-60° in 5° increments) adjustment, adjustable speed motor sheave (675-875 rpm) and fully contained splash oil lubrication. Other features include heavy duty rubber spring suspension system with rubber snubbers and side tension drawbar screen cloth retention system (screen cloth is optional).

KOLBERG MODEL 5044-32T SANDPREP (FINE MATERIAL WASHER):

Tank is of 1/4" and 3/8" plate steel construction and includes the following features: 1) Drive assembly (one

drive assembly per spiral) includes a high efficiency Dodge TA7315H40 shaft mount reducer, 20 HP motor and v-belts (sheave changes are all that is required to adjust the screw speed), 2) Greaseable Dodge upper and lower bearings, 3) Stainless steel wear sleeve, water tight rubber seal and secondary grease seal prevent leakage and wear on the lower stub shafts for longer service life, 4) Double pitch, solid flight spirals with steel inner wear shoes and urethane outer wear shoes (ni-hard outer wear shoes are optional), 5) 26' of adjustable weir boards designed to handle large volumes of slurry and to control the pool level for uniform overflow, 6) A large undisturbed pool area which provides accurate material classification, 7) Rising current manifold with 4" inlet designed to control fines and velocity within the pool and 8) 1 1/2" chase water line to flush water down the inside of the tub wall to clear the drain trough.

Note: See Model 5044-32T specification sheet for further information.

NOTE: Specifications are subject to change without notice.

Attachment # 4 (Pg 2 of 2)

WATER SYSTEM:

All water required for the plant is factory plumbed to a single 6" dia. inlet near the tail end of the sandprep. The primary manifold includes a 4" butterfly valve, 4" swing check valve, 0-100 psi pressure gauge and flexible 4" connection to the screen manifold. A 1½" connection with two (2) gate valves for the chase water of the sandprep (one gate valve for each drain trough) is provided from the screen manifold. The screen manifold also includes seventeen (17) 1¼" gate valves for water control to the seventeen (17) spray bars located on the screen. Each spray bar is fitted with nineteen (19) spray nozzles, each with a capacity of 10.0 gpm @ 40 psi. An additional 3" connection is included in the screen manifold to provide water to the optional feed/slurry box.

SCREEN CHUTES / FINES HOPPER:

Screen overs chutes are constructed of 3/16" plate steel and allow for three stacking conveyors to be positioned under the king pin area of the plant reducing the need for constant moving of material with a loader. The fines hopper located under the screen is also constructed of 3/16" plate steel and transitions to form the feed box and baffle of the 44" twin sand screw.

WALKWAY:

A 28½" wide walkway is provided across the back of the screen and a 19" wide walkway is provided along both sides of the screen. The walkway includes grip-strut decking and 1-1/2" O.D. top and intermediate handrail pipes. Access is via a 16" wide removable ladder to grade. The walkway is an integral part of the heavy duty screen support structure.

CHASSIS:

Main truck frame beams are of heavy 15" I-beam construction. Chassis includes fifth wheel king pin, triple Dana 22,000# axles, dual 11:00 x 22.5 tires (total of twelve), air brakes, travel lights (i.e. - stop, tail and turn), mudflaps and cribbing locations.

PHYSICAL/OPERATING CHARACTERISTICS:

Overall Length: 33'-2" (king pin to axle)
Travel Width: 12'-0"
Travel Height: 15'-4"
Feed Height: 15'-4" (without feedbox)
Feed Height: 18'-1" (with feedbox)
Overall Weight: 75,050 lbs.
King Pin: 22,200 lbs.
Axle: 52,850 lbs.
Second Load Misc. Weight: 6,000 lbs.
Note: Individual plant weights will vary dependent upon options.

Sandprep Capacity: 350 tph (@ 100% of screw speed)
Water Requirements: Up to 2,700 gpm (dependent on feed gradation)

OPTIONAL EQUIPMENT:

- * Feed/Slurry Box: 48" x 48" top opening with one (1) 3" dia. header pipe. Hinged design with manual winch to lower the feed box into the travel position.
- * Wear Liners: 3/16" AR weld-in liners for all three screen overs chutes and the fines collecting hopper.
- * Wedge Bolts: Wedge bolts for screen cloth retention in lieu of standard bolts and beveled washers.
- * Quickstop (screen).
- * Screen Cloth.
- * Electrical: NEMA 4 control panel with main circuit breaker, on/off switches for the screen and sand screw and capacity for additional starters (consult factory for specific details). Control panel mounted on the truck frame and hard wired to the screen and sand screw motors.
- * Ni-hard Outer Wear Shoes vs. Std. Urethane (sand screw).
- * Side-delivery Conveyors: Center & Bottom deck overs side-delivery conveyors (24" x 8' fixed or 24" x 14' folding conveyors).

NOTE: Specifications are subject to change without notice.

**FOR MORE INFORMATION CALL 1-800-542-9311 AND ASK FOR A KOLBERG EQUIPMENT SPECIALIST.
YOUR AUTHORIZED DEALER:**

KOLBERG-PIONEER, INC.

700 W. 21st Street - P.O. Box 20
Yankton, South Dakota 57078
Phone: (605) 665-8771 - FAX: (605) 665-8858
mail@kolbergpioneer.com - www.kolbergpioneer.com

Because Kolberg-Pioneer, Inc. may use in its catalog & literature, field photographs of its products which may have been modified by the owners, products furnished by Kolberg-Pioneer, Inc. may not necessarily be as illustrated therein. Also continuous design progress makes it necessary that specifications be subject to change without notice. All sales of the products of Kolberg-Pioneer, Inc. are subject to the provisions of its standard warranty. Kolberg-Pioneer, Inc. does not warrant or represent that its products meet any federal, state, or local statutes, codes, ordinances, rules, standards or other regulations, including OSHA and MSHA, covering safety, pollution, electrical wiring, etc. Compliance with these statutes and regulations is the responsibility of the user and will be dependent upon the area and the use to which the product is put by the user. In some photographs, guards may have been removed for illustrative purposes only. This equipment should not be operated without all guards attached in their normal position. Placement of guards and other safety equipment is often dependent upon the area and the use to which the product is put. A safety study should be made by the user of the application, and, if required additional guards, warning signs and other safety devices should be installed by the user, wherever appropriate before operating the products.

M01 T830PH Rev. 1 8/03 Printed in USA

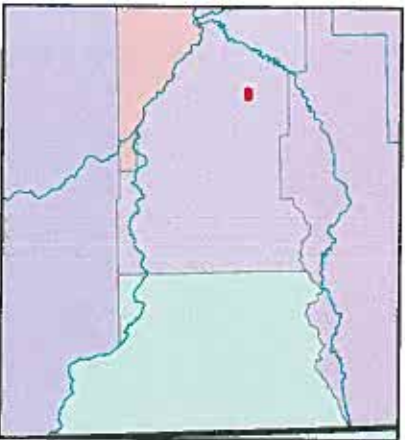


Idaho Department of Water Resources

Application
22-13967
(INDUSTRIAL)

