Guidance for Reclamation and Reuse of Municipal and Industrial Wastewater

Idaho Department of Environmental Quality

September 2007

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Organization of This Internet Version of the Reuse Guidance

The Web-based electronic reuse guidance is topic driven. Interested viewers may click on the topic of their choice in the table of contents for access to the latest guidance information. Other internal links within the topics allow viewers to move between topics on a limited basis.

Additionally, this will be the location in the Reuse Guidance that will outline the sections that have been modified in the past two years.

Date	Brief description of modifications	Sections modified
12/15/2005	Specific revisions to sections 1, 6.3, and 7, including creation of overall guidance Preface from introductory passages of Section 1; division of guidance into Parts A (slow rate land treatment of wastewater), B (high rate land treatment of wastewater), and C (other reuse); addition of reuse templates supplementary information for Section 1, addition of guidance index.	1, 6.3, 7
December 2006	Section 3 now contains material from Section 4 related to wastewater constituents and their descriptions	3, 4, 7
	Section 4 includes sections on runoff control and ground water impact modeling; and revisions of sections related to non-growing season loading, nitrogen loading, and constituent loading calculations.	
	The theoretical background in Section 7 was bolstered.	
July 2007	Section 2: Site Evaluation for Reuse and Land Treatment: An extensive revision of the previous Section 2 - Site Evaluation, Selection and Management. Includes environmental, social, and crop management site evaluation criteria. Also, Tables A-5, A-6, A-7, A-8 and Figures A-8 and A-9 relocated into Section 2.	ALL
	Section 6: Operations: A revision of the previous Section 6, including revised lagoon seepage criteria, buffer zone distances, water supply well protection criteria, and grazing management.	
	All other section have be correct references and/or to include materials previous in the appendices.	

Preface

Note: Department of Environmental Quality (DEQ) guidance does not have the force of law or regulation, nor does not it replace best professional judgment; it provides a starting point and assistance in the design of wastewater reclamation and reuse programs.

Introduction: From Land Application to Reuse

Land application involving land treatment of wastewater has long been recognized as a viable method of wastewater treatment, but, in some cases, it became apparent that surface and ground water contamination related to the wastewater land treatment system operation was occurring. Moreover, experience and a better understanding of how ground water contamination is related to activities on the land surface has raised awareness of the complexity surrounding land treatment methods. These and other issues were the driving forces in developing a wastewater land application permit program in Idaho.

The broader topic of *reuse* of wastewater, introduced in this version of the guidance, includes many other uses besides land treatment and land application. The future direction of the Land Application Permit Program will be to include these additional uses and to periodically update the rules and guidance as needed to address the demand.

Wastewater Land Application Permit (WLAP) Program History

The Wastewater Land Application Permit (WLAP) Program is an established and well developed state regulatory program. Together, the regulations and guidelines have helped establish parameters for workable land application permits that protected surface and ground water quality and met the treatment needs of the wastewater generator.

1988: Introduction of the Original Guidelines

The original program regulations became effective in April 1988, and the companion guidelines were finalized in March 1988. The 1988 guidelines were of necessity very general, focusing on broad considerations for both the design and evaluation of WLAP proposals. Five years into program implementation, however, it became apparent that some program components required more specificity for the second generation of permits to be issued in a fair and consistent manner, while still allowing flexibility for site specific conditions. Also, significant technical changes had been made regarding distances to public or private wells and ground water monitoring, and these changes needed to be made available to the permittee. The 1994 *Technical Interpretive Supplement* (described immediately below) made these technical advances available to the regulated community in addition to the 1988 guidelines.

1993: Expansion of the Original Guidelines

A WLAP technical work group, comprising agency, industry, municipalities, and technical consultants, was formed in September 1993 to expand the original guidelines on four (4) selected issues of concern. The expansion, called the 1994 *Technical Interpretive Supplement*, included-supportive information on the following:

- Growing and non-growing season application rates
- Capture zone analysis and wellhead protection to determine minimum setback distances to public and private wells
- Buffer zones to protect the public
- Grazing on land application sites

Both the 1994 *Technical Interpretive Supplement* and the 1988 guidelines support and reinforce laws and regulations, but, by themselves, are not standards or mandates. Both were published in April of 1996, as a combined paper document called the *Handbook for Land Application of Municipal and Industrial Wastewater*.

2002: Development of New Guidance and Increased Internet Posting

In 2002, a significant amount of new guidance was developed for the reuse program, and more use was made of the Internet to provide this guidance to the public, the regulated community, and to DEQ internally. The inclusion of the new guidance was part of the continuing effort to ensure consistency in the reuse program and to involve public participation.

An effort to post all draft and final permits on the Internet was also initiated in 2002, and this effort will continue in the future to make the public and the permittees more aware of the directions of the program and to make permits more consistent across the state.

It is the intent of the program to use the Internet to continually update information and guidance via the DEQ Web site. Input from the public at large is welcome.

2004: Creation of the Web-Based Guidance

DEQ initiated a renewed public participation process in 2004 to provide for a consistent review of existing guidance and to establish a process for introducing and examining new guidance. With regard to this guidance, DEQ invited the public to form an advisory working group that would meet periodically to review existing and future reuse guidance, providing suggested updates, additions, deletions, or corrections.

DEQ intends to post the suggestions from this group on its Web site for a 30-day public comment period. Following that public comment period, the advisory working group will review public comment, modify the suggested changes if needed, and then submit the final suggested modifications to the Director of DEQ for a final decision on including them in the Reuse Guidance Document.

The advisory working group is open to the public at large and can introduce new suggested guidance to DEQ through its workings.

In May of 2004, DEQ created an electronic Web-based draft, which was simply a reorganization, by topic, of the *Handbook for Land Application of Municipal and Industrial Wastewater*, calling it the *Guidance for Land Application of Municipal and*

Industrial Wastewater. Since that time, DEQ has sought continued public input to update and make corrections to this initial Web-based document.

2005: Expansion of Scope to Include Reuse

As a part of the public process, and in anticipation of a name change from the *Wastewater Land Application Permit Rules* to *Reclamation and Reuse of Municipal and Industrial Wastewater Permit Rules* (*Reuse Rules*), the name of this guidance is now ***Guidance for Reclamation and Reuse of Municipal and Industrial Wastewater (Reuse Guidance)***. This name change will embrace future uses of reclaimed wastewater that may or may not have anything to do with land treatment or land application.

Current and Future Directions for the Reclamation and Reuse of Municipal and Industrial Wastewater

The *Reuse Rules* (IDAPA 58.01.17) apply to both new systems and existing systems:

- New systems must be designed to meet all requirements of the *Reuse Rules*. The *Reuse Guidance* provides assistance to meet the requirements of the rule, and should be used, therefore, by new systems to ensure compliance.
- Existing systems must meet the requirements of the rules and their permit. When a permit comes up for renewal, then the system must meet the requrements of the latest *Reuse Rules*. If a permittee has been experiencing operational or compliance problems with meeting permit conditions or water quality standards, the reuse guidance should be reviewed in order to help attain compliance.

In summary, the *Reuse Rules* address the treatment of municipal and industrial wastewater by different types of land application and treatment systems and other treatment requirements for higher classes of effluent.

Locations of the Rules

Applicants for reuse permits can find the applicable rules at the following locations:

- The *Reuse Rules* (IDAPA 58.01.17) can be located at the following address:

  http://adm.idaho.gov/adminrules/rules/idapa58/0117.pdf

- The *Ground Water Quality Rule* (IDAPA 58.01.11), which has impact on reuse facilities, is located at the following address:

  http://adm.idaho.gov/adminrules/rules/idapa58/0111.pdf

- The *Water Quality Standards and Wastewater Treatment Requirements* (IDAPA 58.01.02) can be located at the following address:

  http://adm.idaho.gov/adminrules/rules/idapa58/580102.pdf

Opportunities to Comment on This Guidance

The *Reuse Guidance* is intended to be a dynamic information source, evolving as new technology becomes available or expanding as additional issues of concern are researched and developed. Given this focus on adapting to change, DEQ is interested in receiving comments on any issue that should be considered for future editions of this document.

Comments, suggestions, or issues of concern may be submitted to:

Department of Environmental Quality
1410 N. Hilton
Boise, Idaho 83706-1255
Attention: Richard Huddleston, Program Manager
Wastewater Program

Part A: Slow Rate Land Treatment of Wastewater

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1. Preparing a Reuse Permit Application for Wastewater Land Treatment

A reclaimed wastewater reuse permit (reuse permit) is required to modify, operate, construct, or discharge to a reuse facility. The application of wastewater to land for treatment (wastewater land application) is one type of reuse. This section provides information on the process of applying for a *land treatment* reuse permit.

> **Note:** Read this section if you are applying for a reuse permit application for the treatment of municipal or industrial wastewater by application to land.
>
> If you are preparing a reuse permit application for other direct uses of municipal reclaimed wastewater—such as toilet flushing, dust control, or Class A wastewater treatment—see Part C, Section 12 of this guidance.

1.1 Required Information

The *Reuse Rules* (IDAPA 58.01.17) specify information required in a reuse permit application. In addition, application processing procedures are outlined in the reuse rules.

Other requirements for land application projects can be found in the following:

- Section 600 of the *Water Quality Standards and Wastewater Treatment Requirements Rules* (IDAPA 58.01.02) specifies requirements for the land application of wastewater (Note – this will be changed to *Wastewater Rules* (IDAPA 58.01.16) in 2006).
- The *Ground Water Quality Rule* (IDAPA 58.01.11) specifies necessary ground water quality requirements.

Applicants are strongly encouraged to review these rules to become familiar with these requirements (links to these rules are provided in the introduction to this document), before the pre-application form submittal and conference.

> **Note:** See *Locations of the Rules*, in the Preface of this document, for information about locating the rules that apply to reuse.

1.2 Definitions

The following definitions apply to this section:

- *Major* permit modifications are those, which if granted, could result in an increased hazard to the environment or to the public health.

- *Minor* permit modifications are those, which if granted, would not result in any increased hazard to the environment or to the public health. Minor modifications are normally limited to the correction of typographical errors, transfer of ownership or operational control, or a change in monitoring or reporting frequency.

1.3 Steps in the Application Process

The three major steps in preparing a land treatment reuse permit application are listed below. These steps pertain to applying for a new permit, a renewal permit, a permit modification (minor or major), or to request a permit waiver.

1. Pre-application form submittal
2. Pre-application conference
3. Reuse permit application submittal.

Step 1. Pre-Application Form Submittal

The first step in preparing a reuse permit application is to submit the Reuse Permit Pre-Application Form and the Facility Basic Information Form, both of which can be downloaded from the following address:

http://www.deq.idaho.gov/water/wlap/instructions.cfm

These Web-based forms should be completed and electronically submitted to a wastewater staff contact in the DEQ Regional Office in which the project is located. For a list of wastewater staff contacts, see the following:

http://www.deq.idaho.gov/permitting/water-quality-permitting/recycled-water.aspx

The Reuse Permit Pre-application Form should identify the type of application (new, renewal, major modification, minor modification, waiver request) and provide contact information. The Facility Basic Information Form is used to identify the types of waste, type of facility, types of reuse, approximate volume of wastewater, legal location, county, and description of the land application process.

By submitting these forms, the DEQ Regional Office is notified that the applicant is initiating the reuse permit application process.

Step 2. Pre-Application Conference

Before submitting a reuse permit application, it is highly recommended that a pre-application conference be held between the applicant and DEQ. For a new site, or if DEQ staff involved have not recently visited an existing site, consider scheduling a short site visit as part of the conference.

If you are applying for a minor permit modification or a permit waiver, contact the Regional DEQ Office to discuss your project prior to scheduling the pre-application conference. It is possible that the detailed information outlined in the remainder of this section does not pertain to your situation.

If you are applying for a waiver, you should know that waivers from the requirements of the Reuse rules may be granted by DEQ on a case-by-case basis upon full demonstration by the applicant that:

- The waiver will not have a detrimental effect upon existing water quality, and uses are adequately protected, and
- The treatment requirements are unreasonable with current technology or economically prohibitive.

For all other types of reuse permit applications (new, renewal and major modification), the applicant and DEQ may consider the more detailed pre-application conference process presented below.

A. In preparation for the pre-application conference, it is recommended that *DEQ*:

1. Review the pre-application form submitted by the applicant.
2. If an existing site, and if time allows, review the permit file prior to the conference:
   a. Determine the status of compliance activities in the current permit.
   b. Review recent annual reports regarding: hydraulic and constituent loading rates, results of monitoring efforts, and other operating issues identified in the reports or through DEQ review of the reports.
   c. Review available site inspection reports.
   d. If applicable, review existing legal agreements, such as Consent Orders or a Notice of Violation (NOV).

B. In preparation for the pre-application conference, it is recommended that the *applicant* consult the "Suggested Outline for Preparing the Technical Report" and the "Guidelines for Preparing the Site Maps" (presented in Section 1.6), assemble as many materials and maps as is practical, and be as prepared as possible to discuss the items listed in the suggested outline.

Items recommended for discussion between the applicant and DEQ during the pre-application conference are listed below. For some applicants, the pre-application conference may be a preliminary inquiry and more than one conference may be necessary.

1. Have the applicant describe their proposal in detail.
2. Discuss scheduling issues:
   a. For a new site, discuss when the applicant proposes to begin land application activities.

b. For an existing site, discuss the timeframe for any proposed changes to land application activities.

3. Discuss the ownership of the land application site. If not owned by the applicant, discuss the need for providing a lease or rental agreement.
4. Review the *Vicinity Ma*p and *Facility Site Map* (see Section 1.6) prepared for the pre-application conference. Discuss site topography, potential buffer zone issues, and other potential site constraints. Discuss what is recommended to be added to these maps for purposes of the reuse permit application submittal.
5. Review site evaluation criteria in Section 2 and discuss site-specific characteristics..
6. Discuss recommended sampling and analysis efforts to be performed for the purposes of preparing the reuse permit application. These efforts may include additional sampling of the land applied wastewater, site soils, site groundwater, and/or other sampling and analysis important for site characterization.
7. Discuss the need (and, if appropriate, a schedule) for seepage rate testing of wastewater structures or ponds.
8. Discuss local permits and approvals that may be required (conditional use permit, planning and zoning requirements, other agency approvals…).
9. Determine if the land application site will be leased or operated by a third party. If a third party is involved, a signed contract or agreement will be required regarding third party responsibilities for operating the site under the conditions of the permit.
10. For renewal permits, discuss if an updated Plan of Operation and/or updates of other site management plans should be submitted with the reuse permit application.
11. Review the *Suggested Outline for Preparing the Technical Report* section below and the materials assembled by the applicant for the pre-application conference. Discuss what additional information is recommended to be included with the Reuse permit application.
12. Discuss the overall steps and schedule for the permit process (refer to Section 1.8).

Step 3. Wastewater Reclamation and Reuse Permit Application Submittal

The reuse permit application submittal, at a minimum, should contain the items listed below.

- *Reuse Permit Application Form*: This form must be submitted with the signature of the owner or an authorized agent.
- *Technical Report* (suggested outline is presented below).
- *Site Maps* (described at the end of this section).
- *Plan of Operation Checklist*:
    - Existing facilities are required to have a plan of operation, which describes in detail the operation, maintenance, and management of the wastewater treatment system. An up-to-date Plan of Operation should be available for DEQ review as part of the reuse permit application.

- For new facilities, a general outline of a plan of operation should be submitted.

1.4 Reuse Permit Application Form

A copy of the Application for Wastewater Reuse Permit can be found in the Section 1.9.3.

1.5 Suggested Outline for Preparing the Technical Report

A suggested outline for preparing the Technical Report is provided below. Depending upon the facility, the outline below may be reduced or, alternatively, expanded upon. For a renewal permit or a permit modification, the outline may be greatly reduced if previously submitted items are still representative of the applicant's activities.

I. Site Location and Ownership

A. Site Location

1. Describe the location of the wastewater treatment facility and, if different, the location of the land application site.
2. Describe relative locations of important land features (cities, roads…) to the treatment facility and land application site.
3. Describe adjacent land uses and identify distances from the boundary of the land application site(s) to the following buffer objects: dwellings, areas of public access, canals/ditches, private water sources, and public water sources.

B. Site Ownership

1. Identify who owns the land application site. If not owned by the applicant, describe any pertinent leases or agreements in place.
2. Within this section, or referring to an appendix, provide the following documentation:
    a. Land Application Site Ownership: provide documentation of site ownership for areas of land application.
    b. If the applicant is leasing or renting the land application site, provide an affidavit stating the specifics of the water use agreement or lease stating the actual control over the property.
    c. Provide copies of any other agreements affecting the ownership and/or operation of the site (right-of-way easements, for example).
    d. List all local, state, and federal permits/licenses/approvals related to the land application facility. For each, list the date(s) of application, the current status, and, if applicable, the approval date. Include any required planning and zoning approvals and/or required conditional use permits.

II. Process Description

A. Process Flow Description

1. Identify the sources of wastewater. Describe any seasonal variations in the wastewater (quantity and quality).
2. Describe the flow path of wastewater from the wastewater source to the land application site.
3. Identify the major treatment steps (equipment) of the wastewater treatment facility. For municipal systems, describe the disinfection treatment system and the proposed level of disinfection.
4. Identify sizes and design capacities of major equipment.
5. Identify the flow design basis. For existing sites, present recent wastewater flow data.
6. If applicable, describe any alternate treatment methods being considered.
7. Describe procedures that would be followed if the principal wastewater treatment procedures could not be used temporarily.
8. Identify sources and types of generated waste solids.

B. Land Application Site

1. Identify the number of land application acres.
   a. If applying for a new permit, identify the proposed number of land application acres.
   b. If applying for a renewal permit or permit modification: 1) list the current hydraulic management units and associated acres and 2) describe any proposed changes to the land application acreage.
2. Identify the type(s) of irrigation system(s) (pivot, hand lines,…) and the corresponding irrigation efficiency(ies).

III. Site Characteristics

A. Site Management History

1. Describe past and current uses and management of the land application site including: important events and dates, cropping information, historic fertilizer use, and other key past and current site management information.

B. Climatic Characteristics

1. Describe the climatic characteristics of the site including precipitation data, high and low temperature data, frost free days, growing degree days, and prevailing wind direction.

C. Soils

1. Describe site soils. Present Natural Resource Conservation Service (or similar) soil survey information and results of any on-site investigations.
2. Present and interpret available soil monitoring results.
3. If wastewater land application in the non-growing season is proposed, calculate and present the available water holding capacity of the soils.

D. Surface Water

1. Identify and describe the location of surface water(s) near the land application site.
2. As applicable, discuss canals, wetlands, springs, floodplains, and other surface water related site characteristics including beneficial uses.

3. Describe, as appropriate, the influence of site land application activities on nearby surface water(s).

E. Groundwater/Hydrogeology

1. Describe the groundwater system, including: depth to first water, depth to regional groundwater, confined or unconfined (if known), flow direction (if known), and seasonal depth and flow direction variations. If applicable, describe the presence of a major aquifer.
2. Discuss the locations and uses of wells (public wells, private wells, monitoring wells, and injections wells) within ¼ mile of the land application site. Include copies of well logs, if available. The IDWR (Idaho Department of Water Resources, www.idwr.state.id.us) may be contacted for assistance.
3. If a Well Location Acceptability Analysis has been performed for the site, present and interpret results of the analysis.
4. Present and interpret available groundwater monitoring results (upgradient and downgradient of the land application site) and/or on-site investigations.
5. Present and interpret results of any groundwater modeling efforts for the site.

IV. Wastewater Characterization, Cropping Plan, and Loading Rates

A. Wastewater Characterization

1. Identify the quantity of land applied wastewater (per day, per month, per year). Document how the quantity values were determined.
2. Characterize the concentrations of key constituents in the wastewater proposed for land application. Document how the concentration values were determined. Basic constituents of interest are: total nitrogen, total phosphorus, and Chemical Oxygen Demand (COD). Depending on the wastewater source, concentrations of other constituents may be important. For industrial systems, concentrations of total dissolved inorganic solids (TDIS) and/or metals may be pertinent. For municipal systems, total coliform counts may be presented.

B. Cropping Plan

1. Describe proposed crop selection and a 5-year rotation plan.
   a. For each crop, describe: planting and harvesting data, irrigation sensitivity, rooting depth, expected yield (compare to yield data published by the Idaho Department of Agriculture (see Section 7), and expected crop uptake values for key constituents in the wastewater.
   b. For each crop, calculate and present the Irrigation Water Requirement (IWR). Document how the IWR value(s) were determined.
   c. If proposing to utilize wastewater for tree irrigation, present a silvicultural plan (a plan covering the care and cultivation of the trees).
2. Describe the proposed future use of fertilizers at the site. Document nutrient loading associated with fertilizer use.

C. Hydraulic Loading Rate

1. Present the expected wastewater hydraulic loading rates by month for growing season and non-growing season.
2. Describe the availability of supplemental irrigation water for the site and whether or not supplemental irrigation water is expected to be used at the site.

Provide documentation that water rights exist to provide supplemental irrigation. If expected to be used, present the typical supplemental irrigation water hydraulic loading rates for potential crops.

3. Discuss irrigation scheduling for the site.
4. If storage of wastewater is proposed, prepare and present a monthly water balance for the storage structure(s) reflecting: number of days of storage, required freeboard, minimum depth, evaporation, precipitation, and flows into and out of the structure.

D. Constituent Loading Rates

1. Calculate and present the expected growing season and non-growing season loading rates for key constituents. If waste solids and/or fertilizers are proposed to be applied to the land application site, reflect the application of these materials in site constituent loading rate calculations.
2. Compare expected constituent loading rates to applicable crop uptake values for the site.
3. Identify the design limiting constituent.

V. Site Management

A. Compliance Activities

1. If applying for a permit modification or a renewal permit, provide a summary and status of compliance activities under the existing permit.

B. Seepage Rate Testing

1. Discuss the need (and, if appropriate, a schedule) for seepage rate testing of wastewater structures or ponds.

C. Site Management Plans

If the site has previously developed any of management plans listed below (or other site specific plans), either separately or as part of the site Plan of Operation, provide any updates to the information presented in the plan(s). If a new site, or if the plans have not been developed for an existing site, address each of the plan topics.

1. *Buffer Zone Plan*:
   a. Discuss disinfection and buffer zone issues for the land application site. Address the following buffer objects: dwellings, areas of public access, canals/ditches, private water sources, and public water sources.
   b. Compare site buffer distances to DEQ guideline buffer distances. As applicable, describe any proposed mitigation measures to potentially reduce the required buffer distances.
   c. Describe current and/or proposed fencing and signing for the facility.
2. *Grazing Management Plan*: required if any grazing activities are proposed at the land application site.
3. *Nuisance Odor Management Plan*: for systems with higher strength wastewater (wastewater with a greater potential to create odors), it is highly recommended that a Nuisance Odor Management Plan be prepared as part of the permit application.
4. *Waste Solids Management Plan*: discuss whether or not solids are to be applied on the permitted reuse site. If so, reflect the application of waste

solids in site constituent loading rate calculations. If waste solids are managed off-site, refer to IDAPA 58.01.02, Section 650 regarding sludge usage.

5. *TDIS (Total Dissolved Inorganic Solids) Management Plan*: to address potential increases in TDS (total dissolved solids) concentrations in groundwater and/or excessive salt levels in soils.
6. *Runoff Management Plan*: to address best management practices for minimization of runoff and ponding.

D. Monitoring

1. Describe how the quantity of land applied wastewater is proposed to be monitored (methodology, frequency, location).
2. Describe proposed sampling and analysis of the land applied wastewater (constituents, disinfection level, methodology, frequency, location).
3. Describe method of calculating hydraulic and constituent loading.
4. If supplemental irrigation water is expected to be used, describe how the quantity of land applied supplemental irrigation water is proposed to be monitored (methodology, frequency, location).
5. Describe proposed soil monitoring (constituents, soil depths, methodology, frequency, location).
6. Describe proposed groundwater monitoring (constituents, methodology, frequency, location).
7. Describe how crop uptake values are proposed to be determined (plant tissue monitoring, table values…).
8. Describe other proposed monitoring for the site.
9. Describe meteorological monitoring for site.

E. Site Operations and Maintenance

1. Describe who will operate and maintain the wastewater treatment facilities and land application site.
2. Describe operator certification credentials—credentials currently held and any plans for future certifications.
3. If a party other than the applicant operates and maintains the land application site, submit a copy of the signed contract or agreement outlining how the site will be operated to meet the conditions of the permit.

1.6 Guidelines for Preparing the Site Maps

If helpful for ease of preparation and/or use, the information listed under Vicinity Map and Facility Site Map may be divided between more than two maps. The maps may be included as an appendix in the technical report.

1.6.1 Vicinity Map

The Vicinity Map is a topographic map, extending one quarter (1/4) mile beyond the outer limits of the facility site. As required in the *Reuse Rules* (IDAPA 58.01.17), identify and show the location and extent of the following:

- Property boundaries of all treatment facilities and land application area(s). Include Township(s), Range(s), Section(s).

- Wells, springs, wetlands, and surface waters.
- Public and private drinking water supply sources and source water assessment areas (public water system protection area information).
- Public roads.
- Dwellings and private and public gathering places.

1.6.2 Facility Site Map

The *Facility Site Map* is a topographic map. As required in the *Reuse Rules* (IDAPA 58.01.17), identify and show the location and extent of the following:

- Wastewater inlets, outlets, and storage structures and facilities.
- Wells, springs, wetlands, and surface waters.
- Twenty-five (25), fifty (50), and one hundred (100) year flood plains, as available through the Federal Insurance Administration of the Federal Emergency Management Agency.
- Service roads.
- Natural or man-made features necessary for treatment.
- Buildings and structures.
- Process chemicals and residue storage facilities.

In addition, the following items are recommended to be identified on the Facility Site Map:

Land application area(s).

- For an existing site, identify the permitted hydraulic management units, including serial number, and clearly show any proposed changes to the land application acreage.
- For an existing site, identify the soil monitoring units, including serial number.

For an existing site, include serial numbers for lagoons/storage ponds (if applicable).

- Wastewater and site monitoring points, including groundwater monitoring wells (if applicable).
- Quantify and label buffer zone distances between the land application area(s) and: dwellings, areas of public access, canals/ditches, private water sources, and public water sources.

1.6.3 Other Site Specific Maps and Drawings

Present other pertinent maps or drawings for the site. These may include:

- Groundwater contours and direction of flow.
- Wastewater treatment facility drawings.
- Irrigation system design drawings showing sumps, pipelines, ditches, irrigation diversions, irrigation systems (pivots, wheel lines, etc.), and other relevant items.
- Location and extent of run-on and/or run-off control systems including berms and tailwater collection systems.
- Other maps important for presenting site characteristics and/or site operations.

1.7 Plan of Operation Checklist

A copy of the Plan of Operation Checklist can be found in Section 1.9.3.

1.8 Reuse Permit, Permit Process Steps

Procedures and timing for processing reuse permit applications are outlined in the *Reuse Rules* (IDAPA 58.01.17). Applicants are encouraged to review the rules to become familiar with these procedures. (See the Preface to this guidance for links to the rules affecting reuse.)

1.8.1 Typical Steps for a Reuse Permit

Typical steps associated with obtaining a reuse permit from DEQ are as follows:

1. Pre-application form submitted to the DEQ Regional Office.
2. Pre-application conference between the applicant and DEQ.
3. Applicant submits a reuse permit application to the DEQ Regional Office.
4. DEQ performs a completeness review. Typically, at this step, DEQ also makes a preliminary decision regarding whether or not to issue a permit.
5. DEQ prepares a *Staff Analysis* and *Draft Permit* for the complete application.
6. DEQ issues a draft permit. This step includes review of the draft permit and staff analysis by DEQ's state program office and the DEQ Director. The draft permit and staff analysis are posted on the DEQ internet site.
7. Comments may be submitted by the applicant and by the public. In some cases, meetings are held between DEQ and the applicant to discuss the draft permit. Also, if appropriate, public information meetings may be held.
8. DEQ prepares responses to comments and prepares the final permit. If substantial modifications are made to the permit, they are reviewed with the DEQ Director.
9. DEQ issues final permit. The applicant may appeal the final permit, if desired.

1.8.2 Reuse Permit Application Timing

The reuse rules specify the following timing for submitting a reuse permit application:

- At least one hundred eighty (180) days prior to the day on which a new activity is to begin;
- At least one hundred eighty (180) days prior to the expiration of any permit issued pursuant to these rules;

To meet this requirement, applicants are encouraged to plan ahead. Some applicants may need to allow six months or more for preparing the permit application *prior* to submittal. Examples for which additional time may be required include the following:

- Applying for a new permit.
- Applying for a major permit modification.
- Applying for a renewal permit when major changes to land application activities are to be addressed with the renewal permit.

If you are applying for a minor permit modification, discuss the scope and timing of the modification application with the DEQ Regional Office. For example, it may not be possible to foresee a transfer of ownership 180 days prior to the change. Requests for changes in the permit processing procedure are addressed by DEQ on a case-by-case basis.

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1.9 Supplemental Materials

1.9.1 Standard Municipal Permits

User's Guide
for the
Standard Municipal Wastewater Reuse Permit Template

08/17/06

Introduction

The Standard Municipal Wastewater Reuse Permit Template is a guidance document for writing Municipal permits. There may be permit specific issues that are not addressed in this template or parts of the template that may not be applicable to the site you are permitting. The template serves to provide for consistent permit limits and language where appropriate.

The template includes a section for abbreviations/acronyms and the layout is arranged to put permit specific information at the beginning and standard limits, requirements, and conditions towards the end of the permit.

The language that appears in yellow highlight is optional and inclusion in the permit needs to be evaluated on a case-by-case basis by the permit writer.

The Wastewater Program Office, as time permits, will update this template. If you have suggestions for modifying the template, please contact Mark Mason at (208) 373-0266.

Section E. Compliance Schedule for Required Activities

Plan of Operation – Inclusion of this compliance activity will depend on the status of the Plan of Operation at the time of permitting. If an existing facility has an adequate Plan of Operation, this is obviously not necessary. For new facilities or re-permits involving significant modifications, this requirement may be appropriate.

Nuisance Odor Management Plan – Preference would be to have the applicant submit this plan with permit application materials, especially for new systems or if there is significant public interest.

TDIS Management Plan – If ground water modeling indicates significant TDS impacts to ground water, this compliance activity should be included.

Water Quality Improvement Plan (WQIP) – For sites that have existing ground water quality that exceeds the limits in the *Ground Water Quality Rule* (IDAPA 58.01.11) for primary or secondary standards as a result of reuse activities, a WQIP may be required. The WQIP requires mapping areas where ground water has been impacted. For areas where ground water quality standards are exceeded, a plan to improve ground water quality, with the objective of attaining standards is required. For areas where ground water quality is degraded, but ground water quality standards are not exceeded, best management practices or other measures described in the GWQR, section

58.01.11.400.02 shall be developed and implemented. For example language, consult with the Wastewater Program Office.

Waste Solids Management Plan – Site specific.

Buffer Zone Plan – The applicant should provide this information as part of the permit application materials. However, for new sites that are in design, this compliance activity may be required. Facilities may be developing plans for the irrigation system during the same timeframe as the draft permit.

Ground Water Monitoring Plan – Site specific. Typically required for new facilities where it is determined ground water monitoring is necessary. May also be required for re-permitting sites in which the existing network is inadequate.

Section F. Special Permit Conditions

Supervision – Requiring supervision of the wastewater treatment system is optional. Poor past management or complex wastewater pretreatment systems prior to reuse are considerations. Also helpful for simple systems where operator is not technically proficient.

Section G. Monitoring Requirements

Composite Sampling - Dependent on wastewater system. For systems with wastewater quality that is variable within a 24-hour period, the system should provide composite samples. For systems that quality does not vary significantly on a daily basis, grab samples are appropriate.

Bacterial Sampling – Required.

Appendix 1. Environmental Monitoring Serial Numbers

Instructions for serial number assignment. Serial Numbers for monitoring points are formatted as follows. XX-xxxxxx. The upper case XX signifies the type of point (MU, WW, SW…). This is followed by a hyphen. The first four lower case x's signify the last four numbers of the permit, excluding the suffix. The last two lower case x's signify the actual point location. If the permit area expands over the life of the project, the point location numbers are just continued and expanded as necessary. No allowance is necessary for suffixes or new expansion area designation.

A. Permit Certificate

MUNICIPAL
WASTEWATER REUSE PERMIT
LA-000xxx-0x

Facility Name, LOCATED AT Street address, city, ID xxxxx-xxxx AND IN **Township(s) xx, Range(s) xx, Section(s) xx IS** HEREBY AUTHORIZED TO CONSTRUCT, INSTALL, AND OPERATE A WASTEWATER REUSE SYSTEM IN ACCORDANCE WITH THE WASTEWATER REUSE RULES (IDAPA 58.01.17) AND THE WASTEWATER RULES (IDAPA 58.01.16), THE GROUND WATER QUALITY RULE (IDAPA 58.01.11), AND ACCOMPANYING PERMIT, APPENDICES, AND REFERENCE DOCUMENTS. THIS PERMIT IS EFFECTIVE FROM THE DATE OF SIGNATURE AND EXPIRES ON **(60 months from issue date)**.

____
Name of RO Administrator
Title i.e. (REGION) Regional Administrator
Idaho Department of Environmental Quality

Date:

DEPARTMENT OF ENVIRONMENTAL QUALITY
Regional Office Address
Regional Office Phone No.

POSTING ON SITE RECOMMENDED

B. Permit Contents, Appendices, and Reference Documents

Appendices

1. Environmental Monitoring Serial Numbers
2. Site Maps

References

1. Plan of Operation (Operation and Maintenance Manual)
   - Nuisance Odor Management Plan
   - Waste Solids Management Plan
   - Etc. – see checklist in Handbook

The Sections, Appendices, and Reference Documents listed on this page are all elements of Wastewater Reuse Permit LA-000xxx-0x and are enforceable as such. This permit does not relieve Company Name, hereafter referred to as the permittee, from responsibility for compliance with other applicable federal, state or local laws, rules, standards or ordinances.

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C. Abbreviations, Definitions

Comment: Items throughout template that are highlighted in yellow are options for considerations and additional thought as to application to a particular permit. Those items may be included, modified or deleted.

Ac-in	Acre-inch. The volume of water or wastewater to cover 1 acre of land to a depth of 1 inch. Equal to 27,154 gallons.
BMP or BMPs	Best Management Practices
COD	Chemical Oxygen Demand
DEQ or the Department	Idaho Department of Environmental Quality
Director	Director of the Idaho Department of Environmental Quality, or the Directors Designee, i.e. Regional Administrator
ET	Evapotranspiration – Loss of water from the soil and vegetation by evaporation and by plant uptake (transpiration)
GS	Growing Season – Typically April 01 through October 31 (214 days)
GW	Ground Water
GWQR	IDAPA 58.01.11 "Ground Water Quality Rule"
Guidance	Guidance for Reclamation and Reuse of Municipal and Industrial Wastewater, DEQ.
HLRgs	Growing Season Hydraulic Loading Rate. Includes any combination of wastewater and supplemental irrigation water applied to reuse hydraulic management units during the growing season. The HLRgs limit is specified in Section F. Permit Limits and Conditions.
HLRngs	Non-Growing Season Hydraulic Loading Rate. Includes any combination of wastewater and supplemental irrigation water applied to each hydraulic management unit during the non-growing season. The HLRngs limit is specified in Section F. Permit Limits and Conditions.
HMU	Hydraulic Management Unit (Serial Number designation is MU)
IWR	Irrigation Water Requirement – Any combination of wastewater and supplemental irrigation water applied at rates commensurate to the moisture requirements of the crop, and calculated monthly during the growing season (GS). Calculation methodology for the IWR can be found at the following website: http://www.kimberly.uidaho.edu/water/appndxet/index.shtml. The equation used to calculate the IWR at this website is: $IWR = (CU - P_e) / E_i$ CU is the monthly consumptive use for a given crop in a given climatic area. CU is synonymous with crop evapotranspiration P_e is the effective precipitation. CU minus Pe is synonymous with the net irrigation requirement (IR) E_i is the irrigation system efficiency. To obtain the gross irrigation water requirement (IWR), divide the IR by the irrigation system efficiency.
IDAPA	Idaho Administrative Procedures Act.
LG	Lagoon
lb/ac-day	Pounds (of constituent) per acre per day
MG	Million Gallons (1 MG = 36.827 acre-inches)
MGA	Million Gallons Annually (per WLAP Reporting Year)
NGS	Non-Growing Season – Typically November 01 through March 31 (151 days)
NVDS	Non-Volatile Dissolved Solids (= Total Dissolved Solids less Volatile Dissolved Solids)
O&M manual	Operation and Maintenance Manual, also referred to as the Plan of Operation

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C. Abbreviations, Definitions

Reuse	The use of reclaimed wastewater for beneficial uses including, but not limited to, land treatment, irrigation, aquifer recharge, use in surface water features, toilet flushing in commercial buildings, dust control, and other uses.
Reuse Reporting Year	The reporting year begins with the non-growing season and extends through the growing season of the following year, typically November 01 – October 31. For example, the 2000 Reporting Year was November 01, 1999 through October 31, 2000.
SAR	Sodium Absorption Ratio
SI	Supplemental Irrigation water applied to the reuse treatment site.
Soil AWC	Soil Available Water Holding Capacity - the water storage capability of a soil to a depth at which plant roots will utilize (typically 60 inches or root limiting layer)
SMU	Soil Monitoring Unit (Serial Number designation is SU)
SW	Surface Water
TDS	Total Dissolved Solids or Total Filterable Residue
TDIS	Total Dissolved Inorganic Solids – The summation of chemical concentration results in mg/L for the following common ions: calcium, magnesium, potassium, sodium, chloride, sulfate, and 0.6 times alkalinity (alkalinity expressed as calcium carbonate). Nitrate, Silica and fluoride shall be included if present in significant quantities (i.e. >5 mg/L each).
TMDL	Total Maximum Daily Load - The sum of the individual waste-load allocations (WLA's) for point sources, Load Allocations (LA's) for non-point sources, and natural background. Such load shall be established at a level necessary to implement the applicable water quality standards with seasonal variations and a margin of safety that takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality. IDAPA 58.01.02 *Water Quality Standards and Wastewater Treatment Requirements*
Typical Crop Uptake	Typical Crop Uptake is defined as the median constituent crop uptake from the three (3) most recent years the crop has been grown. Typical Crop Uptake is determined for each hydraulic management unit. For new crops having less than three years of on-site crop uptake data, regional crop yield data and typical nutrient content values, or other values approved by DEQ may be used.
USGS	United States Geological Survey
WW	Wastewater applied to the reuse treatment site.

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D. Facility Information

Legal Name of Permittee	
Type of Wastewater	
Method of Treatment	
Type of Facility	
Facility Location	
Legal Location	
County	
USGS Quad	
Soils on Site	
Depth to Ground Water	
Beneficial Uses of Ground Water	
Nearest Surface Water	
Beneficial Uses of Surface Water	
Responsible Official Mailing Address **Phone / Fax**	
Facility Consultants Mailing Address **Phone / Fax**	

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E. Compliance Schedule for Required Activities

Optional items to be edited are highlighted in yellow.

The Activities in the following table shall be completed on or before the Completion Date unless modified by the Department in writing.

Compliance Activity Number Completion Date	Compliance Activity Description
CA-xxx-xx **Prior to applying wastewater at site**	A Plan of Operation (Operation and Maintenance Manual or O&M Manual) for the wastewater reuse facilities, incorporating the requirements of this permit, shall be submitted to DEQ for review and comment. The O&M manual shall be designed for use as an operator guide for actual day-to-day operations to meet permit requirements and shall include daily sampling and monitoring requirements to insure proper operation of the wastewater treatment facility. The Plan of Operation shall contain at a minimum all of the information required by the latest revision of the Plan of Operation Checklist in the Reuse Program Guidance. Upon approval, the manual shall be incorporated by reference into this permit and shall be enforceable as a part of this permit.
CA-xxx-xx **Prior to applying wastewater at site**	Submit a Nuisance Odor Management Plan to DEQ for review and approval. The Odor Management Plan shall include wastewater treatment systems, reuse facilities, and other operations associated with the facility. The plan shall include specific design considerations, operation and maintenance procedures, and management practices to be employed to minimize the potential for or limit odors. The plan shall also include procedures to respond to an odor incident if one occurs, including notification procedures.
CA-xxx-xx **Prior to applying wastewater at site**	A TDIS Management Plan may be required if ground water TDS significantly increases across the site. The plan shall identify sources of TDIS, evaluate the feasibility of isolation or removal of TDIS, and propose strategies to minimize TDIS in the wastewater.
CA-xxx-xx **Prior to applying wastewater at site**	For sites that have existing ground water quality that exceeds standards as a result of reuse activities, a Water Quality Improvement Plan (WQIP) may be required.
CA-xxx-xx **Prior to applying wastewater at site**	Submit to the Department for review and approval, a well location acceptability analysis, as outlined in the *Guidance for Reclamation and Reuse of Municipal and Industrial Wastewater*, Section 6.6.3.1 for all applicable wells located around or on the reuse site.
CA-xxx-xx **Prior to application of waste solids**	Submit a Waste Solids Management Plan to DEQ for review and approval. The Plan shall describe how waste solids generated at the facility will be handled and disposed of to meet the requirements of section I, No. 5.

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E. Compliance Schedule for Required Activities

Compliance Activity Number Completion Date	Compliance Activity Description
CA-xxx-xx Prior to applying wastewater at site	Submit a scaled site map delineating buffer zones, homes, public access areas, private wells, canals, etc. and the actual area in acres of each HMU. Site Maps shall be supplied by the permittee and shall include at a minimum all requirements of IDAPA 58.01.17.300.05.e through f.
CA-xxx-xx Prior to applying wastewater at site	Submit plans and specifications for ground water monitoring network for DEQ review and approval, including at least one (1) upgradient well and two (2) downgradient wells.
CA-xxx-xx Prior to applying wastewater at site	For Forest / Tree sites, Permittee shall submit Silviculture Plan to DEQ within 12 months of permit start date.
CA-xxx-xx Within one year of permit renewal	Update O & M Manual, Site Maps etc.
CA-xxx-xx Prior to applying wastewater at site	______ shall prepare and submit to DEQ for approval a runoff management plan with control structures and other BMPs (e.g. collection basins, berms, etc.) designed to prevent runoff from any site or fields used for wastewater reuse to property not owned by ______ except in the event of a 25-year, 24-hour storm event or greater, using Western Regional Climate Center (WRCC) Precipitation Frequency Map, Figure 28 'Isopluvials of 25-YR, 24-HR Precipitation'. For this site, the 25-year, 24-hour event is ___ inches. Upon approval of the plan by DEQ, ______ shall implement the runoff management plan, and shall construct, operate, and maintain the control structures and other BMPs in accordance with the plan.

(Add other optional requirements for grazing plans, and seepage testing here in compliance activities to further describe particular requirements for each site.)

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F. Permit Limits and Conditions

1) The Permittee is allowed to apply wastewater and treat it on a reuse site as prescribed in the tables below and in accordance with all other applicable permit conditions and schedules.

Category	Permitted Limits and Conditions
Type of Wastewater	Municipal Wastewater
Application Site Area	
Application Season	
Growing Season (GS)	Site Specific – define for this permit.
Non-Growing Season (NGS)	Site Specific – define for this permit.
Certified Operator	Required. See IDAPA 58.01.02.406.
Reporting Year for Annual Loading Rates	Site Specific Dates. Comment: It should always be consecutive NGS and GS periods.
Maximum Hydraulic Loading Rate, Growing Season (includes wastewater and supplemental irrigation water, if used)	Growing Season (GS) Hydraulic Loading Rate shall be no greater than the Irrigation Water Requirement (IWR) using data from the tables of the following University Of Idaho web site: http://www.kimberly.uidaho.edu/water/appndxet/index.shtml. IWR is equal to the Mean IR data from these tables divided by the irrigation system efficiency. In lieu of these tables, current climatic and evaporation data, or 30-year average data may be used to calculate the IWR, as defined on page 5 of this permit. Assume no carryover soil moisture and a leaching rate of zero in calculating the IWR. Application shall generally follow consumptive use rates for the crop throughout the season.
Maximum Hydraulic Loading Rate, Non-Growing Season	Soil AWC – Precipitation $_{NGS}$ + Evapotranspiration $_{NGS}$ for each hydraulic management unit (HMU). **Include the allowable amount in inches and MG for each HMU in this section based on this equation.** HMU # — Field Description — Million Gallons — Inches 1 — Pivots 1 and 2 — x.xx — x.xx 2 — Pivot 3 — x.xx — x.xx etc….
Runoff	1. No runoff of wastewater allowed. 2. Furrow and sprinkler irrigation: Operate and maintain structures and BMPs for supplemental irrigation water sediment control in accordance with DEQ approved plan.
Ground Water Quality	Ground Water Quality shall be in compliance with *Idaho Ground Water Quality Rule* IDAPA 58.01.11
Maximum COD Loading, seasonal average in Pounds / acre-day, each HMU	50 pounds/acre-day seasonal average for growing season. 25 pounds/acre-day seasonal average for non-growing season.

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F. Permit Limits and Conditions

Category	Permitted Limits and Conditions
Maximum Nitrogen Loading Rate, pounds / acre-year, each HMU (from all sources including waste solids and supplemental fertilizers).	150% of typical crop uptake (see definition), or UI Fertility Guide
Maximum Phosphorus Loading Rate, pounds / acre-year, each HMU (from all sources including waste solids and supplemental fertilizers).	No maximum. DEQ reserves the right to re-open this permit for inclusion of phosphorus limits
Construction Plans	Prior to construction or modification of all wastewater facilities associated with the reuse system or expansion, detailed plans and specifications shall be reviewed and approved by DEQ. Within 30 days of completion of construction, the permittee shall submit as-built plans to DEQ or submit a certification letter stating that all construction was done in substantial compliance with DEQ approved plans and specifications.
Grazing	A grazing management plan shall be submitted to DEQ for review and approval prior to any grazing activities. Grazing Plans shall follow the guidance located on the DEQ Internet site.
Allowable crops	Crops grown for direct human consumption (those crops that are not processed prior to consumption) are not allowed.
Fencing and Posting	Signs shall be posted every 500 feet designating the fields as wastewater reuse areas or equivalent – see Reuse Guidance.
Supplemental Irrigation Water Protection	For systems with wastewater and fresh irrigation water interconnections, DEQ approved backflow prevention devices are required.
Odor Management	The wastewater treatment plant, reuse facilities, and other operations associated with the facility shall not create a public health hazard or nuisance conditions, including odors. These facilities shall be managed in accordance with a DEQ approved Odor Management Plan.

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F. Permit Limits and Conditions

Buffer Zone Distances (based on sprinkler irrigation)	Disinfection Level* (total coliform)	Distance to Public Access	Distances to Inhabited Dwellings	Distance to streams	Distance to private water sources	Distance to public water sources	Single sample maximum total coliform level
	2.2 /100 ml	0 feet	100 feet	100 feet	500	1000	23/100 ml
	23/100 ml	50 feet	300 feet	100 feet	500	1000	240/100ml
	230/100ml	300 feet	1,000 feet	100 feet	500	1000	2400/100ml

*Compliance determination method for disinfection requirements is as follows:

- For determining compliance with the 2.2 / 100 ml disinfection level, the median value of the last five (5) results must not exceed 2.2 / 100 ml. In addition, no single sample value shall exceed 23 / 100 ml.
- For determining compliance with the 23 / 100 ml disinfection level, the median value of the last five (5) results must not exceed 23 / 100 ml. In addition, no single sample value shall exceed 240 / 100 ml.
- For determining compliance with the 230 / 100 ml disinfection level, the median value of the last three (3) results must not exceed 230 / 100 ml. In addition, no single sample value shall exceed 2400 / 100 ml.

(Also see Guidance for additional requirements for Buffer Zones – Public Exposure and Buffer Zones – Well Head Protection.)

The following are possible Permit Limits and Conditions that would be chosen depending on the particular permit is question. Many other options are available as the permit writer sees necessary.

1. No wastewater reuse is allowed when depth to ground water is 36 inches or less as measured by on-site piezometers.
2. Specific total coliform limit and associated buffer zones.
3. More defined Hydraulic Loading Requirement. In the Cd'A permits, we calculated the monthly IWR in inches and MG, and put those in the permit.
4. Discussion of weekly or monthly limits on hydraulic loading.
5. Other applicable issues.

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G. Monitoring Requirements

1) Appropriate analytical methods, as given in the *Guidance for Reclamation and Reuse of Municipal and Industrial Wastewater* or as approved by the Idaho Department of Environmental Quality (hereinafter referred to as DEQ), shall be employed. A description of approved sample collection methods, appropriate analytical methods and companion QA/QC protocol shall be included in the Operation and Maintenance Manual.
2) The permittee shall monitor and measure parameters and submit information as stated in the Facility Monitoring Table in this section.
3) Samples shall be collected at times and locations that represent typical environmental and process parameters being monitored.
4) Monitoring locations are described in Appendix 1. Environmental Monitoring Serial Numbers.
5) Monitoring is required at the frequency shown in the table below if wastewater is applied anytime during the time period shown. Unless otherwise agreed in writing by the DEQ, data collected and submitted shall include, but not be limited to, the parameters and frequencies in the Facility Monitoring Table as follows.
6) If the soil management unit is less than 15 acres, use 5 sub-samples. If the soil management unit is greater than 15 acres, use 10 sub-samples.
7) Three (3) soil samples shall be collected at each sample location, one at 0-12 inches, one at 12-24 inches, and one at 24-36 inches. The soil samples collected at 0-12 inches from each sample location shall be composited. Similarly, all soil samples collected at 12-24 inches shall be composited and all soil samples collected at 24-36 inches shall be composited. This method will yield three samples for analysis, one for 0-12 inches, one for 12-24 inches and one for 24-36 inches for each soil management unit.
8) Ground Water Monitoring Procedure: Ground Water Monitoring Wells shall be purged a minimum of three casing volumes and/or until field measurements for pH, specific conductance and temperature meet the following conditions: two successive temperature values measured at least five minutes apart are within one degree Celsius of each other, pH values for two successive measurements measured at least five minutes apart are within 0.2 units of each other, and two successive specific conductance values measured at least five minutes apart are within 10% of each other. This procedure will determine when the wells are suitable for sampling for constituents required by the permit. Other procedures, such as low flow sampling, may be considered by DEQ for approval. The static water level shall be measured prior to pumping or sampling for ground water.
9) Annual reporting of monitoring requirements is described in Section H, Standard Reporting Requirements.
10) Surface water sampling guidance: DEQ to review and approve methods, timing and locations for sampling prior to initial sampling event.

Facility Monitoring Table

Frequency	Monitoring Point	Description and Type of Monitoring	Parameters
Daily (when land applying)	Discharge Point of Wastewater to Reuse (Flow Meter)	Volume of Wastewater land applied	Gallons/Month and acre-inches/month applied to each Hydraulic Management Unit – record monthly and report annually.
Monthly (when land applying)	Discharge Point of Wastewater to Reuse	grab sample	Total Kjeldahl nitrogen, nitrate+nitrite-nitrogen, TDS, pH, COD, total phosphorus
Daily (when land applying)	Flow Meter or Calibrated Pump Rate	Supplemental Irrigation Water	Gallons/Month and acre-inches/month applied to each Hydraulic Management Unit – record monthly and report annually.

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G. Monitoring Requirements

Frequency	Monitoring Point	Description and Type of Monitoring	Parameters
Annually	Supplemental Irrigation Water at diversions	Grab Sample	Total Kjeldahl nitrogen, nitrate+nitrite-nitrogen, TDS, pH, COD, total phosphorus
During Application Season For total coliform, monitoring frequency depends on level of treatment. 1. 2.2 / 100 ml. - Twice Weekly 2. 23 / 100 ml. - Weekly 3. 230 / 100 ml. - Twice Monthly	Discharge Point of Wastewater to Reuse	grab sample	Total Coliform
Annually	Hydraulic management unit	Acres used for reuse	Acres
Annually	Hydraulic management unit	COD loading calculation (GS and NGS)	COD applied in lbs/acre-day
Annually	Hydraulic management unit	Report total nitrogen and phosphorus load from fertilizer or all other non-wastewater application.	Nitrogen and phosphorus applied in lbs/acre-year
Annually	Hydraulic management unit	Calculate and Report total nitrogen and phosphorus loading calculation from wastewater	Nitrogen and phosphorus applied in lbs/acre-year
Annually	Hydraulic management unit	Crop Yield Calculation and Crop Type	tons/acre, lbs/acre, or bushels/acre
Annually	Soil Monitoring unit	Composite soil sample	Electrical Conductivity, nitrate-N, ammonium-N, pH, Plant available phosphorous – (use Olsen method for soils with pH 6.5 or greater, use Bray method if soil pH is less than 6.5)
First year of permit only	Soil Monitoring unit	Composite soil sample	SAR, DTPA-FE, DTPA-Mn
Annually	Hydraulic management unit	Crop Nutrient Uptake from Crop Tissue Analysis or from standard tables for Crop Type and yield.	Nitrogen and phosphorus uptake in lbs/acre-year

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G. Monitoring Requirements

Frequency	Monitoring Point	Description and Type of Monitoring	Parameters
Annually	Hydraulic management unit	Calculate Irrigation Water Requirement for Crop Grown	Volume (inches / acre and total gallons) for each month for GS
Annually	All flow measurement locations.	Flow measurement calibration of all flows to reuse.	Document the flow measurement calibration of all flow meters and pumps used directly or indirectly measure all wastewater, tail water, flushing water, and supplemental irrigation water flows applied to each HMU.
Annually	All supplemental irrigation pumps directly connected to the wastewater distribution system.	Backflow testing	Document the testing of all backflow prevention devices for all supplemental irrigation pumps directly connected to the wastewater distribution system(s). Report the testing date(s) and results of the test (pass or fail). If any test failed, report the date of repair or replacement of backflow prevention device, and if the repaired/replaced device is operating correctly.
April of first and last permit years only.	Groundwater Monitoring Wells listed in Appendix 1.	Grab sample of groundwater (See Note 8).	Sodium, Potassium, Calcium, Magnesium, carbonate, bicarbonate, Total Coliform, Nitrate, TDS.

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G. Monitoring Requirements

Frequency	Monitoring Point	Description and Type of Monitoring	Parameters
April of first and last permit years only.	Domestic and municipal wells within ¼ mile of all reuse acreage.	Grab sample from domestic and municipal wells (with well owner's permission. See note 8).	Specific Conductivity, Total Dissolved Solids (TDS), Nitrite + Nitrate Nitrogen, Total Phosphorus, Chloride, Sulfate, Total Iron, Total Manganese, Sodium, Potassium, Calcium, Magnesium, carbonate, bicarbonate, Dissolved Iron[1], Dissolved Manganese[1]
Annually	Each HMU	Calculate crop nitrogen, phosphorous, and ash removal	Pounds/acre and total pounds per HMU (dry basis)
Annually	Each HMU	Calculate NGS wastewater loading rate	Million gallons & Inches/NGS
Annually	Each HMU	Calculate GS wastewater loading rate	Million gallons & Inches/GS
Twice per year (May and Oct)	Nearest Surface Water – DEQ shall review and approve locations prior to initial sampling event.	Grab samples of surface water upstream and downstream from reuse site.	Nitrate + Nitrite Nitrogen, Total Phosphorous, Ortho Phosphorus, Total Dissolved Solids, Volatile Dissolved Solids, Chemical Oxygen Demand, Total Kjeldahl Nitrogen
Daily during NGS if land applying.	Meteorological data and field conditions, each HMU	Temperature, Precipitation, and field conditions.	High and low air temperatures and precipitation during each 24-hour period. Field conditions observations for areas of ponding, etc.
Note: Review permit strategy and policy for phosphorous with program office	Surface water upstream and downstream of site	For sites that apply high levels of phosphorous (for example, twice crop uptake or more) and ground water discharges to nearby surface water.	Total Phosphorous, Ortho Phosphorous, Electrical Conductivity

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G. Monitoring Requirements

1. Analytical results are required for dissolved iron and / or manganese only if the results for total iron and / or manganese exceed the standards in IDAPA 58.01.11.200.01.b.

The following are possible Monitoring Requirements that would be chosen depending on the particular permit is question. Many other options are available as the permit writer sees necessary.

1. For sites requiring groundwater monitoring, a minimum of quarterly grab samples at each of the up-gradient and down-gradient monitoring points will be required.

2. For sites requiring groundwater monitoring, twice annual (April and October) grab samples for Chloride, Nitrate-N, Nitrite-N, TDS, static water level, total iron, total manganese, and pH will be required. Note: If the MCL for total iron and manganese are exceeded, sample the well for dissolved iron and manganese. (include total coliform for systems with shallow ground water).

3. The heavy metals are not necessary unless there is a known industrial contributor. The nitrate, TDS, chloride, iron and manganese are included above.

4. For sites requiring groundwater monitoring, if the monitoring system is appropriate (as determined by staff hydrogeologist), soil sampling frequency may be reduced to the first and last years of the permit.

5. Coliform sampling frequency and other protocol for filtered systems with coliform limit of 2.2 / 100 ml.

6. If the nitrogen loading for the reporting year is 75% or less than the nitrogen permit limit, the permittee may reduce wastewater monitoring to twice per year in July and September for the following reporting year and beyond if the loading rates continues below 75%.

7. Recommendation that operators monitor TSS and BOD of both influent and effluent. This is not a requirement. However, operators can put this additional monitoring into their Operation and Maintenance Manual and use the data as an indicator of treatment performance.

8. Reduction in ground water monitoring if justified by historical data.

9. Eliminate COD wastewater monitoring requirements if historical loading rates are 5 pounds/acre-day or less.

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H. Standard Reporting Requirements

1. The permittee shall submit an Annual Wastewater Reuse Site Performance Report ("Annual Report") prepared by a competent environmental professional no later than January 31 of each year which shall cover the previous year (see section F for reuse reporting period). The Annual Report shall include results for monitoring required in Section G, status of compliance activities, and an interpretive discussion of monitoring data (ground water, vadose zone, hydraulic loading, wastewater etc.) with particular respect to environmental impacts by the facility.

2. The annual report shall contain the results of the required monitoring as described in Section G, Monitoring Requirements. If the permittee monitors any parameter more frequently than required by this permit, the results of this monitoring shall be included in the calculation and reporting of the data submitted in the annual report.

3. The annual report shall be submitted to the Engineering Manager in the applicable Regional DEQ Office.

Boise Regional Office
1445 N. Orchard
Boise, ID 83706-2239
208-373-550

Coeur d'Alene Regional Office
2110 Ironwood Parkway
Coeur d'Alene, ID 83814
208-769-1422

Idaho Falls Regional Office
900 N. Skyline, Suite B
Idaho Falls, ID 83402
208-528-2650

Lewiston Regional Office
1118 "F" Street
Lewiston, ID 83501
208-799-4370

Pocatello Regional Office
444 Hospital Way, #300
Pocatello, ID 83201
208-236-6160

Twin Falls Regional Office
1363 Fillmore St.
Twin Falls, ID 83301
208-736-2190

A copy of the annual report shall also be mailed to:

Richard Huddleston, P.E.
Wastewater Program Manager
1410 N. Hilton
Boise, ID 83706
208-373-0561

4. Notice of completion of any work described in Section E. Compliance Schedule for Required Activities shall be submitted to the Department within 30 days of activity completion. The status of all other work described in Section E shall be submitted with the Annual Report.

5. All laboratory reports containing the sample results for monitoring required by Section G. Monitoring Requirements of this permit shall be submitted with the Annual Report.

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I. Standard Permit Conditions: Procedures and Reporting

1. The permittee shall at all times properly maintain and operate all structures, systems, and equipment for treatment, operational controls and monitoring, which are installed or used by the permittee to comply with all conditions of the permit or the Wastewater Reuse Permit Regulations, in conformance with a DEQ approved, current Plan of Operations (Operations and Maintenance Manual) which describes in detail the operation, maintenance, and management of the wastewater treatment system. This Plan of Operations shall be updated as necessary to reflect current operations.

2. Wastewater(s) or recharge waters applied to the land surface must be restricted to the premises of the application site. Wastewater discharges to surface water that require a permit under the Clean Water Act must be authorized by the U.S. Environmental Protection Agency.

3. Wastewater must not create a public health hazard or nuisance condition as stated in IDAPA 58.01.16.600.03. In order to prevent public health hazards and nuisance conditions the permittee shall:

a. Apply wastewater as evenly as practicable to the treatment area;
b. Prevent organic solids (contained in the wastewater) from accumulating on the ground surface to the point where the solids putrefy or support vectors or insects; and
c. Prevent wastewater from ponding in the fields to the point where the ponded wastewater putrefies or supports vectors or insects.

4. The permittee shall:

a. Manage the wastewater reuse treatment site as an agronomic operation where vegetative cover is grown and harvested or grazed to utilize the nutrients and minerals in the wastewater, and,
b. Not hydraulically overload any particular areas of the wastewater reuse treatment site.

5. All waste solids, including dredgings and sludges, shall be utilized or disposed in a manner which will prevent their entry, or the entry of contaminated drainage or leachate therefrom, into the waters of the state such that health hazards and nuisance conditions are not created; and to prevent impacts on designated beneficial uses of the ground water and surface water. The permittee's management of waste solids shall be governed by the terms of the DEQ approved Waste Solids Management Plan, which upon approval shall be an enforceable portion of this permit.

6. If the permittee intends to continue operation of the permitted facility after the expiration of an existing permit, the permittee shall apply for a new permit at least six months prior to the expiration date of the existing permit in accordance with the Wastewater Reuse Permit Regulations and include seepage tests on all lagoons per latest DEQ procedures.

7. The permittee shall allow the Director of the Idaho Department of Environmental Quality or the Director's designee (hereinafter referred to as Director), consistent with Title 39, Chapter 1, Idaho Code, to:

a. Enter the permitted facility,
b. Inspect any records that must be kept under the conditions of the permit.
c. Inspect any facility, equipment, practice, or operation permitted or required by the permit.
d. Sample or monitor for the purpose of assuring permit compliance, any substance or any parameter at the facility.

8. The permittee shall report to the Director under the circumstances and in the manner specified in this section:

a. In writing thirty (30) days before any planned physical alteration or addition to the permitted facility or activity if that alteration or addition would result in any significant change in information that was submitted during the permit application process.
b. In writing thirty (30) days before any anticipated change which would result in non-compliance with any permit condition or these regulations.
c. Orally within twenty-four (24) hours from the time the permittee became aware of any non-compliance which may endanger the public health or the environment at telephone numbers provided in the permit by the Director (see below).

DEQ Regional Office: see Permit Certification Page
Emergency 24 Hour Number 1-800-632-8000

LA-000xxx-0x	**Facility Name**	**Date**	**Page 19**

I. Standard Permit Conditions: Procedures and Reporting

d. In writing as soon as possible but within five (5) days of the date the permittee knows or should know of any non-compliance unless extended by the DEQ. This report shall contain:

i. A description of the non-compliance and its cause;
ii. The period of non-compliance including to the extent possible, times and dates and, if the non-compliance has not been corrected, the anticipated time it is expected to continue; and
iii. Steps taken or planned to reduce or eliminate reoccurrence of the non-compliance.

e. In writing as soon as possible after the permittee becomes aware of relevant facts not submitted or incorrect information submitted, in a permit application or any report to the Director. Those facts or the correct information shall be included as a part of this report.

9. The permittee shall take all necessary actions to prevent or eliminate any adverse impact on the public health or the environment resulting from permit noncompliance.

10. The permittee shall determine (on an on-going basis) if any noxious weed problems relate to the permitted sites. If problems are present, coordinate with the Idaho Department of Agriculture or the local County authority regarding their requirements for noxious weed control. Also address these control operations in an update to the Operations and Maintenance Manual.

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J. Standard Permit Conditions: Modifications, Violations, and Revocations

1. The permittee shall furnish to the Director within reasonable time, any information including copies of records, which may be requested by the Director to determine whether cause exists for modifying, revoking, re-issuing, or terminating the permit, or to determine compliance with the permit or these regulations.

2. Both minor and major modifications may be made to this permit as stated in IDAPA 58.01.17.700.01 and 02 with respect to any conditions stated in this permit upon review and approval of the DEQ.

3. Whenever a facility expansion, production increase or process modification is anticipated which will result in a change in the character of pollutants to be discharged or which will result in a new or increased discharge that will exceed the conditions of this permit, or if it is determined by the DEQ that the terms or conditions of the permit must be modified in order to adequately protect the public health or environment, a request for either major or minor modifications must be submitted together with the reports as described in I. *Standard Reporting Requirements*, and plans and specifications for the proposed changes. No such facility expansion, production increase or process modification shall be made until plans have been reviewed and approved by the DEQ and a new permit or permit modification has been issued.

4. Permits shall be transferable to a new owner or operator provided that the permittee notifies the Director by requesting a minor modification of the permit before the date of transfer.

5. Any person violating any provision of the Waste Water Reuse Permit Regulations, or any permit or order issued thereunder shall be liable for a civil penalty not to exceed ten thousand dollars ($10,000) or one thousand dollars ($1,000) for each day of a continuing violation, whichever is greater. In addition, pursuant to Title 39, Chapter 1, Idaho Code, any willful or negligent violation may constitute a misdemeanor.

6. The Director may revoke a permit if the permittee violates any permit condition or the Wastewater Reuse Permit Regulations.

7. Except in cases of emergency, the Director shall issue a written notice of intent to revoke to the permittee prior to final revocation. Revocation shall become final within thirty-five (35) days of receipt of the notice by the permittee, unless within that time the permittee request an administrative hearing in writing to the Board of the Department of Environmental Quality pursuant to the Rules of Administrative Procedures contained in IDAPA 58.01.23.

8. If, pursuant to Idaho Code § 67-5247, the Director finds the public health, safety or welfare requires emergency action, the Director shall incorporate findings in support of such action in a written notice of emergency revocation issued to the permittee. Emergency revocation shall be effective upon receipt by the permittee. Thereafter, if requested by the permittee in writing, a revocation hearing before the Board of the Department of Environmental Quality shall be provided. Such hearings shall be conducted in accordance with the Rules of Administrative Procedures contained in IDAPA 58.01.23.

9. The provisions of this permit are severable and if a provision or its application is declared invalid or unenforceable for any reason, that declaration will not affect the validity or enforceability of the remaining provisions.

10. The permittee shall notify the DEQ at least six (6) months prior to permanently removing any permitted reuse facility from service, including any treatment, storage, or other facilities or equipment associated with the reuse site. Prior to commencing closure activities, the permittee shall: a) participate in a pre-site closure meeting with the DEQ; b) develop a site closure plan that identifies specific closure, site characterization, or cleanup tasks with scheduled task completion dates in accordance with agreements made at the pre-site closure meeting; and c) submit the completed site closure plan to the DEQ for review and approval within forty-five (45) days of the pre-site closure meeting. The permittee must complete the DEQ approved site closure plan.

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Appendix 1
Environmental Monitoring Serial Numbers

HYDRAULIC MANAGEMENT UNITS

Serial Number	Description	Acres
MU-xxxxxx		
MU-xxxxxx		
MU-xxxxxx		
MU-xxxxxx		

WASTEWATER SAMPLING POINTS

Serial Number	Description
WW-xxxxxx	
WW-xxxxxx	

SURFACE WATER SAMPLING POINTS

Serial Number	Description
SW-xxxxxx	
SW-xxxxxx	

PEIZOMETERS

Serial Number	Description
SW-xxxxxx	
SW-xxxxxx	

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Appendix 1

Environmental Monitoring Serial Numbers

SOIL MONITORING UNITS

Serial Number	Description	Associated MU
SU-xxxxxx		
SU-xxxxxx		
SU-xxxxxx		
SU-xxxxxx		

GROUND WATER MONITORING

Serial Number	Description (private, irrigation, dedicated monitoring)	Location
GW-xxxxxx		
GW-xxxxxx		
GW-xxxxxx		

LAGOONS

Serial Number	Description
LG-xxxxxx	Lagoon no. 1
LG-xxxxxx	Lagoon no. 2

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Appendix 2
Site Maps

Site Maps shall be supplied by the permittee and shall include at a minimum all requirements of IDAPA 58.01.17.300.05.e through f.

Site Map No. 1

Attach map showing general locations (property boundaries) of municipal plant and reuse site. Include Township(s), Range(s), Section(s).

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Appendix 2
Site Maps

Site Map No. 2

Attach detailed map that shows the following:
- **All Hydraulic Management Units. Include MU serial #'s**
- **All Soil Monitoring Units. Include SU serial #'s**
- **All lagoons/storage ponds. Include serial #'s**
- **All Wastewater and Supplemental Irrigation distribution systems for the reuse site including sumps, pipelines, ditches, irrigation diversions, irrigation systems (pivots, wheel lines, etc.), tailwater collection systems, and any other item of relevance.**

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Appendix 2
Site Maps

Site Map No. 3

Attach detailed map showing location of:

- **All monitoring wells used for permit compliance (may include domestic wells if used for groundwater monitoring compliance).**
- **All public and private drinking water supply sources within ¼ mile of reuse site.**
- **All springs, wetlands, and surface waters within ¼ mile of reuse site.**
- **Groundwater contours & direction of flow (include additional map(s) if flow direction changes seasonally)**

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Appendix 2
Site Maps

Site Map No. 4

Attach map showing location of:
- **All dwellings within ¼ mile of reuse site.**
- **All public and private gathering places within ¼ mile of reuse site.**
- **All public roads within ¼ mile of reuse site.**

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1.9.2 Standard Industrial Permits

User's Guide
for the
Standard Industrial Wastewater Reuse Permit Template

08/15/06
Introduction

The Standard Industrial Wastewater Reuse Permit Template is a guidance document for writing industrial permits. There may be permit specific issues that are not addressed in this template or parts of the template that may not be applicable to the site you are permitting. The template serves to provide for consistent permit limits and language where appropriate.

The template includes a new section for abbreviations/acronyms and the layout has been rearranged to put permit specific information at the beginning and standard limits, requirements, and conditions towards the end of the permit.

The language that appears in yellow highlight is optional and inclusion in the permit needs to be evaluated on a case-by-case basis by the permit writer.

The Wastewater Program Office, as time permits, will update this template. If you have suggestions for modifying the template, please contact Mark Mason at (208) 373-0266.

Section E. Compliance Schedule for Required Activities

Plan of Operation – Inclusion of this compliance activity will depend on the status of the Plan of Operation at the time of permitting. If an existing facility has an adequate Plan of Operation, this is obviously not necessary. For new facilities or re-permits involving significant modifications, this requirement may be appropriate.

Nuisance Odor Management Plan – Preference would be to have the applicant submit this plan with permit application materials, especially for new systems or if there is significant public interest.

TDIS Management Plan – If ground water modeling indicates significant TDS impacts to ground water, this compliance activity should be included.

Water Quality Improvement Plan (WQIP) – For sites that have existing ground water quality that exceeds the limits in the *Ground Water Quality Rule* (IDAPA 58.01.11) for primary or secondary standards as a result of reuse activities, a WQIP may be required. The WQIP requires mapping areas where ground water has been impacted. For areas where ground water quality standards are exceeded, a plan to improve ground water quality, with the objective of attaining standards is required. For areas where ground water quality is degraded, but ground water quality standards are not exceeded, best management practices or other measures described in the GWQR, section 58.01.11.400.02 shall be developed and implemented. For example language, consult with the Wastewater Program Office.

Waste Solids Management Plan – Site specific.

Buffer Zone Plan – The applicant should provide this information as part of the permit application materials. However, for new sites that are in design, this compliance activity may be required. Facilities may be developing plans for the WLAP irrigation system during the same timeframe as the draft permit

Ground Water Monitoring Plan – Site specific. Typically required for new facilities where it is determined ground water monitoring is necessary. May also be required for re-permitting sites in which the existing network is inadequate.

Section F. Permit Limits and Conditions

Supervision – Requiring supervision of the wastewater treatment system is optional. Poor past management or complex wastewater pretreatment systems prior to reuse are considerations. Also helpful for simple systems where operator is not technically proficient.

Section G. Monitoring Requirements

Composite Sampling - Dependent on wastewater system. For systems with wastewater quality that is variable within a 24-hour period, the system should provide composite samples. For systems that quality does not vary significantly on a daily basis, grab samples are appropriate.

Bacterial Sampling - May be required for cheese processors, meat processors, or others in which there is documented evidence of human pathogens present. Also dependent on irrigation delivery method which may cause exposure.

Appendix 1. Environmental Monitoring Serial Numbers

Instructions for serial number assignment. Serial Numbers for monitoring points are formatted as follows. XX-xxxxxx. The upper case XX signifies the type of point (MU, WW, SW…). This is followed by a hyphen. The first four lower case x's signify the last four numbers of the permit, excluding the suffix. The last two lower case x's signify the actual point location. If the permit area expands over the life of the project, the point location numbers are just continued and expanded as necessary. No allowance is necessary for suffixes or new expansion area designation.

A. Permit Certificate

INDUSTRIAL
WASTEWATER REUSE PERMIT
LA-000xxx-0x

Facility Name, LOCATED AT **Street address, city, ID xxxxx-xxxx** AND IN **Township(s) xx, Range(s) xx, Section(s) xx** IS HEREBY AUTHORIZED TO CONSTRUCT, INSTALL, AND OPERATE A WASTEWATER REUSE SYSTEM IN ACCORDANCE WITH THE WASTEWATER REUSE RULES (IDAPA 58.01.17) AND WASTEWATER RULES (IDAPA 58.01.16), THE GROUND WATER QUALITY RULE (IDAPA 58.01.11), AND ACCOMPANYING PERMIT, APPENDICES, AND REFERENCE DOCUMENTS. THIS PERMIT IS EFFECTIVE FROM THE DATE OF SIGNATURE AND EXPIRES ON **(60 months from issue date)**.

____
Name of RO Administrator
Title i.e. (REGION) Regional Administrator
Idaho Department of Environmental Quality

Date:

DEPARTMENT OF ENVIRONMENTAL QUALITY
Regional Office Address
Regional Office Phone No.

POSTING ON SITE RECOMMENDED

B. Permit Contents, Appendices, and Reference Documents

Appendices

1. Environmental Monitoring Serial Numbers
2. Site Maps

References

1. Plan of Operation (Operation and Maintenance Manual)
   - Nuisance Odor Management Plan
   - Waste Solids Management Plan
   - Etc. – see checklist in Handbook

The Sections, Appendices, and Reference Documents listed on this page are all elements of Wastewater Reuse Permit LA-000xxx-0x and are enforceable as such. This permit does not relieve Company Name, hereafter referred to as the permittee, from responsibility for compliance with other applicable federal, state or local laws, rules, standards or ordinances.

LA-000xxx-0x	**Company Name**	**Date**	**Page 4**

C. Abbreviations, Definitions

Comment: Items throughout template that are highlighted in yellow are options for considerations and additional thought as to application to a particular permit. Those items may be included, modified or deleted.

Ac-in	Acre-inch. The volume of water or wastewater to cover 1 acre of land to a depth of 1 inch. Equal to 27,154 gallons.
BMP or BMPs	Best Management Practices
COD	Chemical Oxygen Demand
DEQ or the Department	Idaho Department of Environmental Quality
Director	Director of the Idaho Department of Environmental Quality, or the Directors Designee, i.e. Regional Administrator
ET	Evapotranspiration – Loss of water from the soil and vegetation by evaporation and by plant uptake (transpiration)
GS	Growing Season – Typically April 01 through October 31 (214 days)
GW	Ground Water
GWQR	IDAPA 58.01.11 "Ground Water Quality Rule"
Guidance	Guidance for the Reclamation and Reuse of Municipal and Industrial Wastewater, DEQ
HLRgs	Growing Season Hydraulic Loading Rate. Includes any combination of wastewater and supplemental irrigation water applied to reuse hydraulic management units during the growing season. The HLRgs limit is specified in Section F. Permit Limits and Conditions.
HLRngs	Non-Growing Season Hydraulic Loading Rate. Includes any combination of wastewater and supplemental irrigation water applied to each hydraulic management unit during the non-growing season. The HLRngs limit is specified in Section F. Permit Limits and Conditions.
HMU	Hydraulic Management Unit (Serial Number designation is MU)
IWR	Irrigation Water Requirement – Any combination of wastewater and supplemental irrigation water applied at rates commensurate to the moisture requirements of the crop, and calculated monthly during the growing season (GS). Calculation methodology for the IWR can be found at the following website: http://www.kimberly.uidaho.edu/water/appndxet/index.shtml. The equation used to calculate the IWR at this website is: $IWR = (CU - P_e) / E_i$ CU is the monthly consumptive use for a given crop in a given climatic area. CU is synonymous with crop evapotranspiration P_e is the effective precipitation. CU minus Pe is synonymous with the net irrigation requirement (IR) E_i is the irrigation system efficiency. To obtain the gross irrigation water requirement (IWR), divide the IR by the irrigation system efficiency.
IDAPA	Idaho Administrative Procedures Act.
LG	Lagoon
lb/ac-day	Pounds (of constituent) per acre per day
MG	Million Gallons (1 MG = 36.827 acre-inches)
MGA	Million Gallons Annually (per WLAP Reporting Year)
NGS	Non-Growing Season – Typically November 01 through March 31 (151 days)
NVDS	Non-Volatile Dissolved Solids (= Total Dissolved Solids less Volatile Dissolved Solids)
O&M manual	Operation and Maintenance Manual, also referred to as the Plan of Operation
Reuse	The use of reclaimed wastewater for beneficial uses including, but not limited to, land treatment, irrigation, aquifer recharge, use in surface water features, toilet flushing in commercial buildings, dust control, and other uses.
Reuse	The reporting year begins with the non-growing season and extends through the growing season

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C. Abbreviations, Definitions

Reporting Year	of the following year, typically November 01 – October 31. For example, the 2000 Reporting Year was November 01, 1999 through October 31, 2000.
SAR	Sodium Absorption Ratio
SI	Supplemental Irrigation water applied to the reuse treatment site.
Soil AWC	Soil Available Water Holding Capacity - the water storage capability of a soil to a depth at which plant roots will utilize (typically 60 inches or root limiting layer)
SMU	Soil Monitoring Unit (Serial Number designation is SU)
SW	Surface Water
TDS	Total Dissolved Solids or Total Filterable Residue
TDIS	Total Dissolved Inorganic Solids – The summation of chemical concentration results in mg/L for the following common ions: calcium, magnesium, potassium, sodium, chloride, sulfate, and 0.6 times alkalinity (alkalinity expressed as calcium carbonate). Nitrate, Silica and fluoride shall be included if present in significant quantities (i.e. > 5 mg/L each).
TMDL	Total Maximum Daily Load – The sum of the individual waste-load allocations (WLA's) for point sources, Load Allocations (LA's) for non-point sources, and natural background. Such load shall be established at a level necessary to implement the applicable water quality standards with seasonal variations and a margin of safety that takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality. IDAPA 58.01.02 *Water Quality Standards and Wastewater Treatment Requirements*
Typical Crop Uptake	Typical Crop Uptake is defined as the median constituent crop uptake from the three (3) most recent years the crop has been grown. Typical Crop Uptake is determined for each hydraulic management unit. For new crops having less than three years of on-site crop uptake data, regional crop yield data and typical nutrient content values, or other values approved by DEQ may be used.
USGS	United States Geological Survey
WW	Wastewater applied to the reuse treatment site

LA-000xxx-0x	**Company Name**	**Date**	**Page 6**

D. Facility Information

Legal Name of Permittee	
Type of Wastewater	
Method of Treatment	
Type of Facility	
Facility Location	
Legal Location	
County	
USGS Quad	
Soils on Site	
Depth to Ground Water	
Beneficial Uses of Ground Water	
Nearest Surface Water	
Beneficial Uses of Surface Water	
Responsible Official Mailing Address Phone / Fax	
Facility Consultants Mailing Address Phone / Fax	

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E. Compliance Schedule for Required Activities

Optional items to be edited are highlighted in yellow.

The Activities in the following table shall be completed on or before the Completion Date unless modified by the Department in writing.

Compliance Activity Number Completion Date	Compliance Activity Description
CA-xxx-xx **Prior to applying wastewater at site**	A Plan of Operation (Operation and Maintenance Manual or O&M Manual) for the wastewater reuse facilities, incorporating the requirements of this permit, shall be submitted to DEQ for review and comment. The O&M manual shall be designed for use as an operator guide for actual day-to-day operations to meet permit requirements and shall include daily sampling and monitoring requirements to insure proper operation of the wastewater treatment facility. The Plan of Operation shall contain at a minimum all of the information required by the latest revision of the Plan of Operation Checklist in the Reuse Program Guidance. Upon approval, the manual shall be incorporated by reference into this permit and shall be enforceable as a part of this permit.
CA-xxx-xx **Prior to applying wastewater at site**	Submit a Nuisance Odor Management Plan to DEQ for review and approval. The Odor Management Plan shall include wastewater treatment systems, reuse facilities, and other operations associated with the facility. The plan shall include specific design considerations, operation and maintenance procedures, and management practices to be employed to minimize the potential for or limit odors. The plan shall also include procedures to respond to an odor incident if one occurs, including notification procedures.
CA-xxx-xx **Prior to applying wastewater at site**	A TDIS Management Plan may be required if ground water TDS significantly increases across the site. The plan shall identify sources of TDIS, evaluate the feasibility of isolation or removal of TDIS, and propose strategies to minimize TDIS in the wastewater.
CA-xxx-xx **Prior to applying wastewater at site**	For sites that have existing ground water quality that exceeds standards as a result of reuse activities, a Water Quality Improvement Plan (WQIP) may be required.
CA-xxx-xx **Prior to applying wastewater at site**	Submit to the Department for review and approval, a well location acceptability analysis, as outlined in the *Guidance for Reclamation and Reuse of Municipal and Industrial Wastewater, Section 6.6.3.1*, for all applicable wells located around or on the reuse site.
CA-xxx-xx **Prior to application of waste solids**	Submit a Waste Solids Management Plan to DEQ for review and approval. The Plan shall describe how waste solids generated at the facility will be handled and disposed of to meet the requirements of section J, No. 5.

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E. Compliance Schedule for Required Activities

Compliance Activity Number Completion Date	Compliance Activity Description
CA-xxx-xx Prior to applying wastewater at site	Submit a scaled site map delineating buffer zones, homes, public access areas, private wells, canals, etc. and the actual area in acres of each HMU. Site Maps shall be supplied by the permittee and shall include at a minimum all requirements of IDAPA 58.01.17.300.05.e through f.
CA-xxx-xx Prior to applying wastewater at site	Submit plans and specifications for ground water monitoring network for DEQ review and approval, including at least one (1) upgradient well and two (2) downgradient wells.
CA-xxx-xx Prior to applying wastewater at site	_______ shall prepare and submit to DEQ for approval a runoff management plan with control structures and other BMPs (e.g. collection basins, berms, etc.) designed to prevent runoff from any site or fields used for wastewater reuse to property not owned by _______ except in the event of a 25-year, 24-hour storm event or greater, using Western Regional Climate Center (WRCC) Precipitation Frequency Map, Figure 28 'Isopluvials of 25-YR, 24-HR Precipitation'. For this site, the 25-year, 24-hour event is ___ inches. Upon approval of the plan by DEQ, _______ shall implement the runoff management plan, and shall construct, operate, and maintain the control structures and other BMPs in accordance with the plan.

(Add other optional requirements for grazing plans, seepage testing, and silviculture here in compliance activities to further describe particular requirements for each site.)

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F. Permit Limits and Conditions

Category	Permit Limits and Conditions
Type of Wastewater	
Application Site Area	
Application Season	
Growing Season (GS)	Site specific – Define for this permit.
Non-growing Season (NGS)	Site specific – Define for this permit.
Supervision	Optional (Certified Operator)
Reporting Year for Annual Loading Rates	Site Specific Dates Comment: It should always be consecutive NGS & GS periods
Growing Season Maximum Hydraulic Loading Rate (Applies to wastewater and supplemental irrigation water).	Growing Season (GS) Hydraulic Loading Rate shall be no greater than the Irrigation Water Requirement (IWR) using data from the tables of the following University Of Idaho web site: http://www.kimberly.uidaho.edu/water/appndxet/index.shtml. IWR is equal to the Mean IR data from these tables divided by the irrigation system efficiency. In lieu of these tables, current climatic and evaporation data, or 30-year average data may be used to calculate the IWR, as defined on page 5 of this permit. Assume no carryover soil moisture and a leaching rate of zero in calculating the IWR. Application shall generally follow consumptive use rates for the crop throughout the season.
Non-Growing Season Maximum Hydraulic Loading Rate	Soil AWC – Precipitation $_{NGS}$ + Evapotranspiration $_{NGS}$ for each hydraulic management unit (HMU). Include the allowable amount in inches and MG for each HMU in this section based on this equation. HMU # / Field Description / Million Gallons / Inches 1 / Pivots 1 and 2 / x.xx / x.xx 2 / Pivot 3 / x.xx / x.xx etc.…
Runoff	1. No runoff of wastewater allowed. 2. Furrow and Sprinkler Irrigation: Operate and maintain structures and BMPs for supplemental irrigation water sediment control in accordance with DEQ approved plan.
Livestock Grazing	A grazing management plan shall be submitted to DEQ for review and approval prior to any grazing activities. Grazing Plans shall follow the guidance located on the DEQ Internet site.

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F. Permit Limits and Conditions

Category	Permit Limits and Conditions
Ground Water Quality	Ground water quality shall be in compliance with the Ground Water Quality Rule (GWQR), IDAPA 58.01.11.
Maximum COD Loading, seasonal average in Pounds/acre-day, each HMU	50 pounds / acre-day seasonal average for growing season. 25 pounds / acre-day seasonal average for the non-growing season.
Maximum Nitrogen Loading Rate, pounds/acre-year, each HMU (from all sources including waste solids and supplemental fertilizers)	150% of typical crop uptake (see definition) or UI Fertility Guide.
Maximum Phosphorus Loading Rate, pounds/acre-year (from all sources including waste solids and supplemental fertilizers)	No maximum. DEQ reserves the right to re-open this permit for inclusion of phosphorous limits.
Construction Plans	Prior to construction or modification of all wastewater facilities associated with the reuse system or expansion, detailed plans and specifications shall be reviewed and approved by DEQ. Within 30 days of completion of construction, the permittee shall submit as-built plans to DEQ or submit a certification letter stating that all construction was done in substantial compliance with DEQ approved plans and specifications.
Buffer Zones and Wellhead Protection	Buffer zones of 500 feet or more shall be maintained between reuse areas and domestic water supplies (or 1000 feet for public water supplies) unless a Department approved well location acceptability analysis indicates an alternative buffer zone is acceptable (see Idaho Reuse Guidance for discussion on approved well location acceptability analysis). **(Consult with the regional office to see if a source water assessment has been completed for the area. Consult local ordinances for more strict requirements.)** Berms and other BMPs shall be used to protect the well head of on-site wells.
Industrial Wastewater Buffer Zones	All buffer zones must comply with, at a minimum, local zoning ordinances. See Table 6-7 – Industrial Buffer Zone Scenarios in Chapter 6 of the

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F. Permit Limits and Conditions

Category	Permit Limits and Conditions
	Idaho Guidance for the Reclamation and Reuse of Municipal and Industrial Wastewater.
Supplemental Irrigation Water Protection	For systems with wastewater and fresh irrigation water interconnections, DEQ-approved backflow prevention devices are required.
Odor Management	The wastewater treatment plant, reuse facilities, and other operations associated with the facility shall not create a public health hazard or nuisance conditions including odors. These facilities shall be managed in accordance with a DEQ approved Odor Management Plan.
Fencing and Posting	See Reuse Guidance.
Allowable Crops	Crops grown for direct human consumption (those crops that are not processed prior to consumption) are not allowed.

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G. Monitoring Requirements

The Permittee is allowed to apply wastewater and treat it on a reuse site as prescribed in the table below and in accordance with all other applicable permit conditions and schedules.

1) Appropriate analytical methods, as given in the *Idaho Guidance for Reclamation and Reuse of Municipal and Industrial Wastewater*, or as approved by the Idaho Department of Environmental Quality (hereinafter referred to as DEQ), shall be employed. A description of approved sample collection methods, appropriate analytical methods and companion QA/QC protocol shall be included in the Operation and Maintenance Manual.

2) The permittee shall monitor and measure parameters as stated in the Facility Monitoring Table in this section.

3) Samples shall be collected at times and locations that represent typical environmental and process parameters being monitored.

4) Unless otherwise agreed to in writing by the DEQ, data collected and submitted shall include, but not be limited to, the parameters and frequencies in the Facility Monitoring Table on the following pages. Monitoring is required at the frequency show in the table below if wastewater is applied anytime during the time period shown.

5) Ten (10) soil sample locations shall be selected for each management unit with greater than fifteen acres and Five (5) soil sample locations shall be selected for each management unit with fifteen acres or less. Three (3) soil samples shall be collected at each sample location, one at 0-12 inches, one at 12-24 inches, and one at 24-36 inches. The soil samples collected at each depth shall be composited to yield three (3) samples for analysis from each management unit.

6) Ground Water Monitoring Procedure: Ground Water Monitoring Wells shall be purged a minimum of three casing volumes and/or until field measurements for pH, specific conductance and temperature meet the following conditions: two successive temperature values measured at least five minutes apart are within one degree Celsius of each other, pH values for two successive measurements measured at least five minutes apart are within 0.2 units of each other, and two successive specific conductance values measured at least five minutes apart are within 10% of each other. This procedure will determine when the wells are suitable for sampling for constituents required by the permit. Other procedures, such as low flow sampling, may be considered by DEQ for approval. The static water level shall be measured prior to pumping or sampling for ground water.

7) Surface water sampling guidance: DEQ to review and approve methods, timing and locations for sampling prior to initial sampling event.

8) Annual reporting of monitoring requirements is described in Section H, Standard Reporting Requirements.

9) Monitoring locations are defined in Appendix 1, "Environmental Monitoring Serial Numbers".

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G. Monitoring Requirements

Facility Monitoring Table

Frequency	Monitoring Point	Description/Type of Monitoring	Parameters
Daily	Flow meter	Flow of wastewater into reuse system	Volume (million gallons and acre-inches) to each hydraulic management unit (HMU), record monthly and report annually.
Monthly	Effluent to reuse	Wastewater quality into reuse system – 24-hr. Composite	Chemical Oxygen Demand, Total Kjeldahl Nitrogen, Ammonia-Nitrogen, Nitrite + Nitrate-Nitrogen, Total Phosphorous, Chloride, Electrical Conductivity, Potassium, pH
Quarterly	Effluent to reuse	Wastewater quality into reuse system	Total Dissolved Inorganic Solids (TDIS) – See Table B-1. Submit analysis of individual ions in addition to TDIS.
Quarterly (for the first year only, 4 sample events)	Effluent to reuse	Wastewater quality into reuse system – 24-hr. composite.	Total Dissolved Solids (TDS), Volatile Dissolved Solids (VDS)
Quarterly (for the first year only, 4 sample events)	Effluent to reuse	Grab sample for bacteria	Colony numbers for Fecal Coliform, Total Coliform, Fecal Streptococcus and Pseudomonas, standard presence / absence test for Listeria (if present, determine specific type)
Daily	Flow meter or Calibrated Pump Rate	Supplemental Irrigation Water	Volume (million gallons and acre-inches) to each HMU, record monthly and report annually.
Twice per year (May and Oct)	Supplemental Irrigation at diversions	Grab sample	Nitrate + Nitrite Nitrogen, Total Phosphorous, Ortho Phosphorus, Total Dissolved Solids, Volatile Dissolved Solids, Chloride, Total Kjeldahl Nitrogen
Quarterly (Feb, May, Aug, and Nov)	Ground Water monitoring wells, listed in appendix 1	See Note 6	Nitrate-Nitrogen, Total Phosphorous, Total Dissolved Solids, water table elevation, water table depth, total iron, total manganese, chloride, dissolved iron[1], dissolved manganese[1], pH, conductivity, and temperature.

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G. Monitoring Requirements

Frequency	Monitoring Point	Description/Type of Monitoring	Parameters
Twice per year (May and Oct)	Nearest Surface Water – DEQ shall review and approve locations prior to initial sampling event.	Grab samples of surface water upstream and downstream from reuse site.	Nitrate + Nitrite Nitrogen, Total Phosphorous, Ortho Phosphorus, Total Dissolved Solids, Volatile Dissolved Solids, Chemical Oxygen Demand, Total Kjeldahl Nitrogen
Monthly	Each HMU	Calculate IWR for each crop type	Volume (million gallons and acre-inches) to each HMU, record monthly
Daily during NGS (if land applying)	Meteorological data and field conditions, each HMU	Temperature, Precipitation, and field conditions.	High and low air temperatures and precipitation during each 24-hour period. Field conditions observations for areas of ponding, etc.)
Note: Review permit strategy for phosphorous with program office	Surface water upstream and downstream of site	For sites that apply high levels of phosphorous (for example, twice crop uptake or more) and ground water discharges to nearby surface water	Total Phosphorous, Ortho Phosphorous, Electrical Conductivity
Twice per year (April and Nov)	Each soil monitoring unit	See note 5	Electrical Conductivity, Nitrate-Nitrogen, Ammonium Nitrogen, Plant Available Phosphorus, pH, % organic matter, potassium, DTPA Fe and Mn. Notes: Add SAR if sodium loading rates are high Phosphorous – use Olsen method for soils with pH 6.5 or higher. Use Bray method if soil pH is <6.5
Annually	Each HMU	Crop type and yield	Pounds/acre and total pounds per HMU (specify moisture basis)
	Each HMU	Plant tissue analysis: Composite sample of harvested portion	Nitrate-nitrogen, Total Kjeldahl Nitrogen, Total Phosphorus, ash (dry basis)
	Each HMU	Calculate crop nitrogen, phosphorous, and ash removal	Pounds/acre and total pounds per HMU (dry basis)
	Each HMU	Calculate NGS wastewater loading rate	Million gallons & Inches/NGS

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G. Monitoring Requirements

Frequency	Monitoring Point	Description/Type of Monitoring	Parameters
	Each HMU	Calculate GS wastewater loading rate	Million gallons & Inches/GS
	Each HMU	Calculate seasonal average COD loading rate (GS and NGS)	Pounds/acre-day
	Each HMU	Calculate wastewater nitrogen loading rate	Pounds/acre-year
	Each HMU	Calculate wastewater phosphorous loading rate	Pounds/acre-year
	Each HMU	Calculate wastewater TDIS loading rate	Pounds/acre-year
	Each HMU	Report nitrogen and phosphorous fertilizer application rates	Type and Pounds/acre-year
Annually	Each HMU	Calculate Inorganic TDS loading (NVDS) from supplemental irrigation application.	NVDS applied in lbs/ac-yr
Annually	All flow measurement locations.	Flow measurement calibration of all flows to reuse.	Document the flow measurement calibration of all flow meters and pumps used directly or indirectly measure all wastewater, tail water, flushing water, and supplemental irrigation water flows applied to each HMU.
Annually	All supplemental irrigation pumps directly connected to the wastewater distribution system.	Backflow testing	Document the testing of all backflow prevention devices for all supplemental irrigation pumps directly connected to the wastewater distribution system(s). Report the testing date(s) and results of the test (pass or fail). If any test failed, report the date of repair or replacement of backflow prevention device, and if the repaired/replaced device is operating correctly.

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G. Monitoring Requirements

Frequency	Monitoring Point	Description/Type of Monitoring	Parameters
April of first and last permit years only.	Groundwater Monitoring Wells listed in Appendix I.	Grab sample of groundwater (See Note 6).	Sodium, Potassium, Calcium, Magnesium, carbonate, bicarbonate.
April of first and last permit years only.	Domestic and municipal wells within ¼ mile of all reuse acreage.	Grab sample from domestic and municipal wells (with well owner's permission. See note 6).	Specific Conductivity, Total Dissolved Solids (TDS), Nitrite + Nitrate Nitrogen, Total Phosphorus, Chloride, Sulfate, Total Iron, Total Manganese, Sodium, Potassium, Calcium, Magnesium, carbonate, bicarbonate, Dissolved Iron[1], Dissolved Manganese[1]

1. Analytical results are required for dissolved iron and/or manganese only if the results for total iron and/or manganese exceed the standards in IDAPA 58.01.11.200.01.b.

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H. Standard Reporting Requirements

1.) The Permittee shall submit an Annual Wastewater-Reuse Site Performance Report ("Annual Report") prepared by a competent environmental professional no later than January 31 of each year, which shall cover the previous reporting year. The Annual Report shall include an interpretive discussion of monitoring data (ground water, soils, hydraulic loading, wastewater etc.) with particular respect to environmental impacts by the facility.

2.) The annual report shall contain the results of the required monitoring as described in *Section G. Monitoring Requirements*. If the permittee monitors any parameter more frequently than required by this permit, the results of this monitoring shall be included in the calculation and reporting of the data submitted in the annual report.

3.) The annual report shall be submitted to the Engineering Manager in the applicable Regional DEQ Office.

Boise Regional Office
1445 N. Orchard
Boise, ID 83706-2239
208-373-550

Coeur d'Alene Regional Office
2110 Ironwood Parkway
Coeur d'Alene, ID 83814
208-769-1422

Idaho Falls Regional Office
900 N. Skyline, Suite B
Idaho Falls, ID 83402
208-528-2650

Lewiston Regional Office
1118 "F" Street
Lewiston, ID 83501
208-799-4370

Pocatello Regional Office
444 Hospital Way, #300
Pocatello, ID 83201
208-236-6160

Twin Falls Regional Office
1363 Fillmore St.
Twin Falls, ID 83301
208-736-2190

A copy of the annual report shall also be mailed to:

Richard Huddleston, P.E.
Wastewater Program Manager
1410 N. Hilton
Boise, ID 83706
208-373-0561

4.) Notice of completion of any work described in *Section E. Compliance Schedule for Required Activities* shall be submitted to the Department within 30 days of activity completion. The status of all other work described in Section E shall be submitted with the Annual Report.

5.) All laboratory reports containing the sample results for monitoring required by *Section G. Monitoring Requirements* of this permit shall be submitted with the Annual Report.

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I. Standard Permit Conditions: Procedures and Reporting

1. The permittee shall at all times properly maintain and operate all structures, systems, and equipment for treatment, operational controls and monitoring, which are installed or used by the permittee to comply with all conditions of the permit or the Wastewater Reuse Permit Regulations, in conformance with a DEQ approved, current Plan of Operations (Operations and Maintenance Manual) which describes in detail the operation, maintenance, and management of the wastewater treatment system. This Plan of Operations shall be updated as necessary to reflect current operations.

2. Wastewater(s) or recharge waters applied to the land surface must be restricted to the premises of the application site. Wastewater discharges to surface water that require a permit under the Clean Water Act must be authorized by the U.S. Environmental Protection Agency.

3. Wastewater must not create a public health hazard or nuisance condition as stated in IDAPA 58.01.16.600.03. In order to prevent public health hazards and nuisance conditions the permittee shall:

   a. Apply wastewater as evenly as practicable to the treatment area;
   b. Prevent organic solids (contained in the wastewater) from accumulating on the ground surface to the point where the solids putrefy or support vectors or insects; and
   c. Prevent wastewater from ponding in the fields to the point where the ponded wastewater putrefies or supports vectors or insects.

4. The permittee shall:

   a. Manage the wastewater reuse treatment site as an agronomic operation where vegetative cover is grown and harvested or grazed to utilize the nutrients and minerals in the wastewater, and
   b. Not hydraulically overload any particular areas of the wastewater reuse treatment site.

5. All waste solids, including dredgings and sludges, shall be utilized or disposed in a manner which will prevent their entry, or the entry of contaminated drainage or leachate therefrom, into the waters of the state such that health hazards and nuisance conditions are not created, and to prevent impacts on designated beneficial uses of the ground water and surface water. The permittee's management of waste solids shall be governed by the terms of the DEQ approved Waste Solids Management Plan, which upon approval shall be an enforceable portion of this permit.

6. If the permittee intends to continue operation of the permitted facility after the expiration of an existing permit, the permittee shall apply for a new permit at least six months prior to the expiration date of the existing permit in accordance with the Wastewater Reuse Permit Regulations and include seepage tests on all lagoons per latest DEQ procedures.

7. The permittee shall allow the Director of the Idaho Department of Environmental Quality or the Director's designee (hereinafter referred to as Director), consistent with Title 39, Chapter 1, Idaho Code, to:

   a. Enter the permitted facility,
   b. Inspect any records that must be kept under the conditions of the permit.
   c. Inspect any facility, equipment, practice, or operation permitted or required by the permit.
   d. Sample or monitor for the purpose of assuring permit compliance, any substance or any parameter at the facility.

8. The permittee shall report to the Director under the circumstances and in the manner specified in this section:

   a. In writing thirty (30) days before any planned physical alteration or addition to the permitted facility or activity if that alteration or addition would result in any significant change in information that was submitted during the permit application process.
   b. In writing thirty (30) days before any anticipated change which would result in non-compliance with any permit condition or these regulations.
   c. Orally within twenty-four (24) hours from the time the permittee became aware of any non-compliance which may endanger the public health or the environment at telephone numbers provided in the permit by the Director (see below)

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I. Standard Permit Conditions: Procedures and Reporting

DEQ Regional Office: see Permit Certificate Page
Emergency 24 Hour Number: 1-800-632-8000

d. In writing as soon as possible but within five (5) days of the date the permittee knows or should know of any non-compliance unless extended by the DEQ. This report shall contain:

i. A description of the non-compliance and its cause;
ii. The period of non-compliance including to the extent possible, times and dates and, if the non-compliance has not been corrected, the anticipated time it is expected to continue; and
iii. Steps taken or planned to reduce or eliminate reoccurrence of the non-compliance.

e. In writing as soon as possible after the permittee becomes aware of relevant facts not submitted or incorrect information submitted, in a permit application or any report to the Director. Those facts or the correct information shall be included as a part of this report.

9. The permittee shall take all necessary actions to prevent or eliminate any adverse impact on the public health or the environment resulting from permit noncompliance.

10. The permittee shall determine (on an on-going basis) if any noxious weed problems relate to the permitted sites. If problems are present, coordinate with the Idaho Department of Agriculture or the local County authority regarding their requirements for noxious weed control. Also address these control operations in an update to the Operations and Maintenance Manual.

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J. Standard Permit Conditions: Modifications, Violation, and Revocation

1. The permittee shall furnish to the Director within reasonable time, any information including copies of records, which may be requested by the Director to determine whether cause exists for modifying, revoking, re-issuing, or terminating the permit, or to determine compliance with the permit or these regulations.

2. Both minor and major modifications may be made to this permit as stated in IDAPA 58.01.17.700.01 and 02 with respect to any conditions stated in this permit upon review and approval of the DEQ.

3. Whenever a facility expansion, production increase or process modification is anticipated which will result in a change in the character of pollutants to be discharged or which will result in a new or increased discharge that will exceed the conditions of this permit, or if it is determined by the DEQ that the terms or conditions of the permit must be modified in order to adequately protect the public health or environment, a request for either major or minor modifications must be submitted together with the reports as described in Section I. *Standard Reporting Requirements*, and plans and specifications for the proposed changes. No such facility expansion, production increase or process modification shall be made until plans have been reviewed and approved by the DEQ and a new permit or permit modification has been issued.

4. Permits shall be transferable to a new owner or operator provided that the permittee notifies the Director by requesting a minor modification of the permit before the date of transfer.

5. Any person violating any provision of the Wastewater Reuse Permit Regulations, or any permit or order issued thereunder shall be liable for a civil penalty not to exceed ten thousand dollars ($10,000) or one thousand dollars ($1,000) for each day of a continuing violation, whichever is greater. In addition, pursuant to Title 39, Chapter 1, Idaho Code, any willful or negligent violation may constitute a misdemeanor.

6. The Director may revoke a permit if the permittee violates any permit condition or the Wastewater Reuse Permit Regulations.

7. Except in cases of emergency, the Director shall issue a written notice of intent to revoke to the permittee prior to final revocation. Revocation shall become final within thirty-five (35) days of receipt of the notice by the permittee, unless within that time the permittee request an administrative hearing in writing to the Board of Environmental Quality pursuant to the Rules of Administrative Procedures contained in IDAPA 58.01.23.

8. If, pursuant to Idaho Code 67-5247, the Director finds the public health, safety or welfare requires emergency action, the Director shall incorporate findings in support of such action in a written notice of emergency revocation issued to the permittee. Emergency revocation shall be effective upon receipt by the permittee. Thereafter, if requested by the permittee in writing, a revocation hearing before the Board of Environmental Quality shall be provided. Such hearings shall be conducted in accordance with the Rules of Administrative Procedures contained in IDAPA 58.01.23.

9. The provisions of this permit are severable and if a provision or its application is declared invalid or unenforceable for any reason, that declaration will not affect the validity or enforceability of the remaining provisions.

10. The permittee shall notify the DEQ at least six (6) months prior to permanently removing any permitted reuse facility from service, including any treatment, storage, or other facilities or equipment associated with the reuse site. Prior to commencing closure activities, the permittee shall: a) participate in a pre-site closure meeting with the DEQ; b) develop a site closure plan that identifies specific closure, site characterization, or cleanup tasks with scheduled task completion dates in accordance with agreements made at the pre-site closure meeting; and c) submit the completed site closure plan to the DEQ for review and approval within forty-five (45) days of the pre-site closure meeting. The permittee must complete the DEQ approved site closure plan.

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Appendix 1
Environmental Monitoring Serial Numbers

HYDRAULIC MANAGEMENT UNITS

Serial Number	Description	Acres
MU-xxxxxx		
MU-xxxxxx		
MU-xxxxxx		
MU-xxxxxx		

WASTEWATER SAMPLING POINTS

Serial Number	Description
WW-xxxxxx	
WW-xxxxxx	

SURFACE WATER SAMPLING POINTS

Serial Number	Description
SW-xxxxxx	
SW-xxxxxx	

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Appendix 1
Environmental Monitoring Serial Numbers

SOIL MONITORING UNITS

Serial Number	Description	Associated MU
SU-xxxxxx		
SU-xxxxxx		
SU-xxxxxx		
SU-xxxxxx		

GROUND WATER MONITORING

Serial Number	Description (private, irrigation, dedicated monitoring)	Location
GW-xxxxxx		
GW-xxxxxx		
GW-xxxxxx		

LAGOONS

Serial Number	Description
LG-xxxxxx	Lagoon no. 1
LG-xxxxxx	Lagoon no. 2

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Appendix 2
Site Maps

Site Maps shall be supplied by the permittee and shall include at a minimum all requirements of IDAPA 58.01.17.300.05.e through f.

Site Map No. 1

Attach map showing general locations (property boundaries) of industrial plant and reuse site. Include Township(s), Range(s), Section(s).

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Appendix 2
Site Maps

Site Map No. 2

Attach detailed map that shows the following:

- **All Hydraulic Management Units. Include MU serial #'s**
- **All Soil Monitoring Units. Include SU serial #'s**
- **All lagoons/storage ponds. Include serial #'s**
- **All Wastewater and Supplemental Irrigation distribution systems for the reuse site including sumps, pipelines, ditches, irrigation diversions, irrigation systems (pivots, wheel lines, etc.), tailwater collection systems, and any other item of relevance.**

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Appendix 2
Site Maps

Site Map No. 3

Attach detailed map showing location of:
- **All monitoring wells used for permit compliance (may include domestic wells if used for groundwater monitoring compliance).**
- **All public and private drinking water supply sources within ¼ mile of reuse site.**
- **All springs, wetlands, and surface waters within ¼ mile of reuse site.**
- **Groundwater contours & direction of flow (include additional map(s) if flow direction changes seasonally)**

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Appendix 2
Site Maps

Site Map No. 4

Attach map showing location of:

- **All dwellings within ¼ mile of reuse site.**
- **All public and private gathering places within ¼ mile of reuse site.**
- **All public roads within ¼ mile of reuse site.**

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1.9.3 Program Forms and Spreadsheets

Please contact DEQ, Permits and Enforcement, in Boise at 208-373-0502 or in Coeur d'Alene at 208-769-1422 for any questions or clarification of the application materials.

Application for
Wastewater Reuse Permit

Instructions: Complete the following form and attachments as completely as possible. Failure to provide sufficient information will delay processing of the application and final action on the permit. A pre-application meeting between the applicant and DEQ is strongly encouraged to discuss site specific issues and level of detail needed. If clarification is needed, contact the DEQ office in your Region.

Type of application (attach appropriate checklists) New ☐ Renewal ☐ Waiver ☐ Major Modification ☐ Minor Modification ☐	For DEQ use only

Legal Name of Applicant

Address

Facility Address, if different

	Responsible Official	Alternate Official
Name		
Title		
Address		
Phone/Fax		

Attachments (complete all that apply)

- ☐ Facility Information
- ☐ List of local, state, federal permits, licenses, and approvals related to activity which have been applied for and which have been received and the dates of application or approval. Include planning & zoning or conditional use permit.
- ☐ Copy of lease, rental agreement, or ownership documentation.
- ☐ Preliminary Technical Report and Checklist: including climatic, hydrogeologic, soils, wastewater quantity and quality, site characteristics, buffer distances, and general description of application methods.
- ☐ Plan of Operation and Checklist: including operation, maintenance, and management of land application systems. If new, submit draft outline of plan of operation; if existing, submit detailed plan of operation.

The information contained in this application and attached documents is true and correct to the best of my knowledge and belief.

Signature of Owner or
legally authorized Representative ______________________________________

Title Date

Facility Information

Type of Waste	__Municipal/Domestic __Cheese Processing __Potato Processing ___Sugar Beet Processing __ Industrial Processing __Other __________
Method of Treatment	__Rapid Infiltration ___Slow Rate __Overland Flow
Type of Facility	__Public __ Private __ Federal
Amount of wastewater land applied	_____________ Million Gallons Annually
Site Elevation	_____________ Feet
Legal Location (Township, Range, Section)	__Township __ Range __ Section
County	
USGS Quadrangle	
Representative soil profile (textures and depths to 60 inches)	
Seasonal High Ground Water	__Depth to seasonal high ground water __Season encountered
Depth to Aquifer	__Depth to first water __Depth to regional aquifer
Beneficial Uses of Ground Water	__Agriculture __Industrial __Domestic __Aquaculture
Nearest surface water and distance	
Beneficial uses of surface water	___Agriculture __Industrial __Domestic __Recreation ___Aquatic Life
Engineer/Consultant Name/Address Phone/Fax	
Engineer/Consultant Name/Address Phone/Fax	

Wastewater Reuse
Plan of Operation Checklist

For new facilities, a general outline of the plan of operation must be provided with the permit application. A detailed plan of operation must be provided at the 50% completion point of construction. In addition, after one (1) year of operation, the plan must be updated to reflect actual operating procedures. The checklist should be used as a guide in preparing the plan of operation. Include the completed checklist with your plan of operation. A pre-application meeting between the applicant and DEQ is strongly encouraged. If any item needs clarification, contact the DEQ Office in your Region.

YES	NA	Plan of Operation Checklist
		Operation & Management Responsibility a. Operator, manager responsibility
		b. Training requirements
		c. List of reference publications
		Permits and Standards a. WLAP/NPDES permit included
		b. Permit requirements listed
		c. Treatment requirements
		General Plant Description a. Type of treatment described
		b. Principal design criteria
		c. Flow diagram
		d. Hydraulic profile
		e. Characterization of Wastewater
		h. List of unit operations
		i. Overall plant efficiency
		Description, Operation and Control of Unit Operations a. Description of process
		c. Normal operation or control of process (valve position, flow rate, sludge depth, etc)
		d. List major components & mechanical equipment
		f. Schematic diagram of each unit

YES	NA	**Plan of Operation Checklist**
		h. Discussion of common operating problems
		i. Emergency operation or alternate operation
		k. Discuss laboratory tests for unit control
		l. Discuss startup procedures
		m. Brief operation instructions for each piece of equipment w/reference to manufacturers O&M Manual
		Land Application Site a. Map of the current hydraulic management units and associated acres
		b. Description of any proposed changes to the land application acreage.
		c. Map of type(s) of irrigation system(s) (pivot, hand lines,...) and the corresponding irrigation efficiency(ies).
		Wastewater Characterization a. Identification of the quantity of land applied wastewater (per day, per month, per year) and how the quantity values were determined.
		b. Characterization of the concentrations of key constituents in the wastewater proposed for land application and how the concentration values were determined. *Basic constituents of interest are: total nitrogen, total phosphorus, and Chemical Oxygen Demand (COD). Depending on the wastewater source, concentrations of other constituents may be important. For industrial systems, concentrations of total dissolved inorganic solids (TDIS) and/or metals may be pertinent. For municipal systems, total coliform counts may be presented.*
		Cropping Plan a. Description of proposed crop selection and a 5-year rotation plan. For each crop, description of: planting and harvesting data, irrigation sensitivity, rooting depth, expected yield (compared to yield data published by Idaho county, and expected crop uptake values for key constituents in the wastewater.
		b. For each crop, calculated the Irrigation Water Requirement (IWR) and how the IWR value(s) were determined.
		c. If proposing to utilize wastewater for tree irrigation, a silvicultural plan (a plan covering the care and cultivation of the trees).
		d. Description of the proposed future use of fertilizers at the site and nutrient loading associated with fertilizer use.
		Hydraulic Loading Rate a. Wastewater hydraulic loading rates by month for growing season and non-growing season.
		b. Description of the availability of supplemental irrigation water for the site and whether or not supplemental irrigation water is expected to be used at the site.

YES	NA	Plan of Operation Checklist
		Documentation that water rights exist to provide supplemental irrigation. If expected to be used, the typical supplemental irrigation water hydraulic loading rates for potential crops.
		c. Description of irrigation scheduling for the site.
		d. If storage of wastewater is proposed, a monthly water balance for the storage structure(s) reflecting: number of days of storage, required freeboard, minimum depth, evaporation, precipitation, and flows into and out of the structure.
		Constituent Loading Rates a. The expected growing season and non-growing season loading rates for key constituents including any waste solids and/or fertilizers proposed to be applied to the land application site.
		b. Comparison of expected constituent loading rates to applicable crop uptake values for the site.
		c. Identification of the design limiting constituent.
		Compliance Activities a. A summary and status of and compliance activities.
		Seepage Rate Testing a. Schedule and procedure for seepage rate testing of any wastewater lagoons.
		Site Management Plan a. Buffer Zone Plan including map of land application site that includes the following buffer objects: dwellings, areas of public access, canals/ditches, private water sources, and public water sources. Map to include signage and fencing and both DEQ guideline distances as well as actual distances.
		b. Grazing Management Plan if any grazing activities are proposed at the land application site.
		c. Nuisance Odor Management Plan. *For systems with higher strength wastewater (wastewater with a greater potential to create odors), it is highly recommended that a Nuisance Odor Management Plan be prepared as part of the permit application.*
		d. Waste Solids Management Plan. *If waste solids are managed off-site, refer to IDAPA 58.01.02, Section 650 regarding sludge usage.*
		e. TDIS (Total Dissolved Inorganic Solids) Management Plan
		f. Runoff Management Plan addressing best management practices for minimization of runoff and ponding.

YES	NA	**Plan of Operation Checklist**
		Monitoring a. Description of the quantity of land applied wastewater is proposed to be monitored (methodology, frequency, location).
		b. Sampling and analysis plan for the land applied wastewater (constituents, disinfection level, methodology, frequency, location).
		c. Method of calculating hydraulic and constituent loading.
		d. If supplemental irrigation water is expected to be used, monitoring plan for quantity of land applied supplemental irrigation water (methodology, frequency, location).
		e. Soil monitoring plan (constituents, soil depths, methodology, frequency, location).
		f. Groundwater monitoring plan (constituents, methodology, frequency, location).
		g. Description of how crop uptake values are proposed to be determined (plant tissue monitoring, table values…).
		h. Other proposed monitoring for the site.
		i. Meteorological monitoring plan for site.
		Site Operations and Maintenance a. Description of who will operate and maintain the wastewater treatment facilities and land application site.
		b. Operator certification credentials—credentials currently held and any plans for future certifications.
		c. If a party other than the applicant operates and maintains the land application site, a copy of the signed contract or agreement outlining how the site will be operated to meet the conditions of the permit
		Solids Handling and Processing a. Detailed discussion of processing, storage, and disposal and common problems
		b. Site selection criteria
		Laboratory Testing a. Outline sampling and testing program
		b. Sampling location, specific tests, frequency c. List of laboratory references
		d. Interpretation and significance of lab results
		e. Sample laboratory worksheets

YES	NA	**Plan of Operation Checklist**
		Maintenance a. General maintenance information
		b. Preventative maintenance schedule
		c. Trouble-shooting charts or guides
		d. Maintenance record system
		e. Manufacturer's manuals
		Records and reports a. Describe importance of records & reports
		b. Describe daily operating log & provide sample format
		c. Describe maintenance records and show example
		d. Describe laboratory records & reports & provide sample
		f. Explain requirements of annual reports and show example
		j. How to report permit violations
		h. How to report accidents
		Store room and Inventory a. List of spare parts
		b. List of vendors and outside contractors and suppliers
		Personnel a. Manpower requirements and qualifications
		Emergency Operating Plan a. List of emergency numbers
		b. Description of emergency procedures

January 8, 1993

MEMORANDUM

To: Wastewater-Land Application Permit Program Regulated Community

From: Michael Cook, Program Coordinator
Wastewater-Land Application Permit Program

Subject: Transmittal of Standard Electronic Format for Land Application of Wastewater Program Monitoring Data.

Dear Member of the Regulated Community:

The following describes a major development in the Wastewater-Land Application Permit Program of which you must be aware.

THE NEED FOR PERMITTEES TO SUBMIT MONITORING DATA ON DISK

As a member of the Land Application of Wastewater regulated community, your facility is generating monitoring data on a regular schedule.

To date, the regulated community has been reporting this data in their annual reports hardcopy.

It is important that this data be reported in a uniform way by all permittees for use by Division of Environmental Quality (DEQ) to analyze site performance and permit compliance. Digital format (on a computer) is the most efficient means for DEQ analysis purposes.

ADVANTAGES TO SUBMITTING MONITORING DATA DIGITALLY

It is advantageous not only for the DEQ, but to the regulated community to submit monitoring data digitally. For example:

1) It makes analysis of data tremendously efficient, thus saving tax dollars,

2) It enables DEQ to efficiently evaluate existing monitoring protocols, in order to:

    a) modify frequencies and parameters of the monitoring program in many cases, and

    b) to assist in establishing de minimis criteria for different types of monitoring, and

3) Having data in digital format enables the permittee to evaluate the performance of his own site.

THE NEED FOR PAST MONITORING DATA TO BE SUBMITTED ON DISK

To date, all data generated as part of the Wastewater-Land Application Program has been submitted hardcopy. The Department recognizes the onerous task of entering past data and reporting this to the Department, but asks the regulated community to *please consider entering past data in the digital format provided*. Complete data sets would help in evaluating present monitoring parameters and frequencies.

SOFTWARE DEVELOPED FOR DATA ENTRY

DEQ has developed standard reporting spreadsheets which will take the place of the annual report form previously used. Hardcopy tables of data entered in the above mentioned tables will still be required in the annual report. Use of these spreadsheets to report data requires Lotus 1-2-3 software to enter data on.

If you do not have access to a computer or spreadsheet software please call this office (334-5898). We have an alternate stand alone data entry program you may use to enter data.

SOFTWARE ENCLOSED FOR USE BY THE REGULATED COMMUNITY

Attached is a disk which has the following seven Lotus spreadsheets on it:

- *wastewater,*
- *soils,*
- *lysimeter,*
- *ground water,*
- *hydraulic loading,*
- *management unit summary spreadsheet, and*
- *permit site summary.*

Attached are hardcopy examples of each of the spreadsheets. For each spreadsheet there are examples of both blank spreadsheets and those containing data.

File names for these spreadsheets are, respectively:

- *LWWWFL.WK1*
- *LWSOIFL.WK1*
- *LWLYSFL.WK1*
- *LWGWQL.WK1*
- *LWHYDL.WK1*
- *LWMSUMFL.WK1*
- *LWSSUMFL.WK1*

ANNUAL REPORTING REQUIREMENT CHANGES

The annual report submitted to DEQ should have the following:

- hardcopy tables of data,
- narrative where appropriate and required by permit conditions,
- all monitoring data on the spreadsheets provided to you on disk.

Enter only those data you are required to report. There may be some data you are not required to collect (e.g. lysimeter).

Where reporting conventions differ from the spreadsheet to your permit, please use conventions of the software. For example, Most permits have a Schedule B a "Treatment Field Monitoring" section. The information requested in the spreadsheets attached should be followed rather than that in this section, if there is a conflict.

MONITORING POINT LABELING

We have given serial numbers, as applicable, to each of the following monitoring points:

- monitoring wells,
- wastewater sampling points,
- surface water sampling points,
- hydraulic management units (fields), and
- soil monitoring units.

We have done this so that you may report data to DEQ in a standardized format assuring unique identifiers for all data.

You must use these serial numbers to identify what sampling point or area your data pertains to, and will use these designations when inputting data into the spreadsheets.

Attached are five tables which have listed the serial numbers you are to use. These are listed under your permit number.

ERRORS IN SERIAL NUMBER DESIGNATIONS OR DELINEATIONS

If you discover an error in our labeling of management units, soil monitoring units, monitoring wells, etc. please report these errors to Department immediately so they may be corrected before data is entered under incorrect designations.

HOW TO USE THE SOFTWARE TO INPUT DATA

As mentioned above, the spreadsheets are LOTUS (2.01) 1-2-3 spreadsheets. General instructions follow. More specific instructions peculiar to each spreadsheet are noted within the spreadsheets themselves.

General Instructions for inputting monitoring data into spreadsheets

- Enter your permit number only in the form LA-000XYZ. Note capitol LA, dash and six numbers following- nine characters in all.

- Enter all dates utilizing the Lotus @date() function formatted for long international format.

- Enter the version of Lotus you are using in the upper left corner of each spreadsheet.

- Enter your permit number in the upper left corner of each spreadsheet.

- Enter the reporting year in the upper mid or left corner of each spreadsheet.

- Enter data in the units specified in the respective column.

- Do not alter the spreadsheet heading columns, especially the row just above where you begin entering data.

- If a parameter was analyzed but not detected, enter a -1.0.

- If a parameter was not analyzed, leave the cell blank.

- Cells <u>in the top row only</u> not having an actual value or a -1.0, enter -33.3 (or xxx if a character or label cell) (this is for data translation purposes.

- If you are monitoring for parameters not included on the spreadsheet, add a column to the far right of the spreadsheet.

- Make careful note of all special instructions appearing on each spreadsheet.

<u>SPECIAL INSTRUCTIONS FOR HYDRAULIC APPLICATION RATE SPREADSHEET</u>

One hydraulic load entry for every calendar month is made for each management unit. By convention, date each calendar month entry as the 15th of each month [e.g. @date(92,9,15)].

<u>SPECIAL INSTRUCTIONS FOR GROUND WATER DATA SPREADSHEET</u>

Sampling Station is the township, range, section, 1/4,1/4,1/4 (numeric designator) location of the well. Example:
03N 04S 06bbc02

Please note capitol letters in township and range, spaces between them, preceding zeros if one digit, lower case 1/4, 1/4, 1/4 section designators, and a two digit numeric value if there is more than one well in the same 1/4, 1/4, 1/4 section.

<u>REGULATED COMMUNITY'S INPUT NEEDED ON SOFTWARE DESIGN</u>

To make this a useful tool for the regulated community to perform evaluations on their respective sites, DEQ welcomes your suggestions.

FURTHER QUESTIONS ABOUT THE SOFTWARE

Please contact me at 334-5898 if you have specific questions about this development in the Wastewater-Land Application Program.

ANNUAL REPORT FORM-LAND APPLICATION OF WASTEWATER PERMITTED FACILITY

This is your reporting form for your annual report as required in your land application of wastewater permit. It is important to note that **you are required to provide only that information specified in your permit**. Permits have different reporting requirements, some being more extensive than others.

You will need to make copies of parts B, D, E, F, and H if you have more than one field, sampling date, and/or monitoring well respectively.

Please report analysis results in units as given on the reporting forms.

We hope this form will be of help to you. If you have any questions regarding the use of this form, please contact the DEQ Field Office in your area.

Permitted Facility Name:		
Mailing Address:		
Permit No.:		
Date Submitted:		
Reporting period: (month/year)	from:	to:
Permit Expiration Date:		

Please note: If you have any questions regarding the completion of your annual report, please call the DEQ Wastewater Land Application staff at (208) 373-0502.

A. HYDRAULIC APPLICATION RATE (average rate over entire land application site)

1. Total acreage of land application site(s)
2. Hydraulic application rate:

Column No.					
1	2	3	4	5	6
Year	Month	Million Gallons Wastewater	Acre-Inches Per Acre Wastewater	Million Gallons Supplemental Irrigation Water	Acre Inches Per Acre Irrigation Water
	January				
	February				
	March				
	April				
	May				
	June				
	July				
	August				
	September				
	October				
	November				
	December				
	Totals				
		Million Gallons	Acre-Inches Per Acre	Million Gallons	Acre- Inches Per Acre

Column 1: Enter the appropriate year (e.g. 1995) that the monthly loading took place.
Column 3: Enter total wastewater applied in million gallons.
Column 4: Multiply each monthly entry in column 3 by 36.83 to get acre inches; then divide by total acres to get acre inches per acre.
Column 5: Enter estimate of supplemental irrigation water applied in million gallons.
Column 6: Multiply Column 5 by 36.83 and then divide by the total acreage to get acre-inches per acre of supplemental irrigation water.

B. HYDRAULIC APPLICATION RATE BY MANAGEMENT UNIT

Please use a separate page for each Hydraulic Management Unit.

1. Hydraulic Management Unit _________ Acres _____ (field or parcel #)
2. Hydraulic application rate:

Column No.					
1	2	3	4	5	6
Year	Month	Million Gallons Wastewater	Acre-Inches Per Acre Wastewater	Million Gallons of Supplemental Irrigation Water	Acre Inches Per Acre Irrigation Water
	January				
	February				
	March				
	April				
	May				
	June				
	July				
	August				
	September				
	October				
	November				
	December				
	Totals				
		Million Gallons	Acre-Inches Per Acre	Million Gallons	Acre-Inches Per Acre

Column 1: Enter the appropriate year (e.g. 1995) that the monthly loading took place.
Column 3: Enter total wastewater applied in million gallons.
Column 4: Multiply each monthly entry in column 3 by 36.83 to get acre inches; then divide by total acres to get acre inches per acre.
Column 5: Enter estimate of supplemental irrigation water applied in million gallons.
Column 6: Multiply Column 5 by 36.83 and then divide by the total acreage to get acre-inches per acre of supplemental irrigation water.

C. Nitrogen Loading from Wastewater and Fertilizer

1. Average concentration of nitrogen
   (TKN-N + NO_3-N) in wastewater (ppm)

2. Pounds of Nitrogen per acre per year by Hydraulic Management Unit

Hydraulic Management Unit (field or parcel #)	Nitrogen from Wastewater applied (pounds per acre per year)[1]	Nitrogen from Fertilizer Applied (pounds per acre per year)

1: Multiply average wastewater concentration of nitrogen (in mg/L) by total wastewater volume in MG applied to management unit calculated in B 2 above. Multiply this product by 8.327 and divide by the acreage of the management unit.

2: Enter the amount of fertilizer applied to the management unit in pounds per acre per year.

D. COD LOADING FROM WASTEWATER FOR EACH HYDRAULIC MANAGEMENT UNIT

Please use a separate page for each Hydraulic Management Unit.

1. Hydraulic Management Unit
2. Flow weighted (average) concentration of COD in wastewater (ppm)
3. Pounds per acre per day by month (below)

Column No.			
1	2	3	4
Year	Month	COD applied (pounds)	COD applied (pounds per acre per day)
	January		
	February		
	March		
	April		
	May		
	June		
	July		
	August		
	September		
	October		
	November		
	December		
Pounds per acre per day (average)[1] growing season			
Pounds per acre per day (average)[2] non-growing season			

Column 1: Enter appropriate year (eg 1995) that the monthly loading took place.
Column 3: Multiply average concentration of COD by monthly wastewater volume in MG applied to management unit calculated in B2 above. Multiply this product by 8.327.
Column 4: Divide column 3 by the number of days in the month <u>and</u> by the acres of the Hydraulic Management Unit.

FOOTNOTES

1 Add COD applied for the growing season months and divide by the total days to get pounds per acre per day of the growing season. Then divide by the acreage of the management unit.

2 Add COD applied for the non-growing season months and divide by the total days of the non-growing season. Then divide by the acreage of the management unit.

E. WASTEWATER CHEMISTRY DATA

Please use a separate page for each sampling point (if more than one) or if there are more than four sampling dates.

Sampling Point Identification #

Parameter	Sample Date MM/DD/YY			
Total Kjeldahl Nitrogen (TKN) (ppm)				
Nitrate (ppm)				
Ammonia (ppm)				
Biological Oxygen Demand (BOD) (ppm)				
Chemical Oxygen Demand (COD) (ppm)				
Sodium Adsorption Ratio (SAR)				
pH (S.U.)				
Sodium (ppm)				
Chloride (ppm)				
Chlorine Residual(ppm)				
Potassium (ppm)				
Phosphorus (ppm)				
Total Coliform (count/100ml)				
Specific Conductance (umhos/cm)				
Total Dissolved Solids (ppm)				
Total Suspended Solids (ppm)				
Volatile Dissolved Solids (ppm)				

F. CROP

Please use a separate page for each Hydraulic Management Unit.

1. Hydraulic Management Unit

2. Crop Nutrient Uptake

	Crop # 1	Crop # 2	Crop # 3
1. Crop harvested (type)			
2. Crop yield[1] (tons/acre, bu/acre etc)			
3. crop yield (convert to lbs/acre)[2]			
4. protein percentage			
5. protein-Nitrogen percentage[3] (TKN)			
6. protein-nitrogen removed (lbs/acre)[4] (TKN)			
7. Nitrate-N concentration (ppm)			
8. Nitrate-N removed (lbs/acre)			
9. Total nitrogen removed (add No. 6 & No. 8)			

1: If only a portion of hydraulic management unit was used to grow a crop, express 1 crop yield using the entire acreage of the management unit. For example if 300 tons of hay was taken off 50 acres of a 100 acre management unit, the yield would be 3 tons per acre.

2: If tons, multiply by 2,000; if bushels, multiply by weight of bushel.

3: Divide protein percentage by 6.25 to get protein-nitrogen percentage (except for small grains which factor is 5.70)

4: Multiply No.5 (protein nitrogen percentage) by No.3 (crop yield). Please note that nitrogen concentration must be expressed at the same moisture percentage as yield. If they are not the same, the former must be corrected to the appropriate moisture percentage.

