ARIZONA MINING GUIDANCE MANUAL BADCT
TABLE 1-1
Example Table of Contents - Prescriptive BADCT Demonstration(1)

1. Introduction

2. Site Criteria
   2.1 Relevant Site Characteristics
   2.2 Surface Water Controls
   2.3 Geologic Hazards

3. Design Construction and Operational Criteria
   3.1 Relevant Solution/Effluent Characteristics
   3.2 Storage Components
   3.3 Site Preparation
   3.4 Liner System Specifications
   3.5 Stability Considerations
   3.6 Facility Operation and Monitoring

4. Relevant Facility Inspection Criteria

5. Relevant Closure and Post-Closure Criteria

Example Appendices:

- Solution, Ore and Waste Characterization Data
- Groundwater Data
- Geologic Hazards Evaluation
- Geotechnical Data
- Surface Water Evaluations
- Construction Procedures and QA/QC
- Slope Stability Evaluations
- Water Balance and Storage Capacity Evaluations
- Equivalent Engineering Evaluations

(1) All applicable sections should clearly state the manner in which Prescriptive BADCT criteria are satisfied by the proposed design.
If the APP application and supporting documentation show that the prescriptive criteria are met and appropriately applied, BADCT demonstration in accordance with A.R.S. 49-243.B.1 and the APP application requirement of A.A.C. R18-9-A202(A)(5) are deemed satisfied. ADEQ then proceeds with the processing of the permit application, unless new information warrants an additional applicability check. This processing includes a determination of completeness for other parts of the APP application that are not part of BADCT, such as whether or not applicable water quality standards (AWQS) will be met at the Point of Compliance, and the technical and financial capability of the applicant.

1.1.2.1 Determination of Prescriptive BADCT

The determination of BADCT using prescriptive criteria for an APP application is based on meeting the prescribed design, construction, and operating criteria defined in Part 2 of this manual, or where applicable, by rule (A.R.S. 49-243.01). Since the objective of the Prescriptive BADCT determination is to simplify and expedite the BADCT review process and therefore the APP process, the prescriptive criteria are designed to be generally conservative for most site conditions in order to minimize the need for collection and evaluation of site specific data. Some site evaluations, however, are still required to provide enough information for determination that the Prescriptive BADCT is appropriate. As discussed further in Part 2, these include evaluations of key issues related to site conditions such as identification of flood plains and geologic hazards.

While the Prescriptive BADCT criteria, in part, include specific design criteria for many of the BADCT elements, engineering equivalents to specific elements are also acceptable. Examples of engineering equivalents, and supporting information that may be required by ADEQ for each, are provided in Part 2 (Table 2-1). The ADEQ may require specific supporting evaluations to demonstrate that the proposed element is at least as protective as the specific Prescriptive BADCT element it replaces. Engineering equivalents cannot rely on seepage attenuation or other geologic properties of the vadose zone as part of minimizing aquifer loading.

1.1.3 Individual BADCT Review Process For New Facilities

When submitting an individual application for an APP, an applicant must include a proposed BADCT design to be used at the facility. A.A.C. R18-9-A202(A)(5) requires that the applicant submit, in support of the proposed BADCT, a statement of the technology which will be employed to meet the requirements of A.R.S. 49-243.B.1. This statement shall describe alternative discharge control measures considered, the technical and economic advantages and disadvantages of each alternative, and the justification for selection or rejection of each alternative. The applicant shall evaluate each alternative discharge control technology, relative to the amount of discharge reduction achievable, site specific hydrologic and geologic characteristics, other environmental impacts, and water conservation or augmentation considerations. The economic impact of implementation of Individual BADCT design is further discussed in Section 1.1.3.7.

(1-6) GENERAL INFORMATION
The development of an Individual BADCT design follows the general principles of engineering design. Engineering principles are adhered to during the design process involving the designer's professional judgment of contingencies, risks and uncertainties based on education and experience. It is therefore only possible to provide general guidance for the process to be followed.

Important aspects of developing an Individual BADCT design are:

- Discharge control technologies ordinarily constitute a discharge control system incorporating engineering features, operational measures and site characteristics to achieve BADCT; and,
- Alternative designs must be considered to arrive at a BADCT design.

Discharge control technologies are those design elements which can be included to reduce loading (discharge of pollutants) to an aquifer (e.g., design aspects such as liners, operational aspects such as desaturated tailing disposal for small projects, and closure aspects such as rinsing gold and silver ore residue on heap leach pads after leaching is completed).

Alternative designs can include consideration of alternative technologies or alternative design elements as discussed below, and in some cases, alternative sites. In principle, an Individual BADCT design is developed through the following approach:

- Development of a range of alternative discharge control systems which may or may not include different sites on a conceptual basis;
- Screening these alternative systems by estimating the relative degree of discharge control;
- Selection of the most promising alternative systems for more detailed analysis;
- Refinement of designs for the selected alternative systems;
- Comprehensive estimates of discharge control for the selected alternative systems; and,
- Selection of BADCT design.

In conducting these analyses, the following steps are required:

- Site selection;
- Development of individual site design ("Reference Design") based on demonstrated control technologies and site conditions;
- Estimation of aquifer loading for the Reference Design;
- Alternative design(s) selection as outlined above;
- Estimation of aquifer loading for the promising alternative design(s); and,
- Selection of BADCT design.

Figure 1-2 provides a schematic representation of the process. Each of the steps are described below. An example Table of Contents for describing in the APP application how the design meets Individual BADCT requirements is provided in Table 1-2.
1.1.3.1 Site Selection

Site selection is a powerful tool in developing a protective design. It is sometimes possible to select a site with outstanding characteristics which will enhance the containment of stored materials. Maximum advantage should be taken of site selection in development of a BADCT design.

Site selection can be conducted by the applicant in a formal or informal manner. The formal process will typically consider sites in areas surrounding the mine and the preferred site will be selected through a process of fatal flaw screening, site evaluation and ranking, and in some cases, also limited site investigations and final ranking. Informal site selection is often necessary because of limited availability of suitable sites in the vicinity of the ore body.
TABLE 1-2
Example Table of Contents - Individual BADCT Demonstration(1)

1. Introduction
2. Relevant Site Factors
   2.1 Solution, Ore and Waste Characteristics
   2.2 Site Characteristics
      2.2.1 Surface Hydrology
      2.2.2 Hydrogeology
      2.2.3 Geologic Hazards
3. Site Selection
   3.1 Alternatives
   3.2 Evaluation of Alternatives
   3.3 Recommended Site
4. Reference Design
   4.1 Design
   4.2 Construction Considerations
   4.3 Operations and Operational Monitoring
   4.4 Closure and Post-Closure Considerations
   4.5 Estimated Aquifer Loading
      4.5.1 Potential Release
      4.5.2 Estimated Travel Times to Groundwater Table
      4.5.3 Estimated Attenuation of Pollutants
      4.5.4 Estimated Aquifer Load
   4.6 Estimated Cost of Reference Design
5. Alternative Designs
   5.1 Selection of Alternatives
   5.2 Screening of Alternatives
   5.3 Description of Most Promising Alternative Systems
   5.4 Aquifer Loading of Most Promising Alternative Systems
   5.5 Estimated Cost of Most Promising Alternative Systems
6. Selection of BADCT Design
   6.1 Selection Criteria
   6.2 Evaluation of Reference Design and Alternative Systems
   6.3 Selected BADCT Design

Example Appendices:
- Solution Ore and Waste Characterization Data
- Groundwater Data
- Geologic Hazards Evaluation

(1) All applicable sections should clearly state the manner in which Individual BADCT requirements are satisfied by the proposed BADCT design.
- Geotechnical Data
- Surface Water Evaluations
- Construction Procedures and QA/QC
- Slope Stability Evaluations
- Water Balance and Storage Capacity Evaluations
The design documents submitted for APP permitting must describe the site selection process. It is the applicant’s responsibility to develop this information; ADEQ can only give guidance in this regard.

1.1.3.2 Development of Reference Design

The development of an individual site design must consider: 1) industry-wide DCTs taking into account differences in industry sectors; 2) the type and size of the operation; 3) the reasonableness of applying controls considering the site climatic conditions; and 4) other site specific conditions. In developing this design, a systems approach should be used. This systems approach should consider all phases of the project including:

- Site characterization;
- Design, construction and operations; and
- Closure and post-closure.

The demonstrated control technologies for various facilities are described further in Part 3 of this manual. Table 1-3 provides a “menu” of typical DCTs for each of the above phases.

A Reference Design will typically include DCTs selected from the Table 1-3 menu. For example, in developing a Reference Design, site specific DCTs will be included such as selection of a site with low permeability geologic formations, specific design elements such as single synthetic liners, specific operational technologies such as maintaining the low hydraulic head on a leach pad, specific operational monitoring proposals such as regular inspections by the facility operator, and specific closure and post-closure technologies such as bacterial rinsing for a gold heap leach pad.