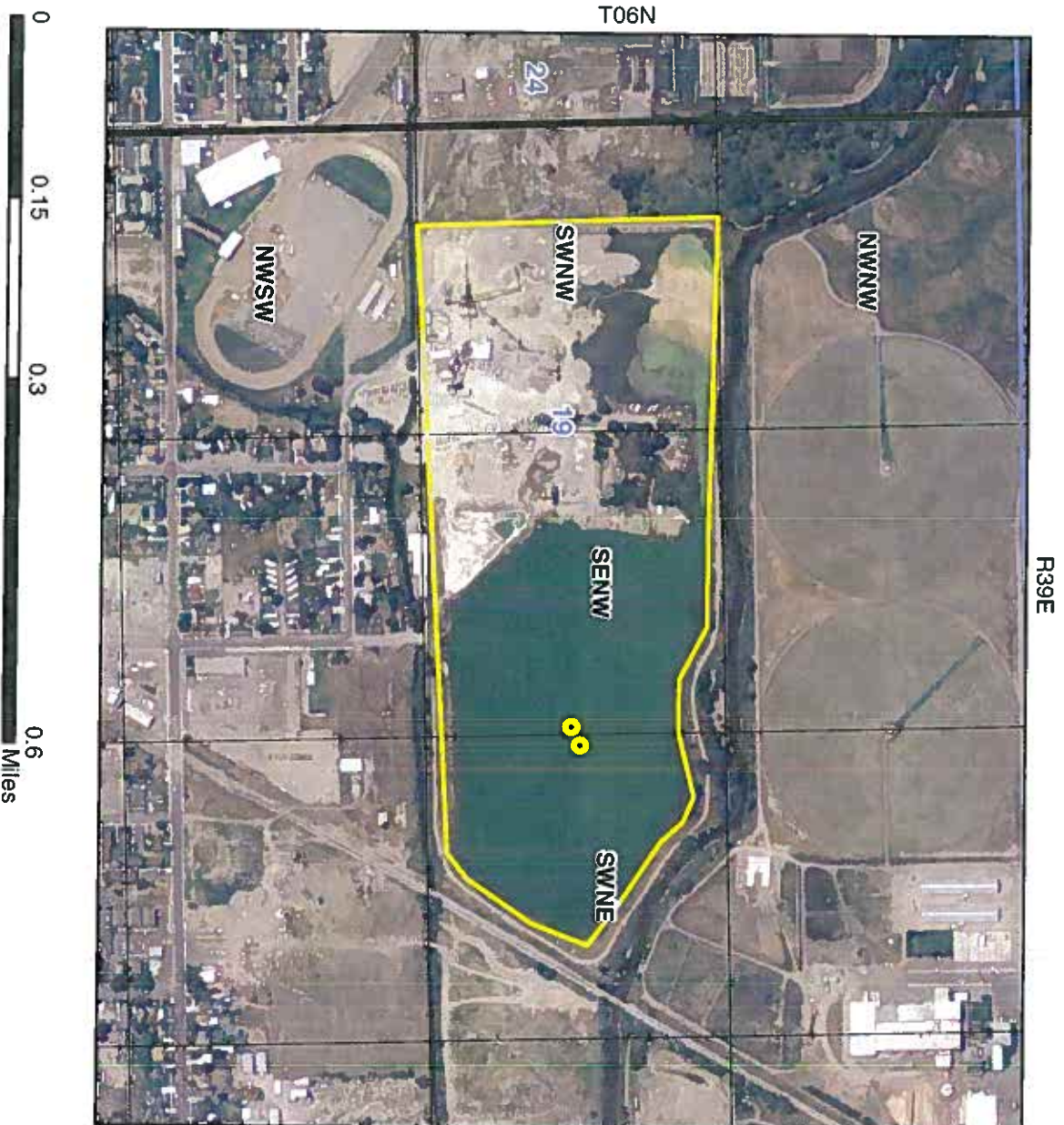
Legend

- Point of Diversion
- Place of Use
- State Outline
- Townships
- PLS Sections
- Quarter Quarters



Madison County
IDWR Basin 22

Prepared by Denise Kidman
On January 28, 2010
2004 Aerial Photography



22-13967



State of Idaho

DEPARTMENT OF WATER RESOURCES

Eastern Region, 900 North Skyline Drive, Suite A • Idaho Falls, Idaho 83402-1718

Phone: (208) 525-7161 • Fax: (208) 525-7177 • Web Site: www.idwr.idaho.gov

February 10, 2010

C. L. "BUTCH" OTTER
Governor

GARY SPACKMAN
Interim Director

WALTERS READY MIX INC
342 W 4TH N
REXBURG, ID 83440

Application For Permit No. 22-13967

Dear Applicant(s):

The Department of Water Resources has received your water right application. Please refer to the number referenced above in all future correspondence regarding this application.

A legal notice of the application has been prepared and is scheduled for publication in the REXBURG STANDARD-JOURNAL on February 18 and 25, 2010. Protests to this application may be submitted for a period ending ten (10) days after the second publication.

If the application is protested, you will be sent a copy of each protest. All protests must be resolved before the application can be considered for approval. If the protest(s) cannot be resolved voluntarily, the Department will conduct a conference and/or hearing on the matter.

Please contact this office if you have any questions regarding the application.

Sincerely,

Sharla Cox
Administrative Assistant

CC: Rocky Mountain Environmental
482 Constitution Way
Idaho Falls ID 83402



State of Idaho

DEPARTMENT OF WATER RESOURCES

Eastern Region, 900 North Skyline Drive, Suite A • Idaho Falls, Idaho 83402-1718

Phone: (208) 525-7161 • Fax: (208) 525-7177 • Web Site: www.idwr.idaho.gov

February 10, 2010

C. L. "BUTCH" OTTER
Governor

GARY SPACKMAN
Interim Director

WATER DISTRICT 100
GENE HANSEN
900 N SKYLINE DR STE A
IDAHO FALLS, ID 83402

RE: Application for Permit of 22-13967

Dear Watermaster:

A copy of the above referenced application is enclosed. Please review the application, then complete the enclosed recommendation form and return it to this office within 21 days of the date of this letter.

If the application is approved, IDWR will include appropriate standard conditions of approval for a water right located within a water district, such as regulation by the watermaster, lockable controlling works, and/or measuring devices. Any special conditions or other concerns you have related to this application should be specifically addressed in your recommendation.

IDWR's regional offices can finish reviewing an unprotested application as soon as the protest period has past. Your prompt response to this request will ensure that your recommendation can be considered. If IDWR has not received your written recommendation within 21 days from the date of this letter, IDWR will presume that you do not oppose approval of the application and that you have no comments for IDWR to consider.

Sincerely,

Sharla Cox
Administrative Assistant

Enclosure(s)

February 10, 2010

LEGAL NOTICE DEPARTMENT
REXBURG STANDARD-JOURNAL
PO BOX 10
REXBURG, ID 83440

RE: Application For Permit No(s): 22-13967

Dear Legal Notice Department:

Please publish the enclosed legal notice on the dates indicated (once a week for two consecutive weekly issues). If you cannot publish the notice on the proposed dates, please contact us immediately.

An affidavit of publication must be submitted to the Department along with the publication bill. Please send the affidavit and bill to this office before March 8, 2010. Your cooperation is appreciated.

Sincerely,

Sharla Cox
Administrative Assistant

Enclosure(s)

The following application(s) have been filed to appropriate the public waters of the State of Idaho:

22-13967

WALTERS READY MIX INC
342 W 4TH N
REXBURG, ID 83440

Point of Diversion SENW S19 T06N R40E MADISON and SWNE S19 T06N R40E MADISON County
Source GROUND WATER Tributary

Use: INDUSTRIAL	04/01 to 10/31	4.99 CFS
	Total Diversion:	4.99 CFS

Date Filed: 4/21/2009

Place Of Use: INDUSTRIAL

T06N R40E S19 SWNE SWNW SENW

Permits will be subject to all prior water rights. Protests may be submitted based on the criteria of Idaho Code § 42-203A. Any protest against the approval of this application must be filed with the Director, Dept. of Water Resources, Eastern Region, 900 N Skyline Dr Ste A, Idaho Falls ID 83402 together with a protest fee of \$25.00 for each application on or before March 8, 2010. The protestant must also send a copy of the protest to the applicant.

GARY SPACKMAN, Interim Director

Published on February 18 and 25, 2010



Idaho Department of Water Resources

MEMORANDUM

File: 22-13967 Walters Ready Mix
Date: February 9, 2010
Subject: Application for Permit

There has been correspondence between the Department and Rocky Mountain Environmental (RME) regarding the specifications provided about the gravel/sand washing facility. I called Roger Warner from RME today to confirm that his client wants to maintain the rate of 4.99 cfs instead of 7.2 cfs that the department calculated by using the manufacturers specifications.

After discussing the Departments view point, Mr. Warner confirmed that the client wants to stay with the 4.99 cfs. Mr. Warner assured me that this rate would be sufficient for the system used by Walters Ready Mix.

From the desk of Denise Kidman



RECEIVED
DEC 30 2009
Department of Water Resources
Eastern Region

December 28, 2009

RMEA 09-0025

Mr. Ernest Carlsen
Water Resource Program Manager
Idaho Department of Water Resources
Eastern Regional Office
900 N. Skyline Drive
Idaho Falls, ID 83402

Re: Water Rate Justification for Walters Application for Permit

Dear Ernie,

Rocky Mountain Environmental Associates, Inc. (RMEA) received your letter dated December 24, 2009. In that letter, you acknowledged our proposal to cover the sand wash apparatus in order to reduce/eliminate evaporation losses but requested additional clarification in regards to the amount of water required to adequately run the equipment and how it was derived. We hope the following will provide the information required to fulfill our permit processing request.