G. SOIL CHEMISTRY DATA

Please use a separate page for each Soil Monitoring Unit and/or sampling date.

Date Sampled _________ Soil Monitor Unit

	DEPTH		
Parameter	0-12"	12-24"	24-36"
Percent[1] organic Matter			
Nitrate-Nitrogen (ppm)			
Ammonia-Nitrogen (ppm)			
Sodium Adsorption Ration (SAR)			
Electrical Conductivity (EC) umhos/cm			
Cation Exchange Conductivity (CEC) (meq/100g)			
Texture (USDA texture)			
Percent moisture[1]			
Sodium (ppm)			
Chloride (ppm)			
pH (S.U.)			
Potassium (ppm)			
Plant Available Phosphorus (ppm)			
DTPA - Iron			
DTPA - Manganese			

1: Expressed as percent of oven dry weight of soil.

H. GROUND WATER DATA

Please use a separate page for each well.

Well Identification #

Parameter	Sampling Date MM/DD/YY			
TKN (ppm)				
Nitrate(ppm)				
COD (ppm)				
Iron (total) (ppm)				
Manganese (total) (ppm)				
pH (S.U.)				
Sodium (ppm)				
Chloride (ppm)				
Potassium (ppm)				
Specific Conductance (umhos/cm)				
Total Dissolved Solids (ppm)				
Static Water Level depth below ground surface (ft)				
Static Water Level (elevation above MSL) (ft)				

I. Lysimeter Data

Please use a separate page for each Lysimeter.

Lysimeter Identification #

Parameter	Sampling Date MM/DD/YY			
TKN (ppm)				
Nitrate(ppm)				
COD (ppm)				
Iron (total) (ppm)				
Manganese (total) (ppm)				
pH (S.U.)				
Sodium (ppm)				
Chloride (ppm)				
Potassium (ppm)				
Specific Conductance (umhos/cm)				
Total Dissolved Solids (ppm)				

J. GROUND WATER STATUS REPORT- An interpretive report of the year's data with respect to ground water impacts by the facility (Please Attach).

2. Site Evaluation for Reuse and Land Treatment

This section provides guidelines for land application site evaluations on the basis of environmental, management, and sociological factors. It is meant to be a general discussion of these factors, rather than an itemized list of materials and topics for permit applications. These lists can be found in Section 1. All sites have limitations, but with appropriate system design, many of these limitations can be overcome. It is incumbent upon the applicant to supply adequate justification to demonstrate feasibility of the proposed design, but DEQ works with wastewater reuse facilities through the permitting process to meet their needs in a reasonable way while protecting the waters of the state and public health and safety.

Land application site characteristics determine the potential for effective reuse of wastewater and its constituents. Although these characteristics also directly influence the potential for the transport of constituents from the site surface to beneficial users of ground water, land based reuse systems are to be evaluated as *treatment*, not disposal systems, the objective being to treat the wastewater to prevent problems related to ground and surface water pollution and nuisance situations. Sites should be evaluated, and systems designed, for sustainability for the long term, so that if and when site closure becomes necessary, land treatment sites may return to other uses involving negligible remedial activity. See Section 6.7 for further discussion of site closure.

The key site-specific features and characteristics to evaluate for land treatment include the following:

- Environmental factors
  - Climate
  - Soil
  - Topography
  - Geology and hydrogeology
- Crop Management
  - Crop selection
  - Crop management
  - Evapotranspiration
  - Crop nutrients
- Sociological factors and land use
  - Proximity to water supply wells and surface water bodies
  - Proximity to the public

Interaction between these factors and their resultant influences on the effectiveness of land application processes are discussed in the following sections.

> **Note:** The 2007 *Manual of Good Practice for Land Application of Food Processing Reuse Water* (California League of Food Processors), the 2001 Spray Irrigation Systems Operators Training Manual (North Carolina Department of Environmental Quality), and the 2005 Implementation Guidance for the Ground Water Quality Standards (Washington Department of Ecology), provided significant contributions to the text of this section.

2.1 Environmental Factors

Initial site evaluation is an important step in determining the potential an area might have for the treatment of wastewater. This general investigation can provide good background for further evaluation and prevent possible costly detailed site reviews. Environmental factors to evaluate include climate, soils, topography, geology and hydrogeology.

A discussion of the needs of the soil crop treatment system is also included in these guidelines and can be helpful in initial site evaluation.

2.1.1 Climate

Climate is the average weather of an area, including seasonal variations and weather extremes (such as prolonged periods of droughts or hurricanes) averaged over a period of at least 30 years (Miller, 2000).

Climate establishes many site characteristics because it

- affects the rates of physical, chemical and biological weathering processes over a large geographic area;
- influences soil properties;
- determines the types of vegetation or agricultural crops that may be grown;
- determines the rates of evaporation and evapotranspiration;
- determines the amount of precipitation that must be accounted for during site and system design; and
- determines the amount of storage that may be necessary for wastewater.

The two main factors that determine climate in a given area are temperature, with its seasonal variations, and the amount and distribution of precipitation.

2.1.1.1 Temperature

Temperature is important because the rates of assimilation and conversion of wastewater constituents by soil microbes are a function of temperature (Barker et al., 2000). The rate of microbial conversion of nitrogen compounds and the oxidation of organic wastes, in particular, *decreases* substantially with cool temperatures, making temperature a consideration in loading rate design. Plant assimilation of nutrients and organic matter *increases* with increasing temperature. Moreover, the length of the growing season and the occurrence of killing frosts and freezing conditions are temperature dependant, and temperature has a direct effect on evaporation and plant water use. See Section 4.4.6 for Idaho mean monthly temperature data (1971 – 2000).

2.1.1.2 Precipitation

The distribution and amount of precipitation is important to land application practices because of the potential implications for runoff, soil erosion, and leaching. For example, if an average annual rainfall of 24 inches is evenly distributed throughout the year (i.e., approximately 2 inches per month), less soil erosion and leaching will likely occur than would be the case if the same annual amount of rain fell at a rate of 4 inches per month over a six month rainy season.

Analysis of rainfall data should be conducted in terms of quantity and seasonal distribution. Types of precipitation data usually necessary for site suitability considerations for wastewater application and treatment include the following:

- total mean annual precipitation;
- mean monthly precipitation;
- peak storm event precipitation; and
- effects of snow on year round application systems.

Other climatic factors that may be considered in site selection include prevailing winds and wind velocity. The prevailing winds can have an important effect on site selection (Section 2.2.2).

See Section 4.1.1 for further discussion of precipitation with respect to crop needs and hydraulic loading. Figure 2-1 is a map of the average annual Idaho precipitation (USDA-NRCS, 1997). Section 4.4.4 has Idaho mean monthly precipitation data. Weather and climate data for a specific area can be obtained from the National Oceanic and Atmospheric Association (NOAA, http://www.crh.noaa.gov). Other sources of data are discussed further in Section 4.1.1.2.2.

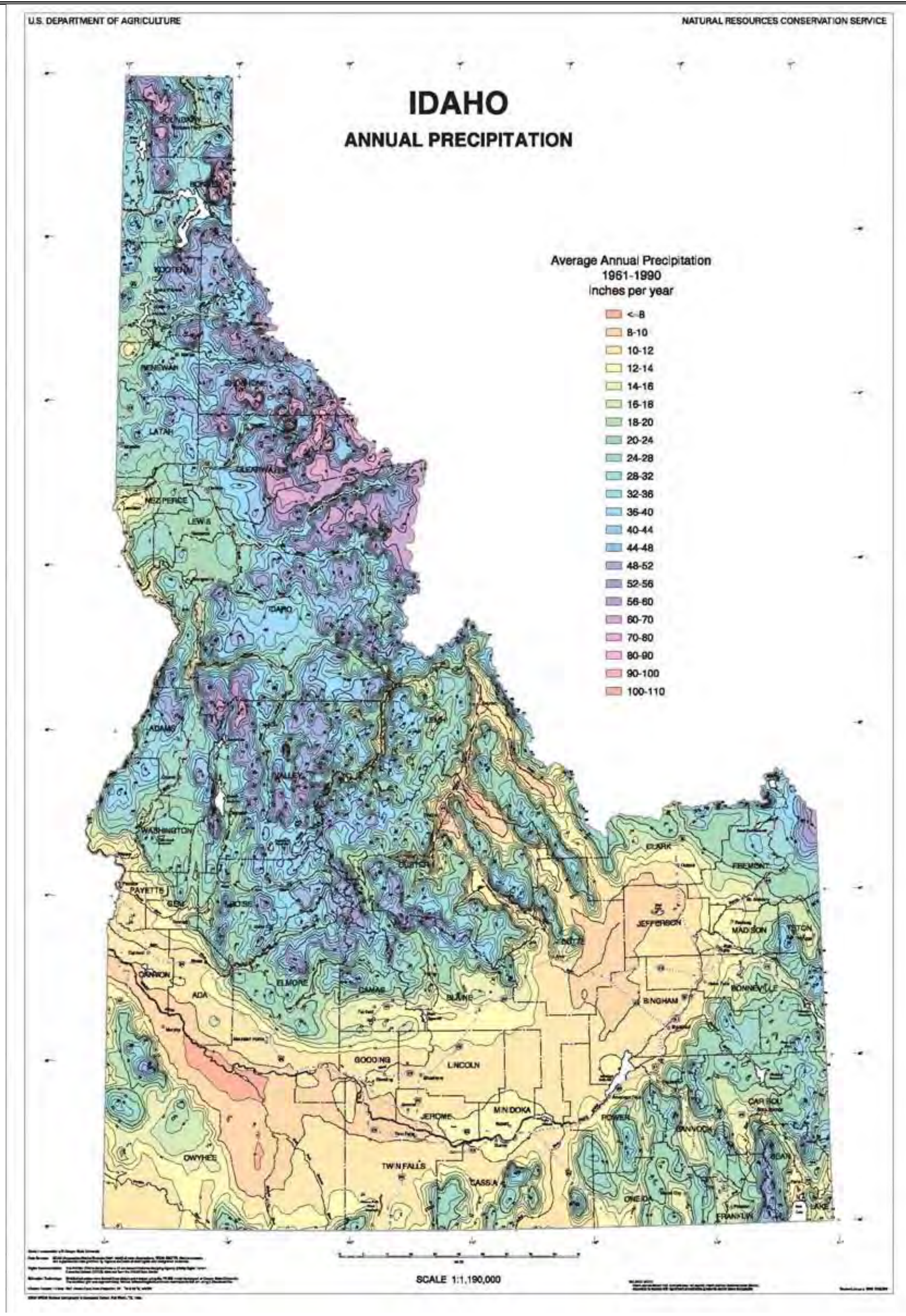

Figure 2-1. Average Annual Precipitation – Idaho (USDA-NRCS, 1997.

2.1.1.3 Climate and Soil Forming Processes

Climate is also considered by many soil scientists to be the most important factor in determining the properties of many soils. The main soil properties that correlate with climate are organic matter and nitrogen content, clay content, type of clay and iron minerals, the presence or absence of calcium carbonate ($CaCO_3$) and more soluble salts, and depth to the top of salt bearing horizons (Birkeland, 1984).

For example, the organic matter and nitrogen content of comparable soils generally tends to increase as one moves from a warmer to a cooler climate. This increase occurs because organic matter production (i.e., plant growth) exceeds destruction or microbial decomposition of organic matter at temperatures less than approximately 75°F (Brady and Weil, 2002). Organic matter and nitrogen also tend to accumulate in soils with increasing moisture.

Clay content tends to be highest in soils developed under conditions of high temperature and moisture because of increased weathering rates. Land application areas with high clay content require more intensive management because clayey soils are more difficult to work than coarser textured soils. Additionally, infiltration and permeability rates *decrease* as the content of clay increases.

Climate also influences the type of clay minerals present, with expansive (shrink-swell type) clays or *smectites*, such as montmorillonite, being more prevalent in drier environments. Non-expansive clays, such as *kaolinite*, are more common in warm, humid environments.

Agricultural soils containing smectites require special irrigation practices because swelling and dispersion of smectites may significantly decrease infiltration rates, particularly if the soils contain large amounts of sodium.

2.1.1.4 Idaho Climate

Idaho has a wide range of climates, which affect temperature, growing season and evapotranspiration. The climate in Idaho is generally suited to seasonal rather than year-round application of wastewater. Cold temperatures and freezing conditions limit the application of wastewater.

Temperatures range from an average of 53 degrees Fahrenheit (°F) in the Boise area to less than 44 °F in the mountains, including the higher mountain valleys. The growing season, where temperatures remain above 32 °F, can range from 135 to 165 days in the Boise area to less than 80 days in high mountain regions. See Section 4.1.1.1 and Figure 4-2 for further information. The evaporation rate from open water ranges from 40 inches in southern Idaho to 26 inches in some of the high valleys during the growing season.

The levels of precipitation in Idaho range from 6 inches in the southwest to nearly 80 inches in some higher mountain areas of the northern part of the state. Precipitation is generally highest when temperatures are at their lowest. In most areas Idaho precipitation is low. See Figure 2-1 for average annual precipitation in Idaho.

2.1.2 Soil

Soil is a porous mixture of organic material (highly decomposed plant and animal material (humus), mineral material (weathered rock, sand, silt and clay), water, and air. A medium-textured mineral soil contains around half soil solids (mineral and organic material) and around half *pore* space (air and water).

Soil is a three-dimensional body, resulting from the physical, chemical and biological weathering of bedrock or from the accumulation of materials weathered elsewhere and transported to a site. As soil develops on the landscape, distinct layers, called *soil horizons,* are formed.

Soil horizons differ from the overlying and underlying layers in some property, such as color, clay content, abundance of cracks, etc. A *soil profile* is a vertical slice of the soil showing the different horizons and their thickness (USDA, 1975).

Soil profiles with similar characteristics or properties are classified as a *soil series*. The characteristics of the soil series present at a proposed treatment site are a significant determining factor as to whether the site is suitable for the application of wastewater.

2.1.2.1 Soils in Agriculture and Land Treatment

Soils have four major roles to play in agricultural or other areas where land application of wastewaters occurs:

- The first role of soil is to function as a medium for plant growth. In this capacity, soils provide anchorage for vegetation, supply nutrients and water, and enable the exchange of gases between plant roots and the above-ground atmosphere.
- The second role of soil is to provide habitat for a multitude of organisms. In fact, soils harbor much of the genetic diversity of the Earth (Dubbin, 2001; Brady and Weil, 2002). A single handful of soil may contain billions of organisms that live and interact within a small space.
- The third role is that soils are important in the degradation and recycling of organic materials. Soils have the capacity to assimilate large quantities of organic waste and convert the nutrients in the waste to forms that may be utilized by plants and animals.
- Finally, soils play a major role in influencing the quality of water passing over or through them. Contaminated water passing through the soil may be cleansed of its impurities through a variety of soil processes, including microbial digestion and filtration. Conversely, clean water passing through a contaminated soil may itself become impacted.

2.1.2.2 Soil Characterization

Because of the important roles played by soil in land application, detailed descriptions of the physical and chemical characteristics of the soil within the entire rooting zone (the upper five feet) should be made prior to land application of wastewaters. Initial information on soil types, characteristics, and depths can often be obtained from the Soil

Survey published by the U.S. Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS) and available online:

http://websoilsurvey.nrcs.usda.gov/app/

Soil Surveys are also available through the NRCS state and regional offices, USDA extension offices, Idaho soil conservation districts, and the Bureau of Land Management (BLM) district offices. Unpublished mapped areas may be available through local NRCS offices or the BLM district offices. For land that is under the jurisdiction of the USDA Forest Service, soils maps may be available through the local Forest Service office.

However, even if soil survey information is available, it should be supplemented with an investigation by a soil scientist to evaluate the suitability of the soil to adequately treat the wastewater. Hand-held soil auger boreholes and/or backhoe pits should be excavated and described.

Both physical and chemical soil characteristics should be described. Soil physical characteristics that should be described include available water capacity, slope, aspect, effective depth, texture of different soil horizons, horizon thickness and boundaries, type and amount of coarse fragments present, consistency; presence of rapidly draining materials; presence and depth of restrictive horizons, underlying bedrock or ground water, mottling, drainage class, roots, estimated organic matter content, color, structure, pH, infiltration rate, flooding potential, soil erodibility by wind and water, and soil temperature and moisture regimes.

Additionally, descriptions of soil chemical parameters may be needed. These include cation exchange capacity (CEC), type of clay, salinity, sodium adsorption ratio, initial nutrient status, coatings of oxides and sesquioxides (important in phosphorus and heavy metal sorption), and horizons with carbonate or salt accumulations may be needed.

Physical and chemical soil properties are described further in Sections 2.1.2.2.1 and 2.1.2.2.2 respectively. Table 2-1 provides a summary of several soil characteristics and rating criteria.

2.1.2.2.1 Soil Physical Properties

Certain physical properties including texture, available water holding capacity, effective depth, structure, infiltration, organic matter, soil color, drainage are discussed in detail below.

Texture

Texture is an important soil characteristic because it strongly influences the retention of water, nutrients, and pollutants:

- Coarsely-textured soils, such as sands and loamy sands, have large spaces (*macropores*) between their soil particles. Water and air pass through these macropores rapidly, so coarsely-textured soils are usually well-aerated and well-drained.

- However, wastewater often passes through these soils too quickly for significant treatment to occur.
- In addition, these soils may not hold sufficient water and nutrients to support a healthy vegetative cover. A poor vegetative cover can result in an increased potential for erosion and reduced uptake of water, nutrients, and pollutants.

Soil *texture* refers to the relative proportion of sand, silt and clay separates. Inorganic soil particles with diameters ranging from 2 to 0.05 millimeters (mm) are classified as sand; those with diameters ranging from 0.05 to 0.002 mm as silt; and those with diameters less than 0.002 mm as clay.

The major soil textural classes, as defined by the percentages of sand, silt and clay, are shown in Figure 2-2. In some soils, coarse fragment modifiers, such as stony, gravelly or cobbly are included as part of the textural class name. Fragments ranging in size from 2 to 75 mm along their greatest diameter are termed gravel, those ranging from 75 to 250 mm are called cobbles, and those more than 250 mm across are called stones or boulders.

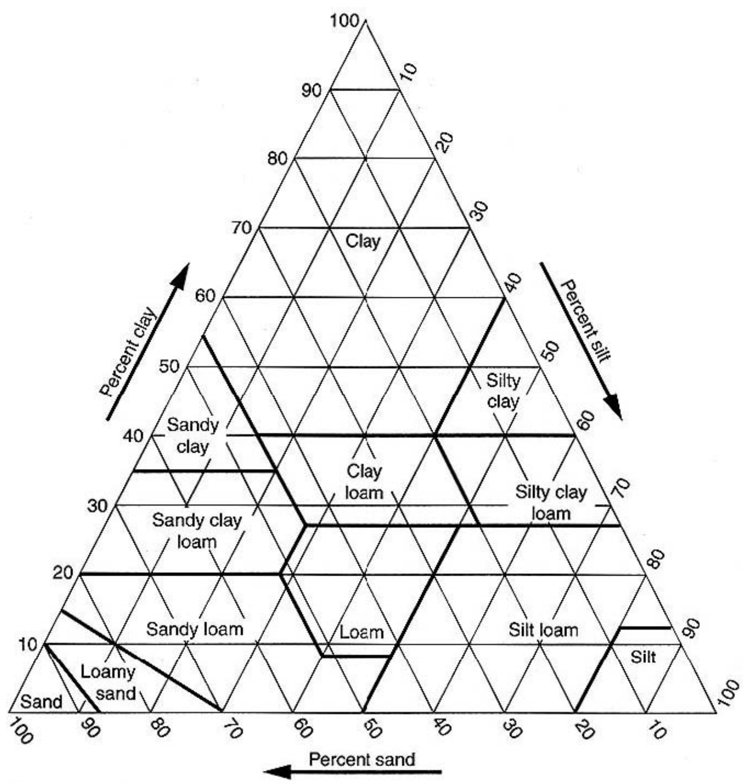

Figure 2-2. Textural triangle. The major soil textural classes are defined by the percentages of sand, silt and clay according to the heavy boundary lines shown (USDA, 2005).

Texture is one of the most important characteristics in determining fundamental soil properties, such as fertility, water-holding capacity, and susceptibility to erosion (Dubbin, 2001; Brady and Weil, 2002).

The typical influence of sand, silt and clay textures on some fundamental properties and behavior of soils are summarized in Table 2-1. Sites with surface textures of sandy loam, slit loam and loam have better tillage characteristics than soils with higher clay contents. In general, coarse-textured (sandy) soils can accept large volumes of water but do not retain much moisture. Fine-textured (clayey) soils can retain large volumes of water but do not drain well. Figure 2-2 shows that at a given soil water potential (Ψ), which units are in bars or atmospheres, the finer textured soils (clay) will have a higher volumetric water content than courser textured soils (sand).

Because of their small relative surface area, the sand and silt elements are far less reactive than clay. Sand and silt provide a relatively rigid framework for containing the clay and organic matter but by themselves function largely as a physical filter. On the other hand, the clays and organic elements of the soil matrix are extremely reactive, thus determining in large part the soil's ability to treat wastewater. Soils that contain high volumes of coarse fragments have less reactive surface area for wastewater treatment.

Overall, deep, medium-textured (loamy) soils exhibit the best characteristic for wastewater irrigated systems. It should also be noted that limitations for land treatment of wastewaters may increase when the proportion of coarse fragments is high, decreasing both soil surface area for treatment of the applied waters and retention of water for crop growth.

Table 2-1. Influence of texture on soil properties and behavior (CLFP, 2007).

	Typical rating[a] associate with textural class		
Property and/or Behavior	Sand	Silt	Clay
Water-holding capacity	Low	Medium to high	High
Rate of drainage	High	Slow to medium	Very slow
Soil organic matter content	Low	Medium to high	High to medium
Organic matter decomposition	Rapid	Medium	Slow
Susceptibility to wind erosion	Moderate High if fine sand	High	Low
Susceptibility to water erosion	Low Moderate if fine sand	High	Low if aggregated High if not
Shrink-swell potential	Very low	Low	Moderate to very high, depending on clay mineralogy
Ease of tillage after rain	Good	Medium	Poor
Inherent fertility	Low	Medium to high	High
Potential for leaching	High	Medium	Low unless cracked
Susceptibility to pH change	High	Medium	Low

a Exceptions to these typical rating may be observed and are often related to soil structure or clay mineralogy.

Available Water Holding Capacity

Available water is defined as that portion of water in a soil that can be readily utilized by plant roots. The effective soil depth and texture have a significant impact on this soil property. Water in soils is held in pores, ranging in size from large cracks or *macropores* to tiny interlayer spaces or *micropores*. When all of the macropores and micropores in a soil are filled with water, the soil is said to be *saturated*.

Water is easily drained from a saturated soil because of gravitational forces. A soil is defined as being at *field capacity* when the soil is holding the maximum amount of water it can against the force of gravity. At this point, the water has drained from the macropores and is present only in micropores.

At field capacity, a plant will initially be able to extract water easily from the soil. However, soil water is held more tightly as the amount of water decreases and larger pores are drained. Eventually, plants are unable to extract sufficient water from the soil to survive, and the soil is said to be at its *permanent wilting point*.

Although clay-textured soils may contain large amounts of water at the permanent wilting point, this water is held so tightly that it is unavailable to plants. As a result, the amount of water held between field capacity and the permanent wilting point, the available water, is a more agronomically meaningful measurement than the total soil water content at field capacity.

The presence of organic matter increases the amount of available water directly, because of its greater water supplying ability, and indirectly, through beneficial effects on soil structure and total pore space. The variation in water content with field capacity (Ψ ranging from -0.1 to -0.3), available water, permanent wilting point ($\Psi = -15$), and unavailable water ($\Psi < -15$) given differing soil textures is illustrated in Figure 2-3.

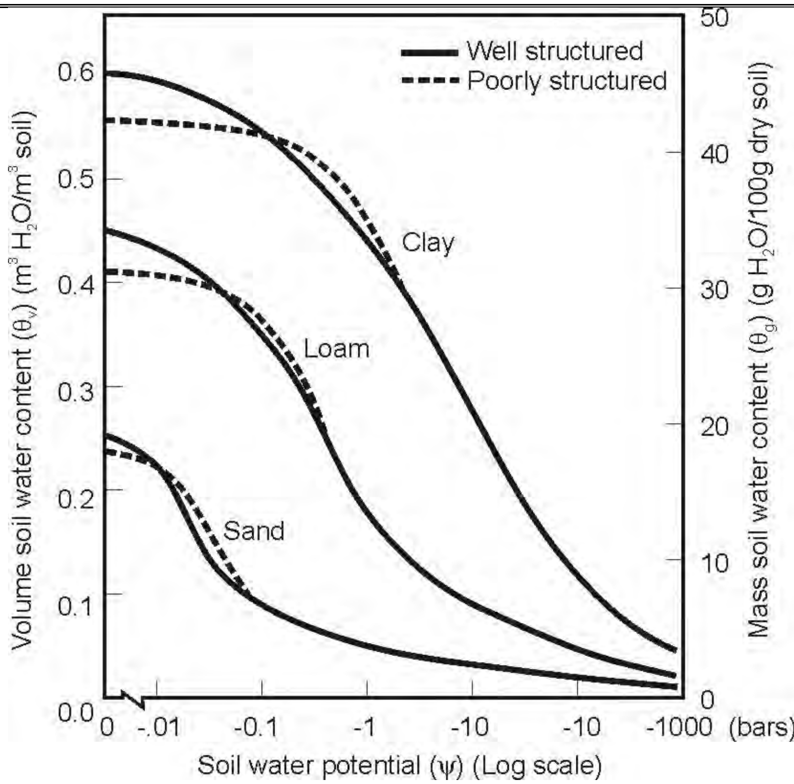

Figure 2-3. General relationship between soil water characteristics and soil texture.

Ranges in the available water holding capacity for different soil textures are summarized in Table 2-2 (Ashley et al. 1997). Additional information concerning the water holding capacities of soils can be found in Section 4.4.9.

Table 2-2. Available water holding capacity for different soil types (Ashley et al. 1997).

Soil Texture Class	Water Holding Capacity (in/in)	Water Holding Capacity (in/ft)
Sand	0.04	0.43
Loamy sand	0.08	0.94
Sandy loam	0.14	1.67
Sandy clay loam	0.14	1.67
Loam	0.17	2.10
Silt loam	0.20	2.44
Silt	0.18	2.12
Clay loam	0.16 – 0.18	2.0 – 2.16
Silty clay loam	0.18	2.16
Silty clay	0.17	2.04
Clay	0.16	1.94

Source of Data: R.E. McDole, G.M. McMaster, and D.C. Larson. 1974. Available Water-Holding Capacities of Soils in Southern Idaho. CIS 236. University of Idaho Cooperative Extension System and Agricultural Experiment Station.

Effective Depth

Effective depth refers to the depth of soil to seasonal ground water and/or a restrictive soil horizon that limits rooting depth. Adequate soil depth is important for root development, retention of wastewater constituents on soil particles, and microbial degradation of wastewater constituents. Most plants, both annuals and perennials, have the bulk of their roots in the upper 10 to 12 inches of the soil as long as adequate moisture is available.

Perennial plants, such as alfalfa and trees, have some roots that are capable of growing to depths greater than nine feet and are able to absorb a considerable portion of their moisture requirements from the subsoil (see Section 2.2.4.3.1 for further discussion of crop rooting depths). Retention of wastewater components is a function of their residence time in the soil and the degree of contact with soil particles. For land application sites, a soil depth of two feet or greater is generally adequate for wastewater treatment (Pettygrove and Asano, 1985; EPA, 2006, Crites et al., 2000). The ranking of soil depth both to bedrock and ground water as it affects site suitability is shown in Table 2-5.

Soil Structure

Soil structure is one of the principle factors that influence the rate of water movement. Soil structure refers to the arrangement of individual soil particles (sand, silt, and clay) into more complex aggregates or “peds”. These peds can be separated from each other along natural planes, zones or surfaces of weakness into distinct units.

Ped units may be granular, blocky, subangular blocky, columnar, prismatic, or platy. Soils that do not form structural units, such as very sandy soils, are considered structureless. Soils that don’t naturally separate into structural units, such as very sticky clayey soils, are considered to have massive structure.

Soil structure affects water movement, both into and through the soil. Because water moves primarily between peds, soil structure can modify the influence of soil texture on water movement. Well-structured fine and coarse textured soils can be suitable for wastewater land treatment (Crites et al., 2000).

Water movement in finely-textured soils can be very slow, but clayey soils with well-developed blocky and subangular blocky structure can transmit reasonably large volumes of water between peds, even though these soils are finely-textured. In finely-textured soils with massive structure, (the clay is so sticky that individual peds do not form); water movement can be expected to be slow and restricted. Water movement can also be slow in soils with some platy, prismatic, or columnar structure.

Unlike texture, structure can be easily altered by management practices. Additions of organic matter can improve soil structure by acting as a binding agent for soil particles. Unfortunately, management practices often damage soil structure. If finely-textured soils are traveled with heavy equipment, tilled, or otherwise worked when wet, soil aggregates are destroyed and macropores disappear, resulting in *soil compaction*. In this condition, water and air cannot move through the soil. Even after the soil dries, structure remains destroyed. It is very important to keep heavy equipment off of land application fields when wet to avoid compacting the soil.

Infiltration

The process by which water enters the soil pore spaces and becomes soil water is termed infiltration. The rate at which water enters the soil surface is termed the infiltration rate (I), and is calculated using Equation 2-1:

$$I = \frac{Q}{A * t}$$

Equation 2-1. Infiltration rate.

Where Q is the volume of water (ft^3) infiltrating the soil, A is the soil surface area (ft^2) exposed to infiltration, and t is time in seconds (s). The units of infiltration are generally converted to inches per hour (in/hr). The infiltration rate is not constant with time, and generally decreases during an irrigation or rainfall event (Brady and Weil, 2002). If the soil is dry at the onset of infiltration, all of the macropores open to the surface will be available to conduct water into the soil.

In soils with expansive clays, the initial rate of infiltration may be quite high as water enters the network of shrinkage cracks formed during periods of drying or desiccation. As infiltration continues, many macropores become filled with water and the shrinkage cracks swell shut. Therefore, the infiltration rate declines sharply initially, and then begins to level off, remaining fairly constant thereafter and is often called the effective saturated conductivity of the soil (Crites et al. 2000).

Once the water has infiltrated the soil, the water moves downward into the soil profile by the process of percolation, or vertical permeability. The vertical permeability is often referred to as the vertical hydraulic conductivity (K_v) of the soil (Crites, et al. 2000).

Both saturated and unsaturated flow are involved in the percolation of water through the soil. Saturated flow occurs when the soil pores are completely filled (or saturated) with water, and unsaturated flow when the larger pores are filled with air, leaving only the smaller pores to hold and transmit water. As a result, macropores account for most of the water movement during saturated flow and micropores for movement during unsaturated flow.

Thus, coarse-textured sandy soils have higher saturated permeability than fine-textured soils, because they typically have more macropore space. Medium-textured soils, such as loam or silt loam, tend to have moderate to slow saturated permeability.

Infiltration and Land Treatment

Sites with soils that have either too rapid or too slow a permeability have lower wastewater treatment potential. Soils with rapid permeability can allow wastes to travel through the root zone without adequate treatment. Those that have slow permeability need more intensive management to avoid runoff, erosion, and hydraulic overloading.

The influence of texture on soil permeability is summarized in Table 2-3. For slow rate systems, typical soil permeabilities range from 0.05 to 2.0 in/hr (moderately slow to moderately rapid). These permeabilities generally correspond to soil textural classes from clay loams to sandy loams (EPA, 2006). Recommended permeabilities range from 0.2 – 6.0 in/hr (Crites et al., 2000; EPA, 2006). The ranking of permeability rates as they affect site suitability is shown in Table 2-5.

Table 2-3. Influence of texture on soil permeability (CLFP, 2007).

Soil Texture	**Permeability (in/hr)**
Coarse-textured soils—sandy soils	Moderately rapid: 2.0 to 6.0 Rapid: 6.0 to 20 Very rapid: > 20
Medium-textured soils—loamy soils	Slow: 0.06 to 0.20 Moderately slow: 0.2 to 0.6 Moderate 0.6 to 2.0
Fine textured soils—clayey soils	Very soil: < 0.06 Slow: 0.06 to 0.20

The conversion of soil permeability rates in the USDA Soil Survey to recommended design percolation rates (here calculated as the planned hydraulic load to be applied per year) is shown in Figure 2-4 (Crites, et al., 2000).

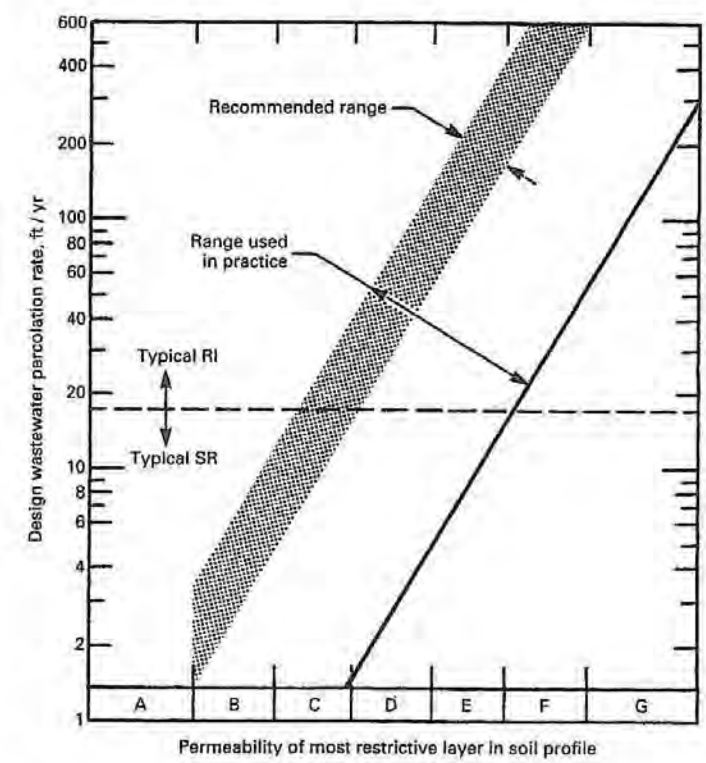

Figure 2-4. Design percolation rate vs. NRCS soil permeability classifications for slow rate and rapid infiltration land treatment (EPA, 1981).

Note: The zones A through G in Figure 2-4 refer to clearwater permeability for the most restrictive layer in the soil profile (K_v = in/h): A = very slow, <0.06; B = slow, 0.06 – 0.2; C = moderately slow, 0.2 – 0.6; D = moderate, 0.6 – 2.0; E = moderately rapid, 2.0 – 6.0; F = rapid, 6.0 - 20; G = very rapid, >20. (Crites, et al., 2000)

Infiltration Rate Testing

For proposed site, or if irrigation methods or application rates used on a site will be changing for the application of wastewater, infiltration rate testing may be warranted. This would be especially true for sites that could be prone to runoff, erosion, or extended ponding. Infiltration rate testing should also be performed if center pivot or linear move sprinklers are contemplated because of their very high instantaneous application rates. Infiltration tests can be performed using cylinder infiltrometers, basin infiltration tests, or other means described in EPA (2006). These tests can be a part of the site soils investigation described previously. The use of data from infiltration tests for system design is discussed in EPA (2006) and Crites et al. (2000).

Irrigation systems should be designed to deliver water at a rate that is less than the infiltration rate of the soil to minimize runoff or excessive percolation. Runoff and erosion may present problems if the soil infiltration rate is low, the land is relatively steep, and/or too much water is applied in one place. Water may be lost to deep percolation or runoff because of uneven distribution of water. Uneven distribution and excessive percolation of water may also result in crop death and yield losses in excessively saturated portions of the field.

Soil Organic Matter

Soil organic matter (humus) is composed of decomposing plant and animals and waste materials produced by soil microorganisms. The organic matter content of most mineral soils is generally less than five percent. However, organic matter serves several important functions in soil/plant treatment systems:

- Organic matter promotes soil structure formation in finer-textured soils. Good soil structure aids water movement in soil by increasing the pore space.
- In sandy soils, organic matter helps fill larger pores and increases the soil's ability to hold water, nutrients, and pollutants, thus increasing its treatment potential.
- Organic matter is a food source for soil microorganisms. Microbial activity, in turn, produces waste products that promote soil structure formation.
- Organic matter contains several plant nutrients, particularly nitrogen, phosphorus, and sulfur. As organic matter decays, these nutrients become available for use by plants and microorganisms.
- Organic matter has a high negative charge, which increases a soil's ability to retain water, nutrients, and pollutants.

Soil Color

Soil color is an indicator characteristic that is used to predict soil/water relationships in a soil profile. Soil color is an extremely useful tool when evaluating a site for suitability as a waste treatment system.

Soils that are well drained and do not have a seasonal high water table for a significant time during the year typically have rather bright colors due to oxidized or ferric iron (Fe^{+3}). Ferric iron imparts a reddish/orange color to the soil. When soil drainage is impeded, and the soil is saturated, the ferric iron contained in the soil is chemically reduced to ferrous iron (Fe^{+2}). Ferrous iron is soluble in water and as the water table recedes, this soluble iron is removed, leaving behind soil that is gray in color.

As the water table rises and falls, a characteristic pattern called *mottling* usually develops. Mottled soils generally contain bright orange and red areas mixed with light gray areas. These mottle patterns are impressed upon the original background, or matrix color, of the soil. The presence or absence of gray mottles or color in a soil is an indication of the wetness or aeration status of the soil:

The presence of light grayish mottles usually indicates a high water table or poorly drained soil. The depth to gray colors can be used to define the drainage class of a soil and indicate the depth of the seasonal high water table.

Soil color is determined by using an international color standard, the *Munsell* system. This standard was developed to describe colors and to avoid confusion that can arise by describing a color as simply red or yellow. The Munsell system uses three components of color to describe coloration within a soil: hue, value, and chroma:

- *Hue* is the dominant spectral color (red, yellow, etc.)

- *Value* describes the degree or darkness or lightness.
- *Chroma* refers to the purity or strength of the color.

A moist soil sample is compared to the color chips in a Munsell color book to identify the most appropriate match.

Soil Drainage

Soil *drainage* or *wetness* refers to the depth of the water table and to the period of time a particular part of the soil profile is saturated. A soil may be classified as *well drained*, *moderately well drained*, *somewhat poorly drained*, *poorly drained*, or *very poorly drained*.

Poorly drained soils have a water table at or within 12 inches of the soil surface for most of the year. Well drained soils have a water table depth of 60 inches or more during much of the year. The drainage class of a soil can usually be determined by observing both the color patterns of the soil profile and the soil's relative position on the landscape.

Poorly drained and very poorly drained soils are not generally considered suitable for the land application of wastewater for several reasons:

- wet soils do not provide adequate treatment capacity, and waste constituents may move directly to ground water
- seasonally wet soils may limit the type of plants that can be grown on the site and can impact the quality of the vegetative cover
- wet soils are subject to compaction by equipment traffic that destroys soil structure and reduces the infiltrative capacity of a site

The drainage class of a soil refers to water table depth, not permeability. Consequently, even though a soil might be coarsely-textured and relatively easily drained, a high water table due to landscape position can render the soil poorly drained. If an outlet or a drainage system is provided for soil water, then this poorly drained sandy soil may be modified. However, installing any type of drainageway or drainage system at a land application site is not recommended, since it could be a violation of the system's permit conditions. The ranking of minimum depth to ground water as it affects site suitability is shown in Table 2-5. Depths to ground water of less that 4 feet may render a site poorly suited for land treatment.

2.1.2.2.2 Soil Chemical Characteristics

Wastewaters often contain nutrients and/or organic matter that can improve soil chemical, physical or biological properties of agricultural land. In fact, soil has a tremendous buffering capacity for receiving wastewater compared to air and water and may serve as the best choice for management of wastewaters with the least impact on the environment. However, there are several soil chemical characteristics that may need to be monitored periodically during land application to ensure that soil quality is not degraded, and that damage and/or toxicity to crops is prevented. These characteristics include:

- pH;

- Cation exchange capacity;
- Salinity; and
- Micronutrient and macronutrient concentrations.

The potential impact of land application of wastewaters on these soil characteristics are discussed in the following sections. The recommended frequency of monitoring for these parameters is discussed in more detail in Section 7.4. Sections 2.5.1 and 2.5.2 have tables of typical soil chemistry values for Idaho soils with low to high ratings dependant upon the agronomic needs of the crop.

Soil pH

The pH scale ranges from 0 (most acidic) to 14 (least acidic), and is logarithmic, meaning that each unit change in pH represents a ten-fold increase in acidity or alkalinity. Of all soil chemical characteristics, pH is the most important and influences diverse properties including nutrient availability, functioning of microorganisms and fate and transport of many contaminants. Table 2-4 gives summary interpretation of soil pH levels with respect to land treatment and crop growth (EPA, 1981).

Typically, a soil pH between 5.5 and 7 is optimal for nutrient availability to plants. The ability of a soil to resist changes in pH as a result of land application of wastewaters or other activities is termed its buffering capacity. The buffering capacity of a given soil increases with increasing organic matter, calcium carbonate content and cation exchange capacity.

Decreasing soil pH directly increases the solubility of manganese, zinc, copper, and iron, thereby increasing the availability of these nutrients. At pH values less than 5.5, toxic levels of manganese, zinc, or aluminum (a non-nutrient element common in soils) may be released. On the other hand, the availability of nitrogen, potassium, calcium, magnesium, and sulfur tends to decrease with decreasing pH.

Soils with pH less than five often contain soluble aluminum in concentrations that are toxic to plants, and show deficiencies of calcium, magnesium and molybdenum. Conversely, plants that require large amounts of iron, such as azaleas and rhododendrons, prefer acidic soil environments in which iron is most available.

The activity of microorganisms is also reduced in acidic soils, resulting in a reduction in the rate of nitrogen and phosphorus mineralization. The decreased rate of microbial activity also adversely affects soil structure, because the production of organic materials required for the formation of stable aggregates is insufficient. Heavy metals are less mobile in soils within a pH range of 5.6 to 7.9 and generally mobilize in soils with a pH value of 5.6 and below.

Soils with pH greater than nine generally contain sodium at concentrations high enough to be detrimental to soil structure (Brady and Weil, 2002; Dubbin, 2001). Additionally, plants grown in high pH soils may exhibit micronutrient deficiencies.

Phosphorus and boron availability decreases at both very low and very high pH, with maximum availability in the range of 5.5 to 7.0. Outside of this pH range, phosphorus and boron tend to form insoluble compounds with other elements, such as aluminum, iron, manganese, and calcium. These reactions bind phosphorus much more strongly than boron, with the result that available boron can be readily leached from soils.

Soil pH can be altered relatively easily with amendments. A typical soil amendment used to raise the pH is calcium carbonate (limestone), although many other possibilities exist. Increasing soil pH, however, is not the primary reason for *liming*. As just mentioned, aluminum and manganese are toxic to plants at relatively low concentrations in the soil solution. Low pH is an indicator that aluminum and manganese toxicity is likely. Liming decreases the solubility of aluminum, manganese, and iron (as well as zinc and copper), causing them to precipitate as relatively insoluble silicate clays, oxides and hydroxides.

Figure 2-5 shows the relationship between pH and nutrient availability.

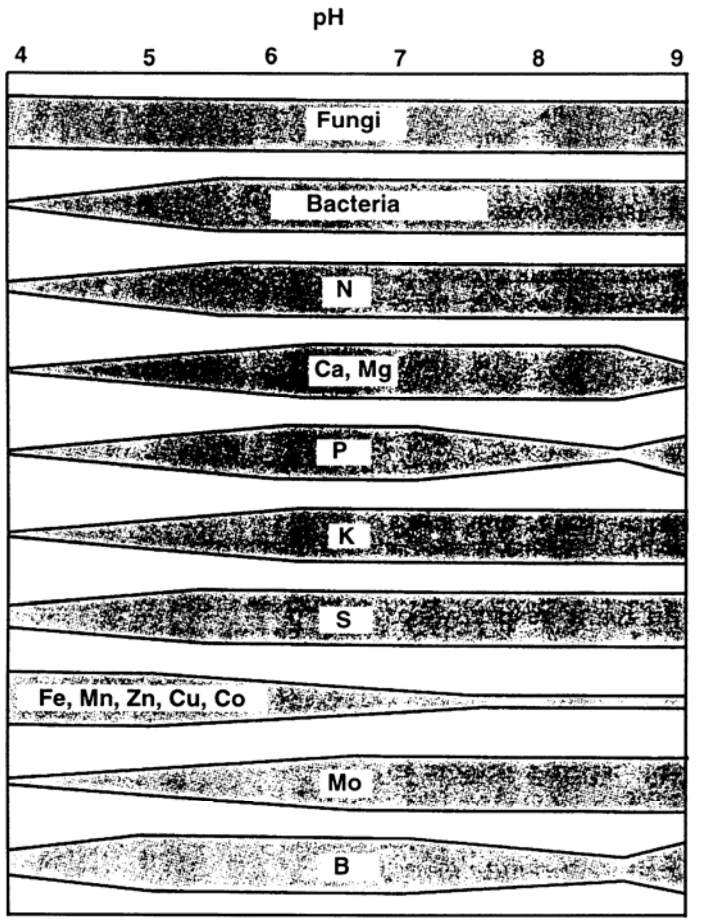

Figure 2-5. Relationships between pH on the one hand and the activity of microorganisms and nutrient availability on the other. The wide portions of the band indicate the zones of greatest microbial activity and the most ready availability of nutrients (Brady 1990)

Depending on the source, lime also supplies significant amounts of calcium and magnesium. Indirect effects of liming include increased availability of phosphorus, molybdenum and boron, the creation of more favorable conditions for microbiological processes such as nitrogen fixation and nitrification, and, in some cases, improved soil structure. By increasing soil pH, liming also improves the effectiveness of several herbicides.

Since lime applications decrease availability of zinc, iron, manganese, and copper, excessive lime applications can cause deficiencies of these elements. Heavy applications of lime have also caused decreased uptake of boron in some cases.

Table 2-4. Interpretation of Soil Chemical Tests (EPA, 1981)

Test Results	Interpretation
pH (Saturated Soil Paste)	
< 4.2	Too acid for most crops to do well
4.2 – 5.5	Suitable for acid-tolerant crops and forest systems
5.5 – 8.4	Suitable for most crops
> 8.4	Too alkaline for most crops: indicates a possible sodium problem
CEC (meq/100g)	
1 – 10	Sandy soils (limited adsorption)
12 – 20	Silty loam (moderate adsorption)
> 20	Clay and organic soils (high adsorption
Exchangeable Cations (% of CEC)	
Sodium	5
Potassium	60 -70
Calcium	5 – 10
Magnesium	10 – 20
ESP (% of CEC)	
< 5	Satisfactory
< 10	Reduced permeability in fine-textured soils
< 20	Reduced permeability in coarse-textured soils
EC_e (mmhos/cm at 25% of Saturation Extract)	
< 2	No salinity problems
2 – 4	Restricts growth of very salt-sensitive crops
4 – 8	Restricts growth of many crops
8 – 16	Restricts growth of all but salt-tolerant crops
>16	Only a few very salt-tolerant crops make satisfactory yields

Cation Exchange Capacity

The *Cation Exchange Capacity* (CEC) of a soil is a measure of the total of exchangeable cations (cationic charge) that may be adsorbed onto soil exchange sites, and therefore, represents an important measure of the nutrient holding capacity of a soil. The CEC is primarily due to the clay minerals present and organic matter content. The contribution of organic matter to CEC, on a weight basis, is approximately four times as much as that from the clay fraction (Dubbin, 2001). Typically, the highest CEC and fertility occur in clayey soils high in organic matter.

The CEC is expressed in terms of centimoles of positive charge adsorbed per kilogram of soil (cmol+/kg) which is equivalent to the more common units of milliequivalents of charge per 100 g of soil (meq/100g). The CEC of most soils typically ranges from approximately 3 to 50 cmol+/kg, and tends to increase with increasing pH (Brady and Weil, 2002).

At pH values <6.0, the CEC is generally lower. The CEC is typically measured at a pH of 7.0 or above to evaluate the maximum retentive capacity. The CEC of the soil is important in land application of wastewaters because leaching of cations from the applied water is more likely to occur in soils with low CEC (<5 cmolc/kg). In contrast, leaching of cations is reduced in soils with high CEC (>10 cmolc/kg). Table 2-4 provides interpretation of soil CEC levels and other chemical tests with respect to crop growth and land treatment (EPA, 1981)

Salinity and Sodium

Characterizing initial site soil salinity status is critical in evaluation of a potential land treatment site. Descriptions of constituents and their measurement are provided here. Discussion of soil salinity and sodium influences with respect to site loading and leaching requirement for salinity control and long-term sustainability is found in Sections 4.2.2.5 and 4.4.7.

Soluble salts are generally composed primarily of calcium (Ca^{+2}), magnesium (Mg^{+2}), sodium (Na^{+}), chloride (Cl^{-}), bicarbonate (HCO_3^{-}), and sulfate (SO_4^{-2}). Sodium is the most problematic of all the ions released by soluble salts. As discussed in Section 4.2.2.5.3, sodium disperses clay and organic matter, thereby degrading soil structure and reducing macropore space.

Soils high in sodium, therefore, are poorly aerated and have reduced permeability to water. Soluble salts alter osmotic forces in soils and impede the uptake of water by plants. Deleterious effects of salts on plants are also caused by toxic concentrations of sodium and chloride. Fruit crops are particularly susceptible to high concentrations of these elements. Additionally, the high pH caused by excess sodium may result in micronutrient deficiencies.

Measurement of Salinity and Sodium

An indirect measure of soluble salt content in soils can be obtained by measuring the electrical conductivity (EC) of the saturation paste extract of the soil water, designated as EC_e. An EC_e greater than 4 decisiemens per meter (dS/m), or millimhos per centimeter (mmhos/cm), indicates a saline soil, and an EC_e of 2 to 4 dS/m indicates moderately high soil salinity. The threshold for yield effects for the most sensitive crops begins at about 1 dS/m. The EC_e of soil subject to land application of wastewaters should be checked as part of the soil monitoring program to ensure that potentially harmful and/or toxic concentrations of soluble salts do not accumulate.

Where a paste-extract test is used, the exchangeable sodium percentage (ESP) and the Soil Absorption Ratio (SAR), two measurements of the sodium content in soils, should also be monitored. The ESP indicates the extent to which the CEC of the soil is occupied by sodium; the SAR provides information on the comparative amounts of sodium, calcium and magnesium in soil solutions. Soils with an ESP greater than 15 are classified as sodic soils. The percent of the CEC occupied by different cations, such as Ca, Mg, K, and Na, is also important, and is similar in concept to ESP. Table 2-4 provides interpretation of soil ESP and salinity (EC_e) levels with respect to crop growth and land treatment (EPA, 1981). Table 2-4 also provides percent ranges of various cations occupying exchange sites reflecting suitable levels with respect to crop growth and land treatment.

Geophysical Mapping of Site Soil Salinity

Discreet soil samples represent relatively very small volumes of soil from a site. Characterizing spatial salinity trends across a site using discrete soil samples is excessively expensive. Geophysical mapping using electromagnetic (EM) equipment can be cost effective for soil conductivity mapping. Using either a backpack or small trailer mounted unit, the site can be traversed to take hundreds of measurement points with a unit that measures electrical current eddies in the soil induced by an above-ground EM source.

Measurement locations are recorded on the fly with a geographical positioning system (GPS) unit. Depending upon the dimensions of the inductive equipment, the results can provide an indication of soil salinity up to 15 feet deep. The EM results should be calibrated with results from discreet soil samples at a few select locations. EM surveys are useful for background surveys of sites where salinity will be a particular concern and for long term (5 or 10 year interval) checking of trends (CLFP, 2007).

Soil Macronutrient and Micronutrient Concentrations

Concentrations of macronutrients and micronutrients should be monitored in soils irrigated with wastewaters. The purpose of this monitoring is to ensure that hazardous, or potentially toxic, levels of nutrients do not accumulate. Additionally, application of excess nitrogen can result in leaching of nitrate to ground water. Soil macronutrients and micronutrients are discussed further in Section 2.2.4.1. The recommended frequency of monitoring for these nutrients will vary depending on the characteristics of the soils and the chemistry of the wastewaters being applied. Soil and wastewater monitoring are discussed in Sections 7.4 and 7.5 respectively.

2.1.2.2.3 Summary Site Characteristic Rating Criteria

Table 2-5 gives ratings of certain site and soil properties for the potential suitability of a wastewater land treatment site (Taylor, 1981; EPA, 2006). Individual ratings are summed to determine whether a site is suitable for wastewater land treatment. Many site limitations can be overcome with appropriate system design, operation, and management. Other limitations may not be possible or economically feasible to overcome. In such cases, other sites should be considered.

Table 2-5. Rating Factors for Slow Rate System Site Selection (Taylor, 1981)

Characteristic	Agriculture	Forest
Soil Depth (feet)[1]		
1 – 2	E[2]	E
2 – 5	3	3
5 – 10	8	8
> 10	9	9
Minimum Depth to Ground Water (feet)		
> 4	0	0
4 – 10	4	4
> 10	6	6
Permeability (in/hr)[3]		
< 0.06	1	1
0.06 – 0.2	3	3
0.2 – 0.6	5	5
0.6 – 2.0	8	8
> 2.0	8	8
Grade (%)		
0 – 5	8	8
5 – 10	6	8
10 – 15	4	6
15 – 20	0	5
20 – 30	0	4
30 – 35	E	2
> 35	E	0
Existing or Planned Land Use		
Industrial	0	0
High Density Residential/Urban	0	0
Low Density Residential/Urban	1	1
Forested	1	4
Agricultural or Open Space	4	3
Overall Suitability Rating[4]		
Low	< 15	<15
Moderate	15 – 25	15 – 25
High	25 - 35	25 - 35

Note: The higher the maximum number in each characteristic, the more important the characteristic; the higher the ranking, the greater the suitability.

1) Depth of the profile to bedrock
2) Excluded; rated as poor
3) Permeability of the most restrictive layer
4) Sum of values

2.1.3 Topography

Topography refers to the configuration of the land surface and may be described in terms of elevation, slope, relief, aspect and landscape position (Birkeland, 1984; Brady and Weil, 2002). Site topography is also important in land application practices because:

- Topographic low positions accumulate water from higher adjacent areas and may have higher moisture contents, shallow ground water, and/or greater salinity,
- The natural horizontal movement of ground water usually follows the ground slope,
- Erosion and runoff potential increase with increasing slope; and
- Slope orientation or aspect affects the absorbance of solar energy.

Topography and Soil Development

The distribution and properties of soils in the landscape are strongly influenced by topography because of the resulting differences in microclimate, soil-forming processes and geological surficial processes. For example, steep slopes generally encourage surface erosion and allow less rainfall to enter the soil prior to runoff. Therefore, the depth of soil development on steep terrain is generally limited. The opposite condition is found in soils in flat flood basin areas, which tend to be deep and fine textured.

Topography and Vegetation

Southerly and westerly slopes receive higher amounts of solar energy. Plants start growing earlier in the spring and have a potential of less frost damage in the spring and fall. Sites in low pockets with higher adjacent areas may have a higher potential for cold air accumulation and frost damage. North and east slopes usually accumulate more snow. Snow accumulations on these positions last longer and result in somewhat shorter growing season. Toe slope positions accumulate water from higher elevation and potentially have higher moisture and possible high water tables.

Topography, Slope and Land Use

The more level topography present, the fewer difficulties in the construction, operation and maintenance of a land treatment system. Potential land treatment sites that have a slope of less than 2% are considered to be the most suitable. As slope increases, it is harder to evenly distribute the wastewater. Sites with slopes above 15% are severely limited and may not be acceptable for wastewater application without special care in both design and operation (see Table 2-5).

In general, the maximum slope recommended for cultivated agriculture is 12 to 15 percent (Pettygrove and Asano, 1985; EPA 2006). It may be possible to adapt crops that do not require cultivation, such as grass-hay, or grapes, to slopes of 15 to 20 percent or more, depending on site-specific runoff constraints. The ranking of slope (or grade) as it affects site suitability is shown in Table 2-5. Moser (1978) also provides grade suitability factors for slow rate agricultural and forest systems. These are in Table 2-6 below.

Table 2-6. Grade Suitability Factors for Identifying Land Treatment Sites (Moser, 1978)

Grade (%)	Agriculture	Forest
0 – 12	High	High
12 – 20	Low	High
> **20**	Very Low	Moderate

Topography may also influence moisture content and the depth to ground water tables. In wet or humid climates, topographic low positions may accumulate moisture from upland areas resulting in a high water table. In arid or semiarid climates, soluble salts derived from weathering in upland areas often naturally accumulate in low-lying areas.

2.1.4 Geology and Hydrogeology

The site-specific geology and hydrogeology are critical components of the land application site. These factors determine the fate of water and constituents that leach through the soil to ground water. A hydrogeologic investigation should be conducted on sites being considered for wastewater land treatment. The following section discusses objectives, scope and content, and elements of hydrogeologic investigations at both prospective and existing wastewater land treatment sites.

2.1.4.1 Objectives of a Hydrogeologic Investigation

Conducting hydrogeologic investigations is discussed in numerous texts, including USDOI Bureau of Reclamation (1977) and EPA (1993).

This section describes how to conduct a hydrogeologic investigation for a wastewater land treatment site. The purpose of such an investigation is to characterize the regional and local hydrogeologic environment with respect to the wastewater land treatment facility and potential or actual impacts from that activity.

The investigation can be submitted as part of a permit application, and can be used to establish permit conditions. The investigation also helps determine the level of monitoring necessary to evaluate both site management effectiveness and compliance, and accurately assess the facility's impact on ground water quality. The investigation is critical to designing a monitor well network including monitoring well locations and well construction plans.

See Section 7.2 for further discussion of ground water monitoring.

2.1.4.2 Scope and Content of the Hydrogeologic Investigation

The scope of work for a hydrogeologic investigation as well as DEQ expectations should be discussed with DEQ prior to conducting an investigation. The scope of a hydrogeologic investigation should be determined based upon the complexity of the facility, wastewater characteristics and loading rates, the site characteristics and potential for ground water quality degradation by the facility.

Not all of the elements discussed below are necessary in all cases. For facilities that are not anticipated to have a substantial impact on the environment, a less intensive hydrogeologic investigation may be appropriate. For sites where information is available, the investigation could be completed through a literature search and description of the site and the proposed activities. Literature would include geological, hydrogeological, and ground water quality studies and reports. Lesser detail would be necessary on simple municipal sites having low hydraulic and constituent loading rates. In some cases the need for an investigation may be waived by DEQ. More detail would likely be needed for larger and more complex facilities that land apply at higher constituent and/or hydraulic loading rates.

The following section discusses information that should be addressed in a hydrogeologic investigation as necessary depending upon the activity and the complexity of the site:

- Geology
- Hydrogeology
    - Hydraulic conductivity and transmissivity
    - Ground water depth, gradient and flow direction
    - Location and construction of existing wells
    - Contaminant transport
- Ground Water Quality
    - Ambient ground water quality
    - Beneficial uses of ground water
- Related Information
    - Waste characterization
    - Area of potential or actual impacts
    - Surface water
    - Contaminant source inventory

Additional information may be needed should DEQ determine that it is necessary to adequately characterize the site. The criteria used to determine the detail of the hydrogeologic characterization necessary are discussed in the following. The following elements are typically addressed when conducting a hydrogeologic investigation to characterize a wastewater land treatment site.

2.1.4.2.1 Geology

The hydrogeologic layers and other subsurface structural information helps characterize contaminant movement and behavior prior to reaching ground water and provides an indication of risk to existing beneficial uses of ground water from constituents in percolate. The geology of a site should be characterized through the interpretation of well logs, geologic maps, and cross sections. Cross sections can be constructed from information contained in drillers' logs and geological reports. Figure 2-6 shows the generalized geology of Idaho. Detailed geological maps of specific Idaho counties can be found at the following web site:

http://imnh.isu.edu/digitalatlas/

Structural Features

Structural features should be delineated, such as faults, fractures, fissures, impermeable boundaries or other subsurface features that might provide preferential pathways for, or otherwise influence, contaminant migration. Fracture zones that extend up to the wastewater application site can provide a more direct path for percolate to reach water supply wells, compared to massive material. The presence of fracture zones may necessitate a more conservative monitoring well network design (see Section 7.2 for further discussion). Fracturing due to rapid contraction at the surface while cooling is characteristic of extrusive igneous rocks, often resulting in high water yielding formations such as the Snake Plain Aquifer. Drilling logs and completion information for nearby production wells can provide information on fracture zones in the bedrock.

Bedrock

Bedrock depth, thickness, kind, permeability and characteristics (i.e., fractured, weathered, solid, dense, tilt or slope) of underlying unconsolidated material (including sediments, alluvium, gravel and sand) should be identified, along with any other characteristics of the vadose zone that effect movement of water (EPA, 1993). Shallow bedrock can affect site planning and monitoring. Depth to bedrock, soil characteristics down to bedrock, and slope will determine hydraulic loading capacity of the site and the potential for percolate to resurface downhill from the site. Observation or exploratory wells may need to be drilled to better define the hydrogeologic framework of a site where adequate information is not available. Such wells may or may not be suitable for use as monitoring wells however. The presence of aerobic or anaerobic conditions should be noted.

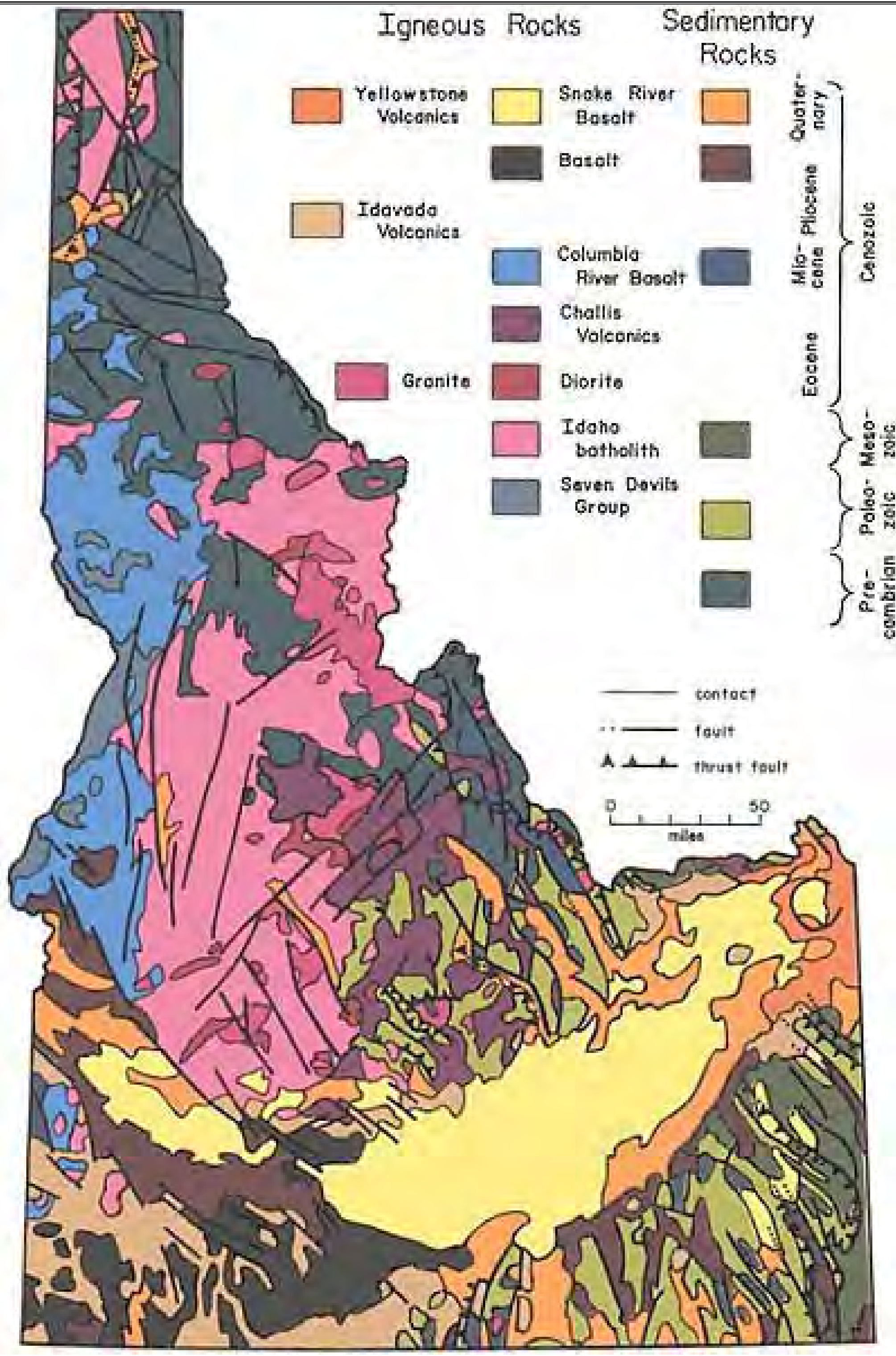

Figure 2-6. Geological Map of Idaho. Copyright 2006 by Andrew Alden, geology.about.com, reproduced under educational fair use."

Limiting Layers

The degree to which a given lithologic unit acts as a barrier (aquiclude, aquitard) or transmitter (aquifer) depends on its porosity and permeability. Thick zones of low permeability beneath the site typically lessen the potential risk of ground water quality impacts to the beneficial uses. Depth to and thickness of limiting layers may effect the usefulness of the site as they affect the mounding potential of water below the site. An understanding of the hydrologic structure also is important to consider when planning a ground water monitoring program. In particular, it is important when determining whether deeper sand or gravel zones should be monitored and existing production wells be incorporated into a ground water monitoring program.

Geomorphology

The geomorphology of the area should be described including the topography and drainage patterns. The soils on the site should be identified and described by type, horizontal and vertical extent, infiltration rate, organic matter content, and mineralology. Hardpan characteristics should be identified. If a hardpan underlies the existing site, it could provide an impediment to the downward flow of percolate. This would provide additional protection for ground water quality. The soil immediately above a hardpan will also tend to stay in a more saturated condition. This could limit hydraulic loading, but could enhance nitrogen removal. It will also affect the interpretation of soil and vadose zone monitoring. See Section 2.1.2 for further discussion of soils characterization.

2.1.4.2.2 Hydrogeology

Aquifer types underlying wastewater land treatment sites in Idaho include basalt, alluvial, mixed volcanic, and sedimentary (Figure 2-7). Understanding how ground water moves under a land application site and transports dissolved constituents can be important when interpreting ground water monitoring results (Section 7.2). While a detailed discussion of ground water hydrology and contaminant transport is beyond the scope of this document, this section presents the types of aquifer parameter data that should be obtained and how the data can be used. Characterizing initial ground water quality and beneficial uses is also discussed.

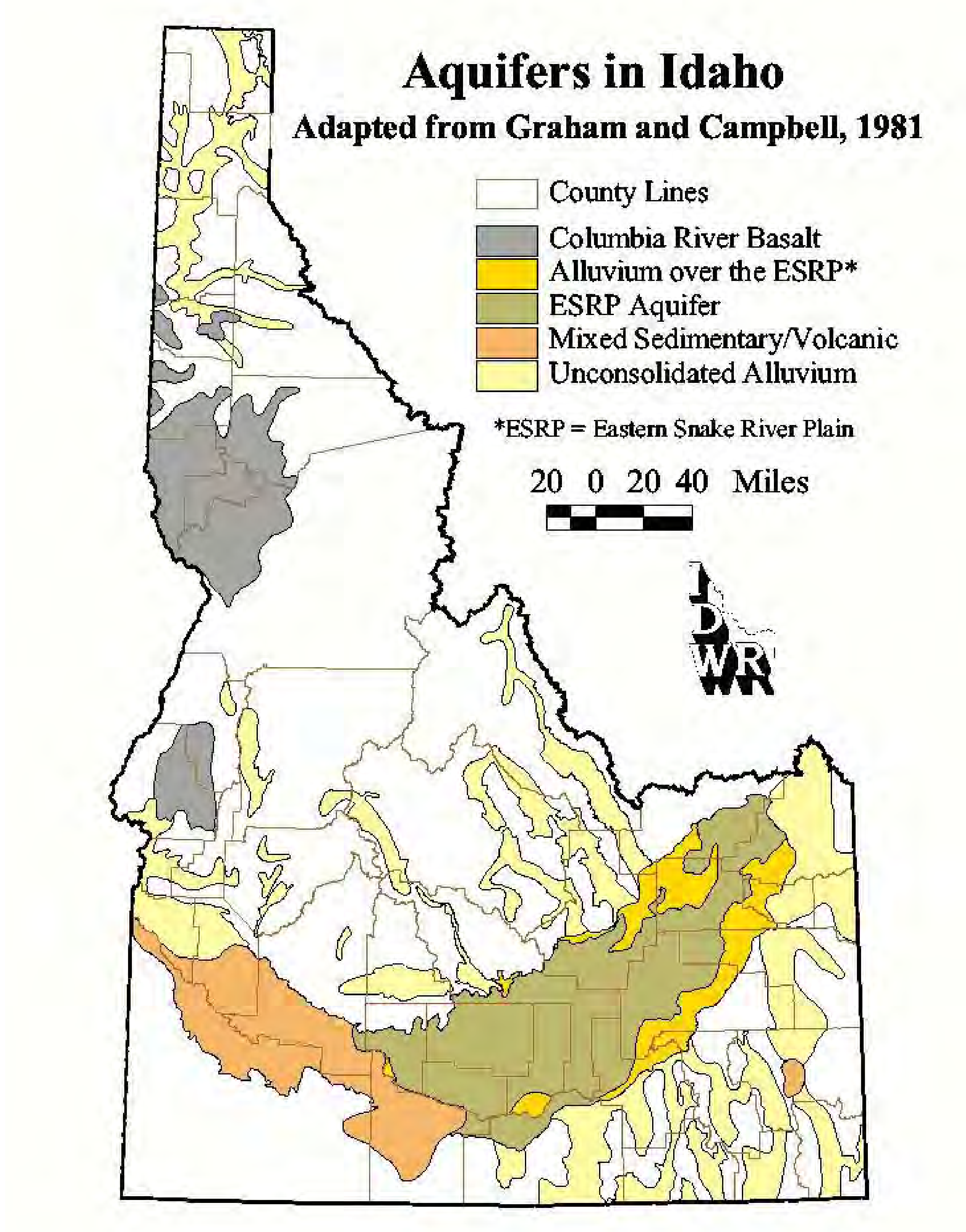

Figure 2-7. Map of major aquifers in Idaho (DEQ, 1997).

Hydraulic Conductivity and Transmissivity

Ground water velocity varies directly with the gradient (difference in ground water surface elevation divided by the distance between monitoring wells), effective porosity, and the lateral hydraulic conductivity of saturated materials.

Sources of Aquifer Parameter Information

Ranges of values for hydrogeologic parameters should be determined. Parameters include hydraulic gradient (Section 2.5.3), ground water velocity, transmissivity (Sections 2.5.3 and 2.5.4), storage coefficient, hydraulic conductivity (Sections 2.5.3, 2.5.5, 2.5.6, 2.5.7, and 2.5.8), porosity (Sections 2.5.3 and 2.5.9), and dispersivity.

These hydrogeologic parameters are used to characterize contaminant movement in the aquifer and to assess the area potentially impacted by the facility's activities. Very approximate estimates for hydraulic conductivity and specific yield can be based on aquifer material texture from driller's logs. Laboratory evaluation of drilling core samples for texture and hydraulic conductivity provide more accurate results. Ground water flow and direction(s) should be identified. Hydrographs and equipotential maps should also be included if available. Precipitation and evapotranspiration rates should be identified for the area to help characterize ground water recharge.

Aquifer Testing

The best hydraulic conductivity data is usually obtained from pumping and recovery tests of site monitoring wells. Depending on the information available for an area, aquifer testing may be necessary to characterize aquifer transmissivity/hydraulic conductivity. Testing methods for particular aquifer types (confined, unconfined, leaky confined, etc.) are discussed in several texts, including USDOI Bureau of Reclamation (1977). Analysis of test data is also discussed in numerous texts and will not be addressed here. It is critical to insure that the particular aquifer test method is appropriate for the site-specific conditions.

There are instances when certain tests are unsuitable for the aquifer conditions present. For example, it is not uncommon for slug tests to be conducted on wastewater land treatment sites because they are relatively simple and inexpensive. Slug tests characterize the hydraulic properties near the well bore. This area may be significantly altered during well construction and thus not be representative of the aquifer matrix (Moench and Hsieh, (1985). Slug tests might not be appropriate in highly transmissive aquifer materials. Response times (change in head vs. time) can be very rapid - only a few seconds in duration - and may indicate that the volume of the aquifer being stressed is very small, perhaps only the sand pack around the well screen. Rapid response times may not provide the data needed for valid data analysis to be done. Pump tests, which stress larger volumes of the aquifer, although more involved, likely will yield more representative results.

Proposed aquifer testing methods and analysis on permitted wastewater land treatment sites should be discussed with DEQ prior to conducting them. Methods should be researched adequately to determine applicability to a given site-specific application.

Ground Water Depth

The depth of first encountered ground water is important in planning for site loading rates and site monitoring. A shallow depth to ground water can limit the hydraulic loading rates and the soil zone treatment effectiveness. Generally, the potential for contamination is greater in sites with water tables at less than five feet. Shallower depths to ground water may require subsurface drainage unless shallow ground water occurs only during non-land application periods and permanent crops susceptible to damage from poor drainage are not grown. Depth to ground water and seasonal variance is critical for deciding where to screen monitoring wells.

Ground Water Gradient and Flow Direction

The direction of ground water movement and gradient can be determined by mapping the static water level recorded from area wells. This is necessary to establish the directions that contaminants would migrate if introduced into the environment. Water level elevations should be monitored on a monthly or quarterly basis from a reasonable number of wells for a period of time sufficient to determine seasonal variations in ground water flow and temporal ground water elevation trends.

Seasonal water level fluctuations in the uppermost aquifer may occur and should be taken into account when developing permit conditions. Seasonal water table elevation can sometimes be detected in the soil horizon by identification of mottled soil. A ground water potentiometric map illustrating ground water flow directions should be prepared for aquifers that have a potential to be contaminated by wastewater land treatment activities. Temporal trends, if observed, should be characterized along with seasonal variability.

Data to determine flow direction and ground water gradient should include locations of wells, dates of measurements, locations of measuring points relative to the land surface elevation, depth to water, time since the wells were last pumped, other area wells which were pumping during the measurement, and any available construction data such as total depth and screened interval. A contour map should be prepared from the resulting information. Ground water divides should also be noted.

A triangulation of observation wells within the same hydrogeologic unit is needed to determine the horizontal component of flow. Therefore, a minimum of three observation well installations are necessary. This practice helps describe the general direction of ground water flow in a relatively simple hydrogeologic setting. Paired wells (wells located adjacent to each other, but screened in separate aquifers) may be needed to define the vertical component of ground water movement, and therefore the potential for contaminant movement, from upper to lower aquifers, and also to determine the ground water flow direction in upper and lower aquifers. Additional information related to site characterization, well location and number of wells may be obtained from Ogden (1987).

Monitoring of multiple aquifers to determine vertical gradient requires nested or cluster wells. Data on ground water levels in nearby wells can be used in certain circumstances to help establish vertical ground water flow gradients. An average upward vertical gradient in ground water may also lessen the risk to existing ground water beneficial uses. Conversely, evidence of significant hydraulic connectivity between shallow ground water and aquifers tapped by water supply wells could indicate a greater risk to beneficial uses and the need for a more conservative system design. See Section 7.2 for further discussion of monitoring well network design.

Leaching to the subsurface can cause ground water mounding, depending on the rate of leaching and subsurface lithology. Mounding can influence the local hydraulic gradients, which may impact the effectiveness of the monitoring wells. The potential of a discharge to alter the gradient due to ground water mounding should be evaluated prior to developing a monitoring plan.

Location and Construction of Existing Area Wells

The location, construction details, and screened interval(s), depth, pumping rates, static water level, geologic information from drillers logs, and hydrogeologic position (up-gradient versus down-gradient) of all water wells within ½ mile of sites should be obtained and evaluated as part of the hydrogeologic investigation of a proposed wastewater land treatment site. This information can be useful in characterizing local geologic and hydrogeologic conditions and shallow or deep aquifers currently or previously utilized as a water source(s). Such data may also be used to assess baseline water quality, develop potentiometric maps, and assist in the design of ground water monitoring wells to be constructed on site. For example, if nearby wells are completed and screened within deeper aquifers, this may indicate that shallow ground water is not capable of yielding economically significant quantities of water to wells (IDAPA 58.01.11.007.02) and/or is of poor quality. Additionally, existing water well data may indicate that multiple aquifers are being utilized and may need to be monitored.

Plans and specifications of all proposed monitoring wells should be submitted to DEQ for review of location and design prior to installation. (Guidelines for monitor well design are discussed in Sections 7.2 and 7.7.3) The assessment of the vulnerability of domestic and municipal wells is discussed in Section 6.6.4.

Contaminant Transport

Understanding how ground water moves under a land treatment site and transports dissolved constituent is important both in interpreting ground water quality data and in predictive modeling. Contaminant transport modeling may be necessary to make preliminary assessments of the feasibility of a proposed activity in a particular hydrogeologic setting. California EPA (1995) has useful guidance for utilizing modeling for hydrogeologic characterization, including identifying objectives, model selection, documentation, and interpretation of results. Other means to characterize, or find evidence of, contaminant transport include ground water age studies, analysis of common ion chemical signatures, and tracer studies.

Determining the average age of ground water can be useful for estimating what portion of a particular ground water sample has been impacted by land application site operations. High accuracy tritium, helium-3, and chlorofluorocarbon (CFC) analysis of ground water samples can provide information on ground water age for ground water less than 60 years old, and can indicate whether a ground water sample is more than 60 years old. The mix of ions in water can provide a characteristic signature that can often be related to the recharge source of ground water. This can be important when determining if applied wastewater is a main component of the ground water from a given monitoring well. Environmental isotopes (non-radioactive isotopes) are also used to determine origin of ground water contamination. Isotopes of oxygen (^{18}O), hydrogen (^{2}H: deuterium), and nitrogen (^{15}N) can be used. See DEQ (2003b) for application of environmental isotopes to ground water impacts and both industrial and municipal wastewater land treatment. Stiff or Piper diagrams provide a visual method to help characterize and group water from monitoring wells.

The mix of ions in water can provide a characteristic signature that can often be related to the recharge source of ground water. This can be important for characterizing initial ground water quality and for subsequently determining whether, and to what degree, applied wastewater is influencing the ground water from a given monitoring well. As discussed in greater detail in Section 7.2.4.2.3, Stiff or Piper diagrams provide a visual method to help characterize ambient conditions and possible contaminant influences of ground water from monitoring wells.

Tracers can be used to see how quickly applied water reaches ground water monitoring wells. An ideal tracer is one that is mobile, low in concentration in monitoring wells, and not a water quality concern at the concentrations needed for tracer use. Iodide, bromide, and boron have been used effectively as ground water tracers, although bromide and boron can have water quality limit concerns. Tracers should only be used when there are significant apparent water quality impacts at a site and ground water transport cannot be explained using the other tools described in previous paragraphs.

2.1.4.2.3 Ground Water Quality

The following sections discuss definitions and determination of site background (or ambient) ground water quality and consideration of beneficial uses in wastewater reuse site characterization and evaluation.

Ambient Ground Water Quality

Ambient ground water quality can be defined as either natural or site background water quality conditions. The difference in quality between these two designations is as follows:

- **Site Background (water quality) Level**. The site background (water quality) level is defined as the ground water quality at the hydraulically up-gradient site boundary (IDAPA 58.01.11.007.25).
- **Natural Background Level.** The natural background (water quality) level is defined as the level of any constituent in the ground water within a specified area as determined by representative measurements of the ground water quality unaffected by human activities (IDAPA 58.01.11.007.19).

The ambient ground water quality characterization constitutes some of the most important information collected in the hydrogeologic investigation. The site background ground water quality characterization documents the condition of the ground water resource up-gradient of a currently operating facility or the condition at up-, cross-, and down-gradient locations prior to its operation. This characterization provides part of the basis for wastewater treatment design and enables future evaluation of the activity on ground water quality. It is important to accurately characterize background water quality for comparative purposes during facility operation. DEQ can establish site-specific ground water quality levels (IDAPA 58.01.11.400.05) for the purposes of establishing permit limits and early warning limits on a site-specific basis. This is done by using current site background water quality data (IDAPA 58.01.11.007.25.

Existing wells may be used to characterize ambient ground water quality and establish a baseline for the evaluation of long term monitoring data if the wells are properly constructed, if the wells are completed in the aquifer of interest. The quality of first encountered ground water is typically the more important of the aquifers in planning for site loading rates and site monitoring. Wells must yield representative samples of ambient ground water. If there are no existing wells located in the uppermost aquifer, or existing wells are inappropriately located with respect to wastewater land treatment activities, then monitoring wells should be installed to assess ambient conditions.

Existing data from appropriately located and constructed wells can be used for determining background water quality if the data are reasonably current. Typically the most recent 10 years of data are considered current.

Ground water quality should be characterized for the constituents of concern (Table 2-7), as these constituents vary both temporally and seasonally. The constituents of concern are the chemicals that are land applied or mobilized as a result of land application. In addition, the basic inorganic chemical parameters (common ions) should also be characterized. See Sections 7.2.4 and 7.2.4.2.3 for further discussion of monitoring parameters and common ions respectively.

A minimum number of samples are needed to characterize background water quality. Individual ground water samples are only representative of ground water quality at a particular time in a particular location. Therefore, one ground water sample cannot be assumed to be representative of ground water conditions throughout the site or over a period of time. Since ground water quality often varies seasonally or changes with time (temporally) due to other influences, the greater the number of samples collected over time, the more representative the characterization. Sufficiently large sample populations increase confidence in determinations of ground water quality impacts.

Monitoring frequency of background water quality is important for characterizing the variability in ground water quality over time. For establishing background water quality, typically eight samples collected over a period of at least one year, with no more than one sample collected during any month in a single calendar year, are necessary to statistically determine seasonal variability and optimal sampling frequency (Barcelona et al. 1989; Barcelona et al. 1985; EPA, 1992) and to establish baseline ground water quality data prior to initiation of land application of wastewaters. However, DEQ (2003a) should be consulted for more program-specific detail.

The initial rounds of sampling are the most critical; they provide a basis for determining the effects of the activity's operations and the actual impacts on the environment. Background water quality samples should be collected and results submitted as part of the permit application. Background water quality is statistically determined based on the procedures described in DEQ (2003a).

It is sometimes difficult to collect sufficient background samples prior to issuing a permit. In some cases, additional background water quality samples may be collected after the permit has been issued. Again, DEQ (2003a) should be consulted. The determination of suitable wells for background water quality monitoring should be determined based upon flow characteristics in the aquifer.

Beneficial Uses of Ground Water

All existing and future beneficial uses for ground water should be identified for the area, which may have potential to be impacted by the facility's wastewater land treatment activity. Beneficial uses are defined in the Ground Water Quality Rule (GWQR) IDAPA 58.01.11.007.03 as "various uses of ground water in Idaho including, but not limited to, domestic water supplies, industrial water supplies, agricultural water supplies, aquacultural water supplies, and mining. A beneficial use is defined as actual current or projected future uses of ground water."

Determination of beneficial use impairment should consider impairment of interconnected surface water uses as well as ground water uses. If additional parameters need to be monitored in order to protect an identified beneficial use, then those should be incorporated into both wastewater and ground water monitoring plans. Beneficial uses of ground water can be evaluated by identifying land ownership, land use, zoning restrictions, and well water use in the surrounding area. Source water assessments for municipal drinking water systems, typically prepared by DEQ, should be consulted as available. See the DEQ website for further information on source water assessments in Idaho: http://www.deq.state.id.us/water/prog_issues/source_water/assessment.cfm.

Future beneficial uses should also be projected if possible.

2.1.4.2.4 Related Information

The following section discusses information related to hydrogeologic investigations, which should be considered. Topics include waste characterization, area of potential or actual impacts, surface water, and compiling a contaminant source inventory.

Waste Characterization

Potential impacts to the environment can be assessed in part by characterizing the quantity and the quality of the waste prior to operation. Facilities should analyze their effluent for those chemical, physical, and biological constituents, which are expected to be in their waste stream. New facilities that have not yet been constructed can make preliminary predictions of the quality of their effluent by analyzing waste streams from similar types of operations. Constituent concentrations and variability, volume, rate, and frequency and duration of wastewater land treatment activity should be described.

Table 2-7 describes common wastewater characteristics of different types of facilities. This is a general list of constituents and should not be considered a comprehensive list. This list provides a base to consider in evaluating wastewater parameters and delineating the constituents of concern that could impact ground water quality. See Section 7.2.4 for further discussion of ground water monitoring parameters.

Table 2-7. Common constituents of concern in ground water for different wastewater land treatment facilities.

Activity	Typical Constituents Of Concern for Ground Water Monitoring
Municipal Facilities	NO_3, TDS,
Cheese Processors	NO_3, TDS, Na, Cl, Fe, Mn
Sugar Beet Processors	NO_3, TDS, Cl, Fe, Mn
Potato Processors	NO_3, TDS, Cl, Fe, Mn

Wastewater impoundments, whether lined or unlined, generally have the potential to contaminate ground water. All liners leak to some extent. The amount of seepage is dependent upon the permeability of the liner material, the thickness of the liner, the depth of the water in the impoundment and the surface area of the liner.

The potential to contaminate ground water should be evaluated to determine if ground water monitoring or additional protection measures are necessary. The potential to contaminate ground water can be assessed by evaluating the volume and concentration of leachate discharged to the aquifer and thus the mass loading of contaminants infiltrating to ground water. The mixing characteristics of the aquifer and percolate should also be assessed. Impoundments that have double synthetic membrane liners with a leak detection system are not generally considered to have a potential to contaminate ground water. See IDAPA 58.01.16.493 for rules concerning wastewater lagoons, and related guidance in Section 6.3.

Area of Potential or Actual Impacts

The area potentially affected by contaminant migration should be described. This is the area that may be affected, either chemically, physically or biologically as a result of wastewater land treatment activities. The area impacted should take into account advection, dispersion, and diffusion of contaminants in ground water. The size of the area will depend upon wastewater quality, volume applied and rates of application, site characteristics and management, aquifer characteristics including mixing characteristics. The applicant can use flow, transport and mixing zone modeling to help describe these areas.

The location of the facility should be illustrated on both a 7.5 minute topographic map, as well as a more detailed map of the facility. Site plans should be submitted that are drawn to approximate scale. Site maps should include the following: property lines, buildings, structures, locations of wells, locations of other underground conveyance systems (i.e., underground storage tanks, septic systems, water lines, gas lines, etc.), location of geologic borings, wastewater land treatment facilities, topography, land ownership or uses of the adjacent property, and any other relevant information.

Other areas of designation should also be identified, such as; Idaho Department of Water Resources (IDWR) Ground Water Management Areas, DEQ Nitrate Priority Areas, Sole

Source Aquifers, Sensitive Resource Aquifers, Wellhead or Source Water Protection Areas, and Critical Aquifer Recharge Areas. Previous land use should be identified to determine what, if any, contaminants may be present in the subsurface. Consideration should be given to those activities that have a potential to mobilize contaminant constituents already present in the environment.

Surface Water

Surface water bodies including lakes, reservoirs, wetlands, streams and the 25 year flood plain should be delineated on a 7.5 minute topographic map within a 1 mile radius of the facility. The possible interaction between surface and ground water should be assessed for the potential of impacted ground water contaminating surface water. Irrigation water quality should also be characterized.

Contaminant Source Inventory

Sources of potential or actual contamination in the local area of a wastewater land treatment facility should be inventoried. Knowledge of these sources is important in the interpretation of ground water data. Pre-existing contamination and its source can be identified prior to wastewater land treatment activities taking place.

2.2 Cropping

A healthy vegetative cover is essential for a wastewater land treatment system to effectively treat wastewater. Characteristics of crops that impact their use in land treatment are described in this section. These include water use, nutrient needs and uptake, and tolerance for trace constituents. Guidance on crop selection and management for land treatment process is also provided.

2.2.1 Crop Selection

The primary role of vegetation in a land treatment system is to recycle nutrients in the wastewater into a harvestable crop. Plant uptake is not the only form of nutrient transformation or removal from the soil-plant systems utilized in land treatment, but plant growth does impact most mechanisms either directly or indirectly. Plants also play a role in stabilization of the soil matrix and help maintain long-term infiltration rates. In slow rate systems designed for agricultural reuse, nitrogen generally is the limiting nutrient.

Varieties (cultivars) of major grain, food, and fiber crops are bred specifically for different regions of the United States because of differences in growing seasons, moisture availability, soil type, winter temperatures, and incidence of plant diseases. Other regional issues include infrastructure for post-harvest processing and demand for harvested by-product. A regional approach, therefore, is generally recommended for selection and management of vegetation at land treatment sites (Jensen et al., 1973). One of the easiest methods for determining regional compatibility is to investigate the surrounding plant systems.

Once regional issues are considered, the final criteria should be based on specific system objectives including nutrient uptake, cultural practices, season of growth, compatibility with hydraulic loading (quantity and timing), and salt tolerance. Although plant uptake is not the only form of nutrient transformation that takes place in the soil-plant system, plants are often selected for their propensity for uptake of a certain nutrient or for use of large quantities of water.

2.2.2 Crop Management

In order to reuse and remove nutrients applied from wastewater land treatment, the crop must be harvested and removed from the treatment site. Harvesting operations should be conducted when soil moisture conditions are below field capacity. If a site is mismanaged and the vegetation dies, the site will not be as effective in treating the wastewater. There should be consideration given in nutrient management planning for the fate of nutrients in those sites where vegetation is not harvested.

Many land treatment sites in Idaho are forested or have native grasses and shrubs. Silvicultural plans for forest/tree sites should be up-dated at approximately five-year intervals. These plans should be prepared by a qualified silviculturist and describe necessary management techniques and recommend harvest cycles.

Plans should include the following items (Inland Forest Management, Inc. 1995):

- Use of long-term, forest management principles
- Minimization of surface water flow by proper irrigation scheduling and maintaining vegetative cover
- Maintenance or enhancement of water quality
- Maximization of productivity of the forest resource
- Protection of the forest resource from insect, disease, and fire hazards

In addition, fate of nutrients in unharvested materials, such as slash and vegetative understory, is important to consider at silvicultural sites. Both EPA (2006; Chapters 4 and 5) and Crites et al. (2000; Chapters 5 and 6), provide important land treatment site characterization guidance for forested sites.

2.2.3 Evapotranspiration

Evapotranspiration (ET) is the sum of plant transpiration and evaporation from plant and soil surfaces and is also known as crop water use (Doorenbos and Pruitt, 1977). As commonly defined, ET does not include other components of irrigation inefficiency or losses such as deep percolation, wind drift, droplet evaporation in the air, and run-off.

Sophisticated computer models can be used to estimate separate transpiration and evaporation components of ET. However, site-specific data for reference ET is often available. Crop ET based on reference ET adjusted for a specific crop is sufficiently accurate for water balances and irrigation scheduling (Allen et al., 1998). See Section 4.1.1.2.2 for further discussion of sources of ET values.

2.2.3.1 Transpiration

Transpiration is the water that passes from the soil into the plant roots. Less than one percent of the water taken up by plants is actually consumed in the metabolic activity of the plant (Rosenberg, 1974). The remainder passes through the plant and leaves as vapor through the openings in the leaves known as stomata.

The drier and hotter the air, the higher the transpiration rate will be. The drier the soil, the slower the transpiration will be, because the water is held more tightly by the soil. A specific plant variety will have a genetic potential to transpire a certain quantity during the growing season. The transpiration on a given day depends on the plant growth stage, weather conditions, the availability of water, and general plant health. Non-plant based modeling used to calculate ET assumes that evapotranspiration is not impacted by plant health or water stress.

2.2.3.2 Evaporation

Evaporation is water converted from liquid to vapor that does not pass through the plant. Evaporation may occur from wet soil or plant surfaces. When plants are young, a large portion of ET is evaporation from the soil surface. When plants achieve 70 to 80 percent canopy cover, soil evaporation will amount to only 10 to 25 percent of the ET. The ET due to soil evaporation primarily occurs immediately after irrigation when the soil surface is wet as illustrated in Figure 2-8.

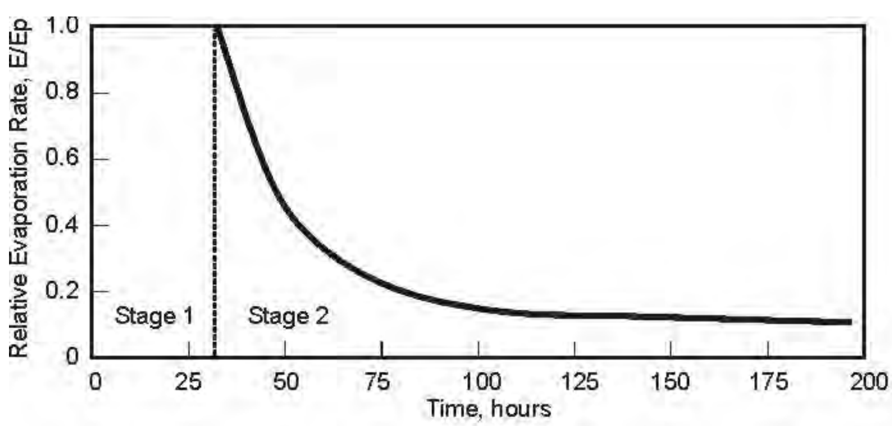

Figure 2-8. Evaporation from bare soil that was initially wet (Hanks and Retta, 1980)

Evaporation from the soil is increased by maintaining moist surface conditions. Figure 4-9 shows increases in the value of K_c (indicating higher ET rates) when frequency of wetting is increased. See further discussion of K_c and ET in Section 4.4.9. Surface or sprinkler irrigation losses are similar to drip irrigation. With drip irrigation a small percentage of the surface is wet all the time compared to surface and sprinkler irrigation that has a large percentage of the area wet for only a small amount of time. The extremes can be represented by sub-surface drip, which has very little evaporation, and small frequent sprinkler applications, which can evaporate a high percentage of the applied water. In the latter case, only the plant canopy and soil surface are wetted, and most of the applied water is lost to evaporation with little if any infiltration into the soil.

2.2.4 Crop Nutrients

Plant nutrition is critical to successful utilization of crops and other vegetation for wastewater land treatment. This section discusses nutrients with respect to crop needs, availability, uptake, and management. Although not a nutrient per se, salt uptake is also discussed as it has important implications for crop health and both soil and ground water quality.

2.2.4.1 Crop Nutrient Needs

Plants require at least 16 elements for normal growth and for completion of their life cycle. Carbon, hydrogen and oxygen are the elements used in the largest amounts; these are non-mineral elements that are supplied by air and water. Plants obtain the other 13 elements from the soil or from amendments added to the soil (fertilizers or wastewater).

2.2.4.1.1 Macronutrients

Plants need relatively large amounts of nitrogen, phosphorus, and potassium. These nutrients are the ones most frequently supplied to plants by fertilizers. Calcium, magnesium, and sulfur are required in somewhat smaller amounts. These six elements, along with carbon, hydrogen and oxygen, are considered *macronutrients*.

2.2.4.1.2 Micronutrients

In contrast to these macronutrients, the *micronutrients* consist of seven essential elements: boron, copper, chlorine, iron, manganese, molybdenum, and zinc. These elements occur in very small amounts in both soils and plants, but their role is equally as important as the macronutrients. A deficiency of one or more of the micronutrients can result in severe reductions in growth, yield, and crop quality.

Some soils do not contain sufficient amounts of these nutrients to meet the plant's requirements for rapid growth and good production. In such cases, supplemental micronutrient applications in the form of commercial fertilizers or foliar sprays should be made.

2.2.4.2 Nutrient Availability

All essential nutrients must be available, continuously, and in balanced proportions, to support photosynthesis and other metabolic processes of plants. If any one of these essential elements is missing, plant productivity will be limited, or the plant may cease to grow entirely. The principle of *limiting factors*, which states that the level of production can be no greater than that allowed by the most limiting of the essential plant growth factors, applies in both cropping systems and in natural ecosystems. This section discusses the chemistry of available nutrients and factors affecting nutrient availability.

2.2.4.2.1 Chemistry of Available Nutrients

Although the soil contains large amounts of nutrients, only a small percentage of these amounts exist in chemical forms that are available to plants. Nutrients can exist in several forms in the soil.

- Soil solution nutrients are readily available to plant roots.
- Adsorbed cations exchangeable with those in soil solution **are** moderately available.
- Cations in structural framework of clays and organic colloids can move in time to the adsorbed state and are slowly available.
- Cations in the rigid structural framework of minerals and organic tissue are released only on weathering or decomposition, and are very slowly available. Most nutrient cations are in this component, the least are in the soil solution (Brady 1990).

Generally, plants can only absorb nutrients when they are in the form of an ion. For example, soil nitrogen occurs in organic and inorganic forms, in solution and as a gas, and as the cation ammonium (NH_4^+) and the anion nitrate (NO_3^-). Plant roots absorb only ammonium and nitrate forms of nitrogen.

Plant-available forms of potassium, calcium, magnesium, manganese, zinc, iron and copper occur as cations. Potassium and ammonium both have a single positive charge, while the remaining cations have two or more positive charges. In general, these positively charged nutrients are adsorbed onto soil colloids (as described in Section 2.1.2.2.2) and are not subject to leaching under normal conditions. The higher the charge of a cation, the more strongly it is attracted to the negative charge sites of the soil. However, when the sum of the positively charged nutrients exceeds the soil's capacity to hold nutrients, these nutrients may be lost through leaching.

One form of plant-available nitrogen is nitrate (NO_3^-). The plant-available form of chlorine is the anion chloride (Cl^-). Both of these anions are repelled by the negative charges of soil colloids. Therefore, they are readily leached when water passes through the soil.

The plant-available forms of sulfur (sulfate: SO_4^{2-}) and molybdenum (molybdate: MoO_4^{2-}) are anions and are also repelled by negatively charged soil colloids. However, these anions may react weakly with positively charged sites, such as occur on iron oxides. Even though these elements are not strongly bound to soil colloids under normal conditions, they do not leach as readily as nitrate and chloride, and are frequently observed to increase in subsoil horizons having higher clay content and lower pH.

Plant-available phosphorus occurs as an anion with either one or two negative charges, depending on soil pH. Although other anions normally leach readily, phosphorus does not. Phosphorus reacts very strongly with iron, aluminum, and calcium in soil solution, with soil solids such as iron oxides, iron and aluminum hydroxides, and with lime. The strength of these reactions limits the movement of phosphorus.

Boron occurs as a leachable, uncharged molecule (boric acid, H_3BO_3), which reacts very weakly with soil clays.

2.2.4.2.2 Factors Affecting Availability of Nutrients

The availability of nutrients is influenced by the following factors:

- soil properties, particularly pH and texture
- the form of nutrients present in wastewater
- nutrient levels in the soil and soil/water solution

Soil Properties Affecting Availability of Nutrients

Soil pH greatly influences availability of nutrients. The influence of pH is discussed in Section 2.1.2.2.2. Soil texture is also an important soil property influencing nutrient availability. Not all soils are susceptible to the same nutrient deficiencies. Differences in soil texture will affect a soil's capacity to retain nutrients, as discussed further in Section 2.1.2.2.1

Table 2-8 shows some soil conditions that can lead to nutrient deficiencies.

Table 2-8. Soil factors that may lead to deficiencies of selected nutrients (NCDEQ, 2001).

Nutrient	Soil Factors Resulting in Deficiency
Nitrogen and Potassium	Excessive leaching on coarse-textured, low organic matter soils.
Phosphorus	Acid, low organic matter soils. Cold, wet soils such as occur during early spring. Newly cleared soils.
Sulfur	Excessive leaching on coarse-textured, low organic matter soils in areas where air pollution is low (minimal levels of SO_x).
Calcium and Magnesium	Excessive leaching on coarse-textured, low organic matter soils. Soils where large amounts of potassium have been applied.
Iron	Poorly drained soils. Low organic matter soils, high pH soils (pH > 7.0).
Zinc	Cold, wet soils low in organic matter and highly leached. High pH soils (pH > 7.0). Soils high in phosphorus.
Copper	Peat and muck soils. High pH, sandy soils.
Boron	Excessive leaching on coarse-textured, low organic matter soils. Soils with pH > 7.0.
Manganese	Excessive leaching on coarse-textured, low organic matter soils. Soils with pH > 6.5.
Molybdenum	Soils high in Fe oxides (high adsorption of molybdenum). Soils cropped for a long time.

Form of Nutrients Applied in Wastewater

Another factor that influences the plant availability of nutrients is the form in which nutrients are present in the wastewater applied to soil. Some nutrients in wastewater are largely present as organic compounds that must be broken down by soil microorganisms before plants can use the nutrients. Other nutrients are present as water-soluble salts that are immediately available for plant uptake.

Levels of Nutrient in the Soil and Soil Water Solution

There are three levels of nutrient availability (Figure 2-9):

- *Deficiency*: marked increases in yield occur with increasing amounts, or availability, of the nutrient, i.e., supply of the nutrient is inadequate and is limiting yield. An addition of the nutrient will increase yield.
- *Sufficiency*: the maximum economic yield has been reached and the nutrient is not limiting crop yield, so increasing the supply or availability of the nutrient has no effect on yield.
- *Toxicity*: further additions or availability of a nutrient beyond the sufficiency range causes marked decreases in yield and, eventually, no growth.

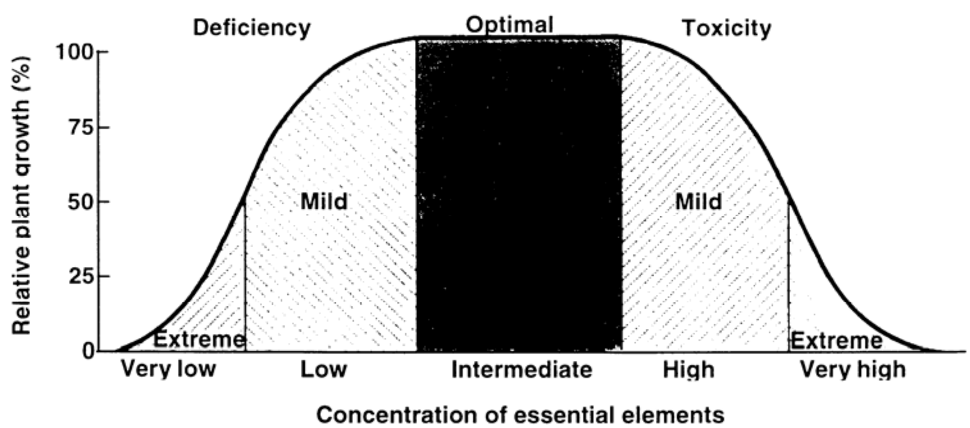

Figure 2-9. Relationship between plant growth and concentration in the soil solution of elements that are essential to plants. Nutrients must be released (or added) to the soil solution in the right amounts over time if normal plant growth is to occur (Brady 1990).

Symptoms of nutrient deficiency usually appear on the plant when one or more nutrients are in short supply. In many cases, a deficiency may occur because a nutrient is not in a plant-available form. Deficiency symptoms for specific elements are listed in Table 2-9.

Table 2-9. Key to nutrient disorders (NCDEQ, 2001).

Nutrient	Symptoms of Nutrient Deficiency
Nitrogen	General chlorosis (yellowing). Chlorosis progresses from light green to yellow. Entire plant becomes yellow under prolonged stress. Growth is immediately restricted and plants soon become spindly and drop older leaves.
Phosphorus	Leaves appear dull, dark green, blue green, or red-purple, especially on the underside, and especially at the midrib and vein. Petioles (the stalk that attaches the leaf to the stem) may also exhibit purpling. Restriction in growth may be noticed.
Potassium	Leaf margins tanned, scorched, or have necrotic (dead) spots (may be small black spots, which later coalesce). Margins become brown and cup downward. Growth is restricted and death (die back) may occur. Mild symptoms appear first on recently matured leaves, then become pronounced on older leaves, and, finally, on younger leaves. Symptoms may be more common late in the growing season due to translocation of potassium to developing storage organs.
Calcium	Growing points usually damaged or dead (die-back). Margins of leaves developing from the growing point are first to turn brown.
Magnesium	Marginal chlorosis or chlorotic blotches, which later merge. Leaves show yellow chlorotic inter-veinal tissue on some species, reddish purple progressing to necrosis on others. Younger leaves affected with continued stress. Chlorotic areas may become necrotic, brittle, and curl upward. Symptoms usually occur late in the growing season.
Sulfur	Leaves uniformly light green, followed by yellowing and poor, spindly growth. Uniform chlorosis does not occur.
Copper	Leaves wilt, become chlorotic, then necrotic. Wilting and necrosis are not dominant symptoms.
Iron	Distinct yellow or white areas appear between veins, and veins eventually become chlorotic. Symptoms are rare on mature leaves.
Manganese	Chlorosis is less marked near veins. Some mottling occurs in inter-veinal areas. Chlorotic areas eventually become brown, transparent, or necrotic. Symptoms may appear later on older leaves.
Zinc	Leaves may be abnormally small and necrotic. Internodes are shortened.
Boron	Young, expanding leaves may be necrotic or distorted followed by death of growing points. Internodes may be short, especially at shoot terminals. Stems may be rough, cracked, or split along the vascular bundles.

2.2.4.3 Crop Constituent Uptake

This section discusses crop constituent uptake including nutrients and salt, with emphasis on nitrogen. Salt, although not regarded as a nutrient except in relation to specific elements, is discussed here with application to crop uptake and salt balance in land treatment systems.

2.2.4.3.1 Nutrient Uptake

Nitrogen is often the limiting design factor, and several crops are heavy users of N. Nutrient uptake is directly related to dry matter yield, and crop stress will reduce yield. Nutrient loading should be balanced to avoid yield reductions from nutrient stress and environmental degradation from excess loading.

The relationship of nutrient availability and yield is non-linear. If the N loading is reduced to half of the expected uptake, it cannot be assumed that half the uptake will result. The actual yield and nutrient uptake will be a function of the initial soil reserve and resulting nutrient stress. Crop residue, straw, and other matter that is left in the field after harvest will eventually contribute nutrients back into the soil reserve. Soil and tissue analysis can help determine nutrient deficiency and proper nutrient loading.

The highest uptake of N, phosphorus, and potassium can generally be achieved by perennial grasses and legumes. It should be recognized that whereas legumes normally fix N from the air, they will preferentially take up N from the soil-water solution, if it is present. The potential for harvesting nutrients with annual crops is generally less than with perennials because annuals use only part of the available growing season for growth and active uptake. Crop nutrient uptake is discussed further in Section 4.4.2.3. Typical annual uptake rates of the major plant nutrients: N, phosphorus, and potassium, are listed in Table 7-30 for several crops.

The nutrient removal capacity of a crop is not a fixed characteristic but depends on the crop yield and the nutrient content of the plant at the time of harvest. Design estimates of harvest removals should be based on yield goals and nutrient compositions that local experience indicates can be achieved with good management on similar soils.

Alfalfa removes N and potassium in larger quantities and at a deeper rooting depth than most agricultural crops as shown in Table 2-10. Corn is an attractive crop because of its potentially high rate of economic return as grain or silage. The limited root biomass early in the season and the limited period of rapid nutrient uptake, however, can present problems for N removal. Prior to the fourth week, roots are too small for rapid uptake of N, and after the ninth week, plant uptake slows. During the rapid uptake period, however, corn removes N efficiently from percolating wastewater (D’Itri, 1982).

Table 2-10. Typical effective rooting depth of crops by growth stages (Ashley, et al., 1997).

Crop	**Weeks After Emergence[1]**	**Stage of Development**	**Growth Stage Indicators**	**Total Depth of Effective Root Zone for Irrigation Water Management[2] (Feet)**
Alfalfa **Established stands**		4.0		
New stand	0 – 5 5 – 13 13 to dormancy	Vegetative Vegetative Vegetative		0.5 - 1.0 1.0 - 1.5 1.0 - 3.0
Cereal Grains, Spring	3 5 6 8 to end of season	Haun Scale 1 to 3 4 to 7 8 to 11.6 12 to 14.5	Two leaves unfolded to four leaves unfolded (tillering) Five leaves unfolded to eight leaves unfolded Flag leaf through flowering Milk development to soft dough	0.5 - 1.0 1.0 - 2.0 2.0 - 3.0 3.0 - 3.5
Cereal Grains, Winter		Haun Scale 1 to 3 4 to 7 8 to 11.6 12 to 14.5	Two leaves unfolded to four leaves unfolded (tillering) Five leaves unfolded to eight leaves unfolded Flag leaf through Flowering Milk development to Soft Dough	0.5 - 1.0 1.0 - 2.0 2.0 - 3.0 3.0 - 3.5
Corn, Field	2 6 8 11		3 leaf 12 leaf Silking Blister kernel	0.6 - 1.0 2.0 3.0 3.5
Dry Beans	2 to 3 4.5 to 5.5 6	V-4 V-10	4 leaf First Flower First Seed	0.8 - 1.0 1.5 2.0 - 2.5
Pasture Established New stand	0 – 5	Vegetative Reproductive Maturity	Flowering Mature seed	1.5 - 4.0 0.0- 0.5 0.5 - 1.5 1.5 - 3.0
Potato[3]	4 6 14.5 16.5 to 18	I Vegetative Growth II Tuber Initiation III Tuber Growth IV Maturation	Emergence to 8 to 12 leaves Tubers begin to form at tips of stolens Early bulking to mid bulking Late bulking to maturity	0.66 - 1.0 1.0 - 1.5 1.5 - 2.0 2.0

The rate of N uptake by crops changes during the growing season and is a function of the rate of dry matter accumulation and the N content of the plant. For planning and nutrient balances, the rate of N uptake can be correlated to the rate of plant transpiration. Consequently, the pattern of N uptake is subject to many environmental and management variables and is crop specific. Examples of measured N uptake rates versus time are shown in Figure 2-10 for annual crops and perennial forage grasses.

The most common agricultural crops grown in Idaho for revenue using wastewater are corn (silage), alfalfa (silage, hay, or pasture), forage grass (silage, hay or pasture), and grains. However, any crop, including food crops, may be grown with food processing wastewater because there is little concern with microbial or viral contamination. In areas with a long growing season, selection of a double crop is an excellent means of increasing the revenue potential as well as the annual consumptive water use and nitrogen uptake of the crop system. Double crop combinations that are commonly used include summer crops of short season varieties of silage corn or winter crops of barley, oats, wheat, or annual forage grass as a winter crop.

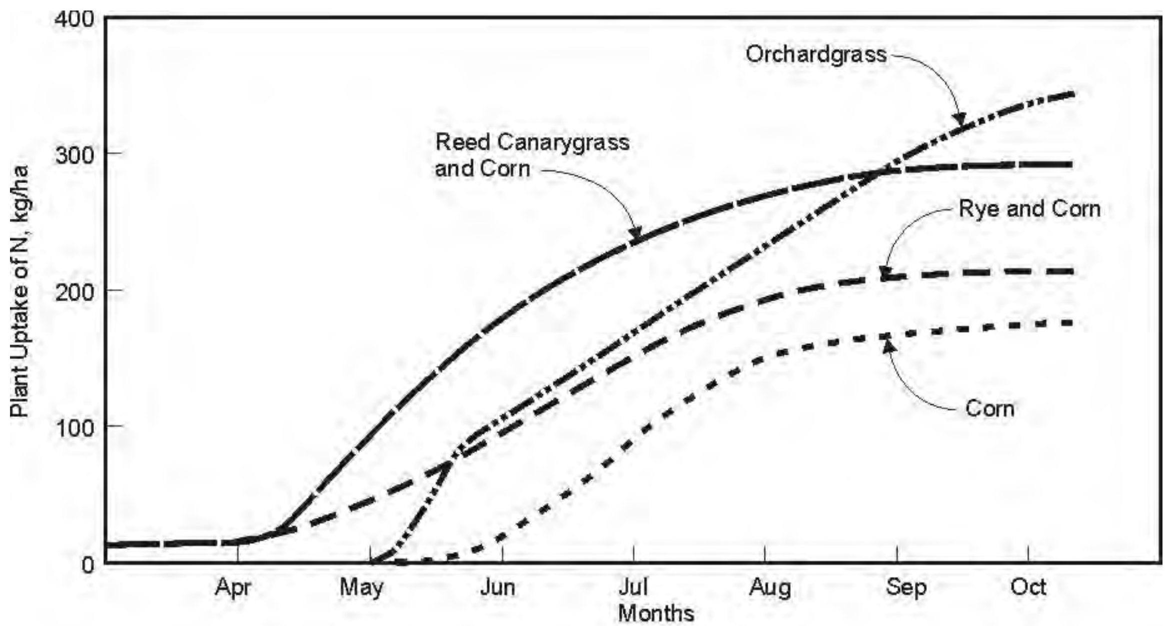

Figure 2-10. Nitrogen uptake for annual and perennial crops (EPA, 2006).

Some forage crops can have even higher N uptakes than those in standard tables. The nitrogen crop uptake measured for turfgrasses in Tucson (common bermudagrass overseeded with winter ryegrass) is 525 lb/acre-yr (Pepper, 1981). “Luxury consumption” may occur in the presence of surplus soil N, and result in higher than normal crop uptake rates.

Essentially all N absorbed from the soil by plant roots is in the inorganic form of either nitrate (NO_3^-) or ammonium (NH_4^+). Generally young plants absorb ammonium more readily than nitrate; however as the plant ages the reverse is true. Soil conditions that promote plant growth (warm and well aerated) also promote the microbial conversion of ammonium to nitrate. As a result, nitrate is generally more abundant when growing conditions are most favorable. Once inside the plant, the majority of the N is incorporated into amino acids, the building blocks of protein. Protein is approximately 16 percent N by weight. N makes up from one to four percent of the plants harvested dry weight.

2.2.4.3.2 Salt Uptake

Along with N, crops also take-up other dissolved minerals including phosphorus, potassium, calcium, magnesium, and sulfur. These dissolved minerals can be measured as the portion (typically 50 – 70 percent) of the ash content of the plant. The ash content is approximately 10 percent of the dry mass of the plant, so increased yield directly correlates to salt uptake. Ash content of cereal crops can be found in Table A-11 of Leonard and Martin (1963). Ash content of field crops can be found in Table A-2 of Martin et al. (1976).

Table 2-11 shows actual field results of salt removal from various crops that were grown with wastewater.

Table 2-11. Yield and salt removal of various crops (CLFP, 2007).

	Average Yield dry tons/acre	Salts Removed lbs/acre	Ash Percentage
Alfalfa[a]	6.6	2093	16%
Barley[a]	3.9	759	10%
Field Corn[b] (Grain plus stover)	11.7	1750	7.5%
Winter wheat[b] (Grain plus straw)	5.2	1321	13%
Tall Fescue[a]	8.4	2083	12%

Source: Tim Ruby, Del Monte Foods Company
a) Process water spray irrigation site located outside Boise, ID, two year average
b) Process water surface irrigation site, Kingsburg, CA, one year.
Note: For data utilized to create this summary table, see CLFP (2007) Appendix H.

The uptake of the constituents that make up TDS is dependent on the crop and the crop yield. Data in Table 2-12 can be used to conservatively estimate the uptake of selected constituents that are applied in wastewater. The 'total uptake' in Table 2-12 underestimates the total mineral removal because certain constituents (e.g. sodium and chloride) are not included. The actual or expected yield can be used to adjust the mineral removal values in Table 2-11 when doing salt uptake calculations.

Table 2-12. Constituent uptake estimates for crops (from Mitchell, 1999).

Crop	Yield Per Acre (tons)	N	P	K	Ca	Mg	S	B	Cu	Fe	Mn	Zn	Totals
		lb/acre											
Alfalfa Hay	8	415	41 333		151	36	26	0.43	0.11 1.67 0.45			0.3	1126
Bermuda grass Hay	8	400	40 286	48		32	0.13	0.02	1.2	0.64	0.48	951	951
Corn, Grain	5.04	170	31	40	15	16	14	0.12	0.06 0.15 0.09			0.16	334
Corn Stover	4	70	13	159 27		34	16	0.05	0.05	0.9	1.5	0.3	372
Corn Silage	16	160	29 133	28		33	20	0.11	0.07	0.7	1.06	0.3	470
Oats, Grain	26	80	11	17	3	5	8	—	0.04	0.8	0.15	0.06	142
Oats, Straw	3.5	35	7	104	10	15	11	0.05	0.04 0.15 0.15			0.36	212
Sorghum-Sudan Hay	4	160	27	193	30	24	23 — — — —					—	531
Tomatoes-Fruit	15	50	5	90	3	14	20		0.07	1.3	0.13	0.16	209
Tomatoes-Vines	—	40	6	50	—	—	— — — — —					—	113
Wheat, grain	2.4	92	19	22	2	12	5	0.06	0.05 0.45 0.14			0.21	183
Wheat, straw	3	42	4	195	9	12	15	0.02	0.02 1.95		.24	0.08	225

Notes:

Data obtained from Auburn University, Alabama Cooperative Extension System and combines data from The Fertilizer Institute, Phosphate and Potash Institute, and independent research resources (http://www.aces.edu/pubs/docs/A/ANR-0449/)

Yields are for high-yielding Alabama crops. Values reported in this table may differ from values from other sources. Healthy, high-yielding crops can vary considerably in the nutrient concentration in the grain, fruit, leaves, stems, and pods. Plant “uptake” is also higher than crop “removal.” Nutrients not actually removed from the land are returned to the soil in organic residues. Crop removal should be adjusted in proportion to the actual yield.

2.2.4.4 Nutrient Management

When plant nutrients are applied to soils as wastewater, wastewater residuals, animal manure, or commercial fertilizers, five things can happen. Nutrients can either:

- be taken up by the plants.
- remain in the soil.
- be lost by leaching through the soil profile or through denitrification or volatilization as gases losses.
- If fertilizers or wastes are left on the soil surface, runoff water may carry nutrients away in solution or as part of eroded sediments.

To make efficient use of nutrients, and minimize impacts to the environment, careful *nutrient management planning* should be done to determine appropriate loading rates for site- and crop-specific circumstances. This is discussed further in Section 4.2.2.3.

2.3 Sociological Factors and Land Use

Sociological factors must be taken into account when evaluating suitability of wastewater land application proposals. Planning and zoning is discussed as well as considerations relating especially to nuisance conditions.

2.3.1 Planning and Zoning Requirements

Chapter 65, Title 67, Idaho Code grants authority for comprehensive land use planning to local government. Contact the local city or county Planning and Zoning (P&Z) authority for zoning permits, conditional use permits and building permits; flood plain and storm water run-off requirements; and other types of planning requirements such as landscaping requirements for both new, expansions or remodels to existing facilities.

Some P&Z departments may require a conditional use permit for the wastewater-land application system separate from the facility's zoning permit for the site. Some P&Z authorities may also act as the coordinator for approvals coming in from various agency inspectors on such issues as plumbing, electrical and fire codes.

An evaluation of the surrounding land uses should take place as part of determining the acceptability of the site by the community. The present land use should be evaluated in site selection. The planned use of the site should not conflict with the present or planned uses of adjacent property. Land uses that need to be considered in site evaluation include proximity of municipal wells and wells for domestic use, proximity of homes, and proximity of other installations and industry that have the potential for impacts on ground water or air quality such as landfills.

Direction from potential conflicting land uses is an important land use consideration. It may not be suitable for a wastewater land application facility to be located upwind from an urban area, or up gradient of a municipal well. See both Section 6.5 (*Buffer Zones and Distances*) and 6.6 (*Protection of Domestic and Public Well Water Supplies*) for additional information. See also DEQ Policy Memorandum PMOO-6, *Policy for Responding to Odor Complaints*:

http://www.deq.idaho.gov/media/72449-pm00_6.pdf

Local officials and the public should be included as part of site selection considerations. Realizing the possible health and nuisance impacts a land-applied wastewater facility can create, public awareness may help determine what may or may not be acceptable. Trying to correct a problem after the fact can be very time consuming and costly.

2.3.2 Nuisance Conditions

Reuse permittees should avoid nuisance conditions during land treatment operations. The most effective way to do this is to prevent them from occurring.

2.3.2.1 Nuisance Prevention

The permittee can initiate its own nuisance prevention program for odors, vectors, insects and other nuisance conditions through:

- Equipment design, i.e. designing drainage of all transfer lines to prevent wastewater turning anaerobic.
- Follow-through on operation and maintenance that includes management of probable or potential nuisance conditions.
- Proactive company outreach to adjacent property owners and/or immediate community to inform them about the facility and wastewater-land application system. Effective outreach may consist of, offering a tour of the facility, or asking the community for its input to jointly resolve a potential nuisance condition before it becomes a reality. One real life solution to an ongoing nuisance situation by a community occurred after an industry officer was elected to city council and saw their company in the eyes of the whole community.

2.3.2.2 Authorities for Nuisance Regulation

In addition to what the permittee might choose to voluntarily do, Idaho law provides direction in regard to nuisance conditions. The Idaho State Constitution and Idaho Code recognize four types of nuisance conditions: private, public, general and public health. Prevention and resolution of nuisance conditions by law are based on:

- *Local (city/county) laws or ordinances* regarding general, public, or public health based nuisances.

  This means that any county law(s) or ordinance(s) pertaining to nuisances that exist may become a condition of the local P&Z permit or building permit issued to a reuse facility. The local city or county should direct any resolution efforts on city/county laws or ordinances.

- *The Idaho State Constitution and Idaho Code*. The constitution and code provides cities and counties with the authority to take necessary steps to protect the public health, safety and general welfare of citizens within their jurisdictions. As such, abatement of general or public nuisances may also be resolved by a local city or county.

  Idaho Code distinguishes between public "health" nuisances and general or public nuisances, granting authority to the district health departments to abate public "health" nuisances.

- *Compliance with Permit Conditions.* Prevention and resolution of nuisance conditions may be a condition of a license or permit. Compliance with required permit conditions is addressed by the agency with permitting authority such as the Department of Water Resources for drilling a well or DEQ for an air quality permit or a reuse permit. One example of language used to address potential nuisance conditions in a reuse permit follows:

"Wastewater must not create a public health hazard or nuisance condition as stated in IDAPA 58.01.16.600.03. In order to prevent public health hazards and nuisance conditions the permittee shall:

a. Apply wastewater as evenly as practicable to the entire treatment area;
b. Prevent organic solids (contained in the wastewater) from accumulating on the ground surface to the point where the solids putrefy or support vectors or insects; and
c. Prevent wastewater from ponding in the fields to the point where the ponded wastewater putrefies or supports vectors or insects."

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2.5 Supplementary Material

2.5.1 Typical Idaho Soil Chemistry Values – Stukenholtz Laboratory, Inc.

Stukenholtz Laboratory, Inc. (4/26/2007)
Addison Avenue East ● Box 353 ● Twin Falls, Idaho 83303-0353
PHONE (208) 734-3050 ● 800-759-3050 ● FAX (208) 734-3919

	LOW	**MEDIUM**	**HIGH**	**VERY HIGH**
pH	4.5–5.5	5.6–7.0	7.1–8.3	8.4+
CEC, meq/100g	0–10	9–18	17–24	25+
Sodium, meq/100g	0–0.5	0.6–1.5	1.6–4.0	4.1+
Salts, mmhos/cm	0–1.0	1.1–2.5	2.6–5.0	5.1+
Organic Matter, %	0–1.0	1.1–1.7	1.8–3.0	3.1+
Lime, %	0–1.0	1.1–4.0	4.1–9.0	9.1+
N-Nitrate, ppm	0–5	6–20	21–40	41+
P Phosphorus, ppm	0–15	15-30	30-50	51+
K Potassium, ppm	0–115	115–250	250–500	500+
Ca Calcium, meq/100g	0-5.0	5.1-10.0	10.1-15.0	15.1+
Mg Magnesium, meq/100g	0–1.0	1.1–3.0	3.1–5.0	5.1+
S Sulfur, ppm	0–8	9–18	19–40	41+
Zn Zinc, ppm	0–0.8	0.9–1.8	1.9–3.0	3.1+
Fe Iron, ppm	0–3.0	3.1–6.0	6.1–15.0	15.1+
Mn Manganese, ppm	0–3.0	3.1–6.0	6.1–15.0	15.1+
Cu Copper, ppm	0–0.5	0.6–1.2	1.3–3.0	3.1+
B Boron, ppm	0–0.6	0.7–1.1	1.2–3.0	3.1+

*These soil test levels help interpret soil tests but are not designed for making recommendations. These nutrient levels are approximate and will vary according to the crop and yield goal. Nutrient levels and resultant recommendations will also vary according to the balance between nutrients such as P/Zn, P/Fe, K/Mg, Zn/Fe and others.