In considering the systems approach to development of a Reference Design it is important to include site characteristics. While it may be important to select a high level of engineered containment for sites underlain by alluvium and shallow groundwater, the same may not be the case when the site is underlain by low permeability bedrock and/or deep groundwater (i.e., a demonstrated geologic barrier). The individual designer will include these considerations in the systems design based on experience as well as industry wide demonstrated control technologies which have been applied for similar site conditions. In developing an individual site design the designer must therefore be encouraged to use creativity to provide the greatest degree of discharge reduction achievable through application of DCTs and, where practicable, an approach permitting no discharge of pollutants.

1.1.3.3 Estimation of Aquifer Loading

An evaluation must next be performed to estimate the potential loading of pollutants to the aquifer as a result of implementing the Reference Design. Loading to the aquifer is used as a basis for evaluating the impacts of discharge from a facility. This evaluation can be done at
various levels of sophistication but at a minimum must include the steps outlined below. It is
important that this evaluation should consider the total life cycle of the facility (i.e., operations as
well as closure/post-closure). For example, during operations a slurry deposited tailing
impoundment will contain free water. After closure and during the post-closure period, this free
water may be removed and therefore the driving head for pollutant migration will be eliminated.

(1-12) GENERAL INFORMATION

PC-APP-000223
<table>
<thead>
<tr>
<th>Project Phase</th>
<th>Element</th>
<th>Demonstrated Control Technologies (DCT)</th>
<th>Evaluation Procedures to be Selected From</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site Characterization</td>
<td>Solution, Ore and Waste Characterization</td>
<td>1) These characterizations are required to determine the DCTs for other elements.</td>
<td>1) Procedures to differentiate between oxide and sulfide materials.</td>
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<tr>
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<td>2) 1312 Leach Procedure.</td>
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<td></td>
<td>3) Meteoric Water Mobility.</td>
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<td>4) Acid Base Accounting.</td>
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<td>5) Humidity Cell Tests.</td>
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<tr>
<td></td>
<td>Geotechnical, Surface Hydrology, Hydrogeologic, and Geologic Hazards Characterizations</td>
<td>1) Siting DCT incorporates selection of locations with:</td>
<td>1) Test pitting, drilling, trenching, sampling and testing.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Low permeability geologic formation</td>
<td>2) In-situ tests of, for example, hydraulic conductivity.</td>
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<td></td>
<td>• Deep groundwater tables</td>
<td>3) Geophysical methods.</td>
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<td>• Naturally poor groundwater quality</td>
<td>4) Water level monitoring.</td>
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<td>• Small contributory watershed.</td>
<td>5) Remote sensing methods.</td>
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<td>2) Selection of sites which avoid or mitigate geologic hazards.</td>
<td>6) Aerial photography mapping and interpretation.</td>
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<td></td>
<td>7) Site reconnaissance.</td>
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<td></td>
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<td></td>
<td>8) Other standard hydrologic and geotechnical field investigation and data evaluation methods.</td>
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<td></td>
<td>3) These characterizations are required to determine the DCTs for other elements.</td>
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<td></td>
<td></td>
<td>2) Excavate and replace weak foundation materials.</td>
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<td></td>
<td>Surface Water Control</td>
<td>1) Diversion ditches.</td>
<td>1) Standard hydrologic design methods.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2) Retention structures.</td>
<td></td>
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<tr>
<td>Project Phase</td>
<td>Element</td>
<td>Demonstrated Control Technologies (DCT)</td>
<td>Evaluation Procedures to be Selected From</td>
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</tbody>
</table>
| Discharge Control | 1) DCTs for discharge control vary significantly depending on the type and size of the operation and the reasonableness of applying controls in arid or semi-arid settings, but may include:  
  - Liners for containment.  
  - Natural containment.  
  - Leachate collection and hydrostatic head control systems consisting of:  
    - Manufactured or imported drain rock and perforated pipes.  
    - Ore materials satisfying drainage requirements.  
    - Granular or synthetic leak collection layers for pond liner systems.  
  - Solution conveyance pipes or lined channels and storage capacity. | 1) Systems approach to liner system design (Appendix C).  
  2) Standard engineering measures for surface containment. |
| Stability | 1) Specified ultimate slope height.  
  2) Stability benches.  
  3) Design to withstand shear forces, e.g., by compaction, use of geosynthetics, etc.  
  4) Control of pore pressures by drainage.  
  5) Buttressing. | 1) Shear strength analysis.  
  2) Static stability analysis.  
  3) Seismic deformation analyses. |
<table>
<thead>
<tr>
<th>Project Phase</th>
<th>Element</th>
<th>Demonstrated Control Technologies (DCT)</th>
<th>Evaluation Procedures to be Selected From</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operations</td>
<td>1) Conduct operations to minimize potential for damage to liners at heap leach sites:</td>
<td>1) Consider operational conditions during design of facility.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Geosynthetic and/or gravel protective layers.</td>
<td>2) Visual observations.</td>
<td></td>
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<tr>
<td></td>
<td>• Low ground pressure equipment.</td>
<td>3) Survey monuments.</td>
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<tr>
<td></td>
<td>• Limit equipment traffic.</td>
<td>4) Instrumentation.</td>
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<td>• Load in uphill direction.</td>
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<td>• Limit rate of rise.</td>
<td></td>
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<td>• Limit maximum height.</td>
<td></td>
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<td></td>
<td>2) Control solution applications at heap leach sites:</td>
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<tr>
<td></td>
<td>• Avoid excessive reagent concentrations.</td>
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<td></td>
<td>• Avoid application rates or storage conditions that result in excessive hydraulic head.</td>
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<td></td>
<td>• Sequence leaching activities.</td>
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<td>3) Managed tailing deposition:</td>
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<td>• Layered or subareal deposition.</td>
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<td>• Limit size of water pond.</td>
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<td>4) Operational monitoring to allow early detection and correction of problems.</td>
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<td>5) Facility maintenance to assure performance is consistent with the design.</td>
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<tr>
<td>Closure and Post-Closure</td>
<td>Physical Stability</td>
<td>1) Surface Water Control to reduce erosion.</td>
<td>1) Stability evaluations.</td>
</tr>
<tr>
<td></td>
<td>2) Recontouring to control surface flow.</td>
<td>2) Long-term erosion evaluations.</td>
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<td></td>
<td>3) Cover placement (e.g., vegetation or rock armor) to reduce erosion.</td>
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<td>4) Erosion protection of ditches.</td>
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<tr>
<td>Project Phase</td>
<td>Element</td>
<td>Demonstrated Control Technologies (DCT)</td>
<td>Evaluation Procedures to be Selected From</td>
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<tr>
<td>Chemical Stability</td>
<td>1) Source control:</td>
<td>• Ore residue rinsing and/or detoxification.</td>
<td>1) Column leach tests.</td>
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<tr>
<td></td>
<td></td>
<td>• Ore residue removal.</td>
<td>2) Fate and transport evaluations.</td>
</tr>
<tr>
<td></td>
<td>2) Migration control:</td>
<td>• Surface grading to enhance run-off.</td>
<td>3) Cover water balance evaluations.</td>
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<td></td>
<td>• Surface grading to minimize run-on.</td>
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<td></td>
<td>• Design cover to minimize infiltration and enhance moisture removal (e.g., increased evapo-transpiration by fine-grained soils and/or vegetation).</td>
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<td>• Cap with low permeability cover.</td>
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<td>3) Interception (e.g., using shallow trenches; cutoff walls) and water treatment.</td>
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The steps which should be followed to estimate aquifer loading for the total life cycle of the facility are as follows:

- Estimate the potential release from the facility by using empirical equations or other appropriate approximate methods.
- Estimate the travel time to the water table beneath the facility by vertical migration using groundwater flow calculation methods such as described in Appendix C of Hutchison and Ellison (1992).
- Estimate attenuation of pollutants in the foundation based on published values or laboratory test results.
- Estimate the load added to the aquifer of constituents that have the potential to impact water quality, particularly those for which there are water quality standards.

The purpose of the load estimation to the aquifer is to provide a consistent method to compare the potential impacts of various designs. It is therefore not intended that this evaluation should turn into a research project or an advancement of the state-of-the-art. However, consistent and realistic approaches should be followed.

1.1.3.4 Alternative Design(s) Selection

Alternative design(s) should next be developed and can include the evaluation of alternative control technologies or design elements for each applicable type of facility (Part 3 summarizes various demonstrated control technologies for different types of facilities) or, as may be appropriate, the evaluation of alternative sites. The selection of the alternative design(s) should be based on the systems approach where control technologies as well as realistic site conditions are considered.

1.1.3.5 Estimation of Aquifer Loading for Alternative Design(s)

Estimating the aquifer loading for the alternative design(s) follows the same approach as described above for estimation of aquifer loading for the Reference Design. By following the same procedures, comparative aquifer loadings from the Reference Design as well as the alternative design(s) can be developed.