Specifications provided by the manufacturer of the Kolberg Series 1800 Screening/Washing Plant, Model 1830PH indicate that equipment functions optimally when "up to" 2,700 gallons per minute (or about 6.02 cfs) are provided which is dependent on feed gradation.

Currently, the Rexburg Walters facility has two water rights. Decreed water right 22-11666 for 0.04 cfs industrial use and licensed water right 22-7627 for 1.0 cfs commercial use. If the Screening/Washing apparatus optimally requires "up to" 6.02 cfs, and the above two existing rights are taken into account, then the applied for 4.99 cfs should supply enough water right for the optimal functioning of the system. As to the difference of 7.2 cfs calculated by Mr. Weaver of IDWR and the 6.02 (2,700 gpm) represented by the manufacturer, we trust the manufacturer has employed competent engineers to not only design but also to accurately measure similar optimally functioning screening/washing equipment. From our review, the calculated values appear reasonable.

Please don't hesitate to call us if you have any questions regarding this project.

Sincerely

A handwritten signature in blue ink, appearing to read "Roger", is written over the typed name.

W. Roger Warner, Hydrologist
Vice-President



State of Idaho

DEPARTMENT OF WATER RESOURCES

Eastern Region, 900 North Skyline Drive, Suite A • Idaho Falls, Idaho 83402-1718

Phone: (208) 525-7161 • Fax: (208) 525-7177 • Web Site: www.idwr.idaho.gov

C. L. "BUTCH" OTTER
Governor

GARY SPACKMAN
Interim Director

December 24, 2009

W. Roger Warner
Hydrologist
Rocky Mountain Environmental
482 Constitution
Idaho Falls, ID 83402-3537

Re: Walters Ready Mix 22-13967

Dear Roger,

I understand from your letter dated December 14, 2009, Walters Ready Mix has decided to cover and/or drape the spray equipment to alleviate and potentially eliminate the issue of evaporative losses due to exposure to wind and dry air, as analyzed by Mat Weaver, PE. Before I confer with our Boise staff about this approach there is a second issue that was also raised by Mat.

This issue is the apparent discrepancy between the diversion rate of 4.99 cfs requested on the permit application and the water requirements identified on the spec sheet provided as attachment #4. Calculating the water demand based on the *water system* description on the spec sheet reveals the spray equipment needs 7.2 cfs which is more than the up to 6.0 cfs identified as the water requirement under the *physical/operating characteristics*. Either rate is greater than the diversion rate listed on the permit application. Though the application does have a detailed description of the water source and an explanation of why the washing operation should be considered non-consumptive, there is no reference to how the 4.99 cfs was derived.

The purpose of this letter is to simply call your attention to this apparent discrepancy and request clarification supporting the diversion rate requested.

With the clarification concerning the diversion rate and the proposal to cover and/or drape the spray equipment, we can proceed with analysis of the application and hopefully determine sufficient information has been provided to publish notice of the application.

Respectfully

A handwritten signature in blue ink that reads "Ernest Carlsen". The signature is written in a cursive, flowing style.

Ernest Carlsen
Water Resource Program Manager



December 14, 2009

RMEA 09-0025

Mr. Ernie Carlsen
Water Right Allocations Manager
Idaho Department of Water Resources
Eastern Regional Office
900 N. Skyline Drive
Idaho Falls, ID 83402

Re: Evaporation Analysis for Walters Application for Permit

Dear Ernie,

Rocky Mountain Environmental Associates, Inc. (RMEA) received an analysis performed by Mat Weaver of the IDWR state office titled, "Walters Ready Mix Application: Estimating spray evaporative losses (consumptive losses) associated with the proposed spray cleaning/washing of mined gravels." Along with the analysis, we received electronic copies of the Excel Spreadsheets, "Ready Mix Spray Evap Calcs.xls" for review and analysis.

We have performed a detailed review and analysis of the calculations that have resulted in significantly less consumptive use than that proffered by Mr. Weaver. However, the specter of attempting to mitigate for any consumptive use, calculated or otherwise, in the Rexburg area is daunting and we would rather find another solution. Hence, we propose to modify the mined gravel washing devise that is proposed in the application to the extent that sprayers are not exposed directly to the atmosphere or outside under wind conditions and that the equipment be sufficiently covered with appropriate coverings so as to make wind or evaporation negligible. With a reasonably adequate enclosure, it would remove the two requirements for evaporation: dry air to receive the moisture and energy to vaporize the water. Such coverings are not standard equipment from the manufacturer but could be added upon conditional use of the water right.

Please don't hesitate to call us if you have any questions regarding this project.

Sincerely

A handwritten signature in blue ink, appearing to read "Roger", is written over a light blue circular stamp.

W. Roger Warner, Hydrologist
Vice-President

MEMO

DATE: July 17, 2009
TO: Ernie Carlsen
FROM: Mat Weaver

RE: Walters Ready Mix Application: Estimating spray evaporative losses (consumptive losses) associated with the proposed spray cleaning/washing of mined gravels

INTRODUCTION

As we are well aware, evaporation and evapotranspiration play a large role in the hydrologic cycle and therefore our day to day responsibilities at the Idaho Department of Water Resources (Department). A good understanding of evaporation and evapotranspiration are essential in our on-going management of the natural water resources of the state of Idaho, and in specific instances our critical assessment of the consumptive losses of water associated with a given application or beneficial use. Evaporation from open bodies of water and evapotranspiration from farm, ranch, urban, and natural environments have been rigorously studied and can be fairly well approximated. The physically based Penmann method for estimating evaporation and evapotranspiration, and its progeny of modified approaches, are many, varied, and nuanced; these approaches are recognized and widely used as the standard method in agricultural and hydrologic engineering applications (Dingman 2002).

On the other hand, evaporation associated with spraying or aerosolization of water appears from my limited research, to be a fundamentally more complicated physical system than the evaporative processes describe above, and not nearly as well researched or presented in engineering references. Despite this limitation, there is a periodic need at the Department to have a method in place to estimate spray evaporation associated with among other things, irrigation sprinkler systems, aesthetic and industrial fountains, and sprayers associated with industrial, timber, and mining applications. A salient example of this need is our desire to estimate the evaporative loss component associated with the spraying and cleaning of mined gravels proposed in the Walters Ready Mix application.

The purpose of this memo is to present two methods, one theoretically based and one empirically based, in estimating spray evaporation and to provide guidance in applying these methods. In addition, this memo will use the information provided in the Walters Ready Mix application to provide illustrative examples in applying the two methods.

METHOD 1 – THEORETICAL APPROACH

A brief review of introductory engineering and hydrologic references found little guidance in presenting approaches for estimating spray evaporation. Only one engineering reference reviewed in my research touched on the subject, presenting a brief discussion on spray evaporation and the physical components of concern, namely, droplet size distribution, latent heat loss, sensible heat loss, and water droplet velocity (Jensen 1981). Unfortunately this reference provided no equations or calculations in which spray evaporation can be, or was estimated. However, one of the citations from the text referred to a paper that did present a theoretical physically based approach to estimating evaporation rates from a freely falling water drop (Kinzer and Gunn 1951). The ideas, concepts, and equations presented in that paper form the basis of the first method.

The theoretical approach to solving the evaporation from a freely falling spherical drop is based upon the transport of heat and vapor from the drop when exposed to moving air (Kinzer and Gunn 1951). Equilibrium evaporation rates can be calculated by two different approaches, the first approach is an energy balance from the perspective of heat transfer, and the second approach is a mass balance from the perspective of molecular water vapor transfer. The resulting equations are compatible since they deal with the same evaporation (Kinzer and Gunn 1951). For the interests and scope of the problem addressed in this memo, focus is limited to the second approach, which describes the mass balance associated with the transfer of water, in the form of vapor, to the atmosphere from the surface of a freely falling water droplet; this process is represented by equation (1).

$$\text{Equation (1): } E = 4\pi a \rho D_v (X_a - X_b)(C)$$

Where,

E = evaporation (g/sec)

a = radius of water drop (m)

ρ = density of ambient air (kg/m³)

D_v = diffusion coefficient of water vapor in air¹ (m²/sec)

X = density ratio (dimensionless quantity)

C = Ventilation Factor-Reynolds' number term (dimensionless quantity)

Equation (1) yields an evaporation rate (E) with the units mass/time. The product of E and the flight time of the volume median drop (VMD) provides an estimate of total evaporative loss in units of mass. The mass value of evaporative loss when divided by the mass of the VMD provides an evaporative rate as a percent of total flow.