SOIL TEXTURE (Approx.)	**CEC (meq/100g)**
Clay	36+
Clay Loam	22–36
Silt Loam	16–24
Sandy Loam	10–18
Loamy Sand	5–12
Sand	0–6

2.5.2 Typical Idaho Soil Chemistry Values – Western Laboratories, Inc.

Soil Chemistry Data from Typical Agricultural Soils
Western Laboratories, P.O. Box 400, Parma ID 83660

	VERY LOW	LOW	MEDIUM	HIGH	VERY HIGH
Organic Matter[1], %	0.0 to 0.9	1.0 to 1.5	1.6 to 2.5	2.6 to 4.9	above 5.0
NO3-N[2], ppm	0-5	6-10	11-25	26-40	41+
Phosphorus[3], ppm	1-4	5-11	12-25	26-45	45+
Potassium-K[4], ppm	0-100	101-200	201-450	451-750	750+
Calcium, ppm	0-900	901-1500	1501-4000	4001-5000	5000+
Sodium, ppm	0-30	31-60	61-175	176-450	450+
Free Lime[5], %	0.0-0.25	0.25-0.5	0.6-2.9	3.0-8.0	8.1+

1) Walkley-Black Titration Method
2) Buffered Extraction Method
3) Sodium Bicarbonate Method
4) Ammonium Acetate Method
5) 1N HCL Method

Organic Matter Release of Nitrogen/Acre/Year

% OM x Factor = Pounds Nitrogen/Ac/Yr

Factors	
60	S.E. Washington-N.E. Oregon
55	Winnemucca, Nevada
50	E. Oregon-S.W. Idaho
40	Magic Valley, Idaho
35	E. Idaho-N. Utah
30	W. Wyoming

Element	Low to Deficient	Adequate	Excessive to Toxic
SO_4-S (sulfate water soluble)	less than 10ppm	10 to 30 ppm	—
Zn (zinc by DTPA-TEA)	less than 0.8 ppm	0.9 to 4.0 ppm	15+ ppm
Mn (manganese by DTPA-TEA)	less than 2.0 ppm	3 to 7 ppm	150+ ppm
Cu (copper by DTPA-TEA)	less than 0.3 ppm	0.7 to 4.0 ppm	20+ ppm
Fe (iron by DTPA-TEA)	less than 5.0 ppm	5 to 10 ppm	—
B (boron by hot water soluble)	less than 0.5 ppm	0.5 to 2.0 ppm	3 + ppm

% Na of the CEC Based on Different Sodium

Concentrations and Cation Exchange Capacities

CEC in meq/100g of Soil

Soil Sodium in ppm-Na	8	10	12	14	16	18	20	22
	% Sodium of the CEC							
100	5.4	4.3	3.6	3.1	2.7	2.4	2.2	2.0
200	10.9	8.7	7.3	6.2	5.4	4.8	4.4	4.0
300	16.3	13.0	10.8	9.3	8.1	7.2	6.5	5.9
400	21.8	17.4	14.5	12.4	10.9	9.7	8.7	7.9
500	27.1	21.7	18.1	15.5	13.6	12.1	10.9	9.9
600	32.6	26.1	21.8	18.6	16.3	14.5	13.1	11.9
700	38.0	30.4	25.3	21.7	19.0	16.9	15.2	13.8
800	43.5	34.8	29.0	24.9	21.8	19.3	17.4	15.8
900	48.9	39.1	32.6	28.0	24.5	21.7	19.6	17.8
1000	54.4	43.5	36.3	31.1	27.2	24.2	21.8	19.8
1500	81.5	65.2	54.3	46.6	40.8	36.2	32.6	29.6
2000	108.8	87.0	72.4	62.1	54.4	48.3	43.5	39.5
2500	135.9	108.7	90.6	77.6	67.9	60.4	54.4	49.4
3000	163.0	130.4	108.7	93.1	81.5	72.4	65.2	59.3
3500	190.3	152.2	126.8	108.7	95.1	84.6	76.1	69.2
4000	217.4	173.9	144.9	124.2	108.7	96.6	87.0	79.0

Crop Tolerance for Percent Na of the CEC

0 to 5%	5 to 10%	10 to 15%	15 + %
Beans	Wheat	Crested Wheat	Barley
Strawberries	Oats	Fescue	Salt Grass
Carrot Seed	Spearmint	Perennial Rye	
Radish Seed	Alfalfa	Sugar Beets	
Onions	Turnip Seed	Tall Wheat	
Lettuce Seed	Sweet Corn	Birdsfoot Trefoil	
Fruit Trees	Field Corn		
Potatoes	Pasture		
Hops	Cotton		
Orchard Grass			
Cabbage Seed			
Most Clovers			
Celery			
Tomatoes			
Peppermint			
Peas			

2.5.3 Hydraulic Data for Hydrogeological Settings in Idaho

Table 2-13. Hydrologic Data and References for the Basic I Calculations, Idaho Wellhead Protection Program (DEQ, 1997)

Hydrogeologic Setting	Transmissivity (T)	Aquifer Thickness (b)	Hydraulic Conductivity (K)	Hydraulic Gradient (I)	Effective Porosity (N_e)	Values Used for Basic I Calculations
East Snake River Plain Basalts	650,000 - 67,240,000 gpd/ft Ref: (12,21,25, 26) 400,000 gpd/ft (Avg) Ref: (18)	Several 100 to 1,000 ft Ref: (21) 500 - 4,000 ft Ref: (20)	3,740 -37,400 gpd/ft' Min = 74.8 gpd/ft^2 Max = 74,800 gpd/ft^2 Ref: (2, 23)	.001 - .006 Ref: (23) Gradient as low as .0003 exist. Ret: (26)	.11 - .19 Ref: (3, 17)	T = 400,000 gpd/ft b = 600 ft. I = 0.004 N_e 0.15
Columbia River Basalts	20,196 - 2,01 9,600 gpd/ft Ref: (1) 40,000 gpd/ft (Avg) Ref: (18)	20 - 800 ft. Ref: (1, 8)		.0002 Ref: (24)	.004 - .19 Ref: (4) 0.0002 Ref: (13)	T= 40,000 gpd/ft b = 400 ft I = 0.0002 N_e=0.1
Rathdrum Prairie	2,019,600 - 97,240,000 gpd/ft Ref: (10,16)	500 -1,000 ft Ref: (10, 6) 250 - 400 ft Ref: (27)	3,740 - 164,560 gpd/ft^2 Ref: (10, 16)	.0004 - .005 Ref: (10, 16) .0005 - .009 Ref: (27)	.25 - .30 Ref: (10)	See Rathdrum Prairies Aquifer delineation in Chapter 3.
Unconsolidated Alluvium	200,000 gpd/ft. (Avg) Ref: (18)	100 ft. estimated	74.8 - 2,992 gpd/ft^2 Ref: (10, 16)	.003 - .02 Ref: (5, 6, 7)	.20 - .35 Ref: (11)	T= 200,000 gpd/ft b= 100 ft. 1= 0.01 N_e = 0.3
Mixed Volcanic and Sedimentary Rocks - Primarily Sedimentary Rocks (Example: Boise/ Nampa area)	6,732 - 160,820 gpd/ft Ref: (29) 30,000 gpd/ft (Avg) Ref: (18)	500 - 4,000 ft Ref: (29) 500 - 1,000 ft Ref: (33)	74.8 -748 gpd/ft^2 upper 500 ft Ref: (29)	.002 - .004 Ref: (22)	.10 - .30 Ref: (11)	T = 30,000 gpd/ft b = 800 ft I = 0.003 N_e = 0.2
Mixed Volcanic and Sedimentary Rocks - Primarily Volcanic Rocks (Example: Mtn Home)	374,000 gpd/ft Ref: (35)	500 -600 ft Ref: (30)		.012 - .015 Ref: (22)	.11 - .19 Ref: (11)	T = 400,000 gpd/ft b = 600 ft I = 0.01 N_e = 0.2

2.5.4 Well Test Data/ Transmissivity Values for Wells in Idaho

Table 2-14. Idaho Department of Water Resources Energy Data (DEQ, 1997)

Aquifer	City	Pumpid	Testdat	SWL	PWL	PWL-SWL	Flow	SC	Est R(')	Est R(")	T(art.)
Alluv	Challis	West Well #2	19880802	317.0	487.5	170.5	522	3.1	0.83	10	4690
Alluv	Rockland	25-hp Vertical Turbin	19890906	111.0	177.0	66.0	245	3.7	0.67	8	5970
Alluv	New Meadows	Submersible	19890901	19.0	78.0	59.0	253	4.3	0.67	8	6980
Alluv	Rockland	25-hp Submersible	19890906	111.0	177.0	66.0	322	4.9	0.67	8	8020
Alluv	Arimo	#1	19890717	30.0	56.0	26.0	346	13.3	0.67	8	23500
Alluv	Ketchum	Well #2	19880929	18.0	39.3	21.3	347	16.3	0.67	8	29100
Alluv	Bancroft	City Pump	19890719	95.0	104.0	9.0	188	20.9	0.67	8	38000
Alluv	Mackay	30-hp Submersible	19890913	11.0	27.0	16.0	420	26.2	0.83	10	47100
Alluv	Mackay	Well Pump #2	19910819	11.7	22.7	11.0	290	26.4	0.67	8	48700
Alluv	Tetonia	Park Well	19891107	101.0	110.0	9.0	395	43.9	0.83	10	81600
Alluv	Riggins	Well #2-new Pump	19900612	50.0	57.0	7.0	388	55.4	0.83	10	104000
Alluv	Grace	Well Pump	19890719	161.0	172.0	11.0	660	60.0	1.00	12	111000
Alluv	Bancroft	Railroad Pump	19890719	106.0	108.0	2.0	115	57.4	0.50	6	115000
Alluv	Ketchum	Well #1	19880929	59.3	75.6	16.3	1054	64.7	1.10	13.25	118000
Alluv	Malad	Five Points Well	19890718	78.0	82.0	4.0	263	65.7	0.67	8	129000
Alluv	Dayton	Park Well	19890718	52.0	56.0	4.0	333	83.3	0.83	10	161000
Alluv	Arco	Park Pump	19891016	125.0	135.0	10.0	906	90.6	0.00	12	172000
Alluv	Sun Valley	Pump #8	19880927	19.0	29.9	10.9	1139	104.5	1.10	13.25	198000
Alluv	Pocatello	Well #32	19880608	59.2	71.5	12.3	1604	130.4	1.10	13.25	251000
Alluv	Pocatello	Well #29	19880607	70.8	87.9	17.1	2493	145.8	1.27	15.25	277000
Alluv	Pocatello	Well #2	19880607	34.9	43.5	8.6	1265	147.0	1.10	13.25	285000
Alluv	Sun Valley	Pump #5	19880927	12.5	16.0	3.5	787	224.9	1.00	12	452000
Alluv	Pocatello	Well #27	19880607	63.3	69.2	5.9	1623	275.2	1.10	13.25	554000
Alluv	Sun Valley	Pump #7	19880927	20.0	23.5	3.5	1039	296.9	1.10	13.25	601000
Alluv	Pocatello	Well #18	19880608	66.2	72.6	6.4	2020	315.5	1.27	15.25	630000
Alluv	Pocatello	Pip Well	19880608	69.6	72.6	3.0	1188	395.8	1.10	13.25	815000
Alluv	Malad	Spring Creek Well/5	19890718	84.0	85.0	1.0	413	413.2	0.83	10	881000
Alluv	Pocatello	Well #16	19880607	46.7	49.5	2.8	2267	809.8	1.27	15.25	1710000
Alluv	Pocatello	Well #28	19880607	34.6	35.9	1.3	1755	1349.8	1.27	15.25	2930000
Alluv	Pocatello	Well #31	19880608	62.2	64.1	1.9	2937	1546.0	1.27	15.25	3380000
Alluv	Pocatello	Well #12	19880607	43.3	44.7	1.4	2812	2008.2	1.27	15.25	4460000
Alluv	Pocatello	Well #10	19880607	52.4	53.9	1.5	3419	2279.5	1.60	19.25	4970000
Alluv	Pocatello	Well #21	19880607	79.6	80.1	0.5	1581	3161.8	1.10	13.25	7300000
Alluv	Pocatello	Cree Well	19880606	35.4	35.5	0.1	388	3877.0	0.83	10	9320000
Alluv	Pocatello	Well #22	19880607	87.5	87.6	0.1	871	8714.0	1.10	13.25	2E+07
CR Basalt	Kooskia	Well #3	19881004	101.0	350.0	249.0	246	1.0	0.67	8	1420
CR Basalt	Council	Pump #1	19870619	277.2	374.2	97.0	337	3.5	0.83	10	5380
CR Basalt	Moscow	Cemetary Well	19880822	170.4	228.2	57.8	467	8.1	0.83	10	13300
CR Basalt	Moscow	Cemetary Well	19880822	170.4	228.2	57.8	708	12.3	1.00	12	20300
CR Basalt	Council	Pump #2	19870619	50.0	79.2	29.2	356	12.2	0.83	10	20700
CR Basalt	Kooskia	Well #1	19881004	43.5	64.0	20.5	248	12.1	0.67	8	21200
CR Basalt	Kooskia	Well #2	19881004	45.5	66.0	20.5	255	12.4	0.67	8	21800
CR Basalt	Univ of Idaho	Well #4	19880824	195.0	295.4	100.4	1901	18.9	1.27	15.25	31300
CR Basalt	Moscow	Well #8	19880822	370.2	404.9	34.7	980	28.2	1.10	13.25	49000
CR Basalt	Moscow	Well #6	19880823	344.9	376.1	31.2	1339	42.9	1.10	13.25	76700
CR Basalt	Moscow	Well #2	19880822	138.7	153.8	15.1	864	57.2	1.10	13.25	104000
CR Basalt	Univ of Idaho	Well #3	19880824	297.0	301.0	4.0	1812	453.1	1.27	15.25	924000
CR Basalt	Lewiston	Well #5	19880713	150.6	152.0	1.4	1160	842.6	1.10	13.25	1810000
E. Snake	Hollister	Well Pump	19890816	158.0	189.0	31.0	197	6.4	0.50	6	11100
E. Snake	Roberts	Well #2	19880626	23.9	47.1	23.2	407	17.6	0.83	10	30600
E. Snake	Filer	Pump #5	19870603	42.4	60.4	18.0	345	19.2	0.83	10	33700
E. Snake	Teton	Well #2	19891019	91.5	100.0	8.5	252	29.6	0.67	8	55300

Header Explanation for Table F- 1

Aquifer = Aquifer Name
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- MVS-Sed = Mixed Volcanic and Sedimentary Rocks, Primarily Sedimentary Rocks
- Rathdrum = Rathdrum Prairie Aquifer

City = City location of the well
Pumpid = Well identification
SWL = Static water level, in feet
PWL = Pumping water level, in feet
PWL-SWL = Difference between PWL and SWL, in feet
Flow = Calculated flow rate, in gallons per minute (gpm)
SC = Specific capacity, in gallons per minute per foot of drawdown
Est R('); Est R(") = Estimated radius of the well in feet; inches

Aquifer	City	Pumpid	Testdat	SWL	PWL	PWL-SWL	Flow	SC	Est R(')	Est R(")	T(art.)
E. Snake	Roberts	Well #3	19880626	64.4	87.6	23.2	727	31.3	1.00	12	55500
E. Snake	Shelley	Pump #4	19880525	103.0	144.6	41.6	1422	34.2	1.10	13.25	60200
E. Snake	Shelley	Pump #1	19880525	107.7	125.0	17.3	576	33.3	0.83	10	60800
E. Snake	Burley	#1	19890804	205.0	228.0	23.0	821	35.7	1.00	12	63800
E. Snake	Ashton	#1	19890912	28.0	44.0	16.0	900	56.3	1.00	12	103000
E. Snake	Aberdeen	Well #2	19870604	25.0	33.0	8.0	634	79.2	0.83	10	153000
E. Snake	Ammon	Well #6	19880524	86.0	102.2	16.2	1340	82.7	1.10	13.25	154000
E. Snake	Idaho Falls	Well #15 Main	19870626	106.0	124.0	18.0	2093	116.3	1.27	15.25	218000
E. Snake	Ririe	Pump #2	19871029	34.0	35.0	1.0	106	106.3	0.50	6	221000
E. Snake	Iona	Tank Pump	19870625	207.0	216.5	9.5	1312	138.1	1.27	15.25	261000
E. Snake	Rigby	Shop Well	19891018	15.0	22.0	7.0	1047	149.5	1.10	13.25	290000
E. Snake	Ammon	Well #7	19880524	65.0	74.4	9.4	1410	150.0	1.10	13.25	291000
E. Snake	Burley	#4	19890804	222.0	230.0	8.0	1227	153.3	1.17	14	295000
E. Snake	Rupert	Well #1	19890801	185.0	190.0	5.0	833	166.7	1.10	13.25	325000
E. Snake	Idaho Falls	Well #11 1435 RPM	19870624	195.0	208.0	13.0	3587	276.0	1.94	23.25	518000
E. Snake	Ririe	Pump #3	19871029	40.0	41.0	1.0	251	251.0	0.67	8	533000
E. Snake	Idaho Falls	Well #4 Main	19870623	155.0	172.0	17.0	4942	290.7	1.94	23.25	547000
E. Snake	Rigby	Well Pump #2	19891018	15.0	22.0	7.0	2441	348.8	1.27	15.25	700000
E. Snake	Idaho Falls	Well #11 1610 RPM	19870624	195.0	208.0	13.0	4861	373.9	1.10	13.25	767000
E. Snake	Dubois	Well #1	19891020	355.0	356.0	1.0	404	403.6	0.83	10	860000
E. Snake	Rigby	Harwood #3	19891018	15.0	16.0	1.0	420	419.9	0.83	10	896000
E. Snake	Dubois	Well #3	19891020	355.0	356.0	1.0	613	613.1	0.83	10	1330000
E. Snake	Shelley	Pump #3	19880525	92.6	95.7	3.1	1995	643.4	1.27	15.25	1340000
E. Snake	Shoshone	Pump #3	19871029	210.8	212.1	1.3	824	633.9	1.00	12	1350000
E. Snake	Rexburg	Well #5	19891017	324.0	327.0	3.0	2060	686.7	1.27	15.25	1430000
E. Snake	Rupert	Well #2'	19890801	185.0	187.0	2.0	1681	840.3	1.10	13.25	1800000
E. Snake	Rexburg	Well #1	19891017	208.0	210.0	2.0	2188	1093.8	1.27	15.25	2350000
E. Snake	Rexburg	Well #6	19891017	208.0	210.0	2.0	2246	1122.8	1.27	15.25	2410000
E. Snake	Jerome	Well Pump #2	19890816	284.8	285.8	1.0	1396	1396.4	1.27	15.25	3040000
E. Snake	Idaho Falls	Well #2 Main	19870622	167.0	169.0	2.0	2803	1401.3	1.27	15.25	3050000
E. Snake	Jerome	Well Pump #1	19890816	284.8	285.8	1.0	1493	1492.9	1.10	13.25	3310000
E. Snake	Idaho Falls	Well #3	19870626	165.0	166.0	1.0	4719	4718.6	1.94	23.25	1E+07
MVS-VS	Kuna	Process Pump	19880815	240.0	310.5	70.5	223	3.2	0.67	8	5030
MVS-VS	Kuna	Well #2	19880815	93.7	112.3	18.6	580	31.2	1.00	12	55300
MVS-VS	Kuna	Well #3	19880815	84.6	115.9	31.3	1801	57.5	1.27	15.25	102000
MVS-VS	Grandview	Pump #2	19880830	82.7	85.4	2.7	226	83.5	0.67	8	166000
MVS-VS	Grandview	Pump #1	19880830	79.7	82.1	2.4	246	102.5	0.67	8	206000
MVS-SED	Homedale	Well #2	19880602	44.2	222	178.1	198	1.1	0.5	6	1700
MVS-SED	Homedale	Old City Hall Well	19880602	41.8	216.0	174.2	206	1.2	0.67	8	1730
MVS-SED	Eagle	#2 Submersible	19910520	50.9	133.8	82.9	266	3.2	0.67	8	5100
MVS-SED	Nampa	Well #10	19880518	17.0	191.0	174.0	605	3.5	0.83	10	5380
MVS-SED	Caldwell	Well #9 1670 RPM	19880816	50.5	233.2	182.7	779	4.3	1.00	12	6510
MVS-SED	Caldwell	Well #13	19880816	10.7	149.5	138.8	772	5.6	1.00	12	8680
MVS-SED	Caldwell	Well #10	19880816	11.6	145.0	133.4	751	5.6	1.00	12	8790
MVS-SED	Homedale	Park Well	19880602	4.6	42.5	37.9	207	5.5	0.67	8	9050
MVS-SED	Nampa	Well #8	19880517	56.1	171.2	115.1	862	7.5	1.10	13.25	11700
MVS-SED	Caldwell	Well #7 1870 RPM	19880816	6.0	110.0	104.0	889	8.5	1.00	12	13700
MVS-SED	Parma	Well #7	19880826	24.5	138.4	113.9	1033	9.1	1.10	13.25	14400
MVS-SED	Caldwell	Well #11	19880816	10.6	112.2	101.6	986	9.7	1.00	12	15800
MVS-SED	Wilder	Pump #2	19880823	98.0	132.0	34.0	337	9.9	0.83	10	16600
MVS-SED	Caldwell	Well #6	19880816	9.5	90.0	80.5	864	10.7	1.00	12	17600

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SC = Specific capacity, in gallons per minute per foot of drawdown
Est R('); Est R(") = Estimated radius of the well in feet; inches
T(art.) = Transmissivity, in gallons per day per foot (gpd/ft)
(Uses confined aquifer storage coefficient)

Idaho Wellhead Protection Plan

Aquifer	City	Pumpid	Testdat	SWL	PWL	PWL-SWL	Flow	SC	Est R(')	Est R(")	T(art.)
MVS-SED	Caldwell	Well #14	19880817	34.9	85.8	50.9	679	13.3	0.83	10	22800
MVS-SED	Garden City	#1	19890726	132.5	160.0	27.5	368	13.4	0.83	10	22900
MVS-SED	Caldwell	Well #8 1200 RPM	19880817	9.4	39.4	30.0	566	18.9	1.00	12	32200
MVS-SED	Notus	#2	19890524	30.0	55.0	25.0	490	19.6	0.83	10	34500
MVS-SED	Nampa	Colorado	19880619	9.5	45.0	35.5	774	21.8	1.00	12	37700
MVS-SED	Nampa	Well #7	19880518	11.3	41.8	30.5	823	27.0	1.10	13.25	467o0
MVS-SED	Nampa	Well #9 1280 RPM	19880518	1.0	18.5	17.5	458	26.2	0.83	10	47000
MVS-SED	Eagle	#1 Submersible	19910520	40.0	59.0	19.0	539	28.4	0.83	10	51200
MVS-SED	Garden City	#5 (Variable Speed)	19890726	22.0	36.0	14.0	490	35.0	0.83	10	64100
MVS-SED	Middleton	Pump #4	19890808	86.0	135.0	49.0	1903	38.8	1.27	15.25	87600
MVS-SED	Nampa	Well #6	19880517	32.0	49.0	17.0	830	48.8	1.10	13.25	88100
MVS-SED	Caldwell	Well #4	19880817	74.0	80.3	6.3	295	46.9	0.67	8	89900
MVS-SED	Garden City	#43	19890727	15.0	35.0	20.0	1219	60.9	1.10	13.25	111000
MVS-SED	Nampa	Holly	19880619	17.3	27.5	10.2	695	68.1	1.00	12	127000
MVS-SED	Eagle	#3 Submersible	19910520	65.5	69.2	3.7	259	69.9	0.67	8	137000
MVS-SED	Nampa	19th Ave. N.	19880619	3.1	10.0	6.9	591	85.6	1.00	12	162000
MVS-SED	Nampa	Venice	19880519	16.8	22.0	5.2	462	88.8	0.83	10	172000
MVS-SED	Nampa	Juniper Square	19880619	23.0	24.0	1.0	137	137.1	0.50	6	290000
Rathdrum	Coeur d'Alene	Atlas Road Well	19870804	241.0	245.0	4.0	1155	288.7	1.10	13.25	58300
Rathdrum	Coeur d'Alene	Fourth St. Well	19870804	194.5	212.0	17.5	3238	185.0	1.60	19.25	347000
Rathdrum	Coeur d'Alene	Linden St. Well	19870804	169.0	178.0	9.0	2604	289.3	1.27	15.25	574000
Rathdrum	Coeur d'Alene	Atlas Road Well		241.0	245.0	4.0	1155	288.8	1.10	13.25	583000
Rathdrum	Coeur d'Alene	Locust St. Well	19870804	174.0	175.8	1.8	1655	919.7	1.10	13.25	1980000

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(Uses confined aquifer storage coefficient)

Idaho Wellhead Protection Plan

2.5.5 Hydraulic Conductivities by Rock Type

Table 2-15. Hydraulic Conductivity Values—Eastern Snake River Plain (feet/second (Garabedian, 1989).

Hydraulic Conductivity Values - Eastern Snake River Plain (From Table 19, Garabedian 1989)					
	Basalt	Sand and gravel	Sand	Clay and Silt	Silicic Volcanics (rhyolite)
Zone No.	($x 10^{-4}$)	($x 10^{-4}$)	($x 10^{-4}$)	($x 10^{-6}$)	($x 10^{-6}$)
feet/second					
1	0.052	11	0.11	2.3	7.5
2	5.5	90	0.90	0.75	7.5
3	550	73	0.73	2.3	7.5
4	0.9	17	0.17	0.75	7.5
5	803	110	1.1	2.3	7.5
6	2.4	47	0.63	2.3	7.5
7	2.1	41	0.41	2.3	7.5
8	56	140	1.4	0.38	7.5
9	0.75	7.5	0.075	0.75	7.5
10	5.7	110	1.1	0.75	7.5
11	3.8	3.8	3.8	0.38	7.5
12	23	75	0.75	2.3	7.5
13	580	2,000	0.1	0.38	7.5
14	1,100	1,900	1.9	2.3	7.5
15	11	71	0.71	0.38	7.5
16	230	38	0.38	2.3	7.5
17	61	330	0.66	2.3	7.5
18	6	11	1.1	2.3	7.5
19	670	1,700	1.7	2.3	7.5
20	150	71	0.71	2.3	7.5
21	590	83	0.83	2.3	7.5
22	50	29	0.29	0.38	7.5
23	120	83	0.83	2.3	7.5
24	440	83	0.83	2.3	7.5
25	2.9	59	0.59	2.3	7.5
26	200	48	0.48	2.3	7.5
27	68	47	0.62	2.3	7.5
28	3	58	0.58	2.3	7.5
29	1.5	31	0.31	0.75	7.5
30	3.9	11	0.11	0.38	7.5
31	1.6	26	0.26	0.75	7.5
32	380	38	0.38	2.3	7.5
33	420	210	2.1	2.3	7.5
34	250	300	0.30	2.3	7.5
35	66	140	66	0.38	7.5
36	600	1,500	600	7.5	7.5
37	15	15	0.23	2.3	7.5
38	150	83	0.83	3.8	7.5
39	120	18	0.18	2.3	7.5

Table 2-16. Hydraulic Conductivity Values—Eastern Snake River Plain (feet/day) (from Garabedian, 1989).

Hydraulic Conductivity Values - Eastern Snake River Plain (From Table 19, Garabedian 1989)					
Zone No.	Basalt	Sand and gravel	Sand	Clay and Silt	Silicic Volcanics (rhyolite)
		feet/day			
1	0.45	95.0	0.95	0.20	0.65
2	47.5	778	7.78	0.06	0.65
3	4752	631	6.31	0.20	0.65
4	7.78	147	1.47	0.06	0.65
5	6938	950	9.50	0.20	0.65
6	20.7	406	5.44	0.20	0.65
7	18.1	354	3.54	0.20	0.65
8	484	1210	12.1	0.03	0.65
9	6.48	64.8	0.65	0.06	0.65
10	49.2	950	9.50	0.06	0.65
11	32.8	32.8	32.8	0.03	0.65
12	199	648	6.48	0.20	0.65
13	5011	17280	0.86	0.03	0.65
14	9504	16416	16.4	0.20	0.65
15	95.0	613	6.13	0.03	0.65
16	1987	328	3.28	0.20	0.65
17	527	2851	5.70	0.20	0.65
18	51.8	95.0	9.50	0.20	0.65
19	5789	14688	14.7	0.20	0.65
20	1296	613	6.13	0.20	0.65
21	5098	717	7.17	0.20	0.65
22	432	251	2.51	0.03	0.65
23	1037	717	7.17	0.20	0.65
24	3802	717	7.17	0.20	0.65
25	25.1	510	5.10	0.20	0.65
26	1728	415	4.15	0.20	0.65
27	588	406	5.36	0.20	0.65
28	25.9	501	5.01	0.20	0.65
29	13.0	268	2.68	0.06	0.65
30	33.7	95.0	0.95	0.03	0.65
31	13.82	225	2.25	0.06	0.65
32	3283	328	3.28	0.20	0.65
33	3629	1814	18.1	0.20	0.65
34	2160	2592	2.59	0.20	0.65
35	570	1210	570	0.03	0.65
36	5184	12960	5184	0.65	0.65
37	130	130	1.99	0.20	0.65
38	1296	717	7.17	0.33	0.65
39	1037	156	1.56	0.20	0.65
40	1728	2246	2.25	0.20	0.65

2.5.6 Hydraulic Conductivity Zones; East Snake River Plain

IV-93-1

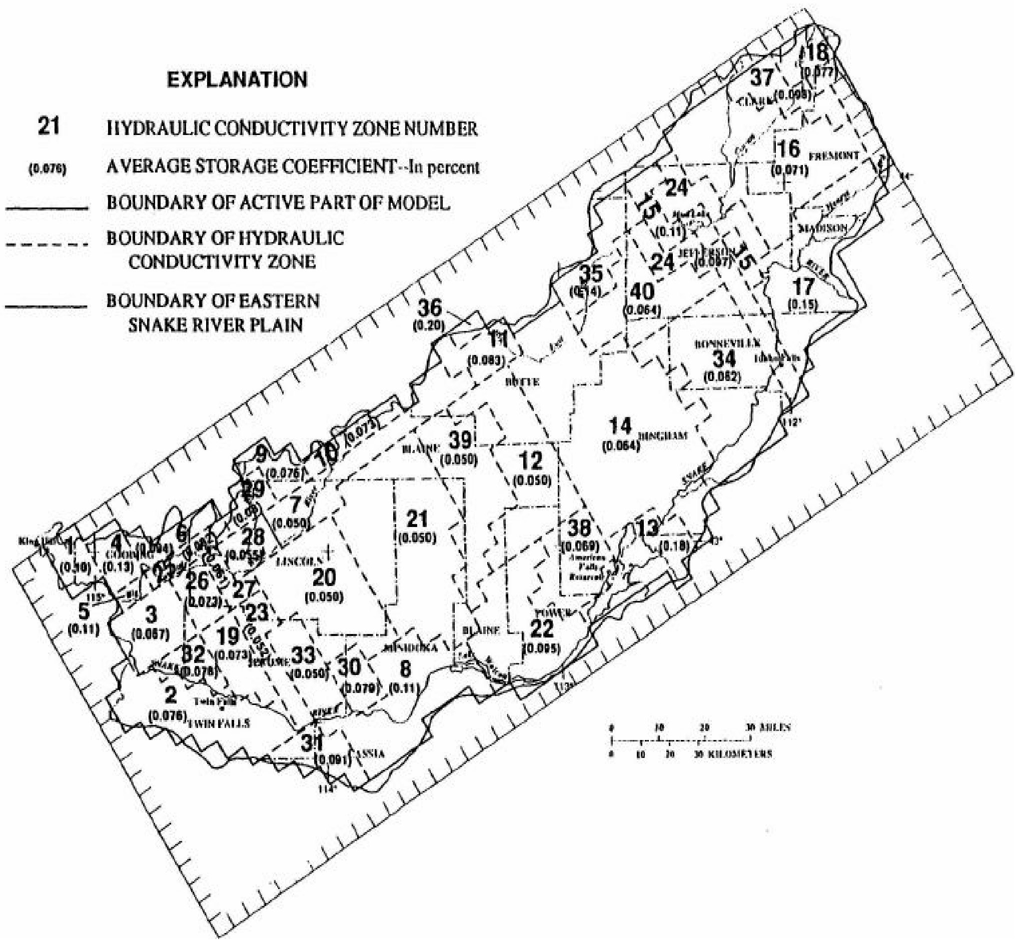

Figure 2-11. Hydraulic Conductivity zones and average storage coefficients, model level 1 (Garabedian, 1989)

2.5.7 Hydraulic Conductivity and Permeability

Table 2.2 Range of Values of Hydraulic Conductivity and Permeability

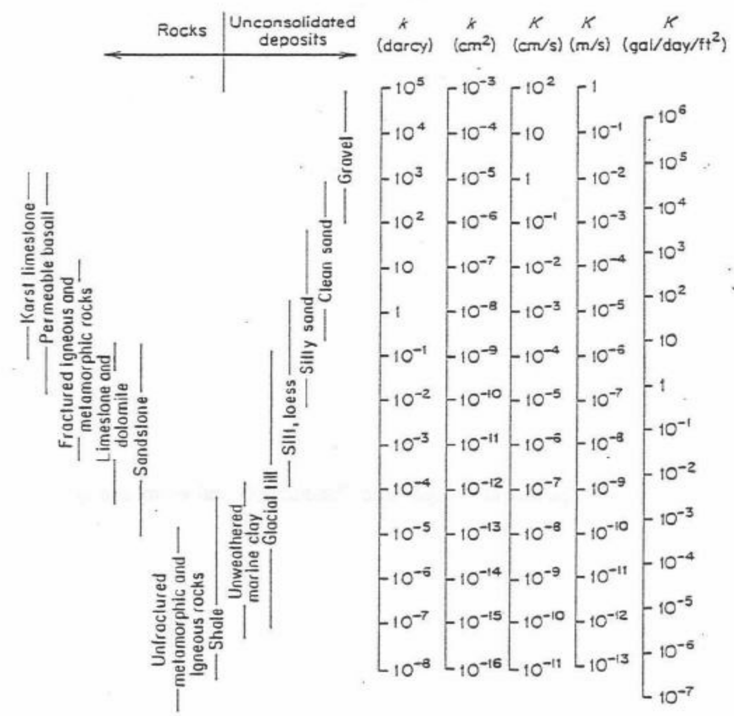

Table 2.3 Conversion Factors for Permeability and Hydraulic Conductivity Units

	Permeability, k*			Hydraulic conductivity, K		
	cm²	ft²	darcy	m/s	ft/s	gal/day/ft²
cm²	1	1.08×10^{-3}	1.01×10^{8}	9.80×10^{2}	3.22×10^{3}	1.85×10^{9}
ft²	9.29×10^{2}	1	9.42×10^{10}	9.11×10^{5}	2.99×10^{6}	1.71×10^{12}
darcy	9.87×10^{-9}	1.06×10^{-11}	1	9.66×10^{-6}	3.17×10^{-5}	1.82×10^{1}
m/s	1.02×10^{-3}	1.10×10^{-6}	1.04×10^{5}	1	3.28	2.12×10^{6}
ft/s	3.11×10^{-4}	3.35×10^{-7}	3.15×10^{4}	3.05×10^{-1}	1	5.74×10^{5}
gal/day/ft²	5.42×10^{-10}	5.83×10^{-13}	5.49×10^{-2}	4.72×10^{-7}	1.74×10^{-6}	1

*To obtain k in ft², multiply k in cm² by 1.08×10^{-3}.

Freeze and Cherry, 1979, Groundwater - Chapter 2, page 29, Tables 2.2 and 2.3

IV-94-1

Figure 2-12. Hydraulic Conductivity and Permeability (Freeze and Cherry, 1979)

2.5.8 Hydraulic Conductivity Values, Treasure Valley Idaho (DEQ, 2005)

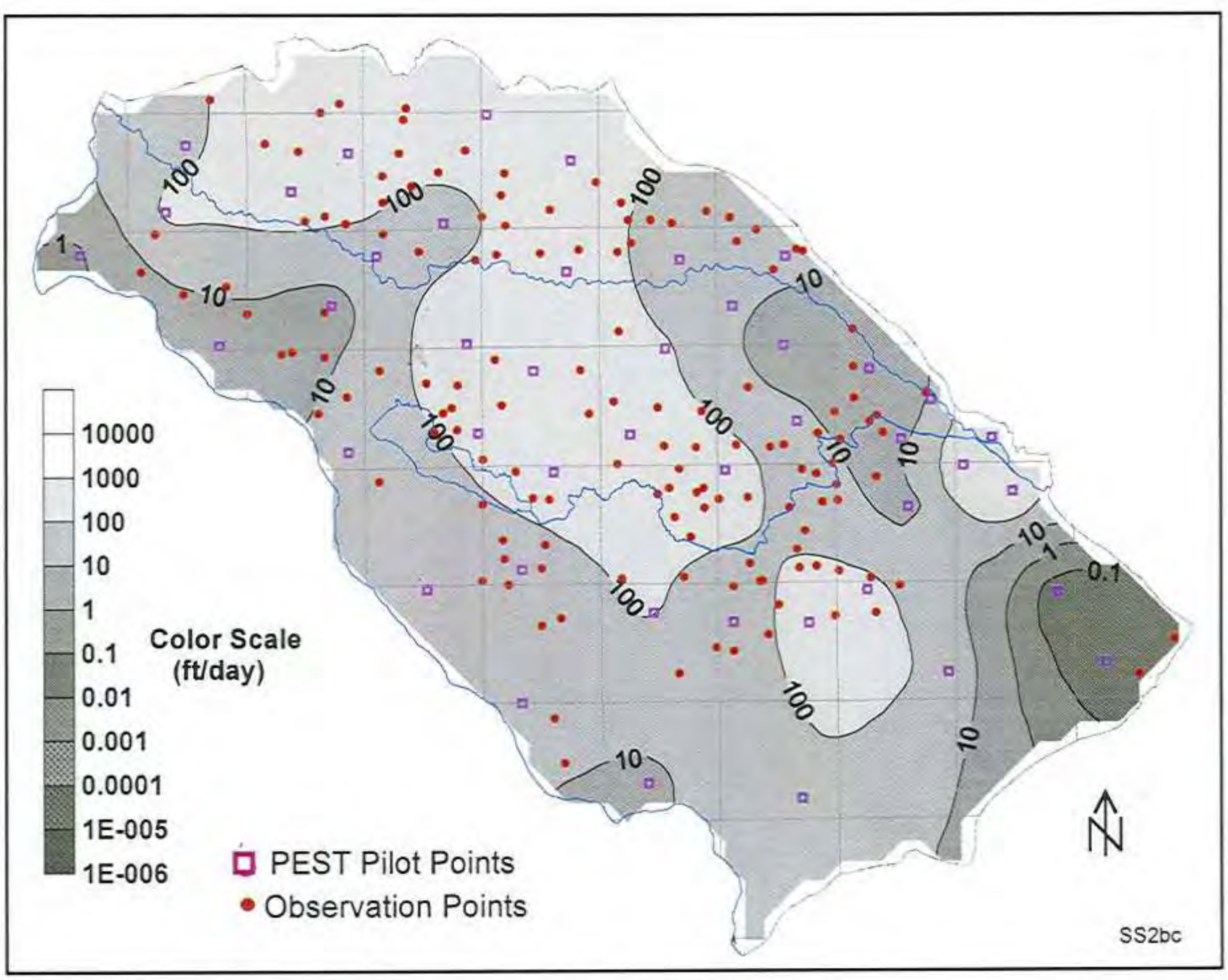

Figure 2-13. Layer 1 Horizontal Hydraulic Conductivity Value Distributions from Treasure Valley Hydrologic Model (IWRRI, 2004b).

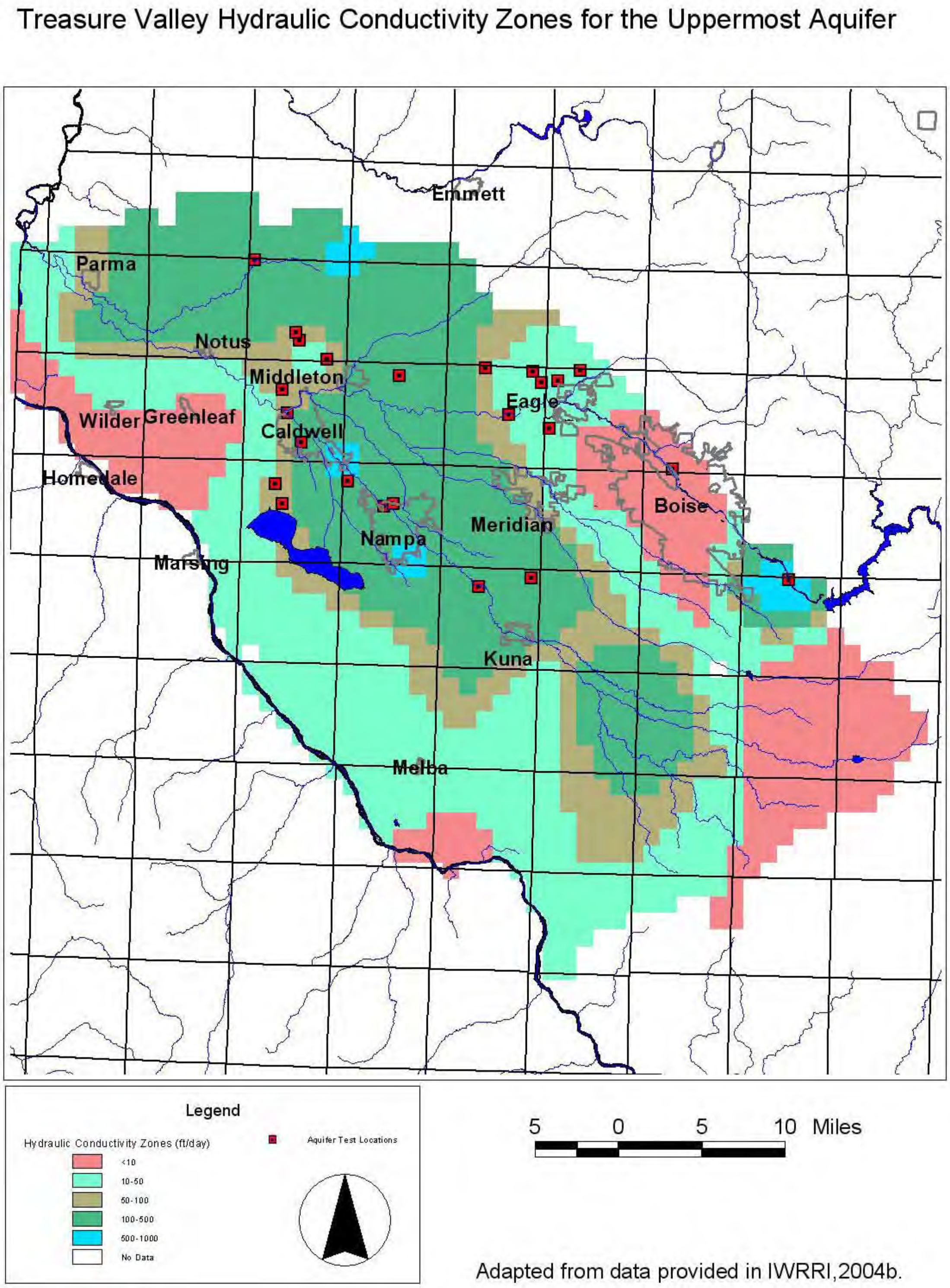

Figure 2-14. Hydraulic Conductivity Zones Adapted from Treasure Valley Hydrologic Model Steady State Layer 1 Horizontal Hydraulic Conductivity Values (feet/day).

2.5.9 Ranges in Porosity Values for Geological Materials

Table 2-17. Ranges of Porosity Values for Geological Materials

	Domenico and Schwartz, 1998		**Freeze and Cherry, 1979**		**Driscoll, 1987**
Material	Porosity (%)	Material	Porosity (%)	Material	Porosity (%)
Sedimentary					
Gravel, coarse	24 – 36	Gravel	25 – 40	Gravel	25 - 40
Gravel, fine	25 – 38			Sand and Gravel mixes	10 – 35
Sand, coarse	31 – 46			Glacial till	10 – 25
Sand, fine	26 – 53	Sand	25 – 50	Sand	25 – 40
Silt	34 – 61	Silt	35 – 50	Silt	35 – 55
Clay	34 – 60	Clay	40 – 70	Clay	45 – 55
Sedimentary Rocks					
Sandstone	5 – 30	Sandstone	5 – 30	Sandstone	5 - 30
Siltstone	21 – 41				
Limestone, dolomite	0 – 20	Limestone, dolomite	0 – 20	Limestone/dolomite (original and secondary porosity)	1 – 20
Karst limestone	5 – 50	Karst Limestone	5 – 50		
Shale	0 – 10	Shale	0 – 10	Shale	0 – 10
Crystalline Rocks					
Fractured crystalline rocks	0 – 10	Fractured crystalline rocks	0 – 10	Fractured crystalline rock	0 - 10
Dense crystalline rocks	0 – 5	Dense crystalline rocks	0 – 5	Dense, solid rock	<1
Basalt	3 – 35	Fractured Basalt	5 – 50	Vesicular Basalt	10 – 50
Weathered granite	34 – 57				
Weathered gabbro	42 – 45				

3. Wastewater Constituents

Wastewater chemistry and physical characteristics are important factors in the design, operation and management of wastewater land application systems. The following sections discuss sources and types of wastewater, and their physical, chemical, and biological properties.

3.1 Sources of Wastewater

Wastewater is normally classified as coming from domestic sources or industrial sources:

- The most common source of wastewater is domestic wastewater. Sanitary (domestic) wastewater comes primarily from residences, non-industrial businesses, and institutional sources. Some examples of sanitary wastewater are restroom, laundry, and kitchen waste. Sanitary wastewater tends to be fairly uniform in composition, and is composed of approximately 99.94% water and 0.06% waste constituents.
- Industrial wastewater is discharged from industrial facilities and some heavy commercial operations. Industrial wastewater characteristics change with changing production rates and schedules, and it is much more variable than sanitary wastewater, possibly containing toxic substances, such as metals. Possible concerns with the land application of high strength industrial wastewater include odor and overloading of the site with constituents (waste elements) in the wastewater stream. These systems typically require additional pretreatment and/or special site management practices to provide good performance. Regulatory definitions of municipal reclaimed wastewater classes can be found in the *Rules for the Reclamation and Reuse of Municipal and Industrial Wastewater* (IDAPA 58.01.17)

3.2 Types of Wastewater

Wastewater contains two primary types of waste: organic and inorganic.

- Organic wastes originate from plant or animal sources and can generally be consumed by bacteria and other organisms. All organic wastes contain carbon.
- Inorganic wastes come from mineral materials, such as sand, salt, iron and calcium, and these wastes are only slightly affected by biological activity.

The source of wastewater influences the amount of organic and inorganic waste in a particular waste stream. For example, wastewater from a meat processing plant will contain high levels of organic waste, while wastewater from a gravel washing operation will contain high levels of inorganic waste.

Two other types of waste are thermal and radioactive wastes. Thermal power stations and industrial cooling processes may produce wastewater with temperatures exceeding the requirements of the enforcing agency. Hospitals, research labs, and nuclear power plants generate radioactive wastes that are usually controlled at their source.

3.3 Wastewater Physical Characteristics

Physical characteristics of wastewater include color, odor, temperature, and the levels of solids present. Changes in these physical characteristics can indicate unusual influent (wastewater entering a treatment system) or operating conditions.

3.3.1 Color

Raw wastewater (prior to any pretreatment and land application) is usually gray in color. Pretreated wastewater will have a color that is indicative of the pretreatment system: wastewater treated in a septic tank will have a gray/black color, but wastewater that has been treated in an aerobic process will have little color. The color of wastewater can also be affected by industrial contributions to the treatment system: color contributed by industry typically is not removed by the pretreatment system.

3.3.2 Odor

Raw wastewater usually produces a musty odor, generally caused by the anaerobic decomposition of organic material. Hydrogen sulfide is frequently the source of a rotten-egg odor in wastewater. Other volatile sulfur-containing compounds, such as mercaptans, can also cause noxious odors. These odors are released into the air when wastewater is aerated and sometimes when the wastewater is discharged to a land application site.

Unusual odors, such as petroleum or solvent odors, may indicate abnormal industrial discharges.

3.3.3 Temperature

Wastewater is generally somewhat warmer than tap water. A significant increase in wastewater temperature over a short period of time may indicate an unusual industrial discharge, while a significant decrease may indicate an influx of storm water into the treatment system.

Temperature is an important factor in microbial activity. Up to a point, an increase in wastewater temperature will increase microbial activity. However, when wastewater reaches high temperatures, microbial activity will be inhibited.

During land application of wastewater, high wastewater temperatures can also adversely impact cover crops.

3.3.4 Solids

One of the primary functions of a wastewater pretreatment system is the removal of solids from wastewater. If the level of solids is not significantly reduced by pretreatment, these materials can reduce the effectiveness of disinfection systems and clog land application equipment.

Determination of the forms and concentrations of solids present in wastewater can provide an operator with useful data for the control of treatment processes. Solids are divided into several different fractions: total solids, dissolved solids and suspended solids, as shown in Figure 3-1.

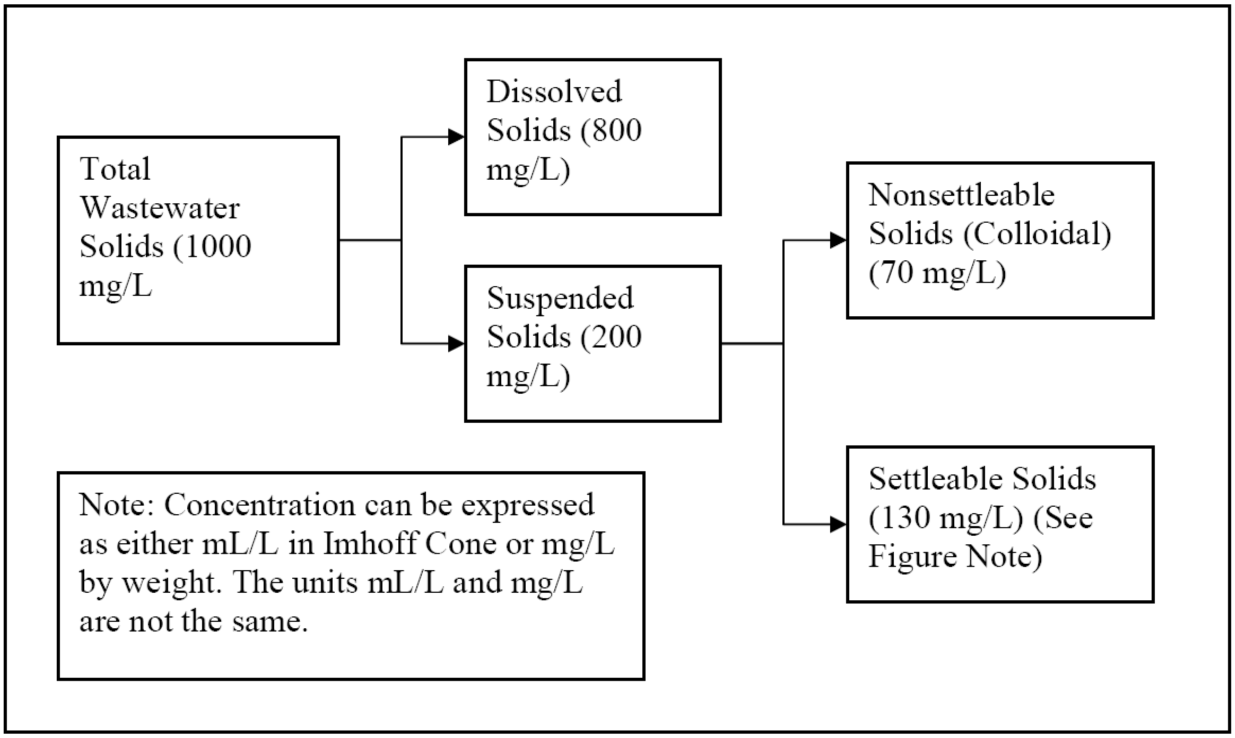

Figure 3-1. Typical composition of solids in raw wastewater (Adapted from EPA 2004).

3.3.4.1 Total Solids (Residue)

Total solids are the amount of material that remains after the wastewater is evaporated at a temperature of 103 °C to 105 °C. Total solids consist of both dissolved solids and suspended solids. Suspended solids consist of both settleable and nonsettleable solids. Total solids are determined by taking a volume of effluent and heating the sample until all of the water is evaporated. For example, a one-liter sample of influent is collected and is heated to evaporate all of the water. The remaining solids weigh 1,000 milligrams. This is total solids (residue), which concentration in the 1-liter sample is 1,000 milligrams per liter (mg/L).

3.3.4.2 Dissolved Solids

Dissolved solids, also called filterable residue, are those solids that will pass through a very fine (0.45-micrometer [µm]) membrane filter. To determine dissolved solids, a sample of raw wastewater (a one-liter sample to continue the example above) is collected and filtered through a very fine mesh filter, such as a fiberglass filter. The dissolved solids will pass through with the water. The sample is then evaporated and residual weighed to determine dissolved solids. In Figure 3-1, the amount of dissolved solids is 800 mg/L.

Removal of dissolved inorganic solids from wastewater is difficult to achieve in standard municipal wastewater treatment systems, so concerns with land applying wastewaters that have high concentrations of dissolved solids include: 1) the potential for increased levels of dissolved solids in ground water and 2) the potential for adversely affecting soil properties that are important to land application operations. See Section 3.4.5 for further discussion of TDS and salts.

3.3.4.3 Suspended Solids

Suspended solids, also called nonfilterable residue, are the portion of total solids retained by filtration. Suspended solids (SS) can be removed from a wastewater stream by physical, biological, and/or chemical processes. These solids are classified as either settleable or nonsettleable (colloidal), depending upon their size, shape, and density (weight per unit volume). Larger particles tend to settle more rapidly than smaller particles. In Figure 3-1, the suspended solids concentration is 200 mg/L.

The amount of settleable solids in the raw wastewater is an important factor for the design of settling basins, sludge pumps, and sludge handling facilities. Also, measuring the amount of settleable solids entering and leaving a treatment unit allows the operator to calculate the efficiency of the treatment unit for removing the settleable solids. When a device called an Imhoff cone is used to measure settleable solids, the results are expressed in milliliters per liter (ml/L). In Figure 3-1, the settleable solids concentration is 130 mg/L. The concentration of nonsettleable solids is 70 mg/L. The weight of nonsettleable solids can be calculated by using Equation 3-1.

$$\text{Weight of Nonsettleable Solids} = \text{Weight of Total Solids} - \text{Weight of Dissolved Solids} - \text{Weight of Settleable Solids}$$

Equation 3-1. Calculation for weight of nonsettleable solids.

3.3.4.4 Total Suspended Solids (TSS)

The total suspended solids content of wastewater may include organic or inorganic particulate matter, with most of the organic solids being volatile. Many of the concerns related to the chemical oxygen demand of the wastewater and related problems with loading rates apply to total suspended solids, as discussed further in Section 4.2.2.1.

3.4 Wastewater Chemical and Biological Characteristics

Important wastewater characteristics addressed in this section include pH, dissolved oxygen, biochemical oxygen demand, chemical oxygen demand, nitrogen, salts, metals, persistent organic chemicals, phosphorus, and pathogenic organisms. Hazardous materials are discussed in Section 4.2.2.8

3.4.1 pH

The measure of the concentration of the hydrogen ions (H^+) in a solution is called pH. Specifically, pH is the negative logarithm of the hydrogen ion concentration expressed in milliequivalents/liter. A pH of 7 is neutral, while a pH reading below 7 indicates acidic conditions and a pH reading above 7 indicates alkaline (basic) conditions. Acidity is the capacity of wastewater to neutralize bases. Wastewater does not have to be strongly acidic (low pH) to have a high acidity. Alkalinity is the capacity of wastewater to neutralize acids. Wastewater does not have to be strongly basic (high pH) to have a high alkalinity

The pH of domestic wastewater typically ranges from 6.5 to 7.5, depending on the pH of potable water in the service system. Significant departures from these values may indicate industrial or other non-domestic discharges.

In land application systems, bacteria may perform wastewater treatment in pretreatment units and in the soil. These bacteria prefer a neutral pH for best performance. Any rapid increase or decrease in pH can cause mortality in the bacteria population, resulting in poor treatment.

3.4.2 Dissolved Oxygen

Dissolved oxygen (DO) is the amount of oxygen dissolved in water and is usually expressed in milligrams per liter (mg/L). Although some microorganisms can survive in anaerobic conditions (without oxygen), many of the beneficial microorganisms that stabilize wastewater require aerobic conditions (with oxygen).

The amount of oxygen that can be dissolved in water is dependent on temperature—as water temperature increases, dissolved oxygen content decreases and vice versa—and the distribution of oxygen within a lagoon will determine whether the treatment processes involved are aerobic or anaerobic. Maintaining adequate oxygen levels allows aerobic biological process to take place and prevents objectionable odors. Low DO concentrations (less than 1.0 mg/L) can indicate inadequate aeration or an excessive amount of organic material entering the system. Dissolved oxygen is measured using an oxygen meter and a membrane-covered probe. Probes require careful cleaning and meters must be calibrated routinely to ensure accuracy.

3.4.3 Biochemical and Chemical Oxygen Demand

Biochemical oxygen demand (BOD) is the rate at which organisms use oxygen to stabilize or break down the organic matter in wastewater. High levels of BOD indicate high levels of organic matter in wastewater. The typical range of BOD in domestic wastewater ranges from 100 to 300 mg/L of BOD.

BOD is measured using a biochemical oxygen demand test, a procedure that measures the amount of oxygen used by a wastewater sample incubated at 20^{o}C for five days. The amount of organic material measured is referred to as BOD_5, referring to the five day length of the test.

The chemical oxygen demand (COD) analysis estimates the amount of organic matter in wastewater in only three to four hours, rather than the five days required for the BOD_5 test, and can be used as an alternative. The COD test measures the oxygen equivalent (in mg/L) of the materials present in the wastewater by oxidizing the wastewater using a strong chemical oxidant. Because the chemical oxidant may react with substances that cannot be broken down by bacteria, COD results are not directly related to BOD_5. However, COD can be used as a means of rapidly estimating the BOD_5 of a sample if BOD_5-to-COD ratios are developed for a particular system.

COD results are typically higher than BOD_5 values, and the ratio between the two will vary from system to system. The BOD_5-to-COD ratio is typically 0.5:1 for raw domestic wastewater and may drop to as low as 0.1:1 for a well-stabilized secondary effluent.

3.4.4 Nitrogen

Nitrogen in the wastewater effluent can be found in both inorganic and organic forms. Inorganic forms include ammonium (NH_4^+), ammonia (NH_3), nitrite (NO_2^-), and nitrate (NO_3^-). In raw wastewater, organic nitrogen and ammonia levels are generally higher than nitrite and nitrate levels. Organic nitrogen includes such natural materials as proteins and peptides, nucleic acids and urea, and numerous synthetic organic materials. Total nitrogen is the sum of organic nitrogen, ammonia, nitrite and nitrate. Total Kjeldahl nitrogen (TKN) is the sum of organic nitrogen and ammonia. Typical ranges of nitrogen concentrations in raw domestic wastewater are 20 to 85 mg/L for total nitrogen, 8 to 35 mg/L for organic nitrogen, and 12 to 50 mg/L for ammonia. Plant available nitrogen (PAN) is nitrogen that exists in forms (NH_4^+ and NO_3^-) that are readily available for uptake by plants.

3.4.5 Salts

Chloride, sulfate, carbonate//bicarbonate, potassium, calcium, sodium and magnesium are common soluble salts (ionic species) that are present in wastewater. Some of the salts may be removed during wastewater treatment prior to effluent irrigation. Other salts, such as ferric chloride and alum, are sometimes added to aid in wastewater treatment by precipitating waste constituents.

Salts in wastewater are measured in a variety of ways. Summing individual ions gives what is often called total inorganic dissolved solids (TDIS). As discussed in Section 7.2.4.1.2, the analysis for total dissolved solids (TDS) measures dissolved solids, including organic as well as inorganic (salt) constituents. So in municipal, and particularly industrial, wastewaters, TDS may not represent the salt content of the wastewater. Non-volatile dissolved solids (NVDS) can be used as a rough estimate of salt content. NVDS is calculated according to Equation 3-2:

$$\text{NVDS} = \text{TDS} - \text{VDS}$$

Equation 3-2. Calculation of non-volatile dissolved solids.

Where VDS is volatile dissolved solids (solids which are incinerated upon heating). Total fixed solids (TFS) are the inorganic solids from the total solids of wastewater and better represents inorganic solids content of wastewater.

3.4.6 Metals

Metals are inorganic chemical elements that are present in varying amounts in most waste streams. Although some metals are essential for proper human and plant nutrition, over time they can accumulate in soils and become toxic to plants, humans, and animals.

Metals of concern include cadmium, copper, lead, nickel, zinc, selenium, arsenic, mercury, and molybdenum. Cadmium, arsenic, chromium, and mercury are extremely toxic; nickel, molybdenum, and lead are moderately toxic; and copper, manganese, and zinc are relatively low in toxicity.

Concentrations of metals will vary with the type of wastewater. A typical domestic wastewater has low concentrations of metals, but an industrial wastewater may be very high in metal concentration. Removal of metals from wastewater normally occurs through sludge generation during initial treatment. For example, effluent from domestic sewage contains very small concentrations of the most toxic metals such as cadmium after treatment and sludge separation.

3.4.7 Persistent Organic Chemicals

Microorganisms can readily decompose most organic wastes. There are some organic chemicals of concern which are not readily biodegradable and can persist in the environment for many years. Persistent organic chemicals of concern are generally anthropogenic (man-made) and have the potential to contaminate soils and ground water. They can also be toxic to animals and humans. Like other contaminants, POCs can reach the soil, and from there to ground water, in many ways. They are sometimes a component of pesticides (insecticides and herbicides), or they may be found in the waste stream that is being treated at the land application site. Persistent organic chemicals are also found where old underground storage tanks have leaked petroleum products into the soil.

With a municipal or domestic waste source, persistent organic chemical concentrations are likely to be extremely low, or nonexistent. These chemicals may be present in higher concentrations, however, in an industrial waste source.

3.4.8 Phosphorus

Certain wastewater land treatment facilities, industrial facilities in particular, may generate appreciable quantities of phosphorus in wastewater streams. Many of these facilities have opted to land treat their wastewater. Since there are unique environmental considerations with respect to treatment of these wastewater streams, it is important to provide additional guidance to promote appropriate design, implementation and successful operation of these land treatment facilities. See Section 4.2.2.7 for further discussion of phosphorus.

3.4.9 Pathogenic Organisms

Microorganisms can live and reproduce when there is substrate (food), appropriate temperatures, water, and time. Both municipal (sanitary) and industrial wastewaters can have significant microbial populations. Food processing wastewaters in particular are rich in substrate, and can have significant populations of microorganisms. Wastewaters resulting from the washing of harvested crops can have great numbers of non-enteric and non-pathogenic soil microorganisms, including coliform bacteria and other organisms ubiquitous in the soil environment. Other wastewaters such as cheese processing wastewaters can have pathogenic organisms including certain species of salmonella and lysteria. Where industrial wasterwaters are stored, water fowl and other animals can deposit fecal material and thus contribute to non-human enteric pathogen populations such as certain species of streptococcus.

Raw sanitary wastewater also has significant populations of microorganisms . Most of these are not harmful to humans, and some of them are helpful in wastewater treatment processes. However, humans and warm-blooded animals with diseases caused by bacteria or viruses may discharge some of these harmful organisms in their body wastes (fecal wastes), and many serious outbreaks of communicable diseases have been traced to direct contamination of drinking water or food supplies by the body wastes from a human disease carrier.

Disease-causing microorganisms (pathogens) include bacteria, viruses, parasitic protozoa and helminths (worms). Some known examples of diseases that may be spread through wastewater discharges are typhoid, cholera, shingellosis, dysentery, polio, and hepatitis. Fortunately, the bacteria that grow in the intestinal tract of diseased humans and warm-blooded animals are not likely to find the environment in a wastewater treatment system favorable for their growth and reproduction.

3.4.9.1 Identification of Pathogens

It is impractical to test wastewater for all pathogens. Instead, indicator bacteria organisms are commonly used to indicate fecal contamination and the possible presence of pathogens in sanitary wastewater. One commonly used indicator is total coliform bacteria, a group of bacteria that are easily identified through laboratory tests. Total coliform bacteria are always present in the digestive systems of humans and warm-blooded animals. If there is a large concentration of coliform bacteria present in wastewater, the potential for the presence of pathogens is high. The Idaho Department of Environmental Quality (DEQ) uses total coliform bacteria as the indicator of potential pathogen levels in land-applied wastewater. Regulatory requirements for treatment and microbiological quality, as well as allowed uses for wastewater classifications are found in IDAPA 58.01.17.600.07 and 08, respectively.

3.4.9.2 Removal of Pathogens

The removal of microorganisms, particularly human pathogens, from sanitary wastewater is an important consideration in land treatment. Wastewater treatment processes remove pathogenic organisms in several ways: physical removal through filtration and sedimentation, natural die-off of organisms because of unfavorable environments, and destruction of organisms by disinfection.

Extensive field observations indicate that bacteria and viruses are removed from wastewater as it moves through the soil. Removal of microorganisms is accomplished initially by filtration and adsorption. Because of their large size, helminths and protozoa are removed primarily by filtration at the soil surface. Bacteria can be removed by filtration in the soil as well as by adsorption. Coliform removal in the soil profile has been shown to be approximately the same when primary or secondary pre-treatment is provided prior to land application. Unless fissures, dissolution channels, or macropores are present for hastened downward movement of organisms, soil will remove bacteria and viruses within several inches or at most a few feet. Fecal coliforms are normally absent after wastewater percolates through five feet of soil. Viruses are removed primarily by adsorption.

After filtration and adsorption, the organisms then die due to radiation, desiccation, predation by other indigenous microorganisms, and exposure to the adverse conditions in the soil. It is not expected that the presence of microorganisms in wastewater will be a limiting factor once wastewater has entered the soil, with the exception of animal grazing. See Section 6.4 for further discussion on grazing management.

The residual concentration of microorganisms in treated wastewater is variable depending on several factors including type of wastewater, the efficiency and degree of disinfection (typically chlorination or ozonation), substrate concentration in wastewater, storage temperature and length of storage. The greater resistance of viruses to most disinfection procedures and the possibility of chlorination breakdown increases the importance of the ability of the soil to remove organisms.

Although many pathogenic organisms are killed (called natural die-off) during the normal treatment processes, sufficient numbers can remain in the effluent (wastewater leaving the treatment system) to cause a threat to any downstream use involving human contact if adequate disinfection is not accomplished in the treatment process.

3.4.9.3 Microbial Risk Analysis and Land Treatment

To help minimize the exposure of human receptors to microorganisms from land treatment system operations, land application methods should be conducted to minimize aerosol drift off site. Section 6.5 should be consulted for tables of microbial wastewater quality and buffer zone requirements.

DEQ is in the process of developing preliminary methodologies for assessing risk from microorganisms at wastewater land treatment sites. This interim effort is described in the following document - *Technical Background Document: Microbial Risk Assessment and Fate and Transport Modeling of Aerosolized Microorganisms: Recommendations at Wastewater Land Application Facilities in Idaho* (DEQ, 2006). This document provides technical and scientific background necessary for making quantitative assessments of risk to human health from microbial constituents in municipal and industrial wastewaters that are land applied. Both municipal and food processing wastewaters in Idaho contain various microbial constituents, which may have the potential to pose a risk to human health.

To evaluate the relative risk of different land application practices, a quantitative microbial risk assessment methodology has been developed that uses microbial densities in air as critical input. The airborne transport pathway involves wastewater aerosolization, dispersion, deposition, and die-off. Irrigation droplet drift and aerosol transport are accounted for to predict microbial densities in air and deposited on surfaces downwind. The fate and transport approach is largely based on early EPA work (1982), with improvements made in aerosolization and dispersion/deposition modeling and in using the results to address human health impacts.

A methodology has also been developed to provide an estimate of risk to public health given modeled microbial densities, type of receptor, mode of entry (ingestion or inhalation), and microorganism-specific characteristics. Preliminary model results suggest that drift and deposition of fine droplets at higher wind speeds may contribute to the risk of infection through ingestion of produce, a pathway not considered in the 1982 EPA guidance.

3.4.10 Pharmaceuticals and Personal Care Products (PPCPs)

The significance of Pharmaceuticals and Personal Care Products (PPCPs) on humans and the environment is an emerging issue to which much research is being devoted. Research on occurrence and potential effects of PPCPs in Europe has been ongoing since the 1980s. PPCPs did not receive much interest in the U.S. until the late 1990s.

PPCPs include all human and veterinary drugs, diagnostic agents, and nutraceuticals (bioactive food supplements). It also includes chemicals such as caffeine, nicotine and aspirin which have been known to be present in surface water at least since the 1970s. Several classes of PPCPs have been identified in environmental samples, including: analgesic/anti-inflammatory drugs, antiseptics/fungicides, lipid regulators, X-ray contrast media, psychiatric drugs, beta-blockers, antineoplastic drugs, contraceptives, antibiotics, antiepileptics, antidepressants, bronchodilators, antihypertensives, sunscreens, and synthetic musks.

Major concerns regarding PPCPs are pathogen resistance to antibiotics and disruption of endocrine systems by natural and synthetic sex steroids, particularly in aquatic organisms. Antidepressants (selective serotonin uptake inhibitors) and calcium channel blockers are also of potential concern for effects on aquatic life. The effects of chronic exposure to complex mixtures of PPCPs at very low concentrations has not been well-studied. Effects on aquatic organisms such as feminization of male fish have been documented at very low (ppt) concentrations of endocrine disrupting compounds (EDCs). The potential for adverse human health effects is currently unknown.

PPCPs are entering the environment primarily from end-use rather than manufacturing. PPCPs come from municipal wastewater, hospital wastewater, and veterinary drugs used at both confined animal feeding operations (CAFOs) and in aquaculture.

There are several effects of wastewater treatment on PPCPs. Degradation of PPCPs in municipal sewage treatment facilities is a function of both treatment technology and the chemical’s structure. Some free excreted drugs and metabolites are not degraded during treatment. Conjugates can be hydrolyzed back to the parent drug. Biologically active PPCPs in treated wastewater are discharged to surface water. They can reach ground water through leaching or recharge.

3.5 References

DEQ. IDAPA 58.01.17, Idaho Department of Environmental Quality, 2006. Rules for the Reclamation and Reuse of Municipal and Industrial Wastewater.

DEQ. Idaho Department of Environmental Quality. January, 2006. Technical Background Document: Microbial Risk Assessment and Fate and Transport Modeling of Aerosolized Microorganisms: Recommendations at Wastewater Land Application Facilities in Idaho.

EPA. U.S. Environmental Protection Agency (EPA).2004. Operation of Wastewater Treatment Plants.

EPA. U.S. Environmental Protection Agency (EPA). May 1982. Estimating Microorganism Densities in Aerosols from Spray Irrigation of Wastewater. EPA 600/9-82-003. USEPA, Washington, DC. 32 pages.

4. Hydraulic and Constituent Loading

Permitted wastewater land treatment sites are to be managed as agronomic or other treatment units for the efficient treatment and beneficial reuse of nutrients and water while maintaining soil productivity, minimizing nuisances, and protecting beneficial uses of ground and surface water. The *treatment capacity* of a land application site is determined by performing a land limiting constituent (LLC) analysis to determine the wastewater component that requires the most land for treatment. The LLC may be either water (hydraulic loading) or a particular constituent (constituent loading).

The LLC analysis is necessary for evaluating wastewater treatment alternatives that include land treatment:

- Sanitary wastewater commonly contains low concentrations of nitrogen, phosphorus, chemical oxygen demand (COD), and other constituents, such as total dissolved solids (TDS). For these wastewater streams, the amount of wastewater that can be applied to a treatment site is typically limited by the hydraulic loading rate (hydraulically limited), based on crop water requirements.
- With higher strength wastewaters, however, the amount of applied wastewater may be limited by constituent concentrations—the amount of nitrogen, phosphorus, or organics (BOD or COD), for example—in the wastewater stream. This chemical LLC then dictates the amount of wastewater that may be land applied. In these cases, sites typically use supplemental irrigation water to ensure the crop is receiving adequate water for crop productivity.

The following sections provide guidance for determining appropriate growing and non-growing season hydraulic loading rates, and chemical constituent loading rates.

4.1 Hydraulic Loading

Hydraulic loading of wastewater and supplemental irrigation water are fundamental land treatment design and operational parameters. Appropriate hydraulic loading rates, in both the growing and non-growing seasons are of critical importance to minimize adverse environmental impacts from wastewater treatment. Water balance parameters and calculations are discussed in Section 4.1.1.2.3.

A schematic of the hydrologic cycle, showing water movement in and out of the land treatment area, is provided in Figure 4-1.

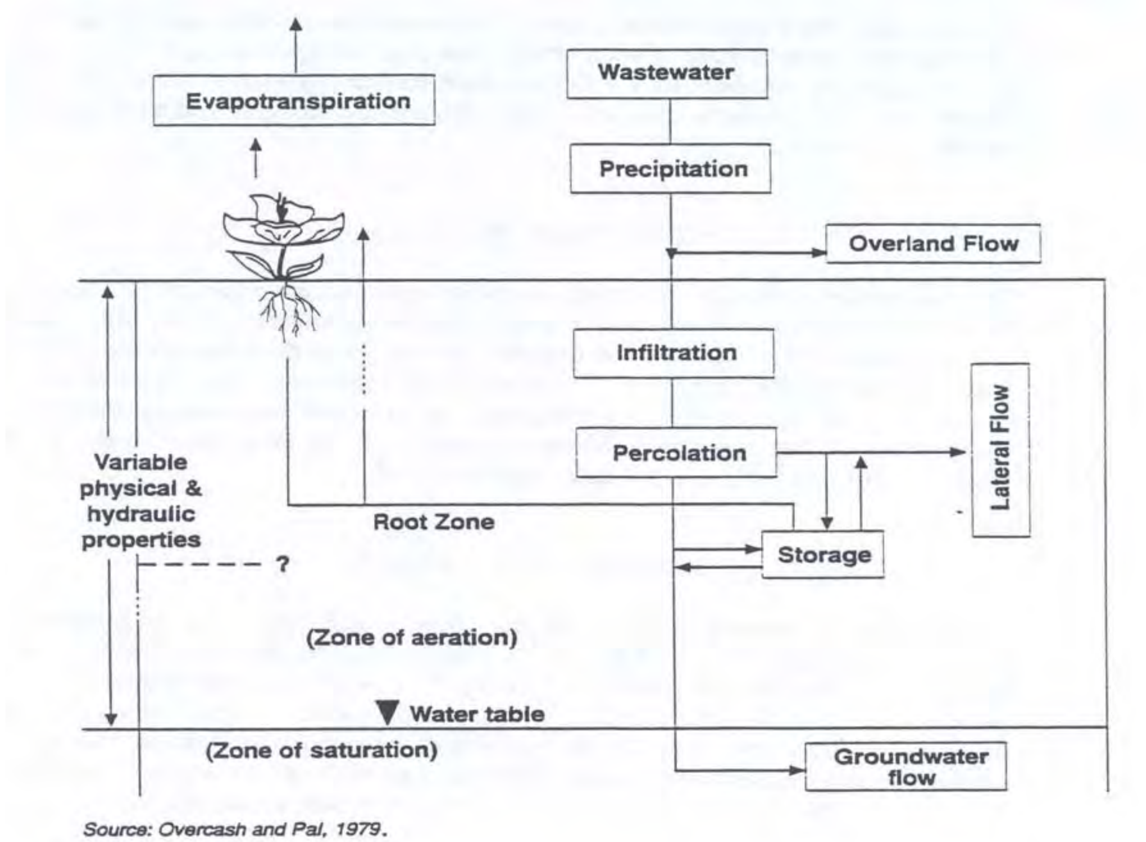

Figure 4-1. Distribution of Wastewater and Precipitation Input to Soil.

An important element of successful wastewater treatment through land-application is the ability of the soil to receive and transmit water. Hydraulic overloading of soil is a common cause of failure of land treatment systems. Uncontaminated overland flow can result in runoff and subsequent surface water contamination problems, as well as wastewater ponding and associated nuisance and vector problems, may result from over-application:

- Many crops are sensitive to poor aeration resulting from hydraulic overloading. Alfalfa, an important crop used at many wastewater land treatment sites, can be harmed or killed by hydraulic overloading.
- Overloading during freezing conditions in winter months can cause excessive ice build-up. Rapid spring thaws can then cause ponding, runoff, or rapid percolation through coarse soils.

Water application rates should not exceed the soil infiltration rate. Soil infiltration capacity should be included in site characterization activities to help determine management requirements, reasonable loading rates, and land area needed. Methods for determining soil hydraulic properties, including soil infiltration rate measurement, are discussed in EPA (1981, Sections 3.3 and 3.4.) NRCS soil surveys provide soil infiltration information, which should be used for preliminary planning only.

Slow-rate land treatment systems generally result in more complete treatment of wastewater than high-rate systems, such as rapid infiltration systems. Slow-rate systems, rather than high rate systems are more appropriate for finer textured soils (silts and clays) with much higher surface areas than high-rate systems. Flow rates through these soil textures are slower, resulting in longer wastewater residence times for biological treatment processes and greater reactive surface areas for physiochemical processes, such as sorption and precipitation, that can effectively treat heavy metals, phosphorus, and certain other constituents.

Rapid infiltration systems can effectively reduce nitrate leaching, and they can effectively filter microorganisms.

The following two sections provide guidance on growing and non-growing season hydraulic loading and on calculating appropriate growing season and non-growing season hydraulic loading rates.

4.1.1 Growing Season Wastewater Land Treatment

Growing season wastewater hydraulic loading rates vary between climatic regions within the state. The following information is provided to assist in the evaluation of wastewater land treatment design during the growing season.

4.1.1.1 Statewide Climatic Regions and Growing Seasons

The length of the growing season is an important criterion when designing a wastewater land treatment system. The growing season is determined by climatic conditions, which vary throughout the state. The *NRCS National Engineering Handbook - Irrigation Guide*, Title 210, Chapter VI, Part 652.0408(c) and (d), September 1997, delineates climatic regions with respect to crops and crop growth (Figure 4-2). Table 4-1 describes each of the climatic regions with respect to location and key parameters for crop growth.

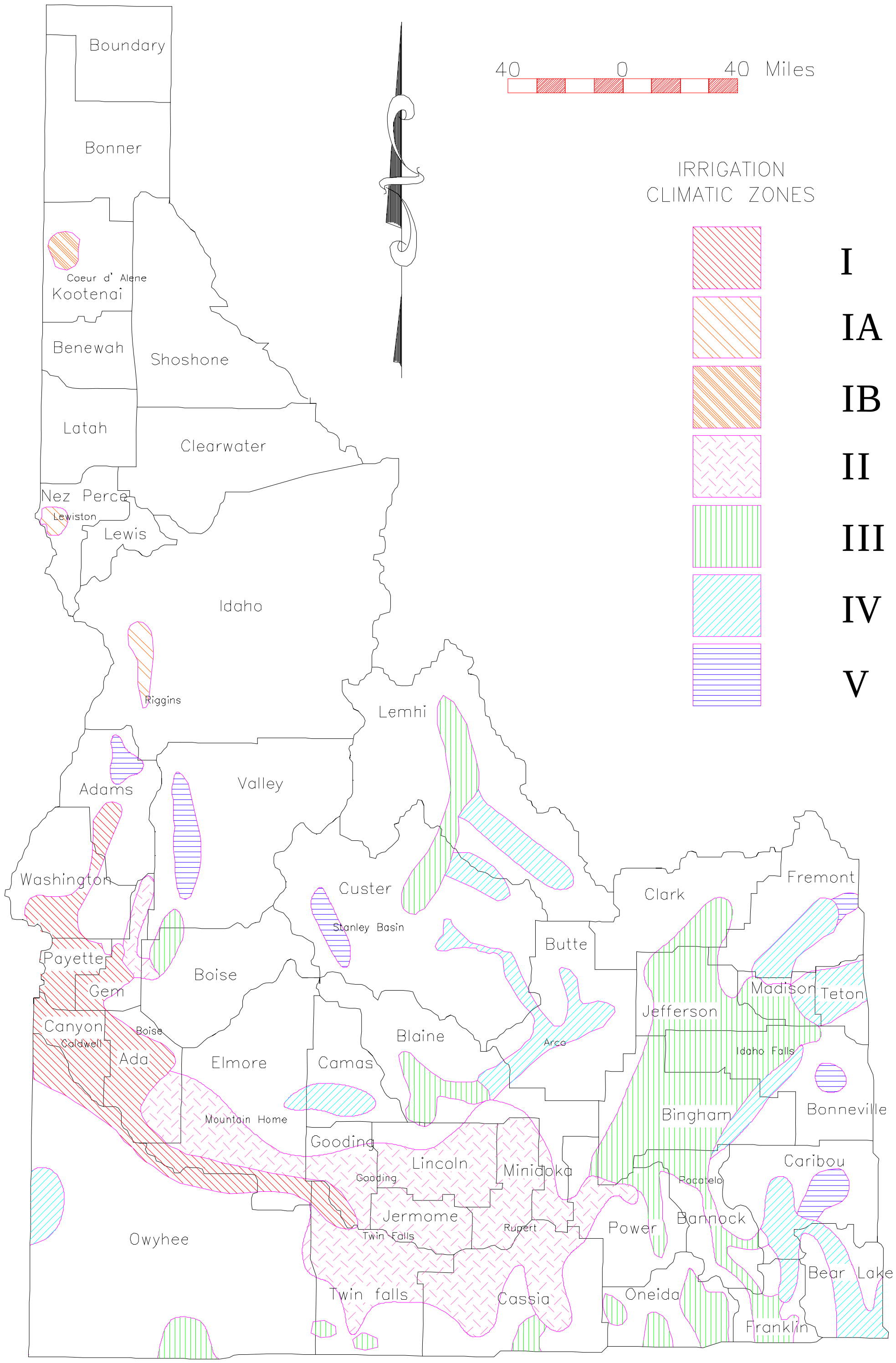

Figure 4-2. Climatic Regions in Idaho (USDA 1997).

Table 4-1. General Description of Irrigated Climatic Areas.

Irrigation Climate Area	General Location of Irrigated Climatic Areas	Frost Free Range (days)	July *f Factor Range	Representative Station			
				Station Location	Frost-Free Period (days)		July *f Factor
		32°-32°			32°	28°	
I	Lower Snake River from Weiser to Hagerman, except Mt. Home plateau. Weiser, Payette, Boise River Areas.	140 to 160	7.6 to 8.1	Caldwell	147	169	7.7
IA	Riggins, White Bird, and Lewiston	175 to 185	7.5 to 8.5	Lewiston	187	225	8.0
IB	Rathdrum Prairie Area	135 to 155	6.9 to 8.1	Coeur d' Alene	145	179	7.5
II	Snake River Plains from Mt. Home Plateau to American Falls, Including Bliss, Gooding, Shoshone, Oakley, Raft River. Middle Payette, Squaw Creek Area.	120 to 140	7.14 to 7.65	Rupert	132	158	7.46
III	Malad & Bear River Valley to Alexander, Marsh Creek and Portneuf River, Dubois, Snake river from American Falls to Chester and Heise on the South Fork, Challis to Salmon and Lower Lemhi.	100 to 120	6.84 to 7.51	Sugar City	104	128	6.98
IV	Ashton, Upper Lemhi, Pahsimeroi, Arco, Mackay, Howe, Montpelier, Grace	80 to 100	6.53 to 7.09	Arco	82	122	6.89
V	McCall, New Meadows, Stanley Basin, Greys Lake, Green Timber	50 to 80	6.62 to 6.69	McCall	59	100	6.69

*f = monthly consumptive use factor from the formula (USDA, 1993., Part 623. Appendix A) for determining water requirements for irrigated areas. It is the product of the mean monthly temperature and monthly percent of daylight hours and provides an index of crop consumptive use requirements in different areas.

Additional information regarding crop growing seasons throughout the state is provided in Sections 4.4.1 and 4.4.3. Crop growing season information, which comes from USDA [1993; the NRCS National Engineering Handbook, Part 652.0408(c) and (d)], is not site specific, but is generalized for each region. Reuse permit proposal designs should substantially reflect these general season lengths, with the understanding that site specific information regarding climatic, site, and management differences may be utilized.

Definitions for crop start, crop cover, and crop termination are found at the following Agrimet Web site:

http://www.usbr.gov/pn/agrimet/cropdates.html

Natural Resource Conservation Service general growing season dates for various locations and crops are found in Section 4.4.1.

More detailed information on growing season dates from Agrimet are found in Section 4.4.3, and a description of Agrimet weather stations is found in Section 4.4.2. Agrimet growing season data may also be found on the following Web site:

http://www.usbr.gov/pn/agrimet/id_charts.html

4.1.1.2 Growing Season Hydraulic Loading Rate

During the growing season, timely applications of wastewater and supplemental irrigation water are needed to use the site at an optimum level, with applications scheduled depending on crop water requirements, the strength and volume of wastewater, weather conditions, harvesting periods, and maintenance requirements. As the seasons change, the operator needs to continually evaluate the rates of application and make necessary changes in management.

Irrigation, in slow rate infiltration systems, may need to be discontinued, at times, due to adverse weather, for maintenance purposes, for harvest periods, or for various other reasons. Rest periods are essential for preventing soil clogging and promoting treatment of organic materials in wastewater. It is common to follow a pattern of one day of application followed by a rest period, but actual dose-rest periods are site specific and dependent upon the characteristics of the wastewater and crop requirements. Rest periods can be several days, several weeks, or even months.

Wastewater, however, may not supply enough water for adequate crop production. Hydraulic loading rates will differ for each site, depending on climate and crop selection, and typically include addition of supplemental irrigation water to meet the demands of plant growth. The guidelines that follow provide a means to quantify growing season hydraulic loading rates.

4.1.1.2.1 The Irrigation Water Requirement (IWR)

The irrigation water requirement (IWR) is any combination of wastewater and supplemental irrigation water applied at rates commensurate with the moisture requirements of the crop. A crop should be irrigated throughout the growing season at the IWR:

- Deficit irrigation occurs when a crop is irrigated significantly less than the IWR. Deficit irrigation can increase the salt content of the soil by reducing leaching below the necessary leaching requirement. Deficit irrigation may adversely affect both the health of the crop as well as reduce the yield. Reduced yields mean reduced uptake of applied nutrients, which may otherwise enter groundwater or surface water as contaminants. There are cases where deficit irrigation may be practiced without adverse effects. For example, limited volumes of wastewater and irrigation water may be applied, by design, to a hay crop such that only one or two cuttings are obtained. Nutrient balance and necessary salt leaching can be achieved under this limited season cropping plan. After harvest, wastewater application would cease until the next limited cropping season.
- Irrigating above the IWR can adversely affect crop yields (King and Stark, no publication date) and wastes irrigation water and energy if the supply is ground water and is pumped.

Also, irrigating above IWR increases leaching through the root zone and subsequent transport of constituents to ground water.

It is important, therefore, that a permit limit for IWR not be expressed as a 'maximum' hydraulic load, as this would imply that rates lower than the IWR would be acceptable, which would often not be the case.

Figure 4-3 shows an example of wastewater and irrigation water hydraulic loading versus irrigation water requirement. It can be seen that deficit irrigation is occurring during the middle of the growing season, possibly due to inadequate supplemental irrigation water. Excess irrigation can be seen during both fall and spring, possibly due to wastewater generation and land application in excess of crop needs, which are minimal at those times.

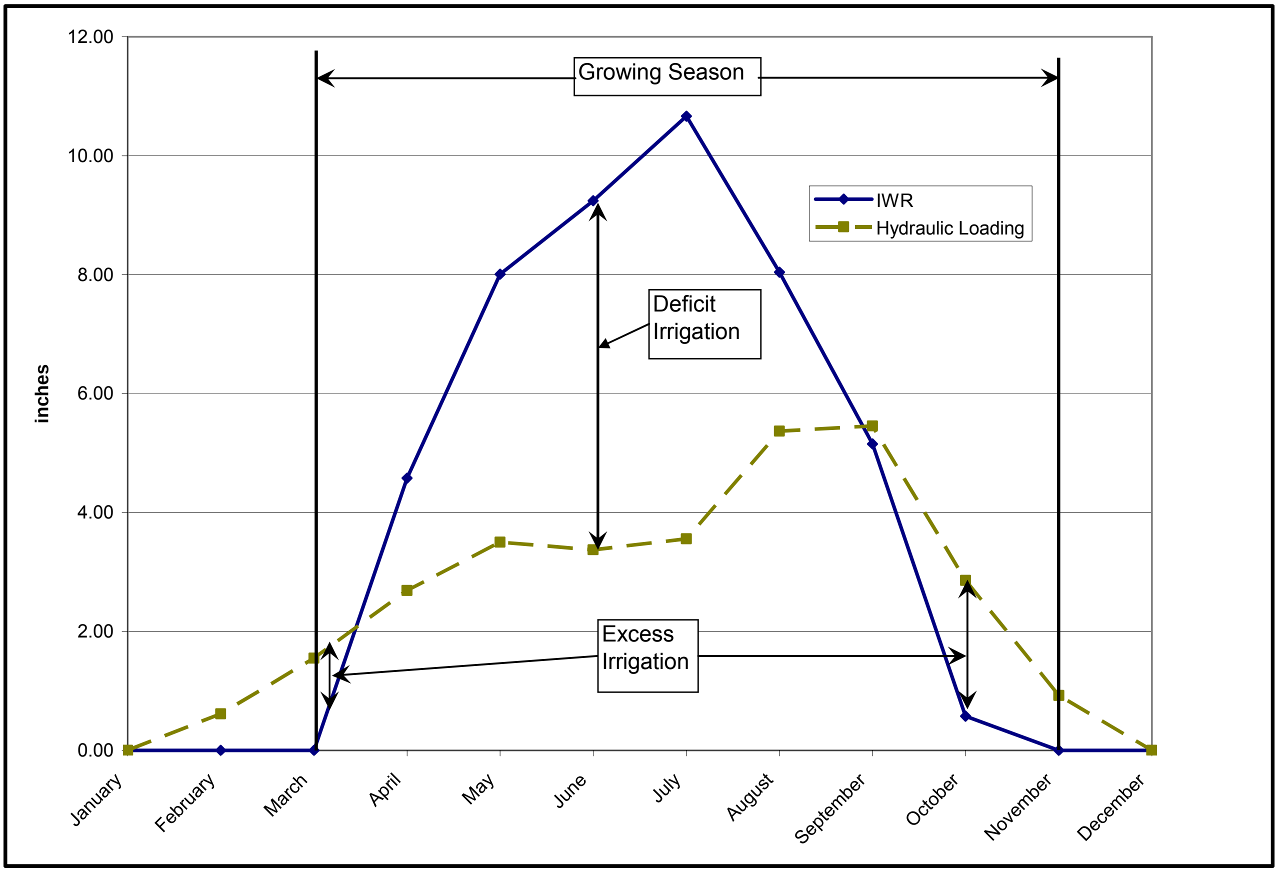

Figure 4-3. Plot of actual wastewater and irrigation water hydraulic loading versus irrigation water requirement showing both deficit and excess irrigation.

Reuse permits should state that growing season hydraulic loading be *substantially* the IWR throughout the growing season – not exactly. Managing an agronomic system is both an art and a science, and it relies very much on the professional judgment of the operator to determine irrigation needs based on weather, daily observation, and previous operations.

The IWR is growing season specific. Utilizing static long term averaged data will necessarily over- or under-estimate the season specific IWR. Planning crop irrigations based upon real-time meteorological data provided by a source, such as USBR Agrimet (Section 4.1.1.2.2), during the growing season is a better option than using static values to determine IWR.

The intent of permit compliance with IWR is to determine whether the permittee is reasonably satisfying crop water requirements. In cases where crop water requirements have been neglected—or where the site did not have an adequate water right to sustain crops—both crop yield and irrigation volumes were dramatically less than what would be expected under typical agronomic management, and demonstrable to be not substantially according to IWR. Given an operating parameter, such as IWR, a somewhat less prescriptive 'limit' is indicated.

4.1.1.2.2 Irrigation Water Requirement Calculations

Both wastewater and supplemental irrigation water should be applied at rates commensurate to the consumptive use requirements of the crop, as these requirements vary during the season. Both EPA (1981, Sections 4.5.1 and 4.5.2) and Crites et al. (2000, Chapter 5) discuss irrigation needs and calculations.

The recommended growing season hydraulic loading rate is the Irrigation Water Requirement (IWR), which can be defined as shown in Equation 4-1 and Equation 4-2:

$$IWR = IR_{net} / E_i$$

Equation 4-1. Calculation of Irrigation Water Requirement (IWR).

Where:

$$IR_{net} = CU - (PPT_e + \text{carryover soil moisture}) + LR$$

Equation 4-2. Calculation of Net Irrigation Requirement (IRnet)

The terms in these equations, in addition to sources of data, are discussed in the following sections.

<u>IR_{net}: Net Irrigation Requirement</u>

IR_{net} is the *net irrigation requirement*—the depth of irrigation water, excluding precipitation, stored soil moisture, and ground water, that is required for crop production and other related uses. Such related uses may include water required for leaching, frost protection, etc. The IR_{net} may be obtained or calculated by several means, depending upon objectives. For planning purposes, The monthly IR_{net} (referred to as the *Mean Net Irrigation Requirement*, or Mean IR) may be obtained by crop type for Idaho weather stations from the following Web site:

http://www.kimberly.uidaho.edu/water/appndxet/index.shtml

It should be noted that data compiled and provided at this Web site is for the historical period of record prior to 1983 and does not reflect the historical period of record from 1983 to present. Updated IR_{net} information (referred to as precipitation deficit can be found in Allen and Robison (April 2007), and at the following Web site:

http://www.kimberley.uidaho.edu/teidaho

CU: Crop Consumptive Use

CU is *crop consumptive use* or *crop evapotranspiration* (ET). Either averaged or daily data can be obtained for CU, depending on whether IR_{net} is to be based upon averaged or season-specific data.

The monthly CU (referred to as *Mean Monthly Consumptive Use,* or Mean CU) may be obtained, by crop type, for the pre-1983 historic period of record for Idaho weather stations from the following Web site:

http://www.kimberly.uidaho.edu/water/appndxet/index.shtml.

Updated CU data (2006) can be obtained from the following Web site:

http://www.kimberley.uidaho.edu/teidaho

The U.S. Bureau of Reclamation maintains the Internet-based Agrimet system of weather stations throughout the state of Idaho. Agrimet is a free service that provides users with various reports of daily, monthly, and annual ET and other weather data. Annual ET totals and averages for several years 1988 to present by crop and Idaho weather station can be obtained at the following Web site:

http://www.usbr.gov/pn/agrimet/ETtotals.html

Current and historical daily ET data for the growing season for a selected crop, cropping year and weather station (various periods of record) can be obtained at the following Web site:

http://www.usbr.gov/pn/agrimet/etsummary.html

The Idaho Crop Water Use Charts on Agrimet provide a useful resource for irrigation scheduling during the growing season. These charts provide the following for each weather station:

- Crop: Abbreviated identifier for the crop being modeled.
- Start Date: Typically the crop emergence date or beginning of vegetative growth for perennials.
- Daily ET: The previous 4 days of crop specific ET
- Daily Forecast: Average of the last 3 days ET
- Cover Date: Typically when the plant reaches full foliage.
- Term Date: Terminate date (frost, harvest, dormancy, etc.)
- Sum ET: Total crop water use to date by crop, since the start date.
- 7 Day Use: Total crop water use for the last 7 days.
- 14 Day Use: Total crop water use for the last 14 days.

Idaho Crop Water Use Chart data can be obtained from the following Web site:

http://www.usbr.gov/pn/agrimet/id_charts.html

Other sources of ET information (evaporation/evapotranspiration for the non-growing season) are discussed in Section 4.1.2.1.

PPT_e: Effective Precipitation

PPT_e is *effective precipitation* or effective rainfall during the growing period of the crop that can meet the consumptive use requirements of crops.

In Idaho, PPT_e does not generally include such precipitation as is lost to 1) deep percolation below the root zone, 2) surface runoff, or 3) wet canopy and wet soil losses associated with irrigation events. In most areas in Idaho, the difference between PPT (precipitation) and PPT_e is assumed to be from surface evaporative losses rather than percolation and runoff, but this is a general assumption and may not always be valid.

The monthly PPT_e for Idaho weather stations for the pre-1983 historic period of record may be derived from data provided at the following Web site:

http://www.kimberly.uidaho.edu/water/appndxet/index.shtml.

PPT_e from this site is calculated as follows: $PPT_e = CU - IR_{net}$ (note: IR_{net} is Mean IR). To back-calculate monthly PPT for a particular weather station for the historic period of record, divide PPT_e by 0.7 (i.e. it is assumed for these data that the effective precipitation ratio is 0.7, or that PPT_e is 70% of PPT).

Table 4-8 (Section 4.4.5) provides information and equations for making more refined estimates of PPT_e from precipitation (PPT) and consumptive use (CU) data (from USDA, 1993).

It should be noted that the table will yield effective precipitation ratios varying, in some cases significantly, from 0.7. It should also be noted that the time step for calculating PPT_e is monthly.

Daily historical weather data, including daily precipitation, mean daily temperature, etc., for any time period within the historical record for a weather station, can be obtained from the Agrimet Web site below. One can select several meteorological parameters and generate a report.

http://www.usbr.gov/pn/agrimet/webarcread.html

Daily historical archive weather data; including precipitation, ET, mean temperature, etc.; for select water years at a given weather station can be obtained from the Web site below. Only one parameter can be selected per search.

http://www.usbr.gov/pn/agrimet/yearrpt.html

The National Weather Service has more stations in Idaho and records over a longer history than Agrimet but does not monitor ET (CU). These data should be used to augment Agrimet data, and in some cases to calculate ET using temperature and other meteorological data methods. Daily, monthly and annual precipitation, temperature, snow depths, and freeze probabilities can be obtained for Idaho weather stations from various periods of record: 1948 to present; 1961 to

1990; and 1971 to 2000. Daily precipitation and temperature for periods of record from 1961 to 1990 and from 1971 to 2000 are available from the following Web site.

http://www.wrcc.dri.edu/summary/climsmid.html

See also Sections 4.4.4 and 4.4.6 for both mean monthly precipitation and temperature data for the period of record 1971-2000, from Desert Research Institute website:

http://www.wrcc.dri.edu/COMPARATIVE.html

Monthly normals of temperature, precipitation, and other data can be found in NOAA (1982) and NOAA (2002) for periods of record 1951-1980 and 1971-2000 respectively.

LR: Leaching Requirement

LR is the leaching requirement, defined as the fraction of the irrigation water that must be leached through the crop root zone to control soil salinity at any specified level. It is important to note that a small LR can be satisfied by irrigation inefficiencies (see below) due to incidental losses caused by non-uniformity of water application (Keller-Bliesner, 1990). Leaching requirement and calculations are discussed further in Section 4.4.7.

E_i: Irrigation Efficiency

E_i is the irrigation efficiency, the percentage of applied irrigation water that is stored in the soil and available for consumptive use by the crop. Ranges for irrigation efficiencies are given in Section 4.4.8 (from Ashley et al. 1998). Additional irrigation efficiency information for typical irrigation systems can be found in Neibling (1998) and at the following US Bureau of Reclamation Web site

http://www.usbr.gov/pn/agrimet/irrigation.html#Efficiency)

4.1.1.2.3 Hydraulic Balance Calculations to Determine Percolate Volume

It is often necessary to determine percolate volume of an operating or proposed wastewater land treatment system. Percolate volumes coupled with constituent concentrations, either measured using soil water samplers or estimated from constituent mass balance calculations, give a percolate concentration. Both percolate concentration and volume can then be used in a ground water mixing model analysis to predict potential impacts of wastewater land application to ground water.

Table 4-2 shows a methodology for calculating leaching losses during both the growing and non-growing seasons. More sophisticated methods involve making the time step shorter. Instead of an annual calculation, it can be done month by month, week-by-week etc.

Table 4-2. Calculating leaching losses.

Estimating Leaching Losses During the Growing Season **Given:**	**Example #1: Wheel Line**	**Example #2: Pivot**	**Units**
1) Soil AWC (to 60 inches or root limiting layer)	7.2	7.2	inches
2) Proportion of Soil AWC filled with water at the Start of the Growing Season	0.95	0.95	inches
3) Soil Water at the Start of the Growing Season [(1)*(2)]	6.84	6.84	inches
4) Soil Carryover Water Used in Growing Season [(3) - (1)*0.65] (0.65 is allowable AWC depletion)	2.16	2.16	inches
5) Soil Water Remaining (Soil Water @ Start - Soil Carryover Water Used) (3) - (4)	4.68	4.68	inches
6) Crop Consumptive Use (CU) for entire growing season	33	33	inches
7) Precipitation (PPT) in Growing Season	4.7	4.7	inches
8) Effective Precipitation (PPTe) = 0.7 * PPT or [0.7 * (7)]	0.7 * 4.7 = 3.0	0.7 * 4.7 = 3.0	inches
9) PPT – PPTe (all surface evaporation) (i.e. non-leaching & non-runoff losses) [(7) - (8)]	4.7 - 3.0 = 1.7	4.7 - 3.0 = 1.7	inches
10) Net Irrigation Requirement (IR_{net}) = CU – PPTe - Soil Carryover Water [(6) - (8) - (4)]	33 – 3 – 2.16 = 27.84	33 – 3 – 2.16 = 27.84	inches
11) Irrigation Efficiency (E_i)	0.75	0.85	unitless
12) Irrigation Water Requirement (IWR) = IR_{net} / E_i $_{[(10)/(11)]}$	27.84 / 0.75 = 37.12	27.84 / 0.85 = 32.75	inches
13) Total Irrigation Losses = IWR - IRnet [(12) - (10)]	37.12 – 27.84 = 9.28	32.75 – 27.84 = 4.91	inches
14) Wind Loss/evaporation of drops in air: Volume of Irrigation Water Applied (V_{ap}) (i.e. IWR) less Volume Irrigation Water 'Caught' (V_c) V_{ap} - V_c = 0.1 * V_{ap} (for Wheel Lines) or Vap - Vc = 0.05 * Vap (for pivots)	0.1 * 37.12 = 3.71	0.05 * 32.75 = 1.64	inches
15) Irrigation Schedule	Weekly Irrigation for 120 days	Bi-Weekly Irrigation for 120 days	
16) Irrigation Events	20	30	events
17) Wet Canopy Losses = 0.1 inch (maximum) per irrigation event [0.1 * (16)]	0.1 * 20 = 2.0	0.1 * 30 = 3.0	inches
18) Excess Water Applied = Total Losses – (Wind Loss + Wet Canopy Losses) [(13) - {(14) + (17)}]	9.28 – (3.71 + 2.0) = 9.28 – 5.71 = 3.57	4.91 – (1.64 + 3.0) = 4.91 – 4.64 = 0.27	inches
19) Residual Water (Excess Water Applied + Soil Water Remaining) [(18) + (5)]	3.57 + 4.68 = 8.25	0.27 + 4.68 = 4.95	inches
20) Water Leached in Growing Season (Amount over Soil AWC) [IF (19) - (1)>0, then((19) - (1), else 0]	8.25 - 7.2 = 1.05	4.95 - 7.2 = negative number so -> 0	inches
21) Soil Water at the End of the Growing Season [IF (20)>0, then (20), else (19)]	7.2	4.95	inches
Estimating Leaching Losses During the Non-Growing Season **Given:**			
22) Soil Water at the Beginning of the Non-Growing Season (same as (21) above)	7.2	4.95	inches
23) Evaporation/Evapotranspiration NGS (ETngs)	4.33	4.33	inches
24) Precipitation (PPT) in Non-Growing Season	3.77	3.77	inches
25) Wastewater Applied (WWapp)	7.5	7.5	inches
26) Net NGS Water Balance (WWapp + PPT - ETngs) [(25) + (24) - (23)]	6.94	6.94	inches
27) Residual Water (Net NGS Water Balance + Soil Water at Beginning of NGS) [(26) + (22)]	14.14	11.89	inches
28) Water Leached in NGS (Amount over Soil AWC) [IF (27) - (1)>0, then (27) - (1), else 0]	6.94	4.69	inches
29) Total Water Leached per Water Year [(20) + (28)]	7.99	4.69	inches
Note: Row 12) can be substituted with water + wastewater applied if substantially different than IWR Note: Row 13) can be substituted with water + wastewater - Irnet			

In Line 18 of Table 4-2, care must be taken in including *wind loss* as a loss of water on the field scale. Most wind loss will reduce ET on other parts of the same field, because the evaporation of the drift loss will cool and humidify the surface air layer in a downwind direction. Therefore, the ET demand downwind is reduced by some amount. This decrease may, from a field scale, offset the drift loss. Of course, if sprinkle irrigation taking place on the edge of a field results in all drift going off site, then this is a loss. Caution should be used not to double count losses.

4.1.2 Non-Growing Season (NGS) Wastewater Land Treatment

The following section includes a general discussion of non-growing season wastewater land treatment, guidelines for non-growing season wastewater land treatment, and criteria for design and operation of wastewater land treatment sites during the non-growing season, including determining non-growing season loading rates.

Some facilities generate and treat wastewater during the non-growing season. Facilities may either discharge to surface water under an NPDES permit issued by EPA, land apply, or store wastewater. Non-growing season loading and storage present economic challenges as land, treatment, and storage costs can be high. If the storage option is utilized, storage ponds must be designed according to the Wastewater Rules (IDAPA 58.01.16) and criteria described in Section 6.3. In addition, plans and specifications must be submitted to DEQ for review and approval.

Factors to be considered in designing non-growing season wastewater land treatment include COD loading, nutrient loading, hydraulic loading, soil, soil-water storage, and climatic conditions.

Excessive non-growing-season wastewater land application may contribute to secondary contamination of the ground water or surface water resource. Excessive COD and/or hydraulic loading coupled with low temperatures limits microbial oxidation and causes accumulation of COD in the soil profile. The rise of soil temperatures during spring thaws with high soil COD levels may cause reducing conditions to develop in the soil. This can cause the reduction of iron and manganese in the soil to mobile forms, which can leach.

Non-growing season-wastewater land application during freezing conditions can cause wastewater to accumulate on the surface of the soil. Accumulated frozen wastewater, with associated chemical constituents, melts during spring thaw conditions and may overload the soils both hydraulically and with respect to constituents such as COD, nitrogen and others. Rapid melting of frozen wastewater may also create the potential for runoff. Wastewater which runs offsite does not undergo land treatment of constituents, and may carry with it sediments which, if these have elevated levels of phosphorus may result in phosphorus contamination of surface water.

Generalized non-growing seasons are found in USDA, 1997, Part 652.0408(d)] and in Sections 4.4.1 and 4.4.3. Reuse permit proposal designs should substantially reflect these season lengths, with the understanding there may be climatic, site, and management differences not reflected in and which may modify the generalized information.

4.1.2.1 General Guidelines for Non-Growing Season Hydraulic Loading

Non-growing season hydraulic loading should conform to the following guidelines. NGS hydraulic loading:

- will not cause significant degradation to ground water as determined by DEQ;
- will preserve beneficial uses of surface and ground water;
- will not cause prolonged anaerobic conditions to develop in the soil or aquifer, such that the flux of redox sensitive constituents and soluble organics beyond the crop root zone causes significant degradation of ground water;
- will be sufficiently designed so that late winter/early spring thaw or precipitation events do not cause runoff, hydraulic overloading, or other crisis conditions (see further discussion of runoff in Section 4.1.3);
- will not create or contribute to nuisance conditions, crop damage, or adversely affect public health and safety;

4.1.2.2 Design and Operational Guidelines for Wastewater Land Treatment Sites During the Non-Growing Season

Non-growing season criteria for the design and operation of wastewater land treatment sites include the following:

- Wastewater should not be applied when it will freeze and accumulate on the surface of the soil, where ice accumulation on the ground surface is uneven and results in non-uniform hydraulic and constituent loading over the land treatment site.

- The site should be sprinkler irrigated with winterized equipment. Flood or furrow irrigation should not be utilized if they result in prolonged saturated conditions at the head end of the furrow or basin causing both the development of reducing conditions and leaching. Snow and ice in furrows or basins can prevent wastewater from spreading evenly along a furrow or over a flood site. Under certain circumstances, such as small flood basins and operation during winter thaws, flood irrigation can achieve coverage as would be achieved during the growing season.
- Engineering and management controls for the non-growing season should be designed, constructed, maintained, and operated to contain precipitation and applied wastewater so that runoff from the land treatment site is minimized. Ice build-up on fields should be minimized since it may constitute a runoff hazard during winter or spring thaws. See Section 4.1.3 for further guidance on runoff control.
- Wastewater ponding at tail ends of fields should be minimized, and should be pumped back and re-applied or stored in approved storage structures. Acceptable frequency, duration, and volume of ponded water should be determined on a site-specific basis.
- Ground water mixing zone and dispersion modeling for constituents of concern may be necessary to determine impact of leaching and constituent mass loss for proposed non-growing season loading rates. TDS and nitrogen are often constituents of concern. DEQ has developed a NGS ground water impact screening tool which generates a conservative estimate of NGS ground water concentration changes based upon (and designed for) low-strength wastewater loading and site-specific aquifer characteristics. See documentation in Section 4.4.11. DEQ Wastewater Program Office may be contacted for the link to download the software application.
- A ‘minimal leaching’ non-growing season hydraulic loading rate (HLL_{ngs}) may be calculated and utilized, according to the methodology provided in Section 4.4.9, as a generally accepted protective approach to non-growing season hydraulic loading

4.1.3 Runoff Control

Engineering and management controls should be designed, constructed, and operated to contain applied wastewater, as well as precipitation and applied irrigation water (if mixed with wastewater) so that runoff from the land treatment site is minimized. There is generally little regulatory concern with runoff of precipitation or irrigation water beyond that of normal irrigated agriculture provided these are not mixed or influenced by wastewater. It is recommended that regulatory expectations with respect to runoff are design-construct-operate-maintain as opposed to performance based. The reason for this is the fact that there are many meteorological conditions which can complicate compliance determination with a single performance standard.

For example, runoff controls may be designed, and contain, a twenty-five (25) year/ twenty-four (24) hour storm event. If, however, this event immediately follows one or more 10 year/ 24 hour events, or if it occurs on snowpack of significant depth, etc., it would not be reasonable to expect such controls to perform under these circumstances.

4.1.3.1 Runoff Control – Design Considerations and Base Case Scenario

It is recommended that runoff control design be based upon risk of contamination or causation of nuisance to receptors. Receptor risks include:

- proximity to surface waters of the state or irrigation canals, laterals, drains, etc. which may be hydraulically connected to waters of the state;
- proximity to domestic and municipal wells
- proximity to residences, commercial and industrial areas, and other areas of human proximity

Other risk factors include:

- strength of wastewater
- pathogen content of wastewater
- size and wastewater generation capacity of the facility

The *Base Case* for initial design criteria recommended below assumes a proximity to all receptors listed; a high strength wastewater food processing wastewater; and a large (400 MGA) facility. To address surface runoff concerns the following should be applied. Less or more stringent design criteria should be considered depending upon degree of risk less or greater than the base case as defined.

4.1.3.2 Runoff Control Design Criteria and Methodology

The irrigation system should include control structures and management practices that are designed to the following criteria:

- Structures and practices should be designed to contain runoff from any site or fields used for wastewater land treatment to property not permitted for land treatment except in the event of a 25 year/ 24 hour storm event. Whether the area being designed for runoff control is a hydraulic management unit (HMU), or whether the area includes areas between HMUs as well, is to be determined on a site-specific basis depending upon what is both protective of the environment, and reasonable and practical for the specific situation.
- The NRCS TR-55 (USDA) method should be used for estimating the time of concentration and runoff calculations. If hand calculations for runoff estimation are not desirable, several public domain and commercially-available software programs automate these calculations, including TR-55, available at the NRCS Web site:

  http://www.wcc.nrcs.usda.gov/hydro/hydro-tools-models-tr55.html

  A Windows-based version of NRCS TR-55 can be downloaded at the following Web site:

  http://www.wcc.nrcs.usda.gov/hydro/hydro-tools-models-wintr55.html

The NRCS Engineering Handbook Part 630, Hydrology (NRCS 1997) provides comprehensive guidance on runoff estimation and control. Below is the web site to access and download this handbook.

http://www.wsi.nrcs.usda.gov/products/W2Q/H&H/tech_refs/eng_Hbk/chap.html

- The NOAA Atlas 2 precipitation isopluvials should be used for determining the 25 year/ 24 hour precipitation at the location of the land treatment site. See Section 4.4.12 or the following Web site:

  http://www.wrcc.dri.edu/pcpnfreq/id25y24.gif

- The NRCS Type II rainfall distribution should be applied as the precipitation hyetograph for all land treatment sites in Idaho.
- Provisions should be designed for both the growing season and non-growing season. If a single system is designed for year-round application, the greatest volume of runoff from either the growing season or non-growing season should be used. There may be an instance where wastewater is applied during the growing season and applied during a part (typically late fall or early winter) of the non-growing season. In this case, specific time periods should be defined, and runoff control measures designed to accommodate specified time periods.
- Growing season – For the growing season, the runoff curve number should be based on the hydrologic soil group as determined from the soil types and typical field ground cover (Table 2-2a through 2-2d in the NRCS Technical Reference 55, page 2-5 through 2-8).
- Non-growing season – For the non-growing season, the runoff curve number should be based upon hydrologic soil group D to simulate frozen ground.

4.2 Wastewater Constituent Loading

As discussed in Section 3, wastewater chemistry and physical characteristics are important factors in the design, operation, and management of wastewater land treatment systems. The following sections discuss constituent loading calculation conventions, and both organic and inorganic constituent loading of wastewater land treatment sites.

4.2.1 Constituent Loading Calculation Conventions for Determining Compliance with Permitted Loading Limits in Wastewater Reuse Permits

Wastewater Reuse Permits specify constituent and hydraulic loading limits. Various means have been employed to calculate loadings, which have the potential to yield significantly different results. This has the potential to cause ambiguity in determining permit compliance. Also, the kind of data utilized, as well as the calculation method, have the potential of not being representative, thus calculations of loading rates to the treatment acreage may not be representative. This section addresses these ambiguities by providing guidance on several constituent loading calculation conventions that may be employed in determining compliance with permitted loading limits in Wastewater Reuse Permits. The particular convention employed should be approved by DEQ in advance.

The following sections discuss constituent loading calculations, variable acreage use in hydraulic management units, sampling and analyses, regulatory sampling period (sampling interval), determining appropriate wastewater flows to apply to chemical analytical data for constituent loading calculations, and permit conditions for both constituent loading calculations and determining permit compliance.

4.2.1.1 Constituent Loading Calculations

The following points should be considered when framing permit conditions related to constituent and hydraulic loading rates.

The means of calculating constituent and hydraulic loading rates should be clearly articulated in the permit. Even though multiple legitimate means to calculate loading rates exist, only one method should be allowed in the permit so that no ambiguities arise. The basic equation for the calculation of constituent loading rates is Equation 4-3:

$$M = (Q \cdot C \cdot k)/A$$

Equation 4-3. Calculation of constituent loading rates.

Where:

M = Mass of constituent applied per acre per unit time (e.g. lbs/ac-yr)

Q = Volumetric flow rate per unit time (e.g. MG/yr where MG = million gallons)

C = Constituent concentration (mg/L).

A = Unit area (acres).

k = Unit conversion from mg/L to lb/million gallons (1 mg/L = 8.34 lb/MG).

Example:

$$1500\,\frac{lb}{ac-mo} = \frac{7.2\,\frac{MG}{mo} * 2500\,\frac{mg}{L} * 8.34\,\frac{\frac{lb}{MG}}{\frac{mg}{L}}}{100\,ac}$$

Or, accounting for all units:

$$1500\ \frac{lb}{ac-mo} = \frac{\frac{7.2\ MG}{mo} * \frac{2500\ mg}{L} * \frac{1\ kg}{10^6 mg} * \frac{2.2\ lb}{kg} * \frac{3.79\ L}{gal} * \frac{10^6 gal}{MG}}{100\ ac}$$

Where:

MG = million gallons	L = liter
mg = milligram	kg = kilogram
mo = month	lb = pound
gal = gallon	ac = acre

Constituent loading calculation results should be reported to the appropriate accuracy according to the rules regarding significant figures found in Section 4.4.15.

4.2.1.2 Variable Acreage Use in Hydraulic Management Units

The full acreage of a hydraulic management unit (HMU) should be utilized in loading calculations, only if the full HMU acreage is used. Keep in mind that the HMUs should be designed during permitting to be the fundamental unit used to describe constituent and hydraulic loading. It should also be specified in the permits that facilities utilize the entire acreage of a HMU unless there is a significant, compelling reason not to do so.

If wastewater application is done only to a portion of an HMU, the total acreage of the HMU to which wastewater was applied should be used in the loading calculations (i.e. averaging constituent loadings over the entire HMU acreage). Effort must be made to load other areas of the HMU in succeeding years if the partial HMU is utilized. In the event that an HMU is typically utilized only partially, redesign of HMUs which adequately reflect actual operations should be considered.

4.2.1.3 Sampling and Analyses

Samples collected for wastewater, irrigation water, or other analyses should be representative of the flow of the monitored stream during the regulatory sampling period specified in the permit.

Permit applications should include a Quality Assurance Project Plan (QAPP) for DEQ review and approval, to be incorporated by reference in the permit, and which specifies:

- location, frequency and type of sampling to be conducted;
- how representative samples will be obtained and how sampling bias will be minimized;
- how additional sampling and analysis (utilizing approved methods, etc.) during the regulatory sampling period may be utilized for constituent loading calculations, in the event the permittee determines this is necessary to better characterize flows under particular circumstances (e.g. clarifier or other unit process upset, etc.).
- quality assurance protocols for analyses utilizing in-house laboratories (address reference samples, duplicates, criteria for determine data quality, actions taken when criteria are not met.

See Section 7.1.6 for further discussion of QAPPs.

All chemical analyses of wastewaters and other waters should be done according to methods approved by DEQ, the U.S. Environmental Protection Agency, or those in a current edition of *Standard Methods for the Examination of Water and Wastewater* (Greenberg et al. 2005). See Section 7 for further information regarding analytical methods.

4.2.1.4 Regulatory Sampling Period (Sampling Interval)

Permits should identify a regulatory sampling period (sampling interval) for each constituent within which a sample is taken. This period would represent an adequate sampling frequency for representative characterization of the media being sampled. Regulatory sampling periods may be hourly, daily, weekly, monthly, quarterly, semi-annually, annually, or once every permit cycle.

Table 4-3 provides examples of regulatory sampling periods.

Table 4-3. Examples of regulatory sampling periods.

Regulatory Sampling Period ->	Daily - 12:00 am to 11:59 pm Note: Many facilities begin their day at the beginning of the morning shift, for example at 8:00 am. The regulatory sampling period can be facility-specific and defined from 8:00 am one day to 7:59 am the next day, or another day.	Weekly - 12:00 am Sunday to 11:59 pm the Following Saturday	Monthly - 12:00 am on the First Day of the Month to 11:59 pm the Last Day of the Month

4.2.1.5 Calculation Methodologies

There are several methods, ranging from simple to complex, which may be used to calculate constituent loading rate from constituent concentration data and flow data. More complex methodologies characterize loading more accurately than simple methods, but involve more sampling and effort in performing calculations. More complex methodologies may be more appropriate in more highly managed wastewater treatment activities, especially where there are closer margins between site loadings and corresponding loading limits. Simpler methods may be more appropriate for sites which are typically loaded substantially less than stipulated loading limits. In this case, the lesser accuracy of simpler methods does not present a great risk in the event simpler methods overestimate loading, since actual loading is substantially less than loading limits. It is important to note that all methods presented may calculate loadings either above or below actual loadings. The error about the value of the actual loading is generally greater with simpler methods and less given more complex methods. A main point of the discussion in this section is to choose an appropriate methodology, and consistently and impartially apply it to avoid perceived or actual irregularities when making loading rate calculations having compliance implications.

Examples in Section 4.4.14 illustrate different means to calculate constituent loadings:

- Example 1 illustrates how the constituent loading rate would be calculated from daily flows and a required monthly sample taken in the middle of the month.
- Example 2 is a rigorous method of assigning daily flows to multiple sampling events during a monthly sampling period and illustrates how the constituent loading rate would be calculated
- Example 3 is similar to the method in Example 2 for assigning daily flows to multiple sampling events during a weekly sampling period and illustrates how the constituent loading rate would be calculated.
- Example 4 in is similar to Example 2, but is simpler to calculate, and it is far simpler to write computer code to do the calculation. Yet another method is simply to arithmetically average all concentration data, and then utilize total flow for a given regulatory interval.

The methodology to calculate loading rates for compliance purposes must be specified, either in the facility QAPP incorporated by reference in the permit, or in the permit itself, so that there is no equivocation regarding permit compliance in this area.

4.2.2 Wastewater Constituent Loading Rates

4.2.2.1 Total Suspended Solids (TSS)

Concerns with the land application of wastewaters with high concentrations of suspended solids include: 1) the potential for reducing the infiltration capacity of the soil (clogging the soil) and 2) the potential for damaging the cover crop. See Section 3 for further discussion of suspended solids.

The total suspended solids content of wastewater may include organic or inorganic particulate matter, with most of the organic solids being volatile. Many of the concerns related to the chemical oxygen demand of the wastewater and related problems with loading rates apply to total suspended solids. Loading rates for total suspended solids need to be carefully evaluated. Acceptable loading for total suspended solids can be defined as that rate which does not significantly reduce the infiltration capacity of the soil or damage the cover crop. Application rates should allow for decomposition of the organic material and the necessary dose-rest cycles to assure that potential problems are minimized.

Although organic solids can be almost completely removed by land treatment, problems with odors, ponding, insects and damage to cover crops can develop. Excess solids loadings could result in a solids build-up on top of the soil reducing infiltration rates. To prevent soil clogging, it is necessary to apply wastewater intermittently, allowing drying or resting periods between applications to permit the infiltration rate, which decreases during application, to recover during the drying cycle and for microorganisms to decompose the organic solids. The higher the total suspended solids content of the wastewater, the faster the soil will clog and the more frequently it should be allowed to dry.

The method of wastewater application will, to some extent, determine the amount of solids that can be applied to a field. Generally, spray irrigation is better suited for the application of more solids per acre than flood irrigation, due to the more uniform distribution of solids. However, the nature of the solids and method of distribution will highly influence the rate of application.

4.2.2.2 Chemical Oxygen Demand (COD)

The following section discusses COD assimilative capacity in the soil system, soil chemistry and oxygen demand, and both growing and non-growing season COD loading guidelines for wastewater land treatment sites.

4.2.2.2.1 Soil COD Assimilative Capacity

Soil has long been identified as a good medium for the assimilation of the organic material in wastes. A common measure of organic material is chemical oxygen demand (COD). This is a particularly useful measurement when considering factors influencing the soil chemical environment. The degree of oxygen demand imposed upon the soil system is an important factor in determining to what degree the soil is aerobic or anaerobic, and what chemical processes would be taking place in the system.

The upper limit on the amount of COD that a soil can assimilate depends largely on the environmental conditions and the nature of the waste applied. The major elements that affect the decomposition of organic material applied to the soil are: 1) carbon:nitrogen ratio; 2) oxygen supply; 3) temperature; 4) soil water content; 5) pH; and 6) salinity.

Soil should not be saturated for extended periods in order to keep oxygen levels up. Certain moisture levels are needed for optimum bacterial decomposition. The rate of decomposition increases with increasing temperature, with about 38 ºF being very slow and maximum rates occurring around 80ºF. Bacteria, which are the most effective waste decomposers, function best in neutral to slightly alkaline soils with a pH range of 6.5-8.5. High levels of salinity can reduce COD removal by organisms in the soil.

Adding organic materials to soil improves many soil properties, both chemical and physical. In terms of chemical properties, organic materials greatly increase the soil's cation exchange capacity and serve as a reservoir for plant nutrients, particularly nitrogen, phosphorus, and potassium (Bohn et al., 1979). In terms of physical properties, additions of organic materials stimulate microbes to produce polysaccharides and other organic exudates that bind soil particles together into aggregates (Donahue et al., 1977; Lehrsch, 1995) and, ultimately, help to strengthen or stabilize the aggregates so formed (Lehrsch et al., 1994). Stable aggregates resist breakdown from freezing (Lehrsch et al., 1991) and from sprinkler droplet impact (Lehrsch et al., 2005b) and minimize erosion under both surface and sprinkler irrigation (Lehrsch et al., 2005a). Well-aggregated, stable soil has a wide range of pore sizes that provide adequate aeration, sustain infiltration rates, and keep infiltration capacity relatively high (Lehrsch, 1995).

Soil clogging associated with high COD loadings, can severely limit the function of a site to treat wastewater. The conditions that could cause such a problem should be evaluated in order to understand the capacity of the soil for wastewater treatment. Clogging can result from biochemical reactions, excessive loading of organic and inorganic materials (both dissolved and particulate), accumulation of microbial tissues in soil pore spaces (Lehrsch and Robbins, 1996), excessive hydraulic loading, poorly designed sprinkler systems (Lehrsch and Kincaid, 2006), and impaired physical properties at and below soil surfaces (Lehrsch et al., 2005a; Lehrsch and Robbins, 1996).

Clogging generally occurs in the top few inches of soil. This can be seen as an organic mat that is largely independent of the coarseness of the soil. The continued existence of anaerobic conditions in the soil surface layer can lead to clogging. Anaerobic conditions result in a low rate of biological activity. This can result in sludge accumulation and production of ferrous sulfide.

In most cases, the organic material content of municipal wastewaters will not be the limiting factor in their rates of application. Industrial wastewaters such as from food processing, may, however, have a COD content sufficiently high to become a limiting factor. With the application of high strength wastewaters, oxygen may be quickly depleted. If the soil pores have been clogged by wastes or are waterlogged, the diffusion of air is restricted, the rate of decomposition is lowered and the chemical end products will differ. Some of these by-products cause nuisance odors. Odors can be controlled however by maintaining conditions favorable to aerobic (oxygen present) waste decomposition. Under anoxic (oxygen absent) conditions, some elements within the soil, such as iron and manganese, can be reduced to soluble and mobile forms. Smith et al. (1977), Smith et al. (1976), Smith and Hayden (1984), and Smith and Hayden (1980) have characterized the fate of land-applied organic and nutrient loadings of potato and sugarbeet processing wastewater, and resulting soil redox changes.

To help maintain aerobic conditions within the soil and to prevent associated problems, the yearly average organic loading rate should not exceed 50 pounds COD per acre per day. These guidelines are based on the application of wastewater all year long. This application rate is most commonly tied to the related nitrogen concentrations. The wastewater application rates can be increased for seasonal (summer) use but should be at or below soil assimilation rates, and at rates to insure ground water protection. Adequate dose-rest cycles will help alleviate soil clogging and eliminate oxygen depletion problems.

A guideline COD loading rate of 50 lb/ac-d (for both the growing and non-growing season) first appeared in the 1988 Wastewater Land Application Guidance, and has been in program guidance since that time. The origin of this rate is derived from Idaho-specific potato processing wastewater land application research of Smith et al. (1978). On page 11 of Smith et al. (1978), the summary section states that from 10 to 85 T/Ha COD was applied to fields without anaerobiosis developing 'near the surface, and therefore organic loading is not a limiting factor'. Table 2 of Smith et al. (1978; page 5) shows annual COD loadings ranging from 10 to 85 T/Ha (i.e. 22 lb/ac-d to 188 lb/ac-d). The median loading is about 28.5 T/Ha, or 63 lb/ac-d which was rounded to 50 lb/ac-d by writers of the 1988 guidance (Hamanishi, 2006).

4.2.2.2.2 Non-Growing Season COD Loading Rate

The COD loading of wastewater land treatment sites during the non-growing season, according to the Guidelines, is to be less than 50 lbs/acre/day based on a non-growing season average. It may be necessary to reduce this rate if the site is flood irrigated.

Justification for proposed COD loading during the non-growing season should be made for loadings near guideline rates. Such justification may reference empirical data (what has worked, or what has not), and/or may involve more theoretical approaches which take into consideration oxygen diffusion rates into soil, re-aeration times, soil porosity, temperature, and irrigation scheduling. See Sections 4.4.15 below for further discussion.

4.2.2.2.3 Growing Season COD Loading Rate

COD loading during the growing season, compared to non-growing season loading, is generally a less constraining design parameter. Nevertheless, justification for loadings in excess of the guideline rate of 50 lb/acre/day (based on a growing season average) should be provided as described in the Non-Growing Season COD Loading Rate section.

Carlisle and Phillips (1976) proposed a methodology for quantifying soil assimilative capacity for organic waste applied to land. This methodology is based upon the rate of oxygen diffusion into a soil to satisfy the oxygen demand imposed upon the soil system by the addition of organic waste. It is assumed that temperature is not a limiting factor, which is reasonable for growing season application. This methodology is described in Section 4.4.18.

4.2.2.3 Nutrients

A nutrient is any substance that promotes growth and can be taken up by plants or organisms. Wastewater generally contains nutrients, such as nitrogen (Section 4.2.2.4), phosphorus (Section 4.2.2.7), potassium, calcium, magnesium, iron, and sulfur. In a land treatment system, wastewater can provide essential nutrients to crops. If present at excessive levels, however, some nutrients can become pollutants.

4.2.2.3.1 Non-growing Season Nutrient Loading Rate (NLR_{ngs})

Nutrient loading of wastewater land treatment sites should be commensurate with crop needs, uptake, and efficiency of crop uptake. Non-growing season applications should be made so that applied nutrients are stored in the soils to be available during the subsequent growing season. Justification for non-growing season nutrient loading should demonstrate leaching of nutrients at rates and amounts which substantially protect beneficial uses of ground water and do not cause significant degradation of ground water or exceedance of ground water quality standards (IDAPA 58.01.11.200).

4.2.2.3.2 Growing Season Nutrient Loading Rate (NLR_{gs})

Determining growing season nutrient loading for crops depends upon many factors including pre-season soil nutrient status, crop, and yield goal. General rates for nitrogen loading have typically been 150% of crop uptake. This approach is somewhat general and allows for a 50% loss of N through various pathways including volatilization, denitrification, microbial/biomass fixation, and leaching. It does not take into consideration nitrogen resident in the soil profile, or nitrogen needs for a particular yield goal as do the University of Idaho crop nutrient guidelines. See Section 4.2.2.4.2 for further discussion of calculating nitrogen loading rates. Needs for other major nutrients such as phosphorus and potassium are also addressed in the University of Idaho crop nutrient guides (see also Section 4.2.2.7 for further discussion of phosphorus loading guidelines). The University of Idaho crop nutrient guides or demonstrated agronomic utilization may also be used to help determine appropriate nitrogen loading rates.

Regardless of the approach chosen, nutrient loadings need to result in compliance with the Ground Water Rule (IDAPA 58.01.11). Spring soil testing is generally needed to determine nitrogen and other nutrients resident in the soil at the beginning of the season, in order to calculate how much additional nitrogen or other nutrient should be applied to the management unit. Calculations and methodology to determine both nitrogen and phosphorus loading limit compliance are found in Sections 4.4.16 and 4.4.19. Fall soil testing can be useful for evaluating the efficiency of nitrogen removal at the end of the crop growing season.

4.2.2.4 Nitrogen

Nitrogen is an important constituent of wastewater and may be one of the main limiting factors in designing a system for wastewater treatment by land application. Therefore, the site's assimilative capacity for nitrogen is an important part of the design of a land treatment system. Nitrogen removal can be very efficient in the soil crop system.

4.2.2.4.1 Nitrogen in the Land Treatment System

Nitrogen is lost or removed from soil systems through several mechanisms including ammonia volatilization, denitrification, crop uptake and harvest, and leaching (Lehrsch et al., 2001). One of these mechanisms, denitrification, requires anaerobic conditions, yet the soil plant system requires an aerobic environment for proper functioning. While both aerobic and anaerobic conditions can coexist at times in soil profiles, but aerobic conditions generally predominate.

On a land treatment site, efforts must be made to control the leaching and runoff losses of nitrogen. Rapid water movement through the root zone via preferential flow paths or macropores such as earthworm burrows or old root channels, or through the porus matrix of the soil itself, which can occur with excess water application to soils, can increase nitrate levels in ground water (Lehrsch et al., 2005c; Wright et al., 1998). The basic approach to reduce leaching is to have a crop that will retain or use the nitrogen. This will help prevent excess nitrate accumulation and potential leaching problems and subsequent ground water pollution. The basic approach in controlling runoff is to implement best management practices to increase infiltration by, for example, paratilling or to minimize runoff by creating small water-storage basins or reservoirs on the site's surface (Lehrsch et al., 2005a). One should also create berms or dikes around the site to keep applied wastewater in place on the land treatment site. Runoff control engineering criteria are discussed further in Section 4.1.3.

Ammonium (NH_4^+) ions tend to remain in the soil and are held in the soil on clay and organic matter cation exchange sites. Ammonium ions can be utilized by both plants and microorganisms as a nitrogen source. Nitrogen as ammonia (NH_3) may be lost from the system as a gas through volatilization. Nitrite (NO_2^-), a highly mobile anion that can be toxic to higher plants, is an intermediate during the microbial conversion of ammonium to nitrate. Nitrite is seldom found in soil, however, because it is quickly converted to nitrate. NO_3^- is readily used by both plants and microorganisms. This completely soluble, highly mobile anion is of primary interest because of its potential impacts on ground water quality.

A soil's organic nitrogen, generally a much larger pool than the soil's inorganic nitrogen, is bound in carbon containing compounds. Examples of organic forms are nucleic acids, proteins (enzymes) and amino acids. Organic nitrogen is generally not available for direct plant uptake. An aerobic environment, however, allows microorganisms to transform organic nitrogen to NH_4^+ and, ultimately, to NO_3^-.

The nitrogen cycle (Figure 4-4) describes the reactions that nitrogen may undergo.

Nitrogen in wastewater may undergo oxidation-reduction reactions when wastes are added to the soil. These reactions are especially important in the case of nitrogen since it is potentially a serious pollutant in wastewater and its behavior in the soil is highly dependent on its state of oxidation. Organic nitrogen is mineralized to form NH_4^+ or NH_3. In well-aerated soil, NH_4^+/NH_3 is nitrified to NO_2^- and then NO_3^-, with the latter moving with the soil water. Under anaerobic soil conditions NO_3^- will be reduced to atmospheric nitrogen (N_2), nitrous oxide (N_2O), and nitric oxide (NO). N_2, N_2O, and NO are lost from the system as gases.