1.1.3.6 Selection of BADCT Design

The final step in developing an individual BADCT design is to make a selection from the Reference Design and the alternative design(s). The basis for this selection is loading to the aquifer. The BADCT design will be that design which results in the least amount of pollutant loading (discharge) to the aquifer. For example if an alternative design results in a lower pollutant loading to the aquifer, then that design will be selected as the BADCT design instead of the Reference Design.

In cases where the Reference Design and/or the alternative design result in similar loadings to the aquifer, and discharges do not contain materials listed in A.R.S. 49-243.I, the design with the

------------------------------------------------------------- GENERAL INFORMATION (1-17)
lowest costs (i.e., capital, operations, closure, post-closure and other applicable costs) may be selected as the BADCT design. In such cases, negligible loadings can be considered similar even if the relative difference between loadings is significant (e.g., where loadings from alternatives are small compared to the highest loading that could still comply with aquifer water quality standards, the fact that the loading from one alternative may be up to orders of magnitude smaller may not preclude these loadings from being considered similar). If the discharge contains materials listed in A.R.S. 49-243.1, the applicant must limit discharges to the maximum extent practicable regardless of cost.

The BADCT design is therefore selected based on DCTs, a systems approach including site conditions, and the estimation of aquifer loadings for alternative designs.

The requirement for this individual BADCT evaluation process to be demonstrated in APP applications is described in regulation as follows (A.A.C. R18-9-A202(A)(5)):

"The applicant shall submit in support of the proposed BADCT a statement of the technology which will be employed to meet the requirements of A.R.S. 49-243.B. This statement shall describe the alternative discharge control measures considered, the technical and economic advantages and disadvantages of each alternative, and the justification for selection or rejection of each alternative. The application shall evaluate each alternative discharge control technology, relative to the amount of discharge reduction achievable, site specific hydrologic and geologic characteristics, other environmental impacts, and water conservation or augmentation. The economic impact of implementation of each alternative discharge technology shall be evaluated on an industry-wide basis. In addition, a statement for a facility in existence on the effective date of this Article shall reflect consideration of the factors listed in A.R.S. 49-243.B.1(a) through (h)."

A.R.S. 49-243.B.1(a) through (h) includes the following:

(a) "Toxicity, concentrations and quantities of discharge likely to reach an aquifer from various types of control technologies.

(b) The total costs of the application of the technology in relation to the discharge reduction to be achieved from such application.

(c) The age of equipment and facilities involved.

(d) The industrial and control process employed.

(e) The engineering aspects of the application of various types of control techniques.

(f) Process changes.

(g) Non-water quality environmental impacts.

(h) The extent to which water available for beneficial uses will be conserved by a particular type of control technology."

As discussed in Section 1.1.2, the BADCT demonstration portion of the application can be deemed complete, and A.A.C. R18-9-A202(A)(5) deemed satisfied without this evaluation where facilities utilize Prescriptive BADCT.

1.1.3.7 Economic Considerations

In regard to new facilities, A.R.S. 49-243.B.1. directs ADEQ to consider economic impacts of the application of BADCT with other factors on an industry-wide basis. The determination of economic impact on an industry-wide basis shall take into account differences in industry sectors (1-18) GENERAL INFORMATION
(i.e., Copper Sector, Gold Sector, Uranium Sector, etc.), the facility type (i.e., heap leaching, dump leaching, in-situ, copper oxide leaching, copper sulfide leaching, etc.), the size of the operation, and the reasonableness of applying controls in an arid or semi-arid setting (gold mining in Northern California vs. gold mining in Arizona, copper mining in Michigan vs. copper mining in Arizona, etc.). ADEQ considers that use of a technology at many other similar facilities in the same industry sector, same type and size, and in the same climatic setting indicates financial feasibility. As indicated above, if a new facility discharges the pollutants identified in A.R.S 49-243.I, then that facility must meet the criteria of A.R.S. 49-243.B.1 (BADCT) to limit discharges to the maximum extent practicable regardless of cost.

1.1.3.8 Discussion

It may be beneficial from a design point of view to include elements which are innovative and therefore may not satisfy the requirement of an industry-wide DCT. In this case, the designer must demonstrate that such technologies will perform as intended. Such demonstration can be based on literature reviews, engineering analyses, laboratory and pilot scale testing, or by providing case histories of analogous applications of the technology.

1.1.4 Individual BADCT Review Process for Existing Facilities

An existing facility is defined in A.R.S. 49-201.14. as one that is neither a new or closed facility and at which construction began before August 13, 1986. According to A.R.S. 49-201.18, a closed facility that is reopened does not constitute an existing facility, but is regarded as a new facility. The distinction between existing and new facilities is important in determining BADCT for the following two basic reasons:

1) At an existing facility, determining BADCT requires ADEQ and the applicant to consider potential upgrades to the facility design, and

2) Additional factors for existing facilities apply as listed in A.R.S. 49-243.B.1(a) through (h), such as, weighing cost vs. discharge reduction, the age of equipment, and the engineering aspects of the application of various types of industrial and control processes. Also, the requirement of A.R.S. 49-243.I that a new facility limit discharges of certain listed organic pollutants to the maximum extent practicable regardless of cost does not apply to existing facilities.

Note that the option of Prescriptive BADCT also applies to an existing facility. If the facility meets the prescriptive criteria identified for the specific type of facility in Part 2, no further demonstration is necessary. Most existing facilities, however, warrant the individual evaluation process.

There are two major differences in approach mandated for determining BADCT for an existing facility, compared to that for a new facility. First, existing design and site conditions offer constraints on what can be achieved with the final BADCT configuration. Second, analysis of cost vs. discharge reduction applies in determining BADCT. To arrive at a BADCT, the existing design and its performance become the basis of comparison for judgments about whether or not to upgrade the design. Possible upgrades must, of course, be limited to those that are feasible from an engineering standpoint given the age, design, and operational controls of the facility.

GENERAL INFORMATION (1-19)
Complicating matters at an existing facility may be the groundwater impact of past operations. While remedial or mitigative efforts may be needed in areas where groundwater quality does not conform to Aquifer Water Quality Standards downgradient of a facility (see A.R.S. 49-243.L), these activities do not constitute part of BADCT for the facility. The reason for this distinction is that BADCT does not include actions or design features which affect groundwater after pollutants have been released into it, since discharge has already occurred in those instances. Thus, while existing groundwater quality may be an indicator of the performance of the current design, remedial or mitigative technologies do not reduce discharge and should not be considered in the BADCT evaluation.

There are five basic steps in the existing facility process. Similar to the new facility process outlined previously, the applicant develops a Reference Design. However, here, the existing configuration of a facility and site represents its Reference Design. Alternatives to the Reference Design are then developed and evaluated as outlined by the following five basic steps:

Step 1 Identify current DCTs and site factors;
Step 2 Estimate performance (determine aquifer loading);
Step 3 Identify technically feasible alternative DCTs and assemble them on a candidate list. Consider water conservation and other environmental factors to reduce or adjust the list;
Step 4 Use the candidate list to arrive at one or more alternative systems;
Step 5 Weigh cost vs. discharge reduction for each alternative system to arrive at BADCT:
  - Calculate improvements in aquifer loading expected from one or more alternative systems with new DCTs, and
  - Determine costs to implement alternative system(s).

1.1.4.1 Steps 1 & 2: Identifying Current Discharge Controls and Assessing Their Performance - The Reference Design

As with new facilities, BADCT determination for existing facilities depends on an adequate characterization of the discharge quantity and type. To establish the Reference Design for an existing facility, the applicant should inventory the discharge controls used in the facility's current design. The control processes and technologies can be identified according to the design elements and site characteristics described in Part 3. Discharge control technologies to consider include process solution controls in conjunction with: solution, ore and waste characterization; site preparation; surface water controls; liners; leachate collection systems; stability design; operational monitoring; closure/post-closure; and site factors. Where original design plans are lacking, the applicant should develop as-built design information for those aspects of the facility which have some bearing on discharge rates and characteristics. To save time and effort, and to promote efficiency, the applicant is encouraged to discuss the level of detail needed with ADEQ prior to developing as-built drawings.

Once existing control processes are identified, the applicant should evaluate the overall discharge control performance of the facility. As for the approach for new facilities, the applicant may assess site factors and their performance for pollutant reduction in the manner presented in Section 1.2. Where practicable, this step should involve direct measurement of discharge quantity and quality. Otherwise, the applicant may calculate expected performance based on

(1-20) GENERAL INFORMATION

PC-APP-000231
industry standards for the engineered controls, test data for components, and site specific characteristics determined from field or laboratory testing. Aquifer loading from the facility for the existing configuration can be estimated by the same methods used in Section 1.1.3. This aquifer loading analysis constitutes the performance of the Reference Design.

1.1.4.2 Step 3: Identifying Technically Feasible DCTs for Improvement

The BADCT design for an existing facility may involve instituting additional control technologies to those in current use. This step in the process involves developing a list of alternative DCTs that are technically feasible for application at the facility. In many situations, new controls may not be feasible. For instance, adding a liner to an existing dump leach system is beyond the realm of normal mine design and operation. In such cases an applicant should consider other design elements or operational controls discussed below to achieve discharge reduction.