Equation (2) is used to solve for the C term in equation (1). For Reynolds' numbers in the range of $10 \leq Re^{1/2} \leq 50$, the Ventilation Factor² F is assumed to be approximately one. For $Re^{1/2}$ values that fall out of these ranges, F values can be difficult to approximate.

$$\text{Equation (2): } C = \left[1 + \frac{F Re^{\frac{1}{2}}}{\left(\frac{4\pi \rho D_v}{\mu} \right)^{\frac{1}{2}}} \right]$$

Where,

F = Ventilation Factor (dimensionless quantity)

Re = Reynolds' number (dimensionless quantity)

ρ = density of ambient air (kg/m³)

D_v = diffusion coefficient of water vapor (m²/sec)

μ = dynamic viscosity of ambient air (kg/m·s)

¹ An equation for solving for the diffusion coefficient, or diffusivity, is presented in the appendix as part of the solution for method 1.

² The Ventilation Factor is taken to be the ratio of evaporation of a ventilated drop (drop in free fall or with air moving rapidly over it) to a drop at rest (Kinzer & Gunn, 1951).

The Reynolds' number term in equation (2) is calculated with equation (3).

$$\text{Equation (3): } Re = \left(\frac{2\rho Va}{\mu} \right)$$

Where,

a = radius of water drop (m)
 ρ = density of ambient air (kg/m³)
 μ = dynamic viscosity of ambient air (kg/m·s)
 V = ventilation velocity³ (m/sec)

At standard atmospheric temperatures and pressures the term ($X_a - X_b$) can be estimated with equation (4).

$$\text{Equation (4): } (X_a - X_b) = \left(\frac{\rho_a - \rho_b}{\rho} \right)$$

Where,

ρ_a = density of water vapor at surface of drop⁴ (kg/m³ or any consistent units)
 ρ_b = density of water vapor in ambient air (kg/m³ or any consistent units)
 ρ = density of ambient air (kg/m³ or any consistent units)

The accuracy of this method is directly linked to the accuracy in which the individual components of the equations are known. Values of D_v can be difficult to calculate accurately and precise values of F , outside the ranges of Reynolds' numbers and water droplet diameters discussed above, are best obtained experimentally. In addition, climatic input parameters such as wet bulb temperature and vapor pressure can be difficult to obtain or estimate for specific locations in the State. However, when well constrained, the probable uncertainty associated with this analytical approach can be less than four percent (Kinzer and Gunn 1951).

Refer to the appendix for a detailed application of this method in estimating the spray evaporation associated with the Walters Ready Mix application.

METHOD 2 – EMPIRICAL APPROACH

The actual quantification of spray evaporation from sprinklers, fountains, or sprayers turns out to be a relatively difficult task to accomplish. The design of catchments that collect *all* of the water emitted from the sprinkler, accounting for *drift* or windage (water that blows away and is not collected in the catchment), and *evaporation* of water from the catchments themselves, are three of the primary factors that make the accurate measurement of evaporation, strictly due to the aerosolization of water, quite difficult. As such there is a paucity of this type of data on which to establish empirical relationships. Frost and Schwalen (1955) are responsible for one of the largest and most widely publicized data sets on spray evaporation, the efforts of their now classical research, yielded a nomograph that estimated evaporation loss as a function of percent

³ The ventilation velocity can be calculated by taking the distance the water droplet falls from sprayer nozzle to ground (h) divided by the flight time (t). Equations for solving flight time are presented in the appendix as part of the solution for method 1.

⁴ This value is assumed to be equal to the density of air fully saturated with water vapor at the temperature of the water droplet or source of supply water (Kinzer and Gunn 1951).

relative humidity, air temperature, wind velocity, nozzle diameter, and nozzle pressure (Jensen 1981). Frost and Schwalen (1955) took great pains to minimize losses from the catchments, and to minimize and account for evaporation from the catchments, however, they acknowledged that drift was not accounted for and likely resulted in the overestimation of evaporation in their research. None the less, their data continues to be widely used in the estimation of spray evaporation, as relatively little data has been published since that improves on the efforts of Frost and Schwalen (Jensen 1981).

The original data set prepared by Frost and Schwalen (1955) has been lost; in addition, accurate usable reproductions of the original nomograph are quite scarce (Trimmer 1987). To assist in the estimation of spray evaporation by utilizing the efforts of Frost and Schwalen (1955), and to prevent the use of poorly scaled and reproduced copies of their original nomograph, the American Society of Civil Engineering (ASCE), through the efforts of W.L. Trimmer (1987), prepared equation (5) below, which approximates the spray evaporation that would be estimated by the use of a reliable and accurate version of the nomograph (Trimmer 1987).

$$\text{Equation (5): } E = \left[1.98D^{-0.72} + 0.22(e_s - e)^{0.63} + 3.6 \times 10^{-4} h^{1.16} + 0.14W^{0.70} \right]^{4.2}$$

Where,

E = evaporation (%)
 D = nozzle diameter⁵ (mm)
 ($e_s - e$) = vapor pressure deficit (kPa)
 h = nozzle pressure⁶ (kPa)
 W = wind speed (m/s)

Vapor pressure deficit can be calculated with equation (6) if average daytime temperature and average daytime relative humidity are known.

$$\text{Equation (6): } (e_s - e) = 0.61 \left[\frac{17.27T}{T + 237.3} \right] (1 - RH)$$

Where,

T = average daytime temperature (deg-F)
 RH = average daytime relative humidity (%)

Use of these equations to estimate spray evaporation will best fit the nomograph for those ranges of input data that are in the center of the original nomograph range (i.e. nozzle pressures > 207 kPa and nozzle diameters < 12.7 mm). Uncertainty increases as you move to the extreme values of the nomograph. Uncertainty between equation (5) and the nomograph is estimated to be between 10-40%, resulting in a minimum uncertainty of approximately 30% between actual spray evaporation losses and those estimated by equation (5) (Trimmer 1987).

At first glance the error associated with this method seems excessive and it should certainly be taken under consideration when determining an appropriate evaporation rate. However, this approach allows for a simple means of estimating spray evaporation based on input parameters that are readily and easily attainable for most areas in Idaho. This approach is also well founded

⁵ Medium sized agricultural sprinkler systems have a typical range in nozzle diameters from 3.18-3.97 mm (1/8-5/32 inches) (Kohl 1974); if possible this value should be confirmed with actual specifications.

⁶ Medium sized agricultural sprinkler systems have a typical range in nozzle pressures from 300-500 kPa (29-73 PSI) (Kohl 1974); if possible this value should be confirmed with actual specifications.

and through its endorsement by the ASCE, can be generally regarded as a standard of engineering practice. In addition, this method links the estimation of spray evaporation to over 700 experimental tests performed by Frost and Schwalen (Jensen 1981).

Refer to the appendix for a detailed application of this method in estimating the spray evaporation associated with the Walters Ready Mix application.

CONCLUSIONS

This memo represents my efforts, by no means exhaustive, in finding practical and accepted methods for estimating evaporation losses associated with the aerosolization of water attributed to sprinklers, fountains, and sprayers. From the material reviewed for this memo, spray evaporation was found to range from 1-40%, with the *predominant* amount of calculated and measured values falling in the lower end of the spectrum between 1-8% (Jensen 1981; Lorenzini 2002). This range is confirmed by the efforts of applying methods 1 and 2 to the Ready Mix application, whereby over the course of the season of use, method 1 estimated a range of evaporative losses from 0.45-1.78% and method 2 estimated a range of evaporative losses from 1.6-2.6%.

Due to the relative agreement between the two methods, the relative ease of implementing method 2 versus method 1, and the endorsement of method 2 by the ASCE, it is my recommendation that method 2 be used as the first option in estimating evaporative losses due to spray. Method 1 may be applied if additional verification is warranted. It should also be noted, although not considered for this memo, that an alternative method of estimating spray evaporation, which focuses on the kinematic analysis of a water droplet has recently been developed by Giulio Lorenzi (2003 and 2006), if desired this method could present a third alternative for estimating spray evaporation.

It is my hope that this memo and the accompanying spreadsheets may serve as a useful resource that can assist in solving similar spray evaporation problems in the review of future applications and transfers.