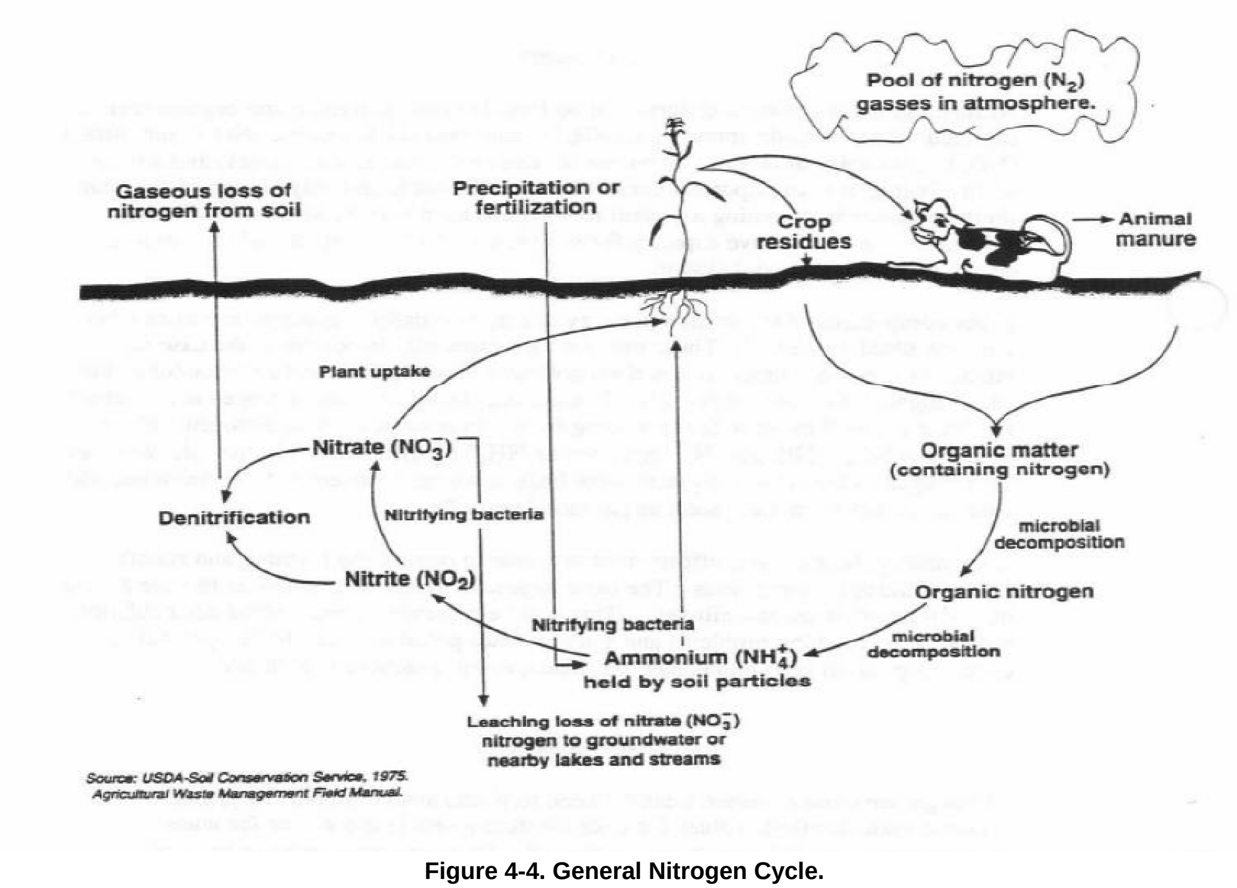

Figure 4-4. General Nitrogen Cycle.

4.2.2.4.2 Nitrogen Loading

The nitrogen loading rates depend upon a number of factors. The main factor is the requirement that the nitrate nitrogen levels of ground water outside the property boundaries of the application system do not exceed either the water quality standard of 10 mg/L NO_3-N, a level of significant degradation as determined by DEQ, or a permit specific level as determined by DEQ. See Section 7.2, *Ground Water Monitoring*, for more information. The previous section describes the different forms of nitrogen and how they are transformed into nitrate. It is therefore important to know the levels of organic nitrogen, ammonium (NH_4^+), and nitrite (NO_2^-) in addition to nitrate. The land treatment system must be operated in a manner that removes nitrogen based on the forms of nitrogen which are known to occur.

To protect ground water quality, keeping in mind that the wastewater application site is for treatment purposes, a design nitrogen application rate should be established. These guidelines recommend that nitrogen loading rates be based on crop uptake efficiency factors (e_f) of 0.60 for annual crops and 0.75 for perennial crops as determined for conditions in the northwest United States (Henry et al., 1999). Equation 4-4 shows how design nitrogen loading rates are calculated utilizing e_f.

$$N_{required} = \frac{N_{crop}}{e_f}$$

Equation 4-4. Nitrogen loading rates using e_f.

where N_{crop} is the content of nitrogen in both harvested and unharvested above-ground portions of the crop. The excess above N_{crop} is provided for normal losses of applied nitrogen over the needs of the crop by gaseous losses, leaching, and immobilization. Additional irrigation water should be adequate to allow for maximum plant growth and eventual harvest but the amounts of water applied should not be excessive (Lehrsch et al., 2001). It should be noted that factors such as high organic material loading to a land treatment site may, as previously mentioned, lower soil redox, increase denitrification, and consequently lower the uptake efficiency factor (e_f)

Alfalfa presents a unique problem when making required nitrogen calculations since it is able to fix atmospheric nitrogen in addition to its ability to take up plant available nitrogen (nitrate, ammonia) from the soil. It is thought that the proportion of alfalfa nitrogen fixation in a nitrogen adequate environment is 10 to 20 % of N_{crop} (Horneck, 2006), or 20 to 25% of N_{crop} according to Lamb et al. (1995) as cited in Hermanson et al. (no publication date). Therefore, calculations for $N_{required}$ may need adjustment to account for nitrogen fixation. Accounting for nitrogen fixation is particularly important in calculating nitrogen balances for ground water impact modeling. Equation 4-4 can be modified as follows:

$$N_{required} = \frac{\left(1 - N_{fixation}\right) * N_{crop}}{e_f}$$

Equation 4-5. Nitrogen loading rates accounting for nitrogen fixation.

Where $N_{fixation}$ is the proportion of N_{crop} which is fixed from the atmosphere. Alfalfa and certain other legume crops have the potential to contribute significant quantities of nitrogen to the soil when these crops are plowed down during normal rotation with other crops. This is due to large amounts of nitrogen which are "fixed and assimilated into leguminous plant roots, nodules and tops" (Carter, 1990). This nitrogen is then released upon plant death. Carter (1990) estimates that from 250 to 300 lb nitrogen/acre can be released the first year from alfalfa plowdown, with continuing significant release occurring three years after plowdown yielding a cumulative release of 350 to 450 lb nitrogen/acre. Nutrient sources from plowdown of legumes should be considered when designing for appropriate nutrient loading rates at land treatment sites.

Crop testing for nitrate as N should be conducted to determine the potential risk of nitrate poisoning. Table 7-30 in Section 7.7.9.1 gives examples of nitrogen demands and typical crop uptake for selected crops.

4.2.2.5 Salts, Salinity, and Sodium Influences

There are a number of potential problems associated with soluble salts and sodium in certain wastewaters when applied to the soil. This section discusses salts, salinity, and sodium influences from wastewater land application to wastewater land treatment sites.

4.2.2.5.1 Salts

Determining the appropriate salt loading rate for a wastewater land treatment site depends upon allowable impacts to the aquifer, aquifer characteristics, and soil quality for crop health. If there is an adequate supply of good quality, supplemental irrigation water nearby, salts can be managed in the soil profile so as not to accumulate to detrimental levels, even at relatively high salt loading rates. (See Sections 4.2.2.5.2 and 4.2.2.5.3 and Robbins and Gavlak, 1989). Determining appropriate salt loading rates for ground water protection may involve ground water modeling, such as mixing zone modeling. Modeling is usually indicated for sites proposing or having elevated salt loadings. A salt mass balance is calculated along with the hydraulic balance. Predicted salt mass losses and percolate losses are mathematically routed to the aquifer and mixed to obtain a predicted ground water constituent concentration at the down-gradient boundary (See Section 7.7.5.2). Different scenarios of the model can be run, varying salt loading among other parameters, until acceptable predicted ground water impacts are obtained. Salt loading resulting in acceptable predicted impacts would be a first approximation of an appropriate loading rate. Sensitivity analysis, model calibration, and validation are also necessary.

Because of the need to protect ground water quality and sustain soil productivity Permitted wastewater land treatment facilities causing significant TDS impacts to ground water, or which pose a risk of causing significant impacts, should develop site specific TDS Management Plans. Plans should include, but not be limited to, the following:

- identification of representative monitoring sites to measure TDS,
- characterization of all known sources of inorganic TDS,
- analysis of alternatives to isolate and reduce TDS being generated or land applied,
- evaluation of the expected improvements to ground water quality, and
- an implementation schedule for TDS reduction

The approach described above is a passive remedial one and may not be appropriate for a facility that has or is currently impacting a ground water supply well. If a public water supply or a private water supply is contaminated by wastewater land treatment activities as described in IDAPA 58.01.11.400, actions on the part of DEQ and/or the facility may be indicated, also as described in Section 400.

4.2.2.5.2 Salinity

High levels of salt in the soil solution may reduce the yield of vegetation or crops grown on the site and adversely impact soil structure which can significantly reduce soil permeability. In most cases salinity will not be a limiting factor. However, considerations should be given to the influence of salt loading to wastewater land treatment sites.

Salinity effects on plants are categorized as: 1) ionic interference; 2) changes in osmotic or diffusion relationships; and 3) toxicity of chemical species. Wastewater high in salts when applied to land can raise the osmotic potential of the soil solution. An excessive rise in the osmotic potential of the soil solution may hinder or prevent plant water uptake. Some of the visible effects of excess salinity are reductions in both total plant size and the growth rate, leaf tip burn, leaf necrosis, and leaf yellowing (Robbins and Gaylak, 1989). Salt-affected plants do not respond to the application of fertilizers because they further increase the osmotic potential of the soil solution and compound the salinity effects.

The salinity of wastewater can be estimated from its electrical conductivity. Electrical conductivity is in turn related to total dissolved solids by the following general equation: TDS (mg/L) = 0.64 * EC (mhos/cm). Each wastewater will have a unique TDS/EC relationship depending upon content of soluble organic or other non-charged species, and type and activity of soluble salts among other factors. It is advisable to irrigate with wastewater, or wastewater/irrigation water mix, which has an electrical conductivity which would not cause foliar burn, plant toxicity, yield decrement etc. USDA Agricultural Handbook No. 60 (U.S. Salinity Laboratory Staff, 1954, Figure 25 and associated text) discusses salinity classifications of irrigation waters and their respective hazards, based upon EC levels. Also shown are classifications of sodium hazards of irrigation waters, based upon SAR levels (see further discussion below). This reference should be consulted when evaluating loading onto wastewater land treatment sites. See the following Web site for further information:

http://www.ars.usda.gov/SP2UserFiles/Place/53102000/hb60_pdf/Hb60ch5.pdf

See also Tanji (1990) for a more recent text.

4.2.2.5.3 Sodium Influences

Sodium (Na^+) is an important constituent of certain wastewaters. When wastewater containing high concentrations of sodium is land-applied, many clay minerals can swell, which hinders or prevents infiltration and reduces water movement through the soil. This tendency occurs when the ratio of sodium to other cations (positively charged ions) is high. This relationship is called the sodium adsorption ratio (SAR) of a wastewater sample or soil extract. The SAR of wastewater should be evaluated frequently, especially when irrigating heavy clay soils.

The importance of Na, calcium (Ca^{2+}), and magnesium (Mg^{2+}) is due to their impact on soil structure, which is a major determinant of water movement and wastewater treatment. Soils with high levels of exchangeable sodium are called sodic soils, and are defined as soils with sodium adsorption ratios (SARs) greater than 15 (Bohn, et al. 1979). To soils with SARs of 10 to 15, one should apply, then incorporate gypsum or calcium chloride or, if the soil contains lime near the surface, elemental sulfur or ferrous sulfate to maintain acceptable soil structure and allow for water infiltration as the SAR is decreased through irrigation and drainage (Kotuby-Amacher and Koenig, 1999; Robbins and Gavlak, 1989). The relationship between the salinity and SAR of irrigation water is critical to soil infiltration capacity, as shown in Figure 4-5. Both crop growth and runoff characteristics of a site can be affected by changes in soil infiltration rates.

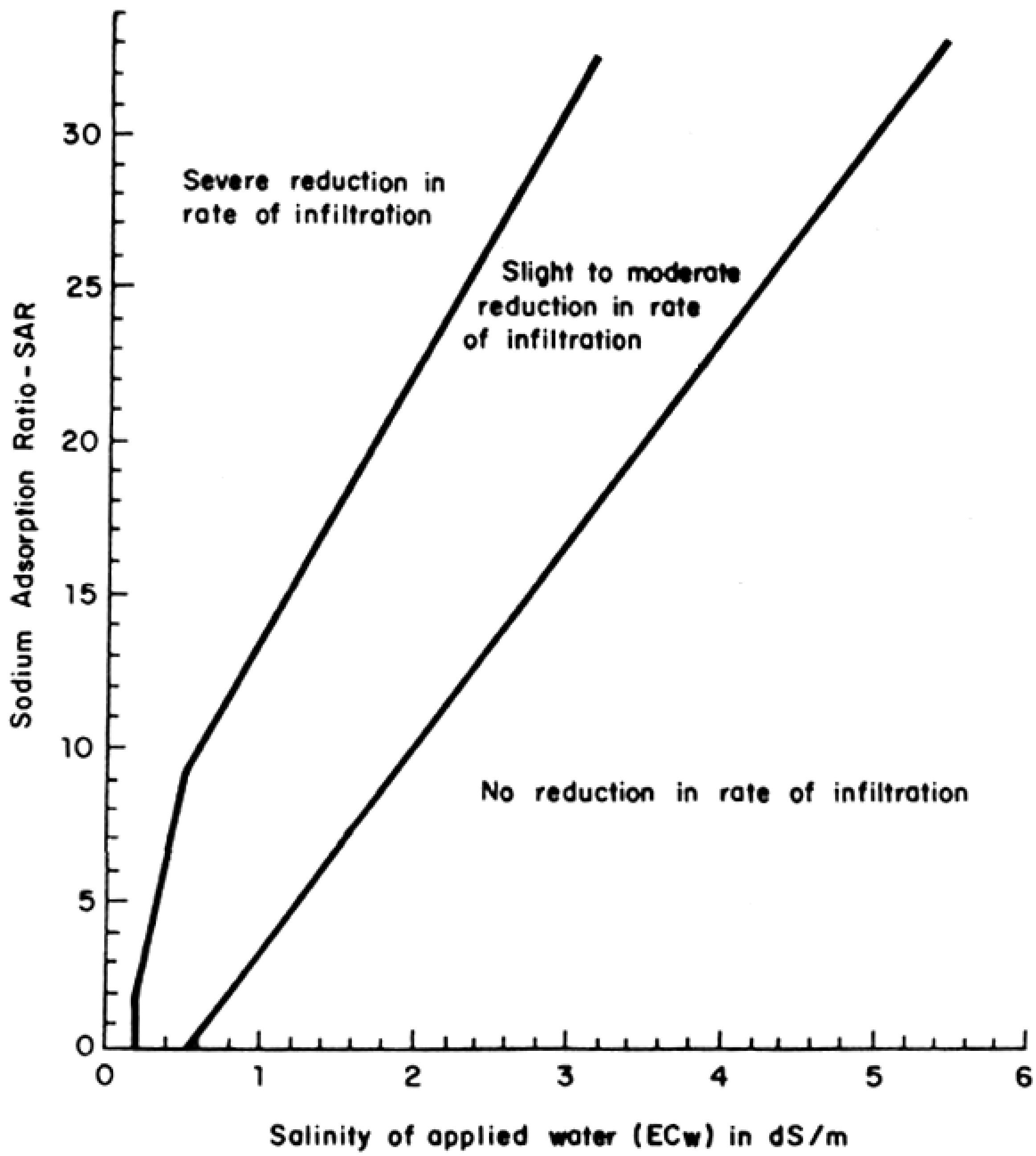

Figure 4-5. SAR as a function of salinity of applied water.

High sodium in wastewater will unfortunately displace calcium and magnesium from the soil's cation exchange sites, leaving high sodium concentrations in the soil. Excessive sodium in soils disperses soil colloids and causes clays to swell. Soil structure collapses and water movement is severely restricted. Decreases in soil hydraulic conductivity reduces the water intake and transmission capacity at a site. Such reductions in soil permeability should be avoided.

The degree to which sodium influences soil structure, and thus the degree to which SAR affects infiltration is soil-specific. For example, coarse-textured soils like sands are generally less affected by exchangeable sodium than are fine-textured soils such as clays. Soils containing expanding-type clays, such as montmorillonite, swell and disperse at an increasing rate with increased soil sodium levels.

Since sodium, can cause soil structural problems, the levels of Na, Ca and Mg should be determined in each horizon of the soil profile. An index of sodium influence upon waters, wastewaters, and soils is the sodium adsorption ratio (SAR). The equation for SAR is as follows:

$$SAR = \frac{[Na^{+}]}{\sqrt{\frac{[Ca^{2+}] + [Mg^{2+}]}{2}}}$$

Equation 4-6. Calculation of sodium adsorption ration (SAR).

where Na, Ca, and Mg are measured in milli-equivalents per liter (meq/L) in a soil solution extract or water sample (See Section 7.4.3 for further information). Exchangeable sodium percentage (ESP) is another measure of the Na content, relative to other cations, on soil's cation exchange sites.

4.2.2.6 Heavy Metals

Heavy metals are generally of little concern at wastewater land treatment sites, but there can be facility-specific exceptions. Soils can assimilate heavy metals. Metals are stable and often resist weathering and decomposition. Trace element removal in the soil system is a complex process involving the mechanisms of adsorption, ion exchange, precipitation, and complexation. Adsorption of most trace elements occurs on the surfaces of clay minerals, organic matter, and metal oxides. Cationic species are generally adsorbed, whereas anions tend to be repelled from the clay's negatively charged surfaces. This makes for differences in the rate at which applied anions and cations move through the soil.

Cations in exchangeable forms generally remain in place on the clay's exchange sites until replaced by another cation. The ability of a soil to retain various cations in exchangeable form depends on several factors, with degree of hydration and valence or charge of the cation being among the most important. On the other hand, anions tend to move with water and generally accumulate near the wetting front of water moving as piston-type flow through the soil.

The magnitude of the exchange reactions depends upon the cation exchange capacity (CEC) of the soil which is a function of the type and quantity of clay and organic matter. In general, soils with more clay and organic matter have higher CECs, and have a larger adsorption capacity for trace elements than sandy soils. Such soils have a resulting higher cation retention capacity. Metals are nearly all removed in high CEC soils, which are suitable for slow rate systems.

Therefore in many land treatment systems, metal removal will not be a limiting factor. Because of the potential health effects of metals, however, it is necessary to properly manage wastewater application sites to minimize the effects of metals on human health and the environment. Most, but not all, plants generally limit the uptake of metals from the soil. However, metals that accumulate on plant leaves through irrigation enter various food chains, where they become part of the life cycle of soil, plants, animals, and humans, possibly accumulating in animal and human body tissue to toxic levels. This situation is especially critical for humans, who reside at the top of the food chain.

Some metals, then, can be toxic to plants and consumers of plants. Toxicity problems can be reduced by maintaining the soil pH above 6.5. Ceiling concentrations, annual loading levels, and maximum loadings over the life of a land treatment system for several metals (see Tables 1 through 3 – Section 4.4.19) have been prescribed in 40 CFR 503.13 Subpart B: Land Application for land applied sewage sludge.

4.2.2.7 Phosphorus

Phosphorus (P) is a required nutrient for crop growth. It is also a major contributor of pollution to streams, causing algae blooms, low dissolved oxygen, undesirable plant growth, and fish kills. Phosphorus can reach streams by runoff from sites or inflow from aquifers that provide baseflow to streams and rivers. Phosphorus has been implicated in the pollution of surface waters throughout the U.S., including Idaho. Phosphorus leaching from wastewater land treatment sites may present a risk of contamination to surface water depending on site-specific hydrologic conditions. To protect surface waters from the effects of excess phosphorus, surface runoff and deep percolation of phosphorus must be controlled. Surface runoff can contain significant amounts of dissolved and precipitated phosphorus.

Phosphorus applied to the soil surface can be stored in the soil profile by precipitation and adsorption to soil particles. Eventually, with significant phosphorus loading, phosphorus can migrate to lower soil levels and even below the root zone. Once it goes beyond the root zone the phosphorus is unavailable for crop uptake. Soil parent material (which may be coarser textured) and underlying rock in the vadose zone frequently have a lower phosphorus sorption potential than the soil. There is the risk that phosphorus may breakthrough to ground water, which in turn can transport phosphorus from the site to other areas.

The concern for phosphorus contamination of surface water should be addressed in the development of Reuse permits. Applying runoff control technologies to limit surface runoff can prevent or mitigate environmental impacts related to surface runoff. Examples of these practices include applying water or wastewater at a rate less than the infiltration capacity of the soil, uniform sprinkler application, and using berms, ponds, and other runoff control structures. Controlling the application, soil accumulation, and leaching of phosphorus can prevent or mitigate impacts to surface water from ground water interconnections.

4.2.2.7.1 Phosphorus Guidelines

The Wastewater Reuse Permit Program recommends the following process to manage the risk of surface water being impaired by phosphorus applied to land treatment sites. This approach is designed to assure compliance with surface water quality standards for nutrients.

Surface Runoff

Surface runoff concerns should be addressed according to Section 4.1.3. Site closure plans should consider accumulated phosphorus in the surface soils. Soil P upon completion of closure must not pose a threat to surface waters as a result of future irrigation practices or lack of adequate runoff control structures.

Ground Water Interconnection

For sites likely to have a ground water interconnection with surface water, the following approach is suggested:

- Site-specific analysis, information, or other justification may be available that indicates that there is no ground water interconnection and discharge to surface water. In the absence of this information the following goals should be considered for the ground water and the soil when preparing the Reuse permit.
- Ground water concentrations at down-gradient compliance wells should be less than 0.1 mg/L total phosphorus. However, if the ortho P concentration (i.e. concentration of phosphate ion expressed as P) in up gradient ground water is greater than 0.1 mg/L, no increase in phosphorus should be allowed to occur at down gradient compliance wells.
- Achievement of an alternate goal, based on a ground water phosphorus allocation contained in a Total Maximum Daily Load (TMDL), should be attained.
- Plant available soil phosphorus values measured in the 24"-36" soil depth increment should be less than the following.
    - 20 ppm P (by the Olsen method[1]) or 25 ppm (by the Bray method[2]) if ground water is less than 5 feet from the ground surface, or
    - 30 ppm P (the Olsen method) or 50 ppm (by the Bray method) if ground water is greater than 5 feet from the ground surface
- If phosphorus levels exceed the goals established, then one of the following courses of action should be taken.
    - A permit holder may prepare a site-specific analysis that demonstrates an alternative limit or approach is protective of potentially impacted surface waters. Upon approval by DEQ, this alternate limit or approach may be incorporated into the permit or otherwise used as appropriate.

[1] "Olsen method" refers to the Olsen ($NaHCO_3$ extractant) method for determining plant available soil phosphorus. This method is applicable to calcareous soils with >2% $CaCO_3$. See "Methods of Phosphorus Analysis for Soils, Sediments, Residuals, and Waters," Southern Cooperative Series Bulletin No. 396.

[2] "Bray method" refers to the Bray method for determining plant available soil phosphorus. This method is applicable to acid and neutral soils with < 2% $CaCO_3$. See "Methods of Phosphorus Analysis for Soils, Sediments, Residuals, and Waters," Southern Cooperative Series Bulletin No. 396.

- In the absence of any site-specific analysis and alternate limits or approaches approved by DEQ, a permit limitation for phosphorus loading should be considered at 100% of crop uptake.

4.2.2.7.2 Phosphorus Monitoring

Phosphorus, like nitrogen, occurs in several forms in wastewater and is an essential element for biological growth and reproduction. Phosphorus can be present as orthophosphate, polyphosphate, and organic phosphate. These forms are often measured in combination, as total phosphate (total phosphorus) In domestic wastewater, total phosphorus levels generally range from 2 to 20 mg/L, including 1 to 15 mg/L of organic phosphorus and 1 to 15 mg/L of inorganic phosphorus. Total phosphorus levels in food processing wastewaters are generally higher and vary depending upon wastewater type.

Soil monitoring for plant available phosphorus, using the methods described in Section 4.2.2.7.1, appropriate for the soil type may be required. Soil sampling frequency and depth intervals to be sampled should be specified by DEQ in the Reuse permit.

Ground water monitoring for ortho phosphorus will normally be required. Frequency and locations for monitoring should be specified by DEQ in the Reuse permit. Calculations and methodology to determine phosphorus loading limit compliance is found in Section 4.4.19.

4.2.2.8 Hazardous Wastes

Land application of wastewaters containing hazardous wastes will not be allowed unless the type, concentration and amount can be identified and determined that it is not regulated as hazardous waste, and will not adversely affect the beneficial uses of waters of the State or public health. . In situations where the nature of the wastewater is such that it is not regulated by the regulations discussed below, an evaluation of the suitability for treatment by land application will be made by the Department of Environmental Quality (DEQ) on a case-by-case basis. The key element that determines the feasibility of land application as a wastewater treatment alternative is the ability of the soil crop system to treat, not just dispose, of the wastewater in question.

Wastewater land treatment systems are subject to the Idaho Hazardous Waste Management Act (HWMA) of 1983 and the Rules and Standards for Hazardous Waste IDAPA 58.01.05. The primary purposes of the Federal Resource Conservation and Recovery Act (RCRA) is to provide "cradle to grave" management of hazardous wastes, solid wastes, and regulation of underground storage tanks. Hazardous wastes are subject to regulation in their generation, transport, treatment, storage and disposal under RCRA, Subtitle C. In Idaho, DEQ has primacy to administer the hazardous waste (RCRA) program under the HMWA. Please direct any inquiries regarding hazardous waste management, testing requirements to determine if a waste is hazardous, or any other issues pertainant to hazardous wastes to RCRA/HWMA DEQ personnel.

Underground storage tanks are regulated according to their contents. RCRA, Subtitle C regulates those underground storage tanks that contain hazardous wastes. The 1984 Amendments to RCRA added Subtitle I, which regulates underground storage tanks containing chemical and petroleum products. Contact DEQ with questions regarding underground storage tanks containing hazardous wastes or questions regarding the requirements for underground storage tanks containing chemical or petroleum products.

The Rules Regulating the Disposal of Radioactive Materials not Regulated under the Atomic Energy Act of 1954, as Amended IDAPA 58.01.10 govern disposal of wastes containing radioactive substances.

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4.4 Supplementary Materials for Hydraulic and Constituent Loading

4.4.1 Cropping Season Table (NRCS Data)

Table 4-4 (USDA - National Resource Conservation Service. National Engineering Handbook - Irrigation Guide, Title 210, Chapter VI, Part 652.0408, September 1997.

		Growing Season			
Climatic		Julian Dates		Calendar Dates	
Area	Crop	Spring	Fall	Spring	Fall
I	Alfalfa & Clovers	98	283	8-Apr	10-Oct
I	Alfalfa Grass	74	304	15-Mar	31-Oct
I	Alfalfa Seed	98	196	8-Apr	15-Jul
I	Beans	145	245	25-May	2-Sep
I	Corn, Field (Grain)	125	265	5-May	22-Sep
I	Corn, Field (Silage)	125	259	5-May	16-Sep
I	Corn, Sweet	125	227	5-May	15-Aug
I	Grain, Small Spring	82	196	23-Mar	15-Jul
I	Hops	100	243	10-Apr	31-Aug
I	Melons & Cantaloupes	121	267	1-May	24-Sep
I	Mint	98	235	8-Apr	23-Aug
I	Onions	91	258	1-Apr	15-Sep
I	Orchard (with Clover)	100	304	10-Apr	31-Oct
I	Pasture	74	304	15-Mar	31-Oct
I	Potatoes	141	253	21-May	10-Sep
I	Sugar Beets	100	283	10-Apr	10-Oct
IA	Alfalfa	101	293	11-Apr	20-Oct
IA	Corn, Sweet	122	186	2-May	5-Jul
IA	Cucumbers	130	263	10-May	20-Sep
IA	Grain	100	207	10-Apr	26-Jul
IA	Orchards with cover	101	304	11-Apr	31-Oct
IA	Peppers	125	263	5-May	20-Sep
IA	Squash	121	293	1-May	20-Oct
IA	Tomatoes	121	253	1-May	10-Sep
IB	Alfalfa	105	265	15-Apr	22-Sep
IB	Grain	108	227	18-Apr	15-Aug
IB	Grass Seed, Blue	105	191	15-Apr	10-Jul
II	Alfalfa, Seed & Clovers	115	276	25-Apr	3-Oct
II	Alfalfa Grass	98	298	8-Apr	25-Oct
II	Beans, Dry	143	244	23-May	1-Sep
II	Beans, Pole	161	232	10-Jun	20-Aug
II	Corn, Field	135	266	15-May	23-Sep
II	Corn, Sweet	135	230	15-May	18-Aug
II	Grain	91	220	1-Apr	8-Aug
II	Grass Seed & Gras Pasture	98	298	8-Apr	25-Oct
II	Peas; Dry & Lentils	110	213	20-Apr	1-Aug
II	Peas, Green	110	182	20-Apr	1-Jul
II	Potatoes	136	266	16-May	23-Sep
II	Sugar Beets	100	276	10-Apr	3-Oct
III	Alfalfa, Seed & Clovers	125	263	5-May	20-Sep
III	Alfalfa Grass	110	288	20-Apr	15-Oct
III	Beans, Dry	155	255	4-Jun	12-Sep
III	Beans, Pole	152	227	1-Jun	15-Aug
III	Corn, Field	147	237	27-May	25-Aug
III	Corn, Sweet	100	230	10-Apr	18-Aug
III	Grain	100	230	10-Apr	18-Aug
III	Grass Seed & Gras Pasture	110	288	20-Apr	15-Oct
III	Peas, Dry	121	220	1-May	8-Aug
III	Peas, Green	121	191	1-May	10-Jul
III	Potatoes	125	255	5-May	12-Sep
III	Sugar Beets	100	263	10-Apr	20-Sep
III	Truck "B"	152	263	1-Jun	20-Sep
IV	Alfalfa	128	258	8-May	15-Sep
IV	Alfalfa Grass	121	291	1-May	18-Oct
IV	Grass Pasture & Gras Seed	121	291	1-May	18-Oct
IV	Small Grain	130	232	10-May	20-Aug
IV	Potatoes	152	253	1-Jun	10-Sep
V	Alfalfa	148	251	28-May	8-Sep
V	Alfalfa Grass	129	288	9-May	15-Oct
V	Clovers	148	251	28-May	8-Sep
V	Small Grain	145	244	25-May	1-Sep
V	Grass Pasture & GrassSeed	129	288	9-May	15-Oct
V	Seed Potatoes	152	227	1-Jun	15-Aug
VI	Silage Corn	125	259	5-May	16-Sep
VI	Potatoes	127	258	7-May	15-Sep
VI	Spring Grain	105	235	15-Apr	23-Aug
VI	Winter Grain	74	234	15-Mar	22-Aug
VI	Fruit Trees (w/Cover)	121	288	1-May	15-Oct
VI	Vegetables	145	274	25-May	1-Oct

4.4.2 Agrimet Weather Station Reference Table

Table 4-5. Agrimet weather station reference table.

Pacific Northwest Cooperative Agricultural Network
Agrimet Weather Station Locations

Station ID	Station Name	State	Elevation	Latitude	Longitude	Install Date
CEDC	Cedarville	CA	4600	41 35 07	120 10 17	4/24/1985
ABEI	Aberdeen	ID	4400	42 57 12	112 49 36	3/20/1991
AHTI	Ashton	ID	5300	44 01 30	111 28 00	6/2/1987
BOII	Boise	ID	2720	43 37 15	116 11 10	7/31/1995
FAFI	Fairfield	ID	5038	43 18 30	114 49 30	6/25/1987
FTHI	Fort Hall	ID	4445	43 04 17	112 25 52	4/2/1993
GDVI	Grand View	ID	2580	42 54 45	116 03 22	2/10/1993
GFRI	Glenns Ferry	ID	3025	42 52 00	115 21 25	4/13/1993
KTBI	Kettle Butte	ID	5135	43 32 55	112 19 33	10/1/1996
MALI	Malta	ID	4410	42 26 15	113 24 50	6/2/1983
MNTI	Monteview	ID	4855	44 00 54	112 32 09	10/1/1996
NMPI	Nampa	ID	2634	43 26 30	116 38 13	3/11/1996
PICI	Picabo	ID	4900	43 18 42	114 09 57	4/21/1993
PMAI	Parma	ID	2305	43 48 00	116 56 00	3/28/1986
RPTI	Rupert	ID	4155	42 35 42	113 50 17	3/9/1988
RXGI	Rexburg	ID	4875	43 51 00	111 46 00	6/3/1987
TWFI	Twin Falls (Kimberl	ID	3920	42 32 46	114 20 43	5/4/1990
COVM	Corvallis	MT	3597	46 20 00	114 05 00	4/27/1984
CRSM	Creston	MT	2950	48 11 15	114 07 40	5/4/1988
DRLM	Deer Lodge	MT	4680	46 20 08	112 46 00	6/4/1998
RDBM	Roundbutte	MT	3040	47 32 22	114 16 50	5/23/1989
SIGM	St. Ignatius	MT	2940	47 18 48	114 05 53	3/28/1991
EURN	Eureka	NV	5897	39 41 07	115 58 43	8/8/2001
FALN	Fallon	NV	3965	39 27 29	118 46 37	3/27/2001
ARAO	Aurora	OR	140	45 16 55	122 45 01	10/22/1998
BANO	Bandon	OR	80	43 05 28	124 25 02	5/15/1985
BKVO	Baker Valley	OR	3420	44 52 55	117 57 49	5/11/2001
BRKO	Brookings	OR	80	42 01 48	124 14 27	9/28/1999
CHVO	Christmas Valley	OR	4360	43 14 29	120 43 41	4/22/1985
CRVO	Corvallis	OR	230	44 38 03	123 11 24	2/27/1990
DEFO	Dee Flat	OR	1260	45 34 25	121 38 50	2/21/1990
ECHO	Echo	OR	760	45 42 40	119 21 00	3/24/1988
FOGO	Forest Grove	OR	180	45 33 11	123 05 01	8/29/1991
HERO	Hermiston	OR	550	45 49 16	119 30 44	5/17/1983
HOXO	Hood River	OR	510	45 41 04	121 31 05	5/19/1987
HRFO	Hereford	OR	3600	44 29 17	118 01 12	4/29/1998
HRMO	Hermiston (Harec)	OR	607	45 49 10	119 17 00	7/15/1993
IMBO	Imbler	OR	2750	45 26 00	117 58 00	4/5/1994
KFLO	Klamath Falls	OR	4100	42 09 53	121 45 18	3/31/1999
LAKO	Lakeview	OR	4770	42 07 20	120 31 23	4/19/1988
LORO	Lorella	OR	4160	42 04 40	121 13 27	3/31/2001
MDFO	Medford	OR	1340	42 19 52	122 56 16	5/23/1989
MRSO	Madras	OR	2440	44 40 48	121 08 55	5/2/1984
ONTO	Ontario	OR	2260	43 58 40	117 00 55	4/30/1992
PARO	Parkdale	OR	1480	45 32 40	121 37 00	10/20/1989
PCYO	Prairie City	OR	3752	44 26 27	118 37 40	4/12/1989
PNGO	Pinegrove	OR	620	45 39 00	121 30 20	10/20/1989
POBO	Powell Butte	OR	3200	44 14 54	120 56 59	9/21/1993
WRDO	Worden	OR	4080	42 01 01	121 47 13	4/19/2000
GERW	George	WA	1150	47 02 38	119 38 32	5/15/1986
GOLW	Goldendale	WA	1680	45 48 43	120 49 28	11/27/1991
HRHW	Harrah	WA	850	46 23 05	120 34 28	5/27/1987
LEGW	Legrow	WA	580	46 12 19	118 56 10	7/17/1986
LIDW	Lind	WA	1475	46 52 02	118 44 22	5/18/1983
MASW	Manson	WA	1972	47 55 01	120 07 28	11/9/1993
ODSW	Odessa	WA	1650	47 18 32	118 52 43	4/24/1984
OMAW	Omak	WA	1235	48 24 09	119 34 34	1/25/1989
AFTY	Afton	WY	6210	42 44 00	110 56 09	10/20/1987

4.4.3 Growing Season Data from Agrimet

Table 4-6. Agrimet growing season data.

Group 1 **Crop Dates**

Stations: ARAO BANO BRKO CRVO ECHO FALN FOGO HERO HRMO LEGW MDFO

Crops	Extremely Early			Very Early			Early			Average			Late			Very Late			Extremely Late		
	S	C	T	S	C	T	S	C	T	S	C	T	S	C	T	S	C	T	S	C	T
Alfalfa	2/15	4/20	10/15	2/20	4/20	10/15	2/25	4/25	10/15	3/05	5/05	10/15	3/15	5/10	10/15	3/25	5/15	10/15			
Pasture	2/10	4/10	10/15	2/15	4/10	10/15	2/20	4/15	10/15	3/01	4/25	10/15	3/10	5/01	10/15	3/20	5/05	10/15			
Lawn				2/15	4/10	10/15	2/20	4/05	10/15	3/01	4/15	10/15	3/10	4/20	10/15	3/20	4/25	10/15			
Grass Hay										3/01	5/05	10/30									
Winter Grain	2/01	4/20	7/01	2/10	4/25	7/01	2/15	5/01	7/10	2/25	5/05	7/10	3/05	5/10	7/15	3/15	5/15	7/20			
Spring Grain				3/01	5/20	7/10	3/05	5/25	7/15	3/10	6/01	7/20	3/15	6/05	7/25	3/25	6/10	8/01	4/01	6/15	8/05
Spring Grain 2				3/15	6/01	7/20	3/20	6/05	7/25	3/25	6/10	8/01	4/01	6/15	8/05	4/10	6/20	8/10	4/20	6/15	8/05
Potato Shepody																					
Potato Russet				3/20	6/05	8/10	3/25	6/10	8/15	4/05	6/15	8/20	4/15	6/20	8/25	5/01	6/20	9/01			
Potato Russet 2				4/05	6/15	8/15	4/10	6/20	8/20	4/20	6/25	8/25	5/01	7/01	9/01	5/15	7/01	9/05			
Potato Russet 3				4/20	6/25	8/20	4/25	7/01	8/25	5/05	7/05	9/01	5/15	7/10	9/05	6/01	7/10	9/10			
Dry Beans				4/15	6/05	8/10	4/20	6/10	8/15	4/25	6/15	8/20	5/01	6/20	8/20	5/10	6/25	8/25			
Dry Beans 2				5/05	6/20	8/20	5/10	6/25	8/25	5/15	7/01	9/01	5/20	7/05	8/25	6/01	7/10	9/05	7/01	8/05	9/25
Field Corn				3/25	6/25	8/25	4/01	7/01	9/01	4/10	7/05	9/05	4/20	7/10	9/05	5/01	7/10	9/10			
Field Corn 2				4/10	7/05	9/05	4/15	7/10	9/10	4/25	7/15	9/15	5/05	7/20	9/15	5/15	7/20	9/20	6/01	8/01	9/30
Sweet Corn				3/25	6/25	8/01	4/01	7/01	8/05	4/10	7/05	8/10	4/20	7/10	8/15	5/01	7/10	8/20			
Sweet Corn 2				4/10	7/05	8/10	4/15	7/10	8/15	4/25	7/15	8/20	5/05	7/20	8/25	5/15	7/20	9/01	5/25	7/25	9/10
Sweet Corn 3				4/10	7/05	8/10	4/15	7/10	8/15	4/25	7/15	8/20	5/05	7/20	8/25	6/25	8/30	10/05			
Sugar Beets																					
Onions				3/01	6/15	8/05	3/05	6/20	8/10	3/15	6/25	8/15	3/25	7/01	8/20	4/05	7/05	8/25	4/10	7/10	8/30
Garlic																					
Apples				3/10	5/05	10/01	3/15	5/10	10/05	3/20	5/15	10/05	4/01	5/20	10/05	4/15	5/25	10/10	4/25	6/01	10/10
Pears				3/10	7/01	9/01	3/15	7/05	9/05	3/20	7/10	9/10	4/01	7/15	9/15	4/10	7/20	9/20			
Peaches				3/10	7/01	9/01	3/15	7/05	9/05	3/20	7/10	9/10	4/01	7/15	9/15	4/10	7/20	9/20			
Asparagus				2/25	7/05	9/10	3/01	7/10	9/15	3/05	7/15	9/20	3/15	7/20	9/20	4/01	8/01	9/25	4/10	8/01	9/25
Peas/Lentils							3/25	5/25	6/25	4/10	6/01	7/01	4/15	6/05	7/05						
Peppermint				3/05	5/20	7/15	3/10	5/25	7/20	3/20	6/01	7/25	4/01	6/05	8/01	4/10	6/10	8/05			
New Mint																					
Bluegrass Seed										3/01	5/01	7/05	3/10	5/05	7/10						
Carrot Seed																					
Concord Grape				3/15	6/01	9/05	3/20	6/05	9/10	3/25	6/10	9/10	4/01	6/15	9/15	4/05	6/20	9/20	4/25	7/01	9/20
Wine Grape				3/25	6/05	9/15	4/01	6/10	9/20	4/05	6/15	9/20	4/10	6/20	9/25	4/15	6/25	9/30	5/05	7/10	9/30
Cabbage				4/15	6/20	8/01	4/20	6/25	8/05	5/01	7/05	8/10	5/05	7/10	8/15	5/10	7/15	8/20			
Broccoli				3/10	7/01	8/10	3/15	7/05	8/15	3/20	7/10	8/20	3/25	7/15	8/25	4/01	7/20	9/01			
Cranberries				2/15	4/01	10/10	2/20	4/05	10/15	3/01	4/10	10/15	3/10	4/15	10/15	3/20	4/20	10/15			
Strawberries	2/20	4/15	8/15	2/25	4/20	8/15	3/01	4/25	8/20	3/05	4/25	8/25	3/10	5/01	9/01	3/20	5/10	9/05			
Trailing Berries				3/10	5/15	7/10	3/15	5/20	7/15	3/20	5/25	7/20	3/25	6/01	7/25	4/01	6/05	8/01	4/15	6/05	8/01
Blue Berries				3/10	5/25	8/01	3/15	6/01	8/05	3/20	6/05	8/10	3/25	6/10	8/15	4/01	6/15	8/20			
Rape Seed										3/15	5/20	7/01									
Cherries																					
Poplar																					
Melon										5/10	7/15	8/15									
Easter Lilies										2/01	6/15	10/30									

Group 2 **Crop Dates**

Stations: BOII GDVI GERW GFRI HOXO HRHW MASW NMPI OMAW ONTO PMAI

Crops	Extremely Early			Very Early			Early			Average			Late			Very Late			Extremely Late		
	S	C	T	S	C	T	S	C	T	S	C	T	S	C	T	S	C	T	S	C	T
Alfalfa				3/01	5/01	10/10	3/05	5/05	10/10	3/15	5/15	10/10	3/25	5/20	10/10	4/01	5/20	10/10			
Pasture				2/25	4/20	10/10	3/01	4/25	10/10	3/10	5/05	10/10	3/20	5/10	10/10	3/25	5/10	10/10			
Lawn				2/25	4/10	10/15	3/01	4/15	10/10	3/10	4/25	10/10	3/20	5/01	10/10	3/25	5/01	10/10			
Grass Hay										3/10	5/15	10/30	3/20	5/20	10/30						
Winter Grain				2/20	5/05	7/05	2/25	5/10	7/15	3/05	5/15	7/15	3/15	5/25	7/20	3/20	5/25	7/20			
Spring Grain				3/05	6/01	7/15	3/10	6/05	7/20	3/15	6/10	7/25	3/25	6/15	8/01	4/15	6/20	8/05			
Spring Grain 2				3/20	6/10	7/25	3/25	6/15	8/01	4/05	6/20	8/05	4/10	6/25	8/10	4/25	7/01	8/15			
Potato Shepody				4/05	6/01	9/01				5/01	6/10	8/10	5/01	6/10	9/01	5/10	6/15	9/01	5/15	6/25	9/05
Potato Russet				4/05	6/15	9/01	4/10	6/20	9/05	4/20	6/15	9/05	5/01	7/01	9/15	5/15	7/05	9/15	5/25	7/10	9/20
Potato Russet 2				4/20	6/25	9/05	4/25	7/01	9/10	5/05	6/25	9/10	5/15	7/10	9/20	5/25	7/10	9/20	6/01	7/15	9/20
Potato Russet 3				5/05	7/05	9/10	5/10	7/10	9/15	5/20	7/05	9/15	6/01	7/20	9/25						
Dry Beans				5/05	6/15	8/15	5/10	6/20	8/20	5/15	6/25	8/25	5/20	7/05	8/25	5/25	7/10	9/01	6/01	7/15	9/01
Dry Beans 2				5/25	7/01	8/25	6/01	7/05	9/01	6/05	7/10	9/05	6/10	7/15	9/05	6/15	7/20	9/05	6/15	7/20	9/05
Field Corn				4/15	7/05	9/05	4/20	7/10	9/10	5/01	7/15	9/15	5/10	7/20	9/15	5/15	7/20	9/20			
Field Corn 2				5/01	7/15	9/15	5/05	7/20	9/20	5/15	7/25	9/25	5/25	8/01	9/25	6/01	7/25	9/30			
Sweet Corn				4/15	7/05	8/10	4/20	7/10	8/15	5/01	7/15	8/20	5/10	7/20	8/25	5/15	7/20	9/01	5/20	7/20	9/01
Sweet Corn 2				5/01	7/15	8/20	5/05	7/20	8/25	5/15	7/25	9/01	5/25	8/01	9/05	6/01	7/25	9/10			
Sweet Corn 3																					
Sugar Beets				3/15	6/20	9/20	3/20	6/25	9/25	4/10	7/05	9/30	4/20	7/10	9/30	4/25	7/10	10/05			
Sugar Beets 2				4/05	7/05	10/01	4/10	7/10	10/05				4/25	7/10	10/05	5/05	7/15	10/15			
Onions				3/15	7/01	8/10	3/20	7/01	8/15	4/01	7/10	8/20	4/15	7/15	8/25	5/01	7/20	9/01			
Garlic																					
Apples				3/25	5/15	9/25	3/25	5/20	9/30	4/05	5/25	9/30	4/15	6/01	10/05	4/25	6/05	10/05	5/05	6/10	10/05
Pears/Peaches				3/20	7/01	9/05	3/25	7/05	9/10	4/05	7/10	9/10	4/15	7/15	9/15	4/20	7/20	9/20			
Cherries										4/10	6/01	9/20	4/25	6/05	9/20						
Asparagus																					
Peas/Lentils				4/01	6/05	7/10	4/05	6/10	7/15	4/10	6/15	7/20	4/20	6/20	7/25	4/25	6/25	8/01			
Peppermint	3/05	5/25	7/20	3/15	6/01	7/25	3/20	6/05	8/01	4/01	6/10	8/05	4/10	6/15	8/10	4/15	6/20	8/15			
New Mint																					
Bluegrass Seed										3/05	5/05	7/10									
Carrot Seed																					
Concord Grape													4/15	6/10	9/30						
Wine Grape										4/15	6/25	9/20	4/25	6/30	9/25						
Cabbage																					
Broccoli																					
Cranberries																					
Strawberries																					
Trailing Berries																					
Blue Berries																					
Rape Seed																					
Poplar										4/20	5/20	10/10									

Group 3 **Crop Dates**

Stations: EURN GOLW IMBO LIDW MALI MRSO PARO RPTI TWFI

Crops	Extremely Early			Very Early			Early			Average			Late			Very Late			Extremely Late		
	S	C	T	S	C	T	S	C	T	S	C	T	S	C	T	S	C	T	S	C	T
Alfalfa	3/1	5/5	10/10	3/5	5/5	10/10	3/10	5/10	10/10	3/20	5/20	10/10	4/1	5/25	10/10	4/5	5/25	10/10	4/10	5/30	10/10
Pasture				3/1	4/25	10/10	3/5	5/1	10/10	3/15	5/10	10/10	3/25	5/15	10/10	4/1	5/15	10/10	4/5	5/20	10/10
Lawn				3/1	4/15	10/10	3/5	4/20	10/10	3/15	5/1	10/10	3/25	5/5	10/10	4/1	5/5	10/10	4/15	5/5	10/10
Grass Hay							3/5	5/15	10/30	3/15	5/20	10/30	3/25	5/25	10/30						
Winter Grain				2/25	5/10	7/10	3/1	5/15	7/20	3/10	5/25	7/20	3/20	6/5	7/25	3/25	6/5	7/25			
Spring Grain				3/15	6/10	7/20	3/20	6/15	7/25	4/1	6/25	8/1	4/10	7/1	8/5	4/25	6/25	8/10			
Spring Grain 2				4/1	6/20	8/1	4/5	6/25	8/5	4/15	7/5	8/10	4/25	7/10	8/15	5/5	7/5	8/15	5/15	7/10	8/20
Spring Grain 3										5/15	7/10	8/20									
Potato Shepody																					
Potato Russet				4/15	6/25	9/5	4/20	7/1	9/10	5/1	7/5	9/15	5/10	7/10	9/20	5/20	7/15	9/20	5/25	7/20	9/25
Potato Russet 2				5/1	7/5	9/10	5/5	7/10	9/15	5/15	7/15	9/20	5/25	7/20	9/25	6/1	7/25	9/25	6/10	7/25	9/25
Potato Russet 3				5/15	7/15	9/15	5/20	7/20	9/20	6/1	7/25	9/25	6/5	7/25	9/30				6/15	8/1	9/30
Dry Beans				5/15	7/1	8/20	5/20	7/5	8/25	5/25	7/15	9/1	6/1	7/25	9/1	6/5	8/1	9/5	6/15	8/10	9/15
Dry Beans 2				6/5	7/15	9/1	6/10	7/20	9/5	6/15	8/1	9/10	6/20	8/10	9/10	6/20	8/10	9/15			
Field Corn				4/25	7/10	9/10	5/1	7/15	9/15	5/10	7/20	9/15	5/20	7/25	9/20	5/25	8/1	9/25			
Field Corn 2				5/10	7/20	9/20	5/15	7/25	9/25	5/25	8/1	9/25	6/5	8/5	9/30	6/5	8/10	9/30			
Sweet Corn				4/25	7/10	8/15	5/1	7/15	8/20	5/10	7/20	8/25	5/20	7/25	9/1	5/20	8/1	9/5			
Sweet Corn 2				5/10	7/20	8/25	5/15	7/25	9/1	5/25	8/1	9/5	6/5	8/5	9/10	6/10	8/15	9/15			
Sweet Corn 3																					
Sugar Beets				4/5	7/1	9/25	4/10	7/5	9/30	4/20	7/10	10/5	4/25	7/15	10/5	5/1	7/20	10/5	5/15	7/20	10/5
Sugar Beets 2				4/25	7/15	10/5	5/1	7/20	10/10	5/10	7/25	10/10	5/15	8/1	10/10	5/15	8/1	10/10			
Onions																					
Garlic				3/1	6/15	8/5	3/5	6/20	8/10	3/15	6/25	8/15	3/25	7/1	8/20	4/1	7/5	8/20			
Apples				4/5	5/25	9/20	4/10	6/1	9/25	4/30	6/5	9/30	5/1	6/10	9/30	5/10	6/15	10/5			
Pears				4/5	7/15	8/30	4/10	7/10	8/25	4/30	7/20	9/1	5/1	7/25	9/1	5/10	7/30	9/5			
Peaches																					
Asparagus																					
Peas/Lentils				4/1	6/5	7/10	4/5	6/10	7/15	4/10	6/15	7/20	4/20	6/20	7/25	4/25	6/25	8/1	5/5	6/25	8/1
Peppermint				3/25	6/25	8/20	4/1	7/1	8/25	4/10	7/5	8/25	4/20	7/10	9/1	4/25	7/15	9/1	5/10	7/20	9/1
New Mint				4/10	7/5	8/25	4/15	7/10	9/1	4/25	7/15	9/5	5/5	7/20	9/15	5/15	7/25	9/25	5/20	7/20	9/25
Bluegrass Seed				3/1	5/1	7/5	3/5	5/5	7/10	3/15	5/10	7/15	3/25	5/15	7/15	4/1	5/20	7/20	4/15	5/25	7/20
Carrot Seed				4/10	6/15	8/20	4/15	6/20	8/25	4/20	6/25	9/1	4/25	7/5	9/5	5/1	7/10	9/10			
Concord Grape																					
Wine Grape																					
Cabbage																					
Broccoli																					
Cranberries																					
Strawberries																					
Trailing Berries																					
Blue Berries																					
Rape Seed																					
Cherries																					
Poplar						10/1	4/10	5/25	10/15			10/15	4/30	6/5	10/15			10/15			10/15

Group 4 Crop Dates

Stations: ABEI FTHI ODSW POBO RDBM SIGM

Crops	Extremely Early			Very Early			Early			Average			Late			Very Late			Extremely Late		
	S	C	T	S	C	T	S	C	T	S	C	T	S	C	T	S	C	T	S	C	T
Alfalfa	3/10	5/15	10/05	3/15	5/15	10/05	3/20	5/20	10/05	4/01	6/01	10/05	4/10	6/05	10/05	4/15	6/10	10/05			
Pasture				3/10	5/05	10/05	3/15	5/10	10/05	3/25	5/20	10/05	4/05	5/25	10/05	4/10	6/01	10/05			
Lawn				3/10	4/25	10/05	3/15	5/01	10/05	3/25	5/10	10/05	4/05	5/15	10/05	4/10	5/20	10/05			
Grass Hay							3/15	5/25	10/25	3/25	6/01	10/25									
Winter Grain	3/01	6/01	7/15	3/05	6/01	7/15	3/10	6/01	7/25	3/20	6/05	7/25	4/01	6/15	8/01	4/05	6/20	8/05	4/10	6/25	8/10
Spring Grain				4/01	6/20	7/25	4/10	6/25	8/01	4/15	7/01	8/05	4/25	7/05	8/10	5/01	7/10	8/15			
Spring Grain 2				4/10	7/01	8/05	4/15	7/05	8/10	5/01	7/10	8/15	5/10	7/15	8/20	5/15	7/20	8/25	5/20	7/20	8/25
Spring Grain 3										5/15	7/20	8/25									
Potato Shepody				4/25	7/01	8/25				5/10	6/25	9/05	5/20	7/05	9/10	5/25	7/10	9/15			
Potato Russet				4/25	7/01	9/10	5/01	7/05	9/15	5/10	7/10	9/20	5/20	7/15	9/25	5/25	7/20	9/30	6/10	7/25	9/30
Potato Russet 2				5/10	7/10	9/15	5/15	7/15	9/20	5/25	7/20	9/25	6/05	7/25	9/30	6/05	7/25	10/05			
Potato Russet 3				5/25	7/20	9/20	6/01	7/25	9/25	6/10	8/01	9/30	6/15	8/01	10/05	6/25	8/01	10/05			
Dry Beans				5/15	7/01	8/20	5/20	7/05	8/25	5/25	7/15	9/01	6/01	7/25	9/01	6/05	8/01	9/05			
Dry Beans 2				6/05	7/15	9/01	6/10	7/20	9/05	6/15	8/01	9/10	6/20	8/10	9/10	6/20	8/10	9/15			
Field Corn				5/05	7/15	9/15	5/10	7/20	9/20	5/20	7/25	9/25	6/01	8/01	9/25	6/05	8/05	9/30			
Field Corn 2				5/20	7/25	9/20	5/25	8/01	9/25	6/05	8/05	9/30	6/15	8/10	10/05	6/15	8/10	10/05			
Sweet Corn																					
Sweet Corn 2																					
Sweet Corn 3																					
Sugar Beets				4/10	7/05	9/25	4/15	7/10	9/30	4/25	7/15	10/05	5/01	7/20	10/05	5/05	7/25	10/10	5/10	7/25	10/10
Sugar Beets 2				5/01	7/20	10/05	5/05	7/25	10/10	5/15	8/01	10/15	5/20	8/01	10/15	5/25	8/01	10/15			
Onions										4/20	7/15	8/25									
Garlic							3/20	6/30	8/20	3/30	7/05	8/25				5/05	7/25	9/01			
Apples																					
Pears																					
Peaches																					
Asparagus																					
Peas/Lentils				4/05	6/10	7/15	4/10	6/15	7/20	4/15	6/20	7/25	4/25	6/25	8/01	5/01	7/01	8/05			
Peppermint				4/25	7/01	9/01				5/01	7/20	9/10	5/15	7/25	9/10	5/25	7/25	9/10			
New Mint													5/15	7/25	9/25	5/20	7/25	9/25			
Bluegrass Seed				3/01	5/05	7/10	3/15	5/10	7/15	3/25	5/20	7/20	4/05	5/25	7/20	4/10	6/01	7/25			
Carrot Seed																					
Concord Grape																					
Wine Grape																					
Cabbage																					
Broccoli																					
Cranberries																					
Strawberries																					
Trailing Berries																					
Blue Berries																					
Rape Seed				3/20	5/25	7/05				4/25	7/01	8/05									
Cherries																					
Poplar							4/25	6/05	10/15												

Group 5 Crop Dates

Stations: CEDC CHVO COVM CRSM KFLO KTBI LORO MNTI WRDO

Crops	Extremely Early			Very Early			Early			Average			Late			Very Late			Extremely Late		
	S	C	T	S	C	T	S	C	T	S	C	T	S	C	T	S	C	T	S	C	T
Alfalfa	3/15	5/30	9/30	3/25	5/25	9/30	4/01	6/01	9/30	4/10	6/10	9/30	4/20	6/15	9/30	4/20	6/15	9/30			
Pasture	3/05	5/20	9/30	3/20	5/15	9/30	3/25	5/20	9/30	4/05	6/01	9/30	4/15	6/05	9/30	4/15	6/05	9/30			
Lawn				3/20	5/05	9/30	3/25	5/10	9/30	4/05	5/20	9/30	4/15	5/25	9/30	4/15	5/25	9/30			
Grass Hay										4/05	6/10	10/20									
Winter Grain				3/15	6/05	7/25	3/20	6/10	8/01	4/01	6/15	8/05	4/10	6/25	8/10						
Spring Grain				4/05	6/25	8/01	4/15	7/01	8/05	4/25	7/05	8/10	5/05	7/10	8/15	5/05	7/10	8/15			
Spring Grain 2				4/20	7/05	8/10	5/01	7/10	8/15	5/10	7/15	8/20	5/15	7/15	8/20	5/15	7/15	8/20			
Spring Grain 3													5/25	7/20	8/25						
Potato Shepody																					
Potato Russet				5/05	7/10	9/15	5/10	7/15	9/20	5/20	7/20	9/25	6/01	7/25	9/30	6/05	8/01	10/05			
Potato Russet 2				5/20	7/20	9/20	5/25	7/25	9/25	6/05	8/01	9/30	6/15	8/05	10/05	6/15	8/10	10/10			
Potato Russet 3							6/10	8/01	9/30												
Dry Beans										6/10	7/20	9/05									
Dry Beans 2																					
Field Corn																					
Field Corn 2																					
Sweet Corn																					
Sweet Corn 2																					
Sweet Corn 3																					
Sugar Beets										5/25	8/01	10/15									
Sugar Beets 2										6/05	8/05	10/15									
Onions										5/01	7/20	9/01	5/05	7/25	9/01	5/10	8/01	9/05			
Garlic										3/25	6/25	8/20									
Apples																					
Pears																					
Peaches																					
Asparagus																					
Peas/Lentils							4/10	6/15	7/20	4/15	6/20	7/25	4/25	6/25	8/01	5/01	7/01	8/05	5/15	7/05	8/10
Peppermint				4/25	7/01	9/01	5/01	7/05	9/05	5/10	7/10	9/05	5/20	7/15	9/10	5/25	7/20	9/15			
Peas / Lentils													5/15	7/05	8/10						
New Mint																					
Bluegrass Seed																					
Carrot Seed																					
Concord Grape																					
Wine Grape																					
Cabbage																					
Broccoli																					
Cranberries																					
Strawberries																					
Trailing Berries																					
Blue Berries																					
Rape Seed				5/01	7/05	8/10				5/15	7/15	8/20									
Cherries																					
Poplar																					

Group 6 Crop Dates

Stations: BKVO HRFO LAKO PCYO RXGI

Crops	Extremely Early			Very Early			Early			Average			Late			Very Late			Extremely Late		
	S	C	T	S	C	T	S	C	T	S	C	T	S	C	T	S	C	T	S	C	T
Alfalfa	3/20	5/20	9/15	4/01	6/01	9/30	4/10	6/05	9/30	4/15	6/15	9/30	4/25	6/20	9/30	5/01	6/20	9/30			
Pasture	3/05	5/10	9/15	3/25	5/20	9/30	4/05	5/25	9/30	4/10	6/05	9/30	4/20	6/10	9/30	5/01	6/10	9/30			
Lawn				4/01	5/10	9/30	4/05	5/15	9/30	4/10	5/25	9/30	4/20	6/01	9/30	5/01	6/01	9/30			
Grass Hay							4/05	6/10	10/20	4/10	6/15	10/20									
Winter Grain				3/20	6/10	8/01	4/01	6/15	8/05	4/05	6/25	8/15	4/20	7/01	8/15	4/20	7/01	8/15			
Spring Grain				4/15	7/05	8/05	4/15	7/10	8/10	5/01	7/15	8/20	5/10	7/20	8/20	5/10	7/20	8/20			
Spring Grain 2				5/01	7/15	8/15	5/01	7/20	8/20	5/15	7/25	8/25	5/20	7/25	8/25	5/20	7/25	8/25			
Spring Grain 3													6/01	8/01	9/01						
Potato Shepody																					
Potato Russet				5/15	7/20	9/20	5/20	7/25	9/25	6/01	8/01	9/30	6/05	8/01	9/30	6/05	8/05	10/05	6/10	8/05	10/05
Potato Russet 2				6/01	8/01	9/25	6/05	8/05	9/30	6/15	8/05	10/05	6/15	8/10	10/05	6/15	8/10	10/10	6/15	8/10	10/10
Potato Russet 3				6/15	8/10	10/01	6/20	8/15	10/05	7/01	8/20	10/10	7/05	8/20	10/10				6/20	8/10	10/10

Group 7 Crop Dates

Stations: AFTY AHTI DRLM FAFI PICI

Crops	Extremely Early			Very Early			Early			Average			Late			Very Late			Extremely Late		
	S	C	T	S	C	T	S	C	T	S	C	T	S	C	T	S	C	T	S	C	T
Alfalfa				4/10	6/05	9/25	4/15	6/10	9/25	4/25	6/20	9/25	5/01	6/25	9/25	5/10	6/25	9/25			
Pasture				4/05	5/25	9/25	4/10	6/01	9/25	4/20	6/10	9/25	4/25	6/15	9/25	5/05	6/15	9/25			
Lawn				4/05	5/15	9/25	4/10	5/20	9/25	4/20	6/01	9/25	4/25	6/05	9/25	4/25	6/05	9/25			
Grass Hay										4/20	6/20	10/15									
Winter Grain				4/01	6/15	7/01	4/05	6/20	8/10	4/15	6/25	8/15	4/25	7/05	8/20	4/25	7/05	8/20			
Spring Grain				4/25	7/15	8/15	5/01	7/20	8/20	5/10	7/25	8/25	5/15	8/01	9/01	5/20	8/01	9/01			
Spring Grain 2				5/10	7/25	8/25	5/15	8/01	9/01	5/25	8/05	9/05	6/01	8/10	9/10	6/10	8/10	9/10			
Spring Grain 3																					
Potato Shepody																					
Potato Russet				5/20	7/20	9/20				6/01	8/01	9/30	6/10	8/05	10/05	6/15	8/10	10/10	6/20	8/15	10/15
Potato Russet 2				6/05	7/01	9/25				6/15	8/10	10/05	6/20	8/10	10/10	6/20	8/15	10/15			
Potato Russet 3																					
Dry Beans																					
Dry Beans 2																					
Field Corn																					
Field Corn 2																					
Sweet Corn																					
Sweet Corn 2																					
Sweet Corn 3																					
Sugar Beets																					
Sugar Beets 2																					
Onions																					
Garlic																					
Apples																					
Pears																					
Peaches																					
Asparagus																					
Peas/Lentils																			5/20	7/10	8/15

Notes: S = crop start date; C = crop cover date; T = crop termination date

See Section 4.4.2, Table 4-5, for Meteorological Station Definitions.

4.4.4 Mean Monthly Precipitation in Idaho

Table 4-7, Mean monthly precipitation in Idaho, 1971-2000.

Number	Station Name	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
1	ABERDEEN EXPERIMNT STN	0.74	0.72	0.86	0.75	1.12	0.92	0.56	0.53	0.77	0.84	0.73	0.7	9.24
2	AMERICAN FALLS 3 NW	1.1	0.97	1.35	1.2	1.6	0.95	0.61	0.6	0.84	0.95	1.2	1.06	12.43
3	ANDERSON DAM	3.23	2.27	2.09	1.4	1.48	0.88	0.53	0.38	0.87	1.2	2.86	3.17	20.36
4	ARBON 2 NW	1.72	1.51	1.64	1.44	1.95	1.24	0.98	0.94	1	1.11	1.42	1.39	16.34
5	ARCO	0.82	1.05	0.86	0.75	1.32	0.9	0.83	0.78	0.7	0.63	0.8	0.81	10.25
6	ARROWROCK DAM	2.87	2.43	2.01	1.52	1.41	0.95	0.4	0.33	0.85	1.07	2.7	2.96	19.5
7	ASHTON	2.25	1.67	1.6	1.47	2.38	1.64	1.12	1.08	1.18	1.41	2.03	2.25	20.08
8	AVERY RS #2	5.19	3.7	3.34	2.74	3.15	2.3	1.46	1.34	1.99	2.67	4.81	4.85	37.54
9	BAYVIEW MODEL BASIN	2.66	2.32	2.18	1.94	2.37	1.92	1.25	1.19	1.25	1.81	3.13	3.29	25.31
10	BLACKFOOT 1 SE	0.86	0.73	0.89	0.93	1.33	0.87	0.53	0.45	0.7	0.84	0.81	0.75	9.69
11	BLISS 4 NW	1.49	1.12	1.01	0.76	0.8	0.54	0.25	0.27	0.53	0.69	1.43	1.22	10.11
12	BOISE 7 N	2.19	1.94	2.24	1.96	2.03	1.13	0.49	0.45	1.07	1.26	2.21	2.23	19.2
13	BOISE LUCKY PEAK DAM	1.78	1.49	1.71	1.49	1.5	0.93	0.39	0.33	0.82	0.9	1.83	1.79	14.96
14	BOISE AIR TERMINAL	1.39	1.14	1.41	1.27	1.27	0.74	0.39	0.3	0.76	0.76	1.38	1.38	12.19
15	BONNERS FERRY	2.7	1.77	1.49	1.42	1.76	1.62	1.02	1.07	1.16	1.61	3.03	2.91	21.56
16	BROWNLEE DAM	2.1	1.67	1.8	1.55	1.86	1.29	0.58	0.6	0.8	1.04	1.91	2.21	17.41
17	BRUNEAU	0.83	0.59	0.84	0.65	0.8	0.68	0.18	0.19	0.55	0.56	0.91	0.74	7.52
18	BUHL NO 2	1.11	0.68	1	0.85	1.08	0.81	0.27	0.3	0.51	0.69	1	0.87	9.17
19	BURLEY MUNICIPAL AP	1.18	0.83	1.08	0.97	1.28	0.87	0.35	0.41	0.64	0.67	1	1.01	10.29
20	CABINET GORGE	4.06	3.13	2.72	2.19	2.43	2.37	1.31	1.3	1.49	2.28	4.37	4.42	32.07
21	CALDWELL	1.55	1.11	1.29	1.13	1.01	0.67	0.3	0.35	0.59	0.73	1.28	1.39	11.4
22	CAMBRIDGE	2.88	2.68	2.18	1.35	1.52	1.04	0.44	0.46	0.83	1.17	2.75	3.2	20.5
23	CASCADE 1 NW	2.73	2.48	2.2	1.87	1.91	1.65	0.69	0.69	1.04	1.48	2.79	3.06	22.59
24	CASTLEFORD 2 N	1.32	0.87	1.08	0.97	1.36	0.81	0.22	0.34	0.62	0.67	1.1	0.94	10.3

25	CENTERVILLE ARBAUGH RNC	4.1	3.3	2.52	2.24	2.11	1.61	0.79	0.52	1.34	1.62	3.54	3.99	27.68
26	CHALLIS	0.51	0.35	0.58	0.58	1.12	0.99	0.78	0.65	0.64	0.43	0.56	0.53	7.72
27	CHILLY BARTON FLAT	0.31	0.27	0.48	0.6	1.29	1.26	0.92	0.81	0.79	0.59	0.44	0.34	8.1
28	COBALT	1.54	0.98	1.2	1.59	2.02	1.84	1.27	1.22	1.1	1.01	1.48	1.58	16.83
29	COEUR D'ALENE	3.28	2.47	2.34	1.89	2.25	2.06	1.02	1.16	1.12	1.67	3.35	3.46	26.07
30	COTTONWOOD 2 WSW	1.88	1.45	1.71	2.39	2.99	2.39	1.53	1.09	1.25	1.5	2.12	1.77	22.07
31	COUNCIL	3.03	2.88	2.56	1.95	2.05	1.49	0.67	0.58	1.11	1.57	3.28	3.19	24.36
32	CRATERS OF THE MOON	1.76	1.65	1.35	1.12	1.8	1.12	0.81	0.78	0.85	0.93	1.48	1.57	15.22
33	DEER FLAT DAM	1.13	0.93	1.21	1.04	1.05	0.75	0.37	0.35	0.54	0.62	1.05	1.11	10.15
34	DIXIE	3.34	2.68	2.45	2.11	2.26	2.19	1.33	1.23	1.33	1.51	3.19	3.58	27.2
35	DRIGGS	1.3	1.04	1.25	1.33	2.14	1.3	1.28	1.04	1.15	1.23	1.22	1.45	15.73
36	DUBOIS EXPERIMENT STN	0.77	0.71	0.95	1.12	2	1.67	1.07	1.01	1.01	0.84	1.01	0.91	13.07
37	DWORSHAK FISH HATCHERY	2.87	2.45	2.41	2.35	2.53	1.69	1.2	0.92	1.32	1.67	3.24	3.02	25.67
38	ELK CITY 1 NE	3.39	2.51	2.62	2.69	3.26	3.14	1.9	1.45	1.75	2.07	3.22	3.14	31.14
39	ELK RIVER 1 S	4.81	4.13	3.13	2.51	2.98	2.33	1.46	1.1	1.73	2.39	4.56	4.93	36.06
40	EMMETT 2 E	1.72	1.6	1.58	1.21	1.29	0.82	0.3	0.33	0.71	0.87	1.72	1.66	13.81
41	FAIRFIELD RANGER STN	2.22	1.71	1.45	1.05	1.33	0.83	0.6	0.42	0.69	0.82	1.77	1.98	14.87
42	FENN RANGER STN (LOWELL	4.64	3.53	3.71	3.6	3.53	3.14	1.39	1.27	2.16	2.84	4.84	4.21	38.86
43	FORT HALL 1 NNE	0.94	0.91	1.17	1.08	1.63	1	0.68	0.77	0.84	1.06	0.99	0.95	12.02
44	GARDEN VALLEY	3.82	2.77	2.45	1.77	1.74	1.4	0.64	0.49	1.18	1.46	3.44	3.87	25.03
45	GIBBONSVILLE	1.99	1.25	1.12	1.15	1.65	1.66	0.91	0.93	0.88	0.74	1.6	1.82	15.7
46	GLENNS FERRY	1.43	1	1.05	0.62	0.81	0.58	0.28	0.27	0.49	0.71	1.22	1.3	9.76
47	GRACE	1.27	1.12	1.43	1.38	2.18	1.31	1.1	1.22	1.32	1.36	1.14	1.14	15.97
48	GRAND VIEW 4 NW	0.64	0.57	0.79	0.66	0.85	0.66	0.25	0.22	0.59	0.51	0.78	0.59	7.11
49	GRANGEVILLE	1.45	1.3	2.37	2.82	3.63	2.84	1.66	1.16	1.62	1.78	1.81	1.5	23.94
50	GROUSE	1.09	1.14	1.25	0.97	1.58	1.55	1.03	0.87	0.79	0.78	1.04	1.2	13.29
51	HAGERMAN 2 SW	1.31	1	1.09	0.64	0.9	0.68	0.21	0.27	0.39	0.63	1.29	1.37	9.78
52	HAILEY 3 NNW	2.32	1.66	1.3	0.98	1.54	1.03	0.64	0.52	0.76	0.74	1.71	1.97	15.17
53	HAMER 4 NW	0.66	0.51	0.7	0.87	1.52	1.18	0.91	0.76	0.61	0.65	0.74	0.66	9.77

54	HAZELTON	1.41	1.02	1.11	0.8	1.14	0.67	0.21	0.29	0.64	0.72	1.29	1.27	10.57
55	HEADQUARTERS	4.93	3.93	3.4	3.09	3.36	2.59	1.49	1.34	1.78	2.6	5	4.93	38.44
56	HILL CITY 1 W	2.23	1.47	1.25	1	1.16	0.85	0.51	0.33	0.76	0.9	1.63	2.04	14.13
57	HOLLISTER	0.91	0.58	0.89	0.95	1.52	1.12	0.47	0.51	0.78	0.84	0.96	0.81	10.34
58	HOWE	0.49	0.62	0.58	0.6	1.1	1.11	0.74	0.77	0.53	0.56	0.65	0.68	8.43
59	IDAHO CITY	3.44	2.77	2.44	1.87	1.88	1.33	0.67	0.51	1.16	1.45	3.08	3.51	24.11
60	IDAHO FALLS 2 ESE	1.25	1.01	1.33	1.27	2.01	1.18	0.74	0.93	0.94	1.12	1.17	1.26	14.21
61	IDAHO FALLS 16 SE	1.41	1.12	1.48	1.43	2.03	1.2	1.06	0.9	1.13	1.17	1.59	1.35	15.87
62	IDAHO FALLS FANNING AP	0.84	0.8	0.95	0.95	1.58	1.1	0.64	0.73	0.76	0.92	0.92	0.83	11.02
63	IDAHO FALLS 46 W	0.64	0.62	0.69	0.79	1.24	1.08	0.66	0.44	0.73	0.57	0.69	0.67	8.82
64	ISLAND PARK	3.38	2.8	2.51	1.91	2.58	2.32	1.6	1.5	1.59	1.69	2.44	3.33	27.65
65	JEROME	1.4	1.07	1.28	0.86	1.14	0.76	0.22	0.27	0.49	0.77	1.29	1.23	10.78
66	KAMIAH	2.23	1.84	2.61	2.53	2.97	2.15	1.23	1.09	1.43	1.69	2.54	2.07	24.38
67	KELLOGG	3.89	2.96	3.03	2.57	2.79	2.23	1.43	1.38	1.69	2.25	4.24	4.31	32.77
68	KETCHUM RANGER STN	2.25	2.06	1.96	1.23	1.83	1.48	0.86	0.82	1.19	1.13	1.78	2.32	18.91
69	KOOSKIA 5 SSE	1.96	1.58	2.65	2.75	3.92	2.36	0.96	0.88	1.23	2.09	2.58	1.94	24.9
70	KUNA	0.99	0.76	1.15	1.06	1.06	0.74	0.28	0.26	0.55	0.6	1.35	1.14	9.94
71	LEADORE NO 2	0.32	0.21	0.45	0.7	1.38	1.12	1.03	0.82	0.71	0.49	0.38	0.4	8.01
72	LEWISTON AP	1.14	0.95	1.12	1.31	1.56	1.16	0.72	0.75	0.81	0.96	1.21	1.05	12.74
73	LIFTON PUMPING STN	0.81	0.81	0.82	1.07	1.62	0.97	0.89	0.89	1.19	1.17	0.84	0.61	11.69
74	LOWMAN	3.57	3.11	2.5	2.18	2.03	1.5	0.68	0.67	1.25	1.57	3.35	3.67	26.08
75	MACKAY LOST RIVER RS	0.65	0.55	0.8	0.66	1.24	1.3	1.06	0.89	0.71	0.58	0.66	0.67	9.77
76	MALAD CITY AP	1.28	1.1	1.2	1.25	2.01	1.13	1.08	0.95	1.09	1.24	1.03	1.05	14.41
77	MALTA 4 ESE	0.79	0.64	0.98	1.11	1.7	1.18	0.92	0.87	0.88	0.79	0.75	0.65	11.26
78	MALTA AVIATION	0.68	0.48	0.75	0.85	1.43	0.91	0.53	0.75	0.74	0.61	0.55	0.44	8.72
79	MASSACRE ROCKS ST PARK	1.09	0.99	1.3	1.34	1.55	0.92	0.63	0.48	0.77	0.99	1.19	1.06	12.31
80	MAY 2 SSE	0.44	0.3	0.31	0.53	1.32	1.13	0.86	0.69	0.66	0.43	0.63	0.54	7.84
81	MCCALL	3.28	2.92	2.55	2.07	2.35	2.08	1.03	1.05	1.45	1.78	3.2	3.45	27.21
82	MCCAMMON	1.81	1.32	1.78	1.27	2.15	0.95	0.98	1.46	1.02	1.05	1.41	1.75	16.95

83	MIDDLE FORK LODGE	1.69	1.35	1.34	1.51	1.65	1.58	0.95	0.98	1	1.21	1.88	1.74	16.88
84	MINIDOKA DAM	1.02	0.83	1.02	0.92	1.19	0.84	0.32	0.38	0.67	0.71	1.03	0.92	9.85
85	MONTPELIER RANGER STN	1.29	1.23	1.31	1.16	1.7	1.25	0.84	0.88	1.25	1.24	1.16	1.16	14.47
86	MOSCOW U OF I	2.99	2.52	2.57	2.52	2.62	1.87	1.12	1.19	1.28	2.01	3.54	3.14	27.37
87	MOUNTAIN HOME	1.32	0.97	1.19	0.92	0.86	0.59	0.38	0.2	0.68	0.76	1.32	1.38	10.57
88	NAMPA SUGAR FACTORY	1.37	1.14	1.35	1.12	1.22	0.63	0.32	0.24	0.58	0.72	1.28	1.4	11.37
89	NEW MEADOWS RANGER STN	2.88	2.62	2.38	2.05	2.26	1.9	0.9	0.81	1.28	1.54	2.71	3.2	24.53
90	NEZPERCE	1.51	1.33	1.85	2.19	3.01	1.99	1.26	1.11	1.31	1.48	1.94	1.43	20.41
91	OAKLEY	0.82	0.64	1.09	1.11	1.71	1.19	0.78	0.73	0.96	0.8	0.79	0.7	11.32
92	OLA 4 S	2.65	2.34	2.35	1.92	1.47	1.15	0.53	0.5	0.88	1.17	2.92	2.87	20.75
93	OROFINO	2.91	2.66	2.53	2.4	2.59	1.67	1.06	0.88	1.24	1.98	3.38	3.29	26.59
94	PALISADES	2.03	1.59	1.63	1.67	2.63	1.68	1.28	1.52	1.44	1.45	1.78	1.71	20.41
95	PARMA EXPERIMENT STN	1.38	1.01	1.25	0.96	1.13	0.84	0.35	0.41	0.65	0.67	1.23	1.27	11.15
96	PAUL 1 ENE	1.02	0.74	0.97	0.89	1.32	0.87	0.41	0.37	0.65	0.7	1.02	0.92	9.88
97	PAYETTE	1.46	1.24	1.1	0.8	0.97	0.73	0.32	0.32	0.46	0.63	1.43	1.6	11.06
98	PICABO	1.62	1.43	1.32	0.92	1.29	0.92	0.46	0.39	0.7	0.89	1.46	1.51	12.91
99	PIERCE	5.44	4.29	3.92	3.39	3.86	2.86	1.8	1.39	2	2.95	5.29	5.13	42.32
100	POCATELLO RGNL AP	1.14	1.01	1.38	1.18	1.51	0.91	0.7	0.66	0.89	0.97	1.13	1.1	12.58
101	PORTHILL	2.13	1.69	1.52	1.43	1.92	1.85	1.34	1.21	1.24	1.41	2.76	2.41	20.91
102	POTLATCH 3 NNE	2.85	2.7	2.52	2.26	2.69	1.78	1.15	1.13	1.29	1.81	3.25	3.18	26.61
103	POWELL	5.16	3.86	3.2	2.65	2.96	2.82	1.58	1.57	2.15	2.77	4.82	5.35	38.89
104	PRESTON	1.39	1.26	1.47	1.39	2.14	1.2	0.94	1.05	1.31	1.61	1.2	1.33	16.29
105	PRIEST RIVER EXP STN	3.74	3.12	2.72	2.25	2.6	2.24	1.39	1.32	1.43	1.92	4.3	4.39	31.42
106	REXBURG RICKS COLLEGE	1.28	1.02	1.11	1.12	1.9	1.49	0.92	0.72	0.87	1.11	1.22	1.09	13.85
107	REYNOLDS	1.18	0.92	1.11	0.94	1.3	0.99	0.38	0.46	0.61	0.77	1.09	1.15	10.9
108	RICHFIELD	1.62	1.28	1.14	0.73	1.07	0.64	0.37	0.32	0.58	0.72	1.32	1.38	11.17
109	RIGGINS	1.18	1.13	1.71	1.78	2.31	1.8	1.08	0.91	1.08	1.12	1.52	1.29	16.91
110	RUPERT 3 WSW	1.14	0.76	1.1	0.79	1.15	1	0.36	0.35	0.56	0.63	0.99	1.01	9.84
111	SAINT ANTHONY 1 WNW	1.26	0.9	1.1	1.13	2.02	1.52	0.97	0.75	0.92	1	1.32	1.3	14.19

112	SAINT MARIES 1 W	3.91	3.1	2.68	2.28	2.49	1.96	1.28	1.13	1.4	2.02	4.13	4.25	30.63
113	SALMON KSRA	0.68	0.49	0.54	0.79	1.42	1.42	1.03	0.82	0.77	0.65	0.73	0.78	10.12
114	SANDPOINT EXP STATION	3.94	3.47	2.85	2.25	2.75	2.46	1.63	1.43	1.6	2.3	4.75	4.75	34.18
115	SHOSHONE 1 WNW	1.38	1.11	1.26	0.69	0.95	0.59	0.26	0.31	0.57	0.65	1.28	1.2	10.25
116	SHOUP	1.3	1.1	0.88	1.18	1.69	1.64	0.99	0.91	0.96	0.91	1.42	1.48	14.46
117	SILVER CITY 5 W	3.21	2.48	2.62	2.26	2.34	1.37	0.68	0.54	0.88	1.51	2.79	3.03	23.71
118	SODA SPRINGS AP	1.14	1.27	1.42	1.35	2.13	1.36	1.25	1.31	1.07	1.26	1.16	1.03	15.75
119	STANLEY	1.66	1.54	1.19	1.07	1.24	1.2	0.73	0.76	0.88	1.14	1.55	2.03	14.99
120	SWAN FALLS P H	0.83	0.59	0.96	1.01	1.06	0.68	0.29	0.22	0.53	0.53	0.89	0.81	8.4
121	SWAN VALLEY 2 E	1.54	0.97	1.38	1.62	2.75	1.48	1.39	1.34	1.39	1.37	1.53	1.3	18.06
122	TAYLOR RANCH	1.09	0.98	1.09	1.59	2.06	1.84	1.16	1.09	0.81	1.01	1.22	1.03	14.97
123	TETONIA EXPERIMENT STN	2	1.19	1.28	1.36	2.61	1.67	1.29	1.26	1.38	1.43	1.48	1.66	18.61
124	TWIN FALLS KMVT	1.07	0.75	1.03	0.83	1.04	0.77	0.22	0.33	0.45	0.75	1.12	1.06	9.42
125	TWIN FALLS 6 E	1.29	0.93	1.21	0.95	1.4	0.84	0.27	0.38	0.65	0.78	1.17	1.12	10.99
126	WALLACE WOODLAND PARK	5.12	4.1	3.68	2.91	3.01	2.61	1.41	1.37	1.75	2.71	5.3	5.25	39.22
127	WARREN	2.64	2.03	2.42	2.25	2.49	2.48	1.41	1.22	1.41	1.81	2.6	2.65	25.41
128	WEISER	1.42	1.38	1.17	0.97	0.96	0.92	0.34	0.31	0.5	0.63	1.65	1.82	12.07
129	WINCHESTER	1.94	1.69	2.46	2.76	3.18	2.18	1.45	1.24	1.44	1.87	2.51	1.99	24.71
130	YELLOW PINE 7 S	3.22	2.83	2.35	1.95	2.1	1.99	1.13	1.09	1.49	1.81	3.22	3.38	26.56

4.4.5 Calculation of Effective Precipitation

From: USDA *National Resource Conservation Service. National Engineering Handbook - Irrigation Water Requirements*, Title 210, Chapter VI, Part 653.0207e. September 1997.

Table 4-8. Average monthly effective precipitation (PPT_e) as related to mean monthly precipitation and average monthly crop consumptive use[1].

MONTHLY MEAN PRECIPITATION PPT INCHES	AVERAGE MONTHLY CROP CONSUMPTIVE USE, CU, IN INCHES										
	0.00	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.00
	Average Monthly Effective Precipitation, PPTe in Inches										
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.5	0.28	0.30	0.32	0.34	0.36	0.38	0.40	0.42	0.45	0.47	0.50
1.0	0.59	0.63	0.66	0.70	0.74	0.78	0.83	0.88	0.93	0.98	1.00
1.5	0.87	0.93	0.98	1.03	1.09	1.16	1.22	1.29	1.37	1.45	1.50
2.0	1.14	1.21	1.27	1.35	1.43	1.51	1.59	1.69	1.78	1.88	1.99
2.5	1.39	1.47	1.56	1.65	1.74	1.84	1.95	2.06	2.18	2.30	2.44
3.0		1.73	1.83	1.94	2.05	2.17	2.29	2.42	2.56	2.71	2.86
3.5		1.98	2.10	2.22	2.35	2.48	2.62	2.77	2.93	3.10	3.28
4.0		2.23	2.36	2.49	2.63	2.79	2.95	3.12	3.29	3.48	3.68
4.5			2.61	2.76	2.92	3.09	3.26	3.45	3.65	3.86	4.08
5.0			2.86	3.02	3.20	3.38	3.57	3.78	4.00	4.23	4.47
5.5			3.10	3.28	3.47	3.67	3.88	4.10	4.34	4.59	4.85
6.0				3.53	3.74	3.95	4.18	4.42	4.67	4.94	5.23
6.5				3.79	4.00	4.23	4.48	4.73	5.00	5.29	5.60
7.0				4.03	4.26	4.51	4.77	5.04	5.33	5.64	5.96
7.5					4.52	4.78	5.06	5.35	5.65	5.98	6.32
8.0					4.78	5.05	5.34	5.65	5.97	6.32	6.68

1/ The PPTe values in the table are based on 3-inches of useable soil water storage (D). D is estimated to be from 40 to 60 percent of the available water holding capacity in the crop root zone, depending on irrigation management practices used. For other values of useable soil water storage, multiply table entries by the soil water storage factors (SF) shown below which correspond to the useable soil water storage (D).

Useable Soil Water storage	(D)		.75	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.00
Soil Water Storage Factor	(SF)		.722	.773	.86	.93	.97	1.00	1.02	1.04	1.06	1.07	1.148	1.288	1.518

Note: Average monthly effective precipitation cannot exceed average monthly precipitation or average monthly crop consumptive use. When the application of the above factors results in a value of effective rainfall exceeding either, this value must be reduced to a value equal the lesser of the two.

Effective Precipitation may also be calculated from the following equations:

$PPTe = SF[(0.70917\ PPT^{(0.82416)} - 0.11556)\ (10)^{(0.02426\ CU)}]$

Where $SF = (0.531747 + 0.295164D - 0.057697D^2 + 0.003804D^3)$

4.4.6 Maximum, Minimum and Mean Monthly Temperatures in Idaho

Table 4-9. Mean monthly temperatures in Idaho (1971-2000).

No.	Station Name		Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
1	ABERDEEN EXPERIMENT STN	MAX	31	37.1	47.3	57.9	66.9	76.3	85	85.1	74.7	62	44.2	32.9	58.4
		MEAN	21.4	26.7	35.9	44	52.5	60.6	67.1	65.9	56.2	45.3	32.5	22.6	44.2
		MIN	11.7	16.3	24.5	30.1	38.1	44.8	49.1	46.7	37.7	28.5	20.8	12.2	30
2	AMERICAN FALLS 3 NW	MAX	32.9	39.2	49.7	60.1	68.7	78.2	86.3	85.8	75.4	61.8	44.1	33.8	59.7
		MEAN	25.2	30.5	39.2	47.5	55.4	63.6	70.4	69.7	60.4	49.1	35.7	26.3	47.8
		MIN	17.5	21.8	28.6	34.9	42	48.9	54.5	53.6	45.3	36.4	27.3	18.7	35.8
3	ANDERSON DAM	MAX	35.9	40.3	48.6	59.6	69.4	79.4	89.1	88.5	77.7	64.4	45.6	35.6	61.2
		MEAN	27	30	37.5	46.2	54.9	63.2	71.3	70.8	61.6	50.6	36.4	27.3	48.1
		MIN	18.1	19.7	26.4	32.8	40.3	46.9	53.4	53	45.4	36.7	27.1	18.9	34.9
4	ARBON 2 NW	MAX	30.2	34.9	45.1	56.2	65.8	76	84.9	84.2	74.1	60.4	41.9	31.7	57.1
		MEAN	22.4	26.5	35.1	43.3	51.4	59.8	67	66.4	57.2	46	32.4	23.4	44.2
		MIN	14.6	18.1	25	30.4	36.9	43.6	49.1	48.5	40.3	31.6	22.9	15.1	31.3
5	ARCO	MAX	29.5	35.5	45.7	58.1	67	76.6	84.6	83.2	73.6	61.1	41.9	30.4	57.3
		MEAN	17.2	22.6	33.2	43.5	51.8	60	66.5	65.1	55.8	45.1	29.8	18.3	42.4
		MIN	4.8	9.6	20.7	28.8	36.6	43.4	48.4	47	38	29	17.6	6.2	27.5
6	ARROWROCK DAM	MAX	34.7	41.5	50.9	60.3	69.6	79.4	89.2	89	77.6	63.8	45.3	35.4	61.4
		MEAN	28	33.2	41.1	48.5	56.6	65	73	72.6	62.3	50.8	37.6	28.9	49.8
		MIN	21.3	24.9	31.2	36.7	43.5	50.5	56.8	56.2	46.9	37.8	29.8	22.4	38.2
7	ASHTON	MAX	29.5	34.4	41.9	53.3	64.4	73.6	81.6	82	72.9	60.6	41.8	30.9	55.6
		MEAN	19	23.9	31.5	41.3	50.7	58	63.9	63.2	54.7	44.5	30.4	20	41.8
		MIN	8.5	13.4	21.1	29.3	36.9	42.3	46.2	44.3	36.5	28.3	18.9	9	27.9
8	AVERY RS #2	MAX	32.1	36.7	47.2	58.4	68.2	76	84.5	84.7	73.3	56.2	38.4	31.2	57.2
		MEAN	26.8	30.3	38.1	46.4	54.4	61.4	67.4	67.1	58.3	45.6	33.3	26.9	46.3
		MIN	21.4	23.8	28.9	34.3	40.6	46.7	50.3	49.5	43.2	34.9	28.1	22.5	35.4

No.	Station Name		Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
9	BAYVIEW MODEL BASIN	MAX	35.1	39	46.5	56.2	65.6	73.5	80.5	80.1	68.6	55.7	42.4	35.5	56.6
		MEAN	28.5	31.5	36.8	44	52	59.1	64.7	63.9	54.3	43.9	35.3	29.1	45.3
		MIN	21.8	23.9	27	31.8	38.4	44.7	48.9	47.6	39.9	32	28.1	22.7	33.9
10	BLACKFOOT 1 SE	MAX	30.5	37.4	48.7	59	67.8	77.3	85	84.8	74.8	61.9	43.9	32	58.6
		MEAN	22.3	28	37.1	45.2	53.2	61.1	67.5	66.8	57.7	46.8	33.4	23.1	45.2
		MIN	14	18.6	25.5	31.4	38.5	44.9	50	48.7	40.5	31.6	22.9	14.2	31.7
11	BLISS 4 NW	MAX	35.9	43.1	53.7	62.8	71.8	81.6	90.1	89.1	78.8	66.2	48	37.2	63.2
		MEAN	27.2	33	41.1	48.7	56.9	65.4	72.2	70.7	61.5	50.3	37	28.4	49.4
		MIN	18.4	22.8	28.4	34.5	41.9	49.2	54.3	52.3	44.2	34.4	25.9	19.5	35.5
12	BOISE 7 N	MAX	35.6	42	50.2	58.4	67.7	77.8	87.6	86.8	75.4	61.7	45.3	36.2	60.4
		MEAN	28.8	34.1	40.7	47	54.7	63.5	72	71.8	62.2	50.8	37.7	29.3	49.4
		MIN	22	26.2	31.1	35.5	41.7	49.1	56.3	56.8	48.9	39.9	30.1	22.4	38.3
13	BOISE LUCKY PEAK DAM	MAX	38.6	45.4	54.4	62.9	72.1	81.4	90.2	90	79.5	66.8	49.3	39.1	64.1
		MEAN	30.2	35.9	42.8	50	58	65.7	72.9	72.8	63.4	53.1	39.9	30.8	51.3
		MIN	21.7	26.4	31.1	37.1	43.8	49.9	55.6	55.5	47.3	39.3	30.4	22.4	38.4
14	BOISE AIR TERMINAL	MAX	36.7	44.5	53.6	61.7	70.7	80.3	89.2	88	77.2	64.3	47.5	37.2	62.6
		MEAN	30.2	36.7	43.8	50.6	58.6	67.2	74.7	73.9	64.2	52.8	39.9	30.6	51.9
		MIN	23.6	28.8	34	39.4	46.6	54.2	60.3	59.8	51.2	41.3	32.4	24.1	41.3
15	BONNERS FERRY	MAX	33.3	39.2	49.5	60.4	69.3	76	83.1	83.4	72.3	57.4	41.3	33.5	58.2
		MEAN	26.9	31.8	39.3	47.6	55.5	61.8	66.9	66.7	57.1	45.8	35	27.8	46.9
		MIN	20.5	24.3	29.1	34.7	41.6	47.6	50.7	50	41.9	34.1	28.6	22.1	35.4
16	BROWNLEE DAM	MAX	37.7	44.9	55.3	65	74.1	83.5	94.1	93.7	82.1	67.5	49.1	39.3	65.5
		MEAN	30.5	36	44.7	52.9	61.1	69.5	78	77.7	67.4	55	41	32.3	53.8
		MIN	23.3	27	34	40.7	48	55.5	61.9	61.7	52.7	42.4	32.8	25.2	42.1
17	BRUNEAU	MAX	40.2	48.3	58.3	66.7	75.1	84.6	93	92	81.5	68.6	51.1	40	66.6
		MEAN	31.4	37.5	45.1	51.9	59.9	68.1	75.1	73.7	63.8	52.8	40.2	31.1	52.6
		MIN	22.5	26.7	31.9	37.1	44.6	51.6	57.1	55.3	46	37	29.3	22.2	38.4

No.	Station Name		Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
18	BUHL NO 2	MAX	33.5	40.1	49.7	58.7	67.1	76.6	85.7	85	74.5	62.2	45.1	34.9	59.4
		MEAN	26.3	31.6	39.4	46.8	54.8	63.2	70.9	69.8	60.1	49.3	36	27.3	48
		MIN	19	23.1	29.1	34.8	42.4	49.7	56.1	54.5	45.6	36.4	26.8	19.6	36.4
19	BURLEY MUNICIPAL AP	MAX	36.9	43.9	52.8	61.8	70.5	80.6	88.6	87.8	77	64.5	47.7	38	62.5
		MEAN	28.3	34.1	41.5	48.8	56.9	65.3	71.9	70.7	61	50.3	37.4	29	49.6
		MIN	19.7	24.2	30.1	35.8	43.2	50	55.2	53.5	45	36	27.1	19.9	36.6
20	CABINET GORGE	MAX	31.6	37.3	45.7	55.2	64.3	70.8	79.6	79.7	69.7	55.8	39.5	32.4	55.1
		MEAN	26.3	30.4	37	44.5	52.3	58.6	64.9	64.9	56.7	46	34.4	27.8	45.3
		MIN	20.9	23.5	28.2	33.7	40.3	46.3	50.1	50	43.6	36.2	29.3	23.2	35.4
21	CALDWELL	MAX	37.1	46.1	57.4	66.3	75.1	84.2	92.6	91.7	80.8	67	49.3	37.9	65.5
		MEAN	29.1	36.2	45	52.4	60.7	68.5	75.4	73.8	63.3	51.8	38.9	29.6	52.1
		MIN	21.1	26.2	32.6	38.5	46.2	52.8	58.1	55.8	45.8	36.6	28.4	21.3	38.6
22	CAMBRIDGE	MAX	30.8	38.1	51.7	63	72	81	90.6	89.8	79.5	65	45.1	32.6	61.6
		MEAN	23	28.9	40.5	49.3	57.2	65.2	72.6	71.3	61.3	49.4	35.8	24.7	48.3
		MIN	15.1	19.6	29.2	35.5	42.4	49.3	54.5	52.7	43.1	33.8	26.5	16.8	34.9
23	CASCADE 1 NW	MAX	29.2	34.7	42.1	51.1	61.2	70.1	79.4	79.3	69.3	56.8	39	29.8	53.5
		MEAN	19.5	23.6	30.7	38.4	47.1	54.6	61.5	60.7	51.6	41.6	29.5	20.6	40
		MIN	9.7	12.5	19.2	25.7	32.9	39	43.6	42	33.8	26.3	19.9	11.3	26.3
24	CASTLEFORD 2 N	MAX	35.3	42.8	52.8	62.6	71.2	80.3	87.3	85.7	76.1	63.9	46.6	36.1	61.7
		MEAN	27.8	33.8	41.3	48.8	56.3	64.3	70.5	69	60.3	49.9	36.8	28.2	48.9
		MIN	20.2	24.8	29.8	34.9	41.4	48.3	53.6	52.3	44.5	35.8	27	20.3	36.1
26	CHALLIS	MAX	31.4	38.8	49	58.7	67.4	76.8	85.3	84	74.3	61.2	42.7	31.6	58.4
		MEAN	21.9	28.2	37.4	45.4	53.4	61.5	68.6	67.1	57.9	47	32.8	22.2	45.3
		MIN	12.4	17.6	25.8	32	39.4	46.2	51.8	50.1	41.4	32.7	22.9	12.7	32.1
27	CHILLY BARTON FLAT	MAX	30.1	35.3	42.9	53.6	62.8	72.4	81.2	80.2	70.9	58.4	39.9	30.5	54.9
		MEAN	17.4	21.9	30.7	39.7	47.9	56	63	61.7	52.8	42.4	27.7	18.1	39.9
		MIN	4.7	8.4	18.4	25.8	32.9	39.6	44.8	43.1	34.7	26.4	15.5	5.7	25

No.	Station Name		Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
28	COBALT	MAX	31.1	38.8	47.2	56.9	65.7	75	84.1	82.9	73.4	60.3	40.7	29.9	57.2
		MEAN	19.4	25.3	33.1	41	48.7	56.2	62.9	61.5	53.2	42.8	29	19	41
		MIN	7.6	11.7	18.9	25.1	31.6	37.4	41.7	40.1	33	25.2	17.2	8.1	24.8
29	COEUR D'ALENE	MAX	34.7	41	49.3	57.8	66.6	73.7	82.6	83.7	73.9	59.9	43.1	35.8	58.5
		MEAN	28.4	33	39.6	46.6	54.7	61.7	68.7	69.2	60.3	48.9	36.7	30.3	48.2
		MIN	22.1	25	29.8	35.4	42.8	49.6	54.8	54.7	46.6	37.9	30.3	24.8	37.8
30	COTTONWOOD 2 WSW	MAX	34.8	39.7	46.1	53.6	61.6	69.2	77.7	79	69.8	57.2	41.4	34.9	55.4
		MEAN	28.9	32.9	38	44.2	51.4	58.6	65.9	66.7	58.3	47.8	35.2	28.9	46.4
		MIN	22.9	26.1	29.8	34.7	41.2	47.9	54	54.3	46.7	38.3	28.9	22.9	37.3
31	COUNCIL	MAX	33.7	40.1	51.1	62	71.5	80.7	90.9	90.8	80.3	65.9	47	35.2	62.4
		MEAN	25.3	30.5	40.1	48.6	56.7	64.7	73	72.6	62.6	50.4	36.9	26.8	49
		MIN	16.8	20.9	29.1	35.1	41.9	48.6	55.1	54.3	44.8	34.9	26.7	18.3	35.5
32	CRATERS OF THE MOON	MAX	29.7	35	43.2	55.2	65.4	75.8	84.9	84.1	73.1	59.8	40.8	30.6	56.5
		MEAN	20.2	24.7	32.3	42.2	51.3	60.3	68.4	67.4	57.1	45.6	30.4	20.9	43.4
		MIN	10.6	14.3	21.3	29.1	37.1	44.7	51.9	50.7	41.1	31.3	19.9	11.1	30.3
33	DEER FLAT DAM	MAX	38	46.1	56.8	65.1	73	80.8	88.2	88	78.9	67.1	50.2	39	64.3
		MEAN	31.2	37.7	46.1	53	60.5	67.4	73.8	73	64.5	53.8	41.3	31.9	52.9
		MIN	24.3	29.3	35.3	40.9	47.9	54	59.3	57.9	50	40.5	32.3	24.8	41.4
34	DIXIE	MAX	30.3	34.6	39.4	46.1	55.8	65.4	74.9	75.5	65.9	53.4	37.6	30.6	50.8
		MEAN	17.2	20.7	26.7	33.7	42.5	50.3	56.3	55.7	47.4	38	25.7	17.6	36
		MIN	4.1	6.7	14	21.2	29.1	35.1	37.7	35.9	28.8	22.6	13.7	4.5	21.1
35	DRIGGS	MAX	28.7	33.1	40.2	51	61.6	71.2	78.8	78.2	68.8	56.6	39.7	29.8	53.1
		MEAN	18.5	22.3	29.7	38.8	47.7	56	62.6	61.5	52.7	42.2	29.1	19.3	40
		MIN	8.3	11.4	19.1	26.5	33.8	40.8	46.3	44.8	36.6	27.8	18.4	8.8	26.9
36	DUBOIS EXPERIMENT STN	MAX	27.9	33	41.9	54.7	64.9	75	84.2	83.7	72.8	58.2	38.9	28.8	55.3
		MEAN	19	23.6	31.8	42.2	51.2	59.8	67.5	66.6	56.7	44.8	29.4	19.8	42.7
		MIN	10	14.1	21.7	29.7	37.5	44.5	50.8	49.5	40.6	31.3	19.9	10.8	30

No.	Station Name		Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
37	DWORSHAK FISH HATCHERY	MAX	38.8	45.9	55.2	63.8	72.2	79.3	88.6	89.7	79.5	64.4	47	38.8	63.6
		MEAN	32.5	37.5	44.5	51.5	58.9	65.4	72.4	72.6	63.6	51.6	39.8	33.1	52
		MIN	26.2	29	33.8	39.1	45.6	51.5	56.1	55.4	47.6	38.8	32.6	27.3	40.3
38	ELK CITY 1 NE	MAX	35	41.8	47.3	54.3	62.6	71	80.3	81.7	72	59.4	41.9	33.7	56.8
		MEAN	23.2	28	33.8	40.4	47.8	55	60.8	60.3	52.2	42.8	31.2	22.6	41.5
		MIN	11.4	14.2	20.2	26.4	33	39	41.2	38.8	32.3	26.2	20.4	11.5	26.2
39	ELK RIVER 1 S	MAX	33.7	39.3	46.2	54.4	63.3	70.8	79.2	80.5	70.6	57.6	40.7	33.1	55.8
		MEAN	25.8	29.9	35.8	42.9	50.5	57	62.8	62.8	54.1	44	33.3	25.9	43.7
		MIN	17.9	20.4	25.4	31.3	37.6	43.1	46.3	45.1	37.6	30.3	25.9	18.6	31.6
40	EMMETT 2 E	MAX	36.6	44.9	55	63.2	72.2	81.3	89.9	88.9	78.7	65.9	48.5	37.7	63.6
		MEAN	29.8	36.4	44	50.6	58.6	66.8	74	72.9	63.6	52.5	39.5	30.9	51.6
		MIN	23	27.8	32.9	37.9	45	52.2	58	56.8	48.5	39.1	30.5	24	39.6
41	FAIRFIELD RANGER STN	MAX	30.8	36.2	44.5	56.9	67.1	76.1	85.3	84.9	75.6	63.4	43.3	31.5	58
		MEAN	18.4	22.6	31.6	42.7	51.5	59	66.4	65.2	56.1	45.5	30.7	19.4	42.4
		MIN	5.9	9	18.6	28.5	35.9	41.9	47.4	45.5	36.5	27.5	18	7.2	26.8
42	FENN RANGER STN (LOWELL	MAX	35.7	42.2	52	61.6	70.7	78.1	87.6	88.3	76	60.8	44.2	35.6	61.1
		MEAN	30.9	35.3	42.4	49.4	56.8	63.5	70.4	70.4	60.9	49.5	38.3	31.3	49.9
		MIN	26	28.3	32.7	37.1	42.9	48.9	53.1	52.4	45.8	38.2	32.3	26.9	38.7
43	FORT HALL 1 NNE	MAX	31.1	37.5	47.4	57.2	66.1	75.6	84.2	84.1	74.2	61.4	43.6	32.4	57.9
		MEAN	22.2	27.6	36.1	43.9	52	60	66.5	65.6	56.6	45.7	32.8	23	44.3
		MIN	13.2	17.6	24.8	30.5	37.8	44.4	48.7	47.1	39	29.9	22	13.5	30.7
44	GARDEN VALLEY	MAX	34.3	41.4	51.2	61	70.3	79.2	88.4	88.3	78.1	64.7	43.8	33.6	61.2
		MEAN	25.9	30.9	38.8	46.2	53.9	61.3	67.7	66.8	58	47.5	34.4	25.9	46.4
		MIN	17.4	20.3	26.3	31.4	37.4	43.4	47	45.2	37.8	30.3	25	18.1	31.6
45	GIBBONSVILLE	MAX	28.1	35.3	45.5	55.6	64.6	73.2	83.1	81.8	71.9	58	38.7	28.2	55.3
		MEAN	18.8	24.2	33.4	41.5	49.2	56.5	63.7	62.4	53.8	42.9	29.5	19.3	41.3
		MIN	9.4	13.1	21.2	27.3	33.7	39.8	44.3	42.9	35.6	27.8	20.3	10.4	27.2

No.	Station Name		Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
46	GLENNS FERRY	MAX	39.8	47.6	57.5	66.7	75.4	85.9	95.2	93.7	82.6	68.9	51	40.1	67
		MEAN	30.4	35.9	43.2	50.3	58	66.7	73.9	72.1	61.9	50.5	38.4	30.2	51
		MIN	20.9	24.2	28.8	33.8	40.6	47.4	52.5	50.5	41.1	32.1	25.8	20.2	34.8
47	GRACE	MAX	31.1	36.5	45.5	56.5	66.1	76.2	85	84.9	74.9	61.6	43.1	33	57.9
		MEAN	21.2	25.1	33.8	42.7	51.2	59.3	66.3	65.6	56.5	45.6	32	22.7	43.5
		MIN	11.3	13.7	22	28.9	36.2	42.4	47.5	46.2	38	29.5	20.9	12.4	29.1
48	GRAND VIEW 4 NW	MAX	38.4	47.2	57.7	66.1	74.5	83	90.7	89.8	79.3	66.5	49.5	38.3	65.1
		MEAN	29.9	36.4	44.3	51.6	59.7	67.4	73.5	71.9	62	51	38.7	29.6	51.3
		MIN	21.4	25.5	30.8	37	44.9	51.7	56.3	53.9	44.7	35.4	27.9	20.8	37.5
49	GRANGEVILLE	MAX	38.1	44	50.4	57.7	64.9	72.3	81.6	82.9	72.8	59.9	45.2	37.9	59
		MEAN	31.2	35.3	40.3	46.3	53.3	60.1	66.9	67.3	58.3	48.1	37.7	31.1	48
		MIN	24.3	26.6	30.2	34.8	41.6	47.9	52.2	51.7	43.7	36.2	30.1	24.2	37
50	GROUSE	MAX	26.6	32.2	40.5	50.4	60.6	69.6	78.7	77.6	68.7	56.6	38.3	27.8	52.3
		MEAN	12.4	17.1	27	37	46.4	53.5	59.8	58.7	50.3	39.5	24.8	14	36.7
		MIN	-1.8	2	13.4	23.5	32.2	37.3	40.9	39.7	31.8	22.3	11.2	0.1	21.1
51	HAGERMAN 2 SW	MAX	40.8	49	58.3	67.5	76.4	85.6	94.5	93.4	83.2	70.8	52.4	41.3	67.8
		MEAN	30.2	36.3	43.9	51.1	59.4	67.4	74	72.2	62.6	52.1	39.5	30.7	51.6
		MIN	19.6	23.6	29.4	34.7	42.4	49.2	53.4	51	42	33.3	26.6	20.1	35.4
53	HAMER 4 NW	MAX	28.3	35	47	59.9	69.3	78.8	87	85.9	75.6	62	41.9	29.6	58.4
		MEAN	16.4	22.5	33.5	43.8	53.1	61.3	67.5	65.7	55.9	44.2	29	17.5	42.5
		MIN	4.4	10	19.9	27.6	36.9	43.8	47.9	45.5	36.1	26.4	16	5.3	26.7
54	HAZELTON	MAX	34.9	41.7	51.2	60.6	69.3	79.5	88.1	87.4	77.2	64.5	46.5	36.2	61.4
		MEAN	26.5	32	39.7	47	55.3	64.1	71.2	69.8	59.9	48.9	35.9	27.3	48.1
		MIN	18.1	22.2	28.2	33.4	41.2	48.6	54.2	52.1	42.6	33.2	25.2	18.3	34.8
55	HEADQUARTERS	MAX	34.8	39.8	46.1	54.5	63.5	71.3	79.7	81	70.5	58	41.3	33.9	56.2
		MEAN	26.6	30	35.4	42	49.4	56.5	62.3	62.5	53.5	43.9	33.1	26.4	43.5
		MIN	18.3	20.2	24.7	29.4	35.3	41.7	44.9	43.9	36.5	29.8	24.9	18.9	30.7

No.	Station Name		Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
56	HILL CITY 1 W	MAX	29.3	33.8	41.8	54.4	65.1	74.6	84.3	84.3	74.5	61.8	41.8	30.7	56.4
		MEAN	18.7	22.8	31.4	42	50.4	57.3	64.5	63.9	54.9	44.5	30.2	19.6	41.7
		MIN	8.1	11.7	21	29.6	35.7	39.9	44.7	43.4	35.3	27.2	18.6	8.4	27
57	HOLLISTER	MAX	37.3	43.4	51.2	59.8	68	77.8	86.1	84.9	75.1	62.9	47.4	38.8	61.1
		MEAN	28.4	33.4	39.5	46.1	53.6	62.2	70	69.1	60.2	49.5	37.4	29.4	48.2
		MIN	19.5	23.3	27.7	32.4	39.2	46.5	53.8	53.3	45.3	36.1	27.4	19.9	35.4
58	HOWE	MAX	30.7	36.9	48	60.6	69.1	78.1	86.9	85.7	75.1	61.5	43	31.4	58.9
		MEAN	18.4	24.3	35.2	45.1	53.3	61.4	68.1	66.6	56.6	45.2	30.3	18.9	43.6
		MIN	6	11.6	22.3	29.6	37.4	44.6	49.3	47.5	38.1	28.8	17.6	6.3	28.3
59	IDAHO CITY	MAX	34.9	41	48	57.3	66.8	76.1	85.8	85.6	75.4	62.8	43.8	34.8	59.4
		MEAN	23.6	28	35	42.5	50.7	58.2	65.1	64.3	55.1	44.8	32.1	23.7	43.6
		MIN	12.2	15	21.9	27.6	34.6	40.2	44.4	43	34.8	26.8	20.4	12.6	27.8
60	IDAHO FALLS 2 ESE	MAX	29.7	36.6	47.6	58.7	67.9	77.8	86	85.8	75.1	61.4	43	31.3	58.4
		MEAN	21.1	26.7	36.2	45	53.3	61.9	68.7	67.9	58.2	46.8	33.1	22.4	45.1
		MIN	12.5	16.8	24.8	31.3	38.7	46	51.4	49.9	41.3	32.2	23.2	13.4	31.8
61	IDAHO FALLS 16 SE	MAX	29.7	34.5	41.1	50.7	60.2	69.6	78.1	77.2	67.9	55.7	39	30	52.8
		MEAN	18.9	23.3	30.6	38.7	46.8	54.1	60.7	59.6	51	40.7	27.6	18.9	39.2
		MIN	8.1	12	20	26.6	33.3	38.5	43.2	42	34.1	25.6	16.2	7.7	25.6
62	IDAHO FALLS FANNING AP	MAX	27.5	33.9	45.8	57.3	66.6	77	85.9	85.1	74	59.8	41.5	29.5	57
		MEAN	19.3	24.8	35.4	44.6	52.9	61.5	68.4	67.1	57.3	45.5	31.8	20.8	44.1
		MIN	11.1	15.6	25	31.9	39.1	46	50.8	49.1	40.6	31.1	22.1	12.1	31.2
63	IDAHO FALLS 46 W	MAX	27.9	34	44.8	56.9	66.3	76.8	86.6	85.7	74.6	60.9	41.4	29.4	57.1
		MEAN	16.2	22.1	32.8	42.4	51.2	60	67.6	66.2	55.7	43.4	28.7	17.1	42
		MIN	4.5	10.2	20.7	27.9	36.1	43.2	48.5	46.7	36.8	25.9	15.9	4.8	26.8
64	ISLAND PARK	MAX	26.5	31.2	38	47.9	58.7	69.8	78.8	79.3	69.7	55.7	36.7	27	51.6
		MEAN	15.9	19.2	26.4	35.6	45.4	53.9	60.6	59.9	51.2	40.5	26.1	16.4	37.6
		MIN	5.3	7.2	14.8	23.3	32.1	38	42.4	40.5	32.6	25.3	15.5	5.8	23.6

No.	Station Name		Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
65	JEROME	MAX	35.6	42.3	52.1	61.6	70.8	81	90.2	89.5	78.3	65.2	47.5	36.9	62.6
		MEAN	27	32.2	39.9	47.3	56	64.8	72.6	71.5	61.5	50.2	36.6	27.8	49
		MIN	18.3	22	27.7	33	41.1	48.6	54.9	53.5	44.6	35.1	25.7	18.6	35.3
67	KELLOGG	MAX	35.7	41.6	49.5	58.6	67.5	74.6	82.6	82.6	72.2	58.4	42.7	35.3	58.4
		MEAN	28.3	32.8	39.2	46.3	54	60.6	66.4	66	57	45.9	35.4	28.6	46.7
		MIN	20.9	24	28.8	33.9	40.5	46.5	50.2	49.4	41.7	33.4	28.1	21.9	34.9
68	KETCHUM RANGER STN	MAX	31.6	37	43.7	53.5	62.9	72.1	80.9	79.9	70.1	58.7	42	32.3	55.4
		MEAN	17.8	22.2	29.6	38.9	47.4	54.8	61.9	60.3	51.7	41.7	28.2	18.9	39.5
		MIN	3.9	7.4	15.4	24.2	31.8	37.5	42.8	40.6	33.2	24.7	14.4	5.4	23.4
69	KOOSKIA 5 SSE	MAX	35.8	42.8	50.7	58.5	66.5	73.1	82.5	85.9	74.8	60.8	44.3	36.1	59.3
		MEAN	29.2	34.1	40.8	47.6	55.1	61.1	68.2	69.4	60.5	49.1	37	29.6	48.5
		MIN	22.5	25.4	30.9	36.7	43.6	49	53.8	52.9	46.1	37.3	29.7	23.1	37.6
70	KUNA	MAX	36.7	45.7	56.7	65.3	73	81.7	89.2	88	78.3	66.1	48.6	37.4	63.9
		MEAN	29.4	36.5	44.6	51	58.3	65.9	71.8	70.5	61.6	51.2	38.8	29.7	50.8
		MIN	22.1	27.2	32.5	36.6	43.6	50	54.3	52.9	44.8	36.3	28.9	21.9	37.6
71	LEADORE NO 2	MAX	29.8	35.4	43.4	53.8	63.3	73.3	82.7	81.2	71.2	57.7	39	29.2	55
		MEAN	16	21.3	30	39.2	47.6	55.7	62.1	60.6	51.9	40.8	26.4	16.1	39
		MIN	2.1	7.1	16.6	24.6	31.9	38.1	41.4	40	32.5	23.9	13.7	2.9	22.9
72	LEWISTON AP	MAX	39.4	45.6	53.8	61.6	70	78	87.6	87.6	76.7	62	46.8	39.2	62.4
		MEAN	33.7	38.4	44.7	51.1	58.5	65.8	73.5	73.4	63.8	51.6	40.4	33.9	52.4
		MIN	28	31.2	35.6	40.6	47	53.6	59.3	59.3	50.9	41.2	34.1	28.5	42.4
73	LIFTON PUMPING STN	MAX	28.8	32.1	40.3	50.8	60.9	71.2	79.3	78.2	68.1	55.4	39.6	30.4	52.9
		MEAN	17.4	19.2	28.8	40.2	50.1	58.9	65.3	63	53.4	42.2	29.6	20	40.7
		MIN	5.9	6.2	17.3	29.5	39.3	46.6	51.3	47.8	38.7	29	19.5	9.6	28.4
74	LOWMAN	MAX	32.7	39.5	48.2	57.8	66.6	75.4	84.9	84.7	75.1	61.8	41.3	31.8	58.3
		MEAN	23.6	28.7	36.2	43.9	51.5	58.5	64.5	63.5	55.2	45.3	32.7	23.1	43.9
		MIN	14.4	17.8	24.1	30	36.3	41.5	44.1	42.2	35.3	28.7	24	14.4	29.4

No.	Station Name		Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
75	MACKAY LOST RIVER RS	MAX	30.4	35.7	44.1	55.8	65.3	74.9	83.8	82.5	73.1	60.1	41.4	30.7	56.5
		MEAN	18.4	23.1	31.9	41.7	50.4	58.5	65.6	64.1	55.4	44.5	29.7	19.1	41.9
		MIN	6.4	10.4	19.6	27.6	35.4	42.1	47.3	45.6	37.7	28.9	18	7.5	27.2
76	MALAD CITY AP	MAX	31.1	37.8	48.6	58.5	68	79.2	88.3	87.2	77	63.5	45.4	33.6	59.9
		MEAN	20.8	25.8	35.6	43.2	52.1	60.8	68	66.7	57.2	45.8	32.8	22.7	44.3
		MIN	10.4	13.7	22.5	27.9	36.1	42.3	47.7	46.2	37.3	28.1	20.2	11.8	28.7
77	MALTA 4 ESE	MAX	36	42.3	51.4	60.7	69	79.1	87.6	86.8	76.2	63.5	46.4	37	61.3
		MEAN	26.5	32	39.2	46.3	53.9	61.7	68.8	67.7	58.2	47.8	35.2	26.9	47
		MIN	16.9	21.6	27	31.9	38.7	44.3	49.9	48.5	40.1	32	23.9	16.7	32.6
79	MASSACRE ROCKS ST PARK	MAX	34.7	41.8	51.3	60.8	70.2	81.1	90.4	89.8	79	65.1	46.1	36	62.2
		MEAN	24.6	30.5	38.4	46.1	55	64	71.7	70.5	60.7	48.7	34.7	25.8	47.6
		MIN	14.4	19.2	25.5	31.4	39.7	46.9	52.9	51.2	42.3	32.3	23.3	15.5	32.9
80	MAY 2 SSE	MAX	30.3	37.8	47.7	57	66.1	76.2	85.3	83.6	74.4	60.8	41.7	30.3	57.6
		MEAN	18.3	24.6	34.2	41.9	50.4	58.8	65.5	63.4	55	43.6	29.2	18.6	42
		MIN	6.3	11.4	20.6	26.7	34.7	41.3	45.7	43.1	35.5	26.3	16.6	6.9	26.3
81	MCCALL	MAX	31.2	36.6	42.9	51.4	61.1	70	79.7	80.1	70	57.8	39.7	31.2	54.3
		MEAN	21.9	25.8	31.8	39.2	47.5	54.7	61.3	60.6	51.6	42.2	30.8	22.7	40.8
		MIN	12.6	14.9	20.6	27	33.8	39.4	42.9	41	33.2	26.5	21.9	14.1	27.3
82	MCCAMMON	MAX	30.5	36.6	47.6	58.3	67.1	77.3	85.5	84.2	74.7	61.8	43.4	32.5	58.3
		MEAN	23.1	27.5	36.8	45.2	52.8	61.1	67.9	66.8	57.8	46.9	33.7	24.3	45.3
		MIN	15.6	18.4	25.9	32	38.5	44.9	50.3	49.4	40.9	32	24	16.1	32.3
83	MIDDLE FORK LODGE	MAX	34.9	41.9	50.8	59.2	67.7	76.5	85.9	85	75.7	62.3	43.6	33.9	59.8
		MEAN	23.7	28.7	37	43.9	51.6	58.8	65.7	64.5	56.1	45.4	32.3	23.4	44.3
		MIN	12.5	15.5	23.1	28.6	35.4	41.1	45.5	44	36.4	28.4	20.9	12.9	28.7
84	MINIDOKA DAM	MAX	35.4	41.8	51.1	60	69	79.3	88.3	88.1	77.8	64.6	47.4	36.8	61.6
		MEAN	25.4	30.8	38.8	46.5	55.1	63.9	71.3	70.5	61.1	49.5	36.2	26.9	48
		MIN	15.4	19.8	26.5	33	41.2	48.5	54.2	52.9	44.3	34.3	25	16.9	34.3

No.	Station Name		Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
85	MONTPELIER RANGER STN	MAX	30.4	34.5	42.8	53.6	64	74.8	84.7	84.7	73.4	60	41.5	31.9	56.4
		MEAN	19.2	21.1	30.5	39.8	49.4	58.4	66.5	65.3	55	43.8	29.7	20.6	41.6
		MIN	7.9	7.7	18.2	25.9	34.8	42	48.2	45.8	36.5	27.5	17.8	9.3	26.8
86	MOSCOW U OF I	MAX	35.6	41.3	49	57.5	65.9	73.1	82.6	84	74.4	60.5	43.1	35.5	58.5
		MEAN	29.4	34.1	40.1	46.5	53.3	59.2	65.5	66.4	58.7	48.3	36.5	29.6	47.3
		MIN	23.2	26.8	31.2	35.4	40.6	45.2	48.4	48.7	42.9	36	29.9	23.6	36
87	MOUNTAIN HOME	MAX	37.6	44.9	53.6	62.5	71.6	82.3	91.7	91.2	79.5	66.2	48.5	38.2	64
		MEAN	29	34.7	41.7	48.8	57.2	66.4	74.2	73.4	62.7	50.8	37.7	29.3	50.5
		MIN	20.4	24.4	29.7	35.1	42.8	50.4	56.7	55.5	45.8	35.4	26.9	20.3	37
88	NAMPA SUGAR FACTORY	MAX	37	44.5	55.3	63.6	72.7	82	90.5	89.4	78.7	66.1	49.1	38.8	64
		MEAN	28.9	35.1	43.2	50	58.2	66.4	73.3	71.8	62.1	51.1	38.7	30.1	50.7
		MIN	20.8	25.7	31.1	36.4	43.6	50.7	56	54.2	45.4	36	28.3	21.3	37.5
89	NEW MEADOWS RANGER STN	MAX	29.7	36.5	45.5	55	64.3	73.2	82.7	83.1	72.8	60.2	41.3	30.2	56.2
		MEAN	18.9	23.8	32.6	40.8	48.6	56.1	62.4	61.8	52.7	42.5	30.6	19.8	40.9
		MIN	8	11	19.7	26.6	32.9	39	42.1	40.4	32.5	24.7	19.8	9.3	25.5
90	NEZPERCE	MAX	34.9	41	47.7	55.4	63.1	70.4	79.5	80.7	71	58	42.2	34.8	56.6
		MEAN	28.3	33.1	38.5	44.5	51.3	57.6	64.1	64.7	56.4	46.3	35.1	28.5	45.7
		MIN	21.7	25.1	29.2	33.6	39.4	44.7	48.6	48.6	41.8	34.5	27.9	22.1	34.8
91	OAKLEY	MAX	36.6	42.6	50.5	58.7	66.6	76	83.1	83.1	73.8	62.4	46	37.4	59.7
		MEAN	27.9	32.9	39.4	45.8	53.4	61.8	68.6	68.3	59.3	49.1	36.3	28.4	47.6
		MIN	19.1	23.2	28.2	32.9	40.1	47.5	54.1	53.5	44.7	35.8	26.6	19.4	35.4
92	OLA 4 S	MAX	34.1	42.5	53.9	63.3	72.3	80.9	89.7	89	78.8	64.4	45.4	34.5	62.4
		MEAN	24.6	31.4	40.1	47.2	55.2	63	70.3	68.8	59.4	47.5	34.6	25.3	47.3
		MIN	15.1	20.2	26.3	31.1	38.1	45	50.9	48.6	39.9	30.6	23.7	16.1	32.1
93	OROFINO	MAX	37.7	45.8	55.4	64	72	79.7	88.9	90.2	78.8	63.2	46.1	37.3	63.3
		MEAN	31.5	36.9	43.7	50.9	58.1	65	71.3	71.6	62.1	49.8	38.6	31.8	50.9
		MIN	25.2	28	32	37.8	44.1	50.3	53.7	52.9	45.3	36.4	31.1	26.2	38.6

No.	Station Name		Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
94	PALISADES	MAX	31	36.6	45.3	56.1	65.8	75.9	84.7	83.8	74.8	61.5	43	32.1	57.6
		MEAN	23.2	26.7	34.4	43.4	52.2	61.1	68.6	67.4	58.8	48.1	34.5	24.9	45.3
		MIN	15.3	16.7	23.4	30.7	38.6	46.3	52.5	51	42.7	34.6	25.9	17.6	32.9
95	PARMA EXPERIMENT STN	MAX	35.5	43.6	55.7	64.5	72.8	81.5	90.6	90.4	79.7	66.6	48.5	36.9	63.9
		MEAN	27.2	34	42.9	50.1	58.2	65.7	72.4	71.2	61.4	50.1	37.5	28.3	49.9
		MIN	18.8	24.3	30.1	35.7	43.6	49.8	54.2	52	43.1	33.5	26.5	19.7	35.9
96	PAUL 1 ENE	MAX	35.1	41.7	51.2	60.3	68.8	78.7	87.4	87.3	76.4	63.9	46.8	36.6	61.2
		MEAN	26.4	31.6	39.4	46.7	54.8	63.4	70.4	69.3	59.3	48.6	35.9	27.3	47.8
		MIN	17.7	21.5	27.5	33	40.8	48.1	53.4	51.2	42.1	33.2	25	17.9	34.3
97	PAYETTE	MAX	36.7	45.8	57.7	66.1	74.3	82.4	90.8	89.6	80.1	67.6	50.1	38.7	65
		MEAN	28.1	35.4	44.8	51.9	60.1	67.8	74.9	73.5	64.1	52.4	39.4	30	51.9
		MIN	19.5	24.9	31.8	37.7	45.9	53.2	58.9	57.3	48.1	37.1	28.6	21.3	38.7
98	PICABO	MAX	30.9	36.7	45.6	56.8	65.7	75.4	84.7	84.2	73.4	61.1	42.4	31.9	57.4
		MEAN	18.8	23.9	32.8	42	50	58	65.4	64.7	55.1	44.5	30.3	20.4	42.2
		MIN	6.7	11	19.9	27.1	34.3	40.6	46	45.1	36.8	27.9	18.1	8.8	26.9
99	PIERCE	MAX	33.2	37.9	45.6	54.3	64	71.7	81.4	82.6	72.3	59	40.5	33	56.3
		MEAN	25	28.2	34.3	41.4	49.6	56.2	62.4	61.9	53.1	43.1	32.2	25.3	42.7
		MIN	16.7	18.4	23	28.5	35.1	40.7	43.4	41.2	33.8	27.2	23.9	17.6	29.1
100	POCATELLO RGNL AP	MAX	32.5	39	48.5	58.5	67.7	78.3	87.5	86.8	75.7	62	44.5	33.8	59.6
		MEAN	24.4	30	37.9	45.6	53.5	62	69.2	68.4	58.8	47.7	34.7	25.3	46.5
		MIN	16.3	20.9	27.3	32.6	39.2	45.7	50.9	49.9	41.8	33.3	24.9	16.8	33.3
101	PORTHILL	MAX	33.3	38.8	48.5	59.3	68.1	74.5	81.6	81.8	71.2	56.7	41.6	33.8	57.4
		MEAN	25.6	30.2	37.9	46.5	54.6	60.9	66.3	65.4	55.8	44.4	34	26.6	45.7
		MIN	17.8	21.5	27.2	33.6	41.1	47.3	51	49	40.4	32	26.3	19.3	33.9
102	POTLATCH 3 NNE	MAX	36	41.7	48.5	56.8	64.8	71.6	80.4	81.9	72.8	59.8	43.2	36.1	57.8
		MEAN	29	33.5	38.8	45	51.4	57.1	62.6	62.8	55.1	45.5	35.7	29.2	45.5
		MIN	21.9	25.2	29.1	33.1	37.9	42.6	44.7	43.7	37.3	31.2	28.2	22.3	33.1

No.	Station Name		Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
103	POWELL	MAX	30.9	37	44.6	53.5	63.3	71.4	80.4	80.4	69.4	56.2	37.8	30	54.6
		MEAN	24.1	28.2	34.6	41.4	49	56.4	62.6	62.1	52.9	43.1	31	23.7	42.4
		MIN	17.3	19.3	24.5	29.2	34.7	41.4	44.8	43.7	36.4	30	24.2	17.3	30.2
104	PRESTON	MAX	30.3	36.6	47.7	57.9	67.5	78	87.1	86.1	76.1	62.5	44.6	32.8	58.9
		MEAN	21.3	26.4	36.6	45	53.5	61.9	69.4	68.2	58.6	46.9	33.6	23.3	45.4
		MIN	12.2	16.2	25.5	32.1	39.5	45.8	51.6	50.3	41.1	31.3	22.6	13.8	31.8
105	PRIEST RIVER EXP STN	MAX	30.4	36.1	45.4	56.6	66.5	73.5	81.4	81.7	71.1	55.5	37.6	30.6	55.5
		MEAN	24.6	28.7	35.2	43.1	51.8	58.1	63.5	63.1	54.1	43	31.6	25.4	43.5
		MIN	18.7	21.3	24.9	29.6	37	42.7	45.6	44.5	37.1	30.4	25.6	20.1	31.5
106	REXBURG RICKS COLLEGE	MAX	28.5	33.9	45	56.8	65.7	74.6	83.6	84	74	59.7	40.9	29.6	56.4
		MEAN	19.3	24.2	33.7	43.2	51.8	59.6	66.1	65.2	55.8	44.2	30.3	19.6	42.8
		MIN	10	14.5	22.4	29.6	37.8	44.5	48.6	46.4	37.6	28.6	19.6	9.6	29.1
107	REYNOLDS	MAX	38.9	44	51	58.9	67.3	76.9	85.7	85.5	74.8	63.3	48	39.4	61.1
		MEAN	29.3	33.7	39.4	45.6	53.3	61.2	68.8	68.2	58.2	47.8	36.5	29.2	47.6
		MIN	19.6	23.4	27.7	32.3	39.2	45.5	51.8	50.9	41.5	32.3	24.9	18.9	34
108	RICHFIELD	MAX	30.2	36.3	47.2	58.2	67	76.7	85.4	85	74.9	61.9	43.2	32.1	58.2
		MEAN	22.2	27.4	36.6	45	53.2	61.3	68.5	67.8	58.4	47	33.3	23.8	45.4
		MIN	14.1	18.5	26	31.7	39.3	45.8	51.6	50.5	41.9	32	23.4	15.4	32.5
109	RIGGINS	MAX	40.9	48.5	56.9	65	72.7	80.6	90.2	90.9	80.3	66.4	49.3	41	65.2
		MEAN	33.9	39.4	45.9	52.5	59.4	66.5	74	74.2	64.9	53.5	41.1	34.4	53.3
		MIN	26.9	30.3	34.9	39.9	46	52.3	57.7	57.4	49.5	40.5	32.9	27.8	41.3
110	RUPERT 3 WSW	MAX	34.4	40.5	50.2	59.9	68.2	77.7	85.5	85.6	75.7	63.4	46.2	35.9	60.3
		MEAN	25	30.2	38.1	45.8	53.5	61.6	67.7	66.8	57.5	46.8	34.5	25.8	46.1
		MIN	15.5	19.8	25.9	31.6	38.8	45.5	49.9	47.9	39.2	30.2	22.8	15.6	31.9
111	SAINT ANTHONY 1 WNW	MAX	28.8	34	43.6	55.7	65.6	74.4	82.8	82.7	73	60.1	41.7	30.3	56.1
		MEAN	17.9	21.6	30.6	40.6	50	57.8	64.3	63	54.1	43.3	29.3	19	41
		MIN	6.9	9.2	17.5	25.4	34.3	41.2	45.8	43.3	35.1	26.4	16.9	7.6	25.8

No.	Station Name		Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
112	SAINT MARIES 1 W	MAX	34.4	41	49.6	58.5	66.7	74	82.9	83.7	73.3	58	40.9	33.8	58.1
		MEAN	28.9	33.7	39.9	46.6	53.8	60.4	66.6	66.8	57.8	46.3	35.3	28.8	47.1
		MIN	23.3	26.3	30.1	34.7	40.9	46.7	50.2	49.8	42.3	34.6	29.6	23.8	36
113	SALMON KSRA	MAX	28.4	37	49.7	59.9	69.1	77.9	87.3	85.5	74.9	60.3	40.7	29.2	58.3
		MEAN	18.9	26.1	37.2	45.9	54.3	62	69.1	67	57.7	45.3	30.9	20.3	44.6
		MIN	9.3	15.2	24.7	31.8	39.5	46.1	50.9	48.5	40.4	30.2	21	11.4	30.8
114	SANDPOINT EXP STATION	MAX	31.6	37.6	46.5	56.4	65.4	72.1	80.1	80.2	70	56.1	40	32.4	55.7
		MEAN	25.5	30.2	37.3	45.3	53.2	59.4	64.9	64.5	55.7	44.7	33.8	26.9	45.1
		MIN	19.4	22.8	28.1	34.2	40.9	46.7	49.7	48.7	41.4	33.2	27.5	21.4	34.5
115	SHOSHONE 1 WNW	MAX	33.4	40.2	51.1	62.1	72	82.7	91.4	90.4	78.6	64.5	45.7	35.1	62.3
		MEAN	25.2	30.6	39.3	47.9	56.8	65.9	73.7	72.7	62	50	35.8	26.6	48.9
		MIN	16.9	21	27.4	33.6	41.6	49.1	55.9	54.9	45.3	35.4	25.9	18	35.4
116	SHOUP	MAX	31.2	39.6	52.1	63	71.9	80.7	89.8	88.7	78.1	61.9	42.1	30.7	60.8
		MEAN	23.1	29.6	40	48.3	55.9	63.3	70.4	69.4	60.1	47.5	33.7	23.5	47.1
		MIN	15	19.5	27.8	33.5	39.8	45.9	51	50	42.1	33.1	25.2	16.2	33.3
117	SILVER CITY 5 W	MAX	35.7	39.3	44	51.6	60.4	71.1	80.9	80.9	71.1	59	43.3	37.1	56.2
		MEAN	28.2	31	35.1	41.3	49.9	58.8	68.1	68.1	59.1	48.2	34.5	28.8	45.9
		MIN	20.7	22.6	26.1	30.9	39.4	46.5	55.2	55.3	47.1	37.4	25.6	20.5	35.6
118	SODA SPRINGS AP	MAX	28.6	32.2	40.5	52.3	63	73.9	83.2	81.8	71.3	58.1	40.6	30.2	54.6
		MEAN	18.4	21.6	29.7	39.5	48.8	57.3	64.2	63	53.3	42.2	29.5	19.2	40.6
		MIN	8.1	10.9	18.9	26.6	34.5	40.7	45.2	44.1	35.3	26.3	18.3	8.1	26.4
119	STANLEY	MAX	27	33.9	42.3	49.7	59	68.1	77.8	77.6	68.4	56.3	37.8	26	52
		MEAN	12.7	16.7	25.4	34.5	43.7	51.2	57.2	56.1	48.1	39.1	25.2	12.5	35.2
		MIN	-1.7	-0.6	8.5	19.2	28.4	34.2	36.6	34.6	27.7	21.8	12.6	-1	18.4
120	SWAN FALLS P H	MAX	39.6	48	58.2	66.6	75.7	85.6	94.5	93.3	83	69.2	50.8	40.2	67.1
		MEAN	31.6	38	46.5	53.7	62.1	70.9	78.6	77.2	67.2	55.3	41	32.1	54.5
		MIN	23.5	27.9	34.7	40.8	48.5	56.1	62.7	61	51.4	41.3	31.1	23.9	41.9

No.	Station Name		Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
121	SWAN VALLEY 2 E	MAX	29.6	35.4	44.1	54.9	64.4	74.7	83.7	82.9	73.1	59.7	41.2	30.6	56.2
		MEAN	20.7	25.1	33.5	41.9	50.2	58.4	65.2	64.3	55.3	44.3	31.2	21.5	42.6
		MIN	11.7	14.8	22.8	28.9	36	42	46.6	45.7	37.5	28.8	21.1	12.4	29
122	TAYLOR RANCH	MAX	27.8	36.1	46.7	56.6	65.7	74.2	84.3	83.9	72.8	56.4	38	27.9	55.9
		MEAN	20.5	26.6	35.6	43.2	50.8	57.9	65	64.3	55.3	43.3	30.6	21.6	42.9
		MIN	13.1	17.1	24.4	29.7	35.9	41.6	45.7	44.6	37.7	30.1	23.2	15.3	29.9
123	TETONIA EXPERIMENT STN	MAX	27	33.1	39.8	49.2	60.6	70.5	78.7	77.9	68.6	55.6	37.8	27.9	52.2
		MEAN	15.3	20.7	27.9	37.2	46.7	54.9	61.5	60.4	51.3	40.4	26.3	16.1	38.2
		MIN	3.5	8.2	16	25.1	32.8	39.2	44.3	42.8	34	25.1	14.7	4.2	24.2
124	TWIN FALLS KMVT	MAX	36.6	43.3	52.3	61	69.8	79.1	87.9	86.7	76.6	64.7	48.2	37.9	62
		MEAN	28.2	33.2	40.7	47.9	56.3	64.9	72.2	70.4	60.7	50.1	37.7	29	49.3
		MIN	19.7	23.1	29.1	34.7	42.7	50.6	56.5	54.1	44.8	35.5	27.2	20	36.5
125	TWIN FALLS 6 E	MAX	34.9	41.4	50.7	59.5	67.7	77	85	84.1	74.2	62.5	46.2	36.4	60
		MEAN	27.1	32.4	39.8	46.6	54.5	62.5	68.9	67.6	58.5	48.4	36.3	27.9	47.5
		MIN	19.2	23.4	28.8	33.7	41.2	48	52.8	51.1	42.8	34.2	26.4	19.3	35.1
126	WALLACE WOODLAND PARK	MAX	33.6	38.9	46	54.7	63.1	70	78.3	79.3	69.6	57.2	40.7	33.3	55.4
		MEAN	26.7	30.8	36.6	43.7	51.1	57.6	63.6	63.9	55.2	45.2	34.1	27.1	44.6
		MIN	19.8	22.6	27.1	32.7	39	45.2	48.9	48.4	40.7	33.2	27.5	20.9	33.8
127	WARREN	MAX	34.2	39.3	43.6	49.6	58.2	67.1	76.1	75.8	67.1	56	39.7	32.7	53.3
		MEAN	20.1	23.9	28.5	34.4	42.2	49.3	55.4	54.7	47.4	39.4	27.5	19.9	36.9
		MIN	5.9	8.4	13.4	19.2	26.1	31.4	34.6	33.6	27.6	22.8	15.2	7	20.4
128	WEISER	MAX	34.8	43.5	56	64.6	73.3	82.2	91.2	89.6	79.7	66.1	47.7	36.2	63.7
		MEAN	27.7	34.8	44.9	52.2	60.5	68.6	75.6	73.7	64	52.1	39	29.3	51.9
		MIN	20.6	26.1	33.7	39.7	47.6	54.9	59.9	57.8	48.3	38	30.3	22.3	39.9
129	WINCHESTER	MAX	35.2	39.7	44.7	52.2	59.6	67.3	76.1	77.8	68.6	56.7	41.4	34.9	54.5
		MEAN	27.5	31.1	35.4	41.6	48.2	54.8	61	61.7	53.8	44.6	33.7	27.3	43.4
		MIN	19.7	22.4	26.1	31	36.7	42.2	45.9	45.6	39	32.5	25.9	19.7	32.2

No.	Station Name		Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
130	YELLOW PINE 7 S	MAX	32.8	38.6	44.9	52.3	61.5	70.1	79.8	79.7	70.3	58	40.3	32.3	55.1
		MEAN	20.2	24.2	30.6	37.3	45.3	52.2	58.7	57.9	49.9	40.9	28.8	20.5	38.9
		MIN	7.6	9.7	16.2	22.2	29.1	34.3	37.6	36	29.4	23.7	17.3	8.6	22.6

4.4.7 The Leaching Requirement (LR) and LR Calculations

The leaching fraction (LF) is the ratio of deep percolation to the applied water. The leaching requirement (LR), as stated in Section 4.1.1.2.2, is the fraction of the irrigation water that must be leached through the crop root zone to control soil salinity at any specified level. The same ratio of deep percolation to applied water exists between the concentration (mg/L) of the conservative mineral salts applied and the concentration of conservative mineral salts in the percolate. There are several valid approaches to determining the leaching requirement, not all of which are discussed below. The following equations used to analyze irrigation related salinity issues typically express salinity in terms of electrical conductivity (EC) in units of dS/m. Unless stated otherwise, EC can be used in lieu of concentration in calculations presented below. However, EC can overestimate salinity in food processing wastewaters because of degradable conductive organic acids present in the rinse water. The EC due to mineral salts can be estimated by dividing the mineral salinity (in mg/L) of wastewater by 0.64 (Luthin, 1978).