Working with only technically feasible technologies, the applicant should assemble a focused, yet complete, list of candidate DCTs for improvement of the existing facility. Ideas for candidate DCTs may be gained from reviewing the lists of DCTs presented in Part 3. However, many DCTs identified in Part 3 may not work as “retrofitted technologies.” The following are types of DCTs which are often easily implemented and may, depending on the facility design and site, offer considerable improvement in facility performance to control discharge:

- Operational controls - physical and chemical (This includes physical controls such as modifying solution application cycles and the amount of solution inventory in the heap or pond storage, and chemical controls such as altering the reagents or reagent dose rates);
- Run-on and other storm water management controls;
- Closure elements such as removal of free liquids, grading, covering, etc.;
- Containment systems for process solution and other potential pollutant sources; and
- Stability improvements by, for example, berming, benching or regrading.

Aside from technical feasibility, certain other factors may disqualify particular DCTs from making the candidate list. Water conservation may be a factor for deciding whether or not a change in discharge control technology is favorable. Simple dilution of a pollutant to achieve lower discharge concentrations, in itself, may not meet BADCT, nor will technologies that consume or alter the quality of large quantities of water. However, there may be extenuating circumstances in which dilution is desirable, such as to facilitate beneficial use of the water or achieve an environment which could enhance natural treatment.

The applicant should also consider other environmental factors. The use of a new discharge control technology at an existing facility may have environmental impacts that are not directly related to aquifer water quality. An example of such a technology is air stripping to remove volatile organic substances from water and mobilize them in air. These environmental tradeoffs must be assessed on a case-by-case basis, and judgments about whether they outweigh discharge reduction are likely to be subjective. Some other common environmental factors that may require consideration are air quality, noise levels, land use, aesthetics, environmentally sensitive areas, endangered species, and the potential for disease transmission.
1.1.4.3 **Step 4: Use Candidate List to Arrive at One or More Alternative Discharge Control Systems**

The selection of alternative design(s) should be based on a systems approach where technologies, as well as site conditions, are considered. The list of alternative DCTs should be used to identify components that may be incorporated alone or in combination in the existing reference design to arrive at the alternative design(s). This step in the process involves considerable professional judgment and the justification for the selected DCTs may require formal exchange of data, and discussion and negotiation between the applicant and ADEQ, depending upon how obvious the available choices are.

1.1.4.4 **Step 5: Weigh Cost vs. Discharge Reduction by Calculating Aquifer Loading for Alternative System(s) and Calculating Cost for New DCTs**

After selecting alternative design(s) in Step 4, an applicant should prepare additional aquifer loading calculation(s) using the same considerations as for the Reference Design. Where additional DCTs are used, their contribution to discharge reduction should be factored into the aquifer loading calculation(s). Where new DCTs are substituted for existing ones, the estimated performance of the new DCT should be used in the calculation. The aquifer loading(s) of the alternative system(s) need to be compared to the Reference Design.

For cost evaluations, the applicant shall compare the total cost/benefit of the application of the technology with the discharge reduction to be achieved from such application, as noted in A.R.S. 49-243.B.1(b). When calculating the total cost/benefit, the applicant may apply acceptable discounting methods used for other accounting purposes within the industry.

### 1.2 USING SITE CHARACTERISTICS AS A PART OF THE BADCT DESIGN

This section, together with Appendix B (Solution, Ore and Waste Characterization), describes site, technical and economic considerations, on an industry-wide basis, applicable to BADCT analysis for a specific facility. It includes discussions on waste types and process solution characteristics, water resource values, climatic conditions, site factors, and passive containment. Such factors may affect the BADCT selection for a facility seeking an Individual APP.

1.2.1 **Waste Types and Process Solution Characteristics**

A.A.C. R18-9-A202(A)(4) requires that a person applying for an APP provide a summary of the known past facility discharge activities and the proposed facility discharge activities indicating:

- The chemical, physical and biological characteristics of the discharge;
- The rates, volumes, and the frequency of the discharge for each facility; and
- The location of the discharge.

All applications should include the characterizations necessary to satisfy the requirements described above. In some cases (e.g., new facilities), the applicant may not be able to adequately define the characteristics of the material to be discharged until the facility becomes operational.

*(1-22) GENERAL INFORMATION*
1.2.4.2 Geology/Stability

To determine how geologic conditions may affect the Individual BADCT design for a facility, the applicant should extensively evaluate the associated physical, hydraulic and geochemical properties.

Specific information that may be appropriate to address, and that may be required for an APP application utilizing Individual BADCT, includes:

- Structural Geology: The degree to which geologic structures may affect the Individual BADCT design depends on the amount of reliance being placed on geologic containment. Information on major geologic structures can be identified using geologic maps, aerial photographs, and existing geologic reports, etc. Detailed onsite geologic mapping or field investigation programs are required to evaluate site specific structures. The types of structures that need to be considered include:
  - Faults must be considered in the design of any facility because they affect stability.
  - Other structures, such as anticlines and synclines which affect rock strata orientation, can influence the rate and direction of liquid migration through the vadose zone and may be important in designing leak detection systems.
  - Fracture systems in bedrock can be important in determining seepage rates and velocities, and the location of monitoring systems.
  - Various other geologic structures or discontinuities can affect the areal continuity of low permeability layers.
- Lithology: Lithology is the physical and mineralogic makeup of geologic materials, including both unconsolidated deposits (e.g., alluvium) and bedrock. Important lithologic considerations include:
  - Horizontal and vertical variations in lithology that cause permeability to vary and which can affect the degree of natural containment provided by the site.
  - Subsurface strength properties that can affect the long-term integrity of the facility (e.g., settlement potential) and seismic stability.
  - The depth to bedrock, degree of subsurface stratification, and variations in strata characteristics, can be important to the design of a facility.
  - Certain alluvial materials and rock types may, by themselves or possibly in combination with planned facility operations, possess geochemical characteristics that contribute to a reduction of discharge and/or limit pollutant migration by attenuation.

The following are representative methods for determining permeability; site specifics will determine which methodologies are applicable:

- Soil and rock classification based on subsurface lithologic logs and the use of literature or other available information to determine approximate permeability values;
- Field permeability testing, including pump tests, packer tests, and other in-situ tests;
- Laboratory grain size analyses and permeability tests;
- Borehole and surface geophysical surveys to define lithologic boundaries, and to characterize the distribution of permeability.

(1-30) GENERAL INFORMATION

PC-APP-000234
The effects of scale should be considered in interpreting results of permeability testing. The permeability measured in isolated borehole packer tests (e.g., local permeability) may vary from the permeability of the larger scale rock or soil mass (bulk permeability). This is due to differences in the persistence, character and interconnectivity of the fractures near the boreholes as compared to the rock mass or due to heterogeneity in soil masses. It is also important to consider possible horizontal and vertical variations in permeability (i.e., does permeability decrease or increase between varying lithologies or with depth) and how the local and regional groundwater regimes at the site are affected.

1.2.4.3 Soil Properties

Soil is generally characterized by relatively high organic content, biologic activity by roots and microorganisms, and concentration of weathering products left by leaching, evaporation or transportation. Soil properties may affect discharge from a facility by physical, chemical and biologic interaction with a pollutant(s).

Soil properties with potential to affect discharge include: type, distribution and thickness, structure, grain-size distribution, organic carbon content, chemical composition, mineralogy, cation exchange capacity, specific surface area and permeability. The applicant should evaluate any changes to soil characteristics that may result from interaction with the discharge. If soil characteristics are to be used for attenuation, the attenuation capacity of the material must be predicted using literature data, or laboratory or field tests.

In addition to analyzing the ability of soil properties to affect the quantity and/or quality of a potential discharge, shear strength must be analyzed to support stability analyses.

Soil tests and data which may be useful in an Individual BADCT determination include:

- Studies of degradation of pollutants in the soils;
- Batch or column tests to react a simulated discharge with site soils to determine attenuation capacity;
- Infiltration tests;
- Permeability tests;
- Chemical analyses (pH, EC, inorganic analyses, organic analyses);
- Material property tests (grain size analyses, moisture content, bulk density, Atterberg Limits);
- Maps of soil distribution and depth;
- Soil boring logs;
- Other pertinent soil information including reference to pollutant attenuation research.

1.2.4.4 Surface Hydrology

If surface water enters waste or processing facilities, leachate can be generated. A key to controlling leachate generation is to design, construct, operate and close facilities in a manner that minimizes the potential for contact of surface water with pollutants and excludes surface water from areas where infiltration may affect groundwater quality. The configuration of surface
water control systems for a mining facility depends on the climate and topography of the site area. Computer models may guide the assessment of surface water effects and the need for surface water control systems. County flood maps may also be helpful.