APPENDIX

Application of Method 1 to the Walters Ready Mix Application

For input this method requires volume median diameter (VMD), average ambient air pressure (P), average daily temperature (T_{air}), average daily relative humidity (RH), average water drop temperature (T_{WD}), distance from spray nozzle to ground (h), and the average daily dynamic viscosity of air (μ). With these values as input the average water droplet radius (a), air density (ρ_{air}), coefficient of diffusion (Dv), the density ratio term ($X_a - X_b$), and the C term can all be calculated and used to solve for the spray evaporation rate (mass/time), which in turn can be coupled with the flight time and average water droplet mass to solve for the percent spray evaporation rate (%). Illustrative calculations for each step are presented for the month of July, for all other months the calculations are internal to the accompanying spreadsheet.

Evaporation can be calculated for any desired time interval (daily, weekly, monthly, seasonally, etc.), however, for the purposes of this example evaporation is estimated for each month of the year. Average daily temperatures, average daily humidity, and average daily wind speeds were obtained from the Bureau of Reclamation's Pacific Northwest Cooperative Agricultural Weather Network (AgriMet) for the RXGI – Rexburg, ID weather station site. Average daily dynamic viscosity of air can be looked up from tabulated resources with a known average daily temperature. Weather data for the past ten years was evaluated for this example; Table 1 depicts AgriMet data for RXGI and dynamic viscosities of air presented as average monthly values.

Table 1 – Summary of Pertinent Climate Conditions

RXGI - Rexburg, ID Agriment Weather Data (1998-2007)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Avg. Temp (deg-F)	20.8	23.1	34.1	44.0	52.3	59.1	67.4	64.8	54.7	43.4	31.3
Avg. Temp (deg-C)	-6.2	-4.9	1.2	6.7	11.3	15.1	19.7	18.2	12.6	6.3	-0.4
Avg. RH (%)	86.55	82.06	72.41	61.91	57.82	60.77	58.68	53.13	57.28	63.32	76.27
Avg. μ kg/m.s	1.66E-05	1.67E-05	1.73E-05	1.79E-05	1.82E-05	1.86E-05	1.91E-05	1.89E-05	1.84E-05	1.78E-05	1.72E-05

An average water droplet diameter of 450 microns (0.45 mm or 0.00045 m) is taken from the manufacturer's data sheet⁷. The calculation of E, ($X_a - X_b$), and C all rely on calculating the average daily density of air. Utilizing the Ideal Gas Law⁸, with the average ambient air pressure (P), average daily temperature (T_{air}), and the gas constant (R) as input, the average air density can be calculated. For the month of July, if $P = 84.3$ kPa, $T_{air} = 292.9$ K (67.45 deg-F), and $R = 0.288$, an air density of 0.999 kg/m³ can be calculated as follows:

$$\text{Air Density, } \rho_{air}: \quad \rho_{air} = \left(\frac{P}{RT} \right) = \left(\frac{84.3 \text{ kPa}}{0.288(292.9 \text{ K})} \right) = 0.999 \frac{\text{kg}}{\text{m}^3}$$

The coefficient of diffusion (Dv) is the next term that must be calculated. In order to calculate Dv, we must first calculate the saturation vapor pressure at ambient air temperature (e_{sat}), the dew

⁷ In a personal phone conversation with a representative of Kolberg, it was determined that the Series 1800 Screening Washing Plant utilizes Spraying Systems Company's Veejet HU Series Spray nozzles. From data sheets provided by the manufacturer (Spraying Systems Company, www.spray.com) for an 80° spray angle, a 1/2" threaded connection, a capacity of 10 gpm, and an operating pressure of 40 psi, the VMD is equal to 450 microns.

⁸ Although the underlying assumptions are not completely met, in this case the Ideal Gas Law gives a good approximation of the density of air. The form of the gas constant R used in this calculation is specific to air and the units of the other terms in the expression.

point temperature (T_{DP}), and the wet bulb temperature (T_{WB}). For the month of July, for an average daily temperature of 19.7 deg-C (67.45 deg-F), the saturation vapor pressure can be calculated as follows:

$$\text{Saturation Vapor Pressure, } e_{sat}: e_{sat} = 0.611 \times 10^{\left(\frac{7.5(T)}{237.7+T}\right)} = 0.611 \times 10^{\left(\frac{7.5(19.7 \text{ deg-C})}{237.7+19.7 \text{ deg-C}}\right)} = 2.29 \text{ kPa}$$

For the month of July, for an average relative humidity (RH) of 58.68% and an $e_{sat} = 22.9$ millibars (2.29 kPa), dew point temperature can be calculated as follows:

$$\text{Dew point temp., } T_{DP}: T_{DP} = \frac{237.7 \ln\left(\frac{e_{sat} RH}{611}\right)}{\left(7.5 - \ln\left(\frac{e_{sat} RH}{611}\right)\right)} = \frac{237.7 \ln\left(\frac{22.9 \text{ mb}(58.68\%)}{611}\right)}{\left(7.5 - \ln\left(\frac{22.9 \text{ mb}(58.68\%)}{611}\right)\right)} = 27.9 \text{ deg-C}$$

For temperatures ranging from 30-70 deg-F, the following meteorological rule of thumb (Rule of 1/3⁹) can be used to approximate the wet bulb temperature (T_{WB}); for the month of July, if $T_{air} = 19.7$ deg-C (67.45 deg-F) and $T_{DP} = 27.9$ deg-C, T_{WB} is approximated as follows:

$$\text{Wet bulb temp., } T_{WB}: T_{WB} = T_{air} - \left(\frac{T_{air} - T_{DP}}{3}\right) = 19.7^\circ \text{C} - \left(\frac{(19.7^\circ \text{C} - 27.9^\circ \text{C})}{3}\right) = 22.4^\circ \text{C}$$

Finally, for the month of July, with a $T_{WB} = 295.6$ K (22.4 deg-C), $P = 0.83$ atm (84.3 kPa), and the following parameters specific to this calculation, the diffusion coefficient can be calculated as follows:

Where,

$$D_o = 0.22 \text{ cm}^2/\text{sec}$$

$$T_o = 273.1 \text{ K}$$

$$\eta = 1.75$$

$$P_o = 1 \text{ atm}$$

$$\text{Diffusion Coefficient, } D_v: D_v = D_o \left(\frac{T_{WB}}{T_o}\right)^\eta \left(\frac{P_o}{P}\right) = 0.22 \frac{\text{cm}^2}{\text{s}} \left(\frac{295.6 \text{ K}}{273.1 \text{ K}}\right)^{1.75} \left(\frac{1 \text{ atm}}{0.83 \text{ atm}}\right) = 0.304 \frac{\text{cm}^2}{\text{s}}$$

The next term that must be solved for is the density ratio term ($X_a - X_b$). In order to solve for ($X_a - X_b$) we must first solve for the water vapor density at the surface of the water drop (utilizing Ideal Gas Law and the e_{sat} at the water droplet temperature) and the water vapor density of the ambient air. With an estimated water droplet temperature (temperature of the source of water) of 15.6 deg-C (60 deg-F) e_{sat} at the surface of the water droplet is calculated as follows:

$$\text{Saturation Vapor Pressure, } e_{sat}: e_{sat} = 0.611 \times 10^{\left(\frac{7.5(T)}{237.7+T}\right)} = 0.611 \times 10^{\left(\frac{7.5(15.6 \text{ deg-C})}{237.7+15.6 \text{ deg-C}}\right)} = 1.76 \text{ kPa}$$

⁹ For temperatures outside the 30-70 deg-F range, the wet bulb temperature must be estimated by the use of a psychrometric chart, a much more arduous and non-automated task.