The leaching requirement is based upon maintaining steady state salinity levels in the crop root zone. Equation 4-7 and Equation 4-8 express this:

$$D_w C_w - D_d C_d = 0$$

Equation 4-7. Equation for steady state salt balance.

or

$$D_w EC_w - D_d EC_d = 0$$

Equation 4-8. Equation for steady state electrical conductivity balance.

Where:

D_d = drainage water depth, m

D_w = depth of water applied, m

C_d = concentration of salt in drainage water, mg/L

EC_d = electrical conductivity of drainage water, dS/m.

C_w = concentration of salt in water applied, mg/L

EC_w = electrical conductivity of water applied, dS/m

Note that EC_d is similar to another term found in the literature known as soil water salinity (EC_{sw}) to which the plant root is exposed. As soil dries, the EC_{sw} will increase. EC_d on the other hand will occur only when soil water content at the bottom of the soil profile is at field capacity or higher. An EC meter inserted into the soil (to read EC_{sw}) will only read the same as EC_d when the soil is at field capacity or greater. The similar terms EC_d and EC_{sw} are not to be confused with soil salinity (EC_e) which is salinity measured from a saturated paste extract of a soil, and is used in standard tables (see discussion below) as threshold criteria for crop salinity yield decrements. EC_e helps to standardize EC_{sw} somewhat by saturating the sample before the EC reading.

The first term of Equation 4-7 and Equation 4-8 represents the mass of applied salts and the second term represents the mass of leached salts. The difference of zero indicates that there is neither an increase nor decrease in root zone salinity. These equations assume that other sources and sinks for salts are steady state also (Tanji, 1990), as Equation 4-9 shows:

$$(S_m + S_f) - (S_p + S_c) = 0$$

Equation 4-9. Steady state for salt for sources and sinks.

Where:

S_m = salt dissolved from soil minerals

S_f = salt added from fertilizers or amendments

S_p = salt precipitated in the soil profile

S_c = salt removed by agronomic crops

Equation 4-7 and Equation 4-8 can be rearranged and modified. A simple form of this relationship is presented in Equation 4-10.

$$LR = \frac{D_d}{D_w} = \frac{C_w}{C_d} = \frac{EC_w}{EC_d}$$

Equation 4-10. Leaching requirement calculations.

Where:

LR = leaching requirement, unitless

If Equation 4-10 is solved for C_d, the salt concentration of the drainage is equal to the concentration of the salt in water applied divided by the leaching requirement as presented in Equation 4-11.

$$C_d = \frac{C_w}{LR}$$

Equation 4-11. Concentration of salt in drainage water.

All terms are described above.

The concentration of salt in the applied water (C_w) includes the salt in wastewater, irrigation water, and precipitation. It can be calculated and expressed in terms of electrical conductivity as well as in terms of concentration. C_w (or EC_w) can be calculated as shown in Equation 4-12:

$$C_w = \frac{C_{ww} D_{ww} + C_i D_i + C_r D_r}{D_{ww} + D_i + D_r}$$

Equation 4-12. Concentration of salt in applied water.

Where:

D_{ww} = depth of applied wastewater, m

D_i = depth of applied irrigation water, m

D_r = depth of precipitation, m

C_{ww} = salt concentration in applied wastewater, mg/L (dS/m)

C_i = salt concentration in applied irrigation water, mg/L (dS/m)

C_r = salt concentration in precipitation, mg/L (dS/m)

The leaching requirement can be obtained from Figure 1 of Ayers and Westcot (1985), reproduced here in Figure 4-6. The salinity of the applied water (C_w above, or EC_w in Ayers and Westcott) must be known. The threshold soil salinity (EC_e) for an acceptable yield decrement is found in Table 4-10 (from Ayers and Westcot, 1985). Figure 4-6 is then read from the given EC_w value, straight up until the threshold soil salinity value is reached. The nearest line encountered with its specified leaching requirement (or leaching fraction, LF in the figure) is the LR. If the point is between two lines, an extrapolation between values of the LF of the two lines can be made.

Additional LF lines (0.25, 0.3, 0.5, 0.6, and 0.7) may be plotted by using data from the third column of Table 4-11, the concentration factor 'X'. The equations for additional lines relating EC_e and EC_w (defined previously) can be derived and subsequently plotted by using Equation 4-13.

$$EC_e = EC_w * X$$

Equation 4-13. Soil Salinity Equation

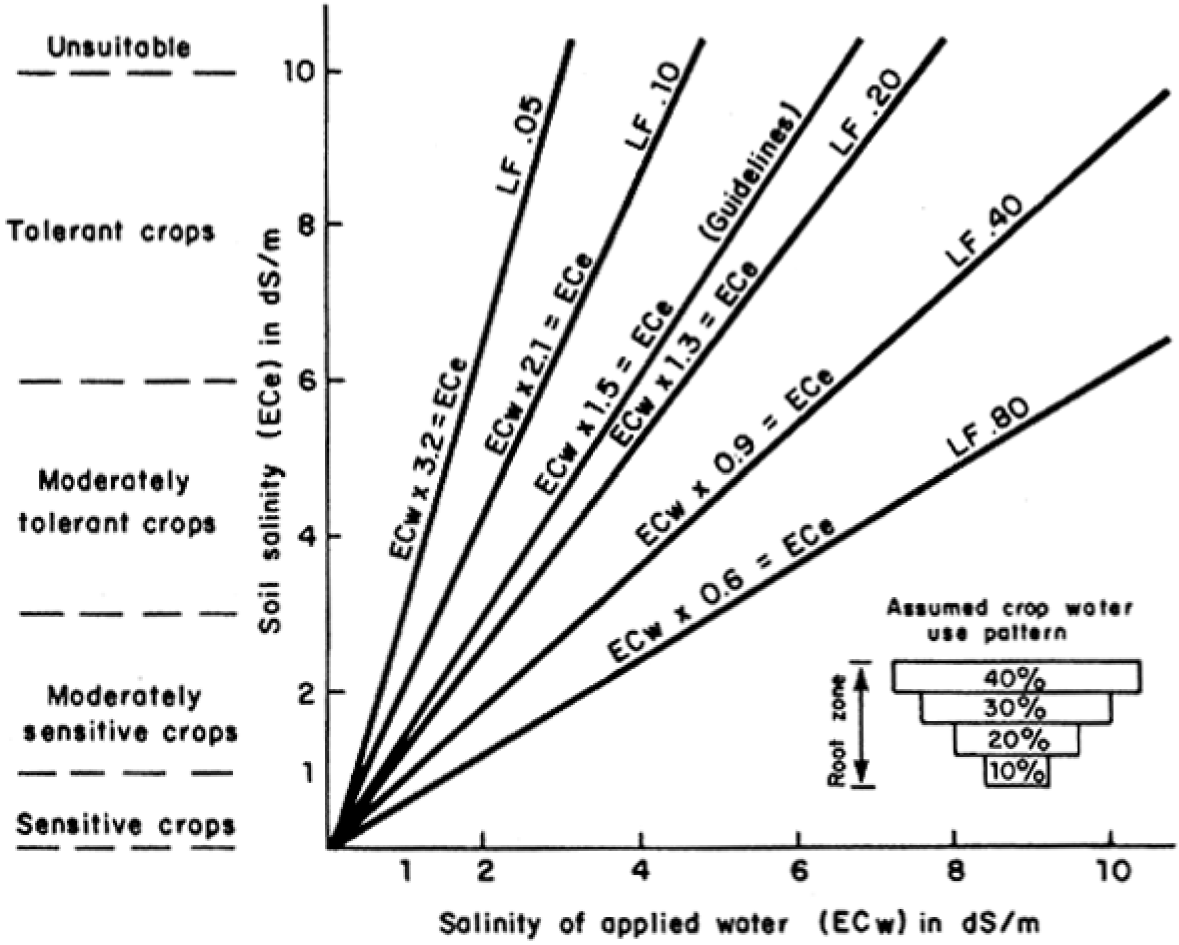


Figure 4-6. Leaching Fraction (Requirement) as Related to Salinity of Applied Water and Soil Salinity (from Ayers and Westcot, 1985).

For example, to find the leaching requirement necessary to obtain a 90% potato yield given an irrigation/wastewater/precipitation composite salinity (EC_w) of 2 dS/m, first find the 90% crop tolerance threshold soil salinity (EC_e) in Table 4-10 (2.5 dS/m). Find 2 dS/m on the x axis of Figure 4-6 and read up until the value 2.5 is reached on the y axis. This point approximately intersects the 0.20 leaching fraction line. This indicates that a leaching requirement of 0.20 would be needed to maintain soil salinity levels below the threshold level.

It should be noted that this calculation is likely conservative, as it assumes that no precipitation of salts occurs in the soil. In general, with the calcareous soils of Idaho, substantial amounts of $CaCO_3$ can precipitate, thereby reducing ECe. See Robbins et al.(1980) and Robbins et al. (1995). More information on soil salinity and salt precipitation is available from the USDA-ARS Kimberly Publications web site:

http://sand.nwisrl.ars.usda.gov/publist.shtml

Another means to estimate the LR can be used. See Rhoades (1974) as cited in Ayers and Westcott (1985). Equation 4-14 should be used for leaching fractions typical of agronomic systems (c. 0.15).

$$\mathrm{LR} = \frac{\mathrm{EC_w}}{5 \cdot \mathrm{EC_e} - \mathrm{EC_w}}$$

Equation 4-14. Leaching requirement formula for a LR around 0.15 (15%).

where terms have been defined as previously. The EC_w is entered along with the soil EC_e for the crop at the particular yield decrement threshold desired (0%, 10%, 25% etc.) and the LR is calculated using Equation 4-15, given both the EC_e of the soil and the EC_w of the applied water.

There are important relationships between applied water EC (EC_w), soil water EC (EC_{sw} or EC_d), and soil salinity (EC_e) which apply at typical leaching fractions (c. 0.15) for agronomic systems. Sometimes salinity data is given in certain terms which need to be converted into other terms to be able to use various tables, figures and equations. These relationships are provided as reference:

$$\mathrm{EC_{sw}}\ (or\ EC_d) = 3\ \mathrm{EC_w}$$

Equation 4-15. Relationship between soil water and applied water.

$$\mathrm{EC_e} = 1.5\ \mathrm{EC_w}$$

Equation 4-16. Relationship between soil salinity and applied water.

$$\mathrm{EC_{sw}}\ (or\ EC_d) = 2\ \mathrm{EC_e}$$

Equation 4-17. Relationship between soil water and soil salinity.

Table 4-10. Crop tolerance and yield potential of selected crops as influenced by irrigation water salinity (EC_w)[1] or soil salinity (EC_e) yield potential[2].

FIELD CROPS	**100%**		**90%**		**75%**		**50%**		**0% "maximum"**[3]	
	EC_e	**EC_w**	**EC_e**	**EC_w**	**EC_e**	**EC_w**	**EC_e**	**EC_w**	**EC_e**	**EC_w**
Barley *(Hordeum vulgare)*[4]	8.0	5.3	10	6.7	13	8.7	18	12	28	19
Cotton *(Gossypium hirsutum)*	7.7	5.1	9.6	6.4	13	8.4	17	12	27	18
Sugarbeet *(Beta vulgaris)*[5]	7.0	4.7	8.7	5.8	11	7.5	15	10	24	16
Sorghum *(Sorghum bicolor)*	6.8	4.5	7.4	5.0	8.4	5.6	9.9	6.7	13	8.7
Wheat *(Triticum aestivum)*[4,6]	6.0	4.0	7.4	4.9	9.5	6.3	13	8.7	20	13
Wheat, durum *(Triticum turgidum)*	5.7	3.8	7.6	5.0	10	6.9	15	10	24	16
Soybean *(Glycine max)*	5.0	3.3	5.5	3.7	6.3	4.2	7.5	5.0	10	6.7
Cowpea *(Vigna unguiculata)*	4.9	3.3	5.7	3.8	7.0	4.7	9.1	6.0	13	8.8
Groundnut (Peanut) *(Arachis hypogaea)*	3.2	2.1	3.5	2.4	4.1	2.7	4.9	3.3	6.6	4.4
Rice (paddy) *(Oriza sativa)*	3.0	2.0	3.8	2.6	5.1	3.4	7.2	4.8	11	7.6
Sugarcane *(Saccharum officinarum)*	1.7	1.1	3.4	2.3	5.9	4.0	10	6.8	19	12
Corn (maize) *(Zea mays)*	1.7	1.1	2.5	1.7	3.8	2.5	5.9	3.9	10	6.7
Flax *(Linum usitatissimum)*	1.7	1.1	2.5	1.7	3.8	2.5	5.9	3.9	10	6.7
Broadbean *(Vicia faba)*	1.5	1.1	2.6	1.8	4.2	2.0	6.8	4.5	12	8.0
Bean *(Phaseolus vulgaris)*	1.0	0.7	1.5	1.0	2.3	1.5	3.6	2.4	6.3	4.2
VEGETABLE CROPS										
Squash, zucchini (courgette) *(Cucurbita pepo melopepo)*	4.7	3.1	5.8	3.8	7.4	4.9	10	6.7	15	10
Beet, red *(Beta*	4.0	2.7	5.1	3.4	6.8	4.5	9.6	6.4	15	10

FIELD CROPS	**100%**		**90%**		**75%**		**50%**		**0% "maximum"** [3]	
	EC_e	**EC_w**	**EC_e**	**EC_w**	**EC_e**	**EC_w**	**EC_e**	**EC_w**	**EC_e**	**EC_w**
vulgaris) [5]										
Squash, scallop *(Cucurbita pepo melopepo)*	3.2	2.1	3.8	2.6	4.8	3.2	6.3	4.2	9.4	6.3
Broccoli *(Brassica oleracea botrytis)*	2.8	1.9	3.9	2.6	5.5	3.7	8.2	5.5	14	9.1
Tomato *(Lycopersicon esculentum)*	2.5	1.7	3.5	2.3	5.0	3.4	7.6	5.0	13	8.4
Cucumber *(Cucumis sativus)*	2.5	1.7	3.3	2.2	4.4	2.9	6.3	4.2	10	6.8
Spinach *(Spinacia oleracea)*	2.0	1.3	3.3	2.2	5.3	3.5	8.6	5.7	15	10
Celery *(Apium graveolens)*	1.8	1.2	3.4	2.3	5.8	3.9	9.9	6.6	18	12
Cabbage *(Brassica oleracea capitata)*	1.8	1.2	2.8	1.9	4.4	2.9	7.0	4.6	12	8.1
Potato *(Solanum tuberosum)*	1.7	1.1	2.5	1.7	3.8	2.5	5.9	3.9	10	6.7
Corn, sweet (maize) *(Zea mays)*	1.7	1.1	2.5	1.7	3.8	2.5	5.9	3.9	10	6.7
Sweet potato *(Ipomoea batatas)*	1.5	1.0	2.4	1.6	3.8	2.5	6.0	4.0	11	7.1
Pepper *(Capsicum annuum)*	1.5	1.0	2.2	1.5	3.3	2.2	5.1	3.4	8.6	5.8
Lettuce *(Lactuca sativa)*	1.3	0.9	2.1	1.4	3.2	2.1	5.1	3.4	9.0	6.0
Radish *(Raphanus sativus)*	1.2	0.8	2.0	1.3	3.1	2.1	5.0	3.4	8.9	5.9
Onion *(Allium cepa)*	1.2	0.8	1.8	1.2	2.8	1.8	4.3	2.9	7.4	5.0
Carrot *(Daucus carota)*	1.0	0.7	1.7	1.1	2.8	1.9	4.6	3.0	8.1	5.4
Bean *(Phaseolus vulgaris)*	1.0	0.7	1.5	1.0	2.3	1.5	3.6	2.4	6.3	4.2
Turnip *(Brassica rapa)*	0.9	0.6	2.0	1.3	3.7	2.5	6.5	4.3	12	8.0
Wheatgrass, tall *(Agropyron elongatum)*	7.5	5.0	9.9	6.6	13	9.0	19	13	31	21
Wheatgrass, fairway crested	7.5	5.0	9.0	6.0	11	7.4	15	9.8	22	15

FIELD CROPS	**100%**		**90%**		**75%**		**50%**		**0% "maximum"**[3]	
	EC_e	**EC_w**	**EC_e**	**EC_w**	**EC_e**	**EC_w**	**EC_e**	**EC_w**	**EC_e**	**EC_w**
(Agropyron cristatum)										
Bermuda grass *(Cynodon dactylon)*[7]	6.9	4.6	8.5	5.6	11	7.2	15	9.8	23	15
Barley (forage) *(Hordeum vulgare)*[4]	6.0	4.0	7.4	4.9	9.5	6.4	13	8.7	20	13
Ryegrass, perennial *(Lolium perenne)*	5.6	3.7	6.9	4.6	8.9	5.9	12	8.1	19	13
Trefoil, narrowleaf birdsfoot[8] *(Lotus corniculatus tenuifolium)*	5.0	3.3	6.0	4.0	7.5	5.0	10	6.7	15	10
Harding grass *(Phalaris tuberosa)*	4.6	3.1	5.9	3.9	7.9	5.3	11	7.4	18	12
Fescue, tall *(Festuca elatior)*	3.9	2.6	5.5	3.6	7.8	5.2	12	7.8	20	13
Wheatgrass, standard crested *(Agropyron sibiricum)*	3.5	2.3	6.0	4.0	9.8	6.5	16	11	28	19
Vetch, common *(Vicia angustifolia)*	3.0	2.0	3.9	2.6	5.3	3.5	7.6	5.0	12	8.1
Sudan grass *(Sorghum sudanense)*	2.8	1.9	5.1	3.4	8.6	5.7	14	9.6	26	17
Wildrye, beardless *(Elymus triticoides)*	2.7	1.8	4.4	2.9	6.9	4.6	11	7.4	19	13
Cowpea (forage) *(Vigna unguiculata)*	2.5	1.7	3.4	2.3	4.8	3.2	7.1	4.8	12	7.8
Trefoil, big *(Lotus uliginosus)*	2.3	1.5	2.8	1.9	3.6	2.4	4.9	3.3	7.6	5.0
Sesbania *(Sesbania exaltata)*	2.3	1.5	3.7	2.5	5.9	3.9	9.4	6.3	17	11
Sphaerophysa *(Sphaerophysa salsula)*	2.2	1.5	3.6	2.4	5.8	3.8	9.3	6.2	16	11
Alfalfa *(Medicago sativa)*	2.0	1.3	3.4	2.2	5.4	3.6	8.8	5.9	16	10

FIELD CROPS	100%		90%		75%		50%		0% "maximum"[3]	
	EC_e	EC_w	EC_e	EC_w	EC_e	EC_w	EC_e	EC_w	EC_e	EC_w
Lovegrass *(Eragrostis sp.)*[9]	2.0	1.3	3.2	2.1	5.0	3.3	8.0	5.3	14	9.3
Corn (forage) (maize) *(Zea mays)*	1.8	1.2	3.2	2.1	5.2	3.5	8.6	5.7	15	10
Clover, berseem *(Trifolium alexandrinum)*	1.5	1.0	3.2	2.2	5.9	3.9	10	6.8	19	13
Orchard grass *(Dactylis glomerata)*	1.5	1.0	3.1	2.1	5.5	3.7	9.6	6.4	18	12
Foxtail, meadow *(Alopecurus pratensis)*	1.5	1.0	2.5	1.7	4.1	2.7	6.7	4.5	12	7.9
Clover, red *(Trifolium pratense)*	1.5	1.0	2.3	1.6	3.6	2.4	5.7	3.8	9.8	6.6
Clover, alsike *(Trifolium hybridum)*	1.5	1.0	2.3	1.6	3.6	2.4	5.7	3.8	9.8	6.6
Clover, ladino *(Trifolium repens)*	1.5	1.0	2.3	1.6	3.6	2.4	5.7	3.8	9.8	6.6
Clover, strawberry *(Trifolium fragiferum)*	1.5	1.0	2.3	1.6	3.6	2.4	5.7	3.8	9.8	6.6
FRUIT CROPS[10]										
Date palm *(phoenix dactylifera)*	4.0	2.7	6.8	4.5	11	7.3	18	12	32	21
Grapefruit *(Citrus paradisi)*[11]	1.8	1.2	2.4	1.6	3.4	2.2	4.9	3.3	8.0	5.4
Orange *(Citrus sinensis)*	1.7	1.1	2.3	1.6	3.3	2.2	4.8	3.2	8.0	5.3
Peach *(Prunus persica)*	1.7	1.1	2.2	1.5	2.9	1.9	4.1	2.7	6.5	4.3
Apricot *(Prunus armeniaca)*[11]	1.6	1.1	2.0	1.3	2.6	1.8	3.7	2.5	5.8	3.8
Grape *(Vitus sp.)*[11]	1.5	1.0	2.5	1.7	4.1	2.7	6.7	4.5	12	7.9
Almond *(Prunus dulcis)*[11]	1.5	1.0	2.0	1.4	2.8	1.9	4.1	2.8	6.8	4.5
Plum, prune *(Prunus*	1.5	1.0	2.1	1.4	2.9	1.9	4.3	2.9	7.1	4.7

FIELD CROPS	100%		90%		75%		50%		0% "maximum"[3]	
	EC_e	EC_w	EC_e	EC_w	EC_e	EC_w	EC_e	EC_w	EC_e	EC_w
domestica)[11]										
Blackberry *(Rubus sp.)*	1.5	1.0	2.0	1.3	2.6	1.8	3.8	2.5	6.0	4.0
Boysenberry *(Rubus ursinus)*	1.5	1.0	2.0	1.3	2.6	1.8	3.8	2.5	6.0	4.0
Strawberry *(Fragaria sp.)*	1.0	0.7	1.3	0.9	1.8	1.2	2.5	1.7	4	2.7

From Ayers and Westcot, 1985[1] Adapted from Maas and Hoffman (1977) and Maas (1984). These data should only serve as a guide to relative tolerances among crops. Absolute tolerances vary depending upon climate, soil conditions and cultural practices. In gypsiferous soils, plants will tolerate about 2 dS/m higher soil salinity (EC_e) than indicated but the water salinity (EC_w) will remain the same as shown in this table.

[2] EC_e means average root zone salinity as measured by electrical conductivity of the saturation extract of the soil, reported in deciSiemens per metre (dS/m) at 25°C. EC_w means electrical conductivity of the irrigation water in deciSiemens per metre (dS/m). The relationship between soil salinity and water salinity ($EC_e = 1.5\ EC_w$) assumes a 15–20 percent leaching fraction and a 40-30-20-10 percent water use pattern for the upper to lower quarters of the root zone. These assumptions were used in developing the guidelines in Table 1.

[3] The zero yield potential or maximum EC_e indicates the theoretical soil salinity (EC_e) atwhich crop growth ceases.

[4] Barley and wheat are less tolerant during germination and seeding stage; EC_e should not exceed 4–5 dS/m in the upper soil during this period.

[5] Beets are more sensitive during germination; EC_e should not exceed 3 dS/m in the seeding area for garden beets and sugar beets.

[6] Semi-dwarf, short cultivars may be less tolerant.

[7] Tolerance given is an average of several varieties; Suwannee and Coastal Bermuda grass are about 20 percent more tolerant, while Common and Greenfield Bermuda grass are about 20percent less tolerant.

[8] Broadleaf Birdsfoot Trefoil seems less tolerant than Narrowleaf Birdsfoot Trefoil.

[9] Tolerance given is an average for Boer, Wilman, Sand and Weeping Lovegrass; Lehman Lovegrass seems about 50 percent more tolerant.

[10] These data are applicable when rootstocks are used that do not accumulate Na^+ and Cl^- rapidly or when these ions do not predominate in the soil. If either ions do, refer to the toxicity discussion in Section 4.

[11] Tolerance evaluation is based on tree growth and not on yield.

Table 4-11. Concentration factors (X) for predicting soil salinity (EC_e) from irrigation water salinity (EC_w) and the leaching fraction (LF).

Leaching Fraction (LF)	Applied Water Needed (Percent of ET)	Concentration Factor [2] (X)
0.05	105.3	3.2
0.10	111.1	2.1
0.15	117.6	1.6
0.20	125.0	1.3
0.25	133.3	1.2
0.30	142.9	1.0
0.40	166.7	0.9
0.50	200.0	0.8
0.60	250.0	0.7
0.70	333.3	0.6
0.80	500.0	0.6

From Ayers and Westcot, 1985.

4.4.8 Irrigation Application Efficiencies

Table 4-12. Application efficiencies (expressed as percents) by system type (Ashley et al., 1998).

Typical irrigation system application efficiencies

Application efficiency

Surface systems		**Sprinkler systems***	(%)
Furrow	35 - 65	Stationary lateral (wheel or hand move)	60 - 75
Corrugate	30 - 55	Solid set lateral	60 - 85
Border, level	60 - 75	Traveling big gun	55 - 67
Border, graded	55 - 75	Stationary big gun	50 - 60
Flood, wild	15 - 35	High pressure center pivot	65 - 80
Surge	50 - 55	Low pressure center pivot	75 - 85
Cablegation	50 - 55	Moving lateral (linear)	80 - 87
		Micro irrigation systems	
		Surface/subsurface drip	90 - 95
		Micro spray or mist	85 - 90

*For sprinkler systems, lower values should be used for wide nozzle spacing and windy conditions.
Source: Sterling, R. and W.H. Neibling. 1994. Final Report of the Water Conservation Task Force. IDWR Report. Idaho Department of Water Resources, Boise, ID.

4.4.9 Determining Site Specific Non-growing Season Hydraulic Loading Rates (HLR_{ngs})

This section provides guidance on determining non-growing season hydraulic loading rates (HLR_{ngs}). The calculation as presented and explained below is a significant simplification of processes taking place. The rate is designed to generate minimal leaching and is likely environmentally protective. However, the appropriateness of the guideline value obtained must be evaluated on a case-by-case basis, particularly with respect to the timing of wastewater land application during the non-growing season, and cumulative precipitation and evaporation (i.e. the available storage capacity at the time of application). The HLR_{ngs} is defined as follows:

$$HLR_{ngs} = [AWC + E - PPT_{ngs}]$$

Equation 4-18. Non-growing season hydraulic loading rate.

where AWC is the soil's available water holding capacity, E is non-growing season evaporation, and PPT_{ngs} is the non-growing season precipitation. These terms are further described below:

AWC is the available water holding capacity of the soil. AWC for purposes here is typically calculated for a 60 inch soil depth or a root limiting layer, whichever is shallowest. AWC values can be determined site-specifically. More general and readily obtainable values are also available from several sources. Soil AWC information may be found in National Resource Conservation Service (NRCS) Soil Survey Reports. Spatial and aspatial data (including soil AWC) may be down-loaded from the following NRCS Web site:

http://www.ftw.nrcs.usda.gov/ssurgo_ftp3.html

Soil AWC can also be estimated from soil textural properties (Saxton et al. 1986). An automated soil-water characteristics/hydraulic properties calculator has been developed, also by Saxton and others at Washington State University, and is available for download at the following Web site:

http://hydrolab.arsusda.gov/soilwater/Index.htm

Soil AWC, as used in Equation 4-18, is typically based on physical soil properties that do not change, so that a general guideline value may be calculated for inclusion into a permit or plan of operation. There are other factors involving the determination of AWC that are important, but if considered make the HLR_{ngs} a constantly changing value. For example, if the crop's effective rooting depth (i.e. the depth at which the crop roots extract the majority of the water utilized by the plant) is considered, the HLR_{ngs} will change as the crop changes. Table 1 of Ashley et al. (1998) shows effective rooting depths of typical Idaho crops varying between 0.5 feet (e.g. winter grains) and 4 feet (e.g. alfalfa).

If the proportion of the soil's AWC already filled with water at the beginning of the non-growing season is determined, and not assumed to be zero, this will also change the HLR_{ngs} value every year. The expediency of having either a static value or one which annually changes must be weighed against the cost of making measurements, sensitivity of the resource being protected, and usefulness of the information in protecting ground and surface water for each site.

Soils are not actually depleted of plant available water, and, in some cases, may be close to field capacity at the end of the growing season given decreasing ET rates and relatively constant wastewater application rates. Good agronomic practice does not dry a field to the wilting point (15 bar) where crop death results. If the application system is operated year round, it is likely that application rates going into the non-growing season during September and October may exceed the ET during that period, thus the soil water content could likely approach that at field capacity. A soil AWC adjusted for typical end-of-growing-season soil water content (dependant upon typical management practices on a site-specific basis), rather than assuming zero water content, would be a more reasonable assumption, but is not typically how Equation 4-18 is applied. As with guidance in general, site-specific circumstances should determine how best to apply Equation 4-18.

Variability of soils on a hydraulic management unit generally means variable AWC values as well. In some cases, an acreage weighted average AWC may be an appropriate estimate for the unit. In other cases, selecting an AWC from the most limiting soil (e.g. coarse textured soils, shallow soils etc.) of reasonable areal extent may be the more environmentally protective. Such determinations need to be done on a case-by-case basis, particularly with respect to the sensitivity and vulnerability of ground water.

PPT_{ngs} = average precipitation falling during the non-growing season. Sources of precipitation data are provided in Section 4.1.1.2.2. A representative period of record should be used when determining PPT_{ngs}, such as the mean from a thirty-year period from present.

Effective precipitation (PPT_e) should not be used when calculating NGS hydraulic balances. As described in Section 4.1.1.2.2, PPT_e is employed to describe precipitation effective for plant growth, and as such has application only in the growing season. Non-growing season evaporative or evapotranspirative losses, determined as described previously, are reckoned to account for non-leaching and non-runoff precipitation losses in non-growing season hydraulic balance calculations.

E = estimate of evaporation/evapotranspiration during the non-growing season. This guidance provides four sources for E estimates:

1. Lysimeter measurement of non-growing season ET for the Kimberly area is found in Wright (1991). This is one of the few non-growing season lysimeter ET studies which have been done. Result of this multi-year study are found in Section 4.4.9 (Table 4-14). Plots of averaged ET and precipitation (including a cumulative plot) during the non-growing season are also provided in Figures 4-10 and 4-11. In the cumulative plot (Figure 4-11), cumulative wastewater loading can also be plotted. Both precipitation and wastewater loading plots can be summed to yield a cumulative water loading received. A value equal to the AWC of the soil (preferably the remaining AWC not filled with water at the end of the growing season) can be added to each point of the cumulative ET plot to obtain the cumulative soil storage capacity. So long as the cumulative water loading plot stays below the cumulative soil storage plot, no leaching would take place. The results of Wright (1991) can be utilized for all of Southern Idaho south of Whitebird in valley areas below about 5000 ft. elevation, since winter conditions are not too different across all of southern Idaho for areas near or on the Snake and Boise plains (Allen, 2006).

2. Non-Averaged NGS ET Data: Non-growing season ET data (for bare wet soil) for different weather stations may be found at the AgriMet Historical Archive Weather Data Access Web Site:

   http://www.usbr.gov/pn/agrimet/webarcread.html

   These values are calculated using the 1982 Kimberly-Penman Equation as modified in Wright (1996) (Dr. James Wright, Personal Communication; August 20, 2003). Daily ET data for a desired period of record (e.g. a thirty-year period from present) may be down-loaded. In order to obtain historical monthly averages of non-growing season ET, down-loaded data from the period of record may then be summed and averaged by month. Data from a single year of record should not be utilized to determine non-growing season ET. After monthly average values of ET are calculated, they should be multiplied by an 'evaporation coefficient' (or a non-growing season ET coefficient, referred to as a crop coefficient, or K_c, during the growing season) (discussed below) to account for periods of both snow cover and dry soil surface conditions (J. Wright, August 20, 2003).

3. Averaged ET Data: Averaged summary non-growing season ET data for various periods of record are found in Table 4-13.. These data are from AgriMet summary spreadsheet tables provided by Mr. Peter Palmer of the USBR. These averaged data have been multiplied by an 'evaporation coefficient' of 0.7 .

4. An evaporation coefficient of 0.7 is recommended by Wright (2003). The evaporation coefficient is derived by calculating monthly ET_r by the Kimberly Penman equation and dividing that into the ET values reported by Wright (1991). Figure 4-7 and Figure 4-8 show the calculated NGS ET coefficients as they vary by month, by year, and by type of cover. A mean value for each month of the NGS could be used. Based on all years data from Wright (1991), a coefficient of 0.6 might be more appropriate and conservative. One consideration to make is that applications by sprinkler during winter time will wet the surface and increase to some degree the coefficient over those derived from Wright (1991). See Allen (2006).

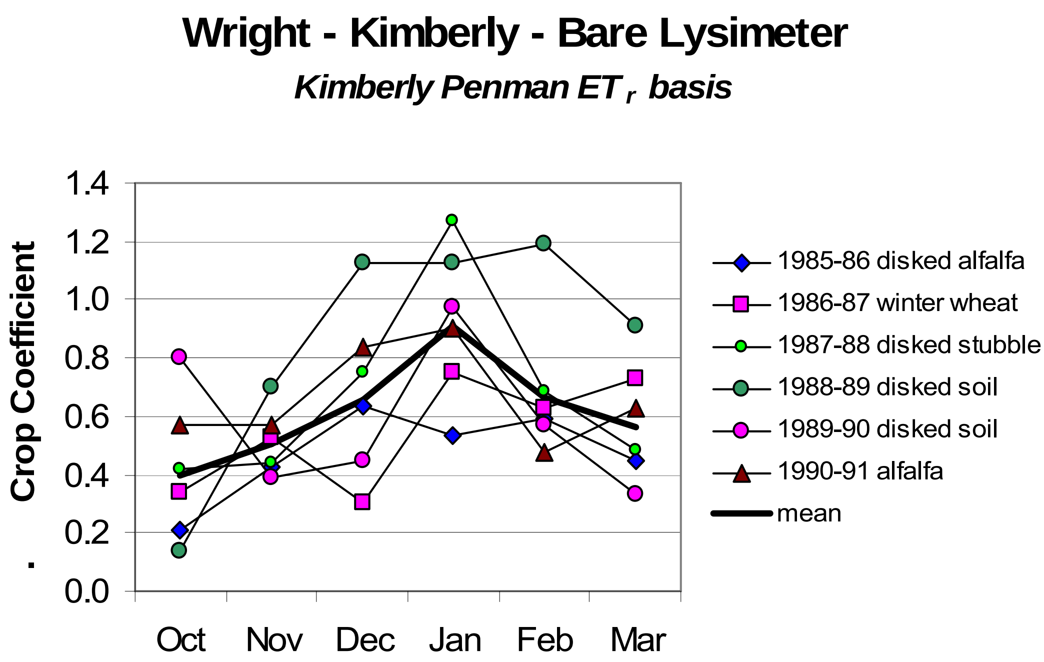


Figure 4-7

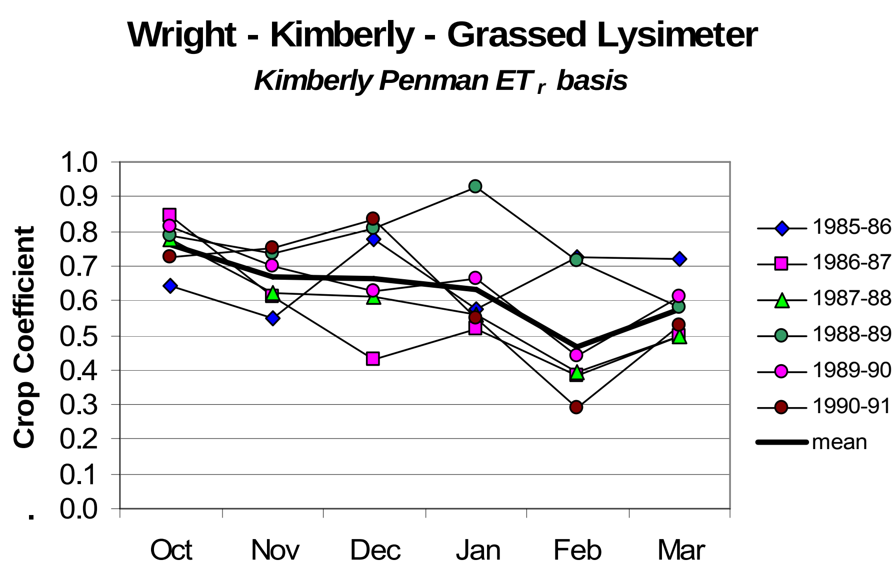


Figure 4-8

Allen (1996) found that, for mountain valley areas with similar climate as Logan UT (Allen, 2006) a coefficient of 0.5 multiplied by the reference grass ET (ET_o) was adequate to predict non-growing season evaporation for days having no snow cover, as Equation 4-19 states:

$$ET_{ngs} = 0.5 \cdot ET_o$$

Equation 4-19. Non-growing season ET.

Agrimet data in Idaho uses alfalfa reference ET (ET_r) as the reference ET rather than ET_o). Wright et al. (2000) provides the following relationship for the conversion of ET_r to ET_o:

$$ET_o = 0.87 \cdot ET_r$$

Equation 4-20. Calculation of ET_o

So, to obtain ET_{ngs} from ET_r, Equation 4-21 may be used (again, for mountain valley areas similar in climate to Logan UT):

$$ET_{ngs} = (0.5) \cdot (0.87) ET_r \quad \text{or } ET_{ngs} = 0.43 \cdot ET_r$$

Equation 4-21. Calculation of ET_{ngs}.

Table 4-13. Non-growing season ET data.

USBR Weather Station Code	Location	Units - All Entries are Inches Oct	Nov	Dec	Jan	Feb	Mar	Apr	Totals Oct -> April	Oct -> Mar	Nov -> April	Nov -> Mar	Period of Record
ABEI	Aberdeen, ID	2.4	0.8	0.4	0.4	0.8	1.9	3.1	9.8	6.7	7.4	4.3	' 91 - ' 02
AFTY	Afton, WY	1.8	0.6	0.2	0.3	0.6	1.4	2.4	7.2	4.8	5.4	3.0	' 87 - ' 02
AHTI	Ashton, ID	2.3	0.8	0.4	0.4	0.8	1.6	2.7	8.8	6.2	6.6	3.9	' 87 - ' 02
BOII	Boise, ID	1.6	0.7	0.4	0.4	0.8	1.7	2.7	8.4	5.7	6.7	4.0	' 95 - ' 02
FAFI	Fairfield, ID	2.4	0.8	0.3	0.4	0.7	1.6	2.8	9.0	6.2	6.7	3.8	' 87 - ' 02
FTHI	Fort Hall, ID	2.6	0.9	0.4	0.4	0.7	1.8	3.3	10.1	6.8	7.5	4.2	' 01 - ' 02
GDVI	Grandview, ID	2.3	1.0	0.5	0.5	1.0	2.1	3.2	10.7	7.5	8.4	5.2	' 93 - ' 02
GFRI	Glenns Ferry, ID	2.8	1.2	0.5	0.6	1.0	2.2	3.1	11.4	8.2	8.6	5.4	' 93 - ' 02
KTBI	Kettle Butte, ID	2.5	0.8	0.2	0.3	0.6	1.7	2.9	9.0	6.1	6.5	3.6	' 96 - ' 02
MALI	Malta, ID	2.7	1.2	0.6	0.7	1.1	2.1	3.3	11.6	8.3	8.9	5.7	' 90 - ' 02
MNTI	Monteview, ID	2.0	0.7	0.2	0.2	0.5	1.6	2.9	8.1	5.2	6.2	3.3	' 96 - ' 02
NMPI	Nampa, ID	2.6	1.1	0.5	0.5	1.0	2.3	3.3	11.4	8.0	8.7	5.4	' 96 - ' 02
ONTO	Ontario, OR	2.4	0.8	0.4	0.4	0.8	2.0	3.3	10.0	6.7	7.7	4.4	' 92 - ' 02
PICI	Picabo, ID	2.2	0.8	0.9	0.4	0.8	1.7	2.9	9.7	6.8	7.5	4.6	' 93 - ' 02
PMAI	Parma, ID	2.3	0.9	0.5	0.4	0.9	2.2	3.4	10.5	7.1	8.3	4.9	' 86 - ' 02
RPTI	Rupert, ID	2.5	1.0	0.5	0.6	0.9	2.0	3.2	10.7	7.5	8.3	5.1	' 88 - ' 02
RXGI	Rexburg, ID	2.1	0.7	0.3	0.3	0.7	1.7	2.9	8.6	5.7	6.5	3.6	' 87 - ' 02
TWFI	Twin Falls, ID	2.6	1.1	0.6	0.7	1.0	2.2	3.2	11.4	8.1	8.7	5.5	' 90 - ' 02

Another approach to estimating the K_c during the nongrowing season is to use the 'initial K_c' procedure from FAO-56 (Allen et al., 1998) where the K_c estimate is a function of wetting frequency and ET_o rate, as Figure 4-9shows. The benefit of this method is that the $K_{c\ ngs}$ increases with increased wetting frequency. The graph is described in detail in

Chapter 5 of Allen et al. (1998; pages 114-119) and the application of the graph for nongrowing periods is described in Chapter 11 of Allen et al. (1998; pages 207 – 210).[3]

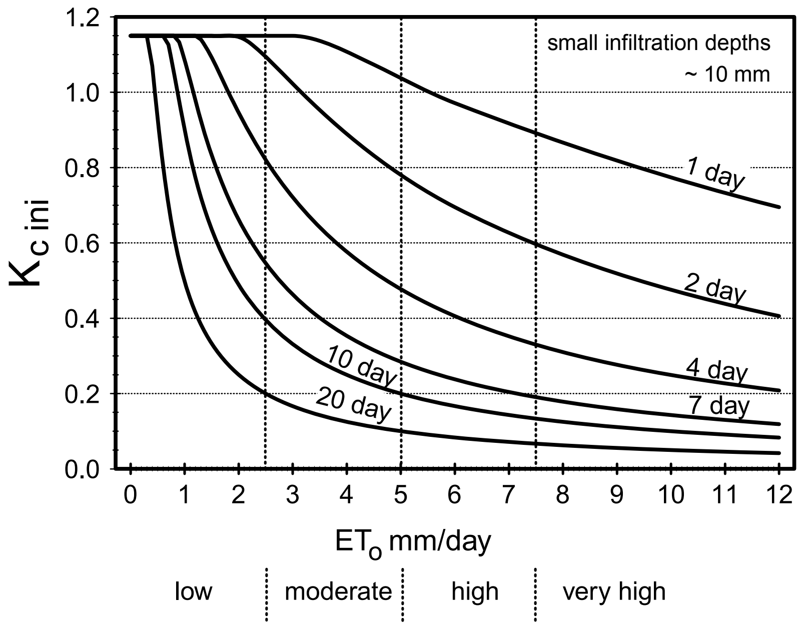


Figure 4-9. ET Crop coefficients as a function of ET_0 (Grass Reference ET) and frequency of soil wetting.

Figure 4-9 shows the average K_c during the nongrowing season (= $K_{c\ ini}$) as related to the level of ET_o and the interval between irrigations and/or significant rain during the period when wetting events are relatively light (about 10 mm per event) (from Allen et al. 1998).

For example, if the month of November has an average ET_o = 2 mm/day and the irrigation frequency of a land application system is every 7 days, then the $K_{c\ ngs}$ from is about 0.6 and the ET_{ngs} = 0.6 (2) = 1.2 mm/day or 36 mm for the month. Since reference ET data is in terms of ET_r, ET data will have to be converted from ET_r to ET_o by using Equation 4-19 before using the method in this figure.

A leaching requirement/leaching fraction was included in previous editions of the Guidance (see definition in Section 4.1.1.2.2). It is generally observed that soil EC levels from wastewater land treatment sites in Idaho seldom show increases over time, which would indicate salt build-up. Soil EC levels usually reflect agronomically acceptable ranges (i.e. salt loading insufficient to cause crop yield decrements). Apparently there is sufficient leaching taking place, both through normal agronomic practices employed at wastewater land treatment sites, and at sites practicing non-growing season application to provide the leaching fraction necessary for the control of salt build-up. DEQ would allow

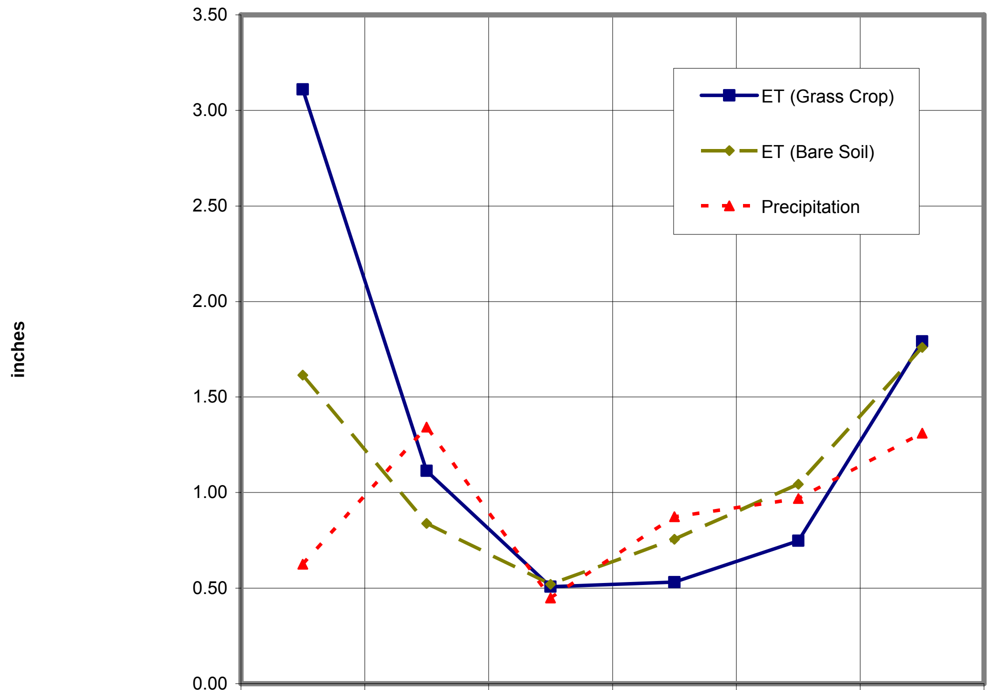
[3] FAO-56 is available on-line at http://www.kimberly.uidaho.edu/water/fao56/index.html and at http://www.fao.org/docrep/X0490E/X0490E00.htm

the inclusion of additional leaching fraction in the event soil EC data indicate salt build-up. Whether the leaching fraction is allowed in the growing or non-growing season would be determined by characterizing potential environmental impacts from either scenario. Leaching requirement calculations are discussed in Section 4.4.7.

4.4.10 Non-Growing Season Lysimeter Evaporation Data

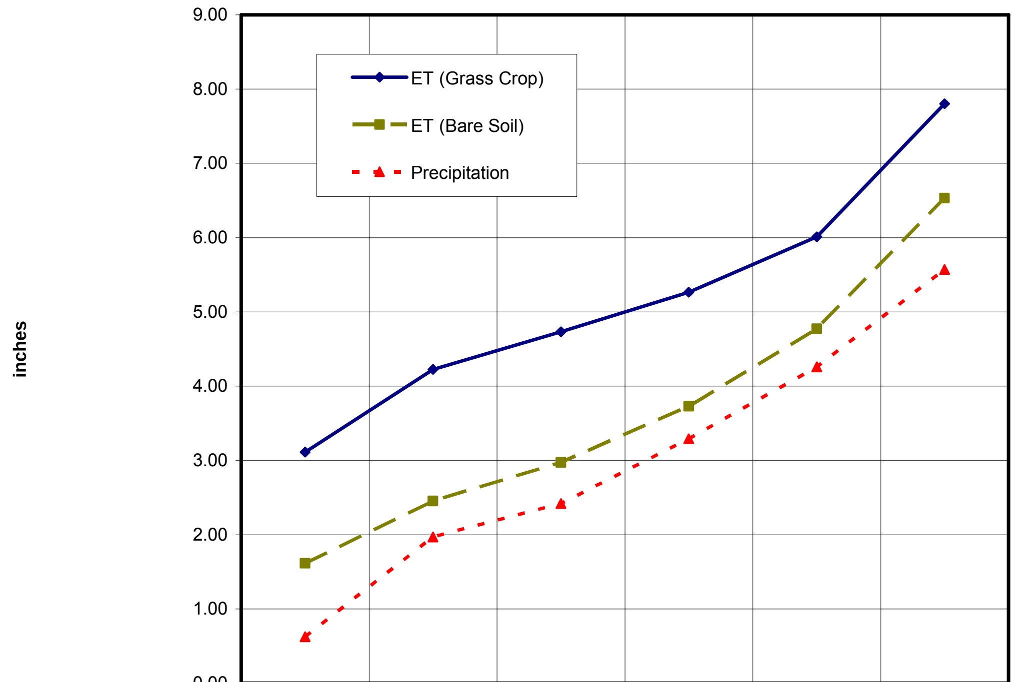
Table 4-14. Lysimeter measurement of non-growing season ET for the Kimberly, ID area.

Year	Total (in)						
	Oct	Nov	Dec	Jan	Feb	Mar	Total
Lysimeter 1 (Grass Crop)							
1985-86	2.52	0.71	0.43	0.59	1.06	2.48	7.80
1986-87	2.95	1.18	0.39	0.35	0.55	1.50	6.97
1987-88	3.58	0.94	0.51	0.43	0.79	1.65	7.91
1988-89	3.78	0.91	0.51	0.75	0.83	1.34	8.15
1989-90	2.64	1.26	0.55	0.59	0.67	2.17	7.87
1990-91	3.19	1.61	0.71	0.43	0.55	1.61	8.07
Mean	3.11	1.11	0.51	0.53	0.75	1.79	7.80
Daily	0.10	0.04	0.02	0.02	0.03	0.06	0.04
Lysimeter 2 (Bare Soil)							
1985-86	0.83	0.55	0.35	0.55	0.87	1.54	4.65
1986-87	1.18	1.02	0.28	0.51	0.91	2.20	6.10
1987-88	1.93	0.67	0.63	0.98	1.38	1.61	7.24
1988-89	0.67	0.87	0.71	0.91	1.38	2.09	6.61
1989-90	2.60	0.71	0.39	0.87	0.87	1.18	6.57
1990-91	2.52	1.22	0.71	0.71	0.91	1.93	8.03
Mean	1.61	0.84	0.52	0.76	1.04	1.76	6.53
Daily	0.05	0.03	0.02	0.02	0.04	0.06	0.04
Precipitation							
1985-86	0.94	1.89	0.79	1.02	3.94	0.67	9.25
1986-87	1.02	0.59	0.08	1.30	0.94	1.46	5.39
1987-88	0.04	1.02	1.14	0.83	0.12	0.83	3.98
1988-89	0.00	3.03	0.00	0.20	0.39	2.56	6.18
1989-90	1.42	1.10	0.04	1.26	0.12	0.98	4.92
1990-91	0.31	0.55	0.67	0.67	0.28	1.38	3.82
Mean	0.63	1.34	0.45	0.87	0.97	1.31	5.59
Daily	0.02	0.05	0.02	0.03	0.04	0.04	0.03



	Oct	Nov	Dec	Jan	Feb	Mar
ET (Grass Crop)	3.11	1.11	0.51	0.53	0.75	1.79
ET (Bare Soil)	1.61	0.84	0.52	0.76	1.04	1.76
Precipitation	0.63	1.34	0.45	0.87	0.97	1.31

Figure 4-10. Plot of monthly non-growing season evaporation/evapotranspiration and precipitation from lysimeter studies in Kimberley Idaho (Wright 1991).



	Oct	Nov	Dec	Jan	Feb	Mar
ET (Grass Crop)	3.11	4.22	4.73	5.26	6.01	7.80
ET (Bare Soil)	1.61	2.45	2.97	3.73	4.77	6.53
Precipitation	0.63	1.97	2.42	3.29	4.26	5.57

Figure 4-11. Plot of cumulative monthly non-growing season evaporation/evapotranspiration and precipitation from lysimeter studies in Kimberley Idaho (Wright 1991).

4.4.11 Non-Growing Season Ground Water Impact Screening Tool for Low-Strength Wastewater Loading

The purpose of this screening tool spreadsheet is to provide a preliminary screening tool for low-strength wastewater applied during the non-growing season (NGS). The screening tool determines worse case increases in ground water nitrate-N concentrations and provides an estimate of an acceptable NGS hydraulic loading rate when change to groundwater is determined to be acceptable.

The screening tool is designed to be simple, conservative, and focused on potential ground water impacts from non-growing season wastewater application. It is meant to provide preliminary information on the feasibility of non-growing season wastewater loading, and is not meant to take the place of more sophisticated modeling which can, and should, be done, depending upon the results of initial screening. Examples of low strength wastewater may include Class A or B municipal reclaimed wastewater, or other industrial or municipal wastewaters with sufficiently low nitrogen, COD, or other constituent concentrations (see further discussion below).

Most of the inputs are relatively straightforward, such as wastewater volumes and concentrations, site dimensions, and meteorological data. The hydrogeologic scenario is critical in estimating changes in ground water nitrate-N concentrations. Therefore, estimates of aquifer parameters should be made by persons having professional expertise in hydrogeology.

There are several simplifying assumptions made in the Non-growing Season Wastewater Loading-Ground Water Screening Tool so that it can serve as a user-friendly screening tool. These are itemized below:

1) The land treatment site is assumed to have a rectangular shape, the length of which is oriented along the ground water flow path. The width is perpendicular to ground water flow. Various length to width ratios can be selected from the spreadsheet.
2) Nitrogen application during the non-growing season is the primary constituent of concern. Other constituents such as TDS or chloride, and their respective changes to ground water concentration during the non-growing season, can also be modeled with this tool. Denitrification/volatilization losses (see below) for other constituents would be set to zero.
3) Rate of denitrification/volatilization losses of NGS applied N can be entered as a proportion in the spreadsheet.
4) In the case of nitrogen, the remainder of the nitrogen applied is conservatively assumed to mineralize, nitrify and leach as nitrate-N.
5) The non-growing season percolate volume is calculated by summing NGS precipitation and wastewater application, and subtracting NGS evaporation (here, Agrimet averaged data with an evaporation coefficient applied).
6) It is assumed that there is no change in either soil water content or soil nitrogen (or other constituent) content from beginning to end of the NGS. Thus, soil storage is not considered in this screening tool for the water balance/percolate

calculations. Further site-specific analyses can be done to incorporate the soil AWC parameter, including end-of-growing-season soil moisture, crop type and rooting depth. It should be noted however, that such analyses progress beyond that of ‘screening’.

7) NGS percolate is mixed with NGS groundwater flow beyond the down gradient cross-sectional discharge boundary at a given background concentration to determine a steady state mixed concentration accounting for only NGS activities. The purpose of this analysis is to isolate environmental influence from NGS wastewater application only.
8) Growing season ground water impacts are assumed for the growing season. Leaching rate is assumed and added to volume of groundwater discharging from the down gradient boundary during the growing season only. This combined volume of ground water and percolate has the assumed impacted ground water concentration.
9) It is assumed that normal agronomic management and nutrient and hydraulic loading are being practiced during the growing season. It is also assumed that fertility guides which use soil monitoring are being utilized so that resident soil nutrients in the spring are used for crop growth, and that appropriate nutrient loading is practiced for the particular crop, location and yield goal.
10) A low NGS wastewater COD loading threshold rate for use of this screening tool should be employed in order to reasonably rule out impacts from solubilization of redox sensitive species such as Fe and Mn.
11) Potential growing season and non-growing season ground water impacts, calculated separately, are combined to arrive at predicted impacts for the entire system. The combined volume of percolate and ground water generated/discharged during the NGS (at its calculated constituent concentration), is mixed with the combined volume of percolate and ground water generated/discharged during the GS (at its assumed constituent concentration), to arrive at an estimate of ground water impacts from the system.

Use of the screening tool is straightforward. Input cells are grouped together in the top half of the spreadsheet (Figure 4-12) and are in red font. Site-specific inputs are made there. All other cells, including calculated cells, are in black font and are not to be changed. Calculated cells, provide various results such as leachate volume, concentration etc. The calculated cell at the bottom of the spreadsheet yields the estimated steady-state down-gradient ground water concentration (C_{mix}) of the entire system (i.e. from both growing and non-growing seasons).

The chart provided in the spreadsheet (Figure 4-13) automatically plots C_{mix} as a function of the aquifer hydraulic conductivity within reasonable ranges for the purpose of sensitivity analysis for the parameter which is most likely the least known of the input parameters. In this example, C_{mix} varies from 2.3 mg/L to 2.9 mg/L nitrate-N as hydraulic conductivity varies from 2000 ft/day to 5000 ft/day. This sensitivity analysis is important to do because there are instances where impacts may vary from being of little regulatory concern to being of significant regulatory concern depending on parameter values input in the model. The output of the model, $C_{mix,}$ can then be compared to relevant program guidance to determine the acceptability of the range of predicted ground water impacts, and permitting decisions can be made from there.

There should be no need for the user of the screening tool spreadsheet to access any worksheet other than 'INPUTS'. There are several other worksheets which contain precipitation and evaporation/evapotranspiration data, lookup tables for area and season-specific date, mixing and dispersion calculations, and data plot files. These other worksheets are automatically invoked to do necessary calculations which appear also in the 'INPUTS' worksheet.

Ground Water Impact Mixing Analysis Screening Tool

Non-Growing Season Wastewater Loading

Revision 1/4/2006

Inputs	Parameter Ent	Units	Comments
COD Wastewater Conc (NGS)	20.0	mg/L	
Nitrogen Wastewater Conc. (NGS)	30.0	mg/L	
NGS Wastewater Applied	10	in/acre	
Site Acreage	100	acres	
Non-Growing Season Length	A. Oct - April		
Ratio of Site Length (along GW Flowpath) to Site Width	2:1		Orient rectangle along GW flow path
Climate Station (label cell)	Boise Wsfo		
Agri Met Weather Station (label cell)	Boise, ID		
Aquifer Hydraulic Conductivity (lower range value)	1750	feet/day	
Aquifer Hydraulic Conductivity (higher range value)	5250	feet/day	
Aquifer Hydraulic Gradient	0.0014	unitless	
Aquifer Thickness (not Mixing Depth)	850	feet	
Up Gradient Ground Water Concentration	1.5	mg/L	
Denitrification/Volatilization Losses	0.15	unitless	Recommend <= 0.15
Assumed impacts from Growing Season			
Constituent increase above ambient GW ->	0.5	mg/L	Assume 0.5 - 1.0 mg/L
Estimated leaching in GS ->	1.0	inches	Assume 10% of IWR for Leaching Fraction

Outputs	Calculation Results	Units	
COD Loading NGS	0.3	lb/ac-day	Should be Less than 5 lb/ac-day
Nitrogen Loading NGS	67.9	lb/ac	
NGS Leaching	14.6	inches	
Nitrogen Loss to Leaching	57.7	lb/ac	
Percolate N Concentration	17.5	mg/L	
Flow Path Length	2952	feet	
Predicted Down Gradient GW Nitrate-N Concentration due	3.5	mg/L	
Kh increment for plotting	350	ft/day	
Combined GS and NGS GW Impacts to System			
Cmix gs	2.0	mg/L	
Cmix ngs	3.5	mg/L	
Qngs = Qp + Qgw (MG/season)	317.4	MG	
Qgs = Qp + Qgw (MG/season)	203.2	MG	
Cmix of system (at low range Kh)	2.9	mg/L	

Figure 4-12. Example input and output sheet of the screening tool.

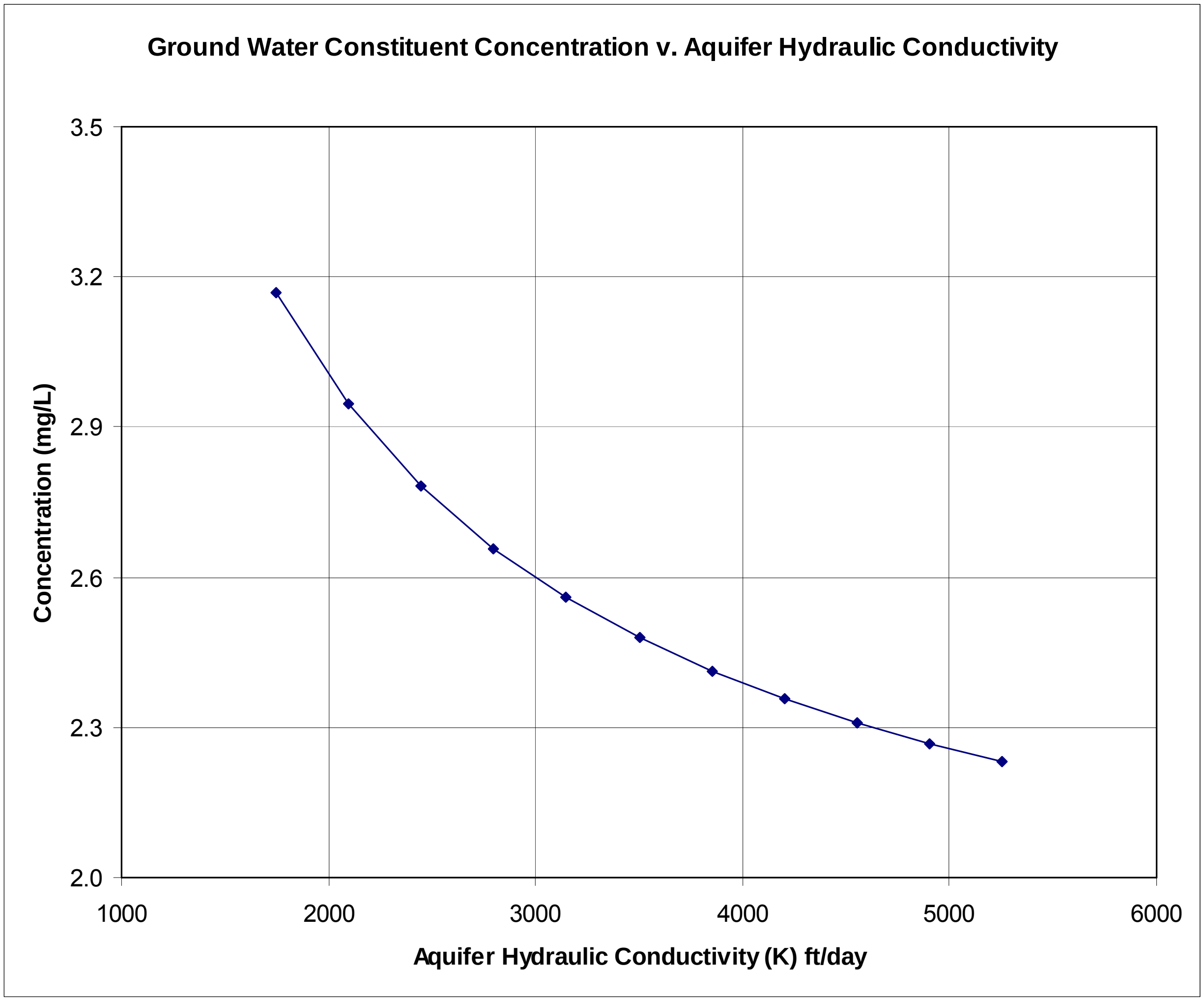


Figure 4-13. Example of sensitivity analysis plot automatically created in the screening tool.

4.4.12 Isopluvials of Precipitation for Runoff Control Design

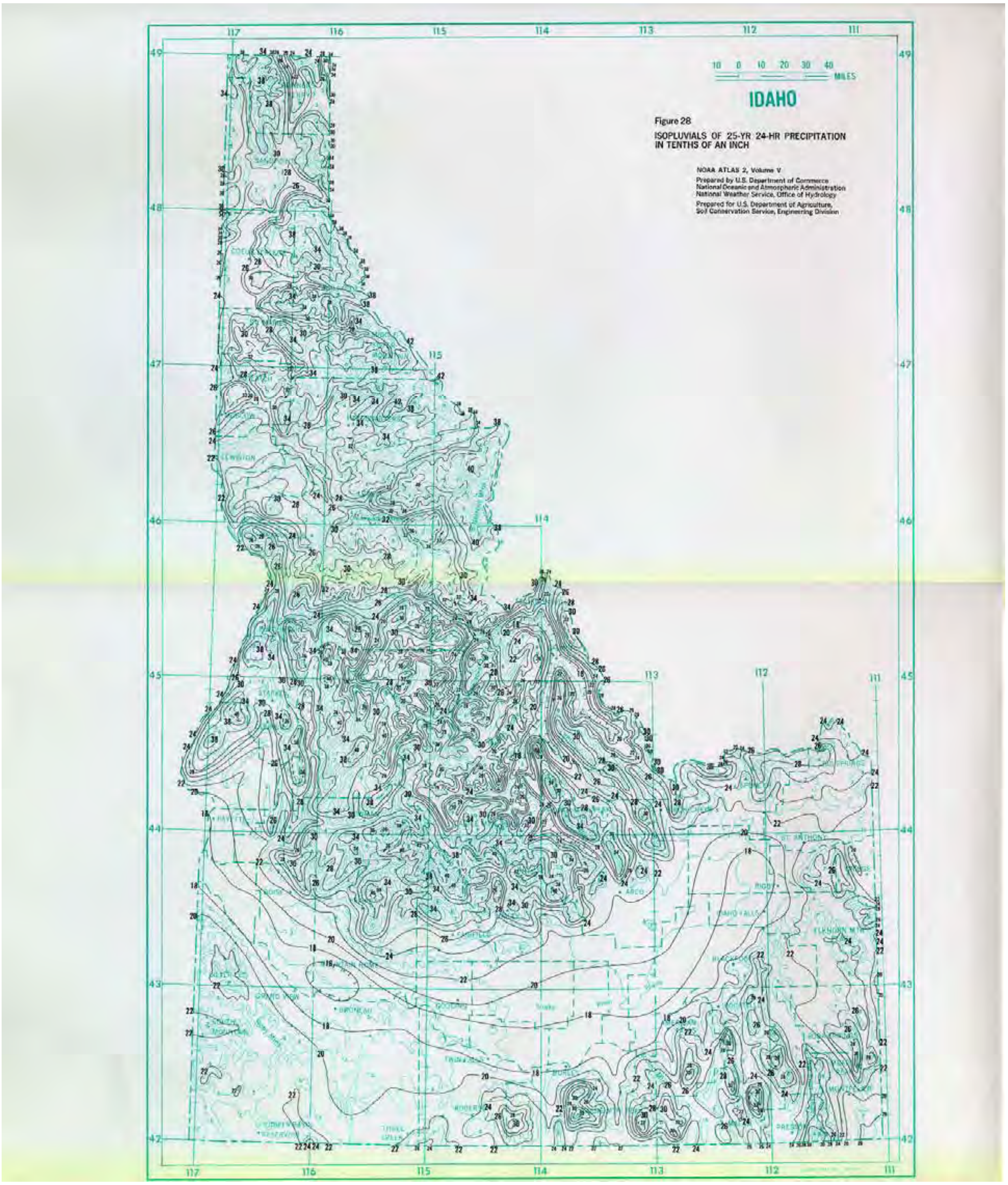


Figure 4-14. 25 year, 24 hour isopluvials.

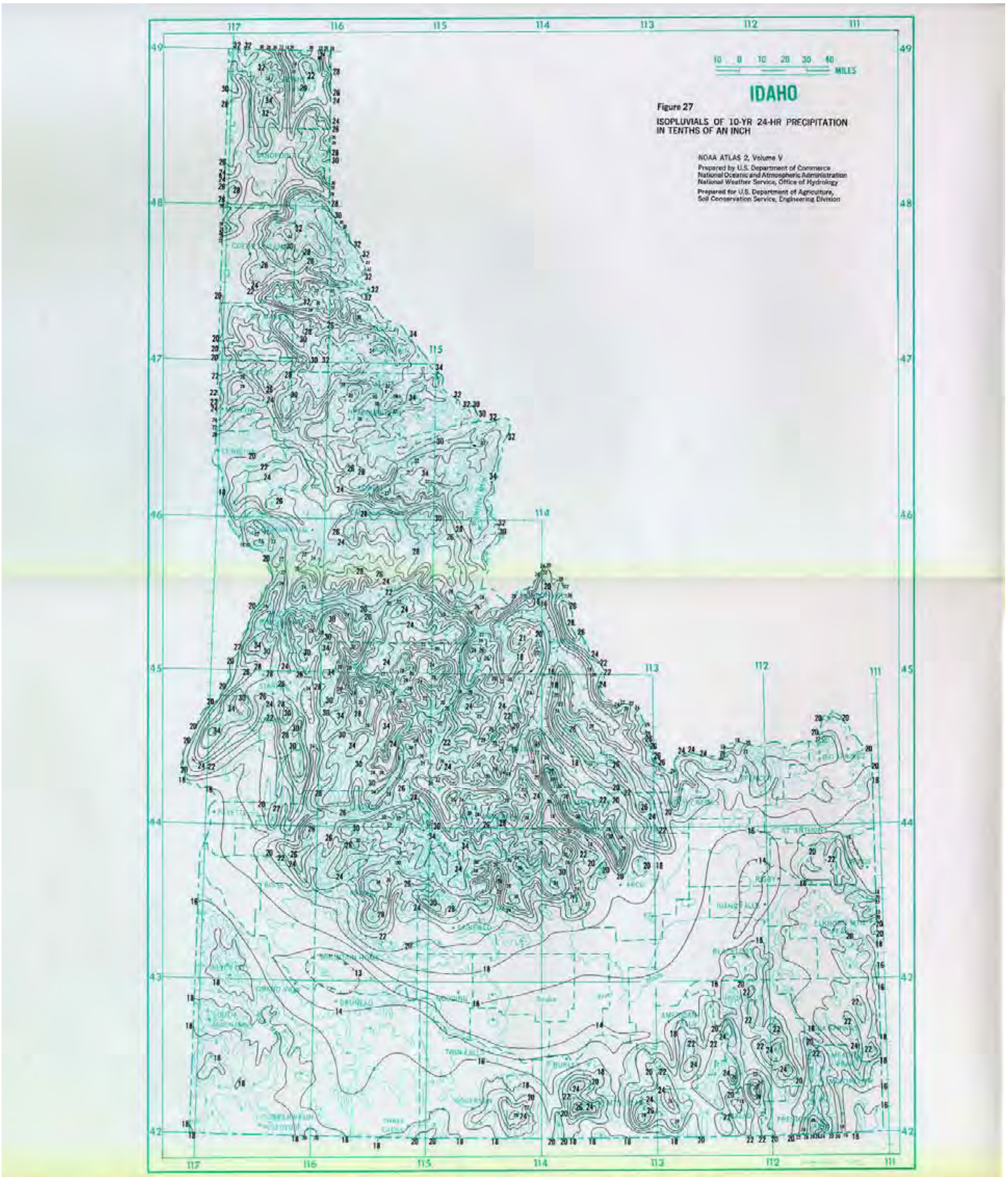


Figure 4-15. 10 year, 24 hour isopluvials.

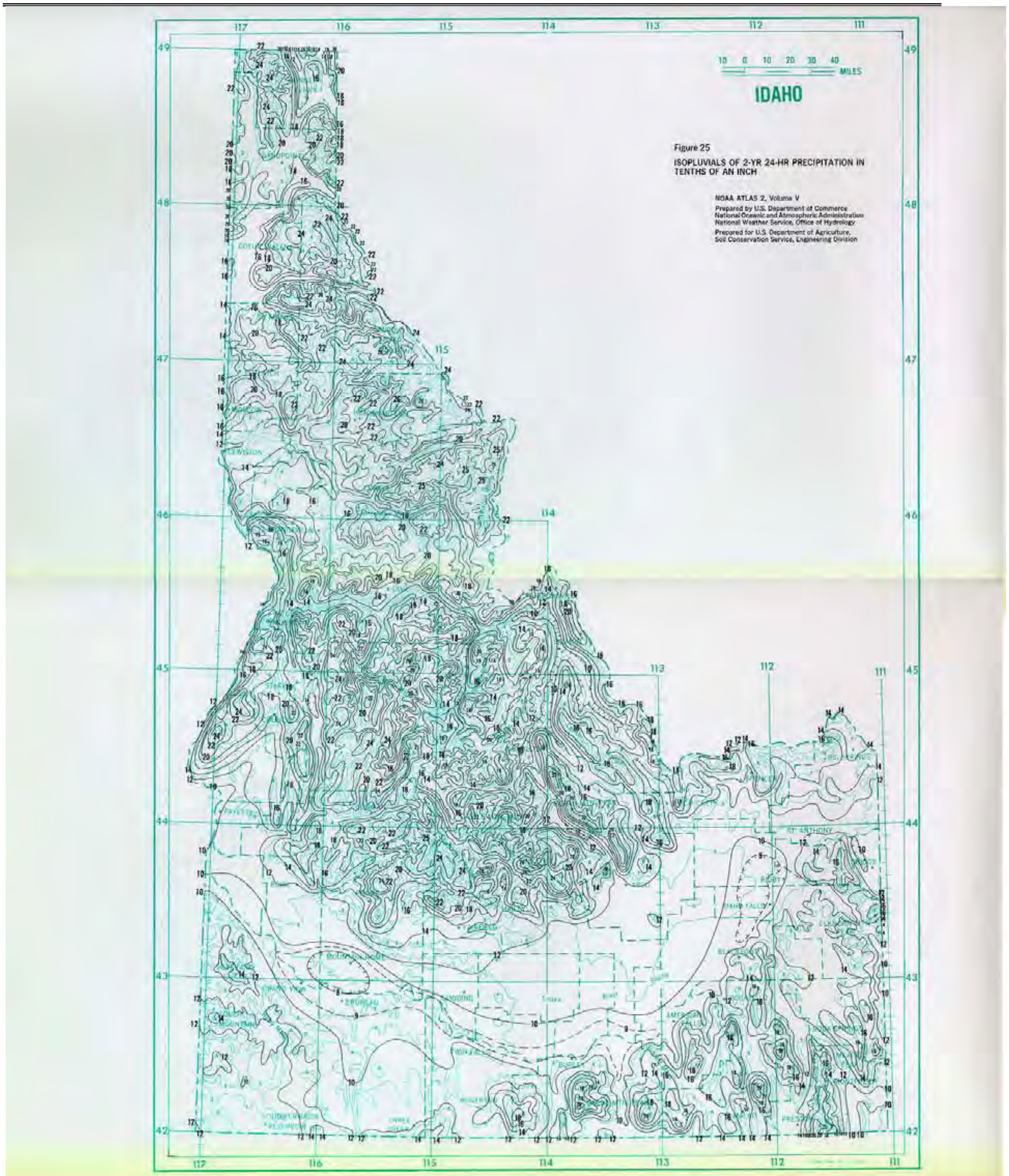


Figure 4-16. 2 year, 24 hour isopluvials.

4.4.13 Determining Appropriate Wastewater Flows to Apply to Chemical Analytical Data for Constituent Loading Calculations

There are several methods, ranging from simple to complex, which may be used to calculate constituent loading rate from constituent concentration data and flow data. These are summarized in Section 4.2.1.5, and are discussed in more detail here. More complex methodologies characterize loading more accurately than simple methods, but involve more sampling and effort in performing calculations.

In the case where a facility samples once during the regulatory sampling period, the concentration of that sample may be applied to the flow during the regulatory sampling period and acres applied to in order to obtain the constituent loading.

In the case where a facility samples more than once during the regulatory sampling period, the concentrations of those samples may be arithmetically averaged and the average applied to the flow during the regulatory sampling period and acres applied to in order to obtain the constituent loading.

In certain cases, characterizing temporal variability of wastewater quality and loading in more detail is very critical for environmental protection. A more accurate way to characterize constituent loading in those cases where a facility finds it necessary to take more than one sample during the regulatory sample period, samples can be associated with, and represent flows in the following manner:

The first sample represents flow from 12:00 am on the first day of the regulatory sampling period (i.e. month, week, etc.) until half-way in time between the first and second samples to the nearest day. If there are an odd number of days between two samples, apply the middle day of flow to the earlier sample.

The second sample represents flow from half-way in time between the first and second samples until half-way in time between the second and third samples to the nearest day, and so forth through the regulatory sample period. The last sample, however, represents flow from half-way in time between the second to the last sample and the last sample until 11:59 pm of the last day of the regulatory sampling period.

Example 2 in Section 4.4.17 illustrates how the constituent loading rate would be calculated from daily flows, a required monthly sample taken in the middle of the month, and three additional samples taken during the month. Sample #1 represents flow from 12:00 am on the first day of the regulatory sampling period (November 1) until half-way in time between Sample #1 and Sample #2 (November 11). Note: Since there are an odd number of days between the two samples, the middle day of flow (November 11) is applied to Sample #1.

Continuing with the example, Sample #2 (the required sample) represents flow from half-way in time between Samples #1 and #2 (November 12) until half-way in time between Samples #2 and #3 (November 17). Sample #3 represents flow from half-way in time between Samples #2 and #3 (November 18) until half-way in time between Samples #3 and #4 (November 23). Sample #4 represents flow from half-way in time between

Samples #3 and #4 (November 24) until 11:59 pm of November 30, the last day of the regulatory sampling period.

Example 3 in Section 4.4.17 illustrates how the constituent loading rate would be calculated from daily flows, a required weekly sample taken in the middle of the week, and two additional samples taken during the week. Sample #1 represents flow from 12:00 am on the first day of the regulatory sampling period (Sunday) until half-way in time between Sample #1 and Sample #2 (11:59 pm Tuesday). Note: Since there are an odd number of days between the two samples, the middle day of flow (Tuesday) is applied to Sample #1.

Continuing with Example 3, Sample #2 (the required sample) represents flow from half-way in time between Samples #1 and #2 (12:00 am Wednesday) until half-way in time between Samples #2 and #3 (11:59 pm Thursday). Sample #3 represents flow from half-way in time between Samples #2 and #3 (12:00 am Friday) until 11:59 pm Saturday, the last day of the regulatory sampling period.

Example 4 (Section 4.4.13.1.4) is similar to Example 2, but is simpler to calculate, and it is far simpler to write computer code to do the calculation. Multiply the sample concentration by the particular flow measured for that day for each sample taken. Then sum these products. Then take the sum of the products and divide by the sum of the flows for those days samples were collected. This will yield a flow-weighted average concentration for those days on which sampling took place. Then apply this flow-weighted concentration to the sum of all flows in the month (or other sampling period) as described in Section 4.4.13.1.4 to obtain the constituent loading rate.

Yet another method is simply to arithmetically average all sample concentration data, and then utilize total flow for a given regulatory interval. Applying this method to Example #2 data yields the following:

$$\left[\frac{(2500+2200+1800+2000)}{4}\right] {}^{mg}\!/_{L} * \; 7.20MG \; * \; 8.34 \; {}^{lb}\!/_{MG} \; * \; \frac{1}{100 \quad ac} = 1280\,{}^{lb}\!/_{ac}$$

4.4.14 Example Calculations

This section presents three examples showing how loading rates are calculated based upon the regulatory sampling period, number of samples, flow, and sample concentration of chemical oxygen demand (COD).

Note that these examples calculate loading rates for the regulatory sampling period (month or week. Both the loading rate, as well as the loading limit, for COD are typically expressed in lb/acre-day based upon a seasonal average. Thus, monthly or weekly COD loading rates calculated above would be summed for the particular season (growing season/non-growing season), and that sum divided by the number of days in the particular season.

4.4.14.1.1 Example #1

One Required Sample for the Regulatory Sample Period (Month)

Month of November. HMU MU-0999-01 (100 acres)

Table 4-15. Data for Example 1.

Wastewater Sample Date and Time	Daily Flows (MG)	Sample Concentration of COD (mg/L)	Notes
1	0.10		12:00 am November 1st is the beginning of the Regulatory Sampling Period
2	0.20		
3	0.50		
4	0.30		
5	0.60		
6	0.40		
7	0.30		
8	0.30		
9	0.00		
10	0.20		
11	0.20		
12	0.10		
13	0.30		
14 Permit Required Sample Taken	0.20	2500	Apply this concentration to Regulatory Sampling Period
15	0.20		
16	0.10		
17	0.10		
18	0.20		
19	0.30		
20	0.60		
21	0.30		
22	0.10		
23	0.10		
24	0.00		
25	0.30		
26	0.40		
27	0.40		
28	0.20		
29	0.10		
30	0.10		11:59 pm November 30th is the end of the Regulatory Sample Period
31	-		
Total Flow For Month	7.20		

Monthly loading is (2500 mg/L * 7.2 MG * 8.34 lb/MG) / 100 acres = 1501 lb/acre.

4.4.14.1.2 Example #2:

One Required Sample for the Regulatory Sample Period (Month) Plus Three Additional Samples. Month of November. HMU MU-0999-01 (100 acres)

Table 4-16. Data for Example 2.

Wastewater Sample Date and Time	Daily Flows (MG)	Sample Concentration of COD (mg/L)	Notes
1	0.10		12:00 am November 1st is the beginning of the Regulatory Sampling Period and of time interval 1
2	0.20		
3	0.50		
4	0.30		
5	0.60		
6	0.40		
7	0.30		
Additional Sample Taken (Sample 1)	0.30	2500	Apply this concentration to time interval 1
9	0.00		
10	0.20		
11	0.20		11:59 pm November 11th is upper time bound for time interval 1
12	0.10		12:00 am November 12th is lower time bound for time interval 2
13	0.30		
Permit Required Sample Taken (Sample 2)	0.20	2200	Apply this concentration to time interval 2
15	0.20		
16	0.10		
17	0.10		11:59 pm November 17th is upper time bound for time interval 2
18	0.20		12:00 am November 18th is lower time bound for time interval 3
19	0.30		
20	0.60		
Additional Sample Taken (Sample 3)	0.30	1800	Apply this concentration to time interval 3
22	0.10		
23	0.10		11:59 pm November 23rd is upper time bound for time interval 3
24	0.00		12:00 am November 24th is lower time bound for time interval 4
25	0.30		
Additional Sample Taken (Sample 4)	0.40	2000	Apply this concentration to time interval 4
27	0.40		
28	0.20		
29	0.10		
30	0.10		11:59 pm November 30th is the end of the Regulatory Sample Period and time interval 4
31	-		
Total Flow for Month	7.20		

Flow for time interval 1 is 3.10 MG. Interval 1 loading is (2500 mg/L * 3.10 MG * 8.34 lb/MG) / 100 acres = 646 b/acre.

Flow for time interval 2 is 1.00 MG. Interval 2 loading is (2200 mg/L * 1.00 MG * 8.34 lb/MG) / 100 acres = 183 lb/acre.

Flow for time interval 3 is 1.60 MG. Interval 3 loading is (1800 mg/L * 1.60 MG * 8.34 lb/MG) / 100 acres = 240 lb/acre.

Flow for time interval 4 is 1.50 MG. Interval 4 loading is (2000 mg/L * 1.50 MG * 8.34 lb/MG) / 100 acres = 250 lb/acre

TOTAL Loading for the Month = 1320 lb/acre

4.4.14.1.3 Example #3:

One Required Sample for the Regulatory Sample Period (Week) Plus Two Additional Samples. Month of November. HMU MU-0999-01 (100 acres)

Table 4-17. Data for Example 3.

Wastewater Sample Date and Time	Daily Flows (MG)	Sample Concentration of COD (mg/L)	Notes
1	0.10		12:00 am Sunday (Day 1) is the beginning of the Regulatory Sampling Period and of time interval 1
Additional Sample Taken (Sample 1)	0.20	2500	Apply this concentration to time interval 1
3	0.00		Tuesday 11:59 pm (Day 3) is upper time bound for time interval 1
Permit Required Sample Taken (Sample 2)	0.20	2200	12:00 am Wednesday (Day 4) is lower time bound for interval 2. Apply this concentration to time interval 2.
5	0.20		Thursday 11:59 pm (Day 5) is upper time bound for time interval 2
6	0.20		Friday 12:00 am (Day 6) is lower time bound for time interval 3
Additional Sample Taken (Sample 3)	0.30	1800	11:59 pm Saturday (Day 7) is the end of the Regulatory Sample Period and time interval 3. Apply this concentration to time interval 3.
Total Flow for Month	1.20		

Flow for time interval 1 is 0.30 MG. Interval 1 loading is (2500 mg/L * 0.30 MG * 8.34 lb/MG) / 100 acres = 63 b/acre.

Flow for time interval 2 is 0.40 MG. Interval 2 loading is (2200 mg/L * 0.40 MG * 8.34) lb/MG / 100 acres = 73 lb/acre.

Flow for time interval 3 is 0.50 MG. Interval 3 loading is (1800 mg/L * 0.50 MG * 8.34) lb/MG / 100 acres = 75 lb/acre.

TOTAL Loading for the Week = 211 lb/acre

Or - Arithmetically Average the Sample Concentration Results and Use the Average to Apply to Weekly Flows

[(2500 + 2200 + 1800) / 3] mg/L * 1.20 MG * 8.34 lb/MG / 100 acres = 217 lb/acre

4.4.14.1.4 Example #4:

One Required Sample for the Regulatory Sample Period (Month) Plus Three Additional Samples. Month of November. HMU MU-0999-01 (100 acres)

Table 4-18. Data for Example 2.

Wastewater Sample Date and Time	Daily Flows (MG)	Sample Concentration of COD (mg/L)	Notes
1	0.10		12:00 am November 1st is the beginning of the Regulatory Sampling Period and of time interval 1
2	0.20		
3	0.50		
4	0.30		
5	0.60		
6	0.40		
7	0.30		
Additional Sample Taken (Sample 1)	0.30	2500	
9	0.00		
10	0.20		
11	0.20		
12	0.10		
13	0.30		
Permit Required Sample Taken (Sample 2)	0.20	2200	
15	0.20		
16	0.10		
17	0.10		
18	0.20		
19	0.30		
20	0.60		
Additional Sample Taken (Sample 3)	0.30	1800	
22	0.10		
23	0.10		
24	0.00		
25	0.30		
Additional Sample Taken (Sample 4)	0.40	2000	
27	0.40		
28	0.20		
29	0.10		
30	0.10		11:59 pm November 30th is the end of the Regulatory Sample Period and time interval 4
31	-		
Total Flow for Month	7.20		

[(2500*0.3 + 2200*0.2 + 1800*0.3 + 2000*0.4) /(0.3 + 0.2 + 0.3 + 0.4] mg/L * 7.20 MG * 8.34 lb/MG / 100 acres = TOTAL Loading for the Month = 1266 lb/acre

4.4.15 Significant Figures

The following discussion of significant figures comes from 'Uncertainties and Error Propagation: Part I of a manual on Uncertainties, Graphing, and the Vernier Caliper', by Vern Lindberg (2001), Copyright July 1, 2000, and is used with permission:

The rules for propagation of errors hold true for cases when we are in the lab, but doing propagation of errors is time consuming. The rules for significant figures allow a much quicker method to get results that are approximately correct even when we have no uncertainty values.

A significant figure is any digit 1 to 9 and any zero which is not a place holder. Thus, in 1.350 there are 4 significant figures since the zero is not needed to make sense of the number. In a number like 0.00320 there are 3 significant figures—the first three zeros are just place holders. However the number 1350 is ambiguous. You cannot tell if there are 3 significant figures—the 0 is only used to hold the units place—or if there are 4 significant figures and the zero in the units place was actually measured to be zero.

How do we resolve ambiguities that arise with zeros when we need to use zero as a place holder as well as a significant figure? Suppose we measure a length to three significant figures as 8000 cm. Written this way, we cannot tell if there are 1, 2, 3, or 4 significant figures. To make the number of significant figures apparent we use scientific notation, 8 x 10^3 cm (which has one significant figure), or 8.00 x 103 cm (which has three significant figures), or whatever is correct under the circumstances.

We start then with numbers each with their own number of significant figures and compute a new quantity. How many significant figures should be in the final answer? In doing running computations we maintain numbers to many figures, but we must report the answer only to the proper number of significant figures.

In the case of addition and subtraction we can best explain with an example. Suppose one object is measured to have a mass of 9.9 gm and a second object is measured on a different balance to have a mass of 0.3163 gm. What is the total mass? We write the numbers with question marks at places where we lack information. Thus 9.9???? gm and 0.3163? gm. Adding them with the decimal points lined up we see

09.9????
00.3163?
10.2???? = 10.2 gm.

In the case of multiplication or division we can use the same idea of unknown digits. Thus the product of 3.413? and 2.3? can be written in long hand as

3.413?
2.3?
  ?????
 10239?
 6826?
7.8????? = 7.8

The short rule for multiplication and division is that the answer will contain a number of significant figures equal to the number of significant figures in the entering number having the least number of significant figures. In the above, Example 2.3 had 2 significant figures while 3.413 had 4, so the answer is given to 2 significant figures.

It is important to keep these concepts in mind as you use calculators with 8 or 10 digit displays if you are to avoid mistakes in your answers and to avoid the wrath of physics instructors everywhere. A good procedure to use is to use all digits (significant or not) throughout calculations, and only round off the answers to appropriate "sig fig."

4.4.16 Determining Nitrogen Loading Limit Compliance

Wastewater Reuse permits typically include limits on the amount of nitrogen that can be applied to the land treatment site. These limits vary according to the treatment capacity of the site and other site-specific factors. Common limits that appear in permits include a) 150% of typical crop uptake based on site records; 150% of uptake values from standard tables; application rates as advised in University of Idaho Fertility Guides; or other site-specific limit.

For example, in order to determine compliance with 150% of typical crop uptake limit, take the following steps:

Calculate the annual nitrogen uptake (in pounds per acre) by the crop or crops harvested from each hydraulic management unit on the site for the three most recent years of plant tissue data. Select the median value from these data and multiply by 1.5. This is the loading limit. (in pounds per acre)

To determine the permit limit for nitrogen using standard tables, find the crop type in Section 7.7.9.1 and look up the nitrogen content. Then multiply by crop yield (per acre) and by 1.5. This is the loading limit based on a standard table. If the crop grown at the site is not included in Section 7.7.9.1, contact DEQ to get nutrient uptake for the crop being grown.

Note that the permit limit may change from year to year as the crop type changes or the crop yield changes.

Calculate the annual amount of nutrients applied (in pounds per acre) by wastewater application or from other sources, such as supplemental fertilizers in pounds per acre. For further information on how to make this calculation, see Section 4.2.1.1.

Compare the permit limit calculated in Step 1 above to the amount of nitrogen applied calculated in Step 2 to determine compliance.

4.4.17 Example Calculations

4.4.17.1.1 Example 1

Crop type:	Alfalfa Hay
Crop yield:	4.5 tons/acre
Wastewater applied to land treatment field:	6 million gallons per year

Land application area:	20 acres
Wastewater total nitrogen:	20 mg/l (ppm)
No supplemental fertilizer applied	

1 Calculate crop uptake of nitrogen

For alfalfa hay, the nitrogen uptake (from Table 7-30 of Section 7.7.9.1) is 50.4 pounds per ton of yield.
Nitrogen uptake: 4.5 tons/acre x 50.4 pounds N/ton = 226.8 pounds/acre

2 Calculate the annual nitrogen permit limits (150% of crop uptake)

Nitrogen application permit limit: 226.8 x 1.5 = 340 pounds/acre

(round off to nearest whole number)

3 Calculate the annual amount of nitrogen applied with the wastewater

$$6\,\frac{MG}{year} * 20\,\frac{mg}{L}N * 8.34\,\frac{\frac{lb}{MG}}{\frac{mg}{L}} * \frac{1}{20\ acres} = 50.0\,\frac{lbs}{acre}$$

4 Compare the annual nitrogen applied versus the annual permit limit to determine compliance.

	Permit Limit 150% of crop uptake	Amount applied	In compliance with permit limit?
Nitrogen	340 pounds/acre	50 pounds/acre	Yes

4.4.17.1.2 Example 2

Crop type:	Forest Site (pine tree)
Crop yield:	Harvest according to silvicultural plan
Wastewater applied to land treatment field:	14 million gallons per year
Land application area:	26 acres
Wastewater total nitrogen:	15 mg/l (ppm)
No supplemental fertilizer applied	

1 Calculate the annual crop uptake of nitrogen

From Table 7-30, Section 7.7.9.1, for tree sites, the nitrogen uptake allowance is up to 220 pounds per acre.

2 Calculate the annual nitrogen permit limits (150% of crop uptake)

Nitrogen application permit limit: 220 x 1.5 = 330 pounds/acre

(round off to nearest whole number)

Calculate the annual amount of nitrogen applied with the wastewater

$$14\ \frac{MG}{year} * 15\ \frac{mg}{L} N * 8.34\ \frac{\frac{lb}{MG}}{\frac{mg}{L}} * \frac{1}{26\ acres} = 67.4\ \frac{lbs}{acre}$$

3 Compare the annual nitrogen applied versus the annual permit limit to determine compliance

	Permit Limit 150% of crop uptake	Amount applied	In compliance with permit limit?
Nitrogen	330 pounds/acre	67.4 pounds/acre	Yes

4.4.18 Quantifying Soil COD Assimilative Capacity

Carlisle and Phillips (1976) proposed a methodology for quantifying soil assimilative capacity for organic waste applied to land. This methodology is based upon the rate of oxygen to diffuse into a soil to satisfy the oxygen demand imposed upon the soil system by addition of organic waste. This methodology assumes that soil microorganisms will mediate the reaction between oxygen and oxygen demand and will not be limiting. This assumption may not hold true when soil temperatures are low and soil microorganisms are metabolizing at lower rates. The methodology involves quantifying oxygen diffusion into the soil, determining oxygen demand imposed on the soil from waste, and accounting for irrigation frequency and drainage times in the calculation of assimilation capacity.

4.4.18.1 Oxygen Diffusion into the Soil

The following equations are used to determine oxygen diffusion into the soil. Equation 4-22 calculates the effective diffusion coefficient through the soil mass

$$D_p = 0.6 * S * D_o$$

Equation 4-22. Calculation of the effective diffusion coefficient through soil.

Where:

D_p = effective diffusion coefficient through the soil mass (cm^2/sec or m^2/day)

D_o = diffusion coefficient in air (cm^2/sec or m^2/day)

S = air filled porosity of soil (at field capacity), as per Equation 4-23:

$$S = P_t - \Theta_{FC} = \left[1 - \frac{D_B}{D_p}\right] - \Theta_{FC}$$

Equation 4-23. Calculation of air-filled porosity of soil.

Where

P_t = total soil pore space

D_B = soil bulk density (see Table 4-19 for general values)

D_p = particle density (generally assume 2.65 g/cm^3 for most soils)

Θ_{FC} = soil water content at field capacity (see Table 4-19 for general values)

Table 4-19. Generalized Soil Porosity Data.

USDA Soil Texture	(I) Saturated Water Content (total porosity) Θs cm3/cm3	(II) Residual Water Content (wilting point) Θr cm3/cm3	(III) Field Capacity Water Content (1/3 bar) Θfc cm3/cm3	(IV) Air-Filled Porosity at Field Capacity cm3/cm3	(V) Water Filled Porosity Θw cm3/cm3	(VI) Dry Bulk Density Db g/cm3
Clay	0.459	0.098	0.332	0.127	0.215	1.43
Clay loam	0.442	0.079	0.257	0.185	0.168	1.48
Loam	0.399	0.061	0.235	0.164	0.148	1.59
Loamy sand	0.39	0.049	0.103	0.287	0.076	1.62
Silt	0.489	0.05	0.284	0.205	0.167	1.35
Silt loam	0.439	0.065	0.295	0.144	0.18	1.49
Silty clay	0.481	0.111	0.321	0.16	0.216	1.38
Silty clay loam	0.482	0.09	0.306	0.176	0.198	1.63
Sand	0.375	0.053	0.055	0.32	0.054	1.66
Sandy clay	0.385	0.117	0.277	0.108	0.197	1.63
Sandy clay loam	0.384	0.063	0.229	0.155	0.146	1.63
Sandy loam	0.387	0.039	0.167	0.22	0.103	1.62

From Environmental Quality Management, Inc. (June 19, 2003)
(I), (II), and (V) from Table 10
(III) from Table 10 = 2*(V) - (II)
(IV) = (I) - (III)
(VI) from Table 4

Equation 4-24 uses the effective diffusion coefficient to calculate oxygen moving into the soil.

$$M = 2(C_o - C_p)\sqrt{D_p T / \pi}$$

Equation 4-24. Calculation of oxygen movement into the soil.

Where:

M = O_2 moving into soil (g/m^2)

C_o = concentration of O_2 in air above ground (mg/L or g/m^3).

C_p = concentration of O_2 in soil air (mg/L or g/m^3)

D_p = effective diffusion coefficient through the soil mass (or oxygen diffusivity for soil) in m^2/day)

T = time (days)

Working the example from Carlisle and Phillips (1976), we are given an S for a Norwalk sandy loam of S = 0.22 and D_o = 1.62 m^2/day to obtain the result of Equation 4-25.

$$D_p = 0.6 * 0.22 * 1.62 = 0.214 \ m^2 / day$$

Equation 4-25. Example calculation of D_p.

Calculating oxygen moving into the soil, we are given the following:

C_o = assume 21 percent O_2 in air above ground, or 300 g/m^3.

C_p = need a concentration of O_2 in soil air greater than 10 percent to prevent root death, so set the boundary condition here to be 143 g/m^3.

D_p = 0.214 m^2/day as previously calculated.

T = 1 day to calculate on a 'per day' basis.

So we have Equation 4-26.

$$M = 2(300 - 143)\sqrt{0.214(1)/\pi} = 82 \ g / m^2 / day = 730 \ lb / acre / day$$

Equation 4-26. Example calculation of M.

Of this calculated 730 lb/acre/day of oxygen diffusing into the soil, respiration of plant roots and microorganisms closely associated with root surfaces require oxygen. Carlisle and Phillips (1979) assume this oxygen use to range from 4 to 6 lbs/acre/hour, or 96 to 144 lb/acre/day. To calculate the amount of oxygen available to oxidize organic waste (O_w), root/microorganism oxygen use (O_r) must be subtracted from the total oxygen entering the soil, as in Equation 4-27.

$$O_w = M - O_r = 732 - 144 = 588 \ lb/acre/day$$

Equation 4-27. Calculation of oxygen available for oxidizing organic waste.

4.4.18.2 Irrigation Scheduling and Calculating Assimilative Capacity

Irrigation events inhibit oxygen diffusion into the soil. Soils must drain to field capacity before oxygen diffusion will take place at rates calculated above. Soil drainage times must be accounted for when calculating assimilative capacity over time, as in Equation 4-28.

$$C_a = [(G_t - I_n D_t)/G_t](O_w)$$

Equation 4-28. Calculation of soil assimilative capacity.

Where:
C_a = soil assimilative capacity (lb/acre/day)

G_t = length of the growing season (days)

I_n = number of irrigation events in the growing season

D_t = soil drainage time to field capacity (days) (see Table 7-26, Section 7.7.7)

O_w = oxygen available to oxidize organic waste (lb/acre/day)

For example, given:

G_t = 214 days

I_n = 30 irrigation events

D_t = 3 days

O_w = 588 lb/acre/day

$C_a = [(214 - (30)(3)/214](588) = 340 \ lb/acre/day$

4.4.18.3 Determining Oxygen Demand Imposed on the Soil from Wastewater

Oxygen demand of wastewater is determined by chemical analysis. Total oxygen demand (TOD) consists of the sum of chemical oxygen demand (COD) and nitrogenous oxygen demand (NOD) as Equation 4-29 relates:

$$TOD = COD + NOD$$

Equation 4-29. Calculation of total oxygen demand (TOD).

The value for COD is obtained through chemical analysis. BOD is sometimes used in lieu of COD. NOD represents the oxygen required to oxidize the reduced nitrogen forms ammonia and organic nitrogen. Total Kjeldahl nitrogen (TKN) is the chemical analysis used to quantify reduced nitrogen species. To convert TKN nitrogen (mg/L) to NOD, it must be multiplied by 4.56 because it takes approximately two moles (or 2 mmol) of O_2 to oxidize one mole (or 1 mmol) of TKN to NO_3, as Equation 4-30 relates:

$$1\,\text{mg N/L} \cdot \left[\frac{2\,\text{mmol}\,O_2}{1\,\text{mmol N}}\right] \cdot \left[\frac{32\,\text{mg}\,O_2 / \text{mmol}\,O_2}{14\,\text{mg N} / \text{mmol N}}\right] = \frac{64\,\text{mg}\,O_2}{14\,\text{mg N}} = 4.56\,\text{mg}\,O_2$$

Equation 4-30. Calculation of oxygen demand.

So the equation for total oxygen demand becomes as shown in Equation 4-31.

$$TOD = COD + 4.56\ TKN$$

Equation 4-31. Total oxygen demand as a function of COD and TKN.

TOD in mg/L is used along with wastewater volume and acreage in loading calculations as described in Section 4.2.1.1 to determine the oxygen demand imposed on the soil from wastewater.

4.4.19 Metal and other Trace Element Loading [40CFR 503.13]

[Code of Federal Regulations]
[Title 40, Volume 28]
[Revised as of July 1, 2004]
From the U.S. Government Printing Office via GPO Access
[CITE: **40CFR503.13**]
[Page 826-827]

TITLE 40--PROTECTION OF ENVIRONMENT

CHAPTER I--ENVIRONMENTAL PROTECTION AGENCY (CONTINUED)

PART 503_STANDARDS FOR THE USE OR DISPOSAL OF SEWAGE SLUDGE
--Table of Contents

Subpart B_Land Application

Sec. 503.**13** Pollutant limits.

(a) Sewage sludge. (1) Bulk sewage sludge or sewage sludge sold or given away in a bag or other container shall not be applied to the land if the concentration of any pollutant in the sewage sludge exceeds the ceiling concentration for the pollutant in Table 1 of Sec. 503.**13**.

(2) If bulk sewage sludge is applied to agricultural land, forest, a public contact site, or a reclamation site, either:

(i) The cumulative loading rate for each pollutant shall not exceed the cumulative pollutant loading rate for the pollutant in Table 2 of Sec. 503.**13**; or

(ii) The concentration of each pollutant in the sewage sludge shall not exceed the concentration for the pollutant in Table 3 of Sec. 503.**13**.

(3) If bulk sewage sludge is applied to a lawn or a home garden, the concentration of each pollutant in the sewage sludge shall not exceed the concentration for the pollutant in Table 3 of Sec. 503.**13**.

(4) If sewage sludge is sold or given away in a bag or other container for application to the land, either:

[[Page 827]]

(i) The concentration of each pollutant in the sewage sludge shall not exceed the concentration for the pollutant in Table 3 of Sec. 503.**13**; or

(ii) The product of the concentration of each pollutant in the sewage sludge and the annual whole sludge application rate for the sewage sludge shall not cause the annual pollutant loading rate for the pollutant in Table 4 of Sec. 503.**13** to be exceeded. The procedure used to determine the annual whole sludge application rate is presented in appendix A of this part.

(b) Pollutant concentrations and loading rates--sewage sludge.--(1) Ceiling concentrations.

Table 1 of Sec. 503.**13**--Ceiling Concentrations

Pollutant	Ceiling concentration (milligrams per kilogram) \1\

Arsenic	75
Cadmium	85
Copper	4300
Lead	840
Mercury	57
Molybdenum	75
Nickel	420
Selenium	100
Zinc	7500

\1\ Dry weight basis.

(2) Cumulative pollutant loading rates.

Table 2 of Sec. 503.**13**--Cumulative Pollutant Loading Rates

Pollutant	Cumulative pollutant loading rate (kilograms per hectare)
Arsenic	41
Cadmium	39
Copper	1500
Lead	300
Mercury	17
Nickel	420
Selenium	100
Zinc	2800

(3) Pollutant concentrations.

Table 3 of Sec. 503.**13**--Pollutant Concentrations

Pollutant	Monthly average concentration (milligrams per kilogram) \1\
Arsenic	41
Cadmium	39
Copper	1500
Lead	300
Mercury	17
Nickel	420
Selenium	100
Zinc	2800

\1\ Dry weight basis.

(4) Annual pollutant loading rates.

Table 4 of Sec. 503.**13**--Annual Pollutant Loading Rates

Pollutant	Annual pollutant loading rate (kilograms per hectare

	per 365 day period)
Arsenic	2.0
Cadmium	1.9
Copper	75
Lead	15
Mercury	0.85
Nickel	21
Selenium	5.0
Zinc	140

(c) Domestic septage. The annual application rate for domestic septage applied to agricultural land, forest, or a reclamation site shall not exceed the annual application rate calculated using equation (1).

[GRAPHIC] [TIFF OMITTED] TC15NO91.192

Where:

AAR=Annual application rate in gallons per acre per 365 day period.

N=Amount of nitrogen in pounds per acre per 365 day period needed by the crop or vegetation grown on the land.

[58 FR 9387, Feb. 19, 1993, as amended at 58 FR 9099, Feb. 25, 1994; 60 FR 54769, Oct. 25, 1995]

4.4.20 Determining Compliance with Reuse Permit Phosphorus Limits

Wastewater Reuse permits may include limits on the amount of phosphorus that can be applied to the land treatment site. These limits are determined utilizing guidance as previously discussed (for example, 100% of crop uptake).

For example, to determine compliance with a limit of 100 % of typical crop uptake, take the following steps:

1. Calculate the annual phosphorus uptake by the crop or crops harvested from each hydraulic management unit on the site for the three most recent years of data plant tissue data. Select the median value from these data. This is the loading limit in pounds per acre.

   To determine the annual permit limit for phosphorus using standard tables, find the crop type and the phosphorus content. This is the loading limit. based on a standard table. Contact DEQ to get nutrient uptake for the crop being grown or consult the following Idaho Department of Agriculture Web site:

   http://www.nass.usda.gov/id/publications/annual%20bulletin/annbulltoc.htm

   Note that the permit limit may change from year to year as the crop type changes or the crop yield changes.

2. Calculate the amount of nutrients applied by wastewater application or from other sources, such as supplemental fertilizers (in pounds per acre). For further information on how to make this calculation, see Section 4.2.1.1.

3. Compare the annual permit limit calculated in Step 1 above to the amount of phosphorus applied calculated in Step 2 to determine compliance.

4.4.21 Example Calculations

4.4.21.1.1 Example 1

Table 4-20 shows an example calculation for crop uptake of phosphorus..

Table 4-20. Values for example calculation of crop phosphorus uptake.

Crop type	Alfalfa Hay
Crop yield	4.5 tons/acre
Wastewater applied to land treatment field:	6 million gallons per year
Land application area:	20 acres
Wastewater total phosphorus:	5 mg/L (ppm)
No supplemental fertilizer applied	

1. Calculate the annual crop uptake of phosphorus

For alfalfa hay, assume for this example a phosphorus uptake of 4.72 pounds per ton of yield.

Phosphorus uptake: 4.5 tons/acre x 4.7 pounds P/ton = 21.2 pounds/acre

2. Calculate the annual phosphorus permit limits (100 % of crop uptake)

   Phosphorus application permit limit: 21.2 x 1 = 21.2 pounds/acre

   (round off to nearest whole number)

3. Calculate the annual amount of phosphorus applied with the wastewater

$$6\,\frac{MG}{year} * 5\,\frac{mg}{L} N * 8.34\,\frac{\frac{lb}{MG}}{\frac{mg}{L}} * \frac{1}{20\,acres} = 12.5\,\frac{lbs}{acre}$$

4. Compare the annual phosphorus applied versus the annual permit limit to determine compliance.

4.4.21.1.2 Example 2

Table 4-21 shows the data values used for an example calculation of annual phosphorus uptake.

Table 4-21. Values for example calculation of annual phosphorus uptake.

Crop type:	Forest Site (pine tree)
Crop yield:	Harvest per silvicultural plan
Wastewater applied to land treatment field:	14 million gallons per year
Land application area:	26 acres
Wastewater total phosphorus:	4 mg/L (ppm)
No supplemental fertilizer applied	

1. Calculate the annual crop uptake of phosphorus

   Assume, for tree sites, the phosphorus uptake allowance is 20 pounds per acre.

2. Calculate the annual phosphorus permit limits (150% of crop uptake)

   Phosphorus application permit limit: 20 x 1 = 20 pounds/acre

   (round off to nearest whole number)

3. Calculate the annual amount of phosphorus applied with the wastewater

$$14\,\frac{MG}{year} * 4\,\frac{mg}{L} N * 8.34\,\frac{\frac{lb}{MG}}{\frac{mg}{L}} * \frac{1}{26\,acres} = 18\,\frac{lbs}{acre}$$

4. Compare annual phosphorus applied versus the annual permit limit to determine compliance

	Permit Limit 100 % of crop uptake	Amount applied	In compliance with permit limit?
Phosphorus	20 pounds/acre	18.0 pounds/acre	Yes

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5. Not Used at This Time

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6. Operations

Wastewater reuse facility operations need to be performed in a manner that addresses the following aspects of operation:

- Pretreatment
- Lagoons
- Grazing
- Buffer Zones
- Protection of Domestic and Public Well Water Supplies
- Site Closure
- Weed Control

Considerations for each of these aspects of reuse facility operation are discussed in the following sub-sections.

6.1 Pretreatment Considerations

The degree of pretreatment is site and wastewater specific and can generally be separated into considerations for *municipal wastewater* versus considerations for *industrial wastewater*.

The main consideration with respect to land treatment, however, is whether the soil-crop system can treat the wastewater in question:

- In some cases, the land treatment area does not have the capacity to treat the wastewater without pretreatment to reduce a land limiting constituent.
- In other cases, typically involving industrial wastewater, a change in the processing method can significantly reduce the concentration of the land limiting constituent. This reduction in concentration could make increased loading and treatment of wastewater possible, up to the point where the next land limiting constituent loading threshold is reached.

Regardless of the reason for pretreatment, these processing changes are evaluated as to their cost effectiveness in terms of the land area needed, the cost of making a process change, and the efficiency realized from a process change. Ultimately, more than one land limiting constituent may need to be reduced to allow higher loading rates.

6.1.1 Municipal Pretreatment

The primary concern regarding municipal wastewater treatment by land application is the potential health risk due to the presence of disease causing organisms. Most municipal wastewaters require pretreatment that reduces indicator organisms prior to land treatment.

The degree of pretreatment needed depends on three factors:

- The type and intended use of the crop
- The method of wastewater application
- The extent of public access and exposure

Specific coliform treatment requirements for direct use of municipal wastewater are found in the *Rules for the Reclamation and Reuse of Municipal and Industrial Wastewater* (IDAPA 58.01.17.600.07).

Exceptions to the treatment requirements can be considered when it is demonstrated that the exception will not adversely impact protection of the public health and safety. See the waiver process in IDAPA 58.01.17.940.

6.1.2 Industrial Pretreatment

Pretreatment for industrial wastewaters tends to involve the additional treatment or removal of organic constituents, suspended solids, nutrients (such as nitrogen and phosphorus), metals, toxic compounds, and, in some cases, salts before the wastewater can be land-applied. Industrial pretreatment processes also tend to be more variable than municipal wastewaters because there is often more diversity of critical wastewater constituents in industrial wastewater streams.

In most cases, pretreatment of industrial wastewater depends how cost effective the treatment is. For example, in a situation in which pretreatment could reduce the land area needed, the savings achieved from using less land must be balanced against the additional costs of pretreatment.

Disinfection of industrial wastewaters is generally not required if it is known by knowledge of process that there are no sanitary sources of microbial contamination (consisting of pathogenic microorganisms from human sources) in the waste stream. There are cases where pathogenic organisms are present in industrial wastewaters from non-sanitary sources, and their risk to human health must be assessed. Methodologies for determining the risk of microorganisms in land applied wastewater are under development by DEQ. See Section 3.4.9 for further discussion of pathogens and microbial risk assessment.

6.2 Not used at this time

6.3 Lagoons

This section discusses the purpose and need for wastewater treatment and storage lagoons at wastewater reuse facilities, design requirements for lagoons, their construction, seepage criteria, and operation and maintenance.

6.3.1 Lagoons: Purpose and Need

For some land treatment systems and reuse systems, treatment and/or storage lagoons may be needed. Treatment lagoons are needed to reduce wastewater constituents through secondary, or biological, treatment, as well as settling of solids, or primary treatment.

Storage lagoons are a second type of lagoon. The volume contained by these lagoons can vary from as little as one day's flow to as much as six months or more. Determining the required volume depends on such factors as the influent flow rate, precipitation, evaporation, safety requirements, and other considerations.

Storage requirements can be reduced, or in some cases eliminated, by providing alternative backup measures, as determined on a case-by-case basis, such as additional land treatment acreage, or the ability to vary a facility’s production and wastewater generation rates.

Storage lagoons may be needed when:

- precipitation causes excessive hydraulic loading,
- cultivating practices prevent wastewater application,
- winter weather precludes operation or a reduction in the rate of application,
- flow variations in quantity and quality require equalization, or
- when an emergency backup for the treatment system is required.

6.3.2 Lagoon Design Criteria

Design criteria for municipal and industrial lagoons are based on the *Recommended Standards for Wastewater Facilities – 2004*, otherwise known as the ‘Ten State Standards’, published by the Great Lakes-Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers. See IDAPA 58.01.16.007, 008 and 493.

Rules for seepage allowances for design of new municipal lagoons are found in Idaho’s *Wastewater Rules* (IDAPA 58.01.16.493.03a). These criteria require lagoons be designed with a seal having a seepage rate less than 500 gallons/acre-day (0.018 inches/day).

6.3.2.1 Lagoon Construction

Lagoons are generally designed and constructed with earthen dams or dikes. The inner dikes of new lagoons are typically lined with a synthetic material to prevent leakage. Figure 6-1 shows a typical lagoon design. To allow mowing of the outer banks, outside slopes are usually no more than 3 units horizontal to 1 unit vertical for slope stability and maintenance. Lagoons must be designed for a minimum *freeboard* (the distance between the top of the dike at its lowest point and the highest allowed wastewater level within the lagoon). This provides a safety factor for wave action, higher than planned wastewater generation rates, or heavy precipitation events. For existing lagoons utilizing clay or earthen liners or lagoons that have a buried synthetic liner, the inside slopes may be protected by riprap from 1 foot below the minimum water surface to the top of the freeboard to protect against wave erosion.

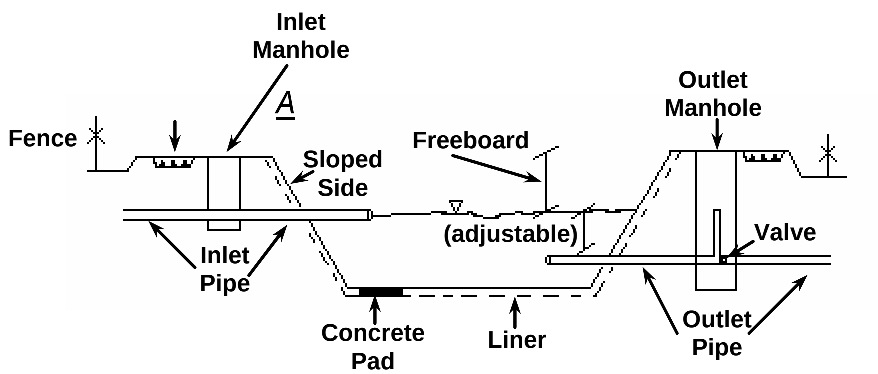

Figure 6-1. Typical lagoon design. [From WPCF, 1981]

Design requirements for new lagoons are meant to minimize seepage losses of the stored effluent. Liners are used to minimize the loss of wastewater to the subsurface or ground water by reducing the permeability of the bottom and sidewalls of lagoons. The typical materials used for liners are synthetic membranes, compacted clay, and bentonite. New installations typically use synthetic membrane liners such as HDPE (high density polyethylene) or buried PVC (poly vinyl chloride) liners. Clay and bentonite liners require submergence in water to retain their sealing characteristics. If exposed and dried, clay and bentonite liners may develop cracks and lose their ability to provide a good seal.

Wastewater enters and leaves a lagoon through inlet and outlet pipes. Inlet structures should be located so that wastewater is distributed evenly in the pond. If wastewater is gravity fed to the lagoon, a concrete pad or riprap is often placed at the end of the inlet pipe to protect the lagoon liner. If the lagoon is used for chlorine treatment, the outlet pipe is located as far as possible from the inlet pipe to increase chlorine detention time and to prevent *short-circuiting* (a condition where some of the wastewater in a lagoon travels faster than the rest of the wastewater, between the inlet and outlet pipes). Short-circuiting is especially a problem in lagoons that are designed to allow for a specific *chlorine contact time* (the amount of time chlorine must be allowed to react with the wastewater prior to discharge and reuse).

Other design considerations for storage lagoons include:

- Multiple cells to provide access for maintenance.
- Proximity to surface waters and well(s) used for drinking water.

- Locating lagoons to minimize odor impacts and consider the use of aeration to reduce odor causing conditions.

6.3.2.2 Determining Lagoon Storage Needs

The following are some of the some factors used to determine the volume of lagoon storage capacity that may be needed:

- The local climate and the period of operation.
- If the land application system is designed for growing season only application, the lagoon(s) may be designed for storage of effluent during the non-growing season.
- If the land application system is designed with a non-growing season application allowance, storage may be necessary:
  - for periods of extreme cold temperatures which can prevent application due to freezing problems in the irrigation system, frozen soils, or buildup of ice on the application site, or
  - to limit wastewater application to ‘soil storage’ rates (see Sections 4.1.2 and 4.4.9 for further discussion of non-growing season hydraulic loading guidance).
- If land application is not possible due to harvesting or heavy precipitation events.
- Analysis of rainfall data also helps identify the storage needs related to expected periods of excessive precipitation. Some storage may be necessary to retain certain storm events on the land treatment site to prevent runoff. (See further discussion of runoff control in Section 4.1.3.)

6.3.3 Lagoon Seepage

It is important for lagoons to be sufficiently sealed, so that they do not become major contributors to the contamination of ground water. For this reason, reuse facilities may be required to demonstrate the integrity of their wastewater treatment and storage structures.

The following Web site provides guidance on methods to determine seepage rates:

http://www.deq.idaho.gov/media/516273-lagoon_seepage.pdf

Rules for seepage allowances for performance of new and existing municipal lagoons are found in Idaho’s *Wastewater Rules* (IDAPA 58.01.16.493.03a) and are discussed in Section 6.3.3.1.

6.3.3.1 Seepage Requirements

Performance criteria in DEQ rules require that municipal lagoons with construction ending after April 15, 2007 be allowed to seep at a rate of not more than 3,400 gallons/acre-day (0.125 inches/day). For municipal lagoons with construction ending prior to April 15, 2007, the rules allow for a seepage rate of not more than 6,800 gallons/acre-day (0.25 inches/day) (IDAPA 58.01.16.493.03b). Seepage testing for municipal lagoons is required every five years. See IDAPA 58.01.16.493.02 for further details. It is recommended that these seepage criteria be utilized for industrial lagoons as well.

6.3.3.2 Submittal of Seepage Data

DEQ typically recommends that recent industrial lagoon seepage data be submitted as part of the permit renewal application package every five years. This submittal is required for municipal lagoons (IDAPA 58.01.16.493.02). Results of the seepage data will determine any permit conditions needed to update or modify existing lagoons.