In general, surface water should be diverted around and drained from areas where facilities are located using engineered features such as diversions and/or retention structures. Diversions and/or retention structures are usually designed to minimize run-on to the facility. This preserves containment integrity and limits the amount of water that may contact process reagents or other sources of potential pollutants. In some cases, drainage controls may also be necessary to protect against inundation of the facility and nearby low areas where infiltration may contribute to pollutant transport in the vadose zone. This can typically be achieved by providing protective berms or dikes.

The design of surface water control systems is influenced by: precipitation (amount, intensity, duration, distribution), watershed characteristics (size, shape, topography, geology, vegetation), run-off (peak rate, volumes, time distribution) and degree of protection warranted.

Timely maintenance is necessary for the continued satisfactory operation of surface water control systems. The principal causes of failure of surface water diversions and/or retention structures are inadequate design peak flow capacity, channel and bank erosion, sedimentation, and excessive growth of vegetation reducing the flow capacity. It is recommended that free-draining features (e.g., ditches and dikes) be capable of handling the design peak flow and that impounding features be designed to handle the design storm volume which occurs over a duration resulting in the maximum storage requirement (ADEQ may approve other design criteria). Evaluation of these design peak flows and storm volumes is discussed in Appendix E (Engineering Design Guidance).

Data that may be presented to evaluate the need for surface water control include:

- Location of any perennial or ephemeral surface water bodies;
- Rates, volumes, and directions of surface water flow, including hydrographs, if available;
- Location of 100-year flood plain;
- Site topography;
- Historical precipitation data.

Any activities in, or discharges to, waters of the United States require 401 Certification with ADEQ, and may require notification to the Army Corps of Engineers for a 404 Permit, the EPA for a 402 Permit, and/or the respective County Flood Control District. Additional information regarding these permits and certifications is presented in Appendix F (Federal, State and Local Environmental Permits).

1.2.4.5 Hydrogeology

Site characteristics are a part of BADCT insofar as they control the quality and/or quantity of discharge before it reaches groundwater. Potentially important hydrogeologic characteristics include vadose zone properties that may help to limit discharge to the aquifer. Dilution,
attenuation and other factors that affect discharges after reaching an aquifer are not normally an inherent part of BADCT.

The exceptions, where characteristics within the aquifer may be an inherent part of BADCT, are the case of in-situ leaching of an ore body and passive containment. In-situ leaching is defined as the underground injection of solutions into an ore body in-place for the purpose of extracting the mineral commodity. In-situ leaching is discussed in Section 3.4. Passive containment is defined by regulation and is discussed in Section 1.2.5.

The remainder of this section addresses vadose zone hydrogeology that may be important to BADCT for mining operations.

Properties of the vadose zone, the unsaturated zone between the land surface and the saturated zone or maximum groundwater table (Figure 1-1), may affect the behavior of a discharge in a number of ways. For example, physical properties of the vadose zone, like the presence of high permeability layers and geologic structures (e.g., faults, fracture zones), may increase movement of a discharge to groundwater. Conversely, the presence of impervious layers and geologic structures (e.g., clay seams, strata boundaries) may retard the movement of a discharge to groundwater or cause the presence of perched water tables; fine grained layers within the zone may physically remove some types of pollutants; and the decrease in bedrock permeability with depth may reduce the possibility of discharge reaching groundwater. Also, chemical and/or geochemical reactions between the discharge and materials in the vadose zone may alter or remove some pollutants; or biodegradation due to microbial interaction with the pollutant may degrade the pollutant.

If the vadose zone consists of layers or lenses of different materials, such as stratified soil horizons or rock units, the properties of each unit must be considered separately in addition to describing the general properties of the vadose zone. The applicant should identify lateral and vertical extent of the geologic units and the type of contacts between the units (e.g., gradational, fault, unconformity, facies change). Perched water tables within the vadose zone may be a consideration.

The attenuation of chemical constituents in soil and rock is a valid consideration that can be factored into site specific evaluations. If vadose materials are to be used for attenuation, the attenuation capacity of the material must be predicted. Below is a brief description of the four major types of attenuation mechanisms. This is further explained in “Mine Waste Management,” Chapter 5 (Hutchison and Ellison, 1992).

- Physical Mechanisms: Physical mechanisms include filtration, dispersion, dilution and volatilization.

- Physiochemical Mechanisms: Physiochemical mechanisms are dependent on both physical and chemical conditions and can include adsorption and fixation.

- Chemical Mechanisms: Chemical mechanisms are dependent on the chemical interaction of an element or mineral with the soil or pore water and includes solution/precipitation of compounds or the increase/reduction in toxicity of a constituent by changing its valence state, or the removal/addition of ions by cation exchange.

GENERAL INFORMATION (1-33)
## Examples of Engineering Equivalents\(^{(1)}\)
for Various Prescriptive BADCT Design Components

<table>
<thead>
<tr>
<th>Perscriptive BADCT Component</th>
<th>Prescriptive BADCT Design Criteria</th>
<th>Example Engineering Equivalents</th>
<th>Potential Evaluations That May be Required to Demonstrate Engineering Equivalence</th>
</tr>
</thead>
</table>
| • Tailing layer to limit infiltration to tailing facility protective/drainage layer. | • Tailing material should be deposited in the impoundment to form a continuous layer that limits the rate of infiltration to the protective/drainage layer.  
• After the deposition of a continuous layer of tailing over the protective/drainage layer, the rate of infiltration into the protective/drainage layer and the flow capacity thereof must be adequate to limit the average and maximum hydraulic head over the liner to less than 2 and less than 5 feet, respectively. Lower heads should be maintained, where practicable. | • Compacted fine-grained soil may be placed over the protective/drainage layer prior to deposition of tailing material. | • Hydraulic calculations may be required to demonstrate expected hydraulic head over the liner. If the prescriptive liner configuration is used, head shall not exceed that specified. Greater hydraulic head may be acceptable if a more conservative liner configuration is used. |
| • Subgrade compaction for ponds, Heap Leach Pads, or Tailing Impoundments. | • Minimum six inches native or natural materials compacted to 95 percent maximum dry density (standard Proctor; ASTM Method D-698) within 3 percent of optimum moisture content. | • Alternative subgrade compaction specification may be suitable. | • Strength properties must be suitable for bearing load and required seismic design, and to prevent significant differential settlement. |

\(^{(1)}\) This table provides examples only. It is not intended to be all-inclusive of potential engineering equivalents or to dictate requirements for equivalency demonstrations.
2.2 NON-STORM WATER PONDS

Prescriptive BADCT criteria for Non-Storm Water Ponds include: siting considerations; design, construction and operations; facility inspection; and closure/post-closure. Non-Storm Water Ponds include lined ponds that receive seepage from tailing impoundment, waste dump and/or process areas where potential pollutant constituents in the seepage have concentrations that are relatively low (e.g., compared to process solutions) but exceed Arizona Surface Water Quality Standards. Non-Storm Water Ponds also include secondary containment structures and overflow ponds that contain process solution for short periods of time due to process upsets or rainfall events.

Ponds that continually contain process solution as a normal function of facility operations are considered Process Solution Ponds and shall be designed in accordance with criteria discussed in Section 2.3.

2.2.1 Siting Criteria

The Prescriptive BADCT criteria are designed to eliminate the need for considering site hydrogeology and vadose zone characteristics, and minimize the need for consideration of other site factors. Therefore, design and operational components of Prescriptive BADCT described in this part are intended to be conservative so that they are protective at most sites. Even though the Prescriptive BADCT process does not require full site characterization, certain siting criteria must be addressed as part of the application to confirm that conditions unsuitable for Prescriptive BADCT do not occur. Basic siting criteria are identified in the following sections.

The prescriptive design appropriately applied is expected to result in an aquifer loading that will result in conformance with AWQS or will not further degrade the quality of any aquifer that already violates the AWQS at the point of compliance (A.R.S. 49-243.B.3). By law, demonstration of conformance with AWQS at the point of compliance, or demonstration of no further degradation in the quality of any aquifer that already violates an AWQS, is still required to obtain an APP permit, but a simplified approach to this demonstration may be used.

2.2.1.1 Site Characterization

Site characterization information can be gathered from data obtained during the initial site evaluation, exploration or development. Site reconnaissance, test pits and exploration drilling may serve, where possible, a dual role of reserve evaluation and also identification and evaluation of foundation materials and potential areas for borrow materials. Site characterization must: 1) provide surface water drainage information; and 2) delineate areas unsuitable for facility location based on surface and groundwater conditions or potential geologic hazards. Shallow groundwater conditions, if present, must be documented for design consideration, and may prohibit the use of Prescriptive BADCT.

_____________________________ PRESCRIPTIVE CRITERIA (2-5)
2.2.1.2 Surface Water Control

The control of surface water is a design factor for the Prescriptive BADCT process. Surface water run-on from upstream watershed areas that the Non-Storm Water Pond is not designed to capture should be diverted around the pond area. The minimum design storm is the 100-year, 24-hour storm event unless another regulatory program requires a larger design storm or other hydrologic criteria due to potential threat to human life (Appendix E, Engineering Design Guidance).