Now, assuming the Ideal Gas Law, if $e_{sat} = 1.76 \text{ kPa}$ at the surface of the water droplet, $T_{air} = 292.9 \text{ K}$ (67.45 deg-F), and $R = 0.463^{10}$, a water vapor density at the surface of the water drop of 0.013 kg/m^3 can be calculated as follows:

$$\text{Water vapor density at surface of water drop, } \rho_{vap, a}: \rho_{vap, a} = \frac{e_{sat}}{R(T)} = \left(\frac{1.76 \text{ kPa}}{0.463(292.9 \text{ K})} \right) = 0.013 \frac{\text{kg}}{\text{m}^3}$$

For the month of July, for an average relative humidity (RH) of 58.68%, the actual vapor pressure of the ambient air can be calculated as follows:

$$\text{Actual vapor pressure, } e: e = \left(\frac{RH}{100} \right) (e_{sat}) = (58.68/100)(2.29 \text{ kPa}) = 1.34 \text{ kPa}$$

Again utilizing the Ideal Gas Law relationship, if $e = 1.34 \text{ kPa}$, $T_{air} = 292.9 \text{ K}$ (67.45 deg-F), and $R = 0.463$, a water vapor density of the ambient air of 0.010 kg/m^3 can be calculated as follows:

$$\text{Water vapor density of ambient air, } \rho_{vap, b}: \rho_{vap, b} = \frac{e}{R(T)} = \left(\frac{1.34 \text{ kPa}}{0.463(292.9 \text{ K})} \right) = 0.010 \frac{\text{kg}}{\text{m}^3}$$

Finally, at ambient temperatures and pressures, with a known $\rho_{vap, a}$, $\rho_{vap, b}$, and ρ_{air} , $(X_a - X_b)$ can be calculated directly as follows:

$$\text{Density ratio, } (X_a - X_b): (X_a - X_b) = \frac{(\rho_{vap, a} - \rho_{vap, b})}{\rho_{air}} = \frac{\left(0.013 \frac{\text{kg}}{\text{m}^3} - 0.010 \frac{\text{kg}}{\text{m}^3} \right)}{0.999 \frac{\text{kg}}{\text{m}^3}} = 3.00 \times 10^{-3}$$

The final term left to solve for is the C term, which contains the ventilation factor (F) and the Reynolds' number. In order to solve for C we must first solve for the flight time of the water droplet and the Reynolds' number.

If the average water droplet diameter (VMD), the density of water (ρ_{water}), the density of air (ρ_{air}), and the distance the average water droplet falls (h) are all known, then an average water droplet flight time and an average ventilated velocity can be calculated. Given an average droplet diameter of 450 microns, a coefficient of drag of 0.5^{11} , a density of air of 0.999 kg/m^3 , a density of water of 1000 kg/m^3 , and a drop distance of 10 feet (3.05 m), a flight time of 1.3 seconds can be calculated as follows:

$$\text{Terminal Velocity}^{12}, v_t: v_t = \sqrt{\frac{2mg}{C(\rho_{air})A}} = \sqrt{\frac{2(4.77 \times 10^{-8} \text{ kg})(9.81 \frac{\text{m}}{\text{s}^2})}{0.5(0.999 \frac{\text{kg}}{\text{m}^3})(1.59 \times 10^{-7} \text{ m}^2)}} = 3.43 \frac{\text{m}}{\text{s}}$$

$$\text{Characteristic Time, } \tau: \tau = \frac{v_t}{g} = \frac{3.43 \text{ m/s}}{9.81 \text{ m/s}^2} = 0.35 \text{ s}$$

¹⁰ The form of the gas constant R used in this calculation is specific to water vapor and the units of the other terms in the expression.

¹¹ Standard coefficient of drag (C) value for a spheroid object.

¹² The mass (m), cross sectional area (A), and volume (V) of the water droplet can be simply calculated by the following expressions when VMD and ρ_{water} are known: $A = \pi r^2$; $V = 4/3 \pi r^3$; and $m = \rho V$.

$$\text{Flight Time, } t: t = \tau \cosh^{-1} \left(e^{\frac{h}{v_i \tau}} \right) = (0.35s) \cosh^{-1} \left(e^{\frac{3.05m}{(3.43m/s)(0.34s)}} \right) = 1.13s$$

$$\text{Ventilated velocity, } V: V = \frac{h}{t} = \frac{3.05m}{1.13s} = 2.71 \frac{m}{s}$$

Next, given an average droplet diameter of 450 microns, a density of air of 0.999 kg/m³, a ventilation velocity of 2.71 m/s, and an average dynamic viscosity of air equal to 9.91x10⁻⁵ kg/m·s, a Re of 63.64 can be calculated as follows:

$$\text{Reynolds' number, Re: } Re = \frac{2\rho_{air}Va}{\mu} = \frac{2 \left(0.999 \frac{kg}{m^3} \right) \left(2.71 \frac{m}{s} \right) (2.3 \times 10^{-4} m)}{1.91 \times 10^{-5} \frac{kg}{ms}} = 63.64$$

Since the square root of Re (7.98) falls between the range of 10-50, we can assume that F is equal to 1.0. Therefore, given F = 1.0, Re^{1/2} = 7.98, a density of air of 0.999 kg/m³, a diffusion coefficient of 3.02x10⁻⁵ m²/s (0.302 cm²/s), and an average dynamic viscosity of air equal to 9.91x10⁻⁵ kg/m·s, a C value of 2.79 can be calculated as follows:

$$C = \left[1 + \left(\frac{F Re^{1/2}}{\left(\frac{4\pi\rho_{air}D_v}{\mu} \right)^{1/2}} \right) \right] = \left[1 + \left(\frac{1.0(7.98)}{\left(\frac{4\pi(0.999kg/m^3)(3.02 \times 10^{-5} m^2/s)}{(1.91 \times 10^{-5} kg/ms)} \right)^{1/2}} \right) \right] = 2.79$$

We finally have all of the terms we need to calculate the spray evaporation mass rate as follows:

Evaporation rate, E (mass/time):

$$E = 4\pi(a)(\rho_{air})D_v(X_a - X_b)C$$

$$E = 4\pi(0.00023m) \left(0.999 \frac{kg}{m^3} \right) \left(3.02 \times 10^{-5} \frac{m^2}{s} \right) (3.15 \times 10^{-3}) (2.79) = 7.5 \times 10^{-10} \frac{kg}{s}$$

The total mass of water lost as spray evaporation from a falling water droplet is equal to the product of the evaporation rate (E) and the flight time (t). The percent of evaporative loss can be calculated by dividing the mass of evaporative loss by the total mass of the average water droplet. The following calculations illustrate this process for the month of July and Table 2 summarizes the mass of evaporative loss from an average water droplet and the percent of spray evaporation loss for each month of the season of use.

$$E (\text{mass}) = (7.5 \times 10^{-10} \text{ kg/s})(1000 \text{ g/kg})(1.13 \text{ s}) = 8.48 \times 10^{-7} \text{ g}$$

$$E (\%) = 100[(8.48 \times 10^{-8} \text{ g})/(4.77 \times 10^{-5} \text{ g})] = 1.75\%$$

Table 2 – Summary of evaporative loss and percent loss to evaporation of water droplet.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
E (g)	--	--	--	2.5E-07	4.7E-07	5.2E-07	8.5E-07	7.6E-07	5.3E-07	2.1E-07	--	--
E (%)	--	--	--	0.52%	0.99%	1.10%	1.78%	1.58%	1.12%	0.45%	--	--

A diversion rate of 4.99 CFS and a season of use from 4/1 to 10/31 are requested on the application. For the purposes of these estimates it is assumed that water will be used eight hours a day, five days a week, and four weeks a month for the duration of the season of use. The specifications indicate a flow rate of 10 GPM per spray nozzle, 19 spray nozzles per spray bar, and a total of 17 spray bars. Therefore, per the specifications, a flow rate of 3,230 GPM (10x19x17) or 7.20 CFS will be used by the screening/washing plant, this is the assumed values for the purposes of this example. The following calculation estimates total evaporative or consumptive losses for the month of July, and Table 3 summarizes estimated total consumptive losses in acre-feet for each month of proposed use as requested in the application.

Consumptive Vol. = (0.00178)(7.20 CFS)(28,800 sec/work day)(20 work days/month)
 Consumptive Vol. = (73,820 cubic feet)(1 ac/43,560 square feet) = 1.69 Ac-Ft

Table 3 – Summary of total consumptive loss per month.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Vol. Water Used (ac-ft)	--	--	--	95.21	95.21	95.21	95.21	95.21	95.21	95.21	--	--
Consumptive Vol. (ac-ft)	--	--	--	0.49	0.94	1.05	1.69	1.51	1.07	0.43	--	--

From this method a total seasonal consumptive loss of 7.18 ac-ft is estimated in association with the beneficial use of water proposed in the Ready Mix application.

Application of Method 2 to the Walters Ready Mix Application

For input this method requires average daily temperature (T), average daily relative humidity (RH), average daily wind speed (W), sprayer nozzle diameter (D), and sprayer nozzle operating pressure (h).

Evaporation can be calculated for any desired time interval (daily, weekly, monthly, seasonally, etc.), however, for the purposes of this example evaporation is estimated for each month of the year. Average daily temperatures, average daily humidity, and average daily wind speeds were obtained from the Bureau of Reclamation's Pacific Northwest Cooperative Agricultural Weather Network (AgriMet) for the RXGI – Rexburg, ID weather station site. Weather data for the past ten years was evaluated for this example; Table 1 depicts AgriMet data for RXGI presented as average monthly values.