6.3.3.3 Options for Addressing Excessive Seepage

If a properly tested municipal lagoon leaks more than the allowable rate, the options for mitigation include the following:

- Retesting the seepage rate immediately to determine the validity of the results of the initial test.
- Repairing or replacing the lagoon (or installing a liner) and retesting.
- Draining the lagoon in an approved manner (IDAPA 58.01.16.493.10) and discontinuing the use of the lagoon.
- Developing a plan, based on ground water sampling and analyses, to determine the effect of the leakage on the local groundwater. If the effect of the seepage does not comply with the requirements of the Ground Water Quality Rule (IDAPA 58.01.11), then option 1, 2 or 3 must be used. See IDAPA 58.01.16.493.04a, b, c, and d. It is recommended that this four-step procedure be followed for industrial lagoons as well.

6.3.4 Lagoon Operation and Maintenance

Regardless of how well-designed, lagoons will not perform to their optimum potential unless properly operated and maintained. Inspections and sampling should be conducted on a routine basis to determine if any problems are apparent. Routine operation and maintenance practices should address and control the following conditions and situations:

- vegetation
- erosion
- odor production
- freeboard
- short-circuiting (if chlorine treatment is a component of the storage lagoon)

In addition, safety precautions such as posting and maintaining warning signs around a wastewater storage lagoon, can improve site safety and minimize public health impacts. Fencing should be provided to discourage unauthorized access and prevent wildlife access. See Zickefoose and Hayes (1977) and Kerri (1990, Chapter 9) for further information on topics discussed in Section 6.3.4.

6.3.4.1 Vegetation

Controlling vegetation around storage lagoons is important. Weeds and grasses on dams and dikes provide sheltered areas for insects and burrowing animals, interfere with the establishment and maintenance of a desirable vegetative cover, and hinder visual inspection of dikes. Trees and other deep-rooting vegetation can impair the structural integrity of lagoon dikes. Regular mowing and weeding are required to avoid these problems.

Emergent and suspended vegetation in lagoons take up valuable space, provide a breeding ground for potential vectors, such as mosquitoes, and hinder pond circulation. In addition, dead vegetation can contribute to BOD levels and cause odors.

6.3.4.1.1 Emergent Vegetation

Emergent growth will occur when sunlight is able to reach the lagoon bottom in older lagoons with earthen bottoms or lagoons with a buried synthetic liner. Emergent growth can be controlled by the following:

- immediate removal of young plants (including roots),
- drowning weeds by raising the water level and preventing sunlight from reaching the plants,
- by installing pond liners, and
- using herbicides according to label instructions and applicable state and federal laws, in addition to taking into consideration potential impacts to the land treatment system.

6.3.4.1.2 Suspended Vegetation

Suspended vegetation, such as duckweed and algae, can occur in any lagoon, regardless of depth. Often mistaken for algae, duckweed floats on a lagoon surface and has long hair-like roots that hang down into the water. It grows rapidly and can cover the entire surface of a lagoon if not controlled. If suspended vegetation is a problem, it should be skimmed off with rakes or other tools or mechanically harvested. Herbicides can be used according to precautions discussed in Section 6.3.4.1.1. If not removed, vegetation may cause plugging in the irrigation system.

Ducks eat duckweed and may control a light growth of suspended vegetation. Fecal waste from ducks and other waterfowl, however, can contribute BOD to the lagoon and increase coliform levels. Depending on the required disinfection level of the effluent, the point of compliance location in the treatment system, and microbial risk assessment, the attraction of waterfowl to a storage lagoon may seriously impact the effluent quality. Disinfection downstream of the storage pond may be necessary in some cases to achieve required effluent quality levels.

6.3.4.1.3 Algae

Excessive algae growth can create serious problems. Algae blooms die off as suddenly as they appear, blocking sunlight and the dead vegetation can cause foul odors. The die-off of algae blooms also causes a very high BOD loading which reduces dissolved oxygen levels, and the lagoon may become anaerobic or septic and cause odor problems.

Blue-Green Algae

A specific type of algae that can be problematic is blue-green algae (Cyanobacteria). A bloom (rapid growth) of blue-green algae can be caused by organic overloading, nutrient overloading, high water temperatures, or stagnant conditions.

Blue-green algae are bacteria that grow in fresh water lakes, ponds and wetlands, as well as wastewater storage lagoons. They are photosynthetic bacteria, and usually occur only in small numbers. They are so small they are invisible to the casual observer.

When a bloom occurs, huge numbers of algae grow and accumulate on the surface of the lagoon, to the point where the surface of the water resembles thick "pea soup." often blue-green in color. Although these blooms occur naturally, water bodies which have been enriched with plant nutrients from municipal, industrial or agricultural sources are particularly susceptible to these growths.

Blue green algae blooms are unsightly, but more important, blue-green algal blooms can be toxic if ingested by wildlife, livestock, or people. Blue green algae produce neurotoxins, which affect the nervous and respiratory systems and hepato-toxins, which affect the liver function.

If blue-green algal blooms are suspected, they should be treated with caution. One of the first signs of toxin contamination in a water body is the presence of stressed, sick or dead wildlife or waterfowl. Contact DEQ or your local District Health Department if you suspect a problem. Water suspected of being contaminated with toxic strains of blue-green algae can be sampled and tested for toxicity.

Algae Control

Algae mats should be broken up and dispersed or physically removed like duckweed. Algae can also be controlled by physical, chemical, and biological means:

- Lagoon covers (artificial or natural) eliminate sunlight, photosynthesis, and vegetative growth.
- Aeration or mixing removes carbon dioxide from the water and reduces plant growth.
- Shock chlorination at high doses for short duration and at a lower chlorine dose for longer duration have both been used successfully in controlling algae.
- Copper sulfate is the most common chemical used to control algae.
- Non-toxic dyes can be used to reduce sunlight penetration in the water.

When considering any chemical or biological means of algae control, an operator must make sure that the action is approved by the Idaho Department of Environmental Quality (DEQ) and is not a violation of permit conditions.

6.3.4.2 Erosion

Erosion can wash away clay liner material on inside banks or create cracks and crevices in outer banks. Both situations reduce the structural integrity of lagoon dikes and can result in leaks and dike failure. Erosion can be caused by wave action, surface runoff from precipitation, holes dug by burrowing animals, lack of proper vegetation on outside slopes, steep slopes, or poor maintenance.

Installing riprap or broken concrete along banks and dikes can minimize erosion and limit weed growth. However, this practice cannot be used for exposed synthetic liners.

Diversion ditches and proper grading around the lagoon may be used to divert surface water away from the lagoon. Burrowing animals, such as gophers, moles, ground squirrels, and groundhogs, should be trapped and removed. Burrowed holes should be repaired immediately to prevent erosion.

6.3.4.3 Odor Prevention

Some storage lagoons can produce odors from time to time, depending on the water quality of the stored wastewater and how the ponds are maintained and operated. If odors are a problem or anticipated to be a problem, an odor management plan should be submitted to and approved by DEQ.

The Odor Management Plan should cover wastewater treatment systems, land application facilities, storage lagoons, and other operations associated with the facility. The plan should include specific design considerations, operation and maintenance procedures, and management practices to be employed to minimize the potential for or limit odors. The plan should also include procedures to respond to an odor incident if one occurs.

Odors related to storage lagoons may be caused by the following:

- Storage of wastewater with a high organic content
- Stagnant conditions or long detention times of water in storage
- Lagoon turnover due to seasonal temperature changes. This causes a vertical movement of the lagoon contents causing the lower anaerobic zone to move towards the surface
- Accumulation of dead vegetation or algae in the lagoon

Most odors in the lagoon water column are caused due to anaerobic conditions which generate odorous gases such as hydrogen sulfide and mercaptans. See Section 2.3.2 for further discussion of nuisance conditions.

6.3.4.4 Freeboard

A properly designed storage lagoon system will provide adequate freeboard or safety volume to prevent an overflow from the lagoon. Unauthorized overflow from lagoons is a violation of state rules (see IDAPA 58.01.16.600.02 and IDAPA 58.01.17.500.03) and is subject to enforcement action. Allowing a lagoon to reach its maximum storage capacity before the start of the non-growing season does not leave room for storing excess precipitation during extended wet periods. In the late summer/early fall, lagoons should be pumped down as necessary to accommodate non-growing season flows, precipitation, etc.

In Idaho, storage lagoons are designed to have a minimum of two feet of permanent freeboard. Under normal operations, the freeboard space will not be used for water storage. However, under some conditions, the freeboard space may be encroached upon:

- Extremely high precipitation event.
- High wastewater generation rates due to rapid population growth, inflow/ infiltration problems or, in industrial systems, plant upsets or unusual operations resulting in greater generation of wastewater.
- Inability to lower storage lagoon volume to minimum levels prior to the winter storage season.

If a situation arises that could result in approaching a lagoon overflow, contact your regional DEQ office to evaluate the situation and to determine what actions and approvals may be needed.

6.3.4.5 Short-Circuiting

Short-circuiting is a condition that occurs when some of the wastewater in a lagoon or basin travels faster than the rest of the flowing water, typically between the inlet and outlet pipes. This problem can be caused by such factors as poor design, sludge accumulation in the lagoon bottom, vegetation that hinders lagoon circulation, and temperature gradients in the water column.

Short circuiting is a concern for lagoons that perform treatment or are used for chlorine disinfection. It is less of a concern for lagoons used solely for storage. Short circuiting may cause stagnant conditions in a portion of the lagoon, which result in odor problems depending on the wastewater quality. Short-circuiting can be verified by the use of dye tests and may be corrected or prevented by using curtains or baffles to redirect flow, relocating inlet and outlet pipes, controlling vegetation, and removing excessive sludge deposits from the lagoon.

6.4 Grazing Management

Although well managed livestock grazing is an effective method for harvesting crops grown on wastewater land treatment sites, poorly managed livestock grazing can result in negative environmental impacts and pathogen transmission to grazing animals when land applying municipal wastewater.

This section discusses livestock grazing on wastewater land treatment sites; avoiding adverse grazing impacts; grazing plans; general, growing and non-growing season grazing conditions; and special considerations regarding grazing on municipal land treatment sites.

6.4.1 Avoiding Adverse Impacts from Grazing

Adverse impacts to the site and the environment caused by livestock grazing can be avoided through careful consideration of nutrient balance and additional nutrient loading rates from livestock manure, compaction of the soil, and the effects of overgrazing.

6.4.1.1 Calculating Nutrient Loading Rates with Grazing

Nutrient loading rates should be calculated as described in Sections 4.2.2, including the additional input from manure deposited by grazing animals and the mineralization (nutrient release) rate over time of the manure being considered. Further information regarding these calculations can be found in USDA (1992), Araji and Abdo (No Date), Cogger and Sullivan (1999), and Beegle (1997).

6.4.1.2 Avoiding Soil Compaction

If animals are allowed on a land treatment site when soils are wet, substantial soil compaction can occur, leading to decreased infiltration rates, a subsequent increase in the potential for runoff, and reduced plant growth. This problem can be avoided by grazing only when soils are adequately drained and soil moisture is below *field capacity,* a measure of moisture percentage after rapid drainage. (See further discussion of soil moisture determination in Section 6.4.2.1 and discussion of field capacity in Sections 2.3, 4.4.7, and 7.7.7.)

6.4.1.3 Avoiding Over-Grazing

Over-grazing of a site can decrease plant growth and vigor, leading to reduced water and nutrient uptake and increasing the potential for deep percolation and contamination of ground water. Moreover, reduced plant vigor causes long-term reduction in yields and the capacity of the site to support grazing.

Over-grazing can be avoided by limiting the number of animals, limiting the time that animals remain on the field or plot, rotating livestock from plot-to-plot based on the amount of remaining vegetation, and adhering to an approved grazing management plan.

6.4.2 Grazing Management Plan

To ensure that crop health and soil properties remain effective for wastewater land treatment, a grazing management plan is necessary for both the growing and non-growing seasons. Grazing plans must be reviewed and approved by DEQ before being implemented.

The grazing plan should follow the guidance and specifications of relevant sections of the USDA Natural Resource Conservation Service (NRCS) *Field Office Technical Guidance* (FOTG), which can be accessed electronically from the following Web site:

http://www.nrcs.usda.gov/technical/efotg

Table 6-1 lists available guidance from NRCS related to grazing management.

Table 6-1. Relevant NRCS grazing guidance and specifications.

Practice Name	Code	Where Applicable
Pasture and Hayland Planting	512	Pasture, hayland, or land converted from other uses
Grazing Land Mechanical Treatment	548	Native grazing land

See also the NRCS *National Range and Pasture Handbook*, which can be accessed at the following Web site:

http://www.glti.nrcs.usda.gov/technical/publications/nrph.html

Of particular interest in this publication is Chapter 5, ‘Management of Grazing Lands.’

6.4.2.1 Conditions for All Wastewater Land Treatment Site Grazing

All wastewater land treatment site grazing is subject to the following conditions:

- Livestock should be on site only until feed is depleted. Minimum leaf length and stubble height before and during grazing should be observed (Table 6-2).
- There should be no irrigation while livestock are on site.
- Livestock should be removed if precipitation wets soil such that soil/crop damage may result.
- A written statement from the permittee to DEQ, stating that the permittee has control over the management of the grazing animals, is needed.
- There should be no supplemental feeding of livestock while on the wastewater land treatment site.

Table 6-2. Minimum leaf lengths and stubble heights recommended for grazing (SCS, 1986).

Column A	Column B	Column C1
Plant Species - Common Name	Minimum Leaf Length Reached Prior To Initiating Grazing (in.)	Minimum Stubble Height to Remain Following Grazing Or Hay Harvesting (in.)
Kentucky bluegrass	6	3
Smooth bromegrass	8	4
Regar bromegrass	8	4
Reed canarygrass	10	6
Tall fescue	8	4
Orchardgrass	8	4
Timothy	8	4
Garrison creeping foxtail	10	4
Tall wheatgrass	10	8
Intermediate wheatgrass	10	4
Pubescent wheatgrass	8	4
Siberian wheatgrass	6	3
Crested wheatgrass	6	3
Russian wild rye	8	4
Alfalfa	14	3
Ladino clover	8	3
Red clover	6	3
Alsike clover	6	3
Sweet clover	8	4
Trefoil	8	3
Sainfoin	12	6
Milkvetch	8	4
White dutch clover	4	2

1 This is the minimum stubble height to be remaining at end of grazing period or hay harvest operation. When a grass-legume mixture is harvested for hay, generally use most limiting stubble height for the mixture.

In the event there is a significant precipitation event, causing standing water or muddy conditions while livestock are on the site, the livestock should be removed. A determination of soil moisture should then be made to assess whether crop damage and/or soil compaction will result from continued grazing. The surface soil layer can be sampled after the precipitation event and evaluated for soil moisture according to Table 7-25 in Section 7.7.7 utilizing the “feel method”. This involves collecting surface soil samples at several places in the field. The soil water status for each sample is estimated by feeling the soil to determine whether soils are like those in the shaded boxes in Table 7-25 (Ashley et al. 1997, and Wright and Bergsrud, 1991). If so, soil conditions may be too wet for grazing.

Soils having moisture characteristics described in the shade portions of
should be allowed to drain to a suitable soil moisture content prior to grazing. General drainage times in days, (from Carlisle and Phillips, 1976 and Donahue et al., 1977) are provided in Table 7-26, Section 7.7.7.

6.4.2.2 Conditions for Growing Season Grazing

When developing a grazing management plan specifically for the growing season, the following items should be included:

- Type and number of animals to be grazed on the site.
- Identification of times when animals can be put on a plot and when they should be removed, based on plant growth characteristics (plant height or other criteria). Indicate the primary growing season or months anticipated for the grazing season.
- A schedule for rotating the animals through the site. Include a map showing plot arrangement, location of salt blocks, protein blocks, and water. The grazing management plan should include a schedule for rotating the location of any salt or protein blocks to prevent excessive traffic on any portion of the site.
- A nutrient balance, accounting for crops grown, crop yield, fertilizers used, and nutrients removed and added by livestock. (See further discussion in Sections 4.2.2.3, 4.2.2.4, and 6.4.1.1)

6.4.2.3 Conditions for Fall "Clean-Up" (Non-Growing Season)

There can be appreciable vegetative material left after harvest on fields, as well as along fence rows and ditch banks. Feed value of this post-harvest material often can be utilized by grazing animals. If a wastewater land treatment site is to be grazed solely for the purpose of fall "clean-up" of the site, then the following conditions should be met:

- Livestock should be on site only after harvest.
- Livestock should be off site no later than December 31st.
- No winter pasturing of livestock or supplemental feeding.

6.4.3 Grazing on Land Application Sites Irrigated with Treated Municipal Wastewater

This section establishes program guidance on the practice of using treated municipal wastewater to irrigate sites grazed by animals used for dairy or meat production. The Idaho State Department of Agriculture (ISDA) and the Idaho Division of Environmental Quality (DEQ) jointly developed this guidance.

In February 1990, DEQ established program guidance disallowing grazing on all land application sites using treated municipal wastewater. The primary reasons cited for this decision were 1) the potential public health risks and 2) the limited resources of the agency to reasonably insure compliance with grazing management plans.

However, with subsequent EPA guidance (1992)—as well as regulations developed by neighboring states—indicating that grazing is acceptable under certain conditions, DEQ drafted a recommendation for grazing municipal sites and sought comments from ISDA and the District Health Departments. ISDA and DEQ formed a working committee to revise the draft guidance to address potential health risks to both humans and grazing animals. Table 6-3 presents the mutual recommendation of ISDA and DEQ, with the exception of an increase in waiting time for Class B wastewater to a 3 day minimum.

Table 6-3. Permissibility of grazing on municipal wastewater land applications sites.

Wastewater Class	Grazing	Approved Grazing Plan[1]	Minimum Waiting Period prior to Grazing after Wastewater Application (to allow for soil drainage and pathogen die-off[2]	Applicability of Odor Provisions[3]
B	Allowed	Required	3 to 7 days[4]	Applicable
C	Allowed	Required	15 to 30 days	Applicable
D	Not Allowed (IDAPA 58.01.17.600.07d)	NA	NA	NA
E	Not Allowed (IDAPA 58.01.17.600.07e)	NA	NA	NA

Notes:
1) See Section 6.4.2 for information on grazing management plans.
2) See Table 6-4 for generalized soil drainage times.
3) See Section 2.4.2 for further discussion of odor and other nuisance conditions.
4) EPA 2006, Section 4.4.2.

6.5 Buffer Zones

Buffer zones provide distance between the boundary where wastewater-land application ceases and the following:

- Dwellings
- Public or private water supplies
- Surface water
- Areas of public access

Buffer distances are established to protect 1) the public from exposure to land applied wastewater, and 2) drinking water supplies and surface water.

This section presents general buffer zone guidance, and more specific guidance applicable to municipal and industrial wastewater land treatment facilities. Also presented are criteria for alternative industrial wastewater buffer zone distances.

6.5.1 General Buffer Zone Distances

The following general recommendations for buffer zones (DEQ, 1988) should be considered to protect against the potential for aesthetic and public health impacts:

- A land treatment system should not be located closer than 300 feet from the nearest inhabited dwelling.
- A land treatment system should not be located closer than 1,000 feet from a public water supply well or 500 feet from a private water supply well used for human consumption. (See further discussion of buffer zones from wastewater land treatment facilities to wells in Section 6.6.4.1.)

- A minimum buffer of 50 feet should be provided between the wastewater application site and areas accessible by the public.
- The distance from the treatment site to permanent or intermittent surface water, other than irrigation ditches and canals, should be 100 feet.
- A 50-foot separation distance should be provided between the land treatment site and temporary surface water and irrigation ditches and canals.

6.5.2 Facility-Specific Buffer Zone Distances

General buffer zone distances listed in Section 6.5.1 may not be suitable in certain site-specific circumstances. Facility-specific considerations often may need to be considered. Recommended buffer zone distances, and signing, and posting guidance for both municipal and industrial wastewater land treatment sites, is provided in the following sections.

6.5.2.1 Municipal Wastewater Buffer Zones

Table 6-4 presents specific buffer zone guidance for municipal wastewater. Sixteen different scenarios are presented for existing and new land application systems. To use the table, read vertically, to find applicable site or facility conditions and associated buffer zone, fencing, and posting recommendations.

For example, Scenario D uses municipal wastewater with effluent of advanced secondary quality. The wastewater land treatment site is in a residential area, and the wastewater is sprinkle irrigated.

Continuing down the column, buffer zone distances, signing, and posting requirements are given. Note that Class A wastewater is not included in Table 6-6, as there are no buffer zones required with this wastewater class.

Table 6-4. Buffer Zone Guidance for Municipal Wastewater Treatment Sites

Site Condition	Scenarios															
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**	**O**	**P**
Wastewater Class and Degree of Treatment																
Class E: Primary, not disinfected, with organisms too numerous to count (TNTC) (1)	X				X				X				X			
Class D: Primary Disinfected to < 230 CFU/100 ml (1)		X				X				X				X		
Class C: Secondary Disinfected to <23 CFU/100 ml (1)			X				X				X				X	
Class B: Advanced Secondary Disinfected to <2.2 CFUg/100 ml (1)				X				X				X				X
Location																
Suburban or Residential Area	X	X	X	X					X	X	X	X				
Rural or Industrial Area					X	X	X	X					X	X	X	X
Mode of Irrigation																
Sprinkler Irrigated	X	X	X	X	X	X	X	X								
Furrow/Flood Irrigated									X	X	X	X	X	X X		X
Resulting Buffer Zone Recommendations																
Buffer Zone Between:																
Site and Inhabited Dwellings (in feet)	1000	500	300	100	1000	500	300	100	300	300	50	50	300	300	50	50
Site and Areas																
Accessible to Public (in feet)	1000	300	50	0	1000	300	0	0	100	100	0	0	50	50	0	0
Fencing Type																
Cyclone w/Barbed Wire									X	X						
Woven Pasture Fence	X	X	X		X						X		X	X		
Three-Wire Pasture Fence						X	X									
None Required				X				X				X			X	X
Posting Recommendations																
Required (2)	X				X				X				X			
Required (3)		X	X	X		X	X	X	X		X	X		X	X	X

(1) Organisms here are total coliform in concentrations of colony forming units per 100 milliliter (CFU/100 mL). Bacteria count represents the total coliform bacteria as a median of the last 7 days of bacteriological sampling for which analysis have been completed
(2) Signs should read 'Sewage Effluent Application - Keep Out' or equivalent to be posted every 250 feet and at each corner of the outer perimeter of the buffer zone(s) of the site
(3) Signs should read 'Irrigated with Reclaimed Wastewater - Do Not Drink' or equivalent to be posted every 500 feet and at each corner of the outer perimeter of the buffer zone(s) of the site

6.5.2.2 Industrial Wastewater Buffer Zones

To protect public health and prevent aesthetic impacts or public nuisance conditions, buffer zones for industrial wastewater apply to both existing land application systems and to all new systems. Table 6-5 provides recommended buffer zone distances for industrial wastewater(s). To use the table, read vertically, to find applicable site or facility conditions and associated buffer zone, fencing, and posting recommendations.

Table 6-5. Buffer Zone Guidance for Industrial Wastewater Treatment Sites.

SITE CONDITIONS FOR INDUSTRIAL WASTEWATER LAND TREATMENT SITES	SCENARIOS			
	A	**B**	**C**	**D**
LOCATION				
Suburban or Residential Area	X	X		
Rural or Industrial Area			X	X
MODE OF IRRIGATION				
Sprinkler Irrigated	X		X	
Furrow Irrigated		X		X
RESULTING BUFFER ZONE REQUIREMENTS:				
BUFFER ZONE BETWEEN:				
Site and Dwellings (feet)	300	200	300	200
Site and Areas access. to Public (feet)	50	50	50	0
FENCING TYPE				
Three-Wire Pasture Fence	X	X		
Not Required			X	X
POSTING				
Required[1]	X	X		
Not Required			X	X

(1) Signs should read 'Irrigated with Reclaimed Wastewater - Do Not Drink,' or equivalent, and should be posted every 500 feet and at each corner of the outer perimeter of the buffer zone(s) of the site.

Greater buffer zone distances may be necessary if the wastewater is of similar quality as raw or primary sewage or has particular industrial contaminants that warrant a more protective buffer zone.

In instances where recommended buffer zones may be either overly protective or insufficient for a particular facility or site, the criteria in Section 6.5.3 should be used to determine proposed alternate buffer zone distances. However, applicants must provide adequate justification of alternative buffer zones as part of the system design.

All buffer zones must comply with local zoning ordinances.

6.5.3 Criteria for Alternative Wastewater Buffer Zones

If a recommended buffer zone is considered unreasonable or unnecessary for a specific site, it is incumbent upon the permittee to propose an alternative distance and justify this proposal to DEQ. The alternative distance proposal should be specific to a given site and should demonstrate how public health and the waters of the state will be adequately protected.

The following approaches to minimizing wastewater spray drift and/or degree of exposure should be considered when proposing alternative buffer zones:

- Conduct a microbial risk analysis, which involves characterizing the type and concentration of pathogens in the wastewater under typical operating conditions, their dispersion in air, and their risk to human receptors. (See further discussion in Section 3.4.9.3.)
- Provide a higher degree of pretreatment, such as oxidation, anaerobic treatment, disinfection, or filtration for the removal of wastewater pathogens, prior to applying to land surface.
- Use alternative methods of irrigation, such as low pressure sprinkler irrigation, to reduce spray or airborne exposure from *drift*[4].
- Provide a physical or vegetative barrier designed to reduce drift or *aerosol*[5] dispersion. Appropriately designed vegetative barriers can provide adequate buffer capability for wastewater land treatment sites. See Spendlove et al., (1980), for one example of how to design vegetative barriers.
- Monitor the wind speed and direction on a real-time and site-specific basis to determine timing of irrigation events.

6.6 Protection of Domestic and Public Well Water Supplies

This section discusses regulatory programs, including federal law and Idaho rules that protect drinking water supplies and drinking water wells near wastewater land treatment facilities.

6.6.1 Source Water Protection and the Safe Drinking Water Act

The amendments to the *Safe Drinking Water Act* (SDWA) of 1986 authorized the *Wellhead Protection Program* for states to develop and implement for protection of ground water and drinking water supply systems. The Act was further enhanced in 1996 with the passage of additional amendments requiring states to develop source water assessment plans for all public water supplies.

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4 Drift is typically considered to be those droplets greater than 200 microns in size and aerosol is generally considered to be droplets less than 200 microns in size (Kincaid, 1995)

5 Aerosols refer to fine spray droplets containing wastewater microorganisms that have evaporated to dryness or near dryness, leaving a much smaller solid or semi-solid particle or bio-aerosol that can travel much farther than the original droplet.

The 1996 amendments also included preventative protection measures for public surface water supplies, in addition to the ground water supplies addressed under the previous Wellhead Protection Program.

Implementing a local *Source Water Protection Program* is encouraged, but is not mandatory.

6.6.2 Source Water Protection under Idaho Rules

Idaho's Source Water Protection Program uses a voluntary approach intended to supplement the *Idaho Rules for Public Drinking Water Systems* (IDAPA 58.01.08). Although Idaho is required, under the Safe Drinking Water Act Amendments of 1996, to assess every source of public drinking water for its sensitivity to contaminants regulated by the Act, communities can utilize information provided in the Source Water Assessments to develop *source water protection areas* to suit local conditions.

6.6.2.1 DEQ Provides Technical Assistance and Guidance

DEQ is designated to provide technical assistance and guidance on the Source Water Protection Program to local governments and water system purveyors. DEQ has developed information on wellhead protection (Wellhead Protection Plan, DEQ 1997) and source water protection (Protection of Drinking Water Sources in Idaho, DEQ 1999) to address the protection of drinking water supplies in Idaho.

6.6.2.2 Local Requirements May Be More Stringent Than State Rules

It is the responsibility of the Reuse permittee or applicant to inquire of appropriate planning and zoning jurisdictions and local governing bodies as to whether their site is within a source water protection area. Because each community can choose to develop its own Source Water Protection Plan as additional protection beyond the requirements of IDAPA 58.01.08, it is recommended that a wastewater reuse permittee contact the local city/county government or water purveyor about established or developing local source water protection programs or ordinances.

Local ordinances and planning-and-zoning requirements are to be followed and, where stricter than state regulations, used in the design of the facility and in the siting of wells and treatment sites.

6.6.2.3 Special Conditions for Sensitive Resource Aquifers

Refer to Section 12.8 for special considerations on source water protection areas and wastewater land treatment systems overlying the Rathdrum Prairie Aquifer.

6.6.3 Protection of Domestic Water Supplies

A permit to construct a well is required by the *Well Construction Standards Rules* (IDAPA 37.03.09) administered by the Idaho Department of Water Resources. This permit applies to all water wells, including domestic wells (individual, public, and non-public wells), irrigation wells, monitoring wells, and low temperature geothermal wells.

The same permitting requirements apply to wells drilled to augment or replace existing wells.

Placement of wells in relation to potential sources of contamination, such as wastewater-land application systems, is addressed by DEQ or the District Health Department, depending on the source of contamination and/or the land use activity.

DEQ is responsible for regulating, in accordance with the Safe Drinking Water Act Program in Idaho, the water quality standards for all public water systems. Inspections and technical assistance services are provided to public water systems by both the DEQ and/or the District Health Departments, depending on the number of connections and source of supply. (For further information, see Idaho Statutes Title 39, Chapter 1.)

Generally, DEQ provides assistance to all surface water systems and public water systems with more than 25 connections. The Health Districts assist smaller public water systems (10 to 25 connections), individual domestic well owners, and commercial systems on individual wells (DEQ, 2000).

6.6.4 Protection of Well Water Supplies near Wastewater Land Treatment Facilities

The buffer zones recommended in Section 6.5.1 (500 feet between domestic wells and a wastewater land treatment site and 1000 feet between a site and a municipal water supply well) are general recommendations and may not be appropriate in all circumstances. The number of domestic and municipal wells, the size of the facility, the local hydrogeology, and the extent of existing or potential contamination are just some of the factors that may indicate the need for a more thorough evaluation of the respective locations of wastewater land treatment sites and wells.

The discussion that follows presents an evaluation methodology called the *Well Location Acceptability Analysis* (WLAA). The WLAA considers the facility type, site constituent loading rate, well proximity to land treatment facilities, hydrogeological setting, and existing and predicted ground water quality, to determine suitability of respective locations of water supply wells and land treatment acreage.

Also discussed are descriptions of capture and mixing zone analyses and methods to conduct these analyses.

6.6.4.1 Well Location Acceptability

The decision flow chart shown in Figure 6-2 provides guidance on determining the acceptability or non-acceptability of domestic private, shared (non-public), or municipal (public) well locations, or other public water systems (PWS) with respect to wastewater land treatment sites:

- "Well/Site Location Acceptable" means the wastewater land treatment site is not likely to cause contamination of the aquifer, and the beneficial uses of the ground water pumped from the well should be maintained. However, the wastewater-land application permit may require monitoring of the well to substantiate that contamination is not occurring at present or likely to occur in the future.

- "Well/ Site Location Not Acceptable" means that the relative positions separating the proposed or existing wastewater land treatment site and an existing or planned well is unacceptable.

When conducting a well location acceptability analysis, it is important to recognize and account for all potential contaminant sources. There may be cases where there are causative factors of ground water contamination unrelated to land treatment activities. These must be considered when conducting the analysis and in making well/location acceptability determinations.

6.6.4.2 Preliminary Questions: Minimum Distances and Hydraulically Separate Aquifers

The first question in Figure 6-2 asks whether the well is closer than 1/4 mile from the site. This question establishes an initial universe of wells to consider the suitability of the wastewater-land application site in relationship to wells. If the well is not within 1/4 mile, it is generally not considered, but can be, depending on site-specific conditions.

The next question asks whether a well is closer than 50 feet, which is the distance required between a public water well and the property boundary on which it is located (Idaho Rules for Public Drinking Water Systems, IDAPA 58.01.08.510.02 and 512. If it is, the location is not acceptable. The same protection is provided for all domestic water systems whether an individual, non-public, or public water supply system.

If the well/site location is greater than 50 feet, the next question asked is whether the well is completed in a hydraulically isolated lower aquifer. If so, the well/site location is acceptable because any contamination from the land treatment site would be of the upper (water table) aquifer only. Determination of hydraulic isolation of a lower aquifer must take into account several factors:

- The well should be completed in a confined aquifer.
- The integrity of the confining layer(s) and vertical hydraulic gradient must be determined.
- The degree of leakage of the aquitard(s) may change during well pumping conditions and should also be considered.
- The adequacy of well construction (see IDAPA 39.03.09 and IDAPA 58.01.08.550.03b) to isolate a lower aquifer must be documented.

If hydraulic isolation can be demonstrated, then generally the well/location is acceptable. If not, the well is regarded to be in a shallow water table aquifer.

The next question asks whether the wastewater land treatment site is a 'municipal site', i.e. whether wastewater from a municipal sewage treatment plant or other sanitary source is applied. If no, this generally indicates little regulatory concern for microbial pathogens, and consideration of impacts from hydraulic, nutrient, and other constituent loading are considered. It is important to note that certain industrial wastewaters may have pathogenic microorganisms at levels of regulatory concern. If this may be the case, a 'yes' answer to the 'municipal site' question would be appropriate. See Section 3.4.9 for further discussion on pathogenic organisms in wastewater.

6.6.4.3 Capture Zone Analyses

If the site is not a municipal site, the next question asks whether the site intersects the capture zone of the well. This section discusses WLAA criteria for acceptability and capture zone analysis methodology.

6.6.4.3.1 Capture Zone Analysis Criteria for Acceptability

A Capture Zone Analysis (CZA) must be conducted. A capture zone (CZ), or *zone of contribution*, is defined as the area surrounding a pumping well that supplies ground water recharge to the well (EPA, 1991). (See further discussion in Section 6.6.3.)

The capture zone analysis determines if the boundaries of a wastewater-land application site or down-gradient off-site areas overlie the delineated zone from which the well draws water. CZ delineations can be calculated to reflect specific times of travel (TOT—always stated in *years* in this document) from the boundary of a delineation to the well, given specific aquifer and well characteristics, pumping rate etc.).

A CZ is calculated for an infinite time of travel (TOT = ∞) to determine the largest possible CZ and any likelihood of the CZ overlying boundaries mentioned above:

- If the infinite TOT CZ does not intersect land treatment boundaries or down gradient areas, it is unlikely that the well would be drawing water from a zone influenced by land treatment activities. The well/site location is acceptable.
- If the wastewater land treatment site lies within the CZ TOT = ∞, questions regarding ground water quality follow.

6.6.4.3.2 Capture Zone Analysis Methodology

A capture zone, or zone of contribution, is defined as the zone surrounding a pumping well that will supply ground water recharge to the well (EPA, 1991). Capture zone analyses are done to see whether the delineated zone where a well draws water overlies the boundaries of a wastewater-land treatment area. A well within these boundaries is subject to potential impacts from this land-use activity.

Methodologies for the delineation of capture zones are discussed in detail in EPA (1994), Chapter 4 'Simple Methods for Mapping Wellhead Protection Areas'. DEQ (1999), Chapter 4 also discusses types of ground water delineations including arbitrary-fixed radius, calculated-fixed radius, and refined analytical methods. Appendix E of DEQ (1999) provides technical guidance for their calculation. DEQ (1997), Chapter 4 discusses Idaho-specific capture zone delineation in detail, and Appendix F of that document provides further technical guidance for calculations and tables of aquifer properties necessary for calculations.

Several important model input sources are appended. Figure 2-1 in Section 2.1.4 shows locations and types of major aquifers in Idaho. Sections 2.5.3 through 2.5.8 contain general tables of aquifer properties, an extended table of transmissivities (and other data) for several wells in Idaho, a table of Idaho-specific hydraulic conductivities by rock type, a map of hydraulic conductivity zones, and hydraulic conductivities for typical aquifer materials. These sections provide general parameter values for input to the capture zone model mentioned above. See Section 2.1.4.2.2 for further discussion of these parameters. Each site should use values as site-specific as possible for input to the model.

EPA (1994) Chapter 6 discusses computer modeling for calculating delineations. DEQ (1999) Appendix E provides a less technical but more current computer modeling discussion including models currently recommended. The Wellhead Protection Area (WHPA) software has been used to define capture zones, which is a modular semi-analytical model developed by EPA (1991). This software, however, has been superseded by WhAEM 2000 (EPA, 2000).

6.6.4.4 Analysis of Ground Water Quality Data

The next question asks whether there is existing ground water quality data from the domestic or municipal well being evaluated, or from monitoring wells (surrogate(s) to the subject well) representative of the subject well.

These data must be of a certain quality to make well location acceptability decisions. Data must be sufficient to document that ground water quality of a site is *representative* of the loading and management of the site as currently permitted, or as proposed in a permit application. For data to be representative, the site must be at steady-state conditions, having been loaded and managed consistently for a period of time, so that ground water quality is reflecting whatever impacts, if any, the land treatment site may be causing to the subject well.

If the site has been operating for a time too short to establish steady state conditions, ground water data would not likely be representative. If the site is at steady state conditions, but proposed management and loading of the site are different than current operations, data would likely not be representative of anticipated operations.

Data may often reflect impacts from other land uses besides wastewater land treatment. Influences from feedlots, dairies, septic systems, and irrigated agriculture must be taken into account when utilizing water quality data from domestic and municipal wells. These influences may complicate the use of the data for WLAA purposes.

6.6.4.5 Compliance with the Ground Water Quality Rule

If there are ground water data available meeting the conditions discussed above, the next question is whether these data are in compliance with the Ground Water Quality Rule (GWQR, IDAPA 58.01.11).

This regulatory analysis, which involves the determination of degradation, significance of degradation, trends, and both of these characteristics in relation to ground water standards and other criteria, is beyond the scope of this guidance, but if the data are in compliance with the GWQR, the well/site location is acceptable. If not, the well/site location is not acceptable.

6.6.4.6 Mixing Zone Analysis

In the event ground water data meeting the conditions discussed above are not available, a mixing zone analysis (MZA) is conducted. This section discusses WLAA criteria for acceptability and mixing zone analysis methodology.

6.6.4.6.1 Mixing Zone Analysis Criteria for Acceptability

An MZA involves calculating hydraulic and constituent balances to determine percolate volume and constituent concentration.

Aquifer flow is also calculated, and both percolate and aquifer flow are mathematically mixed to obtain an estimate of the steady-state concentration of ground water discharging from the down gradient boundary of the land treatment site.

MZA methodologies can be found in EPA (1981) and EPA (1996). Further discussion of MZA methodology can be found in Sections 6.6.3 and 7.7.5.

The final question asks whether the predicted MZA impacts from the wastewater land treatment site are in compliance with the GWQR. If the predicted impacts are in compliance with the GWQR, the well/site location is acceptable. If not, the well/site location is not acceptable.

6.6.4.6.2 Mixing Zone Analysis Methodology

Mixing zone calculations provide rough estimates of potential ground water constituent concentrations resulting from the operation of a wastewater land treatment system: 1) after the system has reached steady state conditions; and 2) under ongoing consistent management of the system.

Mixing zone analysis (dilution analysis) equations used to predict steady state ground water quality are found in EPA (1981) Chapter 3, and EPA (1996) Chapter 2. These analyses provide a rough estimate of the potential of the site, as managed or as proposed to be managed, to impact ground water moving beneath the site. Methodologies are discussed in detail in Section 7.6.5.2.2. Sections 2.5.3 through 2.5.8 provide aquifer parameters for use in mixing zone calculations.

The user should be familiar with the assumptions of the model to be able to interpret the output. Calculation methodologies presented here yield rough estimates and typically do not take into account attenuation mechanisms which will certainly take place to varying degrees in the environment. Attenuation factors that may need to be considered include: decay and degradation; retardation; and adsorption, precipitation and other chemical reactions. Operation and management may need to be considered also. Modifications of methodologies and more sophisticated approaches may be necessary depending on site-specific circumstances.

Calculated steady-state down-gradient ground water concentrations (C_{mix}), should not exceed levels of regulatory concern as determined by DEQ (IDAPA 58.01.11).

6.6.4.7 Municipal Site Well Acceptability

Returning to the question as to whether the site is a 'municipal site', questions regarding wastewater class and distances follow. If the well is not greater than or equal to 100 feet from the site, the well/site location is not acceptable. This distance is derived from distances from a PWS or domestic water supply and various sanitary sources such as septic tanks, drainfields, seepage pits etc. See further IDAPA 58.01.08.900.01 and 58.01.03.007.17, 008.02d.

If the distance is greater than 100 feet, and the wastewater applied is Class B (see IDAPA 58.01.17.600.07b), regulatory concerns for pathogen attenuation and distances are satisfied and concerns regarding hydraulic, nutrient, and other constituent loading can be addressed as with non-municipal wastewaters.

If the wastewater applied is not Class B, but Class C (see IDAPA 58.01.17.600.07c), and the well is greater than 300 feet from the site, regulatory concerns for pathogen attenuation and distances are satisfied and concerns regarding hydraulic, nutrient, and other constituent loading can be addressed as with non-municipal wastewaters. This distance is derived from the largest distance specified in IDAPA 58.01.03.013.04d for large soil sorption systems and all domestic wells.

If the 300 foot distance cannot be met, or wastewater is not Class B or C (i.e. meaning high pathogen count Class D or E wastewaters being applied), a one-year capture zone (CZ TOT = 1) must be met. This distance is derived from the protective minimum for attenuation of pathogens potentially introduced into the aquifer through aquifer recharge (DEQ, 2006, page 12):

- If the well is not within the one-year CZ, the well likely has sufficient pathogen attenuation time, and questions regarding ground water quality follow.
- If it is within the one-year CZ, the well is not deemed to have sufficient pathogen attenuation time, and a Vadose Zone Time of Travel Analysis (VZTTA) analysis is indicated. See Section 7.7.5.2.3 for VZTTA methodologies.

6.6.4.8 Vadose Zone Travel Time

The next question asks whether the total time of travel summing both aquifer and vadose zone time of travel (VZ TOT) is less than one year. If it is, the well is not deemed to have sufficient pathogen attenuation time, and the well/site location is not acceptable.

If the sum of the CZ and VZ TOT is one year or greater, regulatory concerns for pathogen attenuation and distances are satisfied and concerns regarding hydraulic, nutrient, and other constituent loading can be addressed as with non-municipal wastewaters.

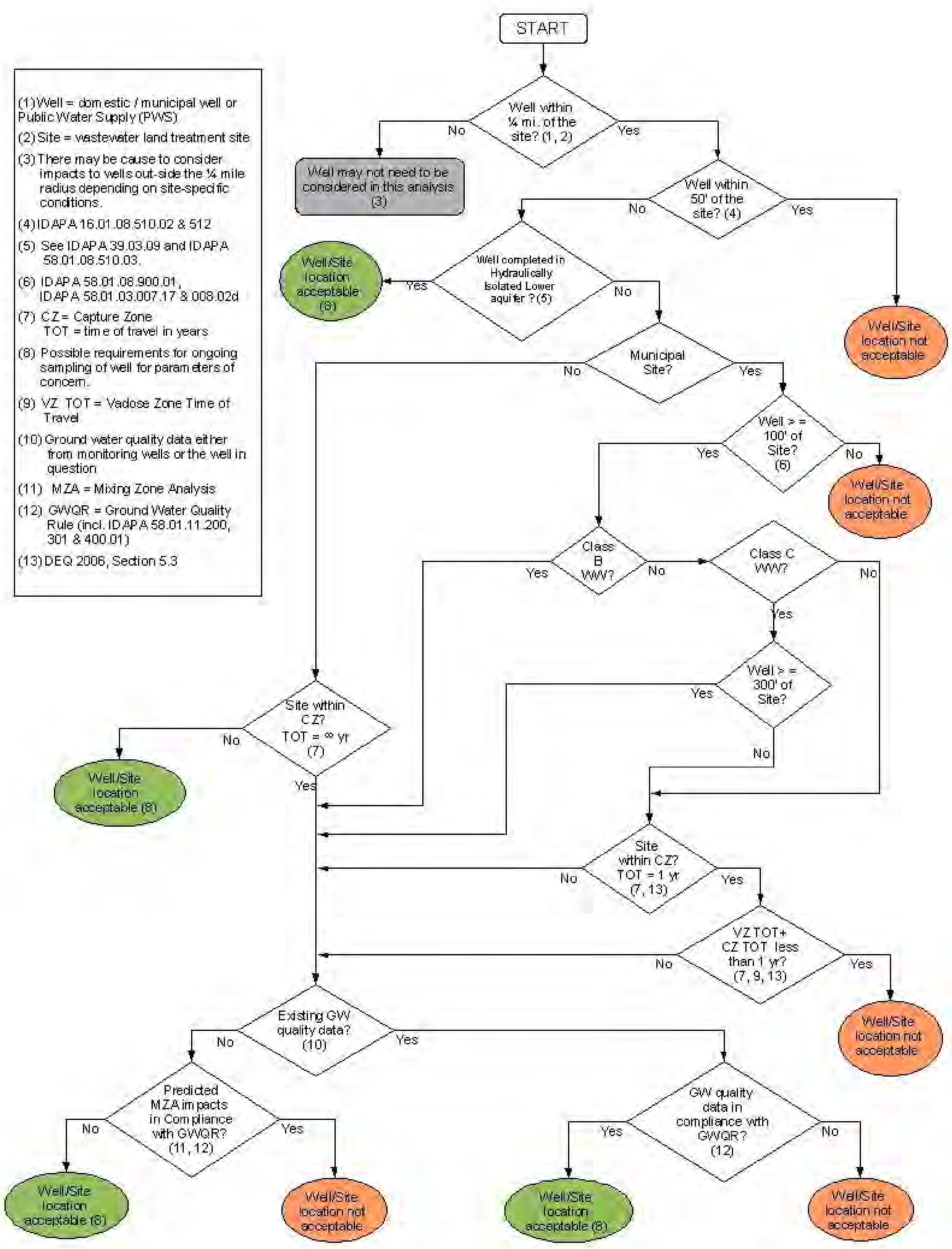

Figure 6-2. Well Location Acceptability Analysis.

6.7 Site Closure

Because protection of public health and the existing and future beneficial uses of the waters of the state must be maintained after site closure, permanent closure of a wastewater land treatment site often necessitates a closure plan. Accordingly, a site closure plan should be included as part of the submittal package for each *new* wastewater land application facility. Updated closure plans should be submitted by permittees at the time of permit renewal.

The closure plan should include an environmental assessment of possible adverse impacts resulting from the prior permitted facility and the decommissioning of pumps, storage lagoons and other equipment; a description of the planned treatment of sludge or wastewater in the lagoons; plans for site restoration; plans for the containment of soils with high-phosphorus levels; and any other necessary corrective actions.

DEQ makes the following recommendations regarding site closure for a wastewater-land application system:

- Site closure is included as a standard permit condition for each wastewater-land application facility.
- The standard permit condition includes two elements:
  - Permittee notification to DEQ six months prior to closure or as far in advance of closure as possible
  - A pre-site closure meeting between the permittee and DEQ, during which specific closure or clean-up tasks will be identified, along with time-lines for completion of tasks for both DEQ and the permittee.
- A site closure plan should be developed by the permittee based on the agreements and results of the pre-site closure meeting. The plan should be submitted to DEQ within 45 days after the pre-site closure meeting and finalized with signatory agreement by all parties prior to commencing site closure activities.

6.8 Weed Control at Wastewater Land Treatment Facilities

Weed control is a necessary practice at wastewater land treatment facilities. Facilities should manage their sites to control weeds, including noxious weeds. Procedures to address control of noxious weeds should be included in the facility plan of operation or O&M manual. DEQ should be kept informed of proposed plans for noxious weeds, because these plans may affect the performance of land application sites.

Lagoon areas should be free of weeds. Vegetation surrounding lagoons, if present, should be controlled for reasons discussed in Section 6.3.4.1. Weed control is also necessary on wastewater land treatment sites. Crops, which beneficially utilize water and nutrients, grow best when not in competition with weedy species.

It is important for facilities to be aware of the Idaho Noxious Weed Law, which is administered by the Idaho State Department of Agriculture (ISDA) under ISDA Noxious Weed Program. The following Web site provides information regarding noxious weeds found in Idaho, ISDA rules and requirements regarding noxious weeds, county contacts to discuss how to deal with noxious weeds, and other related information:

http://www.agri.state.id.us/Categories/PlantsInsects/NoxiousWeeds/indexnoxweedmain.php

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7. Monitoring

Wastewater Land Application Program (WLAP) monitoring is a comprehensive program that provides information for managing and regulating WLAP sites. WLAP monitoring is determined by site-specific environmental and operational parameters.

This section presents guidance and provides the technical references that should be considered when designing a WLAP monitoring plan and establishing permit conditions for monitoring in a wastewater land application facility. General discussions of monitoring as well as particular discussions of commonly monitored media are also presented.

7.1 General Discussion

Several general considerations apply to all facilities in the wastewater land application permit (WLAP) program administered by DEQ:

- Monitoring Objectives
- Monitoring Parameters
- Monitoring Frequency
- Sampling and Sampling Location Determination
- Analytical Methods
- Quality Assurance and Quality Control
- Data Processing, Verification, Validation, and Reporting

Monitoring recommendations for commonly monitored media are provided in the following to assist in the development of a WLAP monitoring program. Each type of monitoring is discussed in a separate section and the discussion follows the outline of the general section.

Commonly monitored media include the following:

- General discussion (Section 7.1)
- Ground water monitoring (Section 7.2)
- Soil-water monitoring (Section 7.3)
- Soil monitoring (Section 7.4)
- Wastewater monitoring (Section 7.5)
- Crop monitoring and yield estimation (Section 7.6)

7.1.1 Monitoring Objectives

The goal of WLAP monitoring is to provide a timely and cost-effective assessment of both wastewater treatment process operations as well as the impact of operation and management activities on ground water, surface water, soil resources, and crop health. Monitoring information provides valuable feedback to determine whether wastewater land treatment changes should be made to manage environmental impacts. All permits need to specify required monitoring sufficient to yield data that are representative of the monitored activity. WLAP monitoring requirements should have well defined objectives – i.e., it should be known how the data will be used. Useful data are generated when the purposes of monitoring are understood.

The three objectives of environmental monitoring are as follows:

a) Site Characterization

It is necessary to characterize baseline conditions of ground water, soil water, surface water, soils, and other media prior to initiation of wastewater land treatment activities and for system design purposes. Characterization of variability in monitored media, particularly wastewater and ground water, is a prerequisite to establishing monitoring schedules.

b) Site Management or Process Control Monitoring

Process control monitoring involves monitoring internal components of both the wastewater land application system and other associated wastewater treatment processes to determine whether they are functioning as designed (Crites et al. 2000). This monitoring can yield information that can be used to modify ineffective management practices.

c) Compliance Monitoring

Compliance monitoring is required in regulatory instruments so that an adequate determination of whether a wastewater-land application system is complying with applicable water quality standards, permit specific limits, and other WLAP permit conditions. Compliance monitoring includes environmental parameters, such as ground water quality. It also includes monitoring of treatment parameters, such as constituent loading, which serve as a first line of monitoring to be protective of the resource (ground water for example)

Consideration of these objectives is necessary to develop a program or strategy with the combination of monitoring that will best fit the needs of a given wastewater-land application site.

A quality assurance project plan should be written as prescribed in Section 7.1.6.

7.1.2 Monitoring Parameters

All parameters with permit limits must have associated monitoring requirements in the permit. Parameters that do not have regulatory-established limits may be included to meet clearly defined monitoring objectives as required by DEQ. Media-specific monitoring parameters are discussed in respective sections below. As will be discussed further, choice of parameters to monitor is facility-specific. Not all parameters are necessary for every site.

7.1.3 Monitoring Frequency

The frequency of sampling should result in the generation of data that provide a reasonable characterization of the media. Reasonableness can be demonstrated on the basis of the value of data collected versus cost. A primary value of the data is the establishment of data variability, an important factor in calculating permit limits, determining compliance, and establishing the basis for monitoring frequency. Routine compliance monitoring frequency may be adjusted to reflect the variability - less variable parameters being sampled less frequently, while more highly variable parameters are sampled more often. The intent is to establish a frequency of monitoring that will detect most events of noncompliance without requiring needless or burdensome monitoring and associated costs.

7.1.3.1 Temporal or Spatial Variability

Variability can be temporal or spatial:

- Soils can have significant spatial variability. Monitoring considerations related to soil spatial variability are discussed in 7.4.5.2 *Sampling Location Determination*, page 7-46.
- Temporal variability of the media being monitored is one of the most important factors in establishing monitoring frequency. Therefore, the degree of monitoring frequency is dependent on the characterization of temporal variability. Various sampled media exhibit different variability. Particular parameters measured from one sampled medium can also exhibit different variability. An example of the variability over time of potato processing wastewater COD levels for one year is shown in Figure 7-1.

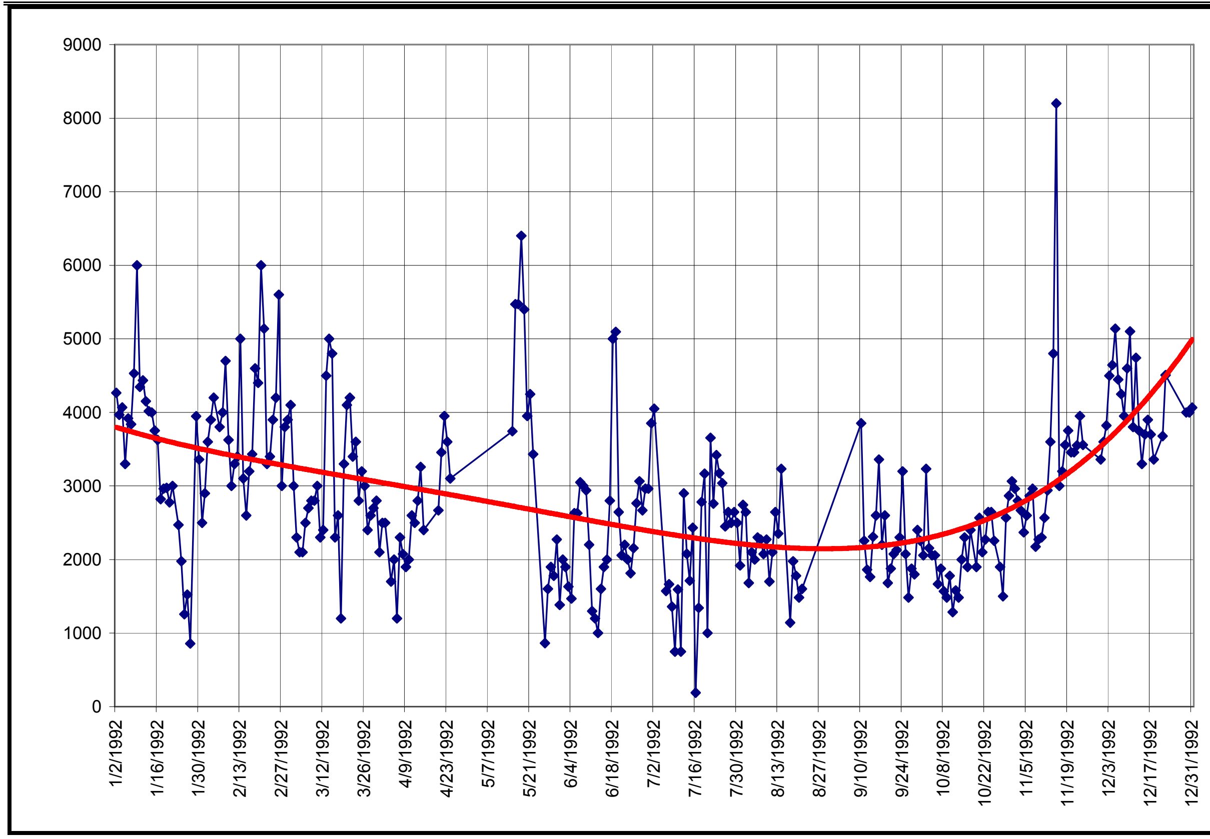

Figure 7-1. Potato processing wastewater COD levels for one year.

- Characterization of medium and parameter variability should be included as a part of the permit application (see Section 1). High frequency monitoring, usually within a tiered framework or as a special study, is recommended to characterize temporal variability of a medium. The frequencies for monitoring may be determined based on the estimated variability.

There are various statistical approaches to determining variability and sampling frequency. DEQ has developed a spreadsheet tool and explanatory text, which provides one such method for use in wastewater land treatment facility permitting. (See *Program Forms and Spreadsheets* in Section 1.9.3)

7.1.3.2 Tiered Monitoring

Tiered Monitoring is a term used to describe a reduction or increase in frequency of monitoring required in a permit. If initial (baseline) sampling shows little variability in a parameter, a reduced monitoring scheme may then apply. Likewise, if initial (baseline) sampling indicates strong variability in a parameter, a more frequent and/or more comprehensive monitoring schedule would apply. Tiered monitoring decisions are based on the results of previous monitoring. The conditions for increase and decrease should be specified in the permit.

The triggers for the tiered elements of a permit should, where possible, be well defined in the permit and explained in the staff analysis. The permit should explain to what frequency the tiered parameter will revert if not detected, not found to be at a level of concern (a trigger), or exceeding a level of concern. The numeric level of concern or other trigger should be defined in the permit and justified in the staff analysis. The reduction, elimination, or increase in monitoring should also be contingent upon formal notification from DEQ to the permittee of the monitoring change, be that a permit modification or written notification. Monitoring changes should be discussed with the permittee prior to formal notification.

7.1.4 Sampling and Sample Location Determination

Monitoring requirements in the permit should specify the sample type (grab, composite or continuous), and the analytical methods for each parameter. Sampling, sample handling, and analytical methods should conform to the guidance provided here and in the technical references cited.

7.1.4.1 Sampling

The sample type will depend on the following:

- The parameter to be monitored. To determine appropriate sample types, consult references provided for each respective media.
- The temporal and spatial variability of the media sampled.
- The type of regulatory limit that may be applied to sample results.

7.1.4.1.1 Discrete Grab or Sequential Grab Samples

A *grab sample* is an individual sample that represents "instantaneous" conditions. Use grab samples when the following is true:

- The characteristics of the media sampled are relatively constant
- The parameters to be analyzed are likely to change with storage
- The parameters to be analyzed are likely to be affected by compositing
- Information on variability over a short time period is desired
- Composite sampling is impractical, or the compositing process is liable to introduce artifacts of sampling
- The spatial parameter variability is to be determined

Another type of grab sample is sequential sampling, which is discussed in 7.5.5.1.1 Discrete Grab or Sequential Grab Samples, page 7-58.

7.1.4.1.2 Composite Samples

A *composite sample* consists of a series of individual samples collected over time and analyzed as one sample. Application of composite sampling to various monitored media is described in the respective media sections.

7.1.4.1.3 Continuous Monitoring

Continuous monitoring is another option for certain parameters and media, such as wastewater flow, pH, salinity and temperature; climate parameters; and soil moisture content. Important factors to remember about continuous monitoring include the following:

- Continuous monitoring is appropriate for a limited number of parameters.
- Reliability, accuracy and cost vary with the parameter.
- Continuous monitoring can be expensive, so the environmental significance of the variation of parameters of a given media should be compared to the cost of continuous monitoring equipment available.
- Continuous monitoring provides a considerable amount of data and its use should be clearly defined.

7.1.4.1.4 Other Sample Types

Several other types of samples can also be taken:

- *Split Sample* - A split sample is portioned into two or more containers from a single container. Portioning assumes adequate mixing to assure the split samples are, for all practical purposes, identical.
- *Duplicate Sample* - Duplicate samples are collected sequentially from the same source, under identical conditions, but into separate containers.
- *Control Sample* - A control sample is collected upstream, up-gradient, or away from the influence of a source or site to isolate the effects of the source or site on the particular medium being evaluated.
- *Background Sample* - A background sample is collected from an area, water body, or site similar to the one being studied but located in an area known or thought to be uninfluenced by site activities being regulated .
- *Sample Aliquot* - A sample aliquot is a portion of a sample that is representative of the entire sample.

7.1.4.2 Sampling Location Determination

The point at which a sample is collected can make a large difference in the monitoring results. The purpose of monitoring is to observe changes in conditions and compare them to expected or desired outcomes. For this reason, permanent sampling locations should be determined and identified in permit monitoring requirements. Monitoring data can then be compared without concern for spatial variability introduced under conditions where sampling locations are not permanent. The permit applicant should provide a description of all proposed monitoring locations in application materials. Important factors to consider in selecting the sampling station include the following:

- The volume of media at the sampling station should be adequate in order to obtain a sample.
- The sampling station should be easily and safely accessible.
- The sample should be truly representative of the media during the period monitored.

Additional sampling information is given in the *Handbook for Sampling and Sample Preservation of Water and Wastewater* (EPA, 1982):

http://yosemite.epa.gov/water/owrccatalog.nsf/e673c95b11602f2385256ae1007279fe/fe398acacbde5cf685256fc1004e5680?OpenDocument&CartID=9992-112918

7.1.5 Analytical Methods

Approved analytical methods for parameters usually include sampling and handling requirements. Media specific analytical methods are found in respective sub-sections of this section.

Standardization of analytical methods is important in the WLAP program, so that data can be consistently interpreted with respect to site performance and compliance with standards and/or permit-stipulated limits. Different analytical methods can yield different results: for example, a soil analysis for plant available phosphorus (P) might yield a result of 15 mg P/kg soil, while an analysis for total phosphorus (most of which is not plant available) may yield a result around 650 mg P/kg soil (Overcash and Pal, 1982; page 394). In addition, plant available phosphorus has useful agronomic interpretive value while total phosphorus does not.

Laboratory analyses have low fundamental detection limits, method detection limits (MDLs) and practical quantitation limits (PQLs):

- MDLs are the minimum concentrations that a laboratory method can measure above the instrument background noise. MDLs indicate only the minimum detection level of an analyte but do not imply any accuracy or precision in the result. As such, MDLs have little reporting value but rather reflect the standard basic capabilities of a laboratory for specified testing methods.
- PQLs are the minimum concentrations that can be reported within specified accuracy or precision criteria. PQLs can be affected by analyst skill, interferences in the sample and other operating factors. Where MDLs are typically consistent, PQLs typically vary. PQLs are always higher than MDLs, and they should be used for reporting and interpretation.

PQLs reported at or above concentrations of interest (regulatory limit, previously established lower background level, etc.) render the data useless.

For example, if the PQL for manganese (Mn) provided by a laboratory is at the ground water standard (previously the maximum contaminant level, or MCL) of 0.05 mg/L for a ground water sample, the data have no interpretive value for the entire range below the ground water standard. A method having a MDL of 0.005 mg/L, for example, would be appropriate so long as sampling protocol minimizes interferences (e.g. minimizing turbidity in ground water samples) such that the PQL is achievable.

The tables in respective sections below provides guidance regarding chemical analytical methods recommended for environmental monitoring required in WLAP permits, including ground water, soil water, soils, wastewater, and plant tissue analyses.

Standard operating procedures regarding sample collection, preservation, storage, transportation, and preparation of samples, are also important to assure sample integrity. Recommended procedures are outlined in EPA (Revised 1979 and March 1983), Greenberg et al (1992), and other relevant texts.

7.1.6 Quality Assurance and Quality Control

Data gathered in WLAP monitoring programs provides information to decision makers on the quality of ground water, soils, wastewater, leachate, etc. data collected, the adequacy of operation and maintenance procedures, and the potential for land application activities to affect the environment. If decision makers are to have confidence in the quality of environmental data used to support their decisions, there must be a structured process for quality in place. A *Quality Assurance Project Plan* (QAPP) is the environmental industry standard for a structured process for quality in the collection of environmental data.

The QAPP is the single most important quality assurance tool at the project or monitoring program level, and is necessary for all data collection and generation activities. The QAPP summarizes the DQOs (Data Quality Objectives) of the project or monitoring program and integrates technical and quality aspects, including planning, implementation, and assessment into a single document.

The purpose of the QAPP is to document planning efforts for environmental data collection, analyses, and data reporting to provide a project-specific “blueprint” for obtaining the type and quality of data needed for a specific decision or use. The QAPP documents the activities that will take place during the project or monitoring program, including: field and laboratory activities; data verification and validation; data storage and retrieval; data assessment; and, project or monitoring program evaluation and process improvement. The QAPP documents how QA (quality assurance) and QC (quality control) are applied to environmental data collection activities to assure that the results obtained are of the type and quality needed and expected. QA is defined as: “An integrated system of management activities involving planning, implementation, documentation, assessment, reporting, and quality improvement to ensure that a process, item, or service is of the type and quality needed and expected by the client.” (EPA QA/R-5, March 2001). QC is defined as: “The overall system of technical activities that measures the attributes and performance of a process, item, or service against defined standards to verify that they meet the stated requirements established by the customer;

operational techniques and activities that are used to fulfill requirements for quality." (EPA QA/R-5, March 2001).

The success of an environmental monitoring program depends on the quality of the environmental data collected and used in decision making, and this may depend significantly on the adequacy of the QAPP and its effective implementation. Data users, data producers, and decision makers should be involved in the QAPP development process for their monitoring program to ensure that their needs are adequately defined and addressed in the QAPP.

7.1.6.1 QAPP Development and Submittal Guidance

The permittee's QAPP should be developed to comply with EPA QA/R-5 *Requirements for Quality Assurance Project Plans* EPA/240/B-01/003, March 2001. QA/R-5 allows flexibility in the degree of rigor to be applied via the QAPP depending on the type of environmental monitoring to be performed, the intended use of the data, and the risk involved in using data of uncertain quality. Section 7.7.2 lists the content elements that should be addressed and included in a QAPP according to QA/R-5. The permittee's QAPP for a monitoring program should be submitted by the permit applicant as part of the application material for review and approval by DEQ.

7.1.6.2 Quality Control (Q/C) Samples for Monitoring

QC procedures should be described in the QAPP as they relate to the use or taking of QC samples during data collection activities. Field duplicate samples should be taken at a minimum rate of 5% (one duplicate for each 20 samples collected) or one duplicate per sampling event, whichever is less, to provide for determining field sampling precision. A field or equipment blank (rinsate blank) should be taken, one for each sample delivery group. Rinsate blanks shall be analyzed to determine if in-field equipment decontamination procedures are adequate. Trip blanks should be taken if there is reason to believe that a possibility of cross contamination may exist. Trip blanks provide a means to check sample collection, handling, and shipping methods to determine if cross contamination is occurring during those activities.

Laboratory QC samples should also be addressed in the QAPP and should be as specified in the applicable analytical method.

7.1.7 Data Processing, Verification, Validation, and Reporting

Data processing, data verification, and data validation are quality assurance tools used to determine if data has been collected as specified in the QAPP with respect to compliance, correctness, consistency, and completeness. In addition, these tools are used to assess the technical usability of the data with respect to the planned objectives or intention of the project or monitoring program. Although these tools are really processes, project or monitoring program specific measurement criteria for the data processing, verification, and validation should be determined during project or monitoring program planning and documented in the QAPP. Guidance for developing QAPPs and data quality objectives can be found in EPA (2002) and EPA (2000)

Data Processing includes data entry, validation, transfer, and storage. The QAPP should describe or reference specific procedures used to maintain the integrity of the data records as well as any project or monitoring program specific data storage/transmittal requirements. This process includes data formats and standards for the transfer of data to external data users. Specific data processing activities may include:

- Collection: For both manual data and computerized data acquisition systems, internal QC checks should be developed and implemented to avoid errors in the data collection process.
- Transfer: Data transfer steps should be minimized and procedures established to ensure that the data is free from errors and is not lost during transfer.
- Storage: At each stage of data processing, procedures should be established to ensure that data integrity and security are maintained. The QAPP should indicate how specified types of data will be stored with respect to format, media, conditions, location, retention time, and access.
- Reduction: Data reduction includes any process that changes either the form of expression, the numerical value of data results, or the quantity of data. This includes verification, validation, and statistical or mathematical analysis of the data. Reduction is distinct from data transfer in that it entails a change in the dimensionality of the data set. Procedures for verifying the validity of the reduction process should be described in the QAPP.

Data Verification refers to the process of evaluating the completeness, correctness, and conformance/compliance of a specific data set against the method, procedural, or permit requirements. It focuses on determining that the data have met the measurement requirements. Verification evaluates the data for basic elements such as sampling the correct sites, sample handling, chain-of-custody procedures were followed, QAPP specified analytical methods were used, the appropriate parameters were analyzed, etc. Data verification is not concerned with evaluating or assessing the quality of the data set.

Data Validation is an analyte and sample specific process that extends the evaluation of data beyond method, procedural, or permit compliance (i.e., data verification) to determine the analytical quality of a specific data set. Data validation criteria are based on the data quality objectives or measurement quality objectives specified in the QAPP.

Additional information and specific guidance and procedures for data verification and data validation can be found in the following EPA documents:

- Guidance on Environmental Data Verification and Data Validation (EPA QA/G-8 EPA/240/R-02/004, November 2002)
- EPA Contract Laboratory Program National Functional Guidelines for Organic Data Review (EPA540/R-99/008 October 1999)
- EPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review (EPA540/R-01/008 July 2002)

The first document above, and other EPA quality assurance requirements and guidance documents can be found at this EPA web site:

http://www.epa.gov/quality/qa_docs.html

The second and third documents above can be found at this EPA web site:

http://www.epa.gov/oerrpage/superfund/programs/clp/guidance.htm

Data Reporting requires that operational, wastewater quality and ground water quality records be maintained. Permits require that this information be reported to the DEQ State Office and to the appropriate DEQ Regional Office. The reporting frequency may be monthly, annual, or may correspond either to the frequency with which the information is collected or as required in the WLAP permit. Permits generally require that all monitoring data collected for required parameters be reported, even if collected at frequencies above that required in the permit. This requirement is meant to help guard against the potential of reporting bias if only certain results out of a greater pool of results are reported. If parameters other than those required in the permit are monitored, these results are not required to be reported.

It is critical that data be given to DEQ in a format suitable for the data's intended use. In all cases, the data must be presented in an organized and clear manner, and if necessary, supporting data may be required (e.g., duplicate measures, spike recoveries, etc.). The data collected as required in the permit should be submitted to DEQ in the *Annual Report* in a standardized electronic Excel spreadsheet format. This spreadsheet and accompanying instructions may be obtained from DEQ by request; they are generally provided during the permit application, issuance and renewal process.

The Annual Report is submitted to DEQ on a regular schedule stated in the permit. Special reports may be required in a permit, which frequency and format should be specified in the permit.

The monitoring data required in the permit is taken from the annual report and entered into a computerized database. This database is called the WLAP Information Management System (WLAP-IMS). The WLAP-IMS, when fully developed, will be able to generate compliance reports as well as data analyses of ground water, soils, soil water, loading rates, wastewater chemistry, trend analyses etc.

7.1.8 References

Crites, R.W., S. C. Reed, and R.K. Bastian. 2000. Land Treatment Systems for Municipal and Industrial Wastes. ISBN 0-07-061040-1. McGraw-Hill Publishers.

DEQ. Idaho Department of Environmental Quality. March 2001. Ground Water and Soils Quality Assurance Project Plan Development Manual.

EPA. U.S. Environmental Protections Agency. 1973. Handbook for Monitoring Industrial Wastewater.

EPA. U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory-Cincinnati (EMSL-Cllll), EPA-600/4-79-020. Methods for Chemical Analysis of Water and Wastes. Revised March 1983 and 1979 where applicable.

EPA. U.S. Environmental Protections Agency. 1982. Handbook for Sampling and Sample Preservation of Water and Wastewater. EPA-600/4-82-029.

EPA. U.S. Environmental Protection Agency. 1999. EPA Contract Laboratory Program National Functional Guidelines for Organic Data Review (EPA540/R-99/008 October 1999)

EPA. U.S. Environmental Protection Agency. 2000. Guidance for the Data Quality Objectives Process – EPA QA/G-4. (EPA/600/R-96/055 August 2000)

EPA. U.S. Environmental Protection Agency. 2001. EPA Requirements for Quality Assurance Project Plans – EPA QA/R-5. (EPA/240/B-01/003 March 2001)

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Greenberg, A.E. et al. (eds). 1992. Standard Methods for the Examination of Water and Wastewater - 18th Edition.

Overcash, M.R. and Pal, D. 1979. Design of Land Treatment Systems for Industrial Wastes-Theory and Practice.

7.2 Ground Water Monitoring

This section describes the elements of a ground water monitoring plan for wastewater land treatment facilities. (It is beyond the scope of this section to address monitoring of sites having hazardous or radionuclide constituents.)

Ground water monitoring provides data that can be used to evaluate a facility's impact on ground water as well as evaluate ground water quality changes with respect to changes in wastewater land treatment management and loading changes. Ground water monitoring also serves to assess compliance with a wastewater land application permit, including ground water quality standards as specified in the *Ground Water Quality Rule* (IDAPA 58.01.11.200) and/or permit specific limits. Ground water monitoring is necessary in most circumstances to define ambient conditions and establish a water quality baseline for the facility. Ground water monitoring often plays a major role in evaluating and modifying treatment processes, management, and loading practices to protect and maintain ground water quality.

The need and level of ground water monitoring is dependent upon facility type and size, wastewater characteristics, management, loading rates, and aquifer and site characteristics. For example, a small facility with low strength wastewater loaded at low rates would have a limited potential to contaminate ground water and may not need as extensive a monitoring program as larger and more complex facilities land applying high strength wastewater at high rates.

7.2.1 Alternatives to Ground Water Monitoring

There are circumstances where ground water monitoring may not be necessary, as in the case where wastewater constituent loading rates are *below levels of regulatory concern* (i.e., *de minimus* rates).

Although monitoring wells are the primary means of assessing ground water quality associated with land treatment systems, there are situations where their use would be impractical, such as in cases where there are long unsaturated and or saturated contaminant travel times (as a result of deep ground water, low percolate generation, and/or low permeability of vadose zone). In those cases, the time interval between land use activities and environmental response would be too large to provide timely feedback for management or compliance purposes.

Short, moderate, and long travel times are subjective, depending on the context. In a regulatory context, a long travel time might be considered to be the length of a typical 5-year permit. It could be considered *untimely* if the impacts from a management activity could not be detected through ground water monitoring beyond the life of the permit.

Other means to assess potential environmental impacts, such as soil-water monitoring, should be considered in such cases. (See Section 7.3 for additional discussion on soil-water monitoring. A simple method of estimating travel time through the vadose zone is presented by 7.7.5.2.3.)

Alternatives to ground water monitoring are considered on a case-by-case basis. A decision flowchart 7.7.1.1) serves to help determine whether ground water monitoring is practical and/or needed at a wastewater land treatment site. In general, 'de minimus loading rates' referred to in the flowchart are loading rates, which pose no regulatory concern. Specific numerical loading rates have yet to be defined and may be facility specific. The reference to *Guideline Loading Rates* refers to those generally recommended loading rates (nutrients, COD, hydraulic etc.) found in Section 4 of this guidance.

7.2.2 Monitoring Objectives

The purpose of ground water monitoring is to determine whether wastewater is being land applied and treated such that the waters of the state are protected for existing and projected future beneficial uses. Monitoring wells are preferred over other types of wells for collection of ground water quality samples. They can be located in a specific location and they can be constructed to monitor specific zones within an aquifer to isolate particular contaminants. Monitoring wells are installed specifically for assessing ground water quality.

Existing wells may be used for ground water monitoring only if the well is properly located, constructed and it is screened in the appropriate interval necessary to monitor the appropriate aquifer and the constituents of concern. Existing wells should be evaluated using the criteria provided below. Exceptions to these criteria may be made by DEQ on a case-by-case basis:

- The well is located within a reasonable distance from the wastewater land treatment facility to provide relevant ground water quality information.
- The well meets the construction requirements outlined in IDAPA 37.03.09.
- The well is completed in the uppermost aquifer.
- The screen length is appropriate for the hydrogeologic conditions and monitoring the constituents of concern.
- The well will yield water quality samples representative of background or other relevant water quality conditions.
- The water quality is not degraded by an activity between the well and the wastewater land application facility.
- The well is approved for use by DEQ.

7.2.3 Monitoring Instrumentation

This section provides guidance on monitoring well design and construction practices for wastewater land application facilities. This monitoring well construction guidance is not applicable for sites where hazardous materials are known to exist.

Monitoring wells should be designed to sample the uppermost ground water potentially affected by the activity plus any other ground water zone where contaminants may impact ground water quality. The number of wells installed should be sufficient to adequately assess background water quality and the impacts to ground water as a result of wastewater land treatment activities. Monitoring well construction is a critical component of the monitoring plan since background water quality data are used to establish baseline levels, and possibly site specific permit limits and early warning values. Each monitoring well should be designed and constructed for the specific hydrogeologic environment and the contaminants of concern.

Several goals should be achieved in monitoring well construction:

- Construct the well with minimal disturbance to the formation.
- Use materials compatible with the geochemical environment.
- Complete the well within the zone of interest.
- Adequately seal the borehole with materials that will not influence the quality of the samples.
- Sufficiently develop the well to remove additives introduced during drilling and allow unobstructed flow through the well, (EPA, 1991).
- Construct the well in such a manner that contamination from the surface will not migrate along the sides of the borehole and ensure that well is sealed properly to prevent cross contamination from other aquifers

Some general guidelines should be considered during the construction of any monitoring well. The most important of these address the following:

- regulatory requirements
- drilling methods
- screened interval
- casing materials
- seals, packing and grouting
- well development

7.2.3.1 Regulatory Requirements

All monitoring well construction must conform to the well construction rules listed in the Idaho *Administrative Procedures Act* (IDAPA) 37.03.09. Monitoring wells more than 18 feet in vertical depth that are constructed to evaluate, observe or determine the quality, quantity, temperature, pressure or other characteristics of the ground water or aquifer require a permit to be issued by the *Idaho Department of Water Resources* (IDWR). Monitoring wells 18 feet deep, or less, also should conform to the well construction rules listed in IDAPA 37.03.09

Siting of monitoring wells in relation to a wastewater land treatment site and other possible sources of contamination should be coordinated with DEQ as part of the WLAP permitting process. Proposed monitoring well designs should be submitted to DEQ for review and approval prior to well construction.

Certification that monitoring well construction is in substantial accordance with proposed monitoring well design should be submitted to DEQ. Such certification may consist of as-built diagrams stamped by an Idaho registered Professional Geologist or Professional Engineer, or prepared by someone under the direct supervision of an Idaho registered Professional Geologist or Professional Engineer. A detailed geologic log for each monitoring well should also be provided to DEQ.

7.2.3.2 Monitoring Well Construction

Specific installation procedures for ground water monitoring wells may be found in the Idaho Administrative Code, Department of Water Resources, *Well Construction Standards Rules* (JAC 2005); Ogden (1987); DEQ (March 2001); EPA (1991); and EPA (1986). Additional guidance is available from ASTM D 5092-90.

Details regarding the construction of monitoring wells are found in 7.7.3.1. Included are discussions of drilling methods; selection of screened interval depths; casing materials; seals, packing and grouting; and monitoring well development.

7.2.3.3 Monitoring Well Protection and Maintenance

The area around groundwater monitoring wells must be protected. Several practices may be employed for this. Highly visible markers may be used to warn equipment operators of the presence of the well. Using posts cemented into the ground to surround the well offers added protection against a well being damaged by equipment.

Damage from equipment includes cracked grouting, cracked or broken well piping, or broken locks or casings. This type of damage can result in the intrusion of surface water into the well and the contamination of groundwater. Such a well may have to be abandoned and another well constructed, at additional time, expense, and loss of data continuity.

Monitoring wells should be regularly maintained. Maintenance should include ensuring that caps are rust-free and locked at all times, that the outer casing is upright and undamaged, and that there is clear, unobstructed access to each well.

7.2.4 Monitoring Parameters

Table 7-1 provides general guidance for ground water monitoring analytical parameters for selected wastewater land treatment scenarios. In general, *well below guideline loading rates* (WBGLR), referred to in the table are loading rates that pose no regulatory concern. Specific numerical loading rates have yet to be defined for the WBGLR designation and may be facility specific. The reference to *Guideline Loading Rates* refers to those generally recommended loading rates (nutrients, COD, hydraulic etc.) found in Section 4 of this document. Microbiological parameters may be needed on a site-by-site basis.

Table 7-1. Common Ground Water Monitoring Analytical Parameters for Wastewater Land Treatment Facilities.

Facility Type — Analytical Parameter	Municipal Facility (Class A Reuse Water)	Municipal Facility (Guideline Loading Rates)	Municipal Facility (Greater than Guideline Loading Rates)	Facility (Well Below Guideline Loading Rates)	Food Processing Facility (Guideline Loading Rates)	Food Processing Facility (Greater than Guideline Loading Rates)
Common Ions[1]	O[3]	O	X	O	X	X
Field Parameters[2]	O	X	X	O	X	X
Static Water Level	O	X	X	O	X	X
NO3-N + NO2-N	O	X	X	O	X	X
Fe	O	O	?	O	?	X
Mn	O	O	?	O	?	X
TDS	O	O	X	O	X	X
COD	O	O	O	O	?	X
P	O	O	?	O	?	X
K	O	O	O	O	?	X
Cl	O	X	X	O	X	X
TC	O	?	?	O	?	?

Notes:

1. Common ions consist of the following ions: Na, K, Ca, Mg, SO_4, Cl, CO_3, HCO_3
2. Field Parameters consist of the following: pH, temperature, electrical conductivity, and dissolved oxygen
3. Symbol Definitions: X = usually monitored; ? = monitored depending upon case specific situation; O = generally not monitored.
4. TC = total coliform

7.2.4.1 Contaminants of Concern: Nitrate, Iron, Manganese, TDS and Phosphorus

Wastewater sites, if not properly loaded and managed, may impact ground water. Typical contaminants of concern include nitrate, total dissolved solids, phosphorus, metals (iron and manganese in particular). The following sections briefly discuss these constituents.

7.2.4.1.1 Nitrate

Nitrate is a primary ground water constituent, meaning there can be health related concerns at ground water levels above ground water standards (IDAPA 58.01.11.200.01a). The ground water standard for nitrate-nitrogen is 10 mg/L. Nitrate contamination at wastewater land treatment sites usually results from nitrogen overloading. Other contributing factors include aquifers with low transmissivity that do not provide the dilution volume, and so magnify the nitrogen (or other constituent) inputs from percolate.

High nitrogen loading of certain wastewaters such can often result in *low* nitrate levels in ground water. This is due to the influence of associated high loadings of chemical oxygen demanding (COD) constituents – generally organic materials. High COD loadings depress the redox state of the soil and reduce nitrate to atmospheric nitrogen or other nitrogen oxides which are lost to the atmosphere. See Section 4 for further discussion of nitrogen chemistry in the environment. Health risks associated with excessive nitrate ingestion include blue baby syndrome (methemoglobinemia) and are discussed at the following DEQ website:

http://www.deq.idaho.gov/water-quality/ground-water/nitrate.aspx

7.2.4.1.2 Total dissolved solids (TDS)

TDS is a secondary ground water constituent, meaning there can be aesthetic related concerns at ground water levels above ground water standards (IDAPA 58.01.11.200.01b). The ground water standard for TDS is 500 mg/L. TDS is a general term that has different interpretations depending on the media it is measured. In ground water, TDS is generally consists of inorganic salts. In wastewaters, TDS can include significant amounts of dissolved organic material. The organic TDS fraction is higher in wastewaters having higher organic constituent levels. When modeling impacts of TDS loading to ground water, it is critical to make some other measure of the inorganic constituents in wastewater to accurately assess the inorganic fraction of TDS. Such measurements include non-volatile dissolved solids (TDS less volatile dissolved solids) or total inorganic dissolved solids (TDIS, the sum of cations and anions in appreciable concentrations). Fixed dissolved solids (FDS) is another analysis which yields the inorganic content of wastewaters (Brown and Caldwell et al., 2002 p. 10-10)

TDS can often be significantly elevated down gradient of wastewater land treatment sites, especially industrial sites. Care must be taken in the interpretation of data to account for other sources of contamination as well. An effective geochemical analysis technique involves the examination of common ions, discussed in Section 7.1.4.3, to characterize chemical signatures of background, and percolate and wastewater sources to determine causes of ground water contamination.

7.2.4.1.3 Phosphorus

Phosphorus has no numeric ground water standard (IDAPA 58.01.11.200). Phosphorus loading and monitoring guidance is described in Section 4. It is a relatively immobile constituent. Concentrations in soil water and ground water are governed by complex chemistry involving sorbed, fixed (covalently bonded), precipitated, organic, and plant available pools. Elevated phosphorus in down gradient ground water can signal breakthrough of wastewater through coarse vadose material – possibly from excessive lagoon seepage or breakthrough from soils that have been loaded to capacity. This is discussed further in Section 4.

7.2.4.1.4 Metals (General)

The ground water quality standards as specified in the *Ground Water Quality Rule* (IDAPA 58.01.11.200.01ci) and the drinking water standards as specified in the Idaho *Rules for Public Drinking Water Systems* (IDAPA 58.01.08.50.01) establish criteria for total metals. Total metals analyses are used to provide an indication of the metals concentration which is available for human consumption. Drinking water wells are designed to maximize water production and minimize sediment intake whereas monitoring wells are designed to monitor changes in ground water quality. Monitoring wells are not designed to produce water for human consumption. The screened interval may not be placed in the most productive part of the formation, rather it is placed in the zone where contaminants are expected to be present which may be in a formation with finer grained sediment.

Total metals analysis measures both the metals dissolved in ground water, and metals which may be sorbed to clay or colloid sized particles suspended in ground water. Upon acidification of a ground water sample for preservation, sorbed or otherwise non-dissolved metals may solubilize. The suspended fraction may be a result of metals from the well casing (metal casing material is not approved for monitoring wells), from collected sediment within the well, or sediment from the formation. A total metals analyses may yield much higher values when wells are place in low hydraulic conductivity formations or when well development has not been properly completed. Dissolved analyses are generally more useful in evaluating the impacts of a wastewater land treatment on ground water quality, since it considers only the fraction, which are not from anthropogenic sources.

The question arises whether metals in ground water should be evaluated using the total or the dissolved fraction. On one hand, only dissolved metals truly migrate in ground water and therefore measuring total metals skews the analytical result by including metals which are adsorbed onto particles of sediment which may only be present in the well due to poor well construction or from a silty formation. On the other hand, total metals not only represent drinking water criteria, but that metals may also move by colloidal transport in ground water, thereby making the total fraction necessary to completely characterize ground water contamination.

If metals are identified as constituents of concern, it is recommended that both total and dissolved metals be analyzed. Dissolved metals should be used to interpret geochemical changes in ground water in relation to wastewater land treatment activities. Water samples analyzed for the dissolved fraction of metals should be filtered in the field, using a filter with a pore size of 0.45 microns and preserved with nitric acid prior to submission to the laboratory.

Another alternative is to measure total metals while using *low flow purge and sampling techniques* recommended by Puls and Powell, (1992). These techniques provide a characterization of both the dissolved fraction and the portion which moves by colloidal transport in ground water. Low flow pump rates allow water from the ground water formation to move into the well while overlying stagnant zones are undisturbed. In order to minimize sample disturbance during collection, a low flow rate of 0.2 to 0.3 liters/minute (not using a bailer) should be used for ground water samples collected for metals analysis with no filtration. Puls and Powell (1992) demonstrated no significant difference in metal concentrations between filtered and unfiltered samples when low flow rates were used. This provides an assessment of both the dissolved and mobile particulates associated with metals transport in ground water.

7.2.4.1.5 Metals (Iron and Manganese)

Iron (Fe) and manganese (Mn) are secondary ground water constituents, meaning there can be aesthetic related concerns at ground water levels above ground water standards (IDAPA 58.01.11.200.01b). The ground water standards for iron and manganese are 0.3 mg/L and 0.05 mg/L respectively. Iron and manganese are often found in ground water down gradient of highly loaded wastewater land treatment facilities. Associated high COD loadings and depressed redox conditions generated in the soil can reduce the valence state of iron and manganese naturally present in soils to soluble forms (see Figure 7-2.) These reduced species are mobile and can leach to ground water. Maximum contaminant levels for iron and manganese are relatively low, being 0.3 mg/L and 0.05 mg/L respectively. Elevated levels of iron and manganese cause aesthetic damage such as staining of kitchen and bathroom fixtures, siding and brickwork of dwellings, and other related damage.

REACTION	Eh AT pH 7 (V)	MEASURED REDOX POTENTIAL IN SOILS (V)
O_2 Disappearance		
$\frac{1}{2} O_2 + 2e^- + 2H^+ = H_2O$	0.82	0.6 to 0.4
NO_3^- Disappearance		
$NO_3^- + 2e^- + 2H^+ = NO_2^- + H_2O$	0.54	0.5 to 0.2
Mn^{2+} Formation		
$MnO_2 + 2e^- + 4H^+ = Mn^{2+} + 2H_2O$	0.4	0.4 to 0.2
Fe^{2+} Formation		
$FeOOH + e^- + 3H^+ = Fe^{2+} + 2H_2O$	0.17	0.3 to 0.1
HS^- Formation		
$SO_4^{2-} + 9H^+ + 8e^- = HS^- + 4H_2O$	−0.16	0 to −0.15
H_2 Formation		
$H^+ + e^- = \frac{1}{2} H_2$	−0.41	−0.15 to − 0.22
CH_4 Formation (example of fermentation)		
$(CH_2O)_n = n/2\ CO_2 + n/2\ CH_4$	—	−0.15 to − 0.22

Figure 7-2. Redox potential and its effect on the chemistry of soil constituents. Bohn et al. 1979.

7.2.4.2 Other Constituents

There are constituents that do not have ground water standard criteria in IDAPA 58.01.11.200, but which are nonetheless important to monitor in ground water. Certain of these constituents, such as COD and potassium, can serve to corroborate (i.e. support with additional evidence) the cause of constituent of concern impacts from certain wastewater land treatment practices. Other constituents serve to characterize the chemical signature of ground waters or indicate the chemical stability of the sample during the sampling event.

7.2.4.2.1 Chemical Oxygen Demand (COD)

It is typical to see COD at low levels in ground water. Sulfides and other reduced constituents will appear as an oxygen demand. COD can appear at elevated levels in down gradient ground water – usually at wastewater land treatment facilities with high COD and hydraulic loading. This serves to corroborate that COD loadings are at rates higher than the soil can filter and soil microorganisms can oxidize. It also can indicate breakthrough of wastewater to ground water, as in an excessively leaking storage structure.

7.2.4.2.2 Potassium

As with COD, potassium does not have a ground water standard, but its presence at elevated levels down gradient of potato processing facilities can indicate impacts from wastewater land treatment. For example, there are appreciable levels of potassium in potatoes. Potassium is released to wastewater upon processing of the potato and is subsequently land applied. Usually there are no other significant sources of potassium to account for the elevated levels seen down gradient. Thus, it is a corroborating constituent.

7.2.4.2.3 Major Cations and Anions

The chemical characterization of ground water quality is important when making a determination of the impacts a wastewater land treatment may have on background water quality. Ground water typically has naturally occurring concentrations of major cations and anions. Major cations and anions may not necessarily be considered constituents of concern, but data collected before and during the operation of the facility can be compared to help assess environmental impacts, (Pennino, 1988).

Major cations and anions for which analyses are typically done are shown in Table 7-2.

Table 7-2. Cations and anions for which analyses typically done.

Cations	Anions
Calcium	Bicarbonate
Magnesium	Carbonate
Potassium	Chloride
Sodium	Sulfate

Natural ground water has a distinct chemical composition, which is characteristic of the geologic formation. Minerals are dissolved in solution as they migrate through the geologic formation. Major ions can be illustrated by using graphical tools such as Stiff Diagrams or Trilinear Plots to characterize the signature of the ground water. Chemical characterization also serves in identifying cross flow between aquifers and mixing within wells. Ionic characterization data can be used to detect water quality changes and trends which may be attributed to the influence of a wastewater land treatment activity.

Common inorganic constituents can be found at elevated concentrations in most contaminant plumes. Chloride, sulfate and nitrate have a high solubility and tend to move at a similar velocity as ground water.

Inorganic constituents provide a check on the reliability of the analyses with a cation-anion balance. This is the most fundamental quality assurance/quality control (QA/QC) procedure. All waters have an equal balance of negatively and positively charged ions. The calculated error between anions and cations is generally higher for lower TDS waters. As a general rule, the sum of cations should not differ from the sum of anions by more than 2 to 3 percent. If the ratio of cations to anions does not balance, the problem is usually a typographical or analytical error; however, it can also indicate the presence of an unusual constituent which was not included in the analysis. Cation/anion analytical results with a difference of greater than 5% should be questioned. It may be an indicator that other analyses may be skewed and should be investigated for possible errors. If the relative difference between the cations and anions is small, then it is safe to assume that there are no errors in the inorganic constituents, (Hem, 1989).

Another QA/QC check is a comparison of the calculated versus the analyzed total dissolved solids values. DEQ generally has facilities analyze ground water for the major cations and anions once before permit issuance, and again near permit expiration. These analyses provide important information to evaluate impacts to ground water quality.

7.2.4.3 Field Parameters

Field parameters are ground water parameters which can be easily and accurately measured in the fieldwith portable electronic instrumentation. These include pH, electrical conductivity, temperature, dissolved oxygen and redox potential.

These field measurements serve to:

- verify when effective well purging has occurred and when ground water has stabilized to assure that the ground water sampled is representative of water in the aquifer,
- verify laboratory measurements and can indicate sample deterioration, and.
- detect abnormalities, and they can be indicative of ground water contamination, (Davis, 1988).

The preferred method of measurement is with a flow through cell which operates at the land surface and is not introduced into the borehole. If this technology is not available, then these measurements should be taken at the wellhead. Although in-situ measurements eliminate interference caused by the atmosphere, there are other interferences which may influence field measurements more dramatically. Therefore, it is recommended that field parameters be measured with a flow through cell at the land surface, or at the wellhead, (Garner, 1988).

Field measurements should stabilize to within 5% variation per casing volume removed during well purging prior to collecting ground water samples. Readings of pH, electrical conductivity, and temperature often stabilize within one casing volume while other chemical constituents take longer to stabilize. Dissolved oxygen is a better indicator of ground water stabilization since it can indicate the redox state of inorganic constituents (Puls and Powell, 1992). Dissolved oxygen is a critical field parameter to determine when representative ground water is entering the formation. Therefore, dissolved oxygen should be included in the suite of field parameters.

Redox potential is also a field parameter which provides important information on whether the ground water is in either an oxidizing or reducing condition. Field measuring devices for redox potential are not as accurate as certain laboratory methods. A qualitative method for determining reducing conditions is the use of the 2-2'dipyridyl test, which indicates the presence of ferrous iron. A positive test indicates that anaerobic conditions are present which may result in the mobilization of metals. This test is simply a screening tool. A few drops of a 0.1% 2-2'dipyridyl (or 1,10 phenathroline) solution added to a ground water sample will cause a bright red or pink reaction if ferrous iron is present, which is indicative of a reducing environment, (Heaney and Davison, 1977), (Childs, 1981). When ground water is in a reducing environment, then the sample should be field filtered rather than filtering the sample at the lab. Total digestion analysis should be requested. Metals may co-precipitate in oxidizing conditions due to a change in redox after filtration. Sampling of field parameters is discussed further in 7.7.4.1.3.

7.2.5 Monitoring Frequency

Monitoring frequency is critical to assure that samples will detect contamination if it is present, while still assuring discrete, independent samples. The frequency of ground water monitoring should be determined on a site specific basis. Factors that should be considered include information from hydrogeologic investigations, wastewater land management and loading rates, and facility type. Statistical variability of water quality data is also critical to determining monitoring frequency. For example, the maximum error about the mean, and confidence interval one is willing to accept, will determine the number of samples one needs to take in a given time period. Statistical evaluation of ground water data is discussed further in DEQ (2003).

Monitoring frequency for compliance can be adjusted during the permit cycle. It may be decreased if it can be determined that background and seasonal variations in ground water quality have been characterized and the data supports that a less frequent sampling interval will not miss significant periods over which elevated levels may be present. Certain parameters may be monitored on a less frequent basis if reasons exist which justify less frequent monitoring. Proper well purging and sampling techniques are especially critical when samples are collected on a less frequent basis, such as annually or biannually (Barcelona et al. 1989).

Special provisions should be made for acreages being developed for wastewater land treatment. If possible, ground water monitoring should be conducted on such sites for a sufficient amount of time in order to adequately characterize baseline potentiometric and chemical characteristics of ground water *prior to initiating wastewater land treatment activities*.

7.2.6 Sampling and Sample Location Determination

Effective monitoring requires sampling, with samples taken from pre-determined locations.

7.2.6.1 Sampling

An effective system for monitoring a land application site for potential sources of ground water contamination should be capable of detecting contamination. This is done through appropriate sampling and analysis from properly designed, located, and constructed monitoring wells. This section discusses well sampling protocols and sampling location determination.

The data collected in a WLAP ground water sampling program must be of sufficient quality to allow proper analysis and interpretation and to provide evidence for the presence or absence, extent, degree, and source of contamination. For these reasons it is essential that sampling be conducted such that the data collected are precise, accurate, representative, comparable and complete.

The goal of ground water monitoring is to sample water from the geologic formation with minimal disturbance. Representative samples should indicate the condition of ambient ground water and any changes in quality as a result of the wastewater land treatment. The facility should have a monitoring plan that includes sampling and analytical protocol to assure ground water samples will be collected and analyzed properly.

The facility is responsible for having samples collected and analyzed as required in the permit. However, DEQ reserves the right to conduct site inspections and collect samples for determining compliance. It is important to assure that the resulting analytical data will adequately represent the conditions in ground water. Therefore, it is critical that sampling and analytical protocol be properly planned to assure that the sample will not be compromised by personnel, the atmosphere, the sample container, preservatives, filtering, sampling equipment, transport, or the laboratory.

The following items should be addressed in the facility's monitoring plan:

- Sampling Supplies and Equipment
- Well purging
- Sample collection
- Decontamination
- QA/QC procedures

Specific guidance related to sampling supplies and equipment, well purging, sample collection, sample packing and shipping, and decontamination are discussed in 7.6.5.

7.2.6.2 Compliance Determination and Confirmatory Sampling

Ground water quality compliance is based on results from routine sample analysis at each compliance monitoring point identified in the facility's WLAP permit. The number of samples collected, testing frequency and constituent analysis stated in the WLAP permit are minimum requirements unless otherwise stated.

Ground water quality permit violations occur when a compliance sample analysis result exceeds a level specified in the permit whether a ground water quality standard or alternate permit limit. Permits may be written such that a first exceedance will not generate enforcement action or penalties. An exceedance may be treated as a warning signal that prompts further actions such as: assessment of wastewater management practices, evaluation of the treatment capabilities and maintenance of the land application system, and assistance from qualified experts. Statistical analyses can be utilized to determine whether there are temporal or other trends in ground water. (See DEQ, June 2003). In the event a continuing violation occurs, DEQ will determine if enforcement action is warranted.

If laboratory results from compliance sampling show an exceedance of a permit limit, then confirmatory sample collection is recommended. Confirmatory samples can validate the analytical results from the previous sample and should be taken as soon as initial exceedances are known or suspected. If confirmatory samples are not collected, then the laboratory results from the original sample may be used for compliance determination. Confirmatory sampling requirements should be included in permit requirements.

Confirmatory sampling may also be conducted and used to establish trends in ground water quality or to monitor a continuing ground water quality violation. Finally, confirmatory samples are recommended, but not required, for samples collected for purposes other than compliance.

7.2.6.3 Sampling Location Determination

A monitoring network should be designed based on the information from a hydrogeologic investigation. A properly designed monitoring network is essential. Ground water monitoring wells must be properly sited to provide areal coverage of the affected site. Wells must be constructed and sampled to obtain representative water quality samples. Sample variability can result from temporal and spatial variability in ground water or from influences during well pumping, purging, and recharge. Therefore, monitoring well location, design, construction, and sampling should be carefully planned initially to help assure that all samples will be useful and representative of ground water quality. The monitoring plan should be facility-specific.

Monitoring well locations must be approved by DEQ prior to installation to help ensure that the wells will be sited, designed, and constructed properly to assess wastewater land treatment impacts.

The number of wells must be sufficient to ensure a high probability of detecting contamination when it is present. Specifically the placement and number of monitoring wells will depend on both aquifer and facility characteristics. Aquifer related characteristics include the ground water gradient and the site hydrogeology. Information on ground water flow direction is essential in siting wells. Aquifer hydraulics may cause spatial and temporal variability in samples, (Barcelona et al. 1989); therefore, monitoring well locations should be carefully considered prior to installation.

Facility characteristics include the volume and quality of wastewater land applied, and the fate and transport characteristics of potential contaminants. The size and configuration of the facility and land treatment acreage are particularly important. Generally, large land application sites with complex hydrogeology may require more monitoring wells than sites that are small or hydrogeologically simple. The number of wells also depends on the type of monitoring requirements. Land application sites with a long down gradient boundary perpendicular to the ground water flow direction may require additional monitoring wells.

Up gradient wells (un-impacted by the facility's activities) define ambient ground water quality, and are necessary to compare background water quality to down gradient water quality (water potentially impacted by the facility's activities). Ideally, up gradient wells should be located along the ground water flowpath toward the site. In Figure 7-3, wells 1, 2, and 3 are improperly located; wells 4, 5, and 6 are properly located.)

Background water quality characterization from up gradient wells will reduce the probability of attributing to wastewater land treatment any contamination originating off-site from other sources, or vice versa. At least one up gradient well is necessary to characterize background water quality.

Location and number of down gradient wells should be determined based on the designated point of compliance. Compliance wells must be located hydraulically down gradient of the wastewater land treatment site, along the flowpath of ground water discharging from the site. Down gradient wells must be reflective of the activity's impacts to ground water quality. At least two down gradient well are necessary in addition to an up gradient well to assess impacts and triangulate ground water flow.

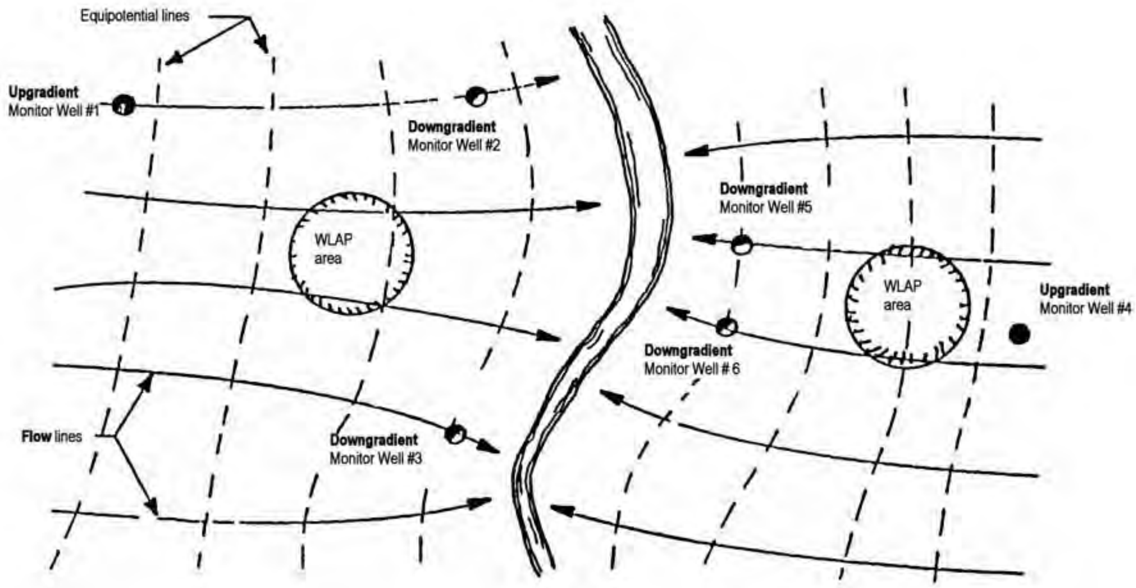

Figure 7-3. Improper and Proper Locations for Groundwater Monitoring Wells (State of North Carolina, 2001).

Ground water monitoring should be conducted in the uppermost saturated zone in addition to any other zones potentially affected by the wastewater land treatment activity. Significant water quality changes will occur in the uppermost saturated zone sooner; however, hydraulic connections between aquifers can cause contamination in lower aquifers. Ground water quality trends are determined by monitoring specific wells consistently over time.

7.2.7 Ground Water Compliance Points Monitoring

Ground water compliance monitoring involves sampling and testing ground water from approved collection points for compliance with permit conditions. Ground water compliance monitoring may not be necessary for every wastewater land treatment site (see Figure 7-5). If ground water compliance monitoring is required, compliance points for sampling and testing must be identified in the facility's WLAP permit. The number, location and frequency of sampling of compliance points are determined through the permit process.

The *point, or points, of compliance are* the locations where the facility must be in compliance with either ground water quality standards as specified in the *Ground Water Quality Rule* (IDAPA 58.01.11.200) or permit specific limits (IDAPA 58.01.11.400.05). Such standards and limits are the maximum allowable contaminant concentrations allowed at a point of compliance.

The point, or points, of compliance are determined by DEQ on a site specific basis for each facility. The point of compliance provides information to assess ground water conditions related to current and reasonable future uses of the ground water.

Ground water is typically designated as the medium where the point of compliance must be achieved since it is the primary resource that is being protected. If the point of compliance is determined to be in ground water, the following criteria should be considered in locating a point, or points, of compliance:

- The point should be as near the wastewater land treatment activity as technically feasible.
- A monitoring well must be used as the device to measure compliance.
- The monitoring wells must be located hydraulically downgradient of the wastewater land treatment activity.
- The monitoring wells must be properly constructed and screened in the uppermost ground water zone.
- If other ground water zones may be affected, then these should also be monitored by separate monitoring wells.
- The monitoring well(s) must measure the impacts of the facility's wastewater land treatment activity on ground water quality.

One well may not be adequate to measure compliance. Therefore, the point of compliance is not necessarily limited to one well, but may include an array of wells if it is determined that the information would provide a better representation of ground water conditions. Additional wells may be required if there are multiple compliance points, if the wastewater is being land applied over a large surface area, if multiple aquifers may be affected, or if the ground water flow direction varies seasonally.

Site specific conditions may warrant setting a ground water point of compliance in an alternate location to assure protection of public health and the environment. DEQ may establish alternate ground water compliance monitoring points if provided sufficient justification. A permit limit should be established in ground water at the point(s) of compliance *unless* one of the following conditions exist:

- A monitoring well will not adequately allow measurement of the impacts a wastewater land treatment activity will have on ground water quality (e.g. screened too deep, not along down gradient flow path etc.).
- The initial point where the leachate from wastewater land treatment reaches ground water cannot be determined. For example, in fractured basalt the wastewater may move along preferential pathways making it difficult to determine the location of its entry into ground water.
- The limit established for ground water at the point of compliance is met prior to release into the environment.

If it is economically infeasible or technically impractical to locate the point of compliance in ground water, monitoring limits can be established in the vadose zone directly under the wastewater land treatment site. Modeling can be done to determine what percolate concentration for a given volume would be expected to result in ground water exceeding ground water quality standards as specified in the *Ground Water Quality*

Rule (IDAPA 58.01.11.200), or permit specific limits. See discussion in Section 7.7.5.2. Thus, vadose zone monitoring can still be used to measure compliance when ground water monitoring is not feasible.

7.2.8 Analytical Methods

IDAPA 58.01.11.200.c requires that analytical procedures to determine compliance shall be in accordance with Environmental Protection Agency, Code of Federal Regulation, Title 40, Parts 141 and 143, revised as of July 2001, or another method approved by the Department. Table 7-19, presents chemical analytical methods recommended for ground water samples. Where more than one method is given, employ the method appropriate for the type of sample, its concentration range, the availability of equipment, and necessary detection limit. Note that detection limits are generally an order of magnitude less than the Ground Water Quality Rule (IDAPA 58.01.11.200) standards for constituents assigned such numerical limits.

7.2.9 Quality Assurance and Quality Control

As discussed in Section 7.1.6.1, the facility should have a quality assurance project plan (QAPP) that includes instructions for field parameter stabilization. For more information on the development of a QAPP, refer to Section 7.1.6.

7.2.10 Data Processing, Verification, Validation, and Reporting

As with other types of monitoring, the facility's permit will specify what parameters to monitor, when to monitor, and when results must be submitted. When reporting ground water monitoring data, describe the well location and use the monitoring serial numbers designated in the permit.

7.2.11 References

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7.3 Soil-water (Vadose) Monitoring

The vadose zone is defined, for the purposes of this document, as occupying the soil and geologic units lying between the bottom of the root zone and the top of the water table. Water samples representing water in the vadose zone are collected with lysimeters.

Monitoring of this kind is referred to in this section as *soil-water monitoring* or *vadose zone monitoring*. Vadose zone monitoring is intended to be a means of providing early detection of migrating contaminants before they reach ground water.

Definitions and characteristics of soil water are discussed in EPA (1993, Section 9). This discussion is excerpted/summarized in this paragraph. Three major types of soil water can be identified in the context of sampling soil water: (1) Macropore or gravitational water, which flows through the soil relatively rapidly in response to gravity (excess of 0.1 to 0.2 bars suction); (2) soil-pore or capillary water, which is held in the soil at negative pressure potentials (suction) from around 0.1 to 31 bars of suction; and (3) hygroscopic water that is held at tensions greater than 31 bars suction. Soil-pore water moves through the vadose zone, but at much slower rates than gravitational water, whereas hygroscopic water moves primarily in the vapor form. The term soil solute or solution sampling has been used loosely in the literature to describe most sampling methods, whereas the term soil pore liquid is typically used in a more restricted sense to apply to sampling of capillary water. The chemistry of the soil solute sample can differ significantly, depending on the sampling method used. Concentrations of inorganic species generally increase as the matric potential increases (i.e. concentration is inversely related to soil pore water volume).

Vadose zone monitoring offers certain advantages for monitoring environmental response to wastewater land treatment activities. Lysimeters are less expensive and easier to install than monitor wells. Lysimeter samples (from gravity lysimeters) reflect percolate quality after wastewater has received treatment in the root zone. Vadose monitoring can provide important information regarding potential impacts of percolate to ground water in a much more timely fashion than monitoring wells if vadose and/or aquifer travel times are long. However, a disadvantage is the difficulty both in obtaining samples on a regular basis, obtaining representative samples, and interpretation of results. Instrumentation can be unreliable. Variations in soils and other factors contribute to high variability and poor reproducibility in data obtained.

Vadose zone monitoring can be used in both a management and regulatory context. For example, a threshold soil water percolate constituent concentration can be calculated above which down gradient ground water constituent concentrations would exceed acceptable levels. Such a threshold leachate concentration can be back-calculated from assumed values of ground water flow, up gradient ground water concentration, and leachate volume. This calculated threshold percolate concentration can then be compared to sample concentration data from lysimeters for management or regulatory purposes. Further discussion of utilization of lysimeter data is found in 7.7.5.2. Further discussion of when vadose zone monitoring is appropriate is found in Section 7.1 and Figure 7-5.

The remainder of this section discusses soil water monitoring objectives, instrumentation, monitoring parameters, sampling, analytical methods, QA/QC and Data Validation. Supplemental data use and interpretation is also included.

7.3.1 Monitoring Objectives

Site and management conditions that would indicate soil-water monitoring as the preferred alternative to ground water monitoring are discussed in 7.2.1. Soil-water monitoring can serve to collect early warning information about strength and volume of percolate and its potential to contaminate ground water. This is especially useful where both depth to ground water is great and percolate travel times are long, making it impractical to wait many years for indicators of contamination to appear in ground water.

7.3.2 Monitoring Instrumentation

Instrumentation is available to 1) collect soil water samples under unsaturated conditions, 2) collect soil water samples and measure percolate loss under saturated flow conditions, and 3) measure soil water content only. These types of instrumentation are discussed below. See EPA (1993, Section 9) for further details.

7.3.2.1 Soil Water Sample Collection Instrumentation

There are two basic types of soil-water monitoring instrumentation: pressure-vacuum (suction) lysimeters (hereafter pressure-vacuum samplers) and free-gravity lysimeters. This section discusses these in addition to ‘wick’ lysimeters and another recently developed sampler.

7.3.2.1.1 Pressure-Vacuum Samplers

The pressure-vacuum samplers withdraw a soil-water sample by vacuum from the soil profile. The sample is then collected by pressurizing the sampler, which forces the water sample to the surface. One of the advantages of pressure-vacuum samplers is they can collect a soil-water sample during unsaturated soil conditions when downward movement of soil-water percolate is unlikely. These lysimeters are easy to install and, for pressure-vacuum samplers, there is no depth limitation for installation. Recently developed ‘advanced tensiometers’ also have no depth limitation and are described in DOE (2002).

There is the possibility of sorption or other interferences from ceramic, or other non-ceramic, cup materials through which the soil water sample must pass. Certain organic chemicals, microorganisms, volatile chemicals and metals may present problems in this regard (EPA, 1993, p. 9-3). See also further discussion in 7.3.3.

Soil water chemistry and quantity information can be valuable to assess the effectiveness of site operations but may have limited utility for compliance purposes. The data collected from pressure-vacuum samplers will allow the evaluation of soil-water quality at the time of sample collection. The constituent concentration will depend highly on the moisture status of the soil at the time of sampling. Such samples may not be representative of percolate unless the sample was taken under free drainage conditions. If the sample was taken under unsaturated conditions, the constituent concentration would likely be higher than under saturated conditions. It would be invalid to assume samples taken under unsaturated conditions represented saturated conditions.

7.3.2.1.2 Free-Gravity (Pan) Lysimeters

Free-gravity or pan lysimeters can only collect a sample when soil-water is percolating downward. The sample collected represents the quality and quantity of soil-water percolate losses below the crop root zone.

Pan lysimeters provide information for system performance and potential ground water impacts from free drainage. A disadvantage of pan lysimeters is that no sample is collected unless soil moisture is high enough to allow for percolate losses. The lack of significant percolate accumulation, under the appropriate circumstances, may also provide important information regarding the likelihood of contaminant transport. Lack of sample can also mean that by-pass is occurring.

By-pass occurs when soil water freely drains around the lysimeter. Soil matric potential (suction or tension) around the lysimeter then increases relative to the soil matric potential above the lysimeter. Soil water then flows in response to the matric potential gradient generated and often moves laterally away from the lysimeter surface and toward the freely drained soil, thus causing lysimeter by-pass.

Other disadvantages of pan lysimeters are that installation can be complex and time consuming, and location is limited to relatively shallow depths (EPA, 1993).

7.3.2.1.3 Other Soil Water Samplers

In addition to the two types of lysimeters described above, there is also the "wick" lysimeter. The wick lysimeter collects both free drainage liquid as well as liquid held at tensions up to 0.4 bars. It offers the advantage of gathering real-time samples. Further information regarding soil water monitoring instrumentation, including method description, selection considerations, frequency of use, standard methods and guidelines, and sources of additional information can be found in EPA (1993, Section 9)

A recently developed lysimeter incorporates both the ability to obtain a soil water sample as well as capacity to measure soil water flux without the complication of by-pass. The vadose zone fluxmeter with solution collection capability is described further in Gee et al. (2003).

Table 7-3 provides a summary of soil monitoring instrumentation, including the advantages and disadvantages of each method (CLFP, 2002).

Table 7-3. Summary of soil water sampling instrumentation).

Method	Description	Advantages/Disadvantages
Soil Sampling	Soil samples are collected and analyzed for pH, ECe, Cl, NO3-N	+ Simple and reliable -Samples totals, not just solution fraction -Destructive sample -Requires a soil water balance calculation to determine whether flow occurs
Suction Lysimeter	A porous ceramic tube is placed in the soil so soil solution samples can be collected and analyzed	+ Inexpensive, simple technique to implement -Extracts soil solution that is not mobile -Known to have large measurement variability -Requires a soil water balance calculation or correlation with soil moisture to determine whether flow occurs
Pan Lysimeter	A small collection pan (1-5 ft2) is buried at a selected depth so that soil solution samples can be collected via gravity drainage for analysis. Side wall extending above the device may improve performance	+ Extracts soil solution during flow events + Provides a measure of both flow and water quality + Installation can approximate undisturbed conditions + Moderate variability among replicate samples -Relatively expensive installation costs -Will not result in samples in unsaturated soil
Basin Lysimeter	A large collection pan (50-400 ft2) is constructed and covered with soil so that soil solution samples can be collected via gravity drainage for analysis	+ Extracts soil solution during flow events + Provides a measure of both flow and water quality -Installation creates disturbed soil conditions + Large sample decreases variability -Long-term installation generally done prior to starting a project
Wick Lysimeter	A porous wick designed to match the water retention characteristics of the soil is buried at a selected depth so that solution samples can be collected using a low negative pressure.	+ Extracts soil solution at near zero water potential + Installation can approximate undisturbed conditions -Requires a soil water balance calculation to determine whether flow occurs

From CLFP (2002)

7.3.2.2 Soil Water Measurement Instrumentation

Measurement of soil water content can be done in both the crop root zone and the vadose zone. Soil moisture measurement in the root zone is typically done for irrigation scheduling purposes. Soil moisture is often measured somewhat qualitatively to determine when sufficient root zone depletion of water has taken place to require irrigation.

Measurement of soil water content in the vadose zone for contaminant fate and transport purposes requires more quantification, and is discussed in Ley et al. (2002) and in EPA (1993, Section 9). This latter discussion is excerpted/summarized in the following two paragraphs. Water state in the subsurface is measured in terms of hydraulic head in the saturated zone and negative pressure potential or suction in the vadose zone. Water movement in the vadose zone is determined by the interaction of three major types of energy potentials: (1) matric potential (the attraction of water to solids in the subsurface), (2) osmotic potential (the attraction of solute ions to water molecules), and (3) gravitational potential (the attraction of the force of gravity toward the earth's center). Water flow in the vadose zone is strongly influenced by the moisture content (or matric potential, which is a function of moisture content), with hydraulic conductivity and resulting flow decreasing exponentially as moisture content decreases.

EPA (1993) provides information on six major techniques for measuring soil water potential and several methods for measuring soil moisture content. The measurement of soil water potential and moisture content in the vadose zone are intimately connected, and a specific measurement technique measures either potential or moisture content. Either measurement can be used to obtain the other if a moisture characteristic curve has been developed (see EPA, 1993; Section 6.3.1). Soil water instrumentation and measurement are also discussed in an agronomic context in Ley, et al. (2002).

Porous cup tensiometers are the most commonly used method for measuring soil water potential in the vadose zone. The gravimetric method is most commonly used to measure moisture content from soil samples, and the neutron probe and gamma methods are most commonly used for in situ measurement of soil moisture. Dielectric or capacitance sensors provides accuracy similar to the neutron probe without some of the disadvantages of nuclear methods. Similarly, time domain reflectometry is becoming more widely used with the advent of commercially available units. Further information regarding soil water content measurement instrumentation, including method description, selection considerations, frequency of use, standard methods and guidelines, and sources of additional information can be found in EPA (1993, Section 6). In addition, ASTM D 6642-01 (2001) can also be consulted for quantification of soil water flux.

7.3.3 Monitoring Parameters

Table 7-4 provides general guidance for soil water monitoring analytical parameters for selected wastewater land treatment scenarios. It should be noted that certain parameters can be sampled with pan lysimeters and should not be sampled with pressure-vacuum lysimeters due to interferences from either ceramic or non-ceramic materials of the porus cup. Wilson et al. (1995), Table 26.3 summarizes potential chemical interferences of various porus cup materials. Table 26.2 summarizes physical properties of porus cup materials.

Table 7-4. Common Soil Water Monitoring Analytical Parameters for Wastewater Land Treatment Facilities

Facility Type Analytical Parameter	Municipal Facility (Class A Reuse Water)	Municipal Facility (Guideline Loading Rates)	Municipal Facility (Greater than Guideline Loading Rates)	Facility (Well Below Guideline Loading Rates)	Food Processing Facility (Guideline Loading Rates)	Food Processing Facility (Greater than Guideline Loading Rates)
Common Ions[1]	O[2]	O	?	O	?	?
pH	O	O	X	O	X	X
Electrical Conductivity	O	O	X	O	X	X
NO_3-N + NO_2-N	O	X	X	O	X	X
Fe	O	O	?	O	X	X
Mn	O	O	?	O	X	X
TDS	O	O	X	O	X	X
COD	O	O	O	?	?	X
P	O	O	?	?	?	X
K	O	O	O	?	?	X
Cl	O	X	X	X	X	X

Notes:
1. Common ions consist of the following ions: Na, K, Ca*, Mg*, SO_4, Cl, CO_3, HCO_3. These ions help characterize the chemical signature of the percolate, which can be compared to up and down gradient ground water in the determination of potential impacts.
2. Symbol Definitions: X = usually monitored; ? = monitored depending upon case specific situation; O = generally not monitored.

7.3.4 Monitoring Frequency

Frequency of monitoring should be addressed on a case-by-case basis. Lysimeters should be sampled at appropriate intervals to monitor for the changes in soil-water percolate quantity and quality. These sampling events do not necessarily need to be at regular intervals. More frequent sampling may be advisable at sites that anticipate large percolate losses within specific months, such as during the spring flush coinciding with snowmelt.

The timing of sample collection is very important to obtain representative data when using suction samplers. Pressure-vacuum samplers should be sampled to represent the largest soil-water percolate flux in order to maximize the potential to obtain samples. Sampling can be timed concurrent with irrigation and precipitation events. Timing for obtaining samples from pan lysimeters is not so critical. Percolate will accumulate in the pan lysimeter until it is sampled at the end of the quarter, or monthly, depending on the soil-water percolate storage capacity of the instrument.

7.3.5 Sampling and Sample Location Determination

7.3.5.1 Sampling

Lysimeter sampling methods are described in EPA 1993, Sections 9.2 (suction methods) and 9.3 (other methods).

7.3.5.2 Sampling Location Determination

Lysimeters for soil-water sampling should be installed below the anticipated crop root zone in order to collect percolate, which may contribute to deep drainage and potentially impact ground water. By collecting samples at this point, it is assumed that most of the treatment has already occurred in the crop root zone. This is a conservative assumption that does not account for the treatment potential in the vadose zone.

Soil-water status can vary widely over a land application site due to variations in irrigation application rates, soil hydraulic properties, and seasonally with changes in the evapotranspiration demand. The number of lysimeters on a land treatment field is dependent upon spatial and temporal variability, and acceptable quality of the data given the site-specifics and use of the data. Areas that are significantly contrasting with respect to soil type, topography, texture, and other properties should be sampled separately.

The data from each lysimeter sampling point, monitored over time, can be compared with site management to look for changes in percolate quality and volume in response to management practices, so that management/response relationships can be established. Such responses will likely be more qualitative and relative in nature.

7.3.6 Analytical Methods

Table 7-20 presents analytical methods recommended for soil water samples. Where more than one method is given, employ the method appropriate for the type of sample, its concentration range, the availability of equipment, and necessary detection limit. Note that detection limits reported by the laboratory should be significantly less than the ground water standard for constituents, which have regulatory limits.

Soil water sample volumes will vary depending on instrumentation used and time of year. It is recommended that there be a priority for testing established in the QAPP. For example, nitrate and EC require little sample volume compared with TDS, which requires about 100 ml. A reasonable priority would be to conduct nitrate-N and EC analyses first followed by COD, and TDS. Other analyses can then be added depending on the concerns of the site.

7.3.7 Quality Assurance and Quality Control

As discussed in Section 7.1.6.1, the facility should have a quality assurance project plan (QAPP). For more information on the development of a QAPP, refer to Section 7.1.6.

7.3.8 Data Processing, Verification, Validation, and Reporting

As with other types of monitoring, the facility's permit will specify what parameters to monitor, when to monitor, and when results must be submitted. When reporting soil water monitoring data, describe the lysimeter location and use the monitoring serial numbers designated in the permit.

7.3.9 References

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7.4 Soil Monitoring

Successful treatment of wastewater through land application takes place through an agronomic mechanism. Soil monitoring is a basic component of wastewater-land application monitoring and is generally necessary for continued agronomic operation and management of a land application site.

The schedule for monitoring and the parameters to be measured will depend on the type of wastewater being applied. Soil monitoring is utilized for both nutrient management and characterizing soil quality. Soil monitoring is usually not utilized for compliance purposes.

Section 7.7.7 discusses soil monitoring as used for grazing management purposes.

7.4.1 Monitoring Objectives

Soil monitoring has a dual purpose within the wastewater-land application program. The first is a *nutrient management* purpose, which is discussed in Section 4. Testing for macro-nutrients such as nitrogen, phosphorus, and potassium; pH; and micro-nutrients, are needed so that nutrient loading through wastewater and/or fertilizer can be managed to maximize both crop growth and the efficiency with which nutrients are being utilized. Extensive research on crop nutrient needs, crop response to fertilization given soil-specific nutrient status, crop health, and economic yield has been done by the University of Idaho Extension Service and others. Fertility guides and other publications are available which should be utilized in the management of wastewater land treatment facilities. Crops that appear unhealthy or for which production is noticeably decreased may indicate a need to further investigate the soil crop system to determine the problem area. For example, soils should be monitored for excessive wetness prior to subsequent application of wastewater (particularly during the wet season). Excessive wetness can effect crop growth, nutrient uptake and mobility of nutrients and metals.

The second purpose of soil monitoring is to assess soil quality. This involves characterizing the chemical and physical properties of soils of wastewater-land application sites initially during site characterization as well as over time. Soil data can be used for determining initial permit loading and management conditions, or can indicate whether loading or management changes may be indicated during the permit cycle. Long term soil characterization can reflect effects of particular land use activities. Trend data of parameters such as available nitrogen, electrical conductivity, sodium adsorption ratio (SAR), concentrations of phytotoxic constituents, salinity, and concentrations of redox sensitive species (iron and manganese) can serve as indicators of excessive wastewater loading when compared to ambient levels in agricultural soils not used for land treatment. Soil quality monitoring can signal the accumulation of constituents which may constitute a risk to ground water, given leaching conditions. Soil data can then be utilized to determine appropriate loading rates and management. Monitoring of soils should also include metals and a periodic infiltration study, if SAR levels or operational observation indicate increased runoff or runoff potential.

7.4.2 Monitoring Instrumentation

Ferguson et al. (1991) provides a description of common soil sampling equipment, and is paraphrased here. The soil probe or tube is the most desirable tool for collecting soil samples. It will give a continuous core with minimal disturbance of the soil. The cores can be divided for the various depths. There should be very little contamination of subsoil sample with surface soil when using a soil probe. A soil probe cannot be used when the soil is too wet, too dry, or frozen. If the soil is frozen, the frozen layer will need to be fractured before a probe can be used. Soil probes cannot be used in soils that contain gravel.

'The soil auger can be used in soils that are frozen or contain gravel; however great care must be taken to obtain representative samples and to avoid mixing of soil from different depths. The use of a soil auger in wet, sticky soils will result in mixing soil from different depths. A soil auger will not effectively gather dry, powdery soils. Use a soil auger only when a soil probe cannot be used.' A spade can also be used for surface samples, but is not satisfactory for subsoil samples. 'A post hole digger can be used for collecting deep samples , but its use requires some special techniques.' Galvanized, brass, bronze, or soft steel equipment should not be used as they may contaminate the sample with metals which are important micronutrients (Self and Soltanpour, 2004). Stainless steel or chrome plated tools and plastic buckets are recommended. Equipment should be clean. Wiping equipment clean between samples is generally sufficient, but washing with non-phosphate detergent and a triple rinse in de-ionized water can also be done (CES, 1997). See DEQ (2001) for further details.

DEQ (2001), Appendix 'C' provides soil sampling SOPs (standard operating procedures). SOPs reference monitoring instrumentation. Mahler and Tindall (1990), page 3, discuss sampling equipment. EPA (1991), Section 1 provides a complete list soil sampling equipment which may be needed. Section 4 of the same document provides a description of both hand held and power driven soil sampling equipment.

7.4.3 Monitoring Parameters

Table 7-5 shows common wastewater-land application facility types and analytical parameters recommended for on-going soil monitoring. For initial characterization of baseline soil conditions, the entire suite of analyses is recommended for all facility types.

Not included in the table are other macro- and micro-nutrients which would be monitored by facility land treatment operators or agronomists as needed to determine nutrient status of constituents which are not usually of environmental concern and wastewater land treatment sites. These include sulfate, calcium, magnesium, zinc, boron, copper, chloride and molybdenum.

Table 7-5. Common Soil Monitoring Analytical Parameters for Wastewater Land Treatment Facilities

Facility Type / Analytical Parameter	Municipal Facility (Class A Reuse Water)	Municipal Facility (Guideline Loading Rates)	Municipal Facility (Greater than Guideline Loading Rates)	Facility (Well Below Guideline Loading Rates)	Food Processing Facility (Guideline Loading Rates)	Food Processing Facility (Greater than Guideline Loading Rates)
pH	O[3]	O	?	O	X	X
Organic Matter	O	?	X	O	X	X
NH_3-N	O	X	X	?	X	X
NO_3-N + NO_2-N	O	X	X	?	X	X
DTPA-Fe[2]	O	O	?	O	X	X
DTPA-Mn[2]	O	O	?	O	X	X
Sodium Adsorption Ratio (SAR)	O	?	?	?	X	X
Specific Conductivity	O	O	X	?	X	X
P	O	O	X	?	X	X
K	O	O	O	?	?	X
Cl	O	?	?	O	?	X
Cation Exchange Capacity[1]	O	X	X	X	X	X
Texture (USDA)[1]	O	X	X	X	X	X

Note:
1. Commonly done once during each permit cycle.
2. Commonly done both at the beginning and end of the permit cycle.
3. X = usually monitored; ? = monitored depending upon case specific situation; O = generally not monitored.

A description of the analytes shown and the rationale for monitoring are provided below:

Cation Exchange Capacity (CEC): Cation exchange capacity is a measure of a soils ability to retain and exchange positively charged ions on colloidal surfaces (Bohn et al. 1979). The finer the texture (i.e. greater surface area) and the greater the OM content of the soil, the greater the CEC will generally be. The greater the CEC, the more cations, including crop nutrients, the soil can retain~~s~~. Higher CEC in soils generally indicates higher fertility.

Chloride (Cl): Chloride is commonly found in municipal and industrial wastewaters. It can move substantially un-attenuated through the soil to ground water (i.e. the ion is conservative). As such, chloride is a good indicator of contaminant movement through soil. Certain industrial wastewaters can have significant chloride concentration and may be loaded at high rates to the soil. Chloride toxicity to crops may result if concentration in the soil exceeds certain threshold levels, depending on the sensitivity of the crops. The following crop tolerance ranges are given in Biggar (1981) (in meq/L of saturated extract): low – 10 to 20; medium – 20 to 25; and high – 25 to 90+.