Erosion of diversion structures should be controlled by placing rip-rap at ditch entrances, exits and other erosion sensitive points. Alternative acceptable methods of erosion control include suitable channel geometry, soil cementation, limiting watershed areas (e.g., through the use of additional diversion trenches and dikes), slope down-drain pipes, energy dissipaters (e.g., gabions, rip-rap), retention basins to attenuate peak flows, etc.

If facilities are proposed within the 100-year flood plain, drainage controls must in addition to the above, be designed to protect the facilities from damage or flooding for 100-year peak streamflows.

Lakes, wetlands, springs and other surface waters must be identified in order to safely design the facility (minimize run-on) and minimize any unnecessary discharge to surface waters. Knowing the location of surface waters also will inform the applicant if other agencies must be contacted (see Appendix F, Federal, State and Local Environmental Permits).

2.2.1.3 Geologic Hazards

Potential geologic hazards should be considered present if conditions prone to the following occur at the proposed facility location:

- Excessive or differential subsidence;
- Collapsing soils;
- Landslides;
- Strong seismic shaking;
- Other potential ground instability.

If present, conditions prone to these hazards must be documented for consideration in facility design. Geologic hazards will not preclude the use of Prescriptive BADCT provided that such hazards do not have a significant potential to impact the effectiveness of the Prescriptive BADCT design (considering mitigating engineering measures, if any).

(2-6) **PRESCRIPTIVE CRITERIA**
2.2.2 Design, Construction and Operations Criteria

2.2.2.1 Solution/Effluent Characterization

Liner selection is determined in part by the chemical compatibility of the liner material and the nature of the liquids/solids to be contained. An analysis is to be made of all potential contained constituents, including organic compounds. Characteristics of importance are outlined in Section 1.2.1.

2.2.2.2 Capacity and Storage Design

Capacity design for Non-Storm Water Ponds must include: 1) the volume of precipitation that may inflow to the pond as a result of the design storm (discussed in Section 2.2.1.2); 2) the estimated volume of other inflows such as seepage; and 3) additional volume adequate to result in two (2) feet

of freeboard while containing these inflows. Ponds should be designed so that there will not be excessive erosion at the low point of the freeboard if the storage capacity is ever exceeded. The applicant must minimize the storage time of process solutions in a Non-Storm Water Pond.

2.2.2.3 Site Preparation

Site preparation includes clearing the area of vegetation, grubbing and grading as well as embankment and subgrade preparation. Supporting surface slopes and foundation are to be stable and structurally sound. Subsurface materials that affect the integrity and/or stability of the final pond design are to be excavated and replaced with appropriately compacted fill. Side slopes are to be no steeper than two (2) feet horizontal run to one (1) foot vertical rise (2:1 slope). Side slopes and bottoms are to consist of, at a minimum, six inches 3/8 inch minus native or natural materials compacted to 95% maximum dry density (standard Proctor; ASTM Method D-698) within 3% of the optimum moisture content. The compacted subgrade surface should be finished flat and smooth (e.g., by rolling) and inspected prior to geomembrane installation to remove protruding particles, if present.

2.2.2.4 Liner Specifications

Non-Storm Water Ponds will be designed with a single geomembrane of at least 30 mil thickness (exception - 60 mil if proposing HDPE). Geomembranes are to be selected based on a compatibility analysis considering liner composition and thickness, depth of fluid stored, chemical composition of solutions to be stored and foundation conditions. In areas that are exposed to the sun, the geomembrane must be certified UV resistant. The geomembrane is to be

__________________________ PREScriptive CРИterIA (2-7)
secured in an engineered anchor trench. The anchor trench is to be at least two feet deep and two feet wide. The geomembrane must extend across the bottom of the trench and at least one foot up the outside trench wall. The anchor trench backfill must consist of minus 1/2 inch material compacted in 6-inch lifts at 95% of maximum dry density according to the standard Proctor compaction effort (ASTM Method D-698).

Ditches that flow only to Non-Storm Water Ponds shall be lined with, at a minimum, a 30-mil geomembrane (except 60-mil if proposing HDPE) ponds over a minimum 6-inch layer of 3/8-inch minus native or natural material compacted to 95% maximum dry density (standard Proctor; ASTM Method D-698) within 3% of the optimum moisture content. The compacted soil layer should be finished flat and smooth (e.g., by rolling) and inspected prior to geosynthetic installation to remove protruding particles, if present. ADEQ may accept a lower level of compaction for the soil component of the ditch liner where 95% compaction is not practically achievable and a lower level of compaction will satisfy performance goals. Piping is an alternative that can be used to transport leachate/solutions to Non-Storm Water Ponds. Piping is not regulated under the APP program.

Geomembranes are not to be used as a structural component in the design. Geomembranes are to be installed over a prepared subgrade. Operations must be conducted in a manner that does not result in unnecessary mechanical stress on the geomembrane.

Standard Number 54 (NSF, 1993), Flexible Membrane Liners, covers geomembranes used in the retention of water and containment of pollutants or chemicals in an environmentally acceptable manner. The successful application of geomembranes covered by this standard depend upon site evaluation, design, material selection, construction, operation and maintenance. The applicant shall refer and adhere to this standard for geomembranes as applicable to the subject facility. Other sources of information on geomembranes include ASTM standards and current technical journals.

A Quality Assurance/Quality Control Program must be developed and implemented that meets or exceeds the geomembrane manufacturer's minimum requirements including inspection procedures, field testing (including limits for test failure and a description of the corrective procedures to be used upon failure), laboratory testing and repair of seams during installation and final inspection of the completed liner for functional integrity. Geomembranes are to be installed in compliance with manufacturer's seaming and seam testing recommendations for installation. Quality assurance/quality control programs must also address site and subgrade preparation. Additionally, guidelines for the operation and maintenance of the liner system are to be formulated and implemented for the life of the facility. Appendix D (Construction Quality Assurance and Quality Control) includes additional guidance on the development of a Quality Assurance/Quality Control Program.

2.2.2.5 Stability Design

Where the pond design includes a large embankment, the stability under static and seismic loading conditions must be considered and may need to be evaluated using quantitative stability analysis techniques.

(2-8) PRESCRIPTIVE CRITERIA
Appendix E provides additional guidance on stability design and the required factors of safety.

Static stability analyses should indicate a factor of safety of at least 1.3. Seismic stability analyses should be based on the Maximum Probable Earthquake (MPE) unless a larger design earthquake is warranted due to potential threat to human life (Appendix E). The MPE is the largest earthquake with a 100-year return interval. The MPE should be evaluated considering all known active faults within a distance of 200 kilometers. Seismic stability analyses may include pseudostatic and deformation analyses methods, as further discussed in Appendix E. When deformation analyses are required, the displacement predicted shall be within the following limits unless engineering evaluations are provided to demonstrate that larger displacements will not jeopardize containment integrity:

- Deformations not affecting geomembranes shall be less than or equal to 1 foot.
- Deformations affecting geomembranes shall be less than or equal to 6 inches.

The pond design shall incorporate necessary measures such that static and seismic stability criteria are achieved.

Figure 2-1 shows a cross section of an example non-storm water pond prescriptive BADCT design.

### 2.2.3 Facility Inspection Criteria

The objective of facility inspections by the permittee is early detection of component damage or degeneration and of potential discharges from the facility so that steps can be taken to prevent, reduce or stop discharges. Facility inspection is to be instituted at the time of pond construction. Thereafter, facility inspection is to be conducted on a quarterly basis and after major storm or surface water events. At a minimum, facility inspection will include: 1) a visual survey of the pond site to evaluate liner integrity, and 2) physical inspection of the pond to ensure the design capacity is not exceeded. Further detail regarding inspections that may be required can be obtained through pre-application consultation with ADEQ staff. Records of inspection shall remain on-site or at other approved locations for a period negotiated with ADEQ.

The applicant must propose and draft a Contingency Plan that will be approved by ADEQ. The plan shall be implemented in the event of an accidental discharge from the facility. The plan will identify the discharge discovery and notification procedure, the general clean-up procedures for chemical discharges, leaks, spills, or other releases from the solution management system, and reporting procedures. In the event of a discharge from a Non-Storm Water Pond, solutions contained within the pond are to be sampled to determine what has been discharged. At a minimum, sampled solutions are to be tested for pH, primary metals, and cyanide when present (Total and Weak Acid Dissociable). Liquids pumped from the pond shall be treated and disposed of in a manner consistent with all appropriate requirements, or recycled back into the facility operational system.
(2-10) PRESCRIPTIVE CRITERIA
If a Non-Storm Water Pond is used for overflow protection, the contingency plan must include procedures to either neutralize leachate/solutions prior to discharge or pumpback overflow so that residence time in the Non-Storm Water Pond can be limited.