Equation (6) allows for the calculation of vapor pressure deficit ($e_s - e$) in PSI with temperature (T) in degrees Fahrenheit and relative humidity (RH) in percent as input. The following calculation is for the month of July, and Table 4 summarizes calculated vapor pressure deficits for each month.

$$(e_s - e) = 0.61e^{\left[\frac{17.27 \times 67.45}{67.45 + 237.3}\right]} (1 - (58.7/100)) = 0.062$$

Table 4 – Summary of monthly vapor pressure deficit values.

	Calculated Vapor Pressure Deficit (e _s -e)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
(e _s -e) (psi)	0.068	0.084	0.094	0.100	0.090	0.072	0.062	0.075	0.086	0.098	0.098	0.078
(e _s -e) (kPa)	0.467	0.580	0.651	0.690	0.622	0.493	0.431	0.518	0.595	0.676	0.605	0.537

A nozzle operating pressure of 40 PSI (275.8 kPa) can be determined from the Kolberg Series 1800 Screening/Washing Plant specifications submitted by the applicant. A nozzle diameter of 0.243 inches (6.17 mm) can be assumed from spray nozzle cut sheet¹³. This information along with wind speed (W) from Table 5, converted to meters/second, and vapor pressure deficit (e_s-e) from Table 4 in kPa, can be used as input into equation (5) to estimate evaporation (E). The following calculation is for the month of July and Table 5 summarizes input parameters and estimated evaporation for each month along with an evaluation of plus and minus 30% uncertainty.

$$E = [1.98(6.17)^{-0.72} + 0.22(0.431)^{0.63} + 3.6 \times 10^{-4}(275.79)^{1.16} + 0.14(1.94)^{0.70}]^{1.2} = 1.7\%$$

Table 5 – Summary of calculation input parameters and percent evaporation values with error estimations.

	Calculated Evaporation Loss as a Percent of Total											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
D (mm)	6.17	6.17	6.17	6.17	6.17	6.17	6.17	6.17	6.17	6.17	6.17	6.17
(e _s -e) (kPa)	0.467	0.580	0.651	0.690	0.622	0.493	0.431	0.518	0.595	0.676	0.605	0.537
h (kPa)	275.79	275.79	275.79	275.79	275.79	275.79	275.79	275.79	275.79	275.79	275.79	275.79
Avg. WS (m/s)	2.16	2.26	2.97	3.21	3.22	2.50	1.94	2.09	2.05	2.33	2.33	2.23
E (%)	1.8	2.0	2.5	2.7	2.6	2.0	1.7	1.9	1.9	2.2	2.1	1.9
E+30%	2.4	2.6	3.3	3.5	3.4	2.7	2.2	2.4	2.5	2.8	2.7	2.5
E-30%	1.3	1.4	1.8	1.9	1.9	1.4	1.2	1.3	1.3	1.5	1.5	1.4

As described in the method 1 example, a diversion rate of 7.20 CFS and a season of use from 4/1 to 10/31 are used in the following calculation to estimate total evaporative or consumptive losses, in acre-feet, for the month of July, Table 6 summarizes estimated consumptive losses for each month of proposed use as requested in the application.

Consumptive Vol. = (0.017)(7.20 CFS)(28,800 sec/work day)(20 work days/month)

Consumptive Vol. = (70,502 cubic feet)(1 ac/43,560 square feet) = 1.6 Ac-Ft

Table 6 – Summary of Monthly Consumptive Loss Volumes (ac-ft)

	Calculated Consumptive Loss per Month Due to Spray Evaporation											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Vol. Water Used (ac-ft)	--	--	--	95.2	95.2	95.2	95.2	95.2	95.2	95.2	--	--
Consumptive Vol. (ac-ft)	--	--	--	2.6	2.5	1.9	1.6	1.8	1.8	2.1	--	--

From this method a total seasonal consumptive loss of 14.3 ac-ft is estimated in association with the beneficial use of water proposed in the Ready Mix application. It may seem counterintuitive that the highest evaporative losses are associated with the cooler wetter months of April and May. However, this is due to the fact that average wind speed is a primary component in estimating spray evaporation via method 2, and the months of March, April, and May have significantly higher average wind speeds than any other months of the year.

¹³ From cut sheets for the Veejet H-U Series spray nozzle provided by the manufacturer (Spraying Systems Company, www.spray.com) for an 80° spray angle, a ½" threaded connection, a capacity of 10 gpm, and an operating pressure of 40 psi, the nozzle diameter is equal to 0.243 inches.

REFERENCES

- S.L. Dingman 2002, Physical Hydrology Second Edition – Prentice Hall Publication.
- K.P. Frost & H. Schwalen 1955, Sprinkler evaporation losses – Agricultural Engineering 36(8), 526-528.
- M.E. Jensen 1981, Design and Operation of Farm Irrigation Systems, Chapter 14 – American Society of Agricultural Engineers Publication.
- G.D. Kinzer and R. Gunn 1951, The evaporation, temperature and thermal relaxation-time of freely falling waterdrops – Journal of Meteorology 8(2), 71-83.
- R.A. Kohl 1974, Drop size distribution from medium-sized agricultural sprinklers – Transaction of the ASAE 17(4), 690-693.
- G. Lorenzini 2002, Air temperature effect on spray evaporation in sprinkler irrigation – Irrigation and Drainage, 51(4), 301-309.
- G. Lorenzini 2003, Simplified modeling of sprinkler droplet dynamics – Biosystems Engineering, 87(1), 1-11.
- G. Lorenzini 2006, Water droplet dynamics and evaporation in an irrigation spray – American Society of Agricultural and Biological Engineers, 49(2), 545-549.
- W.L. Trimmer 1987, Sprinkler evaporation loss equation – Journal of Irrigation and Drainage Engineering 113(4), 616-620.

Estimating the Mass Rate of Evaporative Loss (E)

$$E = 4 \cdot \pi \cdot a \cdot \rho_{\text{air}} \cdot D_v \cdot (X_a - X_b) \cdot C$$

Input

VMD =	450.00	microns (Volume Median Diameter)
P =	84.3	kPa (ambient air press)
T _{air} =	67.4	deg-F (air temp)
RH =	58.7	% (relative humidity)
T _{wd} =	59.9	deg-F (water drop temp)
h =	10	ft (distance water drop falls)
μ =	1.910E-05	kg/m s (dynamic viscosity of air)

Output

M _{wd} =	4.769E-05	g (mass of water drop)
t =	1.13	sec (flight time of water drop)
E =	7.348E-07	g/sec (mass rate of evap loss)
E =	1.73%	% (rate of evap loss as % of total)

Step 1 - Estimate Mean Radius of Water Droplets

VMD =	450.00	microns (volume median drop)
a =	0.23	mm (radius of mean water droplet)
a =	0.00023	m

Step 2 - Calculate Density of Air

P =	84.3	kPa (avg. atmospheric pressure at elevation)
T _{air} =	67.4	deg-F (avg. daily ambient temperature)
T _{air} =	292.9	K
R _{air} =	0.288	unitless (gas constant for air in specific units of step 2)
ρ _{air} =	0.999	kg/m ³ (density of ambient air, ρ = P/(T·R)) ^a

84.3456

Step 3 - Calculate Diffusivity (coeff. of diffusion) of Water Vapor in Air

T _{air} =	67.4	deg-F (avg. daily ambient temperature)
T _{air} =	19.6667	deg-C
e _{sat} =	2.29	kPa (saturation vapor pressure @ ambient temperature; e _{sat} = 0.611x10 ³ /(17.3T/(237.7+T))) ^b
e _{sat} =	22.66	millibars
RH =	58.70	% (average daily relative humidity)
e =	1.34	kPa (actual vapor pressure of ambient air, e = RH·e _{sat})
T _{DP} =	27.9	deg-C (dew point temperature; T _{DP} = (237.7·ln((e _{sat} ·RH)/611))/(7.5·ln((e _{sat} ·RH)/611)) ^c
T _{wb} =	22.4	deg-C (wet bulb temperature; T _{wb} = T _{air} - ((T _{air} - T _{DP})/3)) ^d
Do =	0.22	cm ² /sec (constant)
To =	273.1	K (constant)
η =	1.75	unitless (constant)
Po =	1.00	atm (constant)
P =	84.3	kPa (avg. atmospheric pressure at elevation)
P =	0.83	atm
T _{wb} =	22.4	deg-C
T _{wb} =	295.6	K
D =	0.3037	cm ² /sec (diffusivity of water vapor in air; D = Do·(T _{wb} /To) ^η ·(Po/P)) ^e
D =	3.037E-05	m ² /sec