DTPA Extractable Iron and Manganese (DTPA Fe/Mn): Plant available iron and manganese are extracted by the chelating agent diethylenetriaminepentaacetic acid (DTPA). Fe and Mn extracted by this method are in a reduced valence state (i.e. Fe^{2+} and Mn^{2+}). Soils which have been overloaded hydraulically and/or chemically (COD) may develop reducing conditions. Reducing conditions change oxidized forms of Fe and Mn naturally resident in the soil profile to mobile forms. These forms may then leach to ground water under certain conditions. The presence of high levels of the above reduced species in soils may reflect reduced soil conditions brought on by hydraulic and/or COD overloading.

High levels of soil Fe and Mn, with respect to crop utilization, typically range from 4.1 to 10 mg/kg and 2.6 to 8.0 mg/kg respectively (Stukenholtz no date).

Sodium Adsorption Ratio (SAR): Sodium Adsorption Ratio serves as an index of the potential sodium influence in the soil. SAR values above thirteen (13) classify soils as sodic or alkali (Robbins and Gavlak, 1989), have sodium as the dominant cation, and may possibly experience infiltration problems due to deflocculation of soil colloids. Certain textures of soils can become affected at values lower than 13 (David Argyle, Hibbs Analytical Laboratories, personal communication c. 1993).

Electrical Conductivity (EC): The electrical conductivity of a water extraction of a soil is an indirect measure of the salt content in the soil. High loadings of inorganic TDS may cause salt build-up in the soil leading to crop yield decreases.

Electrical conductivities of the saturated paste extract values greater than 4 dS/m indicate saline conditions in the soil. Other *proposed* limits for defining saline soils are 2 dS/m (Bohn et al. 1979). A general soil test interpretive guide from Stukenholtz Laboratory shows ECs of 0 to 1.0 dS/m being low, 1.0 to 4.0 dS/m being medium, and 4.1 to 8.0 dS/m being high (Stukenholtz, no date).

Nitrate and Ammonium (NO_3^-/NH_4^+): common nitrogen species which are plant available and important in determining the resident nutrient status of soils. Nitrate is very mobile in the soil and is subject to leaching. Excessive nitrate leaching may cause adverse impacts to ground water.

Organic Matter (OM): Organic matter mineralizes over time to yield plant available nitrogen. It is common in crop nutrient guides to correlate the percent of organic matter with the pounds of nitrogen which will be mineralized during the growing season. This mineralization should be taken into account in wastewater land treatment site nitrogen balance calculations. Rules of thumb vary as to the amount of nitrogen released for each percent of organic matter in the soil. Taberna (no date) cites values of 50 pounds of nitrogen per acre for each percent of organic matter released for southwest Idaho, 40 for the Magic Valley, and 35 for eastern Idaho. Extension fertility guides take soil organic matter into account when assessing the need for nutrient addition.

Texture: Soil textures are reported in the Natural Resource Conservation Service Soil Survey reports for many areas. Soil textures can be determined in the laboratory or by manual field methods if no soil survey reports are available, or to verify existing soil survey reports. Available water holding capacity, a very important parameter with respect to non-growing season wastewater loading, is a function of soil texture. Also, cation exchange capacity is correlated with soil texture (see below). Soil textures need only be determined once, since texture is a physical property of the soil and does not normally change over time.

Phosphorus: Phosphorus is relatively non-mobile in the soil and is an essential crop macronutrient~~s~~. Phosphorus is an important species which can cause eutrophication of surface waters, and associated water quality degradation problems. Phosphorus is discussed at length in Section 4.8.

Potassium: Potassium is relatively non-mobile in the soil, and is an essential crop macronutrient~~s~~. Sites which are overloaded with respect to potassium not only show very high levels in the soil profile, but distinct potassium increases from ambient ground water concentrations can often be seen down gradient.

pH: pH is a measure of the acidity/alkalinity of the soil. Generally the pH of soils does not exceed 8.3, this limit reflecting the dominating effect of carbonate on the soil chemistry. When soil pH exceeds this value, a sodic soil condition may be indicated (Robbins and Gavlak, 1989). Soil pH has an important influence on availability of crop nutrients. Productive agricultural soils generally exhibit a pH range of 6.5 to 7.5.

7.4.4 Monitoring Frequency

The frequency of soil monitoring is dependant on the type of facility, wastewater land treatment management, loading rates, and site specific factors. Table 7-6 provides recommendations for soil monitoring frequencies.

In cases where soil sampling is needed, sampling in early spring is generally indicated. Early spring sampling is done to assess the nutrient status of the soil near the commencement of the crop growing season. Fertility guides can be used to interpret the result and provide recommendations for nutrient addition for the cropping year. Soil quality status (i.e. status of non-nutrient parameters affecting crop growth and/or the environment) can also be assessed through spring sampling. Comparing spring sampling data from one year to the next can be used to estimate leaching losses of constituents such as salts. If initial and final soil concentrations are known, crop ash (inorganics) uptake and removal is known, and salts applied with wastewater, irrigation water, waste solids etc. are known, leaching losses can be estimated by difference.

Fall soil sampling after the cropping season is sometimes necessary, as Table 7-6 indicates. Additional fall sampling can be useful at facilities for which nutrient budgets (particularly nitrogen) must be closely monitored. By comparing spring and fall soil nutrient status; nutrient additions from wastewater, waste solids, and fertilizer; and crop uptake and removal; one can estimate by difference the losses of a nutrient to the environment during the growing season. In the case of nitrogen those losses would include leaching, volatilization, and denitrification. By estimating volatilization and denitrification losses, one can arrive at a growing season leaching loss estimate.

The same is true by comparing fall and spring soil nutrient status over the non-growing season, only the nutrient additions would not include fertilizer; and there would not be crop uptake and removal. One can estimate by difference the losses of a nutrient to the environment as described for the growing season. In the case of nitrogen, estimates of volatilization and denitrification may be much more tenuous because other factors, such as organic constituent and hydraulic loading and temperature, influence soil redox potential and microbial metabolic rates, which affect denitrification. This increased uncertainty makes the nitrogen leaching loss estimate more uncertain as well.

Sampling depth intervals for common types of wastewater land treatment facilities are given in the table. To characterize nutrient status for non-mobile species, such as phosphorus and potassium, crop fertility guides typically recommend sampling the 0-12 inch depth. To characterize nitrogen status, both the 0-12 inch and 12-24 inch depths are recommended.

As discussed in Section 4.2, NO_3^- is a mobile constituent. In general, shallower depths are sampled for relatively immobile nutrients. Deeper depths should be sampled for more mobile species. Depending on the type of facility, management, and loading rates, deeper layers of the soil profile should be sampled to obtain qualitative indication of movement of constituents below the crop root zone. In Table 7-6, facilities with higher loading rates, with legacy sites, and industrial facilities generally sample at depths greater than 24 inches. Recommended sampling intervals in Table 7-6 are in 12 inch increments (i.e. 0 – 12 inches; 12 – 24 inches; etc.). It is not generally recommended to select pedogenic horizons to sample; such as A, B and C horizons; since these likely occur at variable depths in a field, and may not be readily distinguishable when sampling. Also, calculating soil constituent content from concentration data is greatly simplified when a 12 inch interval is selected, as the following formula shows:

$$Soil\ \ Content\ \ (lb/acre) = Soil\ \ Constituent\ \ Concentration\ \ (mg/kg) * 4$$

Note: The factor of 4 is approximate and appropriate for many soils, but is dependant on the bulk density of the soil. A more versatile and accurate means of obtaining soil constituent content requires additional inputs of both soil depth considered and soil bulk density. The equation is as follows:

$$M = 0.225 * d * C * D_b$$

Where:

M = soil nutrient content (lb/acre)

d = soil depth considered (inches)

C = soil constituent concentration (mg/kg)

D_b = soil bulk density (g/cm^3)

It should be noted that if monitoring is performed more frequently than required by the permit, the results of this additional monitoring are required to be included in the annual report. If additional parameters are monitored which are not required in the permit, these data do not have to be reported.

Table 7-6. Soil Monitoring Frequency Recommendations for Common Types of Wastewater Land Treatment Facilities.

Facility Type	Municipal Facility (Class A Reuse Water)	Municipal Facility (Guideline Loading Rates)	Municipal Facility (Greater than Guideline Loading Rates)	Food Processing Facility[1] (De-Minimus Loading Rates)	Food Processing Facility (Guideline Loading Rates)	Food Processing Facility (Greater than Guideline Loading Rates)
Soil Monitoring Frequency	none	Annually: Early Spring	Annually: Early Spring	Annually: Early Spring	Annually: Early Spring	Semi-Annually: Early Spring and Fall
Sampling Depths (inches)	none	0 - 12 & 12 - 24 or refusal	0 - 12 & 12 - 24 & 24 – 36 or refusal	0 - 12 & 12 - 24 or refusal	0 – 12; 12 – 24 & 24 – 36 or refusal	0 – 12; 12 – 24 & 24 – 36 or refusal

1) Common food processing facilities in Idaho include potato (fries and dehydrated products), sugar beet, cheese, and whey processing plants. Potato fresh pack facilities, although not a food processing operation, would be included in this category.

7.4.5 Sampling and Sample Location Determination

7.4.5.1 Sampling

Soil sampling protocols for crop nutrient assessment in soils are discussed in Mahler and Tindall (1990). Sampling protocols are summarized in WLAP permits which require soil monitoring. DEQ (2001) provides soil sampling SOPs (standard operating procedures) in (DEQ 2001) Appendix 'C'. Included are SOPs for the following:

- Collecting representative surface soil samples
- Collecting representative subsurface soil samples with hand augers, split spoon samplers, and from pits and trenches
- Decontaminating soil sampling equipment

Soil sampling should be done when there is sufficient time to complete sampling. Sampling should not be done when soils are excessively wet because compositing is difficult. Soils should not be sampled when snow covered; or have had recent fertilizer, lime, or manure applications (Oklahoma State University Extension, September 2003; Mahler and Tindall, 1990). In general, several sub-samples from several locations are taken from each sampling interval (see further discussion below) and are composited by depth in a clean plastic bucket to yield a composite sample for chemical or physical analysis. If taking soil cores, the entire core from the particular depth interval should be included as a sub-sample. As described in Mahler and Tindall (1990), soil samples 'need special handling to ensure accurate results and minimize changes in nutrient levels because of biological activity. Keep moist soil samples cool at all times during and after sampling. Samples can be frozen or refrigerated for extended periods of time without adverse effects.’ Samples can then be transported to the laboratory in a cooler.

Directions for air drying of soil samples in the following paragraph are paraphrased from A&L Plains Labs, Inc. (no date) unless noted otherwise. Samples can be air dried by spreading the sample in a thin layer on a (clean) plastic sheet. Clods should be broken up and soil spread in a layer about ¼ inch deep. The sample should be dried at room temperature. If a circulating fan is available, position it to move the air over the sample for rapid drying. Do not dry where agricultural chemical or fertilizer fumes or dust will come in contact with the samples. Do not use artificial heat in drying. When soil samples are dry, mix the soil thoroughly, crushing any coarse lumps. Take from the sample about 1 pint (roughly 1 pound) of well-mixed soil and place it in a sample bag or other sturdy, spill-proof container (generally provided by the laboratory) which has sample number, depth, date, time, field number and sampler’s name (Mahler and Tindall, 1990). Documentation having sample identification describing the sample and associated information should be written. An example of a soil sample information sheet is in 7.7.6 (Iowa State University, 1997).

7.4.5.2 Sampling Location Determination

Soil monitoring units (SMUs) are specified in wastewater land application permits. SMUs are the predefined areas from which soils are sampled and composite samples are prepared. SMUs are designed so that, in as much as possible, soil properties, cropping practices and wastewater application rates are similar (CES, 1997). Obtaining representative samples is critical to getting valid and interpretable analytical results. Areas should be sampled that are similar in topography, soils, land use and management. Mahler and Tindall (1990), as excerpted and summarized here, recommend that the sampler avoid unusual areas such as eroded sections, dead furrows, fence lines, burn-row areas, wood pile burn areas, gate areas, old building sites, old manure and urine spots, areas of poor drainage, fertilizer bands where row crops have been grown, areas of fertilizer spills, and other unusual areas which would not be representative of SMU soils.

Soil samples should be taken from several different locations in the SMU. Taberna (1992) recommends taking subsamples no closer than 40 feet from the edge of the field. The sampling pattern recommended there is along a transecting loop diagonal (45 degrees) to the field (a diamond shaped transect within a square field). Mahler and Tindall (1990) recommend a zigzag meander pattern to randomly collect samples, being sure to collect samples throughout the unit. Other sampling methods besides a simple random sampling include stratified random sampling, sampling at predetermined locations based upon soil mapping, and using a systematic grid pattern. These are discussed further in CES (1997) and Jacobson (1999).

Special sampling protocols are necessary for furrow irrigated fields, areas where fertilizer has been banded, and on reduced tillage or no tillage fields. These protocols are discussed in Mahler and Tindall (1990)

It is important to note that sampling for nutrient assessment, while adequate for fertility assessment under routine farm management, introduces too much variability for monitoring practices. Soil monitoring should be performed at established locations over time to monitor for changes over time. Valid comparisons over time are not possible if sampling collects from different locations each time. In general, individual locations, grids, or sampling transects should be established to monitor for land application system performance over time.

Table 7-7 gives a recommended number of subsamples to collect based on the size of the field and purpose of sampling:

Table 7-7. Recommended Number of Soil Subsamples.

Field Size in Acres	U of I Recommended Number of Subsamples for Agronomic Nutrient Characterization[1]	DEQ Recommended Number of Subsamples for Regulatory Reconnaissance Characterization
<5	15	5
5-10	18	5
10-15	20	5
15-25	20	10
25-50	25	10
>50	30	10

1) from Mahler and Tindall, 1990

7.4.6 Analytical Methods

Table 7-24 presents analytical methods recommended for soil monitoring. Of particular importance are methods outlined in the Web site:

http://isnap.oregonstate.edu/WCC103/Soil_Methods.htm

This website consists of the on-line version of the Western States Plant, Soil, and Water Analysis Manual, Second Edition, 2003 (hereafter Gavlak et al., 2003).

Where more than one method is given, employ the method appropriate for the type of sample, its concentration range, the availability of equipment, and necessary detection limit. Note that detection limits reported by the laboratory should be significantly less than the ground water standard for constituents that have regulatory limits. Other references which may be consulted for useful soil analytical information include Black et al. (1965), Horneck et al. (1989), Miller and Amacher (1994), and Page et al. (1982).

7.4.7 Quality Assurance and Quality Control

It is recommended that soil testing laboratories utilized for permit required soil analyses are participants in the North American Proficiency Testing Program (NAPT) program for soil, planed and water analyses. The NAPT program is based on the quarterly submission to participating laboratories of six soil and/or three plant materials for chemical analysis using reference methods of analysis described in the four Regional Soil Work Group publications of the Northeast Coordinating Committee on Soil Testing (NEC-67), North Central Regional Soil Testing Committee (NCR-13), Southeast Regional Soil Testing Committee (SERA-6), Nutrient Management and Water Quality Team (WERA-103) and methods outlined in the *Methods Manual for Forest Soil and Plant Analysis* (Forestry Canada.)

Participating laboratories complete sample analysis and provide results to the NAPT program coordinator for statistical evaluation. Quarterly, each laboratory will provide an evaluation of their individual performance on each of the methods listed. Annually, the program will provide a report to each participant of the performance of the individual laboratory and that of the agricultural laboratory industry. An extension outreach program to aid participating laboratories in improving the quality of their analytical results will be implemented in cooperation with regional soil and plant analysis work groups and individual state, regional and provincial representatives from the Web site:

http://www.soiltesting.org/proficiencytesting.html

The following Web site has information regarding quality assurance in the agricultural laboratory:

http://isnap.oregonstate.edu/WCC103/Methods/WCC-103-Manual-2003-Lab%20Quality%20Control.PDF

7.4.8 Quality Assurance and Quality Control

As discussed in Section 7.1.6.1, the facility should have a quality assurance project plan (QAPP). For more information on the development of a QAPP, refer to Section 7.1.6.

7.4.9 Data Processing, Verification, Validation, and Reporting

As with other types of monitoring, the facility's permit will specify what parameters to monitor, when to monitor, and when results must be submitted. When reporting soil monitoring data, describe the soil monitoring unit location and use the monitoring serial numbers designated in the permit.

7.4.10 References

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7.5 Wastewater Monitoring

The quality and quantity of the effluent applied to the land treatment area should be monitored on a regular basis. Wastewater sampling and analysis plans are determined based on individual wastewater characteristics, site specific considerations, and regulatory requirements (see Section 2 and Section 7.1.6).

This section provides wastewater monitoring guidance for both municipal and industrial wastewater land application permits and includes wastewater monitoring objectives, instrumentation, monitoring parameters, sampling, analytical methods, quality assurance/quality control and data processing, verification, validation, and reporting.

7.5.1 Monitoring Objectives

The goal of wastewater monitoring at a wastewater-land application facility is to provide a timely and cost-effective assessment of the adequacy of wastewater treatment unit process operations and operation and management procedures. Wastewater chemical and flow monitoring is also critical for constituent loading calculations for permit compliance purposes.

7.5.2 Monitoring Instrumentation

The following section discusses sample collection equipment and flow measurement instrumentation.

7.5.2.1 Sample Collection Equipment

There are various types of wastewater samplers, which are designed to collect sample types described in Section 7.4.4. Refrigerated samplers are designed to take daily composite samples and keep samples at appropriate temperatures for preservation. There are other portable samplers, which can collect hourly composite samples, and can be readily moved to different locations (Metcalf and Eddy, 2003). Some composite samplers can take time-weighted samples, taking identical sample volumes over time. Other samplers can take flow-weighted samples, taking different volumes of sample proportionate to measured flows over time.

7.5.2.2 Flow Measurement

The accurate and precise measurement of wastewater flow is critical for the operation of wastewater land treatment facilities for many reasons. In-plant wastewater treatment processes, which will not be addressed here, rely on flow measurement. Important from a regulatory standpoint is flow measurement to determine both hydraulic loading and constituent loading rates for site management and permit compliance.

Flow measurement is discussed at length in various wastewater engineering texts and the reader is referred there. Important topics to consider regarding flow measurement include:

- Type and application of the flow measurement (metering) device
- Selection criteria for metering devices, and
- Maintenance of metering devices.

Metcalf and Eddy (1991), Tables 6-2, 6-3, and 6-4 provide summary information regarding application, selection criteria, and characteristics of flow metering devices respectively. Flow measurement for industrial facilities is discussed in EPA (1973).

Table 7-8, from CLFP (2002), provides a convenient summary of flow measurement devices and advantages and disadvantages.

Table 7-8. Flow Measurement Examples.

Method	Alternatives	Advantages/Disadvantages
Intrusive flow meters	Impeller, paddle wheel Hot wire anemometer	- Intrusive devices can clog with solids or from biological growth - higher friction loss/pressure drop - Low pH or high Electrical Conductivity can cause failure of sensing components resulting in higher maintenance
Non-intrusive flow meters	Magnetic Ultrasonic/Doppler	+ These sensors have no parts in the flow - Higher capital cost + Often, these are used at main pump station and alternate methods are used for individual fields
Open channel flow measurements	Weir-type Parshall flume	- Requires controlled channel to establish proper conditions for measurement + Simple, reliable operation + measurements can be recorded continuously
Incoming water supply correlation	Discharge volume is estimated as a percentage of incoming water consumption	+ Supply water is clean and relatively simple to measure using meters - A correlation between incoming flow, in-plant loss, and process/rinse water discharge is required
Pump run time and output calculation	Flow for individual fields can be estimated proportionally from total flow	- Requires a master pump station flow meter or some calibration - Irrigation fields must be maintained so they operate according to specifications - Primarily applicable to sprinkler irrigation systems or surface irrigation using siphon tubes or gated pipe
In-field methods	Rain gauge/catch cans in individual fields Use of soil water measurements to calculate net irrigation	+ Approximates net irrigation (amounts actually received) rather than gross irrigation delivered - Assumptions in water budget method make method approximate; - calibration required. - Measurement of soil moisture at bottom of root zone provides useful information related to leaching - Rain gauges are applicable to sprinkler irrigation only

From CLFP (2002).

Both wastewater and irrigation water flows need to be measured. Irrigation water generally comes from one source, but can come from multiple sources (well, diverted surface irrigation water). In the latter case, each source should be metered. Irrigation water should be metered at every hydraulic management to measure application rates.

Total wastewater flow to land treatment acreage should be metered from the facility. As with irrigation water, each hydraulic management unit should be metered to measure wastewater application.

Flow data is not compromised by sample contamination, but data verification is important to consider when collecting flow measurements. In some cases flow measurements cannot be safely verified because of the position of the flow measurement device. In other cases the flow measurement device may not be properly constructed, so there is doubt about the measurements produced by the device. For example, a weir may not be level, thus the original engineering calculations used to gauge flow on the weir may not be appropriate for use with the structure as built. Data verification for flow devices should be approached carefully, because in many cases the cost of verification can be great. In some cases documentation showing proper calibration can be presented as a flow verification. All flow meters should be maintained regularly, according to manufacturer's recommendations, and should be calibrated at least once each year to insure both accurate and precise measurements are being taken.

Further discussion of flow measurement and an in-depth discussion regarding the evaluation of flow measurement devices and records for regulatory purposes is found in EPA (2004), Chapter 6. This chapter is included in this guidance in the supplementary information (Section 7.7.8), and is available at the following Web site:

http://www.epa.gov/compliance/resources/publications/monitoring/cwa/inspections/npdesinspect/npdesmanual.html

7.5.3 Monitoring Parameters

This section discusses typical chemical monitoring parameters for wastewater, irrigation water, and operations and unit process monitoring.

7.5.3.1 Chemical Monitoring Parameters

Wastewater chemical analytical parameters to be monitored in wastewater are determined from permit application data, history of the facility wastewater generation, wastewater characteristics of similar facilities and other factors. The permit may require monitoring of constituents in the wastewater for reasons other than to determine compliance with loading or other regulatory limits. Additional parameters to monitor may include toxic chemicals or substances that could upset the treatment system. These substances could be introduced from raw materials, compounds resulting from chemical interactions, or impurities in raw materials including solvents.

Municipal systems typically monitor for total suspended solids (TSS) and biochemical oxygen demand (BOD_5). These parameters are useful as an indicator of treatment performance prior to land application.

Table 7-9 shows common wastewater monitoring analytical parameters for wastewater land treatment facilities.

Table 7-9. Table of Common Wastewater Monitoring Analytical Parameters for Wastewater Land Treatment Facilities.

Facility Type Analytical Parameter	Municipal Facility (Class A Reuse Water)	Municipal Facility (Guideline Loading Rates)	Municipal Facility (Greater than Guideline Loading Rates)	Facility (Well Below Guideline Loading Rates)	Food Processing Facility (Guideline Loading Rates)	Food Processing Facility (Greater than Guideline Loading Rates)
Flow	X[2]	X	X	X	X	X
Total Settleable Solids	X	X	X	?	?	?
Total Suspended Solids	X	X	X	?	?	?
Turbidity	X	O	O	O	O	O
pH	X	X	X	X	X	X
Alkalinity	?	?	?	?	?	?
Sodium	O	O	?	?	?	X
NO3-N + NO2-N	X	X	X	X	X	X
TKN	X	X	X	X	X	X
BOD	?	?	?	O	O	O
SO4	O	O	O	?	X	X
Total Dissolved Inorganic Solids[1]	O	O	O	?	?	X
VDS	O	O	?	O	?	?
TDS	O	O	X	?	?	?
FDS/NVDS	O	O	?	?	?	?
Electrical Conductivity	O	X	X	X	X	X
COD	O	O	O	?	?	X
P	O	O	X	?	X	X
K	O	O	O	?	X	X
Cl	O	X	X	X	X	X
Total Coliform	X	X	X	?	?	?
Other Micro-organisms	?	?	?	?	?	?

Notes:
1. Total Dissolved Inorganic Solids generally consist of the following ions: Na, K, Ca, Mg, SO_4, Cl, CO_3, HCO_3 and other species in appreciable concentration.
2. Symbol Definitions: X = usually monitored; ? = monitored depending upon case specific situation; O = generally not monitored.

Irrigation water quality is often measured at wastewater land treatment facilities, where there is need to account for constituent loading from this source. In cases where irrigation water does not vary appreciably during the water year, nor between water years, sampling and analysis during the spring and fall of the first water year of the permit cycle is usually considered sufficient. For cases where there is more variability, additional monitoring may be necessary for chemical characterization. Typical constituents of concern are salts (as measured by TDS analysis) and total nitrogen (as measured by TKN plus nitrate-nitrogen analyses). Chloride may be necessary for sites where ground water modeling is being, or may be, conducted. Chloride is a conservative constituent (i.e. does not undergo chemical transformations in an agronomic soil environment) and can be used for modeling calibration purposes.

7.5.3.2 Operations and Unit Process Monitoring

Operations monitoring is an important component of the wastewater monitoring program. Operations monitoring includes monitoring performance of irrigation systems including inspection and cleaning of sprinklers. Observation during both growing and non-growing season during wastewater irrigation for runoff, ponding, vectors, ice build-up and other irregularities is important. Precipitation and evapotranspiration should also be monitored.

Cumulative constituent and hydraulic loadings onto hydraulic management units should be monitored throughout the application season so that sound wastewater land treatment management decisions can be made.

Lagoon water levels need to be monitored. Lagoon berms need to be inspected regularly for rodent damage and for weed control. Operation of pumps, clarifiers, screens, filter presses, centrifuges and other unit processes must be closely monitored. Ground water mounding around lagoons should also be monitored using piezometers.

Table 7-10, adapted from CLFP (2002), summarizes operations monitoring in a checklist for routine maintenance for use at a wastewater land treatment facility.

Table 7-10. Routine Maintenance Inspection Checklist for Land Application Sites Monitoring.

Feature	**Condition**	**Recommended Action**
Facility Discharge	Check primary screens for solids accumulation, amount of flow, evidence of unusual conditions	
Lagoon or Pond	Pond level, odor, scum on surface, presence of excessive solids, berm inspection for rodent damage and weed control	
Residuals Stockpile	Amount, need for land application, odor	
Main Pump Station	Current operations, flow, pressure, odor, leaks, mechanical concerns	
Transmission Piping	Leaks, odor, pressure at intermediate locations	
Booster Pumps	Current operations, flow pressure, odor, leaks, mechanical concerns	
Other Unit Processes	Monitoring of clarifier, filter presses, centrifuges, etc.	
Fields irrigated	For each field: list irrigation run times, process water or supplemental water supply, odor	
Constituent Loading	Cumulative constituent and hydraulic loadings throughout growing and non-growing seasons	
Fields condition	For each field: assess irrigation uniformity, runoff, erosion, irrigation system condition, odor, solids on surface, ice buildup, ponding, vectors,	
Crop Condition	For each field: general crop health, need for farming activities	
Samples Collected	List samples taken	

Adapted from CLFP (2002).

7.5.4 Monitoring Frequency

Wastewater monitoring frequency is determined based on the measured or estimated variability (see Section 7.1.3). Other factors for determining sampling frequency include the following:

- Size and design capacity of facility
- Type of treatment
- Compliance history
- Number of pollutant sources from a facility
- Cost of monitoring relative to the facility's capability and benefits obtained
- Environmental significance of wastewater constituents
- Detection limits and analytical precision/accuracy
- Production schedule of the facility (seasonal, daily, year round, etc.)
- Plant washdown or cleanup schedule
- Batch type process and discharge or continuous operation

The number of samples necessary to determine compliance for total coliform is related to the degree of public exposure, as rated by total coliform counts in wastewater (see Table 7-11). The WLAP rule (IDAPA 58.01.17.600.07) specifies the use of the median sample value for the last three to seven test results to determine compliance, depending on the effluent classification.

Table 7-11. Total Coliform Testing Frequency and Compliance Determination for Municipal Systems

Wastewater Category	Median Coliform Limit	Single Sample Maximum Value**	Recommended Sampling Frequency	Compliance Determination Method
Class A	Filtered, Total Coliform limit: 2.2/100 ml *	23/100 ml	Daily when land application system is in operation, or project specific	O&M manual must include provisions to divert effluent or shut down application system whenever bacterial excursions occur or may occur; Median value of last 7 results, rolling basis
Class B	Total Coliform limit: 2.2/100 ml	23/100 ml	Twice per week when land application system is in operation	Median value of last 7 results, rolling basis
Class C	Total Coliform limit: 23/100 ml	240/100 ml	Weekly when land application system is in operation	Median value of last 5 results, rolling basis
Class D	Total Coliform limit: 230/100 ml	2400/100 ml	Twice per month when land application system is in operation	Median value of last 3 results, rolling basis
Class D	Too Numerous to Count – Not Applicable	Not Applicable	Twice per month when land application system is in operation	Not Applicable

Notes:
* This category requires filtration performance standards (turbidity or TSS) prior to disinfection.
** The facility shall include provisions to divert effluent or shut down application system whenever bacterial excursions occur or may occur

Municipal wastewater land application permits should include a total coliform maximum limit, in addition to the median limit. For compliance, using the median value allows a certain number of individual samples to have unlimited bacteria counts. Including a single sample maximum value provides needed public health protection, and requires facilities to monitor their disinfection systems more closely. See Table 7-11 for suggested maximum limits according to wastewater category.

Municipal permits typically have hydraulic loading rates be calculated on a monthly basis. If a system is having problems managing the site properly, a weekly basis may be more appropriate.

Frequency of wastewater constituent monitoring for industrial wastewater land application facilities is summarized in Table 7-27. Frequency of wastewater constituent monitoring for municipal wastewater land application facilities is summarized in Table 7-28.

7.5.5 Sampling and Sample Location Determination

7.5.5.1 Sampling

Detailed information for developing a wastewater sampling program is found in Section 7.1.6 in the context of development of the quality assurance project plan (QAPP). The publication, *Monitoring Industrial Wastewater*, EPA, 1973, can also be consulted. The information is also applicable to municipal wastewaters. There are several types of wastewater samples that can be collected: *grab*, *composite*, and *continuous sampling*, all of which are discussed in the following.

The wastewater sample type will depend on several factors:

- The parameter to be monitored.
- The temporal and spatial variability of the wastewater sampled; and
- The type of limit. Limits based on instantaneous or one hour values may be sampled using grab sampling techniques. Limits based on average values or daily maximums may be sampled using time or flow proportional composite samples. This is acceptable for certain conventional pollutants, nutrients, and bio-accumulative pollutants, for which percent removal and total loading to the receiving water are of concern.

7.5.5.1.1 Discrete Grab or Sequential Grab Samples

A wastewater grab sample is an individual sample collected in less than 15 minutes time. It represents more or less "instantaneous" conditions as discussed in Section 7.1.4. Grab samples should be used when:

- Wastewater characteristics are relatively constant.
- The parameters to be analyzed are likely to change with storage such as temperature, dissolved gasses, residual chlorine, soluble sulfide, cyanides, phenols, microbiological parameters and pH.
- The parameters to be analyzed are likely to be affected by the compositing process such as oil,grease, and volatile organic compounds.
- Information on variability over a short time period is desired.
- Composite sampling is impractical or the compositing process is liable to introduce artifacts of sampling.
- The spatial parameter variability is to be determined. For example, variability through the cross section and/or depth of a stream, lagoon or other large body of water.
- Wastewater flows are intermittent from well-mixed batch process tanks. Each batch dumping event should be sampled.

Another type of grab sample is sequential sampling. A special type of automatic sampling device collects relatively small amounts of a sampled stream, with the interval between sampling either time or flow proportioned. Unlike the automatic composite sampler, the sequential sampling device automatically retrieves a sample and holds it in a bottle separate from other automatically retrieved samples. Many individual samples can be stored separately in the unit, unlike the composite sampler, which combines aliquots in a common bottle. This type of sampling is effective for determining variations in media characteristics over short periods.

7.5.5.1.2 Composite Samples

As discussed in Section 7.1.4, a composite sample consists of a series of individual samples collected over time into a single container, and analyzed as one sample. Composite sampling is employed when time or flow-weighted constituent concentration averages are needed (see below), or when mass per unit time information is needed. There are two general types of composite samples.

- **Time composite samples** collect a fixed volume at equal time intervals and are acceptable when flow variability is not excessive. Automatically timed composited samples are usually preferred over manually collected composites. Composite samples collected by hand are appropriate for infrequent analyses and screening. Composite samples can be collected manually if subsamples have a fixed volume at equal time intervals when flow variability is not excessive.
- **Flow-proportional compositing** is usually preferred when Wastewater flow volume varies appreciably over time. The equipment and instrumentation for flow-proportional compositing have more downtime due to maintenance problems. When manually compositing Wastewater samples according to flow where no flow measuring device exists, use the influent flow measurement without any correction for time lag. The error in the influent and wastewater flow measurement is insignificant except in those cases where extremely large volumes of water are impounded, as in reservoirs. Use composite samples when either determining average concentrations, or calculating mass loading/unit of time.

There are numerous cases where composites are inappropriate. Samples for some parameters such as pH, residual chlorine, temperature, cyanides, volatile organic compounds, microbiological tests, oil and grease, and total phenols should not be composited. They are also not recommended for sampling batch or intermittent processes. Grab samples are needed in these cases to determine fluctuations in wastewater quality.

The compositing time period and frequency of aliquot collection should be determined. Whether collected by hand or by an automatic device, the time frame within which the sample is collected should be specified in the permit. The number of individual aliquots which compose the composite should also be specified. A minimum of four aliquots during a 24-hour period is common for wastewater composite samples.

7.5.5.1.3 Continuous Monitoring

Continuous monitoring is another option for a limited number of parameters such as total organic carbon (TOC), temperature, pH, conductivity, fluoride and dissolved oxygen. Reliability, accuracy and cost vary with the parameter. Continuous monitoring can be expensive, and has limited applicability to wastewater land treatment facilities. The environmental significance of the variation of any of these parameters in the wastewater should be compared to the cost of continuous monitoring equipment available.

Process control monitoring has been generally discussed both in Section 7.1.1 and Section 7.4.3.2. It refers to monitoring of internal waste streams in order to verify that proper waste treatment or control practices are being maintained. The wastewater treatment process will determine the types of process control monitoring needed.

Additional sampling information is given in the *Handbook for Sampling and Sample Preservation of Water and Wastewater*, EPA (1982).

7.5.5.2 Sampling Location Determination

Permanent sampling locations should be determined and identified in permit application materials. The permit applicant should provide a description of the wastewater sampling station location and in most cases, a line drawing and description of the flows and processes involved in wastewater treatment.

The point at which a sample is collected can make a large difference in the monitoring results. Important factors to consider in selecting the sampling station are:

- The flow at the sampling station should be measurable.
- The sample should be representative of the wastewater during the time period which is monitored.
- If possible, the sample should be collected where the wastewater is well-mixed. Therefore, the sample should be collected near the center of the flow channel, at a depth of approximately half the total depth, where the turbulence is at a maximum and the possibility of solids settling is minimized. Acceptable sampling locations can include near a Parshall flume or at a location in a sewer with hydraulic turbulence. Weirs tend to enhance the settling of solids immediately upstream and the accumulation of floating oil or grease immediately downstream. Such locations should be avoided for sampling.
- Skimming the water surface or dragging the bottom should be avoided.
- In sampling from a mixing zone, cross-sectional sampling should be considered. Dye may be use as an aid in determining the most representative sampling points.
- If manual compositing is employed, the individual sample bottles must be thoroughly mixed before pouring the individual aliquots into the composite container.

It is often convenient to combine a flow measurement station with a sampling station. When flumes are used for flow measurement, the sample is usually well mixed. Wastewater samples should be collected at a location which represents wastewater quality which is to be land applied. More than one wastewater sampling station may be necessary for two separate wastewater streams which are not mixed, but are land applied separately.

7.5.6 Analytical Methods

Table 7-29 presents analytical methods which are recommended for wastewater monitoring. Where more than one method is given, employ the method appropriate for the type of sample, its concentration range, the availability of equipment, and necessary detection limit. As discussed in Section 7.1.5, practical quantitation limits (PQLs) reported by the laboratory should be appropriate for constituents which have regulatory limits. The following references can be consulted for further information on wastewater analytical methods; EPA (1979/1983), Greenberg et al. (1992), Bordner and Winter (1978), and AOAC (1990).

For chlorine residual "free" chlorine should be specified. Metcalf & Eddy (1991) states "the main reason for adding enough chlorine to obtain a free chlorine residual is that usually disinfection can then be ensured." Chlorine residual monitoring and monthly reporting should be required in permits.

7.5.7 Quality Assurance and Quality Control

As discussed in Section 7.1.6.1, the facility should have a quality assurance project plan (QAPP). For more information on the development of a QAPP, refer to Section 7.1.6.

7.5.8 Data Processing, Verification, Validation, and Reporting

As with other types of monitoring, the system's permit will specify what parameters to monitor, when to monitor, and when results must be submitted. When reporting wastewater monitoring data, describe the sampling location and use the monitoring serial numbers designated in the permit.

Municipal permits should generally require monthly reports for hydraulic loading rates, chlorine residual, and total coliform. The need for this should be determined by the regional office. If monthly reports are necessary to maintain adequate system oversight, it can be specified in the permit.

7.5.9 References

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7.6 Crop Monitoring and Yield Estimation

7.6.1 Monitoring Objectives

Crop monitoring includes maintaining chronology of cropping activities, plant tissue monitoring, and crop yield estimation. Cropping activity chronology would include dates of planting, harvest, tillage operations, fertilizer application, and dates where crop health was observed (CLFP, 2002 p. 10-18). Crop yield estimation is important to calculate crop uptake of nutrients and salts for regulatory compliance purposes.

Plant tissue monitoring is generally used to ascertain the nutrient status of a growing crop for managing fertilizer applications for maximizing crop yield and quality – i.e. for nutrient sufficiency and deficiency determination. Plant tissue monitoring is also conducted to determine feed value, nutrient toxicity and, in certain instances, the presence and concentration of toxic compounds, of a harvested crop.

The purpose of plant tissue monitoring as it pertains to permitted wastewater land treatment facilities is to determine crop uptake of nutrients and other constituents, and their removal from the treatment acreage. Crop uptake monitoring is discussed primarily in this section. Crop uptake monitoring data are used in nutrient and other constituent balance calculations in order to help characterize constituent losses to the environment. For example, if it is known how much nitrogen is in the soil in early spring, the amount of nitrogen applied in wastewater and fertilizers, how much is in the soil after harvest, and how much is taken up and removed by the crop, the difference represents losses of the constituent to the environment. Such loss estimates can then be partitioned into various pathways of loss, such as leaching and atmospheric losses. Estimates of leaching losses can then be used in conjunction with site-specific environmental data and modeling to help characterize the potential and degree of environmental impacts, such as those to ground water.

7.6.2 Monitoring Instrumentation

See Section 7.6.5.1 for description of sampling equipment used for plant tissue monitoring.

7.6.3 Monitoring Parameters

Parameters of interest for plant tissue monitoring at wastewater land application facilities include nitrogen, phosphorus, and some measure of inorganic salts.

7.6.3.1 Nitrogen

Nitrogen in plant tissue is typically measured from TKN analyses. TKN measures reduced forms of nitrogen in plant tissue including proteins and nitrogen in cellular tissues. The TKN analyses does not measure nitrate in plant tissue, so nitrate should be analyzed as well.

Nitrate concentrations in plant tissue can be significant in crops which have been grown with an abundance of supplied nitrogen. The presence of elevated nitrate levels in plant tissue can indicate that luxury consumption – crop uptake above the amount of nutrient a crop would normally need to take up to satisfy growth and development demands – has likely occurred.

Alternately, elevated nitrate levels in plant tissue can indicate nutrient stress; moisture stress; or cloudy, cool weather that can cause slow metabolism of nitrate to ammonia in the synthesis of amino acids in the plant.

Nitrate is also important to characterize because it can be toxic to animals. Lethal dose is determined by the nutritional state, size, and type of animal; and consumption of feed other than nitrate-containing material:

- Ruminant animals are most sensitive to nitrate intake, because nitrate is converted to nitrite in the rumen and nitrite binds and inactivates hemoglobin in the bloodstream.
- Concentrations of less than 1,000 mg/kg in the feed ration are acceptable for all cattle.
- Concentrations greater than 2,000 are not suitable for the entire feed ration and should be blended with other feed.
- Potentially lethal level of nitrate-nitrogen in animal feed is over 2,100 mg/Kg (Ensminger et al., 1990).

Nitrate in plant tissue can be chemically reduced to benign forms by green-chopping and ensiling and crop. This is a common practice at many wastewater land treatment facilities, not only for the removal of nitrate, but to achieve rapid removal of the harvested crop so that wastewater land treatment activities can proceed with only minimal delays.

7.6.3.2 Phosphorus

Phosphorus is also important to assess in plant tissue. A significant amount of phosphorus can be taken up by the crop and removed at harvest. Accounting for these amounts is important when determining permit limits for phosphorus loading to land application sites.

7.6.3.3 Salts

Inorganic salts are important to assess in plant tissue. Accounting for inorganic salt uptake in crops can be significant when modeling salt (i.e. TDS) impacts to ground water. The ash content of plant tissue is assumed to represent these salts. A significant amount of inorganics are taken up by the crop and removed at harvest.

7.6.4 Monitoring Frequency

Plant tissue monitoring for obtaining data for nutrient and other constituent balances is done at harvest. For hay crops, each cutting is a harvest, so samples should be obtained from each cutting and each hydraulic management unit. For crops that are harvested once at the end of their respective growing seasons, sampling should take place then.

7.6.5 Sampling and Sample Location Determination

7.6.5.1 Sampling

Only the plant parts that are removed from the site need be sampled. In the case of a hay crop, the entire plant top is cut and removed, so the entire plant should be sampled. In the case of small grains, if the grain and stover (above-ground plant parts excluding the seed) are both harvested and removed, both should be sampled. If the stover is left on site, then only the grain should be sampled.

CES (1997) outlines plant tissue sampling methods, which are summarized here. Plant tissue samples of green, growing crops such as forages should be taken immediately prior to harvest. Sampling forage crops immediately prior to harvest can result in 10 to 20 percent higher nitrogen levels because of plant tissue degradation following harvest. Samples should be collected to be representative of the crop at the time of harvest or just prior to harvest. Sampling of small areas of the field where plants are under severe moisture or temperature stress is not recommended. Plants that are dust covered, mechanically injured, diseased, or dead should not be sampled (Walsh and Beaton, 1973). The exception to this is when mechanical injury, disease or crop death is representative of the material being harvested. Crop tissue should be tested in these cases.

Samples should be collected at random locations in the hydraulic management unit. Specific crop types require particular sampling methods. For harvested grain, bean, silage or green chop, one grab sample from each day of harvest should be collected. They should be placed in paper bag and refrigerate, then mixed and a composite sample (1 liter wet or ½ liter dry) sent to the laboratory. For bailed hay, collect three composite samples from each harvest from each field. Each hay sample should be composited from at least ten cores from the ends of randomly selected bales. Then mix and send to the laboratory.

Potatoes require special sampling methods due to their size and the presence of two harvested plant parts, namely the potato and the vines. Collect on grab sample per day during harvest consisting of at least five potatoes. Quarter each potato and discard three of the quarters. Retain one quarter from each potato for a daily grab sample. Keep subsamples refrigerated and send all quarters to the laboratory for analysis. If the potato vines are to be burned, vine yield and nutrient (nitrogen only) uptake by the vines should be measured. Collect the vines from three four-foot sections of row in four locations in each hydraulic management unit (CES, 1997). Then reduce the sample size by splitting the pile of collected vines prior to shipping to the laboratory. Refrigerate after sampling and send at least 1 liter, but preferably one gallon, of volume of sample to the laboratory.

For forage crops, each sample should consist of the clippings from a minimum ten square feet of area. A square wooden frame or a wire whoop placed on the forage is effective to delineate the area to be sampled. The frame should be randomly dropped along a transect or grid pattern. The plants should be clipped within the frame at the same level that would result from the mechanical harvesting equipment. Hand operated or other clippers may be used.

Place each composite sample in a large paper bag so the sample can 'breath' (some sources recommend a perforated plastic bag). Put the sample in a cool place and deliver to the laboratory within two hours (CES, 1997). Ship or store samples in a chilled cooler if delivery in two hours cannot be accomplished. Delivery within 24 to 48 hours is acceptable if samples are kept dry and chilled in 'breathable bags. Illinois (No Date) recommends a quick washing of plant tissue in a 0.1 – 0.3 percent non-phosphate containing detergent accompanied by three rinses in de-ionized water, in order to remove any dust, fertilizer, pesticide or other residues from the leaf surfaces.

As an alternative to collecting and transporting fresh plant tissue samples to the laboratory within short time-frames, samples may be dried in a clean muslin bag or tray inside a forced draft oven at 65 C for 48 hours. Tissue samples may then be ground after drying and placed in a bottle and allowed to dry for an additional 24 hours at 65 C. After this, samples are ready for analyses (Illinois, No Date). Walsh and Beaton (1973) may be consulted for further information regarding plant tissue sampling and analyses.

7.6.5.2 Sampling Location Determination

As mentioned in 7.6.4, each harvest of every crop on a hydraulic management unit should be sampled. Sampling within the hydraulic management unit is addressed in 7.6.5.1.

7.6.6 Analytical Methods

Table 7-12 presents analytical methods that are recommended for plant tissue sample analysis.

Table 7-12. Plant Tissue Analyses.

Parameter	Abbreviations	Units	Recommended Methods(1)
Crude Protein	--	% by weight	TKN * factor(2)
Total Kjeldahl Nitrogen	TKN	% by weight	978.04
Total Combustible Nitrogen	TCN	% by weight	990.03 Note: This method yields results comparable to TKN above and is becoming more commonly used.
Nitrate + Nitrite	NO3 + NO2	% by weight	968.07
Ash	--	% by weight	930.04
Moisture	--	% by weight	930.05

1. Association of Official Analytical Chemists, Official Methods of Analysis (AOAC). 1990 15th Edition. All methods cited in this appendix are recommended methods. Other comparable methods yielding the same interpretive results are acceptable unless otherwise stated in the Wastewater Reuse Permit.
2. Use 6.25 for mixed feeds and forages; 5.72 for grains.

7.6.7 Quality Assurance and Quality Control

As discussed in Section 7.1.6.1, the facility should have a quality assurance project plan (QAPP). For more information on the development of a QAPP, refer to Section 7.1.6.

7.6.8 Data Processing, Verification, Validation, and Reporting

As with other types of monitoring, the facility's permit will specify what parameters to monitor, when to monitor, and when results must be submitted. When reporting plant tissue monitoring data, describe the sampling location (hydraulic management unit) and use the monitoring serial numbers designated in the permit.

7.6.9 Crop Nutrient Content Reference Values

Wastewater land treatment sites that are loaded at agronomic rates or up to 150% of the agronomic rate are often required to have crop chemical analyses performed and make crop nutrient removal calculations. It may be appropriate for certain sites loaded at or below agronomic rates to use crop nutrient concentration values found in standard tables. Table 7-30 compiles nitrogen contents of a wide variety of crops. Sources of the data are documented in the footnotes. These sources include Follett et al. (1991), Fonnesbeck et al. (1984), NRCS (June 1999), and DEQ (1988). Ducnuigeen et al. (1997), Tables B-1, B-2, and B-3 provide a comprehensive source of non-crop species nitrogen and phosphorus uptake information. These tables are found at the following Web site:

http://www.potomacriver.org/info_center/publicationspdf/ICPRB97-4.pdf.

Table A-2 of Martin et al. (1976) provides typical ash, nitrogen, phosphorus, and moisture content information for cereal crops. Table A-1 of Martin et al. (1976) gives weight per bushel information for cereal crops. The USDA NRCS web site

http://www.nrcs.usda.gov/technical/land/pubs/nlapp1a.html

also provides nitrogen, phosphorus and potassium uptake rates. Bushel weights of common commodities are also found in Table 31 of Midwest Laboratories (No Date).

Typical yields for common Idaho crops by county and by year can be obtained from the Idaho Department of Agriculture, Agricultural Statistics Division. A useful Web site is the following:

http://www.nass.usda.gov:81/ipedbcnty/c_groupcrops.htm

7.6.10 Crop Yield Estimation

CES (1997) provides guidance on how to estimate crop yields from wastewater land treatment sites. This guidance is summarized here. The date of harvest should be recorded, as should the harvest method (bale, green chop, other) and crop type. The crop yield from each harvest, such as multiple cuttings, should be recorded. For forage crops, either the total measured weight method or average bale weight methods can be used, as discussed below. Both methods require the measurement of moisture content of the harvested material to calculate dry weight.

7.6.10.1 Total Measured Weight Method

The total measured weight method requires each truckload of harvested material to be weighed. This method is best suited to crops that are immediately removed from the field, including corn grain, corn silage small grains, potatoes, and green chopped hay.

The methodology is as follows:

(1) Measure each full truckload weight and empty truckload weight. The difference is the individual truckload weight of harvested material.

(2) Sum all individual truckload weights to obtain total harvested weight.

(3) Calculate the total dry matter weight as follows:

a. Total harvested weight (lbs) * (1 – moisture content expressed as a fraction) = total dry matter content (lbs)

b. Convert total dry matter to average yield as follows:

(4) Total dry matter content (lbs) divided by field size (acres) = average yield (lb/acre)

7.6.10.2 Average Bale Weight Method

The average bale weight method is best suited for forage crops or other crops removed in uniform discrete units. This method involves weighing at least 20 randomly chosen bales or one truck load of at least 20 randomly chosen bales. The average weight per bale of these bales is then calculated from individual bale weights. The total harvest weight consists of counting the number of bales from a field and multiplying by the average weight per bale. The total harvest weight of the field is converted to total dry matter weight and average yield in the manner described in items c. and d. in Section 7.6.10.1 above.

7.6.11 References

AOAC. Association of Official Analytical Chemists, Official Methods of Analysis. 1990 15th Edition.

CES. Cascade Earth Sciences, October 1997. Process Water Irrigation Systems: Design and Management. Soil and Crop Monitoring.

CLFP. California League of Food Processors. September 20, 2002. Final Report: Manual of Good Practice for Land Application of Food Process/Rinse Water for California League of Food Processors. Brown and Caldwell, Kennedy Jenks, Komex H_2O Science.

Ducnuigeen, J., K. Williard, and R.C. Steiner. September 1997. Relative Nutrient Requirements of Plants Suitable for Riparian Vegetated Buffer Strips. Interstate Commission on the Potomac River Basin. ICPRB Report Number 97 – 4.

Ensminger, M.E., J.E. Oldfield, and W.W. Heinemann. 1990. Feeds and Nutrition Digest. Second Edition. The Ensminger Publishing Company, Clovis, California. Page 103.

Fonnesbeck, P.V., H. Lloyd, R. Obray, and S. Romesburg. 1984. International Feed Institute Tables of Feed Composition. Intl. Feedstuffs Inst. Utah State Univ., Logan.

Follett, R.F., Keeney, D.R., and Crose, R.M., 1991. Managing Nitrogen for Ground Water Quality and Farm Profitability.

IDHW-DEQ. Idaho Department of Health and Welfare, Division of Environmental Quality. 1988. Guidelines for Land Application of Municipal and Industrial Wastewater.

Illinois, State of. No Date. Administrative Code, Title 35: Environmental Protection; Chapter II: Environmental Protection Agency; Part 391: Design Criteria for Sludge Application on Land; Section 391.530: Plant Tissue Sampling and Analyses.

Martin, J., W.H. Leonard, and D.L. Stamp. 1976. Principles of Field Crop Production – Third Edition. Macmillan Publishing Company, Inc. 1118 pp.

Midwest Laboratories. No Date. Agronomy Handbook. 132 pp.

USDA-NRCS. National Resource Conservation Service. National Engineering Handbook June 1999. Part 651, Agricultural Waste Management Field Handbook. U.S. Gov. Print. Office, Washington, DC.

Walsh, L.W., and J.D. Beaton (eds), 1973. Soil Testing and Plant Analysis, Revised Edition. Soil Science Society of America, Inc.

7.7 Supplemental Information

7.7.1 General Discussion Supplemental Information

The following supplemental information provides additional information on determining sample size and a recommended QA/QC Plan outline.

7.7.1.1 Statistical Methodology for Determining Sampling Frequency

The following is a method to calculate the sample size (related to sample frequency) required to meet specified accuracy and confidence levels when characterizing the chemistry of wastewater. This methodology is incorporated into the wastewater sampling frequency spreadsheet, *WW_Sampling_Frequency_Tool.xls*. This methodology may be used for determining sampling frequencies of other sampled media as well.

In the spreadsheet, wastewater chemical oxygen demand (COD) concentration from a potato processing WLAP site is used as example data. The true mean is usually unknown, so it is estimated by a flow-weighted average, using:

$$\hat{\mu} = \frac{\sum_{i=1}^{m} Q_i C_i}{\sum_{i=1}^{m} Q_i}$$

Equation 7-1Estimating mean using a flow-weighted average.

Where:

$\hat{\mu}$ = estimated mean or flow weighted average

Q_i = the flow rate in the i^{th} time interval

C_i = the i^{th} constituent concentration

m = the total number of observations

In the *WW_Sampling_Frequency_Tool.xls* spreadsheet, the time interval is one day, therefore i = 1, 2, ..., 366. The weighted average of COD concentration (mg/l) is shown in cell C372 of the Data Input worksheet. Sum (Q_i), the total flow rate (MG), is shown in cell B371 of the *Data Input* worksheet.

Sample size, n, is calculated based on:

$$n = \frac{z^2{}_{\alpha/2} s^2}{B^2}$$

Equation 7-2. Calculating sample size.

Where:

n = sample size required. On the *Stat Output* worksheet of the WW_Sampling_Frequency_Tool.xls, the required n is rounded to the next larger integer value of the calculated n.

$z_{\alpha/2}$ = the $(\alpha/2)^{th}$ percentile of the standard normal distribution

α = the significance level, the confidence level is (1-α)100%. Conventionally, α is specified at 0.05, which gives 95% confidence interval of the estimated parameter. Other confidence levels may be more appropriate depending upon the medium, parameter, and purpose of the data.

s = standard deviation of the sample

B = maximum allowable error in the estimation of the mean and is denoted either by percentile of the mean or as an absolute value.

The *Stat Output* worksheet provides several maximum errors, in estimating the mean (B) and confidence levels, to choose from, and their corresponding sampling frequency requirements (n). An example of the spreadsheet output is shown in Figure 7-4.

Sample Frequency Statisical Output Calculations

Sample size (n) based on different levels of accuracy and confidence
error allowable (B) is taken as percentage of the mean.
following is based on COD, note that final n should be rounded to the
next large integer

				confidence level				
B (% mean)	B	Upper	Lower	80%	85%	90%	95%	99%
5	144	3028	2739	99	126	164	233	401
10	288	3172	2595	25	32	41	59	101
15	433	3316	2451	11	14	19	26	45
20	577	3460	2307	7	8	11	15	26
25	721	3604	2163	4	6	7	10	17
30	865	3749	2019	3	4	5	7	12

Notes:
1) 'B' is the maximum error about the mean one is willing to accept, as expressed as a percent of the mean concentration or as expressed as a number (column B).
2) The upper and lower bounds from the mean with a given 'B' are shown in columns C and D.
3) Need >20 data points; assume normality of data. Use data from several years if necessary to obtain 20 data points.

Figure 7-4. Example of Statistical Output of the Spreadsheet: WW_Sampling_Frequency_Tool.xls

7.7.2 Recommended Contents for a Facility Quality Assurance/Quality Control Plan

Revision 1 12/12/05

Template for Quality Assurance Project Plan

Prepared: March 30, 2001

EPA Documents Relevant to Preparation of a Quality Assurance Project Plan

EPA Order 5360.1 CHG 1, **Policy and Program Requirements for the Mandatory Agency-Wide Quality System** requires that guidelines in ANSI/ASQC E4-1994 AMERICAN NATIONAL STANDARD **Specifications and Guidelines for Quality Systems for Environmental Data Collection and Environmental Technology Programs**, and EPA QA/R-5, EPA **Requirements for Quality Assurance Project Plans** be used in describing a quality management system.

1

Revision 1 12/12/05

1.1 Title and Approval Page

Project Title

Organization
Address
Town, State

Revision: 0
Date:

Applicant Approval:

Approval Signature:
Phone:

IDEQ Acceptance and Approval:

Organization Title: Idaho Department of Environmental Quality

Address: 1410 North Hilton St. Boise, ID 83706

IDEQ Approval:

Approval Signature:
Phone:

2

1.2 Table of Contents

1.0 Project Management

1.3 Distribution List

1.4 Project/Task Organization

1.5 Problem Definition/Background

1.6 Project/Task Description and Schedule

1.7 Quality Objectives and Criteria for Measurement Data

1.8 Special Training Requirements/Certification

1.9 Documentation and Records

2.0 MEASUREMENT / DATA ACQUISITION

2.1 Sampling Process Design

2.2 Sampling Methods Requirements

2.3 Sample Handling and Custody Requirements

2.4 Analytical Methods Requirements

2.5 Quality Control Requirements

2.6 Instrument/Equipment Testing, Inspection, and Maintenance Requirements

2.7 Instrument Calibration and Frequency

2.8 Inspection/Acceptance Requirements for Supplies and Consumables

2.9 Data Acquisition Requirements (Non-direct Measurements)

2.10 Data Management

3.0 ASSESSMENT / OVERSIGHT

3.1 Assessments and Response Actions

3.2 Reports to Management

4.0 DATA VALIDATION AND USABILITY

4.1 Data Review, Validation, and Verification Requirements

4.2 Validation and Verification Methods

4.3 Reconciliation with User Requirements

7.7.3 Ground Water Monitoring Supplemental Information

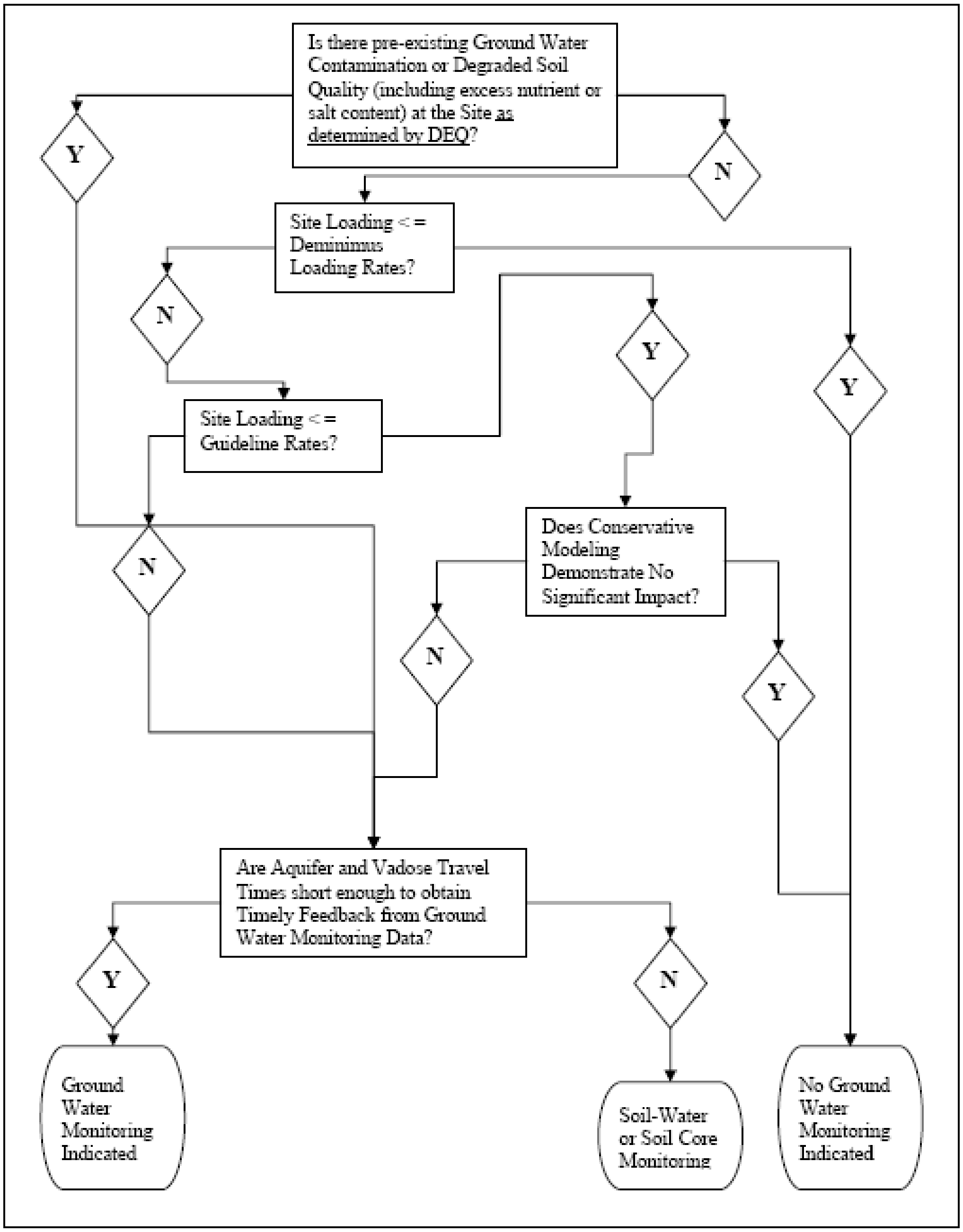


Figure 7-5. Decision Flowchart to Determine Whether Ground Water Monitoring is Needed at a Wastewater Land Application Site

7.7.3.1 Monitoring Well Construction

Details regarding the construction of monitoring wells are found here. Included are discussions of drilling methods; selection of screened interval depths; casing materials; seals, packing and grouting; and monitoring well development.

7.7.3.1.1 Drilling Methods

There is a variety of different types of drilling methods. Care should be taken to minimize the introduction of contaminants into the borehole during drilling since this may compromise the analytical results of the ground water quality samples collected from this well. Table 7-13, summarizes the most common drilling methods.

Table 7-13. Drilling Methods.

Method	Environment	Advantages	Disadvantages
Hollow-stem continuous flight auger	Glaciated or unconsolidated materials (< 150 ft)	mobile fast inexpensive no drilling fluids minimal disturbance to formation	cannot be used in loose large cobbles drilling depth 150 ft
Cable tool	Glaciated or unconsolidated materials (any depth), Consolidated formations (any depth), excellent for glacial till, effective in boulder Environments	excellent for formation sample collection minimal water used easy detection of water table driven casing seals well, preventing cross contamination	relatively slow minimum size diameter limited to 6 inches difficult to collect rock samples
Air rotary (with foam)	Consolidated or unconsolidated formations, no depth limitations	quick and efficient core samples easily collected	introduction of air to ground water may alter chemistry foam may interfere with organic and inorganic parameters (1) loss of circulation in fractured or high permeability zones potential to miss saturated zone
Bucket auger	Fine grained formations, Shallow (< 100 ft), large diameter wells, difficult in boulder environment	less well development is required less potential for cross contamination	disturbs large areas of the formation
Solid-stem continuous flight auger (generally not recommended)	Glaciated or unconsolidated materials (< 150 ft)		limited to unconsolidated fine grained materials drilling depth 150 ft. difficult to collect formation samples

Method	Environment	Advantages	Disadvantages
Reverse circulation rotary (generally not recommended)	Consolidated formations	formation sampling	limited applications uses large quantities of water
Mud rotary (generally not recommended)	Consolidated formations to any depth	fast drilling flowing artesian conditions can be managed.	mud and water circulated through borehole difficult to completely remove all mud mud may contain organic matter high potential for cross contamination may alter ground water chemistry may alter permeability

Notes:

(1) The effects of air injection would not be long-lived if the well is developed properly. Foams approved for potable water wells by the National Sanitation Foundation would not be problematic if used according to specifications.

(2) Not listed in order of preference.

7.7.3.1.2 Screened Interval

The depth and the length of the screen interval of a well should ensure that the samples will be obtained from the portion of the aquifer that will detect the earliest impacts of wastewater land treatment on ground water quality. For the majority of sites, this will be the uppermost portion of the uppermost aquifer.

This element of well construction is site specific, depending upon the contaminants of concern (typically nitrate, total dissolved solids (TDS), iron, manganese, and chloride) and the characteristics of the aquifer. Contaminants may be confined to narrow zones within an aquifer. Table 7-14 describes the advantages and disadvantages of both short and long well screens. In situations where it may not be sufficient to monitor all contaminants with a single well, multiple wells, or well clusters may be installed.

Table 7-14. Advantages and Disadvantages of Short and Long Well Screens.

Well Screen Type	Advantages (+) and Disadvantages (-)
Short well screens (2-5 feet)	+ Allow discrete sampling of the formation. targeting contaminants concentrated at specific depths. + Isolate a single flow zone. - Does not allow for substantial vertical dilution in the borehole. + Easier to detect increases in contaminant concentrations. - Not appropriate for long-term monitoring in aquifers with declining water levels.
Long well screens (10-20 feet)	+ Ideal for aquifers whose potentiometric surface fluctuates dramatically. + Allow sufficient quantities of water to enter the borehole in low-permeability aquifers.

Multiple wells installed with well screens at various depths are appropriate when the aquifer is heterogeneous, when the site geology is complex, when there are fractures or faults present, when multiple aquifers will be affected, when there is a perched aquifer, or when the aquifer is discontinuous, (EPA, 1986).

In areas with extreme water table fluctuations, more than one monitoring well may be needed, so that the water table can be adequately sampled. For example, in paired wells, the upper and lower screens should be 10 to 15 feet in length for the shallow and deep well respectively. The bottom of the upper screen of the shallow well should end where the top of the lower screen of the deeper well begins. All monitoring wells, particularly multiple wells, must be designed and installed to prevent cross contamination of aquifers.

A single well is usually sufficient if the aquifer is homogeneous, the geology is simple, and there are few contaminants. For most applications at wastewater land treatment facilities, the screened interval should be placed in the uppermost water-bearing zone. The length and positioning of the well screen below land surface must be such that the static water table is never above the uppermost or below the lowermost screen openings at any time of the year (Figure 7-6). Screen settings that do not meet this criteria result in either "dry" wells (i.e., the water table is below the screen, precluding collection of a sample) or a situation where the layer of dissolved contaminants in the groundwater may be above the zone where the sample is collected (i.e. the water table is above the uppermost screen openings). As a rule of thumb, monitoring wells should be screened in the top 10 to 15 feet of this uppermost water-bearing zone, with adequate screen above the water table to allow for seasonal water table fluctuations.

Well diameters are generally 2-inch or 4-inch, whichever is sufficient to accommodate the sampling pump. Two-inch or smaller casing material may be used for wells that are sampled using low-flow sampling methods. One problem with two-inch wells is that pump tests cannot be run. Four-inch wells are generally adequate to run pump tests.

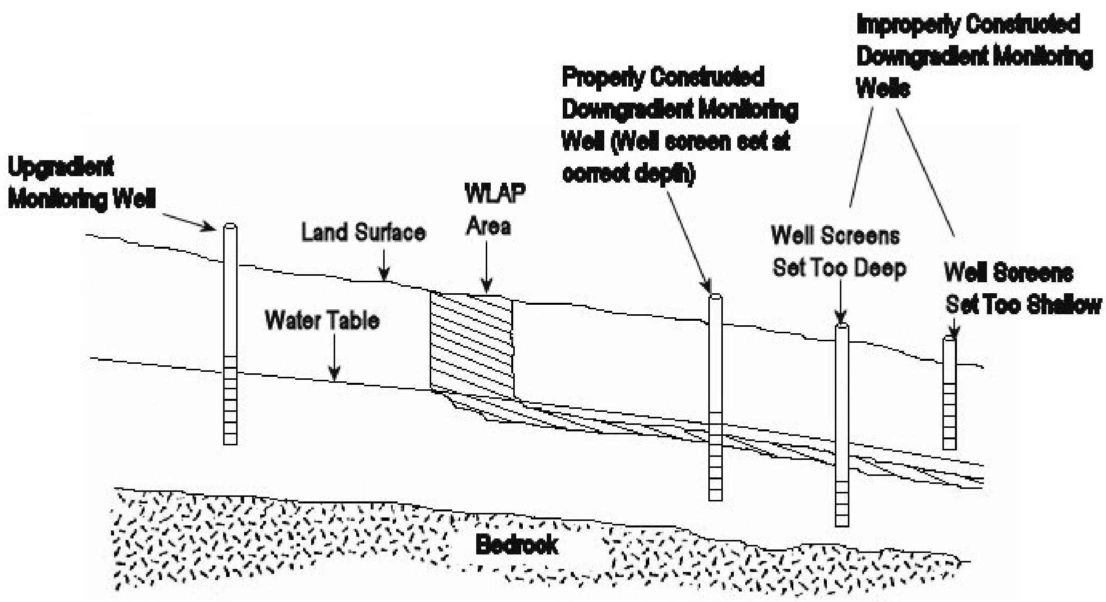


Figure 7-6. Proper and Improper Placement of Screens for Monitoring Wells (State of North Carolina, 2001).

The screen and sand pack material should be selected so that the well can be developed with minimal sediment production over the life of the well. Casing and screen material should be designed to last for the duration of the monitoring program. ASTM D 5092-90 may be used as a guide for selection of casing and screen material. Screen slot size should be determined relative to the interval to be monitored so that the well will produce sediment-free water for the life of the well. (See Driscoll 1987, page 395 and the following pages for further discussion.)

7.7.3.1.3 Casing Materials

A monitoring well is literally an intrusion of foreign material into the subsurface for investigative purposes. It is important to consider chemical reactions between any foreign matter introduced into the aquifer with water chemistry. Typically, care is given to assuring that the well casing and screen materials are compatible with the constituents, which may be present in ground water. Casing material should be selected based on the ground water chemistry to avoid corrosion or chemical degradation.

Additionally, the casing material can influence the water quality of the sample by either sorbing contaminants from ground water or leaching contaminants from the casing material into the ground water sample. Table 7-15 describes several types of casing material and the advantages and disadvantages as they are used in a ground water monitoring network:

- PVC (thermoplastic material) is recommended for inorganic samples. Threaded PVC casing and screen should be used, so that glues are not needed; the volatile and semi-volatile constituents in glues may contaminate samples in certain circumstances.
- Stainless steel is recommended for all ground waters, except acidic waters.
- PTFE (fluoropolymer material, i.e., Teflon®)[6] is excellent for all types of ground water and all types of chemical constituents.
- Mild steel is not advocated.

Table 7-15. Monitoring Well Casing Materials.

Casing Material	Suggested Use	Advantages	Disadvantages
PVC (thermoplastic materials) minimum schedule 40 recommended	Inorganic	Lightweight inexpensive available resistant to acids and alkaloids	less rigid than steel may sorb or leach organic chemicals
Stainless steel 304 or 316 recommended	all ground water except acidic waters	strong rigid resistant to corrosion and oxidation available resistant to organic compounds	heavy expensive may corrode in acidic waters may leach Cr, Fe, Ni
PTFE (fluoropolymer materials - Teflon)	excellent for all types of ground waters and all types of chemical constituents	Lightweight inert resistant to most chemicals good for corrosive environments	expensive not readily available
Mild steel not advocated	organic constituents, not recommended for corrosive conditions	strong rigid available	heavy may leach metals not chemically resistant

[6] Teflon® is a registered trademark of E. I. du Pont de Nemours and Company

Other materials used or placed in the borehole should also be made of compatible materials. These materials include welding compounds, bentonite, sand pack materials, centralizers, packers, and grout. Everything placed in the aquifer must come into equilibrium with the water in the formation. This may mean contaminants may be precipitated onto the material or may be dissolved in ground water (Pennino, 1988). Ultimately, the presence of the monitoring well can alter the chemistry of the ground water, therefore care should be taken to minimize its impacts.

Knowledge of the water quality of the well, as it is being constructed, is highly desirable. Such knowledge can affect decisions regarding continued construction, modifications in construction, selection of materials, or in the planned operations of the completed well. Common problems related to well construction and water quality monitoring include water zones to be excluded by casing or grouting; selected casing perforation; choice of casing and screen material; and screen placement. Section 7.7.3.1.3 summarizes the applicability, advantages, and disadvantages of well casing materials.

7.7.3.1.4 Seals, Packing and Grouting

An adequate concrete surface seal, generally 3 feet thick, or more, should be provided around the outer protective casing to prevent migration of contaminants from the surface to the well screen. This surface seal should be sloped away from the well casing.

A sanitary seal should be placed above the filter pack. Bentonite chips or pellets are typically used to provide this seal. Grout (cement or bentonite) should be placed above the sanitary seal, up to where the surface seal will begin.

The sand pack should extend above the well screen to prevent entry of grout and/or bentonite into the screened interval. See Figure 7-7 and Figure 7-8, for general monitoring well design for ground water sample collection at wastewater land application sites and as-built construction details for monitoring well at wastewater land application sites respectively. DEQ (March 2001) has step-by-step instructions for monitoring well construction (Appendix B p 59-61) that should be consulted for specifics.

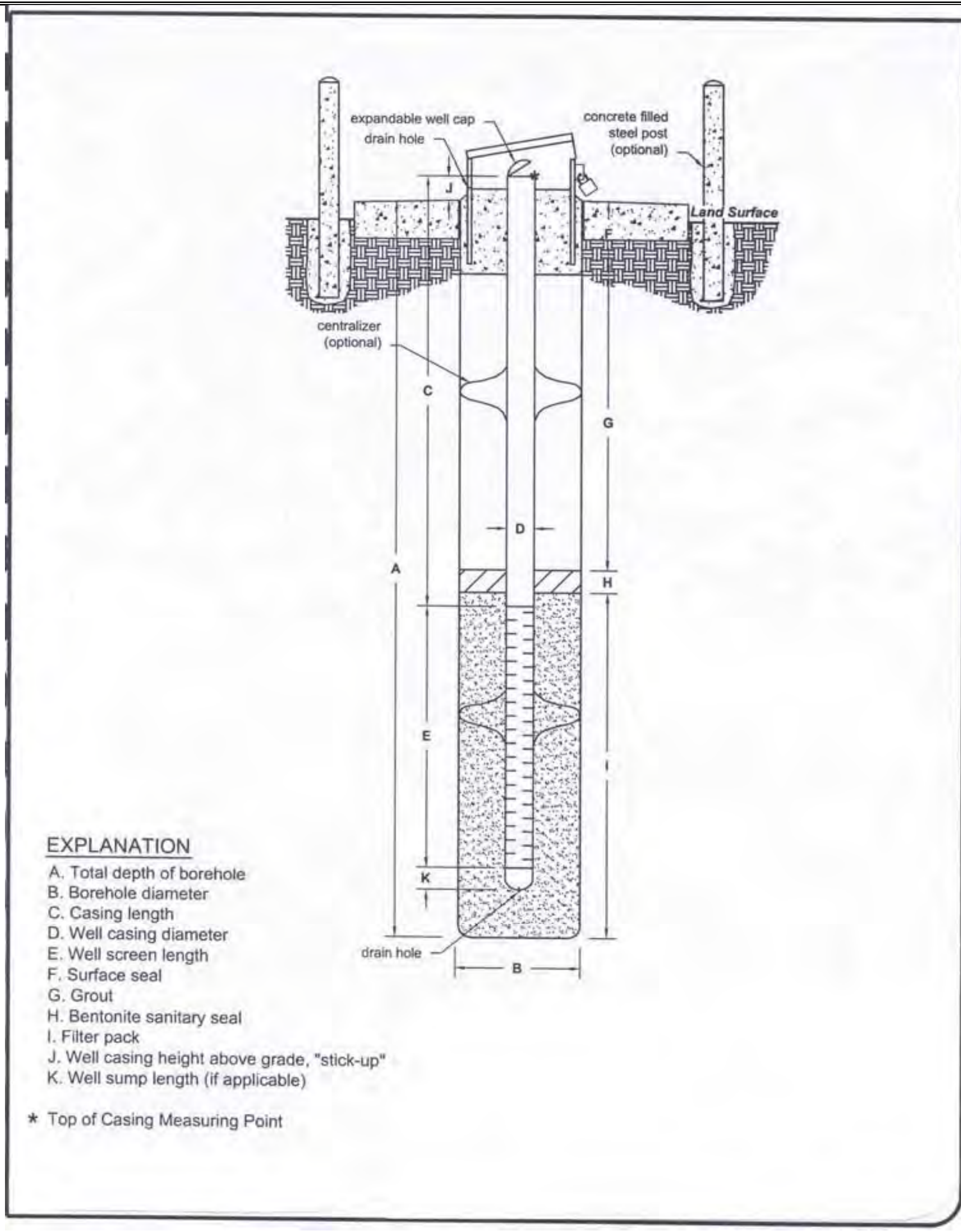


Figure 7-7. General monitoring well design for ground water sample collection at wastewater land application sites.[7]

[7] Reproduced by permission of Cascade Earth Sciences.

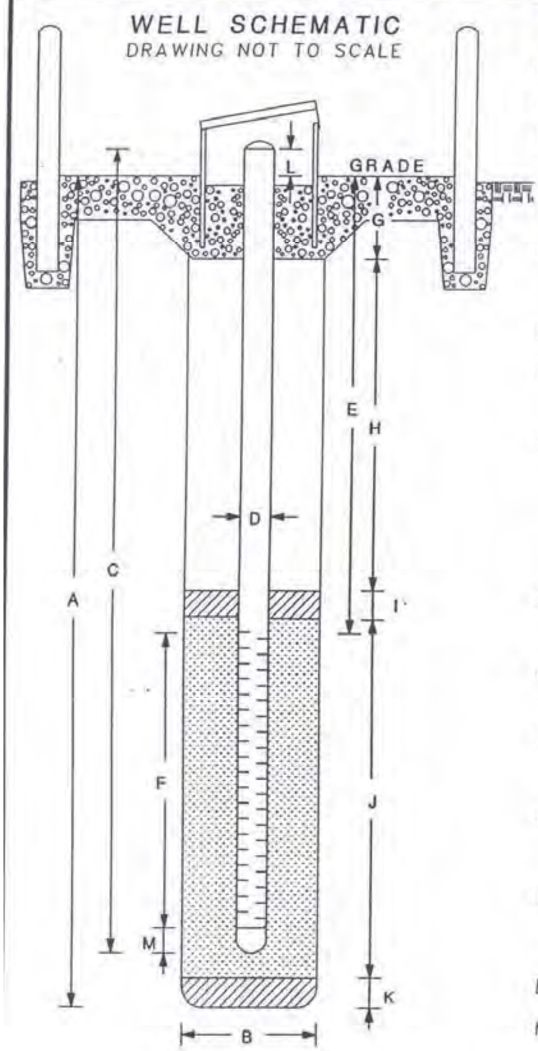
MONITORING WELL CONSTRUCTION DETAILS

PROJECT NAME ______________________
PROJECT NUMBER ______________________
DATE INSTALLED ______________________
WELL PERMIT NO. ______________________
LOCATION ______________________
NOTES: ______________________

BORING/WELL NO. ______________________
TOP OF CASING ELEV. AT MARK –
GROUND SURFACE ELEV. –
DATUM MEAN SEA LEVEL

WELL SCHEMATIC

DRAWING NOT TO SCALE



NOTE: Depths and intervals are measured from ground surface.

BORING INFORMATION

A. Total depth ft. 125.0

B. Diameter in. 10" 0–94' / 6" 94–125'

Drilling method AIR ROTARY TRICORE

WELL CONSTRUCTION

C. Total Casing length ft. 125.0

Material SCH 40 PVC

D. Diameter (I.D.) in. 2.0

E. Depth to top perforations ft. 102.0

F. Perforated length ft. 20.0

Perforated interval from ft. 102.0

to ft. 122.0

Perforation size 0.010

G. Surface seal from 0.0 ft. to 3.0 ft.

Seal materials CONCRETE

H. Grout from 3.0 ft. to 84.0 ft.

Grout material CEMENT/BENTONITE GROUT

I. Sanitary seal from 84.0 ft. to 99.0 ft.

Seal materials BENTONITE PELLETS

J. Filter pack from 99.0 ft. to 122.0 ft.

Pack material 10/20 FOR EROTED SAND ZONE / 20/40 CSSI SAND

K. Bottom zone 3.0 ft.

Material NATIVE FORMATION GRAVEL/SAND

L. Well casing ht. above grade 3.0 ft.

M. Well tail piece length 3.0 in.

Centralizers located at – ft. and – ft.

NOTES: –

Figure 7-8. As-built construction details for monitoring well at wastewater land application sites.[8]

8 Reproduced by permission of Cascade Earth Sciences.

7.7.3.1.5 Monitoring Well Development

During drilling and monitoring well installation, fine sediment particles are forced through the sides of the borehole, which act to clog the formation. This reduces the hydraulic conductivity of the aquifer adjacent to the borehole. The fine materials must be removed from the well intake to assure representative ground water samples will be collected. If the particulate matter is not removed, water moving into the borehole will be turbid and will reduce the integrity of the water sample. Well development also repairs the damage inflicted on the formation during drilling.

All new wells must be developed prior to water quality compliance monitoring. A monitoring well is considered adequately developed when clean, non-turbid water can be removed from the formation. The time interval will vary depending upon the formation material and the amount of damage incurred during drilling. The goal in well development is to continue the process until the water is chemically stable (within 10% per casing volume) and the water is non-turbid.

It is important for the facility to properly develop the wells to assure the wells will yield representative samples. The investment of the monitoring well installation, sampling and analytical costs will not be wasted due to insufficient development time. The additional effort spent on well development will result in samples that are more representative of water chemistry in the formation being monitored.

Table 7-16 describes the common well development techniques. Puls and Powell, (1992), recommend using a water pump which is slowly raised and lowered throughout the length of the screened interval without causing excessive surging. Development techniques which introduce fluids or air into the formation are not recommended due to the possible alteration of ground water chemistry. Bailing, mechanical surging, overpumping and backwashing are all recommended well development techniques. A combination of methods is recommended to assure that adequate surging dislodges the particulates, and that the particulates are physically removed from the well. For wells that are purged using standard pumping methods, purge volumes should include the amount of water contained in the sand pack and inside the casing.

For each monitoring well installed, documentation should be provided for the development method, flow rate, the length of time, and the criteria used for ending the development procedures.

Table 7-16. Well Development Techniques

Method	Description	Advantages	Disadvantages
Bailer	Motion of introducing a bailer into the borehole causes a surge of water to be forced into the formation.	removes fines good for small diameter wells breaks up bridging in formation	not as effective as surge blocks must use sufficiently heavy bailer
Mechanical surging	A block the size of the inner diameter of the well is moved up and down throughout the screened interval. Must be used in conjunction with a bailer to remove fines.	effective at dislodging fines physically breaks up bridges and removes particulates from casing walls good for low yield formations	caution needed to avoid damage to screen and casing caution to prevent plugging screen with particulates may damage filter pack
Overpumping	Pumping at a rate that substantially exceeds the ability of the formation to deliver. The increased velocity causes migration of particles towards the pumping well. Typically used after bailing, or surging and bailing to avoid pump burnout caused by excess particulates in the well bore.	most common least expensive pump removes particulates effective when alternating pump on and off effective when raising and lowering the pump works best in coarse materials minimal time and effort no new fluids introduced	not as vigorous as backwashing can leave the lower portion of large screen intervals undeveloped
Backwashing	The surging action consists of lifting a column of water within the well and then letting it fall back into the well. Reversing the direction of flow breaks down the bridging and the particles are moved back into the well when the pump is restarted.	low cost breaks down bridging in filter pack no new fluids introduced	tends to push fine grained sediments into filter pack potential for air entrainment if air is used unless combined with pumping or bailing, does not remove fines possible disturbance to the gravel pack
Air surging	Air is injected into the well to lift the water to the surface, and then the water is allowed to fall back down the borehole.	develops discrete zones can be used to open fractures	can entrain air permanently into the formation alter the chemistry of the formation water can reduce the permeability
Jetting	Operation of a horizontal jet forces water inside the well screen openings.	develops discrete zones	can drive fines into the formation can alter the chemistry of the formation water can reduce the permeability

Note: A combination of these methods is recommended.

7.7.4 Ground Water Sampling

This section provides guidance on sampling supplies and equipment, well purging, sample collection, sample packing, and decontamination procedures. Guidance regarding documenting of a ground water sampling event can be found in ASTM D 6089 – 97 (2003).

7.7.4.1.1 Sampling Supplies and Equipment

Prior planning and careful preparation of field equipment before sampling will ensure good results from the laboratory. The following provides a list of supplies and equipment to be used when sampling ground water.

- disposable gloves
- documentation (forms, log books, and O&M manual, etc.)
- indelible ink pen
- well lock keys
- tape measure
- water level monitoring device and supplies (batteries, chalk and paste as needed)
- field parameter meters with calibration standards
- decontaminated sampling pump with proper tubing and power supply
- bailers with line
- sample bottles
- sample labels
- packing tape
- stop watch
- graduated cylinder
- filtration equipment
- cooler with cold packs or ice
- cleaning buckets and containers
- plastic garbage bags
- small sealable plastic bags
- plastic sheeting
- paper towels and hand soap
- cleaning brushes

- phosphate-free laboratory soap
- deionized organic-free water and hand sprayers
- high purity laboratory grade hexane, acetone, or isopropanol (all available from laboratory supply companies)

Customized kits for sample collection may be supplied by a contract laboratory. These kits include all the items needed for collection and shipment of samples. Those conducting the sampling event should follow laboratory instructions and read container labels. Care should be taken not to discard preservatives that may have already been added to some containers.

If a laboratory sampling kit is not used, those conducting the sampling event should use only new containers or sanitized reusable containers, supplied by a lab, of the appropriate types for the required parameters. Containers should be selected and prepared according to the contract laboratory's instructions. Sample containers should be labeled before sample collection and the type and amount of preservative required should be recorded on each sample label. All sampling equipment, such as bailers, containers, and tubing should be selected and thoroughly cleaned based on the parameters to be monitored. Disposable bailers of the appropriate composition may be used. Teflon™, stainless steel, or glass should be used when sampling for organics, such as solvents and petroleum product contamination. Do not use PVC or other plastics.

7.7.4.1.2 Well Purging

Stagnant water sitting in a well casing is exposed to the atmosphere which can alter the chemistry of the water. Improper well purging can result in gross errors to analytical results (Barcelona, 1989). Wells should be purged until a representative ground water sample can be collected. The exception to this is taking water level measurements, which must be taken *before the well is purged*. To measure static water level, do the following:

1 From a permanent reference at the top of the well casing, lower a clean weighted steel tape or electric sounder into the well.

2 Record the wet level mark on the tape and subtract it from the reference point to obtain the depth of water. (Use the same reference point each time a water level measurement is made at the well.)

Ground water monitoring wells should be purged for a minimum of three casing volumes and/or until field measurements stabilize. For pH, the following conditions should be met:

- two successive temperature values measured at least five minutes apart are within one degree Celsius of each other,
- pH values for two successive measurements, measured at least five minutes apart, are within 0.2 units of each other
- two successive specific conductance values, measured at least five minutes apart, are within 10% of each other

This procedure will determine when the wells are suitable for sampling for constituents required by the permit. Other procedures, such as low flow sampling, may be considered by DEQ for approval. DEQ (March 2001; Appendix B pp. 40-58) has standard operating procedures for monitoring well sampling and field parameter acquisition which should be consulted for specifics.

To calculate casing volume, use the following equation (from EPA, 1995 Section 8.0):

$$V_w = 7.48\pi \cdot r^2 h$$

Where:

V_w = well volume (gallons)

r = inside radius of the well (feet)

h = height of the water column (feet). Subtract depth to water from total depth of well

Note: 7.48 gal/ft^3 is the conversion factor to express V_w in gallons.

Stabilization of the field parameters especially dissolved oxygen provides assurance that the sample water is representative of aquifer conditions, without disturbing the flow patterns in the aquifer. Purging the well dry and sampling the next day after the well has recovered, is not advisable, since the water entering the borehole will be exposed to the atmosphere and will not be representative of the water in the formation. There are circumstances however, where this may be the only option.

Using low flow pumps for purging generally produces high quality representative samples. Low rate pumping is the preferred method for purging, because bailing may increase turbidity by stirring up sediment in the well. When purging with a pump, slowly lower the pump to just below the top of the standing water column. Continue lowering it as the water level drops and the stagnant water is removed. Barcelona (1989) recommends using low flow rates (0.2-0.3 liters/minute) during both purging and sampling. Purge rates should always be below the rate at which the well was developed. Purge water should be disposed of according to state and federal regulations.

If a pump is not available or cannot be used, use a bottom-emptying bailer to purge and collect samples. To purge using a bailer, lower the bailer slowly, to just below the water level, and retract slowly to reduce aeration and turbidity. Collect the purged water in a graduated bucket to measure a minimum of at least three well volumes, or as discussed above. Bailer lines of braided nylon or cotton cord must not be reused, even if clean, in order to avoid the probability of cross-contamination. Lines must consist of Teflon-coated wire, single strand stainless steel wire, or other monofilament line. Bailers should not be left in wells. Contamination can occur when they are handled outside the wells and placed back inside. Contamination can also occur as a result of deterioration of bailer lines.

7.7.4.1.3 Sample Collection

Proper sample collection is critical to acquiring reliable data which is representative of ground water conditions. Ground water quality samples should be submitted for analysis at a certified laboratory. Samples should be collected according to the laboratory's instructions regarding sample container, preservation, filtering, holding time, and collection procedures. It is standard procedure to follow chain of custody procedures with documentation of the location and handling of the sample from the time of collection until the time of analysis.

Sampling Equipment

It is important to consider the type of sampling equipment and the material of which it is constructed. Dedicated sampling equipment is preferred. Table 7-17 describes the most common and recommended pumps/bailers for ground water quality sampling.

Table 7-17. Ground Water Sampling Equipment

Equipment	Advantages	Disadvantages
Positive Displacement Pump (bladder pump)	Efficient well purging maintains integrity of sample easy to use high quality, consistent, representative samples does not introduce air low flow rates	difficult to decontaminate if the pump and/or tubing is not dedicated limited to depths of < 100 ft (DB says 100's of ft possible) lengthy purge process
Submersible electric pump	efficient purging tool portable variable pump rate reliable	potential for affects on trace organic constituents expensive power source required
Suction Pump (peristaltic pump)	portable, inexpensive, readily available, efficient for purging, not recommended for sampling	useful to depths < 25 ft may cause pH modifications, vacuum can cause loss of dissolved gases and volatile organic constituents silicon tubing has high sorption capacity for organic constituents
Bailer	Inexpensive, portable, no power source, easy to decontaminate	transfer of sample may cause aeration, potential for introducing contamination is high, unsuitable for well purging caution with operation and sample handling time consuming labor intensive
Waterra Inertial Lift Pump	Dedicated Variable flow rates Reliable Simple to Operate Inexpensive tubing and foot valves Manual, electrical power and gas-powered options available	Care must be taken to minimize excessive formation surging Limited to depths of 250 feet.

Note: Methods are listed in order of preference.

Low flow pumps (0.2-0.3 liters/minute) such as the bladder pump, reduce the introduction of oxygen into the sample, which can alter the water chemistry. These pumps also cause the least amount of disturbance to the water in the well and as such are the preferred sampling device. Bailers are not recommended since they disrupt the column of water and re-suspend sediment. Studies show that higher concentrations of metals are detected, mistakenly, in samples collected with bailers, than from samples collected with low flow rates using a peristaltic pump (Puls and Powell, 1992). Ideally the proper sampling equipment which creates the least disturbance to the water in the borehole and formation will yield water quality samples which are representative of true aquifer conditions. Other considerations during sampling include the placement of the intake valve on the pump in order to create the minimum disturbance to the stagnant water above and below the screened interval.

Sampling equipment should be made of inert materials to assure that the sample will not be contaminated during the sample collection process. Table 7-18 describes the recommended material for pumps and bailers based on the type of constituents being analyzed. Teflon is the best inert material for the majority of constituents, and stainless steel is the second choice, (Garner, 1988).

Table 7-18. Sampling Equipment Material.

Material	Advantages	Disadvantages
PTFE (fluoropolymer materials, Teflon)	recommended for organic constituents recommended for corrosive situations where organic constituents are of interest recommended for metals easiest to clean inert east likely to introduce sample bias or imprecision	expensive
Stainless Steel	recommended for organic constituents	may corrode in acidic waters corrosion products may introduce Fe, Cr, Ni expensive
PVC (thermoplastic materials)	lightweight inexpensive resistant to acids recommended for inorganic constituents	not recommended for organic constituents (may sorb or leach) may release Sn or Sb compounds
Mild Steel (low carbon steel, galvanized steel, carbon steel)	readily available	corrosion products Fe, Mn (galvanized Zn, Cd) active adsorption sites for organic constituents and inorganics not recommended for organic constituents not recommended for corrosive conditions

Note: Materials are listed in order of preference.

Ground water samples should be filtered (if necessary), preserved and analyzed in the field as soon as possible after collection to avoid equilibrium changes due to volatilization, sorption, leaching, or degassing, (Barcelona, 1985). Only ground water samples collected for metal or ionic analysis should be filtered. Samples collected for analysis of organic compounds should never be filtered. Traditional filtration protocols for inorganic parameters recommend using an in-line filter with a 0.45 micron pore size. This is also consistent with the *National Pollutant Discharge Elimination System* (NPDES) guidance for metals filtration. Puls and Powell (1992) noted that larger diameter, high capacity filters erroneously produced lower concentrations of contaminants on a routine basis; therefore, they are not recommended.

Sample Collection with Pumps

Low flow pumps (0.2-0.3 liters/minute) such as the bladder pump, reduce the introduction of oxygen into the sample, which can alter the water chemistry. These pumps also cause the least amount of disturbance to the water in the well and as such are the preferred sampling device. When sampling with a portable pump, do the following:

1 Have sample containers ready before turning on the pump.

2 Lower the pump, slowly, to the desired depth in the well. The placement of the intake valve on the pump should be considered during sampling in order to create the minimum disturbance to the stagnant water above and below the screened interval.

3 Adjust the flow rate to less than 100 mL per minute to reduce agitation.

4 Decontaminate the pump before moving to the next well (see 7.7.4.2).

Sample Collection with Bailers

Bailers are not recommended because they disrupt the column of water and re-suspend sediment. Studies show that higher concentrations of metals are detected, mistakenly, in samples collected with bailers, than from samples collected with low flow rates using a peristaltic pump (Puls and Powell, 1992). But if it is necessary to sample with a bailer, do the following:

1 Lower the bailer slowly into the well, avoiding agitation, and allow it to fill.

2 Retract the bailer slowly, and discharge the sample carefully into the container until the correct volume has been collected.

3 Add preservative if required, cap the container, and mix according to laboratory instructions. Take precautions to minimize turbidity and sediment in samples. This will minimize the need for filtering.

4 Use purging and sampling techniques previously described to minimize turbidity and agitation of sediment in wells.

In low-yielding wells and those containing high levels of suspended solids, slowly lower a bailer to the lowest standing water level and allow the water to flow into it. Carefully lift the bailer out of the well without allowing it to scrape or bang against the well casing. Allowing the well to recover into the bailer should produce a cleaner sample.

Minimizing Risk of Contamination

There are several ways to minimize risk of contamination during sampling:

- ensuring that all sampling equipment (bailers, tubing, containers, etc.) has been thoroughly cleaned and selected based on compatibility with parameters to be monitored
- using Teflon, stainless steel, or glass when sampling for organics; do not use PVC or other plastics
- using Teflon or glass when sampling for trace metals
- using new sample containers when sampling for compliance monitoring; do not reuse containers
- keeping containers closed before filling, and do not touch the inside of containers or caps
- wearing a new pair of disposable gloves or decontaminated reusable gloves for each sampling site
- placing new plastic sheeting on the ground near each well to hold the sampling equipment; do not step on the sheeting

- placing small samples that require cooling, such as volatile organics, in sealable plastic bags immediately after collection and before submerging in ice
- not smoking while collecting or handling samples, because volatile residues in the smoke can cause sample contamination
- not leaving your vehicle running near the sample collection area, to prevent contamination from engine exhaust fumes
- when using a pump, setting up the generator about 15 feet away and downwind from the well; performing all generator maintenance and fueling off-site and away from samples
- avoiding unnecessary handling of samples
- if dedicated monitoring systems (those permanently installed in wells) are **not** used, cleaning equipment to be reused thoroughly before sampling each well to minimize the risk of cross contamination; bailers left in wells are **not** dedicated systems
- taking enough pre-cleaned equipment to the field to sample each well, so that cleaning between wells is unnecessary; if field cleaning is necessary, an equipment blank may be used to make sure that no contamination results

Blanks should be used to check for contamination. Blanks consist of organic-free deionized water, which must be obtained from laboratories. Types of blanks include the following:

- a *trip blank* (a sealed container of organic-free, deionized water that must be taken to the field and sent back to the lab, unopened, with the samples); include at least one trip blank per cooler for volatiles to check for sample contamination during transportation.
- a *field blank* consists of organic-free deionized water taken to the field and handled in the same manner as the samples to check for contamination from handling, from added preservatives, or from airborne contaminants at the site, which are not from the waste being disposed of at the treatment facility.
- an *equipment blank* (organic-free deionized water, which is passed through the cleaned sampling equipment with added preservatives) may be used to detect any contamination from equipment used for more than one well.

General Procedures for Packing Samples

The following should be done when packing samples prior to shipment by courier or by personal transport to the laboratory:

1 Line a clean cooler with a large, heavy duty plastic bag, and add bags of ice.

2 Place the properly tagged samples in individual, sealable plastic bags, and seal the bags with chain-of-custody tape to ensure sample integrity.

3 Place bagged samples in the cooler, arranging bags of ice between samples to help prevent breakage; add sufficient ice to maintain the temperature of at 4^{o} C (39.2^{o} F) while the samples are in transit.

4 Enclose the appropriate forms in a sealable plastic bag, place with samples in the chest, and seal the large bag with chain of custody tape.

5 Minimize transport time, and ensure that samples will reach the laboratory without being exposed to temperature variations and without exceeding holding times.

Once the laboratory has completed the sample analysis, a report containing the analytical results will be sent to the person requesting the analysis. Monitoring forms should be carefully filled out, making sure that all information is included and that the data transferred from laboratory reports are recorded in the correct concentration units. Complete identification information, such as permit number and facility, or permit name, should be included on all correspondence and additional laboratory reports. Forms and laboratory reports should be submitted on time. It is vitally important that the procedures demonstrated be followed carefully by the sampler to avoid costly resampling and to ensure that any ground water contamination is appropriately characterized in the event remediation is necessary.

A facility that utilizes a contractor for ground water sampling should still be familiar with the sampling frequencies and parameters and the general requirements of the sampling protocol. If there are any questions regarding facility specific monitoring requirements, DEQ regional office personnel should be contacted.

7.7.4.2 Decontamination

All sampling equipment that is not dedicated should be routinely decontaminated prior to collecting a sample. Portable sampling systems are used more frequently than dedicated systems because of lower costs. However, because portable systems require using the same equipment from well to well, they increase the possibility of cross contamination unless strict cleaning procedures are followed.

Decontamination between each sampling point eliminates the possibility of cross-contamination, which could introduce a level of error into the sampling results. Decontamination typically involves removing or neutralizing contaminants that have accumulated on the surface of the sampling equipment. Care should be taken not to use cleaning solutions which contain a contaminant of concern. Decontamination should be conducted according to appropriate sampling procedures. Cleaning procedures must be selected based on the equipment composition and the parameters to be monitored.

The following is a summary of minimum cleaning techniques for bailers, applicable for other equipment of the same composition. For stainless steel bailers and equipment, use the following:

- phosphate-free soap and hot tap water wash
- hot tap water rinse
- deionized water rinse

- isopropyl alcohol rinse
- deionized water rinse
- air dry
- Wrap the bailer with aluminum foil or other material to prevent contamination before use. Consider target contaminants when selecting a wrap material.
- To clean Teflon or glass bailers and equipment use the following:
- phosphate-free soap and hot tap water wash
- hot tap water rinse
- ten percent nitric acid rinse
- deionized water rinse
- isopropyl alcohol rinse
- deionized water rinse
- air dry

Wrap to prevent contamination before use. Again, consider the target contaminants when selecting wrapping material.

7.7.4.3 Analysis and Methods

Table 7-19. Common Ground Water Analytes and Methods

Parameter	Abbreviations	Units	EPA[1]	Standard Methods[2]	Reportable Detection Limits[4,5]
Alkalinity	Alk	mg/L	310.1 or 310.2	2320	<1.0 mg/L
pH	pH	S.U.	150.1	4500-H+	> 1, <12
Specific Conductance	SC	umhos/cm	120.1	2510 B	<2 umhos/cm
Total Dissolved Solids (inorganic)	TDS	mg/L	160.2	2540 C	<1.0 mg/L
Static Water Level	SWL	feet	NA[6]	steel tape, electric tape or other	<0.01 ft
Chemical Oxygen Demand	COD	mg/L	410.2	5220 B	>5.0 mg/L
Nitrate-N	NO3-N	mg/L	352.1	4500-NO3	<0.1 mg/L
Nitrate-N	NO3-N	mg/L	353.2	4500-NO3	< 0.005 mg/L
Total Kjeldahl Nitrogen	TKN-N	mg/L	351.1, 351.2, 351.3 or 351.4	4500-Norg	<0.1 mg/L
Iron, Total Unfiltered	Fe	mg/L	236.1	3500-Fe	<.01 mg/L
Manganese, Total Unfiltered	Mn	mg/L	200.7	3500-Mn	<.001 mg/L
Manganese, Total Unfiltered	Mn	mg/L	243.1	3500-Mn	<.01 mg/L
Sodium	Na	mg/L	273.1	3500-Na	<0.1 mg/L
Potassium	K	mg/L	258.1	3500-K	<0.1 mg/L
Chloride	Cl	mg/L	325.1, 325.2, or 325.3	4500-Cl	<0.9 mg/L
Calcium	Ca	mg/L	215.1 or 215.2	3500-Ca	<0.1 mg/L
Total Organic Carbon	TOC	mg/L		5310 B > 1 mg/L	<1 mg/L
Total Organic Carbon	TOC	mg/L		5310 C < 1 mg/L	<0.05 mg/L
Total Organic Carbon	TOC	mg/L		5310 D < 1 mg/L	<0.01 mg/L
Magnesium	Mg	mg/L	242.1	3500-Mg	<0.1 mg/L
Fluoride	F	mg/L	340.1, 340.2, or 340.3	4500-F	<0.1 mg/L
Gross Alpha	A	pCi/l	-	7110	NA
Gross Beta	B	pCi/l	-	7110	NA

Parameter	Abbreviations	Units	EPA[1]	Standard Methods[2]	Reportable Detection Limits[4,5]
Ammonia	NH3	mg/L	350.1, 350.2, or 350.3	4500-NH3	<0.005 mg/L
Phosphorus Total	P	mg/L	365.4	4500-P	<0.005 mg/L
Dissolved Oxygen	DO	mg/L	360.1 or 360.2	4500-O	<0.1 mg/L
Sulfate	SO4	mg/L	300.0	4500-SO4-2	<2.0 mg/L
Sulfate	SO4	mg/L	375.1, 375.2, or 375.3	4500-SO4-2	<2.5 mg/L
Total Coliform	TC	#/100 ml	p.1143 or p.1083	9221 B 9222 B	NA
Fecal Coliform	FC	#/100 ml	p.1323 or p.1243	9221 C 9222 D	NA
Fecal Streptococcus	FS	#/100 ml	p.1393, p.1363, or p.1433	9230 B 9230 C	NA

Notes:
1. Methods for Chemical Analysis of Water and Wastes. Environmental Protection Agency, Environmental Monitoring Systems Laboratory-Cincinnati (EMSL-Cllll), EPA-600/4-79-020. Revised March 1983 and 1979, where applicable.
2. Greenberg, A.E. et al. (eds). 1992. Standard Methods for the Examination of Water and Wastewater - 18th Edition.
3. Bordner, R.H., and J.A. Winter, eds. 1978. "Microbiological Methods for Monitoring the Environment, Water and Waste." Environmental Monitoring Systems Laboratory, U.S. Environmental Protection Agency. EPA-600/8-78-017.
4. Reportable detection limits used by IDHW-Bureau of Laboratories as of December, 2005.
5. Estimated Method Detection Limit (MDL) achievable by specific analytical method. For EPA methods, use the EPA methods or Environmental Methods Monitoring Index (EMMI) or for Standard Methods use the latest edition of Standard Methods for the Examination of Water & Wastewater.
6. See Sections 4.1.1 through 4.1.10 in EPA (1993).

7.7.5 Soil-Water (Vadose) Monitoring Supplemental Information

7.7.5.1 Analytical Methods

Table 7-20. Common Soil Water Analytes and Methods.

Parameter	Abbreviations	Units	EPA[1]	Standard Methods[2]	Reportable Detection Limits[4,5]
Alkalinity	Alk	mg/L	310.1 or 310.2	2320	<1.0 mg/L
pH	pH	S.U.	150.1	4500-H+	> 1, < 12
Specific Conductance	SC	umhos/cm	120.1	2510 B	<2 umhos/cm
Total Dissolved Solids (inorganic)	TDS	mg/L	160.2	2540 C	<1.0 mg/L
Chemical Oxygen Demand	COD	mg/L	410.2	5220 B	>5.0 mg/L
Nitrate-N	NO3-N	mg/L	352.1	4500-NO3	<0.1 mg/L
Nitrate-N	NO3-N	mg/L	353.2	4500-NO3	<0.005 mg/L
Total Kjeldahl Nitrogen	TKN-N	mg/L	351.1, 351.2, 351.3 or 351.4	4500-Norg	<0.1 mg/L
Iron, Total Unfiltered	Fe	mg/L	236.1	3500-Fe	<.01 mg/L
Manganese, Total Unfiltered	Mn	mg/L	200.7	3500-Mn	<.001 mg/L
Manganese, Total Unfiltered	Mn	mg/L	243.1	3500-Mn	<.01 mg/L
Sodium	Na	mg/L	273.1	3500-Na	<0.1 mg/L
Potassium	K	mg/L	258.1	3500-K	<0.1 mg/L
Chloride	Cl	mg/L	325.1, 325.2, or 325.3	4500-Cl	<0.9 mg/L
Calcium	Ca	mg/L	215.1 or 215.2	3500-Ca	<0.1 mg/L
Total Organic Carbon	TOC	mg/L		5310 B > 1 mg/L	<1 mg/L
Total Organic Carbon	TOC	mg/L		5310 C < 1 mg/L	<0.05 mg/L
Total Organic Carbon	TOC	mg/L		5310 D < 1 mg/L	<0.01 mg/L
Magnesium	Mg	mg/L	242.1	3500-Mg	<0.1 mg/L
Fluoride	F	mg/L	340.1, 340.2, or 340.3	4500-F	<0.1 mg/L
Gross Alpha	A	pCi/l	-	7110	NA
Gross Beta	B	pCi/l	-	7110	NA
Ammonia	NH3	mg/L	350.1, 350.2, or 350.3	4500-NH3	<0.005 mg/L
Phosphorus Total	P	mg/L	365.4	4500-P	<0.005 mg/L
Dissolved Oxygen	DO	mg/L	360.1 or 360.2	4500-O	<0.1 mg/L

Parameter	Abbreviations	Units	EPA[1]	Standard Methods[2]	Reportable Detection Limits[4,5]
Sulfate	SO4	mg/L	300.0	4500-SO4-2	<2.0 mg/L
Sulfate	SO4	mg/L	375.1, 375.2, or 375.3	4500-SO4-2	<2.5 mg/L

Notes:
1. Methods for Chemical Analysis of Water and Wastes. Environmental Protection Agency, Environmental Monitoring Systems Laboratory-Cincinnati (EMSL-Cllll), EPA-600/4-79-020. Revised March 1983 and 1979 where applicable.
2. Greenberg, A.E. et al. (eds). 1992. Standard Methods for the Examination of Water and Wastewater - 18th Edition.
3. Bordner, R.H., and J.A. Winter, eds. 1978. "Microbiological Methods for Monitoring the Environment, Water and Waste." Environmental Monitoring Systems Laboratory, U.S. Environmental Protection Agency. EPA-600/8-78-017.
4. Reportable detection limits used by IDHW-Bureau of Laboratories as of December 2005.
5. Estimated Method Detection Limit (MDL) achievable by specific analytical method. For EPA methods, use the EPA methods or Environmental Methods Monitoring Index (EMMI) or for Standard Methods use the latest edition of Standard Methods for the Examination of Water & Wastewater.

7.7.5.2 Data Use and Interpretation

The following guidelines provide the framework to interpret lysimeter data. These guidelines, along with criteria which can be included in permits – such as acceptable ground water constituent concentration at a facility down gradient boundary and acceptable modeled percolate constituent concentration - will aid in determining whether wastewater land treatment management strategies have been effective or require modification.

Due to the potential variability within a site, results from respective sampling events from all lysimeters can be averaged – or a median utilized - to estimate the quality of percolate losses. Acreage weighting of lysimeter results – in proportion to the amount of acreage of a field a particular lysimeter represents - can serve to render the data more spatially representative.

Soil-water percolate is collected from the vadose zone and is not yet considered ground water. Therefore, water quality standards are not directly applicable. However, soil-water percolate can be used for system compliance with some knowledge of the aquifer. By using appropriate values for the properties of the aquifer, impacts to ground water can be estimated based on the quality and quantity of percolate losses. Thresholds of percolate quality and quantity can then be determined which would lead to exceedances of water quality standards, and such thresholds can be used in lieu of ground water limits, whether standards stipulated in regulation or site specific limits determined by DEQ.

7.7.5.2.1 Mass Flux Calculations

Mass flux is the mass of a constituent (NO_3-N in this example) that is percolating below the crop root zone into the underlying aquifer. (See EPA (1993) Section 9.5.1 for solute flux calculation methods; and Section 7.7.5 for methods to estimate soil water flux.)

To calculate a mass flux, both the volume and concentration of the soil-water percolate are needed. If pan lysimeters are used, both volume and concentration of macropore flow (which is not the only component of flow) are presumably already known. If pressure-vacuum samplers are used, the concentration of soil water at the extracting tension is known, but the soil-water percolate volume must be determined by another method (water balance, modeling, soil-moisture status, etc.).

While vadose zone monitoring has potential to answer questions about load to groundwater, instrumentation may not be reliable enough to measure concentration and flow to be used for estimating potential ground water impacts and compliance with trigger percolate concentration/flow limits in permits. The following discussion and example is presented to outline in concept how lysimeter data could be used notwithstanding its present limitations.

Mass flux should be determined over a period of time and not from one sampling event. A wastewater land treatment example, using data from a pressure-vacuum sampler and soil-water percolate volume calculated using a water balance method, is presented below.

Table 7-20 summarizes example nitrate nitrogen (NO_3-N) lysimeter data. The example land application field has five lysimeters and is sampled quarterly. The evaluation period (EP) for lysimeter data is nine (9) quarters, or 2.25 years, in this example.

Mass flux can only be calculated where there are soil-water percolate losses. Mass flux can be calculated on a pounds per acre (lbs/ac) basis using:

$$M = 0.227 * C_p * Q_p$$

Equation 7-3. Mass flux calculation.

Where:

M = mass flux (lb/ac)

C_p = percolate constituent concentration (mg/L)

Q_p = percolate flow (inch/ac)

MG = million gallons

Note: the factor 0.227 = 0.0272 MG/inch * 8.34 (lb/MG)/(1 mg/L)

For example, first quarter mass losses would be:

$$M = 0.227 * 27.01 \ mg/L * 3.2 \ in/ac = 19.6 \ lb/ac$$

Table 7-21. Quarterly Gravity Lysimeter Monitoring Data for Nitrate-Nitrogen.

		Soil Water Nitrate-Nitrogen Data: Lysimeters no. 1 - 5					Column I Average Conc	Column II Estimated Percolate Volume	Column III Mass Loss
Quarter	Month	1	2	3	4	5	mg/L	inches	lb/acre
		----------	----------	mg/L	----------	----------			
I	January							1.50	
	February							0.70	
	March		48.3	24.5		8.23	27.01	1.00	19.57
II	April							0.27	
	May							0.24	
	June		0.5	0.3	0.1	0.1	0.25	0.21	0.04
III	July							0.24	
	August							0.23	
	September	16.8	31.4	125.1	48	42	52.66	0.23	8.29
IV	October							0.24	
	November							1.04	
	December	9.92	2.57		15.68	3.13	7.83	1.89	5.62
V	January							1.38	
	February							0.85	
	March	14.55	5.1		11.23	17.9	12.20	1.04	9.03
VI	April							0.30	
	May							0.22	
	June	0.2		0.1	0.1	0.1	0.13	0.21	0.02
VII	July							0.20	
	August							0.19	
	September	53.3	37.4	78	82	56.8	61.50	0.23	8.59
VIII	October							0.20	
	November							1.11	
	December	8.88		0.67	9.22	3.3	5.52	2.01	4.15
IX	January							1.42	
	February							0.90	
	March	31.02	22.2	18.9	16.5	28.99	23.52	0.99	17.63
				Total Percolate Volume (inches/acre) ---->				19.03	
				Total Nitrate Nitrogen Mass Loss (lb/acre) ------------->					72.95
				Average Nitrate Nitrogen Concentration (mg/L) ------->					16.93

Notes: Column III = (Column I) * (sum of percolate volumes in Column II for the Quarter) * (0.2265)

7.7.5.2.2 Estimation of Ground Water Impact

The potential impact to the underlying ground water can be estimated using constituent mass flux information from lysimeter sampling and basic aquifer characteristics. One important simplifying assumption made here is that there is no sorption, denitrification, precipitation or other constituent losses or sequestration between the bottom of the crop root zone and ground water. All of these treatment processes are possible, which makes this assumption conservative.

Continuing with the same example, the potential ground water impacts at the down gradient boundary of the source area can be estimated using the EPA aquifer dilution model (EPA, 1996).

$$C_w = \frac{C_p Q_p}{(Q_p + Q_A)}$$

Equation 7-4. EPA (1991) Ground water dilution model equation .
(Source: eq. 35, page 43. EPA/540/R-95/128 May 1996. Soil Screening Guidance: Technical Background Document)

Where:

C_w = ground water contaminant concentration (not including background ground water constituent concentration .

C_p = constituent concentration in percolate.

Q_p = percolate flow.

Q_A = aquifer flow rate (volume/time).

Q_A is calculated as shown:

$$Q_A = KiA$$

Equation 7-5. Calculation of aquifer flow rate, (Q_A).

Where:

K = hydraulic conductivity (ft/day or m/day)

i = gradient (ft/ft or m/m)

A = cross sectional area of down gradient boundary perpendicular to ground water flow, and is calculated by:

$$A = W * d$$

Equation 7-6. Calculation of down gradient cross sectional area perpendicular to ground water flow (A).

Where:

W = the width of the down gradient boundary perpendicular to ground water flow

d = the depth of the mixing zone. (special note: do depth calculations in metric units (meters), then convert to feet for remainder of the mixing zone calculations. This is calculated by:

$$d = d_{\alpha v} + d_{Iv}$$

Equation 7-7. Calculation of mixing zone depth (d).
(Source: eq. 44, page 45. EPA/540/R-95/128 May 1996. Soil Screening Guidance: Technical Background Document)

Where:

$d_{\alpha v}$ = depth of mixing due to vertical dispersivity, or

$$d_{\alpha v} = (2\alpha_v L)^{0.5}$$

d_{Iv} = depth of mixing due to downward velocity of infiltrating water (Source: eq. 38, page 44. EPA/540/R-95/128 May 1996. Soil Screening Guidance: Technical Background Document)

$$d_{Iv} = d_a\{1 - \exp[(-LI)/(V_s n_e d_a)]\}$$

Where:

α_v = vertical dispersivity (m)

$$a_v = 0.01\alpha_L$$

α_L = longitudinal dispersivity

$$\alpha_L = 0.82(\log_{10} L)^{2.446}$$

(Source: eq. 14b, page 907. Xu, M. and Eckstein, Y. 1995. Ground Water Vol. 33, No. 6; as corrected by Al-Suwaiyan, M.S., 1996, Ground Water Vol. 34 No. 4, page 578.)

Where:

L = length of source parallel to GW flow (meters)
n_e = effective aquifer porosity
d_a = aquifer depth (meters)
I = leachate infiltration rate (meters/yr)
V_s = ground water seepage velocity; (meters/year)

$$V_s = Ki/n_e$$

For this example, we are given the following:

For mixing zone depth calculations:

L = 2087 ft or 636.3 m
n_e = 0.30

d_a = 30 meters

I = 19.03 in/EP * 1 EP/2.25 yr * 1 ft/12 in * 1 m/3.28 ft = 0.218 m/yr

(note EP = evaluation period = 2.25 years in this example; See Table 7-21)

$\alpha_L = 0.82(\log_{10} 636.3\ m)^{2.446} = 10.2$

$\alpha_v = 0.102$

K = 100 ft/day;

i = 0.0015 ft/ft (7.92 ft/mile); and

$V_s = ki/n_e$ = (100 ft/day)*(0.0015 ft/ft)/0.3 * 365 day/yr * 1m/3.28ft = 55.6 m/yr

$d_{Iv} = 30*\{1 - \exp[(-(636.3 * 0.218))/(55.6 * 0.3 * 30)]\} = 7.2$

$d_{\alpha v} = (2 * 0.102 * 636.3)^{0.5} = 11.4$

d = 11.4 + 7.2 = 18.2 meters or 61 ft

Site dimensions: square site of 100 acres (2087 ft by 2087 ft).

In our example,

Q_A = KiA =(100 ft/day)*(0.0015 ft/ft)*(61 ft)*(2087 ft)
= 19096 ft^3/day, or
= (19096 ft^3/day)*(365 days/year)*(1 acre-ft/43,560 ft^3)
= 160 acre-ft/year discharging from the down gradient boundary,
or, for the volume during the evaluation period (EP)
= 160 acre-ft/yr * 2.25 yr/EP = 360 ac-ft/EP

Q_p is 19.03 in/EP (from Table 7-21). Converting to acre-feet we have:

Q_p = (19.03 in/[EP acre-year])*(100 acres)*(1 acre-feet/12 acre-inches)
Q_p = 158.6 acre-ft/EP, or
Q_p = 158.6 acre-ft/EP * EP/2.25 year = 70.5 acre-ft/year

C_p = 16.93 mg/L (from Table 7-21).

Putting these values into the EPA aquifer dilution equation introduced above we have:

$$C_w = \frac{(16.93\ mg/L)*(70.5\ ac\text{-}ft/yr)}{(70.5\ ac\text{-}ft/yr + 160\ ac\text{-}ft/yr)}$$

Solving for C_w, the units acre-ft/year cancel to give units of mg/L, or

C_w = 5.18 mg/L

Since C_w yields the change in constituent concentration in ground water, background (or ambient) ground water concentration must be factored into C_w in order to find estimated final steady state ground water concentration at the down gradient boundary (C_{mix}). This can be done without introducing much error by adding background ground water concentration (C_{gw}) to C_w if the Q_A is significantly larger than Q_p. The following equation shows this calculation:

$$C_{mix} = C_w + C_{gw}$$

In this example, C_{gw} = 3 mg/L, so:

$$C_{mix} = 5.18 + 3.0 = 8.2 \quad mg / L$$

In cases where Q_A is not significantly larger than Q_p (as is the case in this example), the dilution of background ground water constituent concentration C_{gw} with added percolate volume (C_d) should be calculated, and that result added to C_w as follows:

$$C_d = \frac{C_{gw} Q_A}{(Q_p + Q_A)}$$

Substituting values given above:

$$C_d = \frac{(3.0 \text{ mg/L})*(160 \text{ ac-ft/yr})}{(70.5 \text{ ac-ft/yr} + 160 \text{ ac-ft/yr})}$$

C_d = 2.1 mg/L

And:

$$C_{mix} = C_w + C_d = 5.18 + 2.1 = 7.3 \quad mg / L$$

The final ground water NO_3-N concentration is estimated to be 7.3 mg/L when the system achieves steady state conditions (which may or may not occur within the evaluation period). This result indicates that while the ground water standard for nitrate will not be exceeded, it does indicate the ground water concentration for nitrate-nitrogen is estimated to increase from 3.0 mg/L to 7.3 mg/L. Although most of the quarterly lysimeter samples exceeded the ground water standard, the modeled ground water quality down-gradient did not exceed the ground water standard. Beneficial uses may or may not be impacted, depending upon this modeled change in ground water quality, and whether predicted levels are determined significant by DEQ in the site-specific circumstances.

As discussed at the beginning of 7.3, a maximum percolate constituent concentration (given a constant percolation rate) that will comply with site specific permit conditions can be determined. For example, if a down gradient ground water concentration limit (Cmix) is set at 10 mg/L at the down gradient boundary of the source area, and retaining other values assumed above, we can utilize the two dilution equations above and solve for percolate concentration (Cp). First,

$$C_{mix} = C_w + C_d = \frac{C_p Q_p}{(Q_p + Q_A)} + \frac{C_{gw} Q_A}{(Q_p + Q_A)} = \frac{C_p Q_p + C_{gw} Q_A}{(Q_p + Q_A)}$$

Then solving for C_p we have:

$$C_p = \frac{\left[C_{mix} * (Q_p + Q_A)\right] - (C_{gw} * Q_A)}{Q_p}$$

Substituting values given above:

$$C_p = \frac{[10 \text{ mg/L} * (70.5 \text{ ac-ft/yr} + 160 \text{ ac-ft/yr})] - (3.0 \text{ mg/L} * 160 \text{ ac-ft/yr})}{70.5 \text{ ac-ft/yr}}$$

C_p = 25.9 mg/L

Given the assumptions above, the percolate could have a value of less than 25.9 mg/L and theoretically not cause exceedance of the ground water standard of 10 mg/L.

7.7.5.2.3 Depth to Water/Travel Time

As discussed in Section 7.1, the estimated travel time of percolate to ground water and other critical factors should be evaluated to help determine whether vadose zone or ground water monitoring would be more practical and appropriate.

Differences in the thickness and composition of the vadose zone affects travel times and for certain constituents the attenuation of constituents percolating through this zone. For example, fractured basalt, if few or thin interbeds are present, provides rapid travel times and negligible treatment. In this case ground water monitoring may still be warranted, even in areas where the vadose zone thickness is substantial.

There are several computer models that may be utilized to characterize unsaturated flow. A simple method of estimating travel time through the vadose zone employs the unit gradient *Lumped Time of Travel Model* (c.f. Guymon, G.L., 1994 pp 103-104). In this model the system is: 1) assumed to be at steady-state with a uniform moisture content, 2) the vadose zone is unlayered, with uniform hydraulic characteristics, and 3) the hydraulic gradient is equal to unity. Under these conditions the hydraulic conductivity is equal to the net percolation rate (Guymon, 1994). The pore velocity (V) can then be estimated with:

$$V = P_o / \theta$$

Equation 7-8. Calculation of pore velocity (V).

Where:

P_o = net percolation rate (amount of water per unit time; typically expressed in terms such as feet/yr). This variable represents the net amount of water that may be expected to move below the crop root zone. (An example of how P_o may be calculated is found in Guymon, G.L. [1994] pp 81-83.)

θ = soil moisture content (volume of water/total soil volume) and is expressed in dimensionless terms as a decimal fraction. θ may be obtained indirectly from tensiometer data, given a soil-specific relationship between θ and soil tension (soil water characteristic curve), from gravimetric analysis of soil cores taken below the root zone soon after an irrigation event, or may be estimated from the use of unsaturated flow computer models. Also, θ may be estimated by use of Gardener's equations (Gardner 1958) (Eq. Equation 7-9 and Equation7-10) if ψ >= -1 atm of pressure head in the vadose zone. If the latter condition does not hold, other methods should be used (c.f. Guymon 1994 p. 70 ff.)

Guymon also references W.R. Gardner's equations in this model. Using these equations to estimate θ, one must first obtain an estimate of ψ, the pressure head in the vadose zone by using:

$$K(\Psi) = \frac{K_s}{A_k|\Psi|^{\beta} + 1}$$

Equation 7-9. Gardner equation for unsaturated hydraulic conductivity K(ψ).

Where:

K_s = the saturated hydraulic conductivity; and A_k and β, best fit parameters; are found in Guymon, (1994) p. 70, and are reproduced in Table 7-22.

K(ψ), the hydraulic conductivity at a given pressure head is taken to be equal to P_o.

Equation 7-9 is rearranged to solve for ψ.

$$|\Psi| = e^{\{\ln[(K_s - Po)/AkPo]/\beta\}}$$

Equation7-10. Solving Equation 9 for soil pressure head (Ψ).

Table 7-22. Approximate Gardner's Parameters for Calculating Unsaturated Hydraulic Conductivity

Soil Texture	K_s ($cm \cdot h^{-1}$)	A_k (ψ in cm of water)	β
Sand (dirty)	3.75	$0.132 \cdot 10^{-2}$	2.576
Sandy Loam	1.17	$0.127 \cdot 10^{-4}$	3.731
Silt Loam	0.30	$0.132 \cdot 10^{-4}$	3.135

From Gardner 1958.

Solving for ψ, this value is substituted into Equation 7-11 to obtain θ.

$$\theta = \frac{\theta_s}{A_w|\Psi|^{\alpha} + 1}$$

Equation 7-11. Gardner equation for calculating soil moisture content (θ).

Where:

θ_s = soil porosity expressed as a decimal. A_w and α, best fit parameters, are found in Guymon (1994) p. 51, and are reproduced in Tabe 7-24.

Table 7-23. Gardner Parameters for Soils

Soil Texture	Θ_s	A_w	α
Sand	0.36	0.0787	0.614
Sandy Loam	0.42	0.0149	0.743
Loam	0.50	0.0121	0.720
Silty Loam	0.46	0.0024	1.079
Clay Loam	0.39	0.0420	0.418
Silty Clay Loam	0.43	0.0128	0.488
Clay	0.44	0.0002	1.007

[a]Values are approximate and are primarily for ranges of pressure head between zero and -1 atm. Pore-water pressure units are in cm of water.

Fr om Gardner 1958

Travel time (T) is then estimated by:

$$T = \frac{X}{V}$$

Equation7-12. Calculation of travel time (T).

Where:

X = thickness of the vadose zone (units of length).

V = pore velocity as defined previously

For example, if a rapid infiltration basin receives 85 inches of wastewater during a year's time and 80 inches is lost to deep drainage then:

$P_o = K(\psi) = 80$ inches/yr, or 2.32 E-2 cm/hr

If the vadose zone is composed of uniform sandy materials, we utilize Equation 7-10. Obtaining $A_k = 0.132$ E-2, $\beta = 2.576$, and $K_s = 3.75$ from Table A-10 (Guymon, 1994 p. 70), we solve for ψ:

$$|\Psi| = e^{\{\ln[(3.75-2.32\cdot10^{-2})/0.132\cdot10^{-2}*2.32\cdot10^{-2}]/2.576\}} = 94.2 \text{ cm}$$

Next we utilize Equation 7-11, substituting ψ obtained from Equation A-10, obtaining $\theta_s = 0.36$, $A_w = 0.0787$ and $\alpha = 0.614$ from Guymon (1994) p. 51. This expression is then solved for θ:

$$\theta = \frac{0.36}{0.0787 \cdot 94.2^{0.614} + 1} = 0.16$$

Substituting $P_o = 80$ in/yr and $\theta = 0.16$ into Equation 7-8, we obtain the pore velocity under steady-state conditions:

$$V = 80/0.16 = 500 \text{ in/yr or } 42 \text{ ft/yr}$$

If the vadose zone thickness were 50 feet then, using Equation 7-12, the travel time to ground water would be:

$$T = \frac{50}{42} = 1.2 \text{ yr}$$

7.7.6 Soil Monitoring Supplemental Information

7.7.6.1 Soil Sampling Form

Soil Sample Information Sheet

The original will not be returned to you. Keep yellow copy; send original to:
ISU Soil Testing Laboratory, G501 Agronomy, Ames, Iowa 50011.

Date________________

Submitter ______________________________

Address ______________________________
Street or Rural Route

____
City State Zip Code

Phone ______________________________

Lab Space—Do Not Use

payment code __________ x __________

$ __________ adj __________

CC __________ #C __________

Number of extra copies of report (limit 3) ________ *(All copies of report will be sent to submitter.)*

Client name ________________________ **Farm is in** ____________________ **County.**

Note: Recommendations are computer generated. Please use numbers in the boxes below.

				Must be filled in		Crop information (use crop codes listed below)		
Lab no. Do not use	Sample no.	Soil type*	No. of acres	Tillage depth† (inches)	✓ If irr.	Crop to be fertilized	Yield goal bu. or T/A	Test series requested (use test series codes below)

* Use soil map units (smu) from Soil Survey Maps
† If using reduced till or no-till, estimate depth of lime incorporation.

Crop codes (use one code per sample)
1. Corn or sorghum grain
2. Irrigated corn grain
3. Corn or sorghum silage
4. Corn-soybean sequence (2-year recommendation— give yield goal for both crops)
5. Sunflowers
6. Wheat
7. Oats: no forage seeding
8. Oats + forage seeding
9. Alfalfa topdress
10. Bluegrass
11. Tall grass: pasture
12. Tall grass: hay + pasture
13. Legume and grass pasture
14. Sorghum-sudan pasture
15. Soybeans

Test series codes (use one code per sample)	Cost/sample
1. Regular series (pH, lime, P, K)	$ 7.00
2. Regular series + O.M.	$10.00
3. Regular + Zinc	$11.00
4. Regular series + O.M. + Zinc	$14.00
5. pH and lime only	$ 4.00
6. Organic Matter only	$ 5.00
7. Zinc only	$ 5.50

For established charge accounts only:

______charge ____________ County Extension
______charge ____________ County ASC Office
______charge ____________________
Company name

. . . and justice for all
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Note: Please provide as much information as possible. Fertilizer recommendations are modified based on soil type. If soil type is not supplied, we will assume that subsoil P and K are very low.

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7.7.6.2 Soil Analytical Methods

Table 7-24. Common Soil Analytes and Methods.