2.2.4 Closure/Post-Closure Criteria

A closure/post-closure strategy must be drafted and submitted to ADEQ for preliminary approval as part of the APP application. The applicant must still comply with the requirements of A.A.C. R18-9-A209(B) prior to formal closure. Ordinarily, for permanent closure of Non-Storm Water Ponds, contained solutions shall be disposed of by physical removal or containment and evaporation. If physical removal is the chosen option, and if the solution is to be discharged from a point source to “waters of the U.S.” (which requires a NPDES Permit under the CWA), solutions must be treated or neutralized to meet surface water quality standards. Any residues or sludges remaining following discharge must be analyzed for applicable waste listing prior to disposal at an approved site.

The following are example elements of a closure strategy (A.R.S. 49-243.A.8) for a Prescriptive BADCT Non-Storm Water Pond:

- Excavated Ponds
  - Removal and appropriate disposal of solid residue(1) on the liner.
  - Inspection of synthetic liner for evidence of holes, tears or defective seams that could have leaked.
  - If there is no evidence of past leakage, the synthetic liner can be folded in place and covered by filling the excavation or removed for appropriate disposal elsewhere.
  - Where inspection reveals presence of one or more holes or tears or defective seams, the synthetic liner is to be removed, and the underlying surface inspected for visual signs of impact. The ADEQ may require sampling and analysis of the underlying material to determine whether it poses a threat to groundwater quality.
  - If required, conduct soil remediation to prevent groundwater impact.
  - After the residual soil conditions are approved by ADEQ, the synthetic liner material can be placed back into the excavation or be removed for appropriate disposal elsewhere, and the excavation backfilled.
  - The filled area will be graded to drain surface run-off and minimize precipitation infiltration.
  - Capping of the pond area with a low permeability cover may also be part of a closure strategy if it will achieve further discharge reduction that maintains compliance with AWQS at the point of compliance.

- Bermed Ponds

(1) Residue is defined as any solids collected on the liner to a thickness of greater than 1/4-inch or which can readily be removed by physical means such as sweeping or high pressure water sprays.

PRESCRIPTIVE CRITERIA (2-11)
- Closure as for excavated ponds with the following exception: the synthetic liner will not be buried within the pond area and must be appropriately disposed of elsewhere.
<table>
<thead>
<tr>
<th>Category</th>
<th>Element</th>
<th>Prescriptive Criteria</th>
</tr>
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</table>
| 2.2.1 Siting Criteria                 | 2.2.1.1 Site Characterization - Although Prescriptive BADCT does not require full site characterization prior to development of a mining area nor allow for site specific characteristics to be used as components of BADCT, certain siting considerations must be addressed. Obtain data during initial site evaluation, exploration, and/or development, as required to apply and implement the Prescriptive BADCT design. | 1) Evaluate site characteristics such as surface water hydrology and general site suitability.  
2) Determine if shallow groundwater conditions exist, and document if present.  
3) Determine if geologic hazards exist.                                                                 |
|                                       | 2.2.1.2 Surface Water Control - Identify and define floodplains, and need to protect the integrity of the pond from surface run-on/run-off. | 1) Surface water run-on from upstream watershed areas that the pond is not designed to capture should be diverted around the pond. Minimum design storm is the 100-year, 24-hour storm event unless a larger design storm is required by another regulatory program or due to potential threat to human life (Appendix E).  
2) The facility and related diversion structures must be designed to avoid excessive erosion.  
3) If located within the 100-year floodplain, the facility must be protected from damage or flooding from 100-year peak streamflows. |
|                                       | 2.2.1.3 Geologic Hazards - Identify geologic hazards at the site. Potential geologic hazards should be considered present if conditions prone to the following occur:  
• Excessive or differential subsidence.  
• Collapsing soils.  
• Landslides.  
• Strong seismic shaking.  
• Other potential ground instability. | 1) If present, conditions prone to geologic hazards must be documented for consideration in facility design.  
2) Potential geologic hazards must be mitigated such that they do not have significant potential to impact the effectiveness of the Prescriptive BADCT design. |
| 2.2.2 Design, Construction and Operations Criteria | 2.2.2.1 Solution/Effluent Characterization - Identify expected chemical and physical characteristics of potential contents to ensure compatibility with the design. | 1) Chemical characteristics of contained constituents, including organic compounds.  
2) Physical characteristics of contained constituents.  
3) Temperature of contained constituents.  
4) Other parameters as needed for liner design. |

**PRESCRIPTIVE CRITERIA (2-13)**
# Prescriptive BADCT

## NON-STORM WATER PONDS

### Prescriptive Criteria

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<th>Category</th>
<th>Element</th>
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| 2.2.2.2  | Capacity and Storage Design - Determine the design flood event and estimated inflow seepage. | 1) Pond must contain adequate volume for:  
   • The design storm volume.  
   • The estimated volume of other inflows.  
   • Additional two (2) feet freeboard.  
2) Applicant to operate pond to minimize duration of fluid storage. |
| 2.2.2.3  | Site Preparation - Prepare site for pond and embankment construction. | 1) Grub and grade the area.  
2) Excavate and replace unsuitable material.  
3) Subgrade to consist of, at a minimum, six inches of 3/8 minus native or natural materials compacted to 95% maximum dry density (standard Proctor; ASTM D-698).  
4) Side slopes no steeper than 2:1.  
5) Subgrade surface to be smoothed (e.g., rolled) and inspected prior to geomembrane liner installation. |
| 2.2.2.4  | Liner Specifications - Design and install pond components. | 1) Single geomembrane of at least 30 mil thickness or 60 mil if HDPE.  
2) Geomembrane certified to be UV resistant for areas exposed to sunlight.  
3) Geomembrane secured by an engineered trench.  
4) Ditches that carry leachate/solution only to Non-Storm Water Ponds will be designed with a single geomembrane on at least 30 mil thickness, or 60 mil if proposing HDPE, over a minimum of 6 inches of 3/8-inch minus native or natural material compacted to 95% maximum dry density (Standard Proctor; ASTM D-698), unless such compaction is not practicable and a lower compaction is approved by ADEQ. Piping may be used as an alternative to ditches. Piping is not regulated under the APP Program.  
5) Activities over geomembrane to be conducted in a manner that minimizes potential for damage.  
6) Quality Assurance/Quality Control program developed and implemented for liner installation, operation and maintenance. |
| 2.2.2.5  | Stability Design - Design to Provide Stability Under Static and Potential Seismic Loading Conditions | 1) Stability analysis may be required for ponds that include a large embankment.  
2) The minimum recommended static factor of safety is 1.3.  
3) The MPE is the design earthquake for seismic stability analyses, where required, unless a larger design earthquake is warranted due to potential threat to human life (Appendix E). |

(2-14) **PRESCRIPTIVE CRITERIA**
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| 2.2.3    | Inspections to alert permittee of component damage or degeneration, and of potential discharges. | 4) When deformation analyses are required (Appendix E), the displacement predicted shall be within the following limits unless engineering evaluations are provided to demonstrate that larger displacement will not jeopardize containment integrity:  
  - Deformations not affecting a geomembrane shall be less than or equal to 1 foot.  
  - Deformations affecting a geomembrane shall be less than or equal to 6 inches. |
| 2.2.4    | Facility Closure/Post-Closure - Contain and control discharges after closure. | 1) Inspections to be instituted at the time of pond construction and on a quarterly basis thereafter or after a major storm or surface water event.  
  2) Inspection to include visual survey to evaluate liner integrity and physical inspection to ensure pond design capacity is not exceeded.  
  3) Develop and implement Contingency Plan approved by ADEQ that specifies permittee courses of action to be taken in the event of an accidental discharge.  
  4) Inspection records are to remain on-site or at other approved locations for a period negotiated with ADEQ. |

1) Closure/Post-Closure Plan to be submitted to ADEQ for approval.  
2) The following are example elements of a closure strategy (A.R.S. 94-243.A.8) for a Prescriptive BADCT Non-Storm Water Pond:  
   - Excavated Ponds:  
     - Removal and appropriate disposal of solid residue on the geomembrane.  
     - Geomembrane inspection for evidence of holes, tears or defective seams that could have leaked.  
     - Where there is no evidence of leakage, the geomembrane can be folded in place and buried or removed for appropriate disposal elsewhere.  
     - Where geomembrane inspection reveals potential leaks, inspect soil for visual signs of impact. The ADEQ may require soil sampling and analysis to determine the potential for threat to groundwater quality.
**NON-STORM WATER PONDS**

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<th>Category</th>
<th>Element</th>
<th>Prescriptive Criteria</th>
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<td>- Conduct soil remediation if required to prevent groundwater impact.</td>
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<td>- After the residual soil conditions are approved by ADEQ the geomembrane can be buried in the pond or be removed for appropriate disposal elsewhere, and the pond excavation backfilled.</td>
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<td>- The filled area will be graded to minimize infiltration.</td>
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<td>- Capping of the pond area with a low permeability cover may also be part of a closure strategy if it will achieve further discharge reduction that maintains compliance with AWQS at the point of compliance.</td>
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<td>• Bermed Ponds:</td>
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<td>- Same closure procedures as for excavated ponds, except geomembranes will not be buried in place and must be appropriately disposed of elsewhere.</td>
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(1) Non-Storm Water Ponds include ponds that receive seepage from tailing impoundments, waste dumps, and/or process areas where potential pollutant constituents in the seepage have concentrations that are relatively low (e.g., compared to process solutions) but exceed Arizona surface water quality standards. Non-Storm Water Ponds also include secondary containment structures and overflow ponds that contain process solution for short periods of time due to process upsets or rainfall events. Ponds that continually contain process solution as a normal function of facility operations shall be considered Process Solution Ponds and shall be designed in accordance with criteria discussed in Table 2-3.
2.3 PROCESS SOLUTION PONDS

Process Solution Ponds include pregnant or barren solution ponds and recycle ponds. Overflow ponds that contain process solution for short periods of time due to process upsets or rainfall events shall be considered Non-Storm Water Ponds and designed in accordance with criteria discussed in Section 2.2 of this manual. Overflow ponds that continually contain process solution as a normal function of facility operations are be considered Process Solution Ponds and designed in accordance with criteria discussed in this section.

2.3.1 Siting Criteria

The Prescriptive BADCT criteria are designed to eliminate the need for considering site hydrogeology and vadose zone characteristics and minimize the need for consideration of other site factors. Therefore, design and operational components of Prescriptive BADCT described in this part are intended to be conservative so that they are protective enough for most sites. Even though the Prescriptive BADCT process does not require full site characterization, certain siting criteria must be addressed as part of the application to confirm that conditions unsuitable for Prescriptive BADCT do not occur at the facility location. Basic siting criteria are identified in the following sections.

The prescriptive design appropriately applied is expected to result in an aquifer loading that will result in conformance with AWQS or will not further degrade the quality of any aquifer that already violates the AWQS at the point of compliance (A.R.S. 49-243.B.3). By law, demonstration of conformance with AWQS at the point of compliance, or demonstration of no further degradation in the quality of any aquifer that already violates an AWQS, is still required to obtain an APP permit, but a simplified approach to this demonstration may be used.

2.3.1.1 Site Characterization

Site characterization information can be gathered from data obtained during the initial site evaluation, exploration or development. Site reconnaissance, test pits and exploration drilling may serve, where possible, a dual role of reserve evaluation and also identification and evaluation of foundation materials and potential areas for borrow materials. Site characterization must: 1) provide surface water drainage information; and 2) delineate areas unsuitable for facility location based on surface and groundwater conditions or potential geologic hazards. Any shallow groundwater conditions must be documented for design consideration, and may prohibit the use of Prescriptive BADCT.
presently known tectonic framework. The Design Earthquake should be evaluated considering all known active faults within a distance of 200 kilometers. Active faults are those which have experienced rupture in the past 35,000 years. Potential earthquake size can be estimated based on correlations with fault length (dePolo and Slemmons, 1990).

As indicated by published fault maps (Nakata et al., 1982; Pearthree et al., 1989; Demsey and Pearthree, 1990; Maulchin and Jones, 1992; Jennings, 1992; Euge et al., 1992), relatively few active faults have been identified in Arizona. Published sources should be used to define regionally-occurring faults. Aerial photographs should also be utilized to confirm the absence of faults in the immediate site vicinity, or to precisely locate nearby faults, if present. Offsets and age of recent movement can be investigated through trenching studies when necessary.

Tailing facilities should generally not be located on active faults. Where active faults occur adjacent to a proposed tailing facility site, caution must be taken to assure that the fault location is well-defined. Aerial photograph evaluation, and field studies if necessary, should be used to confirm that signs of surface offset (e.g., splay faults) do not occur at the proposed facility location. Where a facility is to be located on an active fault, the applicant must evaluate aquifer loadings for an assumed ground rupture to demonstrate that the proposed location is feasible.

3.5.3.3.4 Collapsing Soils

Collapsing alluvial soils which are widely distributed in Arizona (Beckwith and Hansen, 1989) are alluvial fan deposits formed during the past 11,000 years (Holocene era), since the last episode of continental glaciation. The geotechnical properties of these soils, which generally are susceptible to self-weight settlement of 2 to 6% of their thickness when wetted, are largely a consequence of the dynamics of water-sediment supply in alluvial fan development and associated unsaturated flow processes. Thick deposits of particular concern in engineering analysis occur as coalescing alluvial fans at the base of mountains and along the margins of floodplains of major rivers such as the Gila, San Pedro and Colorado. Deposits as thick as 80 feet occur along the margins of floodplains.

Collapsing soils present the potential for differential subgrade movement and horizontal or vertical strains to liners, piping systems, structural fills, and other facility components similar to those addressed for subsidence in Section 3.5.3.3.2. If conditions susceptible to collapsing soils are present, engineering evaluations should be provided with the APP application that demonstrate the integrity of the facility will not be jeopardized.

3.5.4 Design, Construction and Operations Considerations

The following sections address design, construction, and operations aspects that may constitute part of BADCT for a given facility where they have the potential to affect aquifer loading:

- Section 3.5.4.1 - Site Preparation

(3-56) INDIVIDUAL GUIDANCE
- Section 3.5.4.2 - Surface Water Control
- Section 3.5.4.3 - Discharge Control
- Section 3.5.4.4 - Stability Design
- Section 3.5.4.5 - Operational Measures

Section 3.5.4.6 discusses operational monitoring that should be conducted to ensure that the facility is performing and being operated as designed.

### 3.5.4.1 Site Preparation

Site preparation may consist of a broad range of activities to provide a stable foundation for construction of a facility.

Site preparation for a Tailings Impoundment usually includes stripping and stockpiling of topsoil, vegetation and debris where required for liner installation or starter dam construction. Soils having low strength or high settlement potential may have to be excavated and replaced with structural fill or otherwise treated as required to provide a stable foundation. This is particularly important for the embankment foundation. Care must be taken to provide adequate compaction of structural fill to the extent necessary to adequately limit deformations and provide the required strengths and permeabilities. Subgrade treatment is usually required for liners, embankments, and other structural components.

### 3.5.4.2 Surface Water Control

The objective of a surface water control system at a Tailings Impoundment is to control run-on and run-off in order to: 1) minimize run-on into the Tailings Impoundment; (2) prevent overtopping of the embankment; and 3) protect the overall facility integrity to prevent uncontrolled releases that can discharge pollutants to the aquifer by indirect surface water to groundwater pathways. BADCT surface water controls at a Tailings Impoundment may include the following:

- Upstream surface water diversion channels or dams that divert run-on away from the Tailings Impoundment;
- Upstream storm water detention dams or basins that reduce the rate of run-on that must be diverted away from the Tailings Impoundment;
- Upstream storm water retention dams or basins that store run-off from upgradient areas to reduce the amount of run-on to the Tailings Impoundment;
- Downstream reclaim/storm water containment ponds and related channels and diversion dikes or berms that capture run-off or seepage from the Tailings Impoundment;
- Provisions of freeboard for the impoundment to contain the design flood;

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**INDIVIDUAL GUIDANCE (3-57)**
• Drainage control channels to control run-off from embankment slopes.

BADCT for a proposed facility may use any or all of these components designed to satisfy the following criteria:

• Components that store storm water, rainfall or process fluids (e.g., ponds) must be designed for the design storm volume (See Appendix E);
• Components that divert run-off and run-on (e.g., channels) must be designed to convey the design peak flow.

3.5.4.3 Discharge Control

Containment of tailing has been demonstrated through the use of geologic features, hydrostatic head control, and liner systems. Geologic features such as low permeability sediments (e.g., clay layers) or bedrock (e.g., low permeability shale or claystones) may be used as BADCT containment elements to the extent that they affect discharge reduction prior to reaching the water table. The applicant must demonstrate that such low permeability is areally extensive such that it will function as intended. Additional geologic containment may consist of a demonstration that pollutants would be attenuated in the vadose zone (See Section 1.2.4.5). Thickness, permeability and attenuation capacity of the vadose zone are the factors most commonly relied upon for natural containment beneath a facility. These and any other factors relied upon for natural discharge control must be investigated as part of site evaluations discussed in Section 3.5.3.

A well designed quality assurance/quality control (QA/QC) program has been found to be an important factor in achieving design performance criteria of a facility. Attention to proper construction can make the difference between a facility that performs up to its expected design and one that has problems throughout its operational lifetime. Appendix D (Construction Quality Assurance and Quality Control) provides additional guidance on the development of QA/QC documents.

3.5.4.3.1 Base Metal Tailing Impoundments

The following design elements have been used as part of discharge control systems to achieve BADCT for base metal Tailing Impoundments. Because application of the design elements is site specific, all the design elements may not be a part of BADCT for all facilities.

• Interception of storm run-off and groundwater flow in shallow aquifers to minimize water inflow;
• Natural geologic features functioning as liners;
• Localized lining with geosynthetic materials and/or clay;

(3-58) INDIVIDUAL GUIDANCE