Step 4 - Calculate Difference in Density Ratio's Between Surface of Water Droplet and Ambient Air

T _{wd} =	59.9	deg-F (temperature of the water droplet or source/supply of water)
T _{wd} =	15.5	deg-C
T _{wd} =	288.7	K
T _{air} =	67.4	deg-F (avg. daily ambient temperature)
T _{air} =	19.7	deg-C
T _{air} =	292.9	K
R _{vap} =	0.463	unitless (gas constant for water vapor in specific units of step 4)
ρ _{air} =	0.999459	kg/m ³ (density of ambient air, ρ = P/(T·R)) ^a
e _{sat} =	1.76	kPa (saturation vapor pressure @ temp. of water drop; e = 0.611x10 ³ /(7.5T/(237.3+T))) ^b
ρ _{vap,a} =	0.012969	kg/m ³ (saturation vapor density of air at temp. of air, ρ _{vap,a} = P/(T·R)) ^a
e =	1.34	kPa (actual vapor pressure of ambient air, e = RH·e _{sat}) ^f
ρ _{vap,b} =	0.009898	kg/m ³ (actual vapor density of ambient air @ temp. of air, ρ _{vap,b} = P/(T·R)) ^a
(X _a - X _b) =	3.073E-03	unitless (difference in density ratio's, (X _a - X _b) = (ρ _{vap,a} - ρ _{vap,b})/ρ _{air}) ^g

Step 5 - Calculate C

a =	0.00023	m (radius of mean water droplet)
A =	1.59E-07	m ² (water droplet x-sectional area, A = π·r ²)

$V =$	4.77E-11	m ³ (volume of water droplet, $V = 4/3 \cdot \pi \cdot r^3$)
$\rho_{water} =$	1000.0	kg/m ³ (density of water droplet)
$M_{WD} =$	4.769E-08	kg (mass of water droplet, $M = V \cdot \rho$)
$C =$	0.5	unitless (coefficient of drag, typ. 0.5 for sphere)
$\rho_{air} =$	0.999	kg/m ³ (density of ambient air, $\rho = P/T \cdot R$) ^a
$h =$	10.0	ft (distance water droplet will fall)
$h =$	3.05	m (distance water droplet will fall)
$g =$	9.81	m/s ² (acceleration due to earth's gravity)
$v_t =$	3.43	m/s (terminal velocity of average water droplet, $v_t = ((2 \cdot m \cdot g) / (C \cdot \rho_{air} \cdot A))^{1/2}$) ^b
$\tau =$	0.34	sec (characteristic time of average water droplet, $\tau = v/g$) ^c
$t =$	1.126	sec (flight time of average water droplet, $t = \tau \cdot \text{acosh}(\exp(h/v_t \tau))$) ^d
$V =$	2.71	m/s (ventilation velocity, $V = h/t$)
$D =$	3.037E-05	m ² /sec (dynamic viscosity of air at ambient temperature)
$\mu =$	1.910E-05	kg/m s (dynamic viscosity of air at ambient temperature)
$Re =$	63.77	unitless (Reynolds' Number, $Re = (2 \cdot \rho_{air} \cdot a \cdot V) / \mu$) ^e
$Re^{1/2} =$	7.99	unitless (square root of the Reynolds' Number)
$F =$	1	unitless (ventilation factor, empirically determined look up in Fig. 7, for $10 < Re^{1/2} < 50$ $F = 1$)
$C =$	2.79	unitless (constant, $C = [1 + (F \cdot Re^{1/2}) / ((4 \cdot \pi \cdot (\rho_{air} \cdot D / \mu))^{1/2})]$) ^f

Step 6 - Calculate Mass Rate of Evaporation Loss

$E =$	$4\pi \cdot a \cdot \rho_{air} \cdot D \cdot (X_a - X_b) \cdot C^m$	
$E =$	12.56 · 0.000225 · 0.999 · 3.037E-05 · 3.073E-03 · 2.79	values
	-- m kg/m ³ m ² /sec --	units
$E =$	7.348E-10	kg/sec
$E =$	7.348E-07	g/sec

Step 7 - Calculate the Rate of Evaporative Loss from a Water Droplet as %

$M_{WD} =$	4.769E-08	kg (mass of water droplet, $M = V \cdot \rho$)
$M_{WD} =$	4.769E-05	g
$t =$	1.126	sec (flight time of average water droplet, $t = \tau \cdot \text{acosh}(\exp(h/v_t \tau))$) ^d
$E =$	7.348E-07	g/sec
$M_{EL} =$	8.270E-07	g (mass of evaporative loss from water droplet during free fall, $M_{EL} = t \cdot E$)
$E =$	1.73%	% (rate of evaporative loss as a % of the total rate of diverted water)

Equations

a - ideal gas law solving for density, equation and R value from Dingman 2002

b - saturation vapor pressure from ambient temperature from NOAA

c - dew point temperature from saturation vapor pressure and RH from NOAA

d - wet bulb temperature approximation (rule of 1/3) from weatherprediction.com most valid for temps from 30-60 deg-F.

e - equation of diffusivity from Kinzer & Gunn 1951

f - equation for RH, where $RH = e/e_{sat}$ from Dingman 2002

g - equation for calculating difference in density ratios from equation 18 Kinzer & Gunn 1951; only valid at typical atmospheric temps and pressures

h, i, j - equations for calculating flight time of free falling object with quadratic drag from J.R. Taylor 2005, Classical Mechanics, University Science Book

k - equation for calculating Reynold's Number from equation 13 Kinzer & Gunn 1951.

l - equation for calculating C is a form of equation 17 Kinzer & Gunn 1951.

m - equation for calculating the mass rate of spray evaporation from equation 17 Kinzer & Gunn 1951.

Month by Month Summary

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Avg. Temp (deg-F)	--	--	--	44.0	52.3	59.1	67.4	64.8	54.7	43.4	--	--
Avg. RH (%)	--	--	--	61.91	57.82	60.77	58.68	53.13	57.28	63.32	--	--
Avg. μ kg/m s	--	--	--	1.79E-05	1.82E-05	1.86E-05	1.91E-05	1.89E-05	1.84E-05	1.78E-05	--	--
VMD (microns)	--	--	--	450.00	450.00	450.00	450.00	450.00	450.00	450.00	--	--
P (kPa)	--	--	--	84.3	84.3	84.3	84.3	84.3	84.3	84.3	--	--
h (ft)	--	--	--	10	10	10	10	10	10	10	--	--
T _{wd} (deg-F)	--	--	--	36.5	44.8	51.6	59.9	57.3	47.2	35.9	--	--
M _{wd} (g)	--	--	--	4.8E-05	4.8E-05	4.8E-05	4.8E-05	4.8E-05	4.8E-05	4.8E-05	--	--
t (sec)	--	--	--	1.14	1.14	1.13	1.13	1.13	1.13	1.14	--	--
E (g/sec)	--	--	--	2.2E-07	4.13422E-07	4.64182E-07	7.5E-07	6.68625E-07	4.72277E-07	1.87928E-07	--	--
E (%)	--	--	--	0.52%	0.99%	1.10%	1.78%	1.58%	1.12%	0.45%	--	--
Vol. Water Used (ac-ft)	--	--	--	95.2	95.2	95.2	95.2	95.2	95.2	95.2	--	--
Consumptive Vol. (ac-ft)	--	--	--	0.49	0.94	1.05	1.69	1.51	1.07	0.43	--	--

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
E (g)	--	--	--	2.5E-07	4.7E-07	5.2E-07	8.5E-07	7.6E-07	5.3E-07	2.1E-07	--	--
E (%)	--	--	--	0.52%	0.99%	1.10%	1.78%	1.58%	1.12%	0.45%	--	--

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Vol. Water Used (ac-ft)	--	--	--	95.21	95.21	95.21	95.21	95.21	95.21	95.21	--	--
Consumptive Vol. (ac-ft)	--	--	--	0.49	0.94	1.05	1.69	1.51	1.07	0.43	--	--