Parameter	Abbreviations	Units	Standard Methods(1)	Comments
pH	--	S.U.	12-2.6; 12-2.7 pp 206-9	pH of saturated paste or 1:1 dilution or WSP6 S-2.10
% Organic Matter	%OM	% of oven dried soil(2)	29-4 pp. 574-7	or WSP S-9.10, S-9.20
Electrical Conductivity	EC	mmhos/cm	10-1; 10-2 (esp. 10-2.3.1); 10-3 (esp. 10-3.3)	E.C. of saturated paste extract Ag handbook 60, p. 8); or WSP S-1.20
% moisture	--	% of oven dried soil(2)	7-2.2 pp. 92-96 gravimetric w/oven drying(2)	
Texture	--	--	USDA 1975(3)	percent sand, silt & clay by hydrometer method[2] or pipette method[2] compared to textural triangle to determine textural classification
Sodium Absorption Ratio	SAR	--	calculation (see USDA Agricultural Handbook 60)	soluble conc. of Na, Ca, & Mg from saturated paste; WSP S-1.60
Total Kjeldahl Nitrogen	TKN-N	mg/kg	31-1 through 31-4 pp. 595-618	also used is Total N by combustion (AOAC 955.04 1990 edition) or WSP S-8.10
Ammonium Nitrogen	NH4-N	mg/kg	33-1 through 33-7 pp. 643-676	plant available including soluble & exchangeable (See also AOAC 920.03 1990 edition)
Nitrate Nitrogen	NO3-N	mg/kg	33-1 through 33-6 pp. 643-671; 33-8, pp. 363-682	plant available; WSP S-3.10
Sodium	Na	Meq/100 g	9-1 through 9-3 pp. 159-161; 13-4 pp. 238-241	Exchangeable; WSP S-1.60
Potassium	K	Meq/100 g	9-1 through 9-3 pp. 159-161; 13-3 pp. 228-238	Exchangeable; WSP S-5.10
Calcium	Ca	Meq/100 g	9-1 through 9-3 pp. 159-161; 14 pp. 247-262	Exchangeable; WSP S-5.10
Magnesium	Mg	Meq/100 g	9-1 through 9-3 pp. 159-161; 14 pp. 247-262	Exchangeable; WSP S-5.10
Manganese	Mn	mg/kg	18 (esp. 18-3.4) pp. 313-322	DTPA extractable; WSP S-6.10
Iron	Fe	mg/kg	17-4 pp. 308-311	DTPA extractable; WSP S-6.10
Chloride	Cl	meq/100g	26-3 pp. 455-462	water soluble; WSP S-1.40
Sulfate	SO4	mg/kg	28-3 pp. 518-522	water soluble
Cation Exchange Capacity	CEC	meq/100g	8 pp. 149-157	Do not use sum of bases method for CEC with extractable analyses for Ca, Mg, K, and Na.
Phosphorus	P	mg/kg	24-5.1 through 24.5.5 pp. 416-423	Plant Available bicarbonate extraction (Olson) common for neutral to alkaline soils (WSP S-4.10); Use Bray method for acidic soils (S-4.20; Bray P-1).

Notes:

1. Methods of Soil Analysis, Part 2, Chemical and Microbial Properties, 2nd Edition. Edited by A.L. Page, R.H. Miller and D.R. Kenney. ASA SSSA Publication, Madison WI 1982. #9 in monograph Series.
2. Methods of Soil Analysis, Part 1, Physical and Mineralogical Properties, including Statistics of Measurement and Sampling. Edited by C.A. Black et. al. ASA SSSA Publication, Madison WI 1965. #9 in monograph Series.
3. Soil Survey Staff, Soil Taxonomy: A Basic system of Soil Classification for Making and Interpreting Soil Surveys, Soil Conservation Service, USDA, Washington, D.C., Agriculture Handbook 436 (December 1975).
4. Method of analysis should be reported when submitting data to DEQ.
5. Association of Official Analytical Chemists, Official Methods of Analysis (AOAC). 1990 15th edition. All methods cited in this appendix are recommended methods. Other comparable methods yielding the same interpretive results are acceptable unless otherwise stated in the Land Application of Wastewater Permit.
6. Western States Agricultural Laboratory Exchange Program: Suggested Soil and Plant Analytical Methods. Miller, R. O. and Amacher, J. 1994 version 1.00.
7. Methods of Soil Analysis Used in the Soil Testing Laboratory at Oregon State University. Horneck, D. A., Hart, J. M., Topper, K., and Koespell, B., September 1989. Agricultural Experimental Station, Oregon State University, SM 89:4.

7.7.7 Soil Monitoring for Grazing Management

Grazing animals have the potential to adversely impact soil quality by compacting the soil and decreasing infiltration capacity. Decreasing the soils' infiltration capacity decreases the soils' ability to transport water, nutrients, oxygen and carbon dioxide – all essential processes for crop growth. For most soils, soil moisture status is a critical parameter to consider when assessing the potential of soil quality impacts. Generally, the higher the soil moisture content, the greater the potential for the soil to compress under pressure and decrease the soils infiltration capacity. Irrigation as well as precipitation events can change the soil water status. Soils should be monitored, especially after such events, to see whether they are too moist to bear the traffic of grazing animals. Soils can be sampled and evaluated for soil moisture according to the 'feel method' described in Table 7-25 (from Ashley et al. 1997).

"The feel method involves collecting soil samples in the root zone with a soil probe or spade. Then, the water deficit for each sample is estimated by feeling the soil and judging the soil moisture as outlined in" the table below. "Soil samples should be taken at several depths in the root zone at several places in the field." (Wright and Bergsrud, 1991). Grazing should not be conducted during soil conditions represented by shaded cells in the table.

Table 7-26 shows generalized drainage times for common soil textural classes. Times reflect drainage to field capacity. Unfortunately, field capacity is probably close to optimum moisture for compaction. Soils should be allowed to drain and dry beyond field capacity in the surface to be suitable for grazing After irrigating, soils should be allowed to drain at least as long as these drainage times. After this, soils should be evaluated by the 'feel method' to determine when grazing would be appropriate. Note that intensive, rotational grazing provides for short intense grazing on small paddocks and minimizes compaction from animals because they are on any one part of the field shorter than extended grazing.

Table 7-25. Feel method chart for estimating soil moisture

(Number indicates inches of water deficit per one foot of soil.)
Shaded cells indicate soil conditions which may be too wet for grazing.

Soil-Moisture Deficiency	Coarse Texture (sand, loamy sand)	Moderately Coarse Texture (sandy loam)	Medium Texture (silt loam, loam)	Fine and Very Fine Texture (clay loam, clay)
0% (Field capacity)	Upon squeezing, no free water appears on soil but wet outline of ball is left on hand. (0.0)	Upon squeezing, no free water appears on soil but wet outline of ball is left on hand. (0.0)	Upon squeezing, no free water appears on soil but wet outline of ball is left on hand. (0.0)	Upon squeezing, no free water appears on soil but wet outline of ball is left on hand. (0.0)
0 – 25%	Tends to stick together slightly, sometimes forms a very weak ball under pressure. (0.0 to 0.2)	Forms weak ball, breaks easily will not slick. (0.0 to 0.4)	Forms a ball, is very pliable, slicks readily if relatively high in clay. (0.0 to 0.5)	Easily ribbons out between fingers, has slick feeling. (0.0 to 0.6)
25 – 50%	Appears to be dry, will not form a ball with pressure. (0.2 to 0.5)	Tends to ball under pressure, but seldom holds together. (0.4 to 0.8)	Forms a ball somewhat plastic, will sometimes slick slightly with pressure. (0.5 to 1.0)	Forms a ball, ribbons out between thumb and forefinger. (0.6 to 1.2)
50 – 75%	Appears to be dry, will not form a ball with pressure. (0.5 to 0.8)	Appears to be dry, will not form a ball. (0.8 to 1.2)	Somewhat crumbly but holds together from pressure. (1.0 to 1.5)	Somewhat pliable, will ball under pressure. (1.2 to 1.9)
75 – 100% **(100% is permanent wilt point)**	Dry, loose, single-grained, flows through fingers. (0.8 to 1.0)	Dry, loose, flows through fingers. (1.2 to 1.5)	Powdery, dry, sometimes slightly crusted but easily broken down into powdery condition. (1.5 to 2.0)	Hard, baked, cracked, sometimes has loose crumbs on surface. (1.9 to 2.5)

Note: A ball is formed by squeezing a handful of soil very firmly.
Source: Israelsen and Hansen. *1962. Irrigation Principals and Practices.* Third Edition. New York: John Wiley and Sons, Inc.

Table 7-26. Generalized Drainage Times for Uniform Soil Profiles of Varying Textures

Texture	**Drainage Time (Range in days)**
Loamy Sand	0.5 - 2
Sandy Loam	3 - 4
Silt Loam	4 - 6
Clay Loam	5 - 7

Carlisle and Phillips, 1976 and Donahue et al., 1977

7.7.8 Wastewater Monitoring Supplemental Information

7.7.8.1 NPDES Compliance Inspection Manual, Chapter 6

Source:
http://www.epa.gov/compliance/resources/publications/monitoring/cwa/inspections/npdesinspect/npdesmanual.html

6. FLOW MEASUREMENT

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6. A. Evaluation of Permittee's Flow Measurement

Objectives and Requirements

To comply with the permit requirements established under the National Pollutant Discharge Elimination System (NPDES), the permittee must accurately determine the quantity of wastewater being discharged. Discharge flow an measurement is an integral part of the NPDES program, it is important that the inspector evaluate the accuracy of the measurement.

In addition to providing usable information for enforcement purposes, flow measurement serves to:

- Provide data for pollutant mass loading calculations
- Provide operating and performance data on the wastewater treatment plant
- Compute treatment costs, based on wastewater volume
- Obtain data for long-term planning of plant capacity, versus capacity used
- Provide information on Infiltration and Inflow (I/I) conditions, and the need for cost-effective I/I correction

A Flow Measurement Inspection Checklist for the inspector's use appears at the end of this chapter.

Evaluation of Facility-Installed Flow Devices and Data

There are two types of wastewater flow: closed channel flow and open channel flow. Closed channel flow occurs under pressure in a liquid-full conduit (usually a pipe). The facility will usually have a metering device inserted into the conduit which measure flow. Examples of closed channel flow measuring devices are the Venturi meter, the Pitot tube, the paddle wheel, the electromagnetic flowmeter, Doppler, and the transit-time flowmeter. In practice, closed channel flow is normally encountered between treatment units in a wastewater treatment plant, where liquids and/or sludges are pumped under pressure.

Open channel flow occurs in conduits that are not liquid-full. Open channel flow are partially full pipes not under pressure. Open channel flow is the most prevalent type of flow at NPDES-regulated discharge points.

Measure open channel flow using primary and secondary devices. Primary devices are standard hydraulic structures, such as flumes and weirs, that are inserted in the open channel. Inspectors can obtain accurate flow measurements merely by measuring the depth of liquid (head) at the specific point in the primary device. In a weir application, for example, the flow rate is a function of the head of liquid above the weir crest.

Facilities use secondary devices in conjunction with primary devices to automate the flow measuring process. Typically, secondary devices measure the liquid depth in the primary device and convert the depth measurement to a corresponding flow, using established mathematical relationships. Examples of secondary devices are floats, ultrasonic transducers, bubblers, and transit-time flowmeters. A recorder generally measures the output of the secondary device transmitted to a recorder and/or totalizer to provide instantaneous and historical flow data to the operator. Outputs may also be transmitted to sampling systems to facilitate flow proportioning. Appendix O contains further information on flow measurement devices.

The inspector must assure the permittee obtains accurate wastewater flow data to calculate mass loading (quantity) from measured concentrations of pollutants discharged as required by many NPDES permits. The permittee must produce data that meet requirements in terms of precision and accuracy. Precision refers to data reproducibility or the ability to obtain consistent data from repeated measurements of the same quantity. Accuracy refers to the agreement between the amount of a component measured by the test and the amount actually present.

The accuracy of flow measurement (including both primary and secondary devices) varies widely with the device, its location, environmental conditions, and other factors such as maintenance and calibration. Faulty fabrication, construction, and installation of primary devices are common sources of errors. Improper calibration, misreading, and variation in the speed of totalizer drive motors are major errors related to secondary devices. See Appendix O - "Supplement Flow Measurement Information." When evaluating facility installed devices, the inspector should do the following:

- Verify that the facility has installed primary and secondary devices according to manufacturer's manual instructions.

- Inspect the primary device for evidence of corrosion, scale formation, or solids accumulation that may bias the flow measurement.

- Verify that weirs are level, plumb, and perpendicular to the flow direction.

- Verify that flumes are level, the throat walls (narrowed section of flume) are plumb, and the throat width is the standard size intended.

- Inspect historical records (i.e., strip charts and logs) for evidence of continuous flow measurements. Compare periods of missing data with maintenance logs for explanations of measuring system problems.

- Observe the flow patterns near the primary device for excessive turbulence or velocity. The flow lines should be straight.

- Ensure that the flow measurement system or technique being used measures the entire wastewater discharge as required by the NPDES permit. Inspect carefully the piping to determine whether there are any wastewater diversions, return lines, or bypasses around the system. Make sure the system meets the permit requirement, such as instantaneous or continuous, daily, or other time interval measures. Noted anomalies in the inspection report.

- Verify that the site chosen for flow measurement by the facility is appropriate and is in accordance with permit requirements.

- Verify that the site chosen by the facility for flow measurement is suitable for type of discharge, flow range, suspended solids concentration, and other relevant factors.
- Verify that the facility has closed channel flow measuring devices where the pipe is always full. If these devices are used, then there must be also a means for the permittee and regulatory agencies/inspector to verify the accuracy of these meters. Primary flow measuring devices such as weirs and flumes are ideal for this purpose.
- Verify that the facility uses appropriate tables, curves, and formulas to calculate flow rates.
- Review and evaluate calibration and maintenance programs for the discharger's flow measurement system. The permit normally requires the facility to check the calibration regularly by the permittee. The facility must ensure that their flow measurement systems are calibrated by a qualified source at least once a year to ensure their accuracy. Lack of such a program is considered unacceptable for NPDES compliance purposes.
- Verify that the facility calibrates flowmeters across the full range of expected flow.
- Verify that primary and secondary devices are adequate for normal flow as well as maximum expected flow. Note whether the flow measurement system can measure the expected range of flow.
- Collect accurate flow data during inspection to validate self monitoring data collected by the permittee.
- The facility must install a flow measuring system that has the capability of routine flow verification by the permittee or appropriate regulatory personnel.

Evaluation of Permittee Data Handling and Reporting

The permittee or facility must keep flow measurement records for a minimum period of three years as the permit requires. Many flow measuring devices produce a continuous flowchart for plant records. Flow records should contain date, flow, time of reading, and operator's name, if applicable the facility must also record. The facility should record maintenance, inspection dates, and calibration data.

The inspector should review the permittee's records and note the presence or absence of data such as:

- Frequency of routine operational inspections
- Frequency of maintenance inspections

- Frequency of flowmeter calibration (should be as specified in permit, generally at least once per year)

- Irregularity or uniformity of flow.

Evaluation of Permittee Quality Control

The inspection should evaluate following quality control issues during a compliance inspection to ensure:

- Proper operation and maintenance of equipment
- Accurate records
- Sufficient inventory of spare parts
- Valid flow measurement techniques
- Precise flow data
- Adequate frequency of calibration checks.

Evaluate precision of float driven flow meters when flows are stable. Push the float gently downward, hold for 30 seconds, then allowed to return normally. The recorded flow rate should be the same before and after the float was moved. Evaluate accuracy by measuring the instantaneous flow rate at the primary device used at the facility and comparing the value against the value on the meter, graph, integrator, or company record. The difference between two stable totalizer readings (flow is steady for 10 minutes or more) should not exceed ±10 percent of the instantaneous flow measured at the primary device. Note that most flow measurement systems have both an instantaneous meter readout as well as a totalizer. Both of these devices should be in agreement but that is not always the case due to electrical and other various malfunctions in the flow measuring system. In most cases, the totalizer reading will be what is reported by the permittee. If this is the case, then that device should be checked for accuracy and the permittee's flow measuring system rated accordingly.

In addition, the inspector can evaluate accuracy by installing a second flow measurement system, sometimes referred to as a reference system. Agreement in measured flow rates between the two systems should be within ±10 percent of the reference rate if all conditions are as recommended for the systems.

6. B. Flow Measurement Compliance

Objectives

The current NPDES program depends heavily on the permittee's submittal of self-monitoring data. The flow discharge measured during the NPDES compliance inspection should verify the flow measurement data collected by the permittee, support any enforcement action that may be necessary, and provide a basis for reissuing or revising the NPDES permit.

Flow Measurement System Evaluation

The responsibility of the inspector includes collecting accurate flow data during the inspection and validating data collected during the permittee's self-monitoring.

The NPDES inspector must check both the permittee's flow data and the flow measurement system to verify the permittee's compliance with NPDES permit requirements. When evaluating a flow measurement system, the inspector should consider and record findings on the following:

- Whether the system measures the entire discharge flow.
- The system's accuracy and good working order. This wil include a thorough physical inspection of the system and comparison of system readings to actual flow or those obtained with calibrated portable instruments.
- The need for new system equipment.
- The existence or absence of a routine calibration and maintenance program for flow measurement equipment.

If the permittee's flow measurement system is accurate within ±10 percent, the inspector should use the installed system. If the flow sensor or recorder is found to be inaccurate, the inspector should determine whether the equipment can be corrected in time for use during the inspection. If the equipment cannot be repaired in a timely manner, use the portable flow sensor and recorder used to assess the accuracy of the permittee's system for the duration of the inspection. If nonstandard primary flow devices are being used, request the permittee to supply data on the accuracy and precision of the method being employed.

For flow measurement in pipelines, the inspector may use a portable flowmeter. The inspector should select a flowmeter with an operating range wide enough to cover the anticipated flow to be measured. The inspector should test and calibrate the selected flowmeter before use. The inspector should select the site for flow measurement according to permit requirements and install the selected flowmeter according to the manufacturer's specifications. The inspector should use the proper tables, charts, and formulas as specified by the manufacturer to calculate flow rates.

Four basic steps are involved in evaluating the permittee's flow measurement system:

- Physical inspection of the primary device
- Physical inspection of the secondary device and ancillary equipment
- Flow measurement using the primary/secondary device combination of the permittee
- Certification of the system using a calibrated, portable instrument.

The following sections present, procedures for inspecting the more common types of primary and secondary devices, for measuring flow using common permanent and portable systems, and for evaluating flow data. Please note that the number of primary/secondary device permutations is limitless; therefore, it is not feasible to provide procedures for all systems. When encountering systems other than those discussed here the inspector should consult the manufacturers manual/personnel for advice before preparing a written inspection procedure.

Primary Device Inspection Procedures

The two most common open channel primary devices are sharp-crested weirs and Parshall flumes. Common sources of error when using them include the following:

- Faulty fabrication—weirs may be too narrow or not "sharp" enough. Flume surfaces may be rough, critical dimensions may exceed tolerances, or throat walls may not be vertical.
- Improper installation—the facility may install weirs and flumes too near pipe elbows, valves, or other sources of turbulence. The devices may be out of level or plumb.
- Sizing errors—the primary device's recommended applications may not include the actual flow range.
- Poor maintenance—primary devices corrode and deteriorate. Debris and solids may accumulate in them.

Specific inspection procedures for the sharp-crested weir, the Parshall flume, and the Palmer-Bowlus flume devices follow.

Sharp-Crested Weir Inspection Procedures

- Inspect the upstream approach to the weir.
  - Verify that the weir is perpendicular to the flow direction.
  - Verify that the approach is a straight section of conduit with a length at least 20 times the maximum expected head of liquid above the weir crest.
  - Observe the flow pattern in the approach channel. The flow should occur in smooth stream lines without velocity gradients and turbulence.
  - Check the approach, particularly in the vicinity of the weir, for accumulated solids,

debris, or oil and grease. The approach must have no accumulated matter

- Inspect the sharp-crested weir.
  - Verify that the crest of the weir is level across the entire conduit traverse.
  - Measure the width of the weir crest. The edge of the weir crest should be no more than 1/8-inch thick.
  - Make certain the weir crest corresponds to zero gauge elevation (zero output on the secondary device).
  - Measure the angle formed by the top of the crest and the upstream face of the weir. This angle must be 90 degrees.
  - Measure the chamfer (beveled edge) on the downstream side of the crest. The chamfer should be approximately 45 degrees.
  - Visually survey the weir-bulkhead connection for evidence of leaks or cracks which permit bypass.
  - Measure the height of the weir crests above the channel floor. The height should be at least twice the maximum expected head (2H) of liquid above the crest.
  - Measure the width of the end contraction. The width should be at least twice the maximum expected head (2H) of the liquid above the crest.
  - Inspect the weir for evidence of corrosion, scale formation, or clinging matter. The weir must be clean and smooth.
  - Observe flow patterns on the downstream side of the weir. Check for the existence of an air gap (ventilation) immediately adjacent to the downstream face of the weir. Ventilation is necessary to prevent a vacuum that can induce errors in head measurements. Also ensure that the crest is higher than the maximum downstream level of water in the conduit.
  - Verify that the nappe is not submerged and that it springs free of the weir plate.
  - If the weir contains a V-notch, measure the apex angle. The apex should range from 22.5 degrees to 90 degrees. Verify that the head is between 0.2 and 2.0 feet. The weir should not be operated with a head of less than 0.2 feet since the nappe may not spring clear of the crest.

King's *Handbook of Hydraulics*, 1963, frequently referenced throughout this chapter, provides a detailed discussion on weirs.

Parshall Flume Inspection Procedures

- Inspect the flume approach.
  - The flow pattern should be smooth with straight stream lines, be free of turbulence, and have a uniform velocity across the channel.
  - The upstream channel should be free of accumulated matter.
- Inspect the flume.
  - The flume should be located in a straight section of the conduit.
  - Flow at the entrance should be free of "white" water.
  - The flume should be level in the transverse and translational directions.
  - Measure the dimensions of the flume. Dimensions are strictly prescribed as a function of throat width (see Figure I-5 in Appendix O for critical dimensions).
  - Measure the head of liquid in the flume and compare with the acceptable ranges in Table I-4 in Appendix O.
- Inspect the flume discharge.
  - Verify that the head of water in the discharge is not restricting flow through the flume. The existence of a "standard wave" is good evidence of free flow and verifies that there is no submergence present.
  - Verify whether submergence occurs at near maximum flow (e.g., look for water marks on the wall).

Palmer-Bowlus Flume Inspection Procedures

- Inspect the flume approach as outlined above (these flumes are seldom used for effluent flow measurement).
- Inspect the flume.
  - The flume should be located in a straight section of the conduit.
  - Flow at the entrance should be free of "white" water.
  - Observe the flow in the flume. The profile should approximate that depicted in Figure I-8 in Appendix O.
  - The flume should be level in the transverse direction and should not exceed the translational slope in Table I-6 in Appendix O.

- Measure the head of water in the flume. Head should be within the ranges specified in Table I-6 in Appendix O.

- Inspect the flume discharge.

  - Verify that free flow exists. Look for the characteristic "standing wave" in the divergent section of the flume.

Venturi Meter Inspection Procedures

- Verify that the facility installed the Venturi meter according to manufacturer's instructions.

- Verify that the facility installed the Venturi meter downstream from a straight and uniform section of pipe, at least 5 to 20 diameters, depending on the ratio of pipe to throat diameter and whether straightening vanes are installed upstream. (Installation of straightening vanes upstream will reduce the upstream piping requirements.)

- Verify that the pressure measuring taps are free of debris and are not plugged.

- Calibrate the Venturi meter in place by either the volumetric method or the comparative dye dilution method to check the manufacturer's calibration curve or to develop a new calibration curve.

Secondary Device Inspection Procedures

The following are common sources of error in the use of secondary devices:

- Improper location—gauge is located in the wrong position relative to the primary device.
- Inadequate maintenance—gauge is not serviced regularly.
- Incorrect zero setting—zero setting of gauge is not the zero point of the primary device.
- Operator error—human error exists in the reading.

Specific inspection procedures follow.

Flow Measurement in Weir Applications

- Determine that the head measurement device is positioned 3 to 4 head lengths upstream of a weir.

- Verify that the zero or other point of the gauge is equal to that of the primary device.

The inspector should use an independent method of measuring head, such as with a yardstick or carpenter's rule (be sure to take your measurement at least four times the maximum head upstream and from the weir and convert to nearest hundredth of a foot). To determine flow rate, use the appropriate head discharge relationship formula (see Table I-1 in Appendix O).

Flow Measurement in Parshall Flume Applications

Flow Measurement—Free-Flow Conditions.

- Determine upstream head (H_a) using staff gauge.
  - Verify that staff gauge is set to zero head. Use either a yardstick or carpenter's rule.
  - Verify that staff gauge is at proper location (two-thirds the length of the converging section back from the beginning of the throat).
  - Read to nearest division the gauge division at which liquid surface intersects gauge.
  - Read H_a in feet from staff gauge.
- To determine flow rate, use Figure I-6 in Appendix O in the unit desired, use tables published in flow measurement standard references, or calculate using the coefficients in Table I-5 in Appendix O.

Flow Measurement—Submerged-Flow Condition.

Generally it is difficult to make field measurements with submerged-flow conditions. In cases when measurements can be obtained (using a staff or float gauge), the procedures listed below should be followed:

- Determine upstream head using staff or float gauge.
  - Read to nearest division and, at the same time as for H_b, the gauge division at which liquid surface intersects gauge.
  - Calculate H_a from gauge reading.
- Determine downstream head (H_b) using staff or float gauge.
  - H_b refers to a measurement at the crest.
  - Read to nearest division, and at the same time as for H_a, the gauge division at which liquid surface intersects gauge.
  - Calculate H_b from staff reading.

- Determine flow rate.
  - Calculate percent submergence:

$$\left[\frac{H_b}{H_a}\right] \times 100.$$

  - Consult Table I-6 in Appendix O.
  - When a correction factor is obtained, use H_a and find free-flow from Figure I-6.
  - Multiply this free-flow value by the correction factor to obtain the submerged flow.

The inspector may use an independent method of measuring head, such as a yardstick or carpenter's rule at the proper head measurement point. Because of the sloping water surface in the converging section of a flume, it is essential that the proper head measurement point be used.

Flow Measurement in Palmer-Bowlus Flume Applications

- Obtain head measurements as in the Parshall Flume application, using the secondary device. The head is the height of water above the step. The total depth upstream of the step is not the head.
- Refer to manufacturer-supplied discharge tables to convert head measurements to flow data. Palmer-Bowlus flumes, unlike Parshall flumes, are not constructed to standard dimensional standards. The inspector must not use discharge tables supplied by other manufacturers.

Verification

Most flow measurement errors result from inadequate calibration of the flow totalizer, and recorder. If the inspector has determined that the primary device has been installed properly, verification of the permittee's system is relatively simple. Compare the flow determined from the inspector's independent measurement to the flow of the permittee's totalizer or recorder. The inspector's flow measurements should be within 10 percent of the permittee's measurements to certify accurate flow measurement. Optimally, flow comparisons should be made at various flow rates to check system accuracy.

When the permit requires that the daily average flow be measured by a totalizing meter, the inspector should verify that the totalizer is accurate, i.e., properly calibrated. This can be done during a period of steady flow by reading the totalizer and at the same time starting a stopwatch. Start the stopwatch just as a new digit starts to appear on the totalizer. After 10 to 30 minutes, the totalizer should be read again; just as a new digit begins to appear, the stop watch is read. Subtract the two totalizer readings to determine, the total flow over the measured time period. Calculate the flow rate in gallons per minute by using the time from the stop watch. Compare this flow rate to the flow determined by actual measurement of the head made at the primary device at the time interval. Consider the calibration of the totalizer satisfactory if the two flows are within 10 percent of each other, when the actual measured flow is used as the known value, or divisor, in the percent calculation.

6. C. References and Flow Measurement Inspection Checklist

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FLOW MEASUREMENT INSPECTION CHECKLIST

A. GENERAL

Yes No N/A	1. a. Primary flow measuring device properly installed and maintained.
Yes No N/A	b. Flow measured at each outfall? __________ Number of outfalls? __________
Yes No N/A	c. Is there a straight length of pipe or channel before and after the flowmeter of at least 5 to 20 diameters?
Yes No N/A	d. If a magnetic flowmeter is used, are there sources of electric noise in the near vicinity?
Yes No N/A	e. Is the magnetic flowmeter properly grounded?
Yes No N/A	f. Is the full pipe requirement met?
Yes No N/A	2. a. Flow records properly kept.
Yes No N/A	b. All charts maintained in a file.
Yes No N/A	c. All calibration data entered into a log book.
Yes No N/A	3. Actual discharged flow measured.
Yes No N/A	4. Effluent flow measured after all return lines.
Yes No N/A	5. Secondary instruments (totalizers, recorders, etc.) properly operated and maintained.
Yes No N/A	6. Spare parts stocked.
Yes No N/A	7. Effluent loadings calculated using effluent flow.

B. FLUMES

Yes No N/A	1. Flow entering flume reasonably well-distributed across the channel and free of turbulence, boils, or other disturbances.
Yes No N/A	2. Cross-sectional velocities at entrance relatively uniform.
Yes No N/A	3. Flume clean and free of debris and deposits.
Yes No N/A	4. All dimensions of flume accurate and level.
Yes No N/A	5. Side walls of flume vertical and smooth.
Yes No N/A	6. Sides of flume throat vertical and parallel.
Yes No N/A	7. Flume head being measured at proper location.
Yes No N/A	8. Measurement of flume head zeroed to flume crest.
Yes No N/A	9. Flume properly sized to measure range of existing flow.
Yes No N/A	10. Flume operating under free-flow conditions over existing range of flows.
Yes No N/A	11. Flume submerged under certain flow conditions.
Yes No N/A	12. Flume operation invariably free-flow.

FLOW MEASUREMENT INSPECTION CHECKLIST
(Continued)

C. WEIRS

Yes No N/A	1. What type of weir does the facility use?
Yes No N/A	2. Weir exactly level.
Yes No N/A	3. Weir plate plumb and its top and edges sharp and clean.
Yes No N/A	4. Downstream edge of weir is chamfered at 45°.
Yes No N/A	5. Free access for air below the nappe of the weir.
Yes No N/A	6. Upstream channel of weir straight for at least four times the depth of water level and free from disturbances.
Yes No N/A	7. Distance from sides of weir to side of channel at least 2H.
Yes No N/A	8. Area of approach channel at least (8 × nappe area) for upstream distance of 15H.
Yes No N/A	9. If not, is velocity of approach too high?
Yes No N/A	10. Head measurements properly made by facility personnel.
Yes No N/A	11. Leakage does not occur around weir.
Yes No N/A	12. Use of proper flow tables by facility personnel.

D. OTHER FLOW DEVICES

	1. Type of flowmeter used:
	2. What are the most common problems that the operator has had with the flowmeter?
	3. Measured wastewater flow: ________ mgd; Recorded flow: ________; Error ________%

E. CALIBRATION AND MAINTENANCE

Yes No N/A	1. Flow totalizer properly calibrated.
	2. Frequency of routine inspection by proper operator: ________/day.
	3. Frequency of maintenance inspections by plant personnel: ________/year.
Yes No N/A	4. Flowmeter calibration records kept. Frequency of flowmeter calibration: ________/month.
Yes No N/A	5. Flow measurement equipment adequate to handle expected ranges of flow rates.
Yes No N/A	6. Calibration frequency adequate.

Table 7-27. Wastewater Monitoring for Industrial Wastewater Land Application Facilities

Frequency	Monitoring Point	Description/Type of Monitoring	Parameters
Daily	Flow meter	Flow of wastewater into land application system	Volume (million gallons and acre-inches) to each hydraulic management unit, record monthly and annually
Annually	Each hydraulic management unit	Calculate non-growing season wastewater loading rate	Million gallons & Inches/ non-growing season
Annually	Each hydraulic management unit	Calculate growing season wastewater loading rate	Million gallons & Inches/ growing season
Annually	All flow measurement locations.	Flow measurement calibration of all flows to land application.	Document the flow measurement calibration of all flow meters and pumps used directly or indirectly measure all wastewater, tail water, flushing water, and supplemental irrigation water flows applied to each hydraulic management unit.
Annually	All supplemental irrigation pumps directly connected to the wastewater distribution system.	Backflow testing	Document the testing of all backflow prevention devices for all supplemental irrigation pumps directly connected to the wastewater distribution system(s). Report the testing date(s) and results of the test (pass or fail). If any test failed, report the date of repair or replacement of backflow prevention device, and if the repaired/replaced device is operating correctly.
Monthly	Effluent to land application	Wastewater quality into land application system – 24-hr. Composite	Chemical Oxygen Demand, Total Kjeldahl Nitrogen, Ammonia-Nitrogen, Nitrite + Nitrate-Nitrogen, Total Phosphorous, Chloride, Electrical Conductivity, Potassium, pH
Quarterly	Effluent to land application	Wastewater quality into land application system	Total Dissolved Inorganic Solids (TDIS) – See Table B-1. Submit analysis of individual ions in addition to TDIS.
Quarterly (for the first year only, 4 sample events)	Effluent to land application	Wastewater quality into land application system – 24-hr. composite.	Total Dissolved Solids (TDS), Volatile Dissolved Solids (VDS) for NVDS determination (i.e. NVDS = TDS – VDS)
Quarterly (for the first year only, 4 sample events)	Effluent to land application	Grab sample for bacteria	Colony numbers for Fecal Coliform, Total Coliform, Fecal Streptococcus and Pseudomonas, standard presence / absence test for Listeria (if present, determine specific type)
Daily	Flow meter or Calibrated Pump Rate	Supplemental Irrigation Water	Volume (million gallons and acre-inches) to each Hydraulic Management Unit , report monthly and annually.
Twice per year (May and Oct)	Nearest Surface Water – DEQ shall review and approve locations prior to initial sampling event.	Grab samples of surface water upstream and downstream from land application site.	Nitrate + Nitrite Nitrogen, Total Phosphorous, , Total Dissolved Solids, , Total Kjeldahl Nitrogen
Twice per year (May and Oct)	Supplemental Irrigation at diversions	Grab sample	Nitrate + Nitrite Nitrogen, Total Phosphorous, Total Dissolved Solids, , Chloride, Total Kjeldahl Nitrogen

Table 7-28. Wastewater Monitoring for Municipal Wastewater Land Application Facilities.

Frequency	Monitoring Point	Description and Type of Monitoring	Parameters
Daily (when land applying)	Discharge Point of Wastewater to Land Application (Flow Meter)	Volume of Wastewater land applied	Gallons/Month and acre-inches/month applied to each Hydraulic Management Unit
Annually	Each hydraulic management unit	Calculate non-growing season wastewater loading rate	Million gallons & Inches/ non-growing season
Annually	Each hydraulic management unit	Calculate growing season wastewater loading rate	Million gallons & Inches/ growing season
Annually	All flow measurement locations.	Flow measurement calibration of all flows to land application.	Document the flow measurement calibration of all flow meters and pumps used directly or indirectly measure all wastewater, tail water, flushing water, and supplemental irrigation water flows applied to each hydraulic management unit.
Annually	All supplemental irrigation pumps directly connected to the wastewater distribution system.	Backflow testing	Document the testing of all backflow prevention devices for all supplemental irrigation pumps directly connected to the wastewater distribution system(s). Report the testing date(s) and results of the test (pass or fail). If any test failed, report the date of repair or replacement of backflow prevention device, and if the repaired/replaced device is operating correctly.
Monthly (when land applying)1	Discharge Point of Wastewater to Land Application	grab sample	Total Kjeldahl nitrogen, nitrate+nitrite-nitrogen, TDS, pH, COD, total phosphorus
Daily (when land applying)	Flow Meter or Calibrated Pump Rate	Supplemental Irrigation Water	Gallons/Month and acre-inches/month applied to each Hydraulic Management Unit
Annually	Supplemental Irrigation Water at diversions	Grab Sample	Total Kjeldahl nitrogen, nitrate+nitrite-nitrogen, TDS, total phosphorus
During Application Season For total coliform, monitoring frequency depends on level of treatment. 1. 2.2 / 100 ml. - Twice Weekly 2. 23 / 100 ml. - Weekly 3. 230 / 100 ml. - Twice Monthly	Discharge Point of Wastewater to Land Application	grab sample	Total Coliform
Twice per year (May and Oct)	Nearest Surface Water – DEQ shall review and approve locations prior to initial sampling event.	Grab samples of surface water upstream and downstream from land application site.	Nitrate + Nitrite Nitrogen, Total Phosphorous, , Total Dissolved Solids, Total Kjeldahl Nitrogen

Note:
1) Sampling frequency may be reduced to twice per season if the system nitrogen loading rate is less than 75% of the nitrogen permit limit (125% of crop uptake. The months in which the samples are to be taken should be specified in the permit and/or O&M manual (for example, July and September). This monitoring reduction should not be allowed for municipal systems with industrial users.

Table 7-29. Wastewater Analyses.

Parameter	Abbreviations	Units	EPA[1]	Standard Methods[2]	Comments
Total Flow	--	MGD	--	meter measurement	
pH	--	S.U.	150.1	4500-H+	
Dissolved Oxygen	DO	mg/L	360.1 or 360.2	4500-O	
Chemical Oxygen Demand	COD	mg/L	410.1 see comments	5220 B	for COD>50 mg/L & Cl < 2000 mg/L
Chemical Oxygen Demand	COD	mg/L	410.2 see comments	5220 B	for COD 5-50 mg/L
Chemical Oxygen Demand	COD	mg/L	410.3 see comments	5220 B	for COD > 250 mg/L & Cl > 1000 mg/L
Biochemical Oxygen demand	BOD	mg/L	405.1	5210 B	
Electrical Conductivity	EC	umhos/cm	120.1	2510 B	
Total Dissolved Solids (or Total Filterable Residue)	TDS	mg/L	160.25	2540 C5	This analysis includes both organic and inorganic TDS5
Volatile Dissolved Solids (Total Nonfilterable Dissolved Residue)	VDS	mg/L	160.45	2540 E5	See footnote #5
Fixed Dissolved Solids	FDS	mg/L		2540 E (20th Ed.)	
Non Volatile Dissolved Solids	NVDS	mg/L			Calculated by subtracting VDS from TDS[5]
Total Suspended Solids (or Total Non-Filterable Residue)	TSS	mg/L	160.1	2540 D	
Total Settleable Solids	SS	mg/L	160.5	2540 F	
Ammonia Nitrogen	NH3-N	mg/L	350.1, 350.2, or 350.3	4500-NH3	(See also AOAC4 920.03, 1990 edition)
Total Kjeldahl Nitrogen	TKN	mg/L	351.1, 351.2, 351.3, or 351.4	4500-Norg	(See also AOAC4 955.04, 1990 edition)
Nitrate + Nitrite Nitrogen	NO3 + NO2	mg/L	353.1, 353.2 or 353.3	4500-NO3 + 4500-NO2	(See also AOAC4 958.01, 1990 edition)

Parameter	Abbreviations	Units	EPA[1]	Standard Methods[2]	Comments
Total Phosphorus	P	mg/L	365.4	4500-P	(See also AOAC4 965.09, 1990 edition)
Sodium	Na	mg/L	273.1	3500-Na	(See also AOAC4 965.09, 1990 edition)
Potassium	K	mg/L	258.1	3500-K	(See also AOAC4 965.09, 1990 edition)
Calcium	Ca	mg/L	215.1 or 215.2	3500-Ca	(See also AOAC4 965.09, 1990 edition)
Magnesium	Mg	mg/L	242.1	3500-Mg	(See also AOAC4 965.09, 1990 edition)
Iron	Fe	mg/L	236.1	3500-Fe	(See also AOAC4 965.09, 1990 edition)
Manganese	Mn	mg/L	243.1	3500-Mn	(See also AOAC4 965.09, 1990 edition)
Oil & Grease	--	mg/L	413.1 or 413.2	5520	
Alkalinity	Alk	mg/L	310.1 or 310.2	2320	
Chloride	Cl	mg/L	325.1, 325.2, or 325.3	4500-Cl-	
Chlorine Residual	Clres	mg/L	330.1, 330.2, 330.3, 330.4 or 330.5	4500-Cl	
Fluoride	F	mg/L	340.1, 340.2 or 340.3	4500-F-	
Fecal Coliform	FC	#/100 ml	p. 1323 or p. 1243	9221 C 9222 D	
Total Coliform	TC	#/100 ml	p. 1143 or p. 1083	9221 B 9222 B	
Total Coliform in presence of chlorine	TC	#/100 ml	p. 1143 or p. 1113	9221 B 9222 B+B.5c	
Fecal Streptococcus	FS	#/100 ml	p. 1393, p. 1363 or p. 1433	9230 B 9230C	
Gross alpha	--	pCi/L	--	7110	
Gross beta	--	pCi/L	--	7110	
SAR	SAR	meq0.5/ L0.5	NA	NA	Calculation

Notes:

1. Methods for Chemical Analysis of Water and Wastes. Environmental Protection Agency, Environmental Monitoring Systems Laboratory-Cincinnati (EMSL-Cllll), EPA-600/4-79-020. Revised March 1983 and 1979 where applicable.
2. Greenberg, A.E. et al. (eds). 1992. Standard Methods for the Examination of Water and Wastewater - 18th Edition.
3. Bordner, R.H., and J.A. Winter, eds. 1978. "Microbiological Methods for Monitoring the Environment, Water and Waste." Environmental Monitoring Systems Laboratory, U.S. Environmental Protection Agency. EPA-600/8-78-017.
4. Association of Official Analytical Chemists, Official Methods of Analysis (AOAC). 1990 15th Edition. All methods cited in this appendix are recommended methods. Other comparable methods yielding the same interpretive results are acceptable unless otherwise stated in the Wastewater-Land Application Permit.
5. A measure of inorganic TDS in wastewater is important in order to calculate total salt loading to a site and predict down-gradient ground water concentrations. Estimates of inorganic TDS can be made by subtracting VDS from TDS to obtain Non-Volatile Dissolved Solids (NVDS). Major ions may also be summed to estimate this parameter.

7.7.9 Crop Monitoring and Yield Estimation Supplemental Information

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7.7.9.1 Crop Nutrient Concentration Values

Table 7-30 provides estimated nitrogen contents of the harvested portion of selected crops and vegetables. These values are approximate; actual site values will vary due to crop maturity, crop variety, climate (particularly water stress), and general nutrition status of crop.†

Table 7-30. Crop Nutrient Concentration Values.

		N (Dry matter basis)				N harvested‡	
Crop Description	Data Source	Common value	General range	Unit of measure	Moisture content of unit	Common value	General range
			-------- % --------			%	----lb N/unit ---
Cereal and oil crops							
Barley, grain	1	2.10	1.90-2.30	Bu	14	0.87	0.78-0.95
Straw	1	0.73	0.58-0.88	Ton	10	13	10-16
Barley	5	--	--	Bu	11	--	0.9
Barley	6	--	--	Bu	--	--	1.5 (for 100 bu/ac yield)
Corn, Grain, Shelled	1	1.55	1.35-1.75	Bu	15	0.73	0.64-0.83
Silage	1	1.25	1.10-1.45	Ton	70	7.2	6.6-8.7
Corn, Field for Grain	5	--	--	Bu	13	--	0.8
Corn, Grain	6	--	--	Bu	--	--	1.3 – 1.5 (as yield varies from 200 to 100 bu/ac
Oat, grain	1	2.20	1.95-2.50	Bu	14	0.61	0.54-0.69
Straw	1	0.70	0.55-0.85	Ton	10	13	9-15
Oats	5	--	--	Bu	11	--	0.6
Oats	6	--	--	Bu	--	--	1.5 (for 100 bu/ac yield)
Rice, grain	1	1.40	1.05-1.65	Bu	14	0.54	0.41-0.64
Straw	1	0.65	0.50-0.80	Ton	10	12	9-14
Rye, grain	1	2.20	2.00-2.40	Bu	14	1.05	0.95-1.2
Straw	1	0.50	0.35-0.65	Ton	10	9	6-12

		N (Dry matter basis)				N harvested‡	
Crop Description	Data Source	Common value	General range	Unit of measure	Moisture content of unit	Common value	General range
			-------- % --------			%	----lb N/unit ---
Sorghum, grain	1	1.65	1.45-1.80	Bu	14	0.80	0.70-0.87
Soybean, grain	1	6.50	6.10-6.90	Bu	15	3.3	3.1-3.5
Straw	1	0.85	0.70-1.00	Ton	10	15	13-18
Sunflower, seed Oil type	1	2.70	2.20-3.20	Ton	10	49	40-58
Confection	1	3.20	2.80-3.60	Ton	10	58	50-65
Wheat grain, Hard red winter	1	2.30	2.05-2.50	Bu	14	1.2	1.1-1.3
Soft red winter	1	2.10	1.85-2.30	Bu	14	1.1	0.95-1.20
Soft white winter	1	1.80	1.60-2.00	Bu	14	0.95	0.80-1.05
Hard red spring	1	2.60	2.35-2.85	Bu	14	1.35	1.20-1.50
Straw	1	0.65	0.40-0.85	Ton	10	11	7-15
Wheat	5	--	--	Bu	11	--	1.2
Wheat	6			Bu			2.32 (for 100 bu/ac yield)
Forage crops							
Alfalfa, Hay, sun-cured Vegetative	1	3.30	2.80-3.80	Ton	15	56	48-65
Early bloom	1	3.05	2.55-3.55	Ton	15	52	43-60
Mid bloom	1	2.75	2.25-3.25	Ton	15	47	38-55
Full bloom	1	2.50	2.00-3.00	Ton	15	43	34-51
Green chop Vegetative	1	3.55	3.05-4.05	Ton	75	18	15-20
Early bloom	1	3.15	2.65-3.65	Ton	75	16	13-18

		N (Dry matter basis)				N harvested‡	
Crop Description	Data Source	Common value	General range	Unit of measure	Moisture content of unit	Common value	General range
			-------- % --------			%	----lb N/unit ---
Mid bloom	1	2.90	2.40-3.40	Ton	75	15	12-17
Full bloom	1	2.60	2.10-3.10	Ton	75	13	10-16
Alfalfa Hay	5	--	--	Ton	10	--	50.4
Alfalfa, Green Chop	5	--	--	Ton	75	--	14
Alfalfa Hay	6	--	--	Ton	--	--	53.3 (for 6 ton/ac yield)
Bermudagrass Hay, sun-cured Vegetative	1	2.50	1.90-3.10	Ton	15	43	32-53
Early to mid bloom	1	1.70	1.30-2.10	Ton	15	29	22-36
Full bloom to mature	1	1.10	0.80-1.40	Ton	15	19	14-24
Green chop Vegetative	1	2.75	2.10-3.40	Ton	75	14	11-17
Early to mid bloom	1	1.90	1.40-2.40	Ton	75	10	7-12
Full bloom to mature	1	1.25	0.90-1.60	Ton	75	6	5-8
Birdsfoot trefoil Hay, early bloom	1	3.10	2.60-3.60	Ton	15	53	44-61
Mid to full bloom	1	2.20	1.90-2.50	Ton	15	37	32-43
Green chop Early bloom	1	3.20	2.70-3.70	Ton	75	16	14-19
Mid to full bloom	1	2.30	1.95-2.65	Ton	75	12	10-13
Bluegrass, Kentucky Hay, sun-cured Mid bloom	1	1.75	1.40-2.00	Ton	15	30	24-34

		N (Dry matter basis)				N harvested‡	
Crop Description	Data Source	Common value	General range	Unit of measure	Moisture content of unit	Common value	General range
			-------- % --------			%	----lb N/unit ---
Mature	1	1.00	0.85-1.15	Ton	15	17	15-20
Hay, green chop Mid bloom	1	2.00	1.60-2.40	Ton	75	10	8-12
Mature	1	1.05	0.90-1.20	Ton	75	5	4-6
Bluestem Early bloom	1	1.40	1.10-1.70	Ton	20	22	18-27
Full bloom	1	1.10	0.90-1.30	Ton	20	18	14-21
Mature	1	0.70	0.60-0.80	Ton	20	11	10-13
Bromegrass, smooth, Hay, sun-cured Vegetative	1	3.05	2.60-3.50	Ton	15	52	44-60
Early bloom	1	2.10	1.75-2.45	Ton	15	36	30-42
Mid to late bloom	1	1.80	1.40-2.20	Ton	15	31	24-37
Mature	1	0.95	0.80-1.10	Ton	15	16	14-19
Hay, green chop Vegetative	1	3.35	2.85-3.85	Ton	75	17	14-19
Early bloom	1	2.25	1.90-2.60	Ton	75	11	9-13
Mid to late bloom	1	1.80	1.50-2.20	Ton	75	9	8-11
Mature	1	0.95	0.80-1.10	Ton	75	5	4.6
Bromegrass	6	--	--	Ton	--	--	60 (for a 6 ton/ac yield)
Clover Alsike Hay	1	2.40	2.05-2.75	Ton	15	41	35-47
Green chop	1	2.75	2.35-3.15	Ton	75	14	12-16
Clover Hay	2, 3	--	--	Ton	15	--	41

		N (Dry matter basis)				N harvested‡	
Crop Description	Data Source	Common value	General range	Unit of measure	Moisture content of unit	Common value	General range
			-------- % --------			%	----lb N/unit ---
Crimson Hay	1	2.65	2.25-3.05	Ton	15	45	38-52
Green chop	1	2.75	2.35-3.15	Ton	75	14	12-16
Ladino Hay	1	3.50	3.00-4.00	Ton	15	60	51-68
Green chop	1	4.00	3.50-4.50	Ton	75	20	17-23
Red, hay, sun-cured Late vegetative	1	3.35	2.85-3.85	Ton	15	57	49-66
Early to mid bloom	1	2.50	2.10-2.90	Ton	15	42	36-49
Full bloom	1	2.35	1.95-2.75	Ton	15	40	33-47
Red, green chop Late vegetative	1	3.40	2.90-3.90	Ton	75	17	15-20
Early to mid bloom	1	2.60	2.20-3.00	Ton	75	14	11-15
Full bloom	1	2.40	2.00-2.80	Ton	75	12	10-14
Sweet, hay	1	2.65	2.25-3.05	Ton	15	45	38-52
Green chop	1	2.90	2.50-3.30	Ton	75	15	13-17
White, hay	1	3.40	2.90-3.90	Ton	15	58	49-66
Green chop	1	4.00	3.50-4.50	Ton	75	20	18-23
Corn, silage	1	1.25	1.10-1.45	Ton	70	7.5	6.6-8.7
Corn, silage	5	--	--	Ton	72	--	7.1
Corn, silage	6	--	--	Ton	--	--	6.25 (for 32 ton/ac yield)
Fescue, tall Hay, late vegetative	1	2.70	2.20-3.20	Ton	15	46	37-54

		N (Dry matter basis)				N harvested‡	
Crop Description	Data Source	Common value	General range	Unit of measure	Moisture content of unit	Common value	General range
			-------- % --------			%	----lb N/unit ---
Mid bloom	1	1.50	1.20-1.80	Ton	15	26	20-31
Mature	1	1.00	0.80-1.20	Ton	15	17	14-20
Green chop Late vegetative	1	2.90	2.30-3.50	Ton	75	15	12-18
Mid bloom	1	1.70	1.40-2.00	Ton	75	9	7-10
Mature	1	1.10	0.90-1.30	Ton	75	6	5-7
Fescue, tall	2, 3	--	--	Ton	15	--	46
Grass Silage	5	--	--	Ton	75	--	14
Grass Hay	6	--	--	Ton	--	--	60 (for 4 ton/ac yield)
Meadow Foxtail	6	--	--	Ton	--	--	60 (for 6 ton/ac yield)
Orchardgrass Hay, late vegetative	1	2.40	1.90-2.90	Ton	15	41	32-49
Mid bloom	1	1.60	1.30-1.90	Ton	15	27	22-32
Mature	1	1.20	1.00-1.40	Ton	15	20	17-24
Green chop Late vegetative	1	2.50	2.00-3.00	Ton	75	13	10-15
Mid bloom	1	1.70	1.40-2.00	Ton	75	9	7-10
Mature	1	1.20	1.00-1.40	Ton	75	6	5-7
Orchardgrass	2, 3	--	--	Ton	15	--	41
Orchardgrass	6	--	--	Ton	--	--	60 (for 6 ton/ac yield)
Peanut, hay	1	1.85	1.50-2.20	Ton	15	31	26-37
Reed Canarygrass	6	--	--	Ton	--	--	60 (for 6 ton/ac yield)

		N (Dry matter basis)				N harvested‡	
Crop Description	Data Source	Common value	General range	Unit of measure	Moisture content of unit	Common value	General range
			-------- % --------			%	----lb N/unit ---
Ryegrass Hay, late vegetative	1	1.85	1.50-2.20	Ton	15	31	26-37
Mid bloom	1	1.30	1.00-1.60	Ton	15	22	17-27
Green chop Late vegetate	1	2.00	1.60-2.40	Ton	75	10	8-12
Mid bloom	1	1.40	1.10-1.70	Ton	75	7	6-9
Sorghum, silage	1	1.00	0.70-1.30	Ton	74	5.2	3.5-6.8
Sorghum-sudan Green chop Immature	1	2.65	1.90-3.45	Ton	82	9.5	6.8-12
Mid-mature	1	1.40	1.00-1.80	Ton	77	6.4	4.6-8.3
Silage	1	1.50	0.95-2.05	Ton	77	6.9	4.5-9.5
Timothy Hay, sun-cured Vegetative	1	2.25	1.90-2.60	Ton	15	38	32-44
Early to mid bloom	1	1.55	1.30-1.90	Ton	15	26	22-32
Late bloom	1	1.20	1.00-1.40	Ton	15	20	17-24
Mature	1	0.95	0.80-1.10	Ton	15	16	14-19
Hay, green chop Vegetative	1	2.30	1.95-2.65	Ton	75	12	10-13
Early to mid bloom	1	1.70	1.35-2.00	Ton	75	9	7-10
Late bloom	1	1.25	1.05-1.45	Ton	75	6	5-7
Mature	1	0.95	0.80-1.10	Ton	75	5	4-6
Vetch Common Hay, early bloom	1	3.60	3.10-4.10	Ton	15	61	53-70

		N (Dry matter basis)				N harvested‡	
Crop Description	Data Source	Common value	General range	Unit of measure	Moisture content of unit	Common value	General range
			-------- % --------			%	----lb N/unit ---
Full bloom	1	2.90	2.50-3.30	Ton	15	49	43-56
Green chop Early bloom	1	3.70	3.10-4.20	Ton	75	19	16-21
Full bloom	1	3.00	2.60-3.40	Ton	75	15	13-17
Hairy fresh Mid bloom	1	3.70	3.10-4.20	Ton	75	19	16-21
Wheatgrass, crested Hay, early bloom	1	1.60	1.30-1.90	Ton	20	26	21-30
Full bloom	1	1.40	1.10-1.70	Ton	20	22	18-27
Mature	1	0.60	0.50-0.70	Ton	20	10	8-11
Wheatgrass, crested	2, 3	--	--	Ton	20	--	26
Fiber and miscellaneous crops							
Flax, seed	1	3.80	3.30-4.30	100 lb (1 cwt)	7	3.5	3.1-4.0
Hay	1	1.85	1.50-2.20	Ton	15	31	26-37
Potato, white tubers	1	1.60	1.20-1.90	100 lb (1 cwt)	75	0.4	0.3-0.5
Potato	6	--	--	100 lb (1 cwt)	--	--	0.55 (for a 400 cwt yield)
Rangeland	5	--	--	--	--	--	24
Sugarbeet Tops w/crown	1	2.10	1.80-2.30	--	82	7.6	6.5-8.3
Roots w/o crown	1	0.80	0.60-0.95	Ton	77	3.7	2.8-4.4
Tops w/o crown	1	2.50	2.20-2.80	Ton	82	9.0	7.9-10.1

		N (Dry matter basis)				N harvested‡	
Crop Description	Data Source	Common value	General range	Unit of measure	Moisture content of unit	Common value	General range
			-------- % --------			%	----lb N/unit ---
Roots w/crown	1	1.10	0.90-1.30	Ton	77	5.1	4.1-6.0
Sunflower, seed Oil type	1	2.70	2.20-3.20	Ton	10	49	40-58
Confection	1	3.20	2.80-3.60	Ton	10	58	50-65
Trees	4						80 - 220
Vegetable crops							
Bean, snap, pods	1	3.00	2.50-3.50	Ton	87	7.8	6.5-9.0
Dry bean seed	1	4.00	3.50-4.50	100 lb (1 cwt)	10	3.6	3.2-4.1
Tops	1	3.50	3.00-4.00	Ton	85	11	9-13
Onion, bulbs	1	2.20	1.90-2.50	Ton	90	4.4	3.8-5.0
Pea, seed only	1	4.20	3.50-4.70	Ton	80	17	14-19
Vine-no pods	1	2.00	1.50-2.50	Ton	75	10	8-13
Pepper, sweet green	1	2.30	1.90-2.70	Ton	92	3.7	3.0-4.3
Squash, summer	1	3.10	2.70-3.50	Ton	92	5.0	4.3-5.6
Winter	1	2.10	1.70-2.50	Ton	88	5.0	4.1-6.0
Sweet corn, stover	1	1.30	1.10-1.50	Ton	70	7.8	6.6-9.0
Ears with husks	1	1.60	1.40-1.80	Ton	73	8.6	7.6-9.7
Sweet potato, root	1	1.10	0.90-1.30	Ton	72	6.2	5.0-7.3
Tomato	1	2.70	2.30-3.10	Ton	94	3.2	2.8-3.7
Tree and fruit crops							
Apple	1	0.35	0.25-0.45	Ton	82	1.3	0.9-1.6

		N (Dry matter basis)				N harvested‡	
Crop Description	Data Source	Common value	General range	Unit of measure	Moisture content of unit	Common value	General range
			-------- % --------			%	----lb N/unit ---
Almond, with shell	1	3.30	3.00-3.60	Ton	15	56	51-61
Cherry	1	1.15	1.00-1.30	Ton	82	4.1	3.6-4.7
Grape	1	0.60	0.50-0.70	Ton	80	2.4	2.0-2.8
Peach	1	1.00	0.80-1.20	Ton	88	2.4	1.9-2.9
Pear	1	0.40	0.30-0.50	Ton	82	1.4	1.1-1.8
Pecan, with shell	1	2.80	2.50-3.10	Ton	15	48	43-53
Strawberry	1	1.35	1.10-1.60	Ton	91	2.4	2.0-2.9

†Percent N and N harvested will generally be above the common value for crops grown on N-rich soils (luxury amounts of manure, fertilizer, etc.) and for crops grown in water-stress conditions (low dry matter production); percent N and harvested N will generally be below the common value for crops grown in N poor soils (low N inputs (and for crops with above-average dry matter production (good rainfall years, irrigation, etc.)
‡CHh as defined in Chapter 12 by Pierce et al., is the N removed in the harvested biomass.
Data Sources:
1) Follett et al. 1991;
2) Fonnesbeck et al., 1984;
3) Part 651, Agricultural Waste Management Field Handbook
4) From various references for poplars, other deciduous trees, conifers, and woodlands; Note: Alternative uptake values provided by a qualified silviculturist are acceptable.
5) 1992 Census of Agriculture, refer to the following website: http://www.nhq.nrcs.usda.gov/land/pubs/nlapp1a.html
6) DEQ 1988 WLAP Guidelines. Adapted from Kelling, K.A., and A.E. Peterson and the Land-Applied Wastewater Technical Advisory Committee

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7.7.10 References

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Part B: High Rate Land Treatment of Wastewater

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9. Rapid Infiltration Land Application Permitting Guidance

In 1996, the *Interpretive Supplement* was published within a comprehensive guidance document entitled *Handbook for Land Application of Municipal and Industrial Wastewater*. Guidelines were established for slow rate land application systems. Rapid infiltration (RI) systems are allowed under the *Wastewater Land Application Rules*, but with the promulgation of the *Ground Water Quality Rule* and other technical questions, additional guidance is needed to assist permit writers and the regulated community in understanding criteria for designing and permitting rapid infiltration systems.

9.1 Guidance and Regulations for Rapid Infiltration

EPA identified rapid infiltration systems in the mid-70s, as effective alternative treatment for municipal wastewater. Design criteria and methods are presented in the U. S. Environmental Protection Agency (EPA) documents*, Process Design Manual: Land Treatment of Municipal Wastewater*, 1981, and *Process Design Manual: Land Treatment of Municipal Wastewater*, *Supplement on Rapid Infiltration and Overland Flow, 1984*. These documents have generally been applied in designs for Idaho rapid infiltration systems.

From the *Wastewater-Land Application Permit Rules* (IDAPA 58.01.17), Rapid Infiltration Systems are to be permitted:

- 200.15. Definition: Rapid Infiltration System. A wastewater treatment method by which wastewater is applied to land in an amount of twenty (20) to six hundred (600) feet per year for percolation through the soil. Vegetation is not generally utilized by this method. (4-1-88)
- 600.06. Rapid Infiltration Systems. The following minimum treatment requirements are established for land application of wastewater. (4-1-88)
  - a. Suspended solids content of wastewater, which includes organic and inorganic particulate matter shall not exceed a thirty (30) day average concentration of one hundred (100) mg/l. (4-1-88)
  - *b. Nitrogen (total as N) content of wastewater shall not exceed a thirty (30) day average concentration of twenty (20) mg/l. (4-1-88)*

9.2 Site Specific Permitting Considerations

There are three (3) ground water/surface water scenarios encountered when considering the regulation of rapid infiltration systems.

Scenario 1: Rapid infiltration systems having surface water impacts only. These systems are generally found very close to natural surface waters. Any local ground water discharges to the surface water entirely. There are no ground water uses between the basin and the receiving water. *Water Quality Standards and Wastewater Treatment Requirements*, IDAPA 58.01.02, apply. A *National Pollutant Discharge Elimination System* (NPDES) permit would be the most appropriate permitting mechanism. If EPA is unable or unwilling to issue a NPDES permit, a *Wastewater Land Application Permit* should be issued that adequately protects the surface water. Consideration should be given to surface water monitoring upstream and downstream for parameters of concern, vadose zone monitoring to determine degree of treatment, and monitoring the wastewater as it enters the basin.

Scenario 2: Rapid Infiltration systems having ground water impacts only. Most ground water eventually discharges to surface water, however, if the affected surface water is more than 1,320 feet from the rapid infiltration system, the system would be assumed to have ground water influences only and be included in this scenario. Additionally, if there is any diversion or reasonable potential diversion of the ground water, it would be included in this scenario. In this case, the *Ground Water Quality Rule*, IDAPA 58.01.11, governs the impacts to the ground water. A Wastewater Land Application Permit should be issued. Ground water monitoring wells are required to determine impacts.

Scenario 3: Rapid Infiltration systems impacting both ground water and surface water. In this scenario it may be necessary to issue an NPDES permit and a Wastewater Land Application Permit. Elements of Scenario 1 and Scenario 2 would be incorporated into the Wastewater Land Application Permit and NPDES permits. If EPA issues an NPDES permit, it may be possible to include monitoring and permit limits for ground water concerns in the NPDES permit.

Existing facilities: Certain existing facilities that have NPDES permits were not required to obtain a Wastewater Land Application Permit. These facilities should be evaluated to determine which Scenario would be appropriate. If they are determined to be Scenario 1, DEQ will rely on the NPDES Permit process. Most likely these facilities would not be Scenario 2 since an NPDES permit presumes some surface water impact, but they might fall into the Scenario 3 scenario. If this is the case, the facility is required to obtain a Wastewater Land Application Permit unless the NPDES permit can be modified to satisfy wastewater land application issues. Since there is some time required for application preparation, permit processing, and construction, a consent order may be the appropriate mechanism to enable the facility to evaluate their situation and comply with the regulations. The Director may issue a waiver to the facility to exempt them from obtaining a Wastewater Land Application Permit, as provided in the Act.

9.3 References

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Part C: Other Reuse

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12. Other Regulatory Requirements Associated With Wastewater Land Application Facilities

This handbook focuses on applying wastewater to the land surface and the permit program that manages this land use activity. However, while issuance of a wastewater-land application permit is essential, it is also important for permittees and their consultants to be aware of other relevant environmental considerations associated with a given wastewater-land application site and system to knowledgeably plan and anticipate issues of concern.

An overview of the "big environmental picture" associated with a land application system involves many interrelated issues, such as protection of public health and public safety, prevention and resolution of nuisances, protection of ground water quality, and conservation of ground and surface water supplies to name a few. Most issues or potential sources of contamination are managed by programs that may either be: (1) regulatory, or those based on numerical standards, narrative standards, rules, permits or other mandated features, or (2) non-regulatory, or those based on guidance, management strategies, education and technical assistance or other voluntary efforts suited to the potential source(s) of contamination.

The wastewater-land application permit is just one of several that need to be considered by each company before doing business in Idaho. In addition to the wastewater-land application permit, each permittee should consider the full complement of applicable state and local rules and regulations for the jurisdiction in which their wastewater-land application facility is located. While the Department of Environmental Quality (DEQ) wastewater-land application permit assures the WLAP permittee that the wastewater-land application treatment system has been approved for operation, the WLAP permit is not intended to imply compliance with other local and state rules or regulations.

A list of relevant environmental considerations has been compiled as an informational tool for the WLAP applicant and permittee. This list includes local, state and federal requirements and is not intended to be exhaustive for every location in the state or to distinguish which requirements apply to new facilities versus modifications on existing facilities, but rather provides general information to help direct the permittee to the appropriate contact agencies.

12.1 Domestic Sewage Disposal

Sanitary wastes or domestic sewage wastes generated by a facility can be included with the industrial waste stream and land applied. If combined with industrial wastewater, the sanitary wastes must be addressed as part of the wastewater-land application system permit. Combined sanitary and industrial waste streams typically have to meet the buffer zone distances for municipal wastewater.

If the sanitary wastes are disposed of separately from the wastewater-land application treatment system, then the method of treatment determines the contact agency. If an individual or community subsurface sewage disposal system (septic tank/drainfield) is the treatment method of choice, then the local District Health Department should be contacted for permitting requirements. Application must also be made and a replacement permit issued by the District Health Department in the event of a subsurface sewage system failure.

If an above ground sewage disposal system, such as a lagoon or connection into a municipal sewage plant, is the treatment method of choice, then DEQ should be contacted.

12.2 Plan and Specification Reviews

Idaho Code 39-118 states that all plans and specifications for the construction of new sewage systems, sewage treatment plants or systems, other waste treatment or disposal facilities, public water supply systems or public water treatment systems or for modification or expansion to existing sewage treatment plants or systems, waste treatment or disposal facilities, public water supply systems or public water treatment systems, shall be submitted to and approved by DEQ before construction begins. This review can be coordinated through the land application permit process for new systems.

12.3 Non-Contact Cooling Water

The Wastewater-Land Application Permit Regulations' definition for wastewater (IDAPA 58.01.17.200.19) specifically excludes non-contact cooling water as a component of wastewater and as such, non contact cooling water is not included in the wastewater loading conditions of the WLAP permit. However, a permit to discharge non-contact cooling water to surface water is required by the *National Pollutant Discharge Elimination System* (NPDES) Program administered by EPA. Non-contact cooling water may be used as a supplemental source of irrigation water and as such may be applied to some or all of the same fields as the wastewater is being land applied. Non-contact cooling water may also be discharged into shallow or deep underground injection wells in accordance with the *Rules for Construction and Use of Injection Wells* as administered by the Department of Water Resources (IDAPA 37.03.03).

12.4 Water Appropriations and Allocations

Long term use of water supplies requires receipt of specific water rights from the Idaho Department of Water Resources. Water rights should be obtained for every domestic or irrigation well. Established water rights may benefit a facility or permittee, particularly if competing uses for the same water becomes an issue at some point in time. If irrigation water is derived from a reservoir and canal (surface water) system rather than ground water wells, then the water rights reside with the owner or owners' designee for a privately owned surface water system or, with the Bureau of Reclamation for a federal reclamation irrigation project. The Bureau of Reclamation or private owner contracts with the irrigation district(s) for the water stored in the reservoir and the irrigation districts then contracts with individual property owners. Magic Reservoir or Mackay

Reservoir are two examples of privately owned reservoir systems, while Cascade Reservoir is an example of a federally administered project.

Many wastewater-land application sites and systems also need a source of fresh water to supplement the wastewater being applied for crop production. If supplemental water is needed for the system, then documentation of an established water right should be submitted with the wastewater-land application permit application.

12.5 Disposal of Truck Wash Sand & Grit Sumps, Grease Traps and Other Miscellaneous Small Volume Waste/Wastewater

Wastes generated by truck washing operations or maintenance shops typically originate from sand and grit sumps, which need periodic cleaning and disposal. Likewise, grease and other floatable wastes are often separated from the main waste stream and collected in a grease trap, which needs routine maintenance and cleaning. This type of small volume waste may be addressed as part of the wastewater land application permit if desired by the permittee. When combined as part of the wastewater land application permit, the permittee is responsible for submitting pertinent information on any miscellaneous small volume waste or wastewater as part of the WLAP permit application materials to DEQ.

If the miscellaneous small volume waste/wastewater is disposed of separately from the wastewater-land application treatment system, then often those wastes are physically pumped from some type of holding area into a watertight tank truck or equivalent and transported to a location off site approved for treatment and disposal.

12.6 Sludge Management

Municipal sludge must be managed according to 40 CFR Part 503-*Standards for the Use and Disposal of Sewage Sludge*. Requirements reflecting these rules are a part of every NPDES permit issued by EPA to a publicly owned wastewater treatment plant. Municipalities should be in contact with DEQ for approval of sludge treatment and disposal methods.

Industrial sludge is exempted from the requirements of 40 CFR Part 503. Instead, industrial sludge is managed in accordance with the *Water Quality Standards and Wastewater Treatment Requirements* (IDAPA 58.01.02.650) administered by DEQ or by the District Health Departments if the industrial sludge meets the definition of a non municipal solid waste.

12.7 Discharges to Surface Waters

The National Pollutant Discharge Elimination System (NPDES) program was established by Section 402 of the Clean Water Act. An NPDES permit is required for any direct discharge to surface (navigable) waters of the state or waters of the United States from new or existing sources.

Since EPA has permitting authority for the NPDES program in Idaho, the EPA Idaho Operations Office in Boise should be contacted for permitting information on any type of point source discharge from a facility. EPA then coordinates with DEQ for regional input on each NPDES permit issued.

12.8 Designated Special Resource Waters or Sole Source Drinking Water Aquifers

On January 1, 1995, the Spokane Valley-Rathdrum Prairie Aquifer was designated as a special resource *ground* water in Idaho. A special guidance document has been developed that has specific recommendations for wastewater-land application treatment systems on this aquifer. The *Special Supplemental Guidelines for Spokane Valley-Rathdrum Prairie Aquifer Wastewater Land Application* can be found in Section 12.11.1. This guidance is intended to work in conjunction with the Wastewater-Land Application Permit Regulations and other guidance.

Existing permitted facilities, or entities anticipating applying for a WLAP permit that will be located over the Spokane-Valley Rathdrum Prairie Aquifer, should direct questions to DEQ's North Idaho Regional Office in Coeur d'Alene at (208) 769-1422.

12.9 Ongoing Education

To maximize ground water protection while achieving and maintaining the most efficient and cost effective wastewater-land application treatment system requires ongoing education. It is important that the public and regulated community is informed about the reasons for preventing contamination, the activities of a land application system that may lead to ground water contamination and ways to prevent ground water contamination from a specific and unique land application site. An informed public and regulated community are more likely to work together to prevent contamination voluntarily and without the need for as much regulatory oversight.

Participating in educational opportunities should help to inform and enhance networking for both industry and the state. Currently, classes and conferences on issues related to the land application of wastewater are available from a variety of sources, including DEQ and as well as contractors. Other educational opportunities exist through the individual or joint efforts of DEQ and the regulated community such as bringing technical expert(s) in periodically to teach classes or seminars on Land Application of Wastewater or related topics such as how land application activities can impact ground water or finding the balance between resource protection, economic development and societal needs.

12.10 References

IDHW-DEQ. Idaho Department of Health and Welfare, Division of Environmental Quality. January 1995. Special Supplemental Guidelines: Spokane Valley-Rathdrum Prairie Aquifer Wastewater Land Application. 18 pages.

12.11 Supplemental Materials

12.11.1 Wastewater Land Application Sites Overlying Designated Special Resource Water

The Ground Water Rule, IDAPA 58.01.11.006, establishes policies to protect ground water quality, maintain beneficial uses, differentially protect ground water, and establish numerical and narrative ground water quality standards. IDAPA 58.01.11.300.01a designates the Spokane Valley – Rathdrum Prairie Aquifer as a sensitive resource. IDAPA 58.01.11.150.02 (Table 1) prescribes the highest level of protection for this aquifer category.

12.11.1.1 Land Application of Wastewater Over the Spokane Valley-Rathdrum Prairie Aquifer

Wastewater-land application systems overlying designated sensitive resource water may require additional considerations prior to permit issuance to assure the integrity of the special resource water remains intact. These considerations include but are not limited to: an in-depth evaluation of the nutrient transport to the sensitive resource water if the land application system recharges the sensitive resource water, background information on limiting nutrients in the sensitive resource water, and a design approach for limiting the nutrient transport to the sensitive resource water. This includes calculation of the nitrogen and phosphorus balance and calculation of loss to ground water.

To date, the sensitive resource water designation has rarely been used for ground water. However, extensive work has and is continuing to be done in North Idaho on land application systems overlying the SpokaneValley-Rathdrum Prairie Ground Water Aquifer.

12.11.1.2 Guideline Development

The CH_2M-Hill "Rathdrum Prairie Land Application Feasibility Study" was published in November 1990. Based on the information from this feasibility study, a pilot project was conducted and a report (Hayden Land Application Pilot Study) published in June 1994 by CH_2M-Hill and J. A Riley. The information from these two reports and the status of the Spokane Valley-Rathdrum Prairie as a state designated sensitive resource water, and a federally designated sole source drinking water aquifer, resulted in EPA providing grant monies for the development of guidelines. The guidelines are to specifically address the land application of wastewater over the Spokane Valley-Rathdrum Prairie Aquifer. The guidelines were developed by a Technical Advisory Group in cooperation with DEQ's North Idaho Regional Office.

Special Supplemental Guidelines

Spokane Valley-Rathdrum Prairie Aquifer
Wastewater Land Application

January, 1995

Idaho Department of Health and Welfare
Division of Environmental Quality

Spokane Valley-Rathdrum Prairie Aquifer Wastewater Land Application
Special Supplemental Guidelines

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Spokane Valley-Rathdrum Prairie Aquifer Wastewater Land Application Special Supplemental Guidelines

CONTENTS (continued)

Part 1: The Spokane Valley-Rathdrum Prairie Aquifer

THE SPOKANE VALLEY-RATHDRUM PRAIRIE AQUIFER

This document sets guidelines for managing one of the pollution sources of the Spokane Valley-Rathdrum Prairie Aquifer: municipal wastewater. The guidelines establish conditions under which secondarily-treated municipal wastewater can be spray irrigated over the aquifer in Idaho without causing contamination to the groundwater.

The Spokane Valley-Rathdrum Prairie Aquifer lies below the surface of about 325 square miles of north Idaho and eastern Washington, and is the sole source of drinking water for the region's 400,000 people. The aquifer is composed of glacial outwash soils, making it extremely permeable, high in groundwater velocity and susceptible to contamination. Unfortunately, the vulnerability of the resource has been proven with detections of nitrates, industrial solvents and pesticides in public water supply wells. Despite many protection efforts, a few water supply wells have had to be abandoned.

Coeur d'Alene Lake and the Spokane River contribute about one-third of the flow of the aquifer. The Hayden, Spirit, Twin, Hauser and Blanchard lake watersheds make up most of the additional flow crossing the state line. At the Idaho/Washington border, total flow is estimated to be 750 cubic feet per second or 485 million gallons per day. The movement of water particles ranges from less than a foot to almost 50 feet per day, as it flow west from Idaho into Washington. The depth to the water table varies from 400 feet to only 50 feet at some points in Washington.

In 1978 the Spokane Valley-Rathdrum Prairie Aquifer was declared a "sole source" drinking water supply pursuant to Section 1424e of the Safe Drinking Water Act. This designation requires all projects receiving any federal funding to implement aquifer protection measures. In addition, it proclaimed the significance of this groundwater resource to the region as well as provided support for local protection efforts.

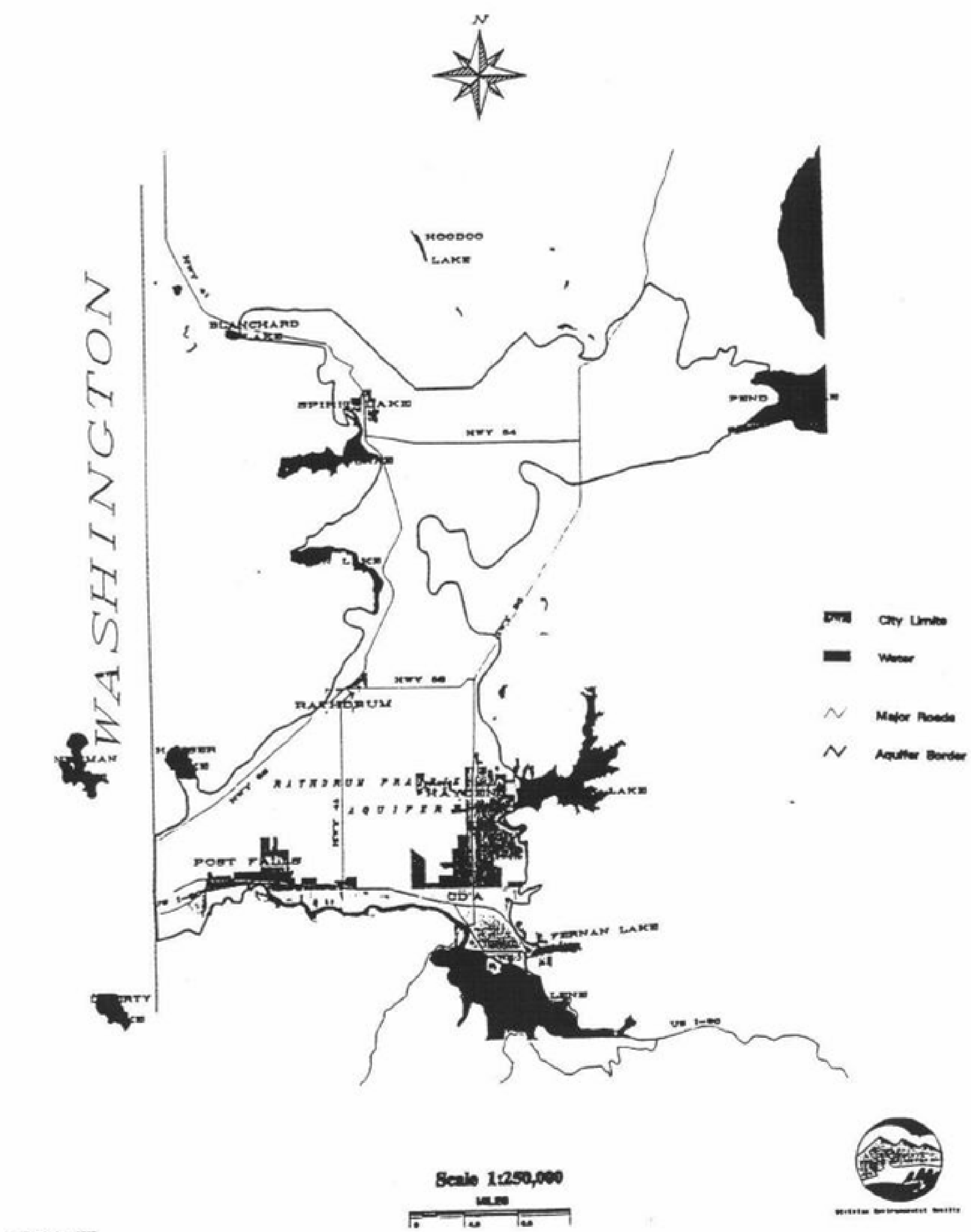
An aquifer protection project, administered in Idaho by the state Department of Health and Welfare, Division of Environmental Quality (DEQ) and the Panhandle Health District, has been in place for many years. The overriding premise for the protection project is this: Prevent contamination before it occurs. The goal is to avoid contamination and remediation, which can be extremely costly. To do this, the project has programs which can be divided into three main categories: 1) Managing pollution sources; 2) Promoting public awareness; and 3) Coordinating and cooperating with other public agencies.

The Special Supplemental Guidelines for land application over the Rathdrum Aquifer fall into the category of "managing pollution sources." Studies in the 1970s found that 60 percent of all aquifer pollutants were from sub-surface septic systems and 30 percent were from stormwater. The remaining 10 percent resulted from chemical and petroleum products.

To address the problem of septic discharges, the Panhandle Health District in 1977 adopted a regulation limiting new construction to one house per five acres over the aquifer. Higher housing densities are allowed in Sewage Management Areas (SMA). The health district enters into legally binding agreements cities and sewer districts over the aquifer to establish boundaries for SMAs. The cities agree to provide sewer to the higher density developments.

Since 1977, sewer construction has helped to mitigate aquifer contamination. There are now three municipal wastewater treatment plants treating the area's sewage and discharging effluent to the Spokane River. However, the river is reaching its assimilative capacity. The land application guidelines were developed to give the growing cities over the Rathdrum Aquifer another option for sewage disposal, while still maintaining high quality drinking water for the region's residents.

Rathdrum Prairie Aquifer, North Idaho



Part 2: Special Supplemental Guidelines

I. Introduction

A. Intent and Goals

This document is an appendix to the ***Interpretive Supplement to the "Guidelines for Land Application of Municipal and Industrial Wastewater, March, 1988"*** (***Supplement***) prepared by the Permits and Enforcement Bureau, Division of Environmental Quality, Idaho Department of Health and Welfare. The intent of this document is to present specific guidelines for the design and operation of wastewater land application facilities located over the Spokane Valley-Rathdrum Prairie Aquifer (Rathdrum Aquifer). The goal of this document is to provide an environmentally sound wastewater treatment and disposal alternative for communities near and over the Rathdrum Aquifer. This document will be reviewed and revised on a regular basis.

B. Special Resource Water and the Idaho Water Quality Standards

The Rathdrum Aquifer is designated a Special Resource Water under the ***Idaho Water Quality Standards and Wastewater Treatment Requirements***. Special Resource Waters are specific segments or bodies of water recognized as needing intensive protection to preserve outstanding characteristics or to maintain current beneficial use. The ***Idaho Water Quality Standards and Wastewater Treatment Requirements*** (IDAPA 58.01.02.299.01) specifically states:

> "The waters of the Spokane Valley-Rathdrum Prairie Aquifer, as described by the US Environmental Protection Agency in its designation as a 'sole source' aquifer under Section 1424(e) of the Safe Drinking Water Act, must not be lowered in quality, as relates to appropriate beneficial uses, as a result of a point source or non-point source activity unless it is demonstrated by the person proposing the activity that such change is justifiable as a result of necessary economic or social development." (1-30-80)

In 1990 the Idaho Division of Environmental Quality (DEQ) selected a consultant to study application of secondary treated municipal wastewater to the land surface located above the Rathdrum Aquifer. The completed report entitled ***Rathdrum Prairie Land Application Feasibility Study*** was cautiously optimistic that land application is an environmentally sound alternative for wastewater treatment over the Rathdrum Aquifer. Although the report stated that potential contaminants may be present in the wastewater, it suggested that a properly designed, sited and operated system could minimize contaminant migration, producing minimal ground water degradation.

In 1993 the Idaho Division of Environmental Quality (DEQ) commissioned a consultant to report on a wastewater land application pilot study over the Rathdrum Aquifer. This cooperative project between DEQ, the Hayden Area Regional Sewer Board and Spokane County was conducted to demonstrate land application technology and to obtain environmental data to improve the accuracy of the impact assessment and, ultimately, to determine the feasibility of using land application over the Rathdrum Aquifer as a permanent solution to wastewater treatment and disposal. The result of this work, the ***Hayden Land Application Pilot Study***, provides the information necessary to comply with the water quality regulations for initially establishing best management practices specific to land over the Rathdrum Aquifer.

C. Acknowledgements: Rathdrum TAC and the CH_2M-Hill Report

These supplemental guidelines are based on work conducted between 1990 and 1994 as a cooperative effort between the Hayden Area Regional Sewer Board (HARSB), the Division of Environmental Quality (DEQ), Spokane Water Quality Management Program and select individuals who served on a Technical Advisory Committee (TAC). A consulting firm, CH_2M-Hill, prepared the feasibility study, subcontracted site monitoring to Dr. John Riley, and presented the final data interpretation and report in cooperation with Dr. Riley.

The Hayden Area Regional Sewer Board (HARSB) purchased the center pivot irrigation equipment for applying wastewater and provided the piping to the pilot study field. DEQ and Spokane County, through EPA grant awards, funded the consultant to monitor and report on the pilot study site. The pilot study site was operated as a cooperative effort in the 1992 and 1993 growing seasons. At the direction of the TAC, the final pilot study report, including conclusions and recommendations, was published in June 1994. All consulting work was completed by CH_2M-Hill and its subconsultant, Dr. John Riley. The HARSB and its consultant, Kimball Engineering, are recognized for their efforts and contributions in helping make this project possible.

The Technical Advisory Committee was created in May 1991 to provide guidance to DEQ regional office staff in crop selection, center pivot system operation, soil moisture monitoring, and numerous other technical areas. Frequency of meetings depended on the amount of site activity and varied from monthly, at the start of the project, to about twice a year in late 1993 and 1994. The technical advice and direction from the TAC made the project a success. The members of the Technical Advisory Committee are acknowledged below. Their help has been greatly appreciated.

<u>Rathdrum Aquifer Land Application Technical Advisory Committee Members</u>

Dick Jacquot (Farmer on Land Application Site) - Kootenai County Soil Conservation District
Ken Babin - Panhandle Health District
David Brown and Kim Golden - USDA, Soil Conservation Service
Vickie Parker-Clark - University of Idaho Cooperative Extension Service
Stan Miller - Spokane County Public Works
Jonathan Williams - US EPA, Region X
Jim Kimball and Mike Wilson - Kimball Engineering (Hayden Area Regional Sewer Board)

Dale Arnold - City of Spokane, Environmental Programs Department
Dr. John Riley - Consulting Hydrogeologist (Consultant)
Larry Comer - Welch, Comer Engineers (Kootenai Perspectives Representative)

D. Pilot Study Report Conclusions and Recommendations

CH_2M-Hill's report, ***Hayden Land Application Pilot Study***, presented the following conclusions and recommendations:

Conclusions

1. Land application of treated effluent has occurred over the Rathdrum Prairie Aquifer under carefully managed conditions with limited increases for monitored constituents in vadose zone water.

2. Irrigation scheduling using daily soil moisture measurements can be used to minimize migration of nutrients past the root zone.

3. Nutrients can be applied with wastewater effluent with little or no observable migration beyond the root zone of the crops.

4. The tradeoffs between crop production and fertilizer use should be evaluated for each site considering the potential for nutrient migration and the need to establish and maintain vigorous crops.

5. Crop selection is critical to the successful operation of a land application system.

Recommendations

1. Limit the hydraulic loading rate to the mean monthly crop water requirement.

2. Limit nitrogen to crop nitrogen requirements.

3. Select deep rooting crops with high uptake rates.

4. Apply effluent with an irrigation system that is well maintained and efficient in distributing water evenly across the site.

5. Assess the site soils, hydrology, and climate.

6. Prepare a management plan that integrates effluent management with suitable agricultural best management practices (BMPs).

7. Phosphorus should also be monitored, but annual application rates need not be limited to agronomic rates.

8. To determine acceptability of loading rates beyond the agronomic rates recommended, additional studies are needed.

II. Wastewater Land Application

A. Types of Wastewater Land Application Allowed

Slow rate wastewater land application systems located over the Rathdrum Aquifer are allowed when designed and operated in accordance with these guidelines. "Slow rate" application is a controlled distribution of wastewater to the land surface by spraying or surface spreading to support plant growth. Treatment is accomplished through physical, chemical and biological processes occurring in the plant/soil matrix. Overland flow and rapid infiltration land application systems are not allowed over the Rathdrum Aquifer.

B. Application Season

The season for wastewater land application over the Rathdrum Aquifer will be limited to the period when the specific crop water requirement exceeds the average monthly precipitation. Climatic conditions in the Rathdrum Prairie area generally restrict land application to the period: May 1 to October 31. The hydraulic requirements of specific crops may further shorten the application season.

C. Precipitation and Climate

The Rathdrum Prairie area is generally subhumid with warm, dry summers and cold, wet winters. The average annual precipitation is about 26 inches in the Coeur d'Alene area; but significant local variation is present, particularly west across the prairie near the state line where reported annual precipitation is about 20 inches.

When designing a land application facility, effective precipitation, rather than precipitation values, should be used. "Effective precipitation" is a calculated value (see the ***Supplement***) that represents the precipitation during the crop-growing season that is available to meet the consumptive water requirements of the crop.

D. Crop Selection

The site crop is a critical element of a successful land application system over the Rathdrum Aquifer, and each land application system should have a Crop Management Plan. The Crop Management Plan should include:

1. Selection criteria should be related to soil parameters and management capacities. Deep rooting crops are recommended. Possible crops include alfalfa, grass hay, small grains, turf grass, and poplar trees. Consultation with agronomic experts, such as the County Extension Service, is recommended.

2. Harvest schedule should be established and related to wastewater production and storage. For example, the harvesting practice for bluegrass precludes application from about mid-June until mid-August, making this an unsuitable

sole crop for a municipal land application site where flows are constant or higher in the summer or when sufficient wastewater storage is unavailable.

3. Hydraulic requirements for each crop should be included. Limited crop hydraulic information may be found in the ***Supplement***.

4. Nutrient requirements for each crop should be established. Since wastewater cannot provide enough nutrients for crop sustainability, supplemental nutrients should be provided. Studies have shown that frequent application of low fertilizer concentrations during the active plant growing periods are more effective than large, infrequent fertilization in limiting nutrient migration through the soil profile. Fertilizer type, application rate and application frequency should be established in the Crop Management Plan; and any changes should be reviewed and approved by DEQ.

5. Rotation schedule for each crop should be provided, when applicable.

6. Pest control strategy for each crop should be established. Pesticide type, application rate and application frequency should be established in the Crop Management Plan; and any changes should be reviewed and approved by DEQ.

E. Application Rates

The total application of water from all sources on wastewater land application sites located over the Rathdrum Aquifer is limited to the crop water requirement. The water used to satisfy the crop water requirement, also called the crop evapotranspiration, may include: precipitation, irrigation water (ground water and/or surface water), and treated wastewater.

crop water requirement = precipitation + irrigation water + treated wastewater

For wastewater land application sites located over the Rathdrum Aquifer, the hydraulic loading rate is identical and equal to the crop water requirement. The actual daily application volumes may vary daily and are affected by crop type, plant growth cycle, precipitation, evaporation, and available water capacity of the soil.

1. Design application rates: For initial design, the wastewater application rate will be the estimated crop water requirement minus the effective precipitation based on a 5 to 10 year precipitation recurrence. The results of a statistical analysis of precipitation in the Coeur d'Alene area from 1950 through 1993 (taken from an unpublished 1994 DEQ document "Coeur d'Alene Precipitation Analysis and Recommended Precipitation Values for Wastewater Land Application on the Rathdrum Prairie") are provided in the following table:

Recommended Design Precipitation Values for Rathdrum Prairie Sites (based on 1950 - 1993 Coeur d'Alene area data)			
Month	Average Precipitation	Design Precipitation	Recurrence Period
May	1.99"	3.15"	6.7 years
June	2.00"	3.04"	5.4 years
July	0.86"	1.65"	6.1 years
August	1.24"	2.32"	6.3 years
September	1.11"	1.79"	6.1 years

2. Supplemental irrigation: Since 5 to 10 year recurrence precipitation values are used to compute design wastewater application rates, in most years supplemental irrigation of the crop will be needed to insure vital plant growth. Supplemental irrigation can be treated wastewater, agricultural irrigation water, or a combination of the two.

3. Daily application rates: For daily operations, soil moisture instrumentation will be used to determine application rates and frequency. Soil moisture instrumentation will be installed on the site and will be monitored daily during the application season. The initial soil moisture threshold is 10 centibars, and wastewater application is allowed only when the soil moisture value (in centibars) as measured by the site instrumentation is equal to or drier than the threshold. Wastewater will not be applied when the soil moisture value (in centibars) as measured by the site instrumentation is wetter than the threshold value, except during periods of extreme climatic conditions. Threshold values wetter than 10 centibars may be approved by DEQ if satisfactory scientific evidence is presented that the lower values will not increase wastewater movement past the root zone.

4. Extreme climatic conditions: During months when precipitation exceeds the 5 to 10 year recurrence design precipitation values, wastewater may be applied at the design rate even if the soil moisture levels are high or saturated soil conditions are present.

F. Nutrient Loadings

1. Nitrogen will be limited to the crop nitrogen requirements. For most crops, nitrogen sources are wastewater and fertilizers. The nitrogen application rate should include a fraction above crop uptake to allow for losses that occur in the soil. The fraction should be based on soil and soil water testing, but may initially be 10%-20%. Since nitrate is more

mobile than other forms of nitrogen, if it is used, then soil moisture monitoring should be used to schedule irrigation and limit conditions that enhance leaching.

2. Phosphorous should also be monitored, but phosphorous application rates are not limited to the crop requirements. Most soils have a generous, but not unlimited, capacity to absorb phosphorous and limit its mobility. However, since this capacity is finite, the soil phosphorous level should be monitored to ensure the soil capacity is not exceeded.

G. Higher Application Rates

To determine acceptability of wastewater application rates beyond the rates recommended, additional studies are needed. The extent of the studies will depend on loading rates, nutrient forms, site specific conditions, and management objectives. For example, the form and concentration of nitrogen plays a significant role in evaluating application rates. Application of effluent at rates above monthly hydraulic rates may be practical if nitrogen is in the form of ammonia. However, because of concerns regarding leaching of synthetic organics and other environmental contaminants without sufficient treatment, an extensive study may be justified. These studies may include:

- More extensive and frequent effluent monitoring
- Unsaturated zone monitoring below the root zone
- Ground water monitoring
- Crop suitability

Application rates beyond the recommended values may be acceptable if additional technical information and studies are provided that substantiate aquifer protection.

H. Commercial/Industrial Wastewater

Land application of commercial or industrial wastewater on the Rathdrum Prairie is not allowed. Exceptions may be granted only if the constituents and concentration levels in the industrial/commercial wastewater do not vary significantly from treated municipal wastewater.

III. Site Selection Criteria

A. General

The evaluation of a site as a potential wastewater land application area requires consideration of a number of related site specific elements. An unacceptable evaluation on just one site element is sufficient to eliminate that site from consideration. Although the major site characteristics are discussed in this section, other site specific elements should also be considered and evaluated as warranted.

B. Soil

Not all soils over the Rathdrum Aquifer are suitable for land application of wastewater. Excessively stony and drained soils, such as the Garrison very stony silt loam, show poor potential for land application treatment of wastewater and should be avoided. Water holding capacity of the soil is a critical factor in applying wastewater without carrying nutrient load below the root zone. Soils that are excessively drained often do not have the capacity to hold the wastewater load long enough for the plants to extract nutrients. The result is poor crop production and excessive leaching.

Sites with soil classifications having good soil moisture holding capacity will be considered for permitting. A soil survey of the proposed site that includes test borings and soil classifications should be performed by a qualified soil scientist. Past cropping history of the site will also give an insight into the soil type and water holding capacity. Therefore, this information should also be submitted with an application.

C. Buffer Zones

The buffer zone for wastewater land application sites over the Rathdrum Aquifer will be as specified in the ***Supplement***, Table 3 - Municipal Wastewater Buffer Zone Treatment Sites. The development potential near potential land application sites will be considered: sites in "rural" areas that have a potential of being adjacent to "suburban or residential" uses will be evaluated for buffer zones according to the other uses.

D. Land Use

Land use suitability determination for a wastewater land application site is the responsibility of local government. Anyone proposing a wastewater land application project over the Rathdrum Aquifer should inform the responsible planning and zoning department and obtain preliminary zoning approval prior to submitting an application to DEQ. Wastewater land application projects may be allowed in an agricultural or rural zoning, but such projects in other zone classifications may require a conditional use permit and may require a public hearing. Public meetings to present the proposed land application project to neighbors and the community are recommended.

E. Wellhead Protection

The well head protection zone for wastewater land application sites over the Rathdrum Aquifer will be as specified in the ***Supplement***, Buffer Zones - Wellhead Protection. Drinking water wells closer than 100 feet to the land application site are not allowed. Wells between 100 feet and ¼ mile from the land application site are considered within the influence zone of the site and should be evaluated according to the ***Supplement*** by a qualified hydrogeologist or professional engineer with appropriate expertise.

IV. Wastewater Lagoons

A. General

Wastewater treatment systems near the Rathdrum Aquifer may be classified into two categories: single outfall systems and multiple outfall systems. Single outfall systems, such as Spirit Lake, use land application exclusively and, therefore, should completely contain all treated wastewater for treatment and disposal during the application season. Multiple outfall systems, such as Hayden, use an outfall to surface water during the non-growing season. Wastewater lagoon design for either system type should be based on a detailed monthly water balance.

B. Single Outfall Systems

Single Outfall Systems should have storage lagoon volume to completely store treated wastewater for the 6 - 7 month period when land application is not allowed. A detailed lagoon water balance should be created for this system that considers: precipitation, evaporation, seasonal wastewater variances, and temporary growing season application cessation.

C. Multiple Outfall Systems

Multiple Outfall Systems should have two storage lagoons systems: operations lagoons and seasonal lagoons. Operations lagoon storage should be provided for temporary growing season application cessation due to weather conditions or harvest schedules. This lagoon volume should be based on an analysis of the climate and the crop, but it should accommodate at least one week of wastewater flow during the application season. Seasonal lagoon storage should be provided for periods in the fall and spring when neither surface water discharge nor land application is allowed. This storage lagoon volume should be based on an analysis of average climatic and environmental conditions.

D. Lagoon Criteria

Wastewater lagoons often contain millions of gallons of partially treated sewage that is a potential ground water contamination source. Wastewater lagoons located over the Rathdrum Aquifer should be designed and maintained to a higher standard than lagoons in other areas due to the adverse affects a leaking lagoon would have to the aquifer. All lagoons should meet the leakage criteria (500 gallons per day per acre for most lagoons) found in the Recommended Standard for Wastewater Facilities published by the Great Lakes-Upper Mississippi River Board of State Public Health and Environmental Managers (10 State Standards). The following criteria will be used for lagoons located over the Rathdrum Aquifer:

1. <u>Small lagoons and temporary lagoons</u>: Small lagoons are lagoons with a design volume less than 500,000 gallons. Temporary lagoons are lagoons that store wastewater for less than two months annually. Small lagoons and temporary lagoons should be constructed with a synthetic liner (60 mil polyethylene or equal), and they should be leak tested at least

once every five years.

2. Large lagoons and storage lagoons: Large lagoons are non-temporary lagoons with a design volume greater than 500,000 gallons. Storage lagoons are lagoons that store wastewater for more than two months annually. Large lagoons and storage lagoons should be constructed with a synthetic liner (60 mil polyethylene or equal), and they should have a second level of protection approved by DEQ that includes, but is not limited to, the following:

   a) a system that continuously monitors lagoon seepage, or
   b) a double liner system, or
   c) additional liner strength and reliability (such as extra thickness)

V. Monitoring and Sampling

A. General

Monitoring and sampling are essential elements of managing land application sites over the Rathdrum Aquifer to ensure that land application activities are not affecting the aquifer water quality. A monitoring and sampling program is unique to each land application site, but the program should include:

1. wastewater effluent sampling
2. soil moisture monitoring
3. soil water sampling
4. soil sampling
5. ground water monitoring and sampling

All monitoring and sampling will be in accordance with the *Water and Soil Monitoring* section of the ***Supplement***.

B. Wastewater Effluent Sampling

The analytical parameters for wastewater effluent sampling will be in accordance with the ***Guidelines for Land Application of Municipal and Industrial Wastewater*** and will include, but not be limited to: TDS, COD, BOD_5, TSS, total coliform, pH, phosphorous, TKN, ammonia nitrogen and nitrate nitrogen. The frequency of sampling is dependent on the consistency of the effluent constituents, but in no case will the frequency be less than once per year during the land application season.

Complete wastewater characterization is a necessary element of a properly designed and operated land application system. Although many potentially toxic constituents receive some degree of treatment (volatilization and biogradation of organics) or are retained in the soils (heavy metals), some toxic elements may have a detrimental effect on the crops, livestock or the ground water. The land applied wastewater should not create phytotoxicity and food chain contamination. Regular testing for cadmium, copper, zinc, nickel, and other potentially toxic constituents may be necessary.

Wastewater facilities that have industrial or commercial contributions should have an active and effective pretreatment program.

C. Soil Moisture Monitoring

Soil moisture will be used to determine the irrigation schedule, and soil moisture data will be used to manage crop vitality. A tensiometer or soil moisture sensor clusters will be installed in accordance with the monitoring plan, and soil moisture data will be recorded daily during the application season. A soil moisture based irrigation strategy may allow more effluent application in drier years. (See this document, Section II, Paragraph E.3. *Daily Application Rates*)

D. Soil Water Sampling

Soil water sampling will be in accordance with the *Water and Soil Monitoring* section of the ***Supplement***. At least two lysimeter sampling points will be used at each sampling station: within the root zone and immediately below the root zone.

E. Soil Sampling

Soil sampling will be in accordance with the *Water and Soil Monitoring* section of the ***Supplement***. In addition to the analytical parameters specified in the ***Supplement***, phosphorous will also be sampled and monitored.

F. Ground Water Sampling and Testing

Each land application site will have a ground water monitoring plan. Ground water sampling and analytical parameters will be in accordance with the ***Supplement***. Each site will have at least three ground water monitoring wells: one up gradient and two down gradient of the ground water flow. Before land application commences on a site, sampling and testing will determine the existing background levels of the sampling parameters. The land application management goal is: no detectable increase in wastewater related constituents in the ground water as determined by the monitoring program.

VI. Operations and Maintenance

A. General

A successful land application system requires diligent operations and maintenance. Individuals who manage the site should have expertise and knowledge of agricultural practices as well as wastewater treatment processes. According to the pilot study report, wastewater land application over the Rathdrum Aquifer can comply with the intent of the Special Resource Water designation only **under carefully managed conditions**.

B. Management Plan

Each land application site should have a management plan that integrates effluent management with suitable agricultural best management practices. The plan should address specific program elements that include: effluent, nutrients, crop selection, crop vitality, soil moisture, chemical fertilizers, and pesticides. A higher level of chemical fertilizer management than employed in normally accepted agricultural practices may be necessary to limit nutrient migration below the root zone.

C. Daily Soil Moisture Monitoring and Irrigation

A daily reading of soil moisture at several places on a land application site will allow integration of crop needs and wastewater application. A soil moisture reading that indicates soil saturation needs to be established for each land application site. (See this document, Section II, Paragraph E.3. *Daily Application Rates*.) Irrigation based on soil moisture will allow higher application rates than average in some of the drier or warmer growing seasons.

D. Crop Production and Fertilizers

The primary function of a wastewater land application site is the treatment of wastewater. While a viable and healthy crop is necessary for optimum wastewater treatment, chemical fertilizers that are commonly used to promote crop production can become the primary nutrient source for aquifer degradation. Fertilizer application should be balanced -- sufficient to produce good plant growth but insufficient to produce a detectable nutrient level below the plant root zone.

E. Disinfection

Wastewater disinfection will be as specified in the ***Supplement*** as related to buffer zone requirements.

F. Irrigation Systems

The irrigation system should be well maintained and efficient in distributing the water evenly across the site. The goal for irrigation efficiency is 75-90%. The irrigation system should be operated to reduce spray drift.

Part 3: Miscellaneous Information

Terms and Definitions

agronomic - Activities relating to field crop production and soil management. "agronomic rate" as related to land application means the amount of water or nutrients that can be utilized by a crop over time.

beneficial use - Any of the various uses which may be made of the waters of Idaho including, but not limited to, domestic water supplies, industrial water supplies, agricultural water supplies, navigation, recreation in and on the water, wildlife habitat, and aesthetics.

BOD_5 (Biochemical Oxygen Demand) - A measure of the dissolved oxygen in wastewater used by microorganism in the biochemical oxidation of organic matter over a 5 day period. It is often used to determine the efficiency of wastewater treatment facilities.

centibar - A unit of pressure equal to 1/100th of a bar (1 bar = 10^6 dynes per square centimeter). In soil monitoring, a measurement of soil moisture with decreasing values corresponding to increasing soil moisture.

COD (Chemical Oxygen Demand) - A measure of the oxygen-consuming capacity of inorganic and organic matter present in water or wastewater.

DEQ - The Idaho Department of Health and Welfare acting through the Division of Environmental Quality (DEQ).

lysimeter - A device for measuring and collecting the water percolating through soil.

nutrient - Chemicals such as nitrogen, potassium and phosphorus that are needed by plants in the soil for satisfactory plant and crop growth.

TDS (Total Dissolved Solids) - Small solid particles in water or wastewater (generally 1 micron or less in diameter) that are not removed by filtering or settling.

tensiometer - An instrument for measuring moisture content of soil.

TKN (Total Kjeldahl Nitrogen) - The nitrogen content of a material that is analyzed by a Kjeldahl method. This method measures the sum of free ammonia plus organic nitrogen.

TSS (Total Suspended Solids) - Solids in water or wastewater (generally 1 micron or more in diameter) that can be removed by filtering or settling.
uptake rate - The amount of water or nutrients used by plants over time.

vadose zone - The unsaturated area in the soil above the water table.

Wastewater Land Application Permit Program

Wastewater land application in Idaho is regulated by state law and is administered by the Division of Environmental Quality through a permit. This Wastewater Land Application Permit (WLAP) sets forth the general requirements as well as the site specific requirements for each permitted facility. Presently, Idaho has over 100 permitted wastewater land application sites.

An application for WLAP may be obtained through the DEQ regional office in Coeur d'Alene. Prior to submittal of the application packet, applicants are encouraged to schedule a pre-application meeting with DEQ staff. An initial application for a permit can take six months to process through the regulatory and administrative steps. Permits are issued for a five year period and are renewable.

Additional Information Sources

Wastewater Land Application Permit Program:

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Editor's note:
These contacts have been updated as of September 2007.

Rathdrum Prairie Aquifer Project

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Glossary

Term	Definition
Aerosol	A gaseous suspension of fine solid or liquid particles.
Agricultural Activity/Agriculture	Any activity conducted on land or water for the purpose of producing an agricultural commodity, including crops, livestock, trees, and fish.
Agronomic Rate	The application rate of nutrients and moisture required to achieve anticipated or documented crop yields for a specific region. The agronomic rate may be estimated by published information or determined from actual field measurements.
Agronomic Uptake	The amount of nutrients or salts harvested from a land application field or system.
Applicable Requirements	Any state, local or federal statutes, regulations or ordinances to which the facility is subject.
Aquic	Saturated at least part of the time; reducing conditions in the soil prevail.
Aquifer	"A geological unit of permeable saturated material capable of yielding economically significant quantities of water to wells and springs."(IDAPA 58.01.11.007.02)
Aridic	Soil dry most of the time.
Available Water Capacity	Moisture content of soil between field capacity and wilting point that is available for crop use. Use soil survey or site specific information to determine.
Bacteria	A group of universally distributed, rigid, essentially unicellular microorganisms. Bacteria usually appear as spheroid, rodlike or curved entities, but occasionally appear as sheets, chains, or branched filaments.
Beneficial Use	Any of the various uses which may be made of the water of Idaho, including, but not limited to, domestic water supplies, industrial water supplies, agricultural water supplies, navigation, recreation in and on the water, wildlife habitat, and aesthetics. The bendficial use is dependent upon actual use, the ability of the water to support a non-existing use either now or in the future, and its likelihood of being used in a given manner. The use of water for the purpose of wastewater dilution or as a receiving water for a waste treatment facility effluent is not a beneficial use.
Beneficial Uses of Ground Water	Various uses of ground water in Idaho including, but not limited to, domestic water supplies, industrial water supplies, agricultural water supplies, aquacultural water supplies and mining. A beneficial use is defined by actual current uses or future uses of the ground water.
Best Available	Any system, process, or method which is available to the public for

Method	commercial or private use to minimize the impact of point and nonpoint source contaminants on ground water quality.
Best Management Practice	A practice or combination of practices determined to be the most effective and practical means of preventing or reducing contamination to ground water and/or surface water from nonpoint and point sources to achieve water quality goals and protect the beneficial uses of the water.
Best Practical Method	Any system, process, or method that is established and in routine use which could be used to minimize the impact of point or nonpoint sources of contamination on ground water quality.
Biochemical Oxygen Demand (BOD)	The measure of the amount of oxygen necessary to satisfy the biochemical oxidation requirements of organic materials at the time the sample is collected; unless otherwise specified, this term will mean the five (5) day BOD incubated at twenty (20) degrees C.
Board	The Idaho Board of Environmental Quality.
Buffer Distances (Zones)	The distances between the actual point of reuse of reclaimed wastewater and other uses such as wells, adjoining property, inhabited dwellings, and other features.
Calcareous	Consisting of or containing calcium carbonate (CaCO3).
Capture Zone	A capture zone, or zone of contribution as it is sometimes called, is the area surrounding a pumping well that encompasses all areas and land use activities that supply ground water recharge to the well (EPA 1991).
Carryover Soil Moisture	Moisture stored in soils within root zone depths during the winter, at times when the crop is dormant, or before the crop is planted. This moisture is available to help meet the consumptive water needs of the crop.
Chemical Oxygen Demand (COD)	A measure of the oxygen-consuming capacity of inorganic and organic matter present in water or wastewater. It is expressed as the amount of oxygen consumed from a chemical oxidant in a specific test. It does not differentiate between stable and unstable organic matter and thus does not necessarily correlate with biochemical oxygen demand.
Class A Effluent	Class A effluent is treated municipal reclaimed wastewater that must be oxidized, coagulated, clarified, and filtered, or treated by an equivalent process and adequately disinfected. For comprehensive Class A Effluent criteria and permitting requirements refer to IDAPA 58.01.17, “Rules for the Reclamation and Reuse of Municipal and Industrial Wastewater.”
Coagulation	In water and wastewater treatment, the destabilization and initial aggregation of colloidal, finely divided suspended matter and/or bacterial cells by the addition of a floc-forming chemical or by biological processes.
Coliform-group Bacteria	A group of bacteria predominantly inhabiting the intestines of man or animal, but also found in nature. It includes all aerobic and facultative anaerobic, gram-negative, nonspore-forming bacilli that ferment lactose with production of gas. This group of "total" coliforms includes E. Coli which is considered the typical coliform of fecal origin.
Confined Aquifer	A geological formation in which water is isolated from the atmosphere

	by an overlying less permeable geologic formation. Confined ground water is generally subject to pressure greater than atmospheric; thus, the water level rises above the top of the aquifer.
Consumptive Irrigation Requirement	The depth of irrigation water, exclusive of precipitation, stored soil moisture, or ground water, that is required consumptively for crop production.
Consumptive Use	Consumptive use, often called evapo-transpiration is the amount of water used by the vegetative growth of a given area in transpiration and building of plant tissue and that evaporated from adjacent soil or intercepted precipitation on the plant foliage in any specified time. If the unit of time is small, consumptive use is usually expressed as acre inches per acre or depth in inches, whereas, if the unit of time is large, such as a growing season or a 12-month period, it is usually expressed as acre feet per acre or depth in feet.
Consumptive Water Requirement	The amount of water potentially required to meet the evapo-transpiration needs of vegetative areas so that plant production is not limited from lack of water.
Contamination	The direct or indirect introduction into ground water of any contaminant caused in whole or in part by human activities.
Crop Root Zone	The zone that extends from the surface of the soil to the depth of the deepest crop root and is specific to a species of plant, group of plants or crop.
Denitrification	The reduction of oxidized nitrogen compounds (such as nitrates) to nitrogen gas.
DEQ	The Idaho Department of Environmental Quality
Director	The Director of the Department of Environmental Quality or the Director's designee.
Disinfection	A method of reducing the pathogenic or objectionable organisms by means of chemicals or other acceptable means.
Disinfected Wastewater	Wastewater in which pathogenic organisms have been destroyed by chemical, physical or biological means.
Downgradient Boundary	The boundary where wastewater-land application ceases perpendicular to the flow of ground water beneath the wastewater-land application site.
Effective Rainfall	Precipitation falling during the growing period of the crop that is available to meet the consumptive water requirements of crops. It does not include such precipitation as is lost to deep percolation below the root zone nor to surface runoff.
Effluent	(1) Wastewater or other liquid, treated or untreated, flowing from a reservoir, basin, treatment plant or part thereof. (2) Any wastewater discharged from a treatment facility.
EPA	The United States Environmental Protection Agency.
Evaporation Rate	The quantity of water evaporated from a given water surface per unit of time. It is usually expressed in millimeters (inches) depth per day, month or year.
Fault	A break or fracture in the earths crust along which, relative movement of rocks on either side of the plane of the fracture has occurred.

Field Capacity	The moisture percentage, on a dry weight basis, of a soil after rapid drainage has taken place following an application of water, provided there is no water table within capillary reach of the root zone. This moisture percentage usually is reached within two to four days after an irrigation, the time interval depending on the physical characteristics of the soil.
Filtration	The process of passing a liquid through a filtering medium (which may consist of granular material, such as activated carbon, sand, magnetite, diatomaceous earth, finely woven cloth, unglazed porcelain or specially prepared paper) for the removal of suspended or colloidal matter.
Flocculation	In water and wastewater treatment, the agglomeration of colloidal and finely divided suspended matter after coagulation by gentle stirring by either mechanical or hydraulic means. In biological wastewater treatment where coagulation is not used, agglomeration may be accomplished biologically.
Flood Irrigation	Irrigating soils by means of surface application of water in basins.
Food Crops	Any crops intended for human consumption.
Frozen Soil	0o C or less in the upper 6 inches of soil.
Ground Water	Any water of the state which occurs beneath the surface of the earth in a saturated geological formation of rock or soil
Ground Water Compliance	A collection of environmental monitoring sites typically identified as the downgradient boundary of the area that wastewater is physically being applied to or as identified by DEQ on a case-by-case basis. The collection of monitoring points is where biological, chemical and radiological parameters must comply with appropriate water quality standards.
Growing Season	That period of time during the year when climatic factors are typically conductive to crop growth, and a crop is normally planted, cultivated and harvested.
Hazardous Waste	A material or combination of materials, which, because of its quantity, concentration or characteristics (physical, chemical or biological), presents an actual or potential hazard to human health or the environment if not properly treated, stored, disposed of or managed.
Heavy Metals	Metals which exist naturally or can be introduced to the earth and water which can adversely affect human health and the environment. Includes, but not limited to arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, selenium, silver and zinc.
Hydraulic Loading	The amount of water applied to the land surface.
Hydraulic Loading Rate	The rate at which water, whether supplemental irrigation water or wastewater, is applied to a wastewater-land application site. Precipitation, although included in water balance calculations, is not considered to be an applied hydraulic load.
Industrial Wastewater	Any wastewater discharged from an industrial treatment facility that does not contain sanitary waters.
Infiltration	The process whereby a liquid enters the soil or other filtering medium.
Infiltration Capacity	The flux of water which the soil profile can absorb through its surface when it is maintained in contact with water at atmospheric pressure.

Irrigation Efficiency	The percentage of applied irrigation water that is stored in the and available for consumptive use by the crop. When the water is measured at the headgate, it is called farm-irrigation efficiency; when measured at the field, it is gnated as field-irrigation efficiency; and when measured at the point of diversion, it be called project-efficiency.
Irrigation Water Requirement	The net irrigation water requirement divided by the irrigation efficiency.
Land Application	The application of municipal or industrial wastewater to land for the purpose of land treatment.
Land Application Facility or Facility	Any structure or system designed or used to treat wastewater through application to the land surface.
Land Treatment	The use of land, soil, and crops for treatment of municipal or industrial wastewater.
Leaching Requirement	The fraction of the irrigation water that must be leached through the root zone to control soil salinity at any specified level.
Loading	The amount of organic matter, water, and nutrients applied to land in wastewater. See Nutrient Loading.
Municipal Wastewater	(1) Waste water that contains sewage. (2) Unless otherwise specified, sewage and associated solids, whether treated or untreated, together with such water that is present. Also called domestic wastewater. Industrial wastewater may also be present, but is not considered part of the definition.
Natural Background Conditions	No measurable change in the physical, chemical, biological, or radiological conditions existing in a water body without human sources of pollution within the watershed.
Net Irrigation	The amount of irrigation water that is delivered to a land application site after all application losses are considered. Application losses include wind drift and evaporation. This does not consider evapotranspiration.
Net Irrigation Requirement	The depth of irrigation water, exclusive of precipitation, stored soil moisture, or ground water, that is required consumptively for crop production and required for other related uses. Such uses may include water required for leaching, frost protection, etc.
New Activity	Any significant change in operation or construction of the wastewater treatment system which may impact the waters of the state.
Non Public Drinking Water System (Well)	Includes an individual domestic well, or any domestic well that serves 2 through 14 connections or less than 25 people. It is any system that is not defined as a public drinking water system.
Non-Contact Cooling Water	Water used to reduce temperature which does not come into direct contact with any raw material, intermediate product, waste product (other than heat) or finished product.
Non-Growing Season	That period of time during the year when climatic factors are typically not conductive to crop growth, and a crop is not normally planted, cultivated or harvested.
Nuisance	Anything which is injurious to the public health or an obstruction to the free use, in the customary manner, of any waters of the state.
Nutrients	The major substances necessary for the growth and reproduction of aquatic plant life, consisting of nitrogen, phosphorus, and carbon

	compounds.
Nutrient Loading	The amount of plant nutrients applied to soil in wastes, either solid or liquid.
Nutrient Loading Rate	The rate at which nutrients, such as nitrogen, potassium and phosphorus, are applied to a wastewater-land application site.
Operating Personnel	Any person who is employed, retained, or appointed to conduct the tasks associated with the day-to-day operation and maintenance of a public wastewater system. Operating personnel shall include every person making system control or system integrity decisions about water quantity or water quality that may affect public health.
Overland Flow	A method of wastewater treatment by land application where wastewater is applied to gently sloping, relatively impermeable soils planted with vegetation. Treatment is accomplished by physical, chemical and biological processes as the wastewater flows through the vegetative cover.
Pathogen	A causative agent of disease.
Peak Period Consumptive Use	Peak period consumptive use is the average daily rate of use of a crop occurring during a period between normal irritations when such rate of use is at a maximum.
Percolation	The flow or trickling of a liquid downward through a contact or filtering medium. The liquid may or may not fill the pores of the medium.
Permeability	Also known as Hydraulic Conductivity, it is the capacity of a porous medium to transmit water. It is expressed as the volume of water that will move in unit time under a unit hydraulic gradient through a unit area measured at right angles to the direction of flow.
Permit	Written authorization by the Director to modify, operate, construct or discharge to a reclamation and reuse facility.
Permittee	The person to whom the reclamation and reuse permit is issued.
Person	An individual, corporation, partnership, association, state, municipality, commission, political subdivision of the state, state agency, federal agency, special district, or interstate body.
Pesticides	Chemicals used to destroy specific organisms that cause disease, hinder food production or affect other commercial activities. The most widely used pesticides are synthetic compounds derived from petrochemicals and include insecticides, herbicides and fungicides.
pH	"Power of the Hydrogen Ion" (S. Sorenson, 1909). Defined as the negative logarithm of the hydrogen ion concentration: pH = -Log10[H+]. Hydrogen ion concentration is expressed in moles/liter (i.e. M). (M&H)
Point of Compliance	That point in the reclamation and reuse facility where the reclaimed wastewater must meet the requirements of the permit. There may be more than one (1) point of compliance within the facility depending on the constituents to be monitored.
Point Source	Any discernible, confined, and discrete conveyance, including, but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are, or may be,

	discharged to surface waters of the state. This term does not include return flows from irrigated agriculture, discharges from dams and hydroelectric generating facilities or any source or activity considered a nonpoint source by definition.
Political Subdivision	The state of Idaho, or any corporation, instrumentality or other agency thereof, or any incorporated city, or any county, school district, water and/or sewer district, drainage district, special purpose district or other corporate district constituting a political subdivision of the state, any quasi-municipal corporation, housing authority, urban renewal authority, other type of authority, any college or university, or any other body corporate and political of the state of Idaho, but excluding the federal government. (Idaho Code).
Pollution	The presence in a body of water (or soil or air) of a substance in such quantities that it impairs the water's usefulness or renders it offensive to the senses of sight, taste or smell. In general, a public health hazard may be created, but in some instances, only economic or aesthetics are involved as when waste salt brines contaminate surface waters or when foul odors pollute the air. (definition from Glossary 1)
Potable Water	A water which is free from impurities in such amounts that it is safe for human consumption without treatment.
Pretreatment	Any process or activity conducted for the purpose of removing or reducing wastewater constituents prior to or in preparation for ultimate treatment.
Primary Effluent	Raw wastewater that has been mechanically treated by screening, degritting, sedimentation and/or skimming processes to remove substantially all floatable and settleable solids.
Primary Treatment	Wastewater treatment processes or methods that serve as the first stage of treatment intended for removal of suspended and settleable solids by gravity sedimentation providing no changes in dissolved or colloidal matter.
Process Food Crop	Any crop intended for human consumption that has been changed from its original form and further disinfection occurs.
Public Drinking Water System (Well)	Includes wells supplying 15 or more connections or 25 or more individuals daily for at least 60 days out of the year. Public drinking water supply wells are identified as either Community Systems or Transient or Non-Transient Non Community Systems depending on whether individuals are served regularly more than or less than 6 months of the year.
Rapid Infiltration	A method of wastewater treatment by land application where wastewater is applied to relatively permeable soils allowing a high rate of infiltration and treatment of larger volumes of water over a small land surface area. Treatment is accomplished by physical, chemical and biological processes as the water percolates through the soil profile.
Rapid Infiltration System	A wastewater treatment method by which wastewater is applied to land in an amount of twenty (20) to six hundred (600) feet per year for percolation through the soil. Vegetation is not generally utilized by this method.
Raw Food Crop	Any crop intended for human consumption which is to be used in its original form.

Recharge	The process of adding water to the zone of saturation.
Recharge Waters	Water that is specifically utilized for the purpose of adding water to the zone of saturation.
Reclaimed Wastewater	Wastewater that is used in accordance with the rules IDAPA 58.01.17.
Reclamation	The treatment of municipal or industrial wastewater that allows it to be reused for beneficial uses. Reclamation also includes land treatment for wastewater that utilizes soil or crops for partial treatment.
Reclamation and Reuse Facility or Facility	Any structure or system designed or used for reclamation or reuse of municipal or industrial wastewater including, but not limited to, industrial and municipal wastewater treatment facilities, pumping and storage facilities, pipeline and distribution facilities, and the property to which the reclaimed wastewater is applied. This does not include industrial in-plant processes and reuse of process waters within the plant.
Restricted Public Access	Preventing public entry within one thousand (1,000) feet of the border of a facility by site location or physical structures such as fencing. A buffer strip less than one thousand (1,000) feet may be accepted if aerosol drift is reduced.
Reuse	The use of reclaimed wastewater for beneficial uses including, but not limited to, land treatment, irrigation, aquifer recharge, use in surface water features, toilet flushing in commercial buildings, dust control, and other uses.
Rural Area/Industrial Area	An area whose land use is predominantly rural or industrial, having scattered inhabited dwellings.
Saline	A nonsodic (nonsodium) soil containing sufficient soluble salts to impair its productivity.
Saturated Zone	A zone or layer beneath the earths surface in which the interconnected pore spaces of rock and sediments are filled with water.
Secondary Treatment	Processes or methods for the supplemental treatment of wastewater, usually following primary treatment, to affect additional improvement in the quality of the treated wastes by biological means of various types which are designed to remove or modify organic matter.
Sewage	The water-carried human wastes from residences, buildings, industrial establishments and other places.
Slow Rate Irrigation	A method or wastewater treatment by land application which involves controlled distribution of wastewater to the land surface by spraying or surface spreading to support plant growth. Treatment is accomplished through physical, chemical and biological processes occurring in the plant/soil matrix.
Sludge	The semi-liquid mass produced by treatment of water or wastewater.
Sodium Adsorption Ratio (SAR)	An expression of the degree to which sodium will be adsorbed by soils from a solution in equilibrium with the soil. As the SAR increases above 10, soil permeability decreases.
Special Resource Water	Those specific segments or bodies of water which are recognized as needing intensive protection to preserve outstanding or unique characteristics; or to maintain current beneficial use.

Spray Irrigation	Means of wastewater application by spraying it from orifices in piping.
State	The state of Idaho.
Subsurface Irrigation	A planned irrigation system which provides for the efficient distribution of irrigation water below the surface of the ground without causing erosion or water loss. Some examples include, low pressure, trickle application below ground surface, underground pressurized pipelines, or controllable seepage based on limiting crop and depth to ground water. (USDA SCS FOTG, 430, 441, & 443).
Suburban/ Residential Area	An area whose land use is predominantly suburban or residential. An otherwise rural or industrial area having a housing subdivision in close proximity to the WLAP site would be classed as a suburban/residential area.
Surface Irrigation	Application of water by means other than spraying such that no aerosols are produced.
Surface Water Body	All surface accumulations of water, natural or artificial, public or private, or parts thereof which are wholly or partially within, which flow through or border upon the state. This includes, but is not limited to, rivers, streams, canals, ditches, lakes, and ponds. It does not include private waters as defined in Section 42-212, Idaho Code.
Suspended Solids	(1) Solids that are in water, wastewater or other liquids, and which are largely removable by laboratory filtering. (2) The quantity of material removed from wastewater in a laboratory test, as prescribed in Standard Methods for the Examination of Water and Wastewater, American Public Health Association, Washington, DC, and referred to as nonfilterable residue.
Time Distribution of Flows	A measurement of the volume of wastewater distributed over a specified area during a specified time period. Typical unit of measure is inches per acre per week.
Total Dissolved Solids (TDS)	(1a) The total concentration of dissolved constituents in solution, usually expressed in milligrams per liter. (1b) The total concentration of dissolved material in water [as] ordinarily determined from the weight of the dry residue remaining after evaporation of the volatile portion of an aliquot of the water sample (Hem, 1985). (1c) The total dissolved (filterable) solids as determined by use of the method specified in Appendix I "Wastewater Analysis". (USGS, 1989. Federal Glossary of selected terms; subsurface; Water Flow and Solute Transportation. Department of the Interior). (2) A measure of inorganic TDS in wastewater is important in order to calculate total salt loading to a site and predict down-gradient ground water concentrations. Estimates of inorganic TDS can be made by subtracting VDS from TDS to obtain Non-Volatile Dissolved Solids (NVDS). Major ions may also be summed to estimate this parameter.
Total Kjeldahl Nitrogen (TKN)	The nitrogen content of a material that is analyzed by a Kjeldahl method. This method measures the sum of free ammonia plus organic nitrogen.
Treatment	A process or activity conducted for the purpose of removing pollutants from wastewater.
Treatment Facility	Any physical facility or land area for the purpose of collecting, treating, neutralizing or stabilizing pollutants including treatment

	plants; the necessary collecting, intercepting, outfall and outlet sewers; pumping stations integral to such plants or sewers; disposal or reuse facilities; equipment and furnishing thereof; and their appurtenances. For the purpose of these rules, a treatment facility may also be known as a treatment system, a wastewater system, wastewater treatment system, wastewater treatment facility, or wastewater treatment plant.
Turbidity	A measure of the interference of light passage through water, or visual depth restriction due to the presence of suspended matter such as clay, silt, nonliving organic particulates, plankton and other microscopic organisms. Operationally, turbidity measurements are expressions of certain light scattering and absorbing properties of a water sample. Turbidity is measured by the Nephelometric method.
Udic	Soil moist, but not wet, most of the time.
Vadose Zone	The unsaturated area above the water table.
Wastewater	Unless otherwise specified, industrial waste, municipal waste, agricultural waste, and associated solids or combinations of these, whether treated or untreated, together with such water as is present but not including sludge, or non-contact cooling water.
Wastewater Lagoon	Manmade impoundments for the purpose of storing or treating wastewater.
Wastewater System Operator	The person who is employed, retained, or appointed to conduct the tasks associated with routine day to day operation and maintenance of a public wastewater treatment or collection system in order to safeguard the public health and environment.
Wastewater Treatment System	All phases of wastewater treatment including any pretreatment equipment and the land application facility.
Water Pollution	Any alteration of the phy sical, thermal, chemical, biological, or radioactive properties of any waters of the state, or the discharge of any pollutant into the waters of the stat e, which will or is likely to create a nuisance or to render such waters harm ful, detrimental or injurious to public health, safety or welfare, or to fish and wildlife, or to domestic, commercial, industrial, recreational, aesthetic, or other beneficial uses.
Water Table	The upper surface of ground water or that level below which the soil is saturated with water.
Waters and Waters of the State	All the accumulations of water, surface and underground, natural and artificial, public and private, or parts thereof which are wholly or partially within, which flow through or border upon the state.
Watershed	The land area from which water flows into a stream or other body of water which drains the area.
Wellhead	The physical structure, facility, or device at the land surface from or through which ground water flows or is pumped from subsurface, water-bearing formations.
Wellhead Protection Area	The surface and subsurface area surrounding a wellhead or well field, supplying a public water system, through which contaminants are reasonably likely to move toward and reach such water well or well field.
Wellhead Setback Area	An area immediately surrounding a wellhead in which potential sources of contamination are controlled or restricted.

Wilting Point	The wilting point is the moisture percentage, also on a dry weight basis, at which plants can no longer obtain sufficient moisture to satisfy moisture requirements and will wilt permanently unless moisture is added to the soil profile.
Xeric	Mediterranean: Wet winters, dry summers.

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Guidance Index

Errata: Corrections to the *Guidance for Reclamation and Reuse of Municipal and Industrial Wastewater*.

Date	Location	Correction	
9/2007	Sec. 6, pg. 6-28, Fig. 6-2, Note (4)	Reads Should Read	IDAPA 16.01.08.510.02 & 512 IDAPA 58.01.08.510.02 & 512
9/2007	Sec. 4.2.2.5.2, pg. 4-28, 3rd para., 3rd line	Reads Should Read	(mg/L) = 0.64 * EC (mhos/cm) (mg/L) = 0.64 * EC (μmhos/cm)
9/2007	Sec. 6.5.2.1, pg. 6-18, Table 6-4, Footnote (1)	Reads Should Read	Bacterial count represents the total coliform bacteria as a median of the last 7 days of bacteriological sampling for which analysis have been completed. Bacterial count represents the total coliform bacteria as a median of the last number of days of bacteriological sampling for which analyses have been completed. For Class B wastewater, it is the last 7 days of bacteriological sampling etc. For Class C wastewater, it is the last 5 days; and for Class D wastewater, it is the last 3 days. There is no total coliform limit for Class E wastewater (c.f. IDAPA 58.01.17.600.07).
9/2007	Pg. 12-27	The address and contact information for Dick Martindale and the Panhandle Health District have changed: 8500 North Atlas Road Hayden, ID 83835 208-415-5100